Russia’s carbon emission pathways and cumulative emission budgets

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Abstract

Despite climate change being an increasingly important focus of scientific and policy discourse and against a backdrop of rising greenhouse gas emissions, the Russian government has, thus far, failed to commit to an ambitious emission reduction target based on the latest science. For Russia to develop informed, internally consistent and scientifically literate policies, it is important to assess the scale of the challenge and explore implications of different levels of mitigation. To this end, the thesis derives Russia’s cumulative emission budgets and generates associated low-carbon pathways in the context of both a re-developing economy and international climate change objectives (in particular, keeping the global mean temperature increase below 2°C relative to pre-industrial levels).

This thesis draws on several disciplines, bringing together bottom-up energy system modelling from engineering and physical sciences, as well as stakeholder and expert interviews from social sciences. The principal methodological approach used here is backcasting, with a number of stakeholder interviews providing a ‘reality check’ for the scenarios.

Given the global delay in acting on climate change, the contextual 2°C scenarios generated are ambitious and extremely challenging. With significant changes on both demand and supply sides, an annual post-peak emission reduction rate of at least 10% is required to meet the cumulative budget constraint; this despite the dramatic fall in Russia’s emissions in the 1990s. Such radical reduction rates are well in excess of anything achieved or, indeed, deemed possible within existing mitigation policies and integrated assessment models – either in Russia or in any other part of the world.

The necessary emission reductions would involve significant material changes to the energy system. Even with early reductions, to attain a low-carbon energy system in 2050 in accordance with the 2°C cumulative emission constraint, all of the available ‘mature’ technological options would need to be employed. In particular, short-term mitigation can be facilitated by Russia’s large energy efficiency potential and a significant biomass potential. In the long term, mitigation could draw on the country’s considerable renewable energy resources.

If the peak in Russia’s emissions is delayed until 2020–2025, staying within a national 2°C budget constraint will require a rapid and widespread deployment of currently speculative negative-emission technologies. Whilst the suggested mitigation pathways with emissions peaking early are demanding, they are potentially less challenging and destabilising than failing to mitigate and subsequently adapting to climate change impacts of a 6–16°C temperature rise across Russia. The precautionary principle, together with the multiple uncertainties associated with negative emissions, would suggest that starting the decarbonisation process early is critical.

Along with other big emitters, Russia has a pivotal role in influencing the future direction of international climate change mitigation and adaptation. Not only is Russia a major emitter of greenhouse gases and a global supplier of fossil fuels, but also it remains a major force in geopolitics, and its diverse territory is both vulnerable and resilient to the impacts of climate change. This unique confluence of circumstances leaves Russia with a challenging dilemma. The country can choose to acquiesce to short-term political and economic considerations, adopt weak mitigation measures and face potentially devastating impacts. Or it can apply its considerable attributes and powers to instigate an epoch of national and global action to secure a low-carbon and climate-resilient future. Whilst the former will see Russia subsumed into the international malaise on climate change, the latter may both quench the nation’s “thirst for greatness” and fill the void of climate leadership.
Declaration

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The author

Maria obtained her first graduate degree at the Far-Eastern Federal University (Vladivostok, Russia) specialising in Global Economy and International Management. She worked as an assistant economist-intern in a state-owned enterprise when she was accepted for a Master’s programme in Economics at the Central European University in Budapest, Hungary.

At the end of the programme’s first year, she joined the Centre for Climate Change and Sustainable Energy Policy (3CSEP). Maria’s work there mainly focused on the Former Soviet Union and Central & Eastern Europe countries. She was involved in various research projects and consultancies spanning from measuring Hungarian households’ electricity consumption to modelling and forecasting energy use in the building sector worldwide to designing new Kyoto Protocol flexible mechanisms – green investment schemes.

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Maria’s research interests include energy and emission modelling; whole-system scenario analysis; cumulative emission budgets; and, energy and climate policies.
PART 1: INTRODUCTION AND BACKGROUND
Chapter 1: Introduction to the thesis

1.1 Outlining the problem and its significance

The urgency and scale of the climate change challenge is reinforced by recent studies illustrating how, despite the global economic downturn, greenhouse gas emissions continue to grow at the highest rates envisaged by the Intergovernmental Panel on Climate Change and well in excess of that necessary to avoid the 2°C characterisation of ‘dangerous’ climate change (Friedlingstein et al., 2010; Peters et al., 2012a). The outcome of the 17th Conference of the Parties in Durban suggests that no emission reduction deal will be operationalised before 2020 (Boyle, 2011), which, in the near term, provides little incentive for countries to curb their greenhouse gases. If current emission trends continue, the largest amount of carbon dioxide in the human history is likely to be emitted within this decade (Peters et al., 2012b). Given that CO$_2$ remains in the atmosphere for at least a hundred years and potentially longer (Archer and Brovkin, 2008; Archer et al., 2009), the emissions produced before 2020 will shape the future climate for centuries to come. The post-2020 deal is essentially meaningless in the context of a diminishing cumulative emission budget$^1$. If the Copenhagen Accord commitments are to be met, immediate and large-scale emission reductions are necessary.

Against this backdrop of accelerating emissions, Russia presents an important and interesting case. Whilst an Annex 1 nation, it witnessed a rapid fall in its emissions as its economy collapsed in the early 1990s. Despite such rapid reductions, Russia remains amongst the five highest emitting nations, with, since the 2008 economic crisis, its emissions now resuming their upward trajectory. Not only is Russia a major emitter of greenhouse gases, but also it is a leading global supplier of fossil fuels, remains an influential force in international politics and is predisposed geographically to the impacts of climate change. Russia occupies more than a tenth of the global land area, with nearly two-thirds of the country underlain by methane-rich permafrost; consequently the impacts of temperature increases on its territory are likely to have global repercussions.

The global nature of climate change implies that climate-related policies in Russia should link to broader international scientific and political discourses on climate change. Yet, to date, the country’s short-term national priorities have taken precedence over international negotiations and the accompanying science, as has indeed been the case in most nations. Given the geographical, geopolitical and socio-economic significance of Russia both regionally and

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$^1$ Compatible with a reasonable chance of not exceeding the 2°C mean surface temperature increase over pre-industrial.
globally, it is important to provide science-based guidance for decarbonising Russia’s energy system. Existing climate-related studies and policies have evidently failed to make a noticeable change in Russia’s emission trajectory. Hence, it is essential to identify factors likely to prevent or trigger a low-carbon modernisation of the country and to explore alternative development pathways that are appropriate for the national context and linked to a global climate objective.

1.2 The aim, research objectives and scope

This thesis aims to derive cumulative emission budgets for Russia and to generate associated low-carbon pathways in the context of both a re-developing economy and international climate change goals. This aim is achieved through three key research objectives: 1) to assess the political and economic background in Russia in relation to climate change science and international climate change negotiations; 2) to generate national medium-term emission scenarios for Russia’s energy system; and, 3) to suggest alternative sets of measures as to how 2°C emission pathways for Russia’s energy system could be implemented.

Given that, within the constraints of a PhD, it is impossible to cover all aspects of Russia’s potential transition to a low-carbon future, it is necessary to set clear limits to the scope of the research. For the purposes of this thesis, the scope is defined by (amongst other things) the significance of the problem outlined above, the aim of the study and the research process as a whole. As section 1 suggests, there is a need to inform the national climate- and energy-related debate, based on the latest climate change science and in accord with international climate targets. This thesis will show that exploratory backcast scenarios, in particular, can indicate mitigation options and recourses that were previously unnoticed and, thereby, create new ways of thinking and strategic, innovative solutions. To this end, the thesis will focus on deriving a range of quantitative—but contextualised—medium-term mitigation targets and pathways towards them, building on the expertise of the author of the thesis (hereafter, ‘the researcher’) and on previous work of the research group (Tyndall Centre for Climate Change Research, Manchester) where this PhD project has taken place. Although this project aims to generate and analyse policy-relevant scenarios within associated political and socio-economic contexts, it does not intend to draw policy recommendations from the analysis and is not framed theoretically from a political economy perspective. Note that the research process has been highly iterative, with the scope, research boundaries and objectives slightly changing throughout the project until they took the current shape reported within this thesis.
1.3 The overview of the thesis

One of the key criteria for identifying research boundaries and scope is establishing what is particularly relevant for achieving the aim of the study. To explain how the aim of this thesis is achieved, this section outlines the content and order of the chapters and justifies the logic behind the structure of this work. The thesis is organised in four parts: introduction and background (chapters 1 to 4), empirical methods (chapter 5), results of the scenario exercise (chapters 6 to 9), discussion and concluding remarks (chapter 10).

Following the introduction to the thesis, chapter 2 ("Climatic changes in Russia: observations, projections and impacts") considers Russia’s climatic conditions in the 20th and 21st centuries and summarises evident and potential climate change impacts and adaptation strategies. The chapter elaborates on how the climate has changed in the 21st century and what further changes are likely to occur if no policies are implemented to reduce greenhouse gas emissions globally. Uncertainties evident in climate change observation and assessment are then discussed in relation to the Russian context.

To better comprehend the developments relevant to Russia, it is necessary to situate the country’s engagement with climate change against the backdrop of associated public perceptions, international negotiations and domestic politics. To this end, chapter 3 ("The political and social context of climate change and energy debate in Russia") reviews and synthesises a breadth of literature (including scientific works, policy documents, governmental communications and mass media reports) to deliver insights on the interplay between Russia and the global community around climate change and, to a lesser extent, energy issues.

Through meta-analysis of scientific literature and policy documents, chapter 4 ("2 degrees C' and climate target-setting") considers the contemporary framing of climate-related temperature targets as they pertain to Russia, in order to identify and justify one of the essential research boundaries of this thesis. In particular, this chapter sets the foundations of the empirical method (backcasting)—used in this work for generating low-carbon emission scenarios—in the form of a temperature target (2°C) to be achieved by staying within a range of carbon budgets.

Chapter 5 ("Research design: scenarios, participatory backcasting and thematic analysis") establishes and justifies methodological boundaries of the thesis emphasising its interdisciplinary nature. This chapter presents a theoretical critique of backcasting in
application to climate change, arguing that participatory backcasts offer policy-significant insights and are more appropriate for dealing with the climate change problem than other scenario approaches. The chapter then describes how the backcasting approach is applied specifically within this thesis, including details of the ASK-Russia scenario generator and of the stakeholder engagement process.

Chapters 6 to 9 cover the six stages of the backcasting approach. The first stage of backcasting requires an overarching objective, placing a constraint on results of the scenario exercise. Chapter 4 has made the first step towards formulating such an objective within the framework of this thesis, by explaining the reasoning behind 2°C as a global climate change target. The question is now how 2°C can be translated into national emission target/s and, subsequently, into specific changes that the national energy system would need to undergo in order to achieve the target/s. Accordingly, to make a global temperature target meaningful in the national context, chapter 6 ("The strategic objective: Russia's carbon emission budgets") derives a range of cumulative emission budgets for Russia, thereby completing the first stage of backcasting for the purposes of this thesis.

There are three broad types of constraint placed on scenarios in this thesis: emission budgets commensurate with a given probability of the 2°C objective; a momentum in both the energy system and in the socio-economic environment; and, the ‘feasibility’ of implementing the scenarios. The previous chapter has elaborated on the first type of constraint, developing a range of emission budgets for the strategic objective of the scenario exercise. Chapter 7 ("The past and present states of Russia's energy system") expands on the second and touches on the third type of constraint, by describing and analysing past and current trends in Russia’s energy system and related economic, demographic and technological aspects of the re-developing economy. This chapter corresponds to the second stage of backcasting.

Chapter 8 ("The research’s journey: the iterative process of refining the backcast scenarios") merges the two final stages of backcasting (stages 5 and 6) and the main aspects of iterations that the backcast scenarios underwent throughout the project. As chapter 5 has explained earlier, the fifth stage of backcasting ensures the backcast scenarios are relevant and consistent, whilst the sixth stage evaluates relative feasibility and potential implications of the generated scenarios and desired future states. This is achieved through engaging both internal peer-reviewers and external experts, as this chapter shows. In reporting the iterations of and adjustments in the backcast scenarios—one of the main outputs of the thesis—this chapter essentially narrates the ‘journey’ of this research project.
Chapter 9 (“Desired future states of the energy system and transitions towards each future”) explores ‘desirable’ future states of Russia’s energy system in 2050 and pathways towards them, covering the third and fourth stages of backcasting. The chapter describes how four heuristic backcast scenarios have been constructed that capture a breadth and diversity of interesting and informative heuristics and that can be appropriately developed within the resource constraints of a PhD project. It is the final version of the scenarios that is presented here, i.e., after the iterations and adjustments reported in chapter 8 have taken place. For the purposes of this thesis, this chapter considers, first and foremost, how technology and behaviour can contribute to decarbonisation in the four scenarios, followed by a brief analysis of aspects of governance, socio-political values and other ‘trends’ (analysed in chapter 7) that may hinder or facilitate a low-carbon transition.

Finally, chapter 10 (“Discussion and concluding remarks”) integrates the scenario analysis with insights from the background chapters and expert interviews to contextualise the challenges facing Russia in mitigating emissions in accord with its international commitments to the 2°C target. In this regard, the chapter demonstrates how this thesis has delivered on its aim of deriving cumulative emission budgets for Russia and generating associated low-carbon pathways in the context of both a re-industrialising economy and international climate change goals.
Chapter 2: Climatic changes in Russia: observations, projections and impacts

2.1 Introduction

Having established the overall context, aim and scope of this thesis in the previous (introductory) chapter, this chapter considers Russia’s climatic conditions in the 20th and 21st centuries and summarises evident and potential climate change impacts and adaptation strategies. The climatic system has an immediate influence on the development of a country. Understanding the main past and present characteristics of the climate is necessary for making informed projections of its future states and of their impacts on the elements of the economic system.

Much of the information about the climate and climatic changes in Russia comes from the Russian Federal Service for Hydrometeorology and Environmental Monitoring (‘RosHydromet’) that has accumulated a significant record of the country’s weather and climatic conditions. This chapter starts with a general description of Russia’s climate and its elements including, amongst others, temperature, precipitation and extreme weather events (section 2.2). The following two sections elaborate on how the climate has changed in the 21st century and what further changes are likely to occur if no policies are implemented to reduce greenhouse gas emissions globally. Section 2.5 discusses uncertainties evident in climate change observation and assessment, followed by a conclusion to the chapter.

2.2 Climate in the 20th century

Russia occupies the Northern part of Eurasia, has a large territory, a varied underlying terrain and a subsequent diversity of atmospheric circulation processes. These factors explain many characteristics of the country’s climate, including long winters, a large extent of permafrost and distinct seasons. There are four climatic zones (Arctic, Subarctic, Temperate and Subtropical) in Russia with the continental climatic region predominant in each zone. Solar radiation patterns across the country vary by season, both in terms of the light incidence angle and daylight length. The seasonality is particularly prominent in the temperate climatic zone. Sub-zero temperatures are observed for at least six months of the year on much of area, apart

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2 Chapters 2 and 3 have been published as a peer-reviewed journal article: see Sharmina et al. (2013) in the reference list at the end of the thesis.

3 This subsection draws on RosHydromet (2008a, pp.10–17) unless otherwise stated. Only temperature and precipitation are covered here, whilst other elements of the climatic system—cloud cover, solar radiation, wind conditions, waterways—are outside the scope of this work.
from the southern territories that, instead, experience frequent droughts, dust storms, wild fires and other heat-related extreme weather events.

Russia is the coldest country in the world with the mean annual temperature of -4.1°C over the 1961–1990 measurement period. Averages however fail to reflect the diversity across large territories, and this is particularly true for Russia whose four climatic zones are divided into 18 climatic regions. Whilst the warmest areas (the Black Sea coast) enjoy above-zero temperatures in winters, the average winter temperature in the coldest regions (Eastern Siberia) is -40°C. Average summer temperatures across the country vary from 4–5°C in the Far North to 20–22°C in the southern regions.

Two main distinguishing characteristics of the precipitation regime in Russia are the abundance of solid precipitation (e.g., snow, hail and sleet) and the uneven distribution of rainfall throughout the country. The first characteristic is due to a large number of cold climatic regions; the second one is attributable to the country’s vast area. The average annual precipitation is as low as 150 mm on the Arctic islands and arid valleys of South-East Altai and reaches up to 3,200 mm on the Black Sea coast. In contrast to the temperature regime, average monthly precipitation variation is greater in summer than in winter. For example, the Caspian Sea coast sees less than 30 mm of summer rainfall, whereas it measures up to 100–140 mm in Primorsky Krai and the Altai Mountains. Winter precipitation stays at about 20–40 mm a month in most regions.

Another distinct feature of Russia’s climate is permafrost. It extends over almost 70% of the country’s area, with the frost penetration in some areas reaching as deep as 1,300 m. Permafrost evolution has a major bearing on both climate formation and socio-economic performance in Russia. The maintenance of existing infrastructure and new construction projects are dependent on the state of the permanently frozen ground, particularly, in the northern parts of Western Siberia which is Russia’s main gas province. Along with permafrost, soils characterised by seasonal freezing and thawing are part of the cryosphere. Most of Russia’s intensive agriculture takes place in regions affected by such seasonal changes, and the depth of soil freezing is likely to influence the agricultural productivity.

The soil freezing-thawing cycle is a direct consequence of seasonal changes in solar radiation. Total annual solar radiation varies across Russia from 700 kWh/m² in the north west to 1,800 kWh/m² in the south east.

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4 The ground is considered permanently frozen if its temperature remains below zero for longer than two years.
kWh/m² in the south. About 60% of the country, including vast areas in Siberia, the Far East and the North Caucasus, enjoys more than 1,600 kWh/m² per year, which creates a significant potential for harvesting solar energy (Chumakov, 2010, p.41). Amongst other factors, total solar radiation is affected by the amount and shape of clouds. On much of Russia’s territory, cloud cover is at its minimum in summer and at its maximum in winter or late autumn; with the opposite annual cycle in the Far East. If the country’s solar power potential is to provide secure supply, the infrastructure may need to consider exporting solar energy from one region to another within the country, depending on the season.

Alongside solar radiation and cloud cover, wind is another element of the climate shaping the country’s renewable energy potential cyclically and on a large scale. The Westerlies define the wind pattern over much of Russia, with the Atlantic Ocean having a significant influence on the country’s atmospheric circulation processes, despite bordering Russia’s coasts only indirectly. The wind direction and force are affected by terrain. In winter, some landscape differences, for example, vegetation, are levelled by the snow cover, whereas the geological relief affects the climate throughout the year. Most of the country sees weak winds in summer and strong winds in winter, whilst the North East (apart from the coastlines) have the opposite wind patterns. The Far-Eastern and Northern coasts are the most wind-intensive areas in Russia with wind speeds reaching up to 34–38 m/c, promising a high wind energy potential. Strong winds are also characteristic of the southern part of Western Russia, with recorded maximum wind speeds of 34–36 m/c but with more favourable living and working conditions than in the Far East and Far North.

Wind is responsible for the majority of extreme weather events in Russia. RosHydromet reports that as many as ca.4700 extreme weather events were registered in 1995–2008, with much of the disruptive weather caused by intensifying winds. Other important factors include heavy or protracted rains and ensuing landslides. The largest number of the recorded extreme weather events took place in the Far East and North Caucasus (743 and 738 events respectively) and Siberia (522–689 events), with the least number occurring in the North Western and Central Black Earth regions (118–145 events). Despite the high frequency of such events, Russia is much less likely to experience devastating hydrometeorological phenomena than other countries, with the Far Eastern coastline currently considered the only region at risk.
2.3 Climatic changes and 21st century projections

The mean land-surface air temperature on the Russian territory is expected to rise more rapidly than the global average. Temperature projections by the Russian Federal Service for Hydrometeorology and Environmental Monitoring (‘RosHydromet’) are based on coupled atmosphere-ocean general circulation models and a range of storylines from the IPCC’s ‘Special Report on Emissions Scenarios’, or ‘SRES’ (IPCC, 2000b). The RosHydromet argues that there are only “minor variations” between outputs of different scenarios for Russia by the middle of the century (RosHydromet, 2008c). In particular, the annual mean temperature for Russia is projected to rise 1.1±0.5°C by 2020 and 2.6±0.7°C by 2060 above a 1990 baseline; with the winter mean surface temperature projected to increase 3.4±0.8°C by 2060 (RosHydromet, 2008a). Therefore, Russia would cross the 2°C threshold earlier than the world ‘on average’ if significant and effective mitigation is not forthcoming. Average warming for the Russian territory for the period 1907–2006 is estimated to have been 1.29°C compared to 0.75°C globally (RosHydromet, 2008a). In a more recent study, Sanderson et al. (2011) report that by 2100, at the high end of the SRES A2 scenario family, “the northern half of Asia”, including Russia, is likely to experience a temperature increase of 6–16°C, compared to a ~4°C global mean temperature increase, relative to pre-industrial levels. Simulations by the UK Met Office Hadley Centre, exploring the SRES highest emission scenario family A1FI, demonstrate that the 4°C global average could be reached as early as in 2058 if relatively strong carbon-cycle feedbacks are assumed (Betts et al., 2011). Other recent analyses also warn of the global temperature change trending towards 4°C by as early as 2060–2070 (Met Office, 2009; Anderson and Bows, 2011, p.36; New et al., 2011, p.143).

The mean surface temperature in Russia’s territory is predicted to change unevenly, with the regions closer to the North Pole experiencing higher temperature increases in winter and lower temperature increases in summer, compared to the south of the country, as Figure 1 illustrates. Notably, over the recent years the areas of intensive gas exploration and production, Nadym and Urengoy, have experienced the highest soil surface temperature increase in the Northern region (Bulygina et al., 2010, p.58).

Similarly to temperatures, predicted changes in precipitation vary across the country, although RosHydromet (2008a, p.208) expects that winter precipitation will intensify in all Russian regions. In summer, only high and mid-latitudes are likely to experience raised precipitation levels, whereas the southern regions will develop arid conditions. Overall, water resources are expected to increase in water-abundant areas and shrink in drought-prone regions. As to the changes that are already evident, over the past decades there has been some increase in the
average annual precipitation country-wide, although there was no definite precipitation trend over the 20th century as a whole (ibid., p.80).

Figure 1. Projected winter (on the left) and summer (on the right) temperature increases in Russia by the middle of the 21st century compared to the 1990 levels, based on the SRES's A2 scenario (RosHydromet, 2008a, p.183)

The changes in temperatures and precipitation are likely to raise the probability of droughts in the south of Russia by 2100 (RosHydromet, 2008b, p.277). At the same time, forest flammability is expected to grow throughout the first half of the 21st century (ibid., p.278), as average annual and monthly temperatures continue to climb. Latest data show that 2011 was amongst the five warmest years since instrumental meteorological observations started (RosHydromet, 2012a, p.79), with 2010 illustrating how temperature anomalies and associated impacts may transpire in the future if no mitigation action is taken. In the 2010 summer, Moscow experienced the highest monthly average temperatures on record (Lokostchenko, 2012, cited in RosHydromet, 2012b), and a similar situation was observed elsewhere in western Russia. The heat wave produced temperatures three standard deviations higher than local seasonal average near-surface air temperature (Hansen et al., 2012, pp.3–4). Barriopedro et al. (2011, p.221) estimate that weekly and monthly mean temperatures exceeded the 1970–1999 averages by about 10°C, i.e., by more than four standard deviations. Figure 2 shows how the 2010 heat wave developed over different time scales.

Assessments of the heat wave impacts suggest increased morbidity and mortality, uncontained forest and peat land fires, and an acute failure of a quarter of an annual crop yield (RBC, 2010; Vesti, 2010a, b; Barriopedro et al., 2011, p.220; Sidortsov, 2011, pp.4–8; Wegren, 2011, pp.145–150). A number of scientists consider the heat wave a direct result of climate change (Rahmstorf and Coumou, 2011, p.4; Hansen et al., 2012, p.6), although other assessments make only a tentative link between the two (Dole et al., 2011, pp.4–5). Hansen et al. (2012, pp.6–8) explain that, although meteorologists tend to rule out climate change as a cause of the

5 Despite the heat wave, 2010 on average is not amongst the warmest years due to a combination of an extremely cold winter and a record-setting heat in the summer (RosHydromet, 2011, p.64).
2010 heat wave, evidence suggests that the temperature at the time was amplified by the greenhouse gas effect. Similarly, other elements of the water cycle are likely to be affected by the changing climate and, hence, to aggravate disruptive weather (ibid.). The bottom row of Table 2 lists several potential extreme weather events, in addition to temperature anomalies and droughts.

Figure 2. Temperature anomalies during 7-, 15, 31- and 81-day periods in summer 2010 compared to the 1970–1999 average. The black dots indicate the highest values on record with the size of each dot corresponding to how much the mean value was exceeded. (Barriopedro et al., 2011, p.221)

2.4 Climate change impacts and adaptation strategies

Observing and understanding climatic trends and variation is essential for exploring how they may change and how they may subsequently affect the country’s development. This is particularly important for countries with an inhospitable environment that typically locks them into climate-specific infrastructures. Russia has some of the harshest conditions in the world for living and working on much of its territory. Despite the difficulties, the population and institutions have adapted to the environment over the decades of relatively stable climatic conditions. If the scale or the pace of climate change exceeds that of adaptation, the repercussions may be far-reaching and damaging.

The impacts of a temperature increase will be more immediate and detrimental for some areas than others. In the short term Russia is expected to have an increased vegetation period for
crops and fruit trees. At the same time, the variability of weather patterns is predicted to bring about untimely frosts and thaws as well as inadequate protective snow cover during winter that could damage plants (Klimov et al., 2006, p.368). Table 2 at the end of this chapter summarises climate change implications for Russia as presented in Russian-language literature (see references in the caption of the table). The impacts listed in the second column do not assume adaptation and, for the purposes of this thesis, are ranked as positive (+), negative (-) or uncertain (•). Some impacts and, consequently, adaptation strategies are unique to particular regions, as is detailed in the first column. For instance, Russia’s Arctic and Subarctic territories will likely face the most far-reaching implications compared with other parts of the country in terms of ecological, economic and human aspects (RosHydromet, 2008b).

The Northern region is an example of both positive and negative impacts of climate change. For instance, the living and working conditions in the area may improve because of a warmer climate, making it easier to populate the region and extract natural resources. However, the permafrost degradation will make it difficult to maintain existing infrastructure and buildings (Kokorin and Gritsevich, 2007, p.3; UNEP, 2012b, p.15). Additionally, radioactive waste depositories on one of the Arctic islands, the Novaya Zemlia, are likely to become a major concern as the permafrost weakens (RosHydromet, 2005, p.16). In general, RosHydromet (2008a, p.204) suggests there are three types of changes that the permafrost is likely to undergo: an increasing thickness of the seasonally thawed layer, higher temperatures of the permanently frozen ground and the separation of the deep-seated relict permafrost from seasonally frozen ground in some areas. Such separation is likely to result in land subsidence, floods and the drying-out of marshes, amongst other impacts (ibid.).

RosHydromet (2008a, pp.14–15) highlights nine elements of Russia’s natural and socio-economic system that are likely to be or have already been affected by the changing climate. Although all of the elements are vulnerable to climate change, their adaptive capacities vary. For example, only one element is considered highly adaptable (infrastructure and living conditions), whereas two elements have a low adaptive capacity (forest resources and safety from wild fires; permafrost and cryosphere) and the remaining elements are likely to demonstrate a medium adaptive capacity (health, water resources, the agricultural sector and food security, ecosystems and biodiversity, coastal areas, extreme weather events and hydrometeorological safety). The main criterion RosHydromet uses to describe adaptive capacity is the extent to which people and/or natural processes are able to sustain their current states and practices, regardless of costs. The report warns that such qualitative assessment necessarily involves judgement and is to be adjusted as new research findings emerge.
According to RosHydromet (ibid.), a high adaptive capacity in relation to living and working conditions is mainly due to the population and institutions being better equipped to deal with changes than other eight elements are. Another potential explanation is that, at least up to a certain temperature increase, Russia’s climate is expected to become more comfortable for living than it is today. In particular, the discomfort of living conditions is predicted to decline throughout the country. As Table 1 shows, a doubling of pre-industrial CO₂ concentration would result in a 14% decrease of ‘absolutely uncomfortable’ areas compared to 1981–1990 (Sergeev, 2010). Under the same assumptions, ‘comfortable’ areas are expected to expand. It is unclear from the study if the results have been normalised by the number of people living in different areas. A climate sensitivity range assumed in the study is not reported either.

<table>
<thead>
<tr>
<th>Degree of discomfort</th>
<th>Share of Russia’s total area, %</th>
</tr>
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<tbody>
<tr>
<td>Absolutely uncomfortable</td>
<td>39</td>
</tr>
<tr>
<td>Extremely uncomfortable</td>
<td>22</td>
</tr>
<tr>
<td>Discomfortable</td>
<td>17</td>
</tr>
<tr>
<td>Relatively uncomfortable</td>
<td>6</td>
</tr>
<tr>
<td>Comfortable</td>
<td>16</td>
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</tbody>
</table>

Effectively, adaptation in Russia is still at the research and planning stage. In this sense, the low level of commitment to addressing the issue of mitigation is exacerbated by the absence of an adequate adaptation strategy. Climate change risks are to some extent considered in various programmes for the development of economic sectors and provinces, but there is no comprehensive and clear set of policies at either national or regional levels. Severe heat waves in the central part of the country during 2010 demonstrated how the Russian government was unprepared to respond to extreme weather events on such a scale. The 2010 heat wave gives rise to serious concern as to how, in the absence of coherent adaptation strategies, Russia would tap its high adaptive capacity to cope with the potential ramifications of a 2°C or more global mean surface temperature rise. One evident political consequence of the heat waves was that the then-President started voicing concerns regarding climate change impacts on Russia. Although the Russian government is often at risk of confusing climate change with weather, such high-level engagement could potentially trigger a more meaningful commitment to dealing with issues of mitigation and adaptation.
2.5 Uncertainties and knowledge gaps in the assessment of climatic changes and impacts in Russia

Similarly to broader implications of climate change impacts, modelling-related uncertainties for Russia are in line with those of the global climate science community. Issues more pertinent to the national circumstances relate to the insufficiency of Russia’s current meteorological observational capacity. For example, the density of the federal meteorological observational network is, on average, one observation station per 10,000 km², compared to up to three stations in OECD countries. In addition to the Ministry of Natural Resources and Environment, there are a number of governmental departments, including the Ministry of Defence and the Ministry of Health and Social Development, maintaining observational stations for their own purposes. RosHydromet suggests that the number of such stations may total 30–40% of its own observational network. In particular, the Ministry of Defence operates stations in remote areas of the Far North, where RosHydromet’s observational capacity is limited. The integration of all stations into a nation-wide network could enhance the amount and quality of collected meteorological data (RosHydromet, 2008a, p.29).

Studies on Russia typically fail to discuss broader climate change implications, for instance, the issue of climate refugees from neighbouring states. Central Asian countries increasingly face water supply shortages and water quality deterioration (Perelet, 2007, p.8–10; WB, 2008, p.20–21). This is likely to affect health, ecosystems and agricultural practices and may result in forced migration to areas more suitable for living, of which Russia is the nearest. Such external pressures may be aggravated by potential tensions within Russia linked to water scarcity, dwindling crop yields in certain regions and populations being displaced by extreme weather events such as floods and mudslides (see Table 2 for more details). In addition, low-frequency high-impact climate change events and their implications are seldom explored (for notable exceptions see Alcamo et al., 2007; and Dronin and Kirilenko, 2011). This research gap is evident in many climate change impact studies, as the risks of catastrophes often become sidelined when the impacts are averaged geographically and temporally.

Regardless of uncertainties evident in analyses of Russia’s climate, the country is likely to be less vulnerable to changes in the climate than, for example, nations in the low latitudes (Mendelsohn et al., 2006, p.162). For some countries, the 2°C threshold is associated with impacts that will threaten their existence per se, whilst for many nations in the high latitudes, holding the temperature increase to 2°C will avoid such dramatic impacts (Richardson et al., 2009, p.16). Russia, on the whole, is insulated from the most extreme impacts of a global 2°C rise. As a consequence of its vast territory, abundance of water resources and low population
density of its more vulnerable regions, it has a high adaptive capacity compared to many of its neighbours.

2.6 Conclusion

Observing and understanding climatic trends is essential for predicting how they may change and thereby affect the development of a country. This is particularly important for countries with an inhospitable environment that typically locks them into climate-specific infrastructures. Russia has some of the harshest conditions in the world for living and working on much of its territory. Despite the difficulties, the population and institutions have adapted to the environment over the decades of relatively stable climatic conditions since official records began. If the scale or the pace of climate change exceeds that of adaptation, the repercussions may be far-reaching and damaging.

Some changes to Russia’s climate are already evident. For example, the average temperature increase in Russia in 1907–2006 suggests that future climatic changes are likely to be more rapid here than the global average change. If contained at a certain level, a higher temperature during the cold season will benefit agricultural production, improve living conditions and reduce energy use for heating. This prediction feeds the popular belief that climate change is ‘good’ for Russia. It may be problematic that ‘popular beliefs’ tend to overlook that such predictions are bound by uncertainty and conditional on the extent of climate change.

Whereas it is possible to develop resilience against gradual changes to seasonal climatic patterns, extreme weather events present a different challenge, being both highly disruptive and mostly unpredictable. The significant damage and low adaptability evident during the 2010 heat wave give an indication of the impacts that future extreme weather might have. This and other consequences of the changing climate are expected to intensify over the 21st century and inevitably affect the country’s development path. The vulnerability of different regions and sectors varies. If no mitigation or adaptation policies are implemented, the Far North will be more at risk of disruptive impacts than other regions, whilst agriculture and the extraction industry are cited as the most vulnerable sectors. These, however, may change depending on the timeframe. A high degree of uncertainty pertains to predicting climate change and its impacts, particularly with regard to Russia’s limited observational capacity compared to that of more developed countries. Despite the uncertainty, the country’s natural adaptive capacity is evidently higher than that of its neighbours.
This chapter has summarised manifest and potential climatic changes and impacts, as well as existing adaptation strategies in Russia. Evidently, to avoid and/or to adapt to climate impacts, the climate change issues need to be amongst the priorities of both the country’s government and population. The next chapter (chapter 3) explores whether they are indeed a priority, by analysing institutional, policy and societal aspects of the climate- and energy-related debate in Russia.
Table 2. Potential climate change implications for Russia summarised from Russian-language literature (Kirilenko et al., 2004; Klimov et al., 2006; Perelet et al., 2007; WWF, 2008; RosHydromet, 2008b; UNDP/RREC, 2009; UNDP, 2010; Sidorov et al., 2012)

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<tr>
<th>Affected areas</th>
<th>Impacts</th>
<th>Potential adaptation</th>
</tr>
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<tbody>
<tr>
<td>Terrestrial ecosystems (country-wide)</td>
<td>• Changes in borders of vegetation zones (species migration)</td>
<td>Land-use and forest management</td>
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<tr>
<td></td>
<td>• Altering regional albedo</td>
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<td></td>
<td>• Potential extinction of certain plants (particularly, those endemic to Arctic and Subarctic regions)</td>
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<td></td>
<td>• More frequent and intensive wildfires</td>
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<td></td>
<td>+ Terrestrial CO$_2$-fertilisation</td>
<td></td>
</tr>
<tr>
<td>Cryosphere (Arctic and sub-arctic regions; the Caucasus, the Ural and the Altai mountains)</td>
<td>• Increased sea-ice thickness in some North-West regions (Barents sea, Kara sea) in 2020–30</td>
<td>Suspension of new oil field exploration until effective methods of minimising impact of exploration/extraction in Arctic conditions are utilised</td>
</tr>
<tr>
<td></td>
<td>• Increased methane emissions from permafrost by 6–10 million tonnes pa by 2050</td>
<td>Monitoring and development of early warning systems in Arctic areas affected by climate change</td>
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<td></td>
<td>• Intensified coastal erosion due to permafrost degradation; consequently, increased risk of subsidence (see ‘Infrastructure and buildings’)</td>
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<td></td>
<td>• Declining ice extent and thickness on Arctic islands and archipelagos</td>
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<td></td>
<td>• Complete melting of certain mountain glaciers in Kamchatka peninsula</td>
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<tr>
<td></td>
<td>• Accelerated Caucasus glacier melt and decrease in glacier-derived runoff</td>
<td></td>
</tr>
<tr>
<td>Seas (maritime regions, seas and oceans)</td>
<td>• 3–5°C mean sea temperature increase by 2100 for seas of North-East Russia</td>
<td>Increased attention and diplomatic efforts regarding Arctic region geopolitics</td>
</tr>
<tr>
<td></td>
<td>• Increased sea-ice thickness in some North-West regions (Barents sea, Kara sea) in 2020–30; decreased sea winter ice thickness and extent in other seas</td>
<td>Fortification of buildings and infrastructure in regions threatened by sea level rise</td>
</tr>
<tr>
<td></td>
<td>• Changes in marine biodiversity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Increased access to energy resources in Arctic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Higher sea level in Southern regions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• More accessible navigation routes in Arctic</td>
<td></td>
</tr>
<tr>
<td>Rivers and water resources (country-wide)</td>
<td>• Ecosystem and biodiversity changes along rivers</td>
<td>Enhanced water supply management: building water reserves; rationed water distribution</td>
</tr>
<tr>
<td></td>
<td>• Extended river shipping season and shorter river ‘ice road’ season (due to approx. 20–27-day shorter river freeze-up and 20–40% thinner river ice)</td>
<td>Increased straightening and deepening of river channels to facilitate river shipping</td>
</tr>
<tr>
<td></td>
<td>• Decreased river flow by 3% in Southern regions; 10–20% decrease in local water resources by 2040</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ Increased river flow by 9–10% in European part of Russia; 4–8% in Arctic regions; 3–11% in Asian part of Russia (by 2040)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ Increased electricity production at most hydro-electro stations (except Southern regions)</td>
<td></td>
</tr>
</tbody>
</table>
| Infrastructure and buildings (country-wide) | Implementing energy efficiency measures in buildings sector  
Fortification of building and infrastructure in Arctic and Subarctic regions; evacuation of population at risk |
|------------------------------------------|-------------------------------------------------------------------------------------|
| - Shorter service life of buildings/infrastructure with increased temperature variability causing more thaws and cold spells during cold season  
- Undermined buildings, pipelines and other infrastructure in regions built on permafrost  
- Increased air-conditioning during warm season  
+ Shorter cold season and lower energy use for maintaining comfortable thermal condition inside buildings | |
| Agriculture (country-wide) | Innovative methods of pest/disease control  
Water management in potentially arid regions  
Developing agricultural practices in Northern and Eastern regions |
| - Longer annual vegetation periods that might lead to plants damage by early frosts (this risk is forecasted to persist until 2015 when warmer climate establishes itself in Russia)  
- Risks of new plant pests/diseases/invasive species with increasing aridity and warmer winters  
- Increased aridity of main crop-producing regions, leading to lower crop yields  
+ Increased output from marginal lands through reduced variability in temperature in some regions with fertile soil (Urals and Siberia) | |
| Population and health (country-wide) | Smart urban planning: increased albedo of roofs, planting trees, building shades and so on  
Improved water storage and supply management  
Vaccination and other preventive measures for containing diseases  
Education and development of new occupations for indigenous peoples |
| - Extremely high/low temperatures and large/rapid temperature variations (e.g., a 10°C temperature rise within 24 hours compared to a climatic normality results in 8% morbidity increase)  
- Potable water scarcity with decreased water flows and higher aridity in South  
- Aggravating air and water pollution problems  
- Proliferation of climate- and season-dependent allergies and/or vector-, rodent- and water-borne diseases  
- Indigenous people and their lifestyle affected by: changing flora and fauna; increasing drowning accidents during hunting/fishing with thinner ice; more frequent food poisoning caused by food conservation problems (as cold outside temperatures fail to serve as ‘refrigerators’)  
- Ecosystems and population affected by extreme weather events (see below)  
- Population migration caused by climate change  
+ Developing/populating Arctic/Subarctic regions with better climate conditions/energy resources exploration | |
| Extreme weather events (country-wide) | Enhanced water supply management  
Refined system of predicting and monitoring extreme weather events |
| - Potential increase in frequency/intensity of droughts in South of country (particularly, in Stavropolsky and Krasnodarsky regions)  
- Increase in frequency/intensity of mudslides (Caucasus)  
- Potentially increasing risk of avalanches (Caucasus)  
- Higher risks of wildfires in European part (except North-West) and South of Asian part of Russia  
+ Lower risks of wildfires in North-West and North-East of Asian part | |
Chapter 3: The political and social context of climate change and energy debate in Russia

3.1 Introduction

Climate-related policies in Russia have been linked with broader international scientific and political discourses on climate change. To better comprehend the developments relevant to Russia, it is necessary to situate the country’s engagement with climate change against the backdrop of the accompanying science, public perceptions, international negotiations and domestic politics. Through meta-analysis of scientific works, policy documents, governmental communications and mass media reports, this chapter reviews and synthesises a breadth of literature to deliver insights on the interplay between Russia and the global community around climate change and, to a lesser extent, energy issues.

With the science of climate change impacts covered in the previous chapter, this chapter focuses on institutional, policy and societal aspects of the debate. Section 3.2 analyses Russia’s legislative and institutional frameworks that are likely to affect the climate change issue directly or otherwise. Section 3.3 discusses public perceptions and mass-media representation of climate change and the formation of a climate-focused civil society in the country. The concluding section summarises key characteristics of Russia’s geopolitics and society that are likely to either impede or facilitate the country’s transition to a low-carbon economy.

3.2 Climate change and energy governance

3.2.1 Climate-related governmental institutions

Established in 1834 (RosHydromet, 2012b) the Service for Hydrometeorology and Environmental Monitoring (abbreviated as ‘RosHydromet’), nested within the Ministry of Natural Resources and Environment, is the main governmental department responsible for climate-related issues in Russia. The inclusion of climatology within RosHydromet’s Environmental Monitoring Laboratory occurred in the 1980s, coinciding with the suggestion that the Laboratory could combine all environment-related departments from different ministries under the umbrella of RosHydromet. The idea was eventually dropped, as was an initiative to protect the environment alongside simply monitoring it. Larin et al. (2003) suggest that the Laboratory failed to pursue active environmental quality control at the behest of its founder and long-standing director Yuri Izrael. His explicit view was that monitoring should be decoupled from active environmental protection (ibid.). This culture of ‘passive
observation’ subsequently continued after the Laboratory was renamed as the Institute of Global Climate and Ecology in 1990. The Institute currently retains its focus on monitoring and information provision, but with a more proactive approach evident from its expanded remit to include prevention and adaptation research.

A number of other ministries and agencies contribute to the work of the Institute where their remits match specific activities. A relatively new institutional player in climate change is the Russian Central Bank, acting as the national ‘carbon unit operator’ for Joint Implementation projects within the first commitment period of the Kyoto Protocol (Decree of the Government of the Russian Federation No.843 of 28 October 2009). No governmental institution, however, exists in isolation from the regulatory environment. For the purposes of this thesis, national legislation is classified into the policies that have the potential to abate emissions and those likely to increase emissions. Abatement, in this study, covers regulations intended to address climate change directly (i.e., are climate-focused) and those that have an indirect positive effect on the climate (i.e., are synergistic).

3.2.2 Climate-focused and synergistic national legislation

There are two main climate policy decrees in Russia: the Climate Doctrine published in 2009 and the Climate Action Plan passed in 2011. Their combined outcome has been to endorse a number of plausible policies at the highest legislative level. However, neither the Doctrine nor the Plan contains quantitative, or definitive, climate change targets. Although the Doctrine acknowledges that “a major part of the Russian Federation is within the geographic area affected by maximum climatic changes, in terms of both observations and predictions” (The Climate Doctrine, 2009), little has been done to put the suggested policies in place. The reality is often at odds with the written word. For example, out of the four points in the following passage from the Doctrine, only items (a) and (c) have so far received some attention from the government, despite the professed “maximum effort”:

“The Russian Federation expends maximum effort to mitigating anthropogenic greenhouse gas emissions and increasing their uptake by carbon sinks. The intention is to implement measures aimed at:

(a) increasing energy efficiency in all sectors of the economy;
(b) developing and deploying renewable and alternative energy sources;
(c) reducing market imbalances and realising financial and fiscal policies to encourage anthropogenic greenhouse gas emission reduction;
(d) protecting and enhancing the capacity of carbon sinks, including sustainable forestry, 
forestation and re-forestation” (The Climate Doctrine, 2009, emphasis added).

More recently (18 March 2013) the Ministry of Natural Resources and Environment released a 
draft decree on ‘The Level of Greenhouse Gas Emissions’ necessary to facilitate the 
implementation of the Doctrine. The draft announces a national emission ‘reduction’ target of 
25% below 1990 by 2020 (Draft Decree of the President of Russia, 2013); in practice, 
however, this implies growth in Russia’s emissions, as the current emission level is about 30% 
lower than in 1990 (UNFCCC, 2012). The draft decree also suggests that, within six months 
of it coming into effect, the government is to develop and approve an ‘action plan’ for 
achieving the pledged emission ‘reduction’ (Draft Decree of the President of Russia, 2013). It 
is currently unclear whether and how the new ‘action plan’ will relate to the Climate Action 
Plan adopted in 2011.

Although the existing Climate Action Plan provides a list of more detailed measures, the 
largest proportion of the document is focused on adaptation, despite the Doctrine’s 
proclaimed “maximum effort” to mitigate. In particular, the first paragraphs of the Plan (§1–
6) address climate change research and awareness; §7–17 focus on adaptation and minimising 
risks for and impacts on various socio-economic areas – health, forests, infrastructure and 
agriculture. Mitigation activities are detailed in §18–23 and include overall political and 
economic instruments, along with policies for intensive industries, the energy sector and land 
transport, to be implemented between 2011 and 2020. A shorter timeframe, 2011–2013, is 
considered for the buildings sector, consumer white goods and equipment, agriculture and 
forestry. The Plan also covers civil aviation and shipping, with both emerging at the end of the 
document. The document sets no quantitative objectives and identifies no sources of financial 
or professional support.

About a dozen ministries and subordinate offices share responsibility for implementing the 
Plan, with the Ministry of Natural Resources and Environment co-ordinating most of the 
adaptation and mitigation work. Some responsibilities are assigned to unexpected 
departments. For example, it is the Ministry of Industry and Trade, rather than the Ministry of 
Transport, that is in charge of improving the fuel efficiency of vehicles and most other 
transport-related measures. By contrast, other important agencies, such as the Federal 
Environmental, Industrial and Nuclear Supervision Service (‘RosTekhNadzor’) have no 
explicit roles.
The government’s drawing on a host of its departments can facilitate synergies amongst policies in different sectors. In the context of this thesis, legislation is termed ‘synergistic’ if, without overtly addressing climate change priorities, it nevertheless has significant potential to reduce emissions. Although high-level officials briefly acknowledge such synergies (Russian Government, 2006), there has been no attempt to assess their potential benefits. Such benefits may be considerable, as, for instance, studies conducted in the UK context demonstrate (DEFRA, 2010). Examples of synergistic policies in Russia include, amongst others, the 2009 energy efficiency law, the communal services reform aiming to eliminate fossil fuel subsidies, the introduction of European transport fuel and vehicle standards, the reforestation article of the Forestry Code and penalties for flaring more than 5% of associated petroleum gas. The scope of this thesis only allows for a cursory review of the first three synergistic policies; those likely to have the most discernable impact on reducing emissions, particularly, through demand-side measures.

The 2009 energy efficiency legislation

The energy efficiency legislation is a flagship energy-demand policy. If successful, it will provide a solid start to challenging the energy system inertia; by contrast, if implemented poorly, it will likely aggravate issues of carbon lock-in. In 2008, President Medvedev pledged a 40% reduction in the energy intensity of the country’s GDP by 2020 compared to 2007 (Decree of the President of Russia No.889 of 4 June 2008). A year later the government adopted the ‘Energy Strategy for 2030’, followed by the Energy Efficiency Federal Law and a number of related bylaws. The set of policies is ambitious in attempting to cover all sectors and activities where energy is used. Although it lays out specific targets, unlike the Climate Doctrine and the Climate Action Plan, the energy efficiency legislation has implementation difficulties similar to the climate policies. The Scientific Advisory Board of the working group that monitors the implementation of the Law, argues that the current quality of execution, in many respects, does not stand up to scrutiny and that delivering on the 40% pledge within the specified timeframe is very unlikely (Roketsky, 2011).

The communal services reform in the residential sector

The communal services reform, with its market-based residential energy prices, is another important synergistic policy implemented with varying success. A similar reform has already been completed for electricity prices in industry, with natural gas market-based pricing mechanisms to be implemented in 2014, whilst coal and oil prices have received no subsidies since the mid-1990s (Popov, 2012). Upon the completion of the residential reform, households are to cover the full costs of housing maintenance and utility services. The original expectation was to increase the share of expenses funded by residents from 35% in 1997 to
100% within six years. However by 2001 it was, at best, 60%, and with benefits and subsidies it was as low as 40%, with the slow progress often explained by the difficult socio-economic conditions of the time (Anestratenko, 2012). The government later ruled that the share should reach 100% by 2005, with a lower share funded by local governments. However even in 2012 some municipalities maintain it as low as 50% (Council of People's Deputies Press Office, 2012). Furthermore, although the 'marketisation' has succeeded to some extent, experts from the Accounts Chamber of the Russian Federation argue that the reform has hardly improved issues of safety, quality and security of the service (RBC, 2012b).

The government has now rescheduled the elimination of the cross-subsidy in the electricity sector to take place within the next 4 years (Decree of the Government of the Russian Federation No.1056 of 16 October 2012, ; Federal Law No.371-fz of 30 November 2011, ; RBC, 2012a). One of the suggestions is to develop a ‘social quota’ for monthly electricity consumption per person, above which the electricity tariffs will be significantly higher (Selliakhova, 2012). Electric energy is the first utility where the government intends to impose a ‘social quota’, facilitated by high penetration of metering equipment (about 95%, compared with 20 to 40% in heat and water supplies) and the largest cross-subsidisation scale (ibid.). A conservative projection of the electricity subsidy for 2013 is 200 billion roubles (6.3 billion USD), up from 135 billion roubles in 2008 (Construction News Agency, 2011). These figures are about four times lower than the IEA’s estimates (see Table 3 below), a discrepancy explained, in part, by large uncertainties in the data sources.

Although the scale of heating cross-subsidisation is small in comparison, eliminating it may prove harder than reducing the electricity subsidy. During the 2002–2008 electricity reform, the heating sector received little attention, and experts describe its current state as ‘a shambles’, with the attribution of responsibility unclear for different levels of government (Big Electric Power News, 2011). Often contradictory decisions have created an atmosphere of uncertainty in the sector, discouraging much needed investment (ibid.). The low level of investor trust and innovation is not disimilar to the situation in the power industry as a whole (Antropov et al., 2012).

**European emission standards for vehicles and transport fuels**

Emission policies in the transport sector have also faced implementation issues. In the mid-2000s, the Russian government committed to adopt a series of progressively stringent European standards for regulating exhaust emissions. The country is currently at the second stage (Euro-2) of implementing the fuel-focused policy. The intention is to phase out Euro-3
fuels by the end of 2014 and Euro-4 a year later (Decree of the Government of the Russian Federation No.748 of 7 September 2011). However, given the failed attempts by the government to withdraw Euro-2 transport fuels by 2008, experts warn that the policy is unlikely to deliver on schedule, as around half of Russia’s 25 thousand petrol stations operate independently from the vertically integrated oil companies, and so are likely to have compliance issues (Arzumanov, 2012).

The situation is similar with the European emission standards for vehicles. Their introduction has recently been postponed for one year, with Euro-4 cars and engines now allowed to remain until the end of 2015 (Decree of the Government of the Russian Federation No.2 of 20 January 2012). Previously, this policy was suspended from 2009 until 2011 to factor in the financial crisis, whereas the current delay is explained by the need to synchronise the production of vehicles with that of fuel (ProGOST, 2012). The non-compliance and legislative setbacks, in many respects, stem from Russia’s transitional challenges complicated by considerable fossil fuel reserves. Being an indigenous producer is almost certain to affect the country’s fossil fuel-dominated energy supply mix (BP, 2011; IEA, 2011a) and facilitate policies leading to increased emissions. Paradoxically, as some experts have noted, in order to generate revenue for diversifying the economy away from hydrocarbons, Russia will have to heavily invest in its fossil fuel industry (Bradshaw, 2012) driving emissions still higher.

3.2.3 Domestic policies likely to drive higher emissions

As Russia continues to undergo significant political and economic transitions, socialist and market-based ideologies co-exist and, on occasion, merge to provide new policy regimes. The last two decades have witnessed the Russian government increasingly introducing elements of \textit{laissez-faire} capitalism. For example, many state-owned enterprises have been privatised; the prices of most goods and services are now set through the interaction of demand and supply on the market; and a financial industry has been established. However, elements of a centrally planned economy remain, in particular, the re-nationalisation of some energy companies and, more importantly, fossil fuel price support (Overland, 2010).

As with other nations, maintaining fossil energy subsidies alongside a long-term climate strategy risks the development and implementation of inconsistent policies. Whilst Russia has gradually raised domestic energy prices since the early 2000s, the transition to a market-based price for energy has nevertheless been slow (Overland, 2010). The World Energy Outlook (IEA, 2011b) reports that in 2010 Russia still provided a total \textit{pre-tax} fossil fuel subsidy of 39.2 billion USD (1.2 trillion roubles), which constituted 2.7\% of Russia’s GDP that year.
Table 3 presents the subsidy breakdown by energy source over 2008–2010. Furthermore, the IMF estimates Russia’s total post-tax energy subsidies at 116 billion USD (3.6 trillion roubles), making it globally the third largest subsidiser of energy, behind the US and China (IMF, 2013).

Table 3. Pre-tax fossil-fuel consumption subsidies by energy source in Russia in 2008–2010 (billion USD) (IEA, 2011b)

<table>
<thead>
<tr>
<th>Energy source</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gas</td>
<td>28.47</td>
<td>18.57</td>
<td>16.95</td>
</tr>
<tr>
<td>Coal</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electricity</td>
<td>23.03</td>
<td>14.40</td>
<td>22.26</td>
</tr>
</tbody>
</table>

As regards ‘emission-inciting’ policies, in January 2012 the Russian government approved a long-term strategy for development of the coal industry. According to the official press-release the investment, planned through to 2030, amounts to 3.7 trillion roubles (119 billion USD), with 251.8 billion roubles (8.1 billion USD) to be direct state-finance (Ministry of Energy, 2012b). The government intends to operationalise new and refurbished coal extraction capacities of 505 million tonnes, which is predicted to result in a 25% higher annual extraction rate by 2030 compared with 2012 (Aliev, 2012). Some analysts suggest that, to deliver on the coal strategy, domestic consumption of coal will need to be encouraged through lower prices for coal-sourced energy, achieved, in part, by siting new coal power plants adjacent to mineral deposits so as to reduce transport costs (ibid.). The press-release and associated analyses make no mention of carbon capture and storage as an option to ‘clean’ Russian coal. The failure to consider the impacts domestic policies may have on emission rates, inevitably affects how Russia engages with international climate-related negotiations.

### 3.2.4 The Kyoto Protocol developments

Ultimately climate change is a global problem, with national policies insufficient to stay below any particular temperature threshold; hence, the need to co-ordinate mitigation policies between nations. Amid the global negotiations on climate change in the 1990s, the Russian government remained unconvinced as to the necessity of having an emission target. However, once the negotiations coalesced into the Kyoto Protocol, the government welcomed the near-term nature of the treaty for two principal and related reasons.

First, the fall in Russia’s emissions accompanying the economic collapse of the 1990s, as Figure 3 shows, was sufficient to ensure the short-term emission target could be easily met. Although strong economic growth resumed by the end of the decade, Russia’s share of global CO₂ emissions from fuel combustion had fallen to 6.5% in 1999 compared to 10.9% in 1990, with a further fall to 5.4% by 2010 (IEA, 2012a). The post-2000 decrease was mainly due to
the contraction of the Russian economy during the 2008 financial crisis, although its emissions have since resumed their upwards trajectory. Much of the decline in the energy and emission intensity of GDP since 1990 is explained by the decline in industry and a subsequent economic restructuring towards the services sector. A partial switch from coal and oil to natural gas and hydroelectricity in Russia’s energy supply fuel mix (BP, 2011; IEA, 2011a) also accounts for a share of the reduced emission intensity.

Second, following the break-up of the USSR, the relative security and stability of the Soviet system had given way to considerable economic and political uncertainty (Tsygankov, 2006). New market activities developed before any formal ‘rules’ such as legislation and accountability were established, triggering widespread corruption (Levin and Satarov, 2000). Against this backdrop, the government was not expected to commit to specific policies, and so the limited period of the Protocol, along with the fall in emissions, matched Russia’s national circumstances. Moreover, it offered the opportunity for the country to withdraw from any post-Kyoto commitments, should compliance prove too expensive for the Russian economy.

Whilst the Kyoto Protocol did not initially arouse significant attention within Russia, it later became an important issue dominated by interplay of vested interests (Kotov, 2002; Korppoo et al., 2006). Table 4 summarises a range of headline considerations evident in the debate around signing and ratifying the Protocol. Whilst some analyses point out a number of hidden motives behind the on-the-record viewpoints (Novikova, 2004), this thesis only refers to publicly declared positions.
Table 4. Russia and the Kyoto Protocol: positives and negatives as perceived by various stakeholder groups in Russia prior to ratification

<table>
<thead>
<tr>
<th>Stakeholder group</th>
<th>Positives</th>
<th>Negatives</th>
<th>Source</th>
</tr>
</thead>
</table>
| President; President’s economic advisor | • Russia was offered support in accessing the World Trade Organisation, if it signed and ratified the Kyoto Protocol. | • Treaty risked stifling economic growth.  
• Trading carbon quotas was considered ‘a pure unadulterated myth […] like trading air’.  
• The Kyoto Protocol would be an ‘intergovernmental GULAG’ with ‘interventionism at the level of international governance’.  
• Treaty was not based on principles of justice and equality unless signed and ratified by all countries. | (Zagorodniaia et al., 2003; Finansovye Izvestia, 2004b; a; Aglamish’ian and Frumkin, 2005, Korppoo et al., 2006) |
| Government        | • Kyoto Protocol could assist modernisation of the economy.  
• Selling emission quotas could provide a revenue source for federal budget.  
• The treaty implementation could help to control power of natural monopolies, supporting competitors via Kyoto flexible mechanisms. | • Existing environmental regulations were inadequate for monitoring emissions.  
• There would be a trade-off between economic growth and Russia’s emission obligation.  
• ‘Giving in’ to the European Union during Kyoto negotiations risked impression of Russia’s ‘political weakness’. | (Leskov, 2003; Aglamish’ian, 2004; Aglamish’ian and Frumkin, 2005, Korppoo et al., 2006) |
| Industry          | • Big companies could receive funds through flexible mechanisms, for modernisation.  
• Gas companies would benefit if Europe switches to more Russian natural gas.  
• Importers of Russian oil/coal would decrease their oil/coal consumption. | | (Korppoo et al., 2006; Kramer, 2006) |
| Scientists and NGOs | • Kyoto Protocol could tighten environmental requirements for production processes, phasing out inefficient industries. | • There is no link between climate and CO₂; hence Kyoto Protocol a scientific scam.  
• Even if Kyoto Protocol is implemented, impact on climate will be insignificant.  
• Protocol is part of EU’s conspiracy to increase cost of competitors’ goods via ‘greening’. | (Izrael et al., 2002; Zagorodniaia et al., 2003; Deliyagin, 2004) |
| General public    | No poll or research found on public views on Kyoto Protocol.                                                         | | --- |

Although there was no poll of public views on the Kyoto Protocol specifically, a survey did suggest that, in 1999, 12.3% of the Russian population claimed to be anxious about “global climate warming” (Ivanova, 2002). Assuming this adequately captures the broader public concern on climate change, it appears reasonable to infer that a small proportion of the population would have been actively in favour of signing and ratifying the Kyoto Protocol.

Another aspect of the Kyoto Protocol process where the Russian government has shown limited progress relates to the Protocol’s Flexible Mechanisms. In July 2010, the Ministry of Economic Development approved fifteen joint implementation (JI) projects, estimated to reduce emissions by 30 million tCO₂-equivalent by 2012 (Kruppa, 2010). This was the first carbon-projects tender and took place six years after the Kyoto Protocol was ratified, despite investors being willing to offer joint implementation projects immediately after the ratification. As a result, potential carbon investments and early emission reductions did not
materialise, suggesting inadequate political commitment to climate abatement. As of November 2012, 108 projects were approved with an estimated total mitigation potential of 311.6 million tCO$_2$-equivalent (CCGS, 2012). It is worth noting that the majority of Emissions Reduction Units were issued between May and October 2012, suggesting the process overall may have been rushed.

On the face of it, the delays in operationalising JI are difficult to explain given the potential benefits of Russia’s participation in the Kyoto Protocol spelt out in earlier assessments and largely confirmed by completed JI transactions. Some experts argue that the ratification problems were part of the “de-ecologisation” trend that started in Russia in the late 1990s (Averchenkov, 2003; Yanitsky, 2005). Following the collapse of the USSR, the industrial and financial lobby impeded an emerging strong environmental regulation, as an obstacle to exploiting Russia’s natural resources (ibid.). By extension, the same power struggle has probably caused the delays in setting up the joint implementation mechanism. If this is indeed the case, Russia’s relatively passive and often ambiguous stance in the current climate negotiations may have similar underlying reasons.

3.2.5 Post-Kyoto international climate-related commitments

Whilst the Russian government was engaging with the Kyoto negotiations, there was evidence of Russia’s “still terrible thirst for greatness” (Lieven, 2002) in how it exerted control over its abundant energy resources at a time of escalating oil prices (Giddens, 2009). However the advent of the Kyoto Protocol suggested, at least to some, that the era of fossil fuel consumption may be cut short, together with Russia’s energy supremacy. At the same time, the Protocol offered an opportunity for Russia to demonstrate it was willing to become a key driving force in the abatement of climate change, thereby securing a dominant position in the international climate negotiations. Not only the country’s size and resources, but also its share of world emissions (UNFCCC, 2012) and vast cost-effective abatement potential (Douraeva, 2003; Bashmakov et al., 2008) gave it the capacity to play a leading role in international talks.

The leadership considerations Russia may have had during the Kyoto Protocol debate have made little impact on the country’s role in more recent negotiations. Although the Russian government did sign the Copenhagen Accord and two subsequent non-committal agreements between 2009 and 2011, the country’s stance has been undecided. In the run-up to the Conference of the Parties in Doha in 2012, Russian news agencies reported at least three contradictory governmental positions, based on ‘confidential sources’. Some observers have likened the ambiguity of Russia’s current position to the pre-ratification uncertainty in the
early 2000s (Dobrovidova, 2012). In December 2012, at the 18th Conference of the Parties to the UNFCCC, Russia officially announced its refusal to participate in the second commitment period of the Kyoto Protocol, putting an end to speculations in the national media. Yet, the language of the statement was less than clear with regard to the country’s emission reduction target and a number of other important issues. In particular, Russia’s representative stated that, “the Russian Federation, by remaining a party to the Protocol, will continue to respect all of its current obligations (except quantitative ones)” (Bedritskiy, 2012, emphasis added).

Similar equivocation is manifest in Russia’s other climate-related international endeavours. For example, in May 2012 Russia signed the Camp David Declaration whereby, in addition to reaffirming the 2°C target commitment (Group of Eight, 2012), it agreed to join the UNEP’s Climate and Clean Air Coalition to Reduce Short-Term Climate Pollutants (Group of Eight, 2012). However, as of 27 September 2013, Russia remained the only G-8 nation not listed amongst the country partners of the Clean Air Coalition (UNEP, 2012a).

Russia’s recent accession to the World Trade Organisation suggests that economic and trade negotiations are associated with less ambiguity than global climate talks, although the implications of WTO membership for energy-related activities are not straightforward to assess. Decreasing import levies and quotas and rising export tariffs are expected to affect all economic sectors except the mineral extraction industry (Babkin et al., 2012; Golos Rossii, 2012), which is likely to intensify the nation’s already heavy dependence on raw material exports (Babkin et al., 2012). On the other hand, both households and industry may be persuaded to become more energy-efficient due to higher energy prices and cheaper imports of modern equipment. More importantly, the high-profile international negotiations through the WTO and UNFCCC processes have increased the Russian population’s awareness of the issues involved. The climate-focused civil society, in particular, started emerging in the late 1990s when the Kyoto Protocol discussions in the mass media put the issue in the spotlight.

3.3 Climate change and society

3.3.1 The development of a climate-focused civic society

The head and machinery of the Russian state have traditionally had a high level of autonomy in making decisions, with this power and resources used for both uniting a multinational population across a vast territory and remaining resilient to external enemies (Kljuchevskij, 1987). Against this historical backdrop, Russian society has evolved a relatively passive engagement with a paternalistic government and, consequently, has not developed a strong civil society (Tsygankov, 2006). For instance, when it came to ratifying the Kyoto Protocol,
the initiative was driven by the President rather than scientists, industrialists or campaigners; and the focus was mostly on advancing Russia’s geopolitical interests, regardless of other environmental or financial benefits (Kotov, 2004; Henry and Sundstrom, 2007; Andonova, 2008).

It was not until the mid-2000s that the climate *per se* received more attention in Russia’s broader policy circles (Kotov, 2004), this despite Russian scientists being involved in the activities of the Intergovernmental Panel on Climate Change from its inception. Furthermore, interviews with the scientists suggest that they “did not seem to play a role in deliberative processes leading to key decision-making moments”, such as ratification of the Kyoto Protocol (Wilson Rowe, 2012). Instead, Russia’s scientific community and its activities came to the fore after the political decision was taken and the climate change issue gained more importance at the national level.

Along with scientists, non-governmental organisations are an increasingly vocal part of Russia’s emerging civil society. In 2009 there were about 360 thousand non-commercial organisations registered in Russia, with 136 thousand of those active (Mersiianova, 2010). For comparison, there are an estimated 1.5 million NGOs in the United States (U.S. Department of State, 2012) and 3.3 million NGOs in India (Shukla, 2010). To date no NGO in Russia is exclusively focused on climate change issues. Instead, such issues are typically piggybacked on other environmental interests, and, since the mid-1990s, it has become common for already established Russian NGOs, such as the Russian Socio-Ecological Union (est. 1988), to embrace climate-related activities.

Despite their growing numbers, the online visibility of environmental NGOs is fairly limited. Salmenniemi et al. (2008) cite an expert opinion that the reputation of and trust towards not-for-profit organisations in Russia is extremely low, which may be attributed to the people’s wariness of social institutions in general. Arguably, the social distrust was somewhat mitigated during and after the 2010 heat wave and subsequent wildfires, which catalysed a more vocal dissatisfaction amongst the population. Sociologists suggest that the extreme weather event highlighted the inertia and inefficiency of the vertical chain of command and strengthened the socio-environmental movement in Russia (Yanitsky, 2011).

The social distrust, the centralisation of power and long distances have diminished the involvement of Russia’s ‘regions’ (from Russian: *regiony* – areas outside of Moscow and St. Petersburg) in civil society. In particular, although ‘regions’ are likely to be significantly
affected by the changing climate, they have little influence on climate-related policies. Local and regional citizen representation is in many ways powerless (Makarova, 2012); provincial areas are underdeveloped compared to Moscow and St. Petersburg (Kliueva, 2012); and, as a result of top-down publicity campaigns, the trust in local and regional authorities is lower than in the federal government (Yurasov and Yurasova, 2012). These issues have persisted despite recent and slight improvements in the dialogue between Russian civil society and the state (Makarova, 2012; Petukhova, 2012), and a surge of climate- and energy-related activities co-ordinated by regional, national and international NGOs (Senova, 2011). Citizens and NGOs have filed petitions to regional and federal authorities, for example, regarding the construction of new hydropower stations without factoring in climate change impacts and adaptation strategies (Shapkhaev et al., 2011). A number of formal meetings for discussing regional aspects of climate change have taken place outside of the capital cities (Pitsunova, 2010; Russian Geographical Society, 2012).

Yet, no consolidated public effort has transpired so far. Makarova (2012) identifies NGO-specific and citizen-specific barriers to the interaction between authorities and civic society institutions. Although the study does not specify a policy area, the barriers are nonetheless relevant for the climate change issue. Makarova (ibid.) attests that NGOs struggle with unstable financial support, little experience in defending their interests and insufficient professional capacity and expertise. At the same time, citizens tend to prioritise their own problems over those of their city or region, have little trust in authorities, underestimate the significance of their own contribution, and have low awareness of their rights and privileges with regard to resolving local issues (ibid.).

### 3.3.2 Public perceptions of climate change

Any views the Russian population may have of climate change have been influenced by successive economic recessions, limited scientific and public discussion of the issue and the legacy of bureaucracy. Climate change does not feature prominently in Russian public opinion polls, with climate-related questions typically embedded within general environmental surveys. For instance, the website of the Russian Public Opinion Research Centre (abbreviated as ‘WCIOM’) provides only three survey results that relate to climate change. The surveys enquired, “What aspects of environmental degradation, if any, are evident in your place of residence?” and suggested respondents choose up to five answers. In survey years 2005, 2009 and 2010, respectively 20%, 16% and 28% of respondents listed climate change as problematic, with it ranking 8th in 2005, and 7th in 2009 and 2010, out of 12 environmental concerns covered by the WCIOM’s poll (WCIOM, 2010).
In 2011, the Levada Analytical Centre asked the public, “What ecological problems of your city / town / village are you concerned about most?” and grouped responses by the size of a residential area (Levada Centre, 2011). The results, summarised in Table 5, demonstrate that the variation across settlements of different sizes is low, with 24% of the population on average anxious about climate change. Moscow stands as an outlier with 42% of its residents listing it as a concern. In August 2012, responses to a slightly rephrased question, “What worries you most in the ecological conditions of your city / town / village?” suggest 22% of Russians are concerned. Despite a two-percentage point decrease compared to the 2011 Levada poll, climate change is amongst the top five (out of 14) environmental concerns in 2012, compared to the 6th place a year earlier. The Levada Centre does not report the result breakdown for different residential area sizes in 2012.

Table 5. The share of the population concerned about climate change (survey date 13–16 May 2011, sample size 1,600 people) (Levada Centre, 2011)

<table>
<thead>
<tr>
<th>Russia, total</th>
<th>Moscow</th>
<th>City / town size (persons)</th>
<th>Villages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&gt;500 thousand</td>
<td>100–500 thousand</td>
</tr>
<tr>
<td>24%</td>
<td>42%</td>
<td>23%</td>
<td>21%</td>
</tr>
</tbody>
</table>

SuperJob, one of Russia’s largest online recruitment portals, provides more detailed and contextual, if relatively informal, findings. In 2009, SuperJob conducted a ‘global warming’ survey amongst 3,000 economically active adults from across the country, grouping the results by respondents’ age and gender (Table 6). In particular, trust in climate science appeared stronger amongst the young than amongst the elderly. SuperJob (2009) reports that those under 30 years old perceived climate change as a side-effect of humanity’s technological advances, whereas the middle-aged group attributed the phenomenon to natural cyclical processes. In terms of gender, a larger proportion of men than women were inclined to “deny” global warming, but on average nearly half of all respondents “believed” in it.

Table 6. Responses to the question “Do you believe in global warming?” by age group and gender (survey date 7 December 2009, sample size 3,000 people) (SuperJob, 2009)

<table>
<thead>
<tr>
<th>Response</th>
<th>All</th>
<th>By gender</th>
<th>By age group (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Yes</td>
<td>49%</td>
<td>48%</td>
<td>51%</td>
</tr>
<tr>
<td>No</td>
<td>33%</td>
<td>36%</td>
<td>30%</td>
</tr>
<tr>
<td>Don’t know</td>
<td>18%</td>
<td>16%</td>
<td>19%</td>
</tr>
</tbody>
</table>
The respondents were also asked what policy measures can prevent global warming and what specific individual actions they would undertake to help. More than a quarter of the respondents struggled to suggest policy measures for addressing global warming, with most believing that the problem should stay within the remit of science. 27% of respondents were certain that no measures would be effective and, hence, nothing should be done. Similarly, in response to the question on personal action, 24% of the sample could suggest no personal contribution, whilst about a fifth openly said they were not ready to contribute at all (see Figure 4).

![Figure 4. Responses to the question “What would be your personal contribution to reducing the threat of global warming?” (survey date 7 December 2009, sample size 3,000 people) (SuperJob, 2009)](image)

In addition to demographic characteristics (summarised in Table 6), climate change attitudes are influenced by ideological and political preferences of respondents. Ivanova (2002) analysed a 1999 survey on fears in former Soviet Union countries, classifying respondents as either ‘pro-West’ or ‘traditionalist’ based on their answers to scoping questions. The study reports that pro-West respondents were significantly more concerned about global ecological problems than ‘traditionalists’. Amongst those problems, “global climate warming” was a concern expressed by 22% of people in the first group and 11% in the second (ibid.). In both groups, however, climate change was associated with external and hence less immediate problems, as opposed to domestic problems that were perceived more dominant and urgent (ibid.).

Finally, there are a number of climate change surveys undertaken in Russia by foreign organisations. For instance, the BBC conducts an annual Global News poll on the “most important problems facing the world”. In 2009, 36% of respondents in Russia assessed climate change as a ‘very serious’ issue, which is significantly lower than the average of 58% across the 23 countries covered in the study (BBC, 2010). A year later the proportion of concerned people in Russia increased by ten points to reach 46%, whilst still remaining below...
the global average of 56% (BBC, 2011). In a 2010 poll by the World Bank (2010b) across 15
countries, a consistently large proportion of Russian respondents chose the “Don’t
know/Refuse” option in response to the survey questions, which could imply either a
relatively low awareness of, or a low interest in, climate change issues.

Three of the reviewed surveys have some level of contextualisation. Ivanova (2002) classifies
respondents by ideological preferences; SuperJob (2009) reports findings by gender and age
groups; whilst the World Bank (2010b) covers four dimensions including level of concern,
beliefs, attitudes to international cooperation and the willingness to pay. However, in the
absence of high quality and longitudinal survey data it is not possible to draw robust
conclusions as to the dynamics of public opinion. Nevertheless and despite numerous
uncertainties, the surveys reviewed in this subsection do add to a limited body of research on
Russian’s public opinion around issues of climate change.

The main differences are evident between survey results from the 1990s and 2000s and
between foreign and Russia-led surveys; although the actual number of surveys is insufficient
to infer a particular pattern. Overall, Russian-conducted surveys in the 2000s show that a fifth
to a quarter of the respondents are concerned about climate change, i.e., approximately double
the proportion who had expressed a concern in the 1990s. By contrast, foreign-conducted
surveys (by the BBC and World Bank) report that nearly 50% of respondents consider climate
change to be a serious issue. However, these higher proportions relate more to questions of
‘belief’ rather than concern-based framing of Russia-led surveys.

Any results the surveys have so far yielded should be interpreted with caution, as climate
change-related questions are often neither contextualised nor matched with respondents’
socio-economic profiles, and are usually bundled together with other questions broadly related
to the environment. These caveats also make comparisons of results across time and across
surveys problematic. Despite the differences, there is some evidence that, compared to the
global average, Russian citizens have lower awareness of and concern about climate change.
Yet, in the 2000s more people in Russia are concerned about climate change than in the
1990s, whereas more recently the opinions have fluctuated year on year. An increased public
awareness of the issue may be explained by a greater prominence of climate change in
international politics and recent extreme weather events amplified by wider media coverage.
3.3.3 Climate change in the Russian mass-media and other communication channels

According to the Russian Public Opinion Research Centre, 14% of respondents think that it is the mass media that initiate environmental action (Kokhanova, 2007). Nonetheless, a recent analysis of eco-reporting at the regional level argues that only 2% of all media communications in the studied region cover environmental issues (Sharkova, 2012a). Most communications in that 2% share relate to activities of the regional authorities and are used for strengthening the image of those in power (Sharkova, 2012b). It is reasonable to conclude that, as part of environmental reporting, climate change coverage in regional and local media is inadequate.

At the national level, the situation varies depending on the media type. Yanitsky (2011) argues that, in the Russian mainstream media, ecology-related analytical reviews and public debates have all but disappeared giving way to sensationalism. Television in Russia continues to attract very large audiences, although in 2011/2012, the size of the online audience in Russia overtook the number of television viewers for the ‘under 34’ age group (Bryzgalova and Matveeva, 2012). Climate change coverage on television has been limited to occasional and brief extreme-weather-event features on news programmes. A notable exception, duration-wise, relates to a conspiracy-focused and British-made documentary ‘The Great Global Warming Swindle’ translated and broadcast by Russia’s Channel One (Pervyi Kanal, 2009).

Newspapers, although sometimes prone to sensationalism, are on aggregate more neutral than television, and periodically report ‘mundane’ details of international climate negotiations, relevant legislation and viewpoints of stakeholders. However, overall, the coverage is scant even in the most climate-aware and balanced sources. For example, Wilson Rowe (2009) reports that there were 82 climate change related publications in Rossiiskaia Gazeta over 2000–2007. For a leading state-owned daily newspaper, ten articles per year at the height of public debate on climate change (the pre- and post-Kyoto Protocol ratification discussion) indicate a low importance assigned to the topic.

The Internet is a growing platform for the unfolding climate change debate. A recent survey by the Levada Centre (2012) reports that 57% of adults in Russia use the Internet, up from 42% in 2010. According to Kokhanova (2007), Internet-based environmental reporting in Russia tends to be less sensationalist than traditional mass media. Online authors are usually non-governmental organisations, who mostly report best practice and success stories as
opposed to attention-grabbing negative information. It is argued that, across online sources, there is a noticeable shift towards a more balanced coverage of environmental issues (ibid.).

A recent review of English and German online sources concludes that “climate and environmental NGOs seem to be the champions of online climate communication” (Schäfer, 2012); a situation similar to Russian online eco-reporting (Kokhanova, 2007). This appears at variance with the alleged ‘online backwardness’ of Russian NGOs in general, and Mardar’s (2009) assertion that they lag behind online activities of the government and businesses is probably too simplistic. Apart from a recent surge of official communication related to Joint Implementation projects, it is reasonable to conclude that NGOs are at the forefront of online climate change activities in Russia. Their leading role can be partly interpreted as a response of the civil society to the de-ecologisation process and a way to compensate for the deficiency of state environmental institutions.

Despite the relatively active climate-related online presence, environmental NGOs in Russia manifest behaviour similar to those of Russian NGOs in general. In particular, the online activities of non-commercial organisations are relatively unassertive, obscure and often detached from the public (Mardar, 2009), although this pattern changes significantly during emergency situations. The case in point is the civil society consolidation and an associated flurry of online and other network activities after the 2010 heat wave. Whether a similar degree of consolidation and communication is achievable in support of a pro-active, as opposed to reactive, climate debate remains to be seen.

Another important aspect of many NGOs’ online presence relates to their financial situation. Several foreign charities have withdrawn from Russia since the mid-2000s, and the dwindling financial support has inevitably reflected on the state of online resources, with some websites abandoned (Mardar, 2009). This trend may intensify if controversial legislation on internationally-financed NGOs (Federal Law No.121-fz of 20 July 2012) comes into force in its 2012 edition. The most online-active environmental NGOs (e.g., WWF-Russia, Greenpeace and the Bellona Foundation) receive foreign funding; hence they are likely to be affected by the repercussions. This complex interplay between the civil society and political forces may be interpreted as adverse; yet, it was politicians that eventually triggered the climate debate in Russia. Despite Russian climate scientists being engaged in international collaborations since the late 1980s, climate change was perceived as a non-issue by broader society in Russia. The politicisation of climate discussions at the national level has made climate science more visible than ever before.
3.4 Conclusion

The analysis of national developments shows that, despite the existence of an overarching climate change policy in Russia, the implementation has been slow. To ensure it is put into practice, the legislation needs to specify final and interim objectives, clear responsibilities of each executing agency, a risk management framework and alternative ways of achieving the objectives. Russia’s Climate Doctrine, although currently serving as little more than a rhetorical guideline, may yet provide a meaningful framing of climate challenges at a national scale. Complemented with near-term policies, specified targets and longer-term qualitative roadmap, the Doctrine could offer an appropriate umbrella for a coherent programme of mitigation and adaptation. It is, however, important that the Doctrine is aligned with international targets and commitments. Integrating both global and national dimensions of climate change will help to ensure consistent and evidence-based policies, facilitate synergies and abate conflicts.

The semi-authoritarian policy regime in Russia can, seemingly, more readily impose climate-related policies, with a historically passive civil society further facilitating the top-down approach. On the other hand, the weakness of the civil society and a low level of interest in climate change issues amongst the population are a handicap when it comes to long-term national priorities. For example, the culture of ‘passive observation’ evident in the evolution of the main Russian environmental advisory body, RosHydromet, can partly explain the country’s climate change inaction. Yet, the climate-related track record of the government (related to both the unwillingness and policy implementation issues) has demonstrated that civil society actors are more likely than the ruling establishment to emerge as ‘levers for change’. The level of awareness and concern amongst the Russian population, albeit comparatively low, is growing steadily. The engagement of the public is likely to intensify as climate change impacts become increasingly prominent. The next chapter reviews aspects of climatic change on the Russian territory that are of both immediate and long-term policy relevance.
4 Chapter 4: ‘2 degrees C’ and climate target-setting

4.1 Introduction

A 2°C global average surface temperature increase above pre-industrial levels has been widely adopted as a threshold between acceptable and ‘dangerous’ climate change. Scientific studies introduced the threshold about three decades ago, with it surfacing in international political discussions in the mid-1990s. Since 2009 more than one hundred nations, including Russia, have endorsed the 2°C target by signing the Copenhagen Accord. Despite some strong criticism of 2°C (Tol, 2007, p. 430), it has persisted, evolving into what may be described as “a political anchor for mitigation policy” (Randalls, 2010, p. 602). To some extent, the 2°C threshold has become a climate change ‘mantra’, repeated without awareness of its origins, meaning or implications. At the same time, current emission trends suggest that containing the global mean surface temperature rise to 2°C above pre-industrial levels is increasingly challenging (Rogelj et al., 2010, p. 1128; Anderson and Bows, 2011, p. 41; New et al., 2011, p. 15). Recent studies suggest that the current framing of the 2°C threshold, in relation to the extent of potentially ‘dangerous’ climate change, may be obsolete (Shaw, 2013). For 2°C to continue providing a meaningful climate change target, it needs to be re-framed in line with the latest science.

Through meta-analysis of scientific literature and policy documents, this chapter considers the contemporary framing of climate-related temperature targets as they pertain to Russia, in order to identify and justify one of the essential research boundaries of this thesis. Specifically, the chapter sets the foundations of the empirical method (backcasting) used in this work for generating low-carbon emission scenarios in the form of a temperature target (2°C) to be achieved by staying within a range of carbon budgets. Not only does the choice of a temperature target shape the first stage of backcasting, but also several simplifying assumptions behind the scenarios necessitated by the target-related uncertainties. The scenarios, in turn, affect the results of the thesis and suggested decarbonisation measures.

After the introduction, Section 4.2 considers the concepts of ‘normal’ and ‘dangerous’ climate. Section 4.3 presents a brief account of the history of the 2°C threshold and summarises the uncertainties and ambiguities around it, followed by the section on target-setting through policy and science. The chapter then reflects on the relevance of the target for international climate negotiations (Sections 4.5 and 4.6), followed by the concluding section.
4.2 Climate and ‘dangerous’ climatic changes

The term ‘climate’ is used and understood differently. Similarly, the concept of ‘climate change’ can be framed in terms of different geographical, politico-economic and cultural characteristics of nations and regimes. Climate perceptions and expectations typically are constructed relative to “climatic normalit[ies]” (Hulme et al., 2009, p.204), i.e., implicit and explicit climate baselines. The choice of a ‘normal’ climate influences expectations and related political and social discourses that in turn help to embed climatic norms into a consensual decision-frame. Along similar lines, the choice of a climatic norm influences perceptions of climate change. By definition, climate change is benchmarked relative to a certain baseline, and future climate expectations are sensitive to baseline-related assumptions. Expected or predicted changes in the climate can have meaningful interpretations only contextually, for instance, in terms of rate of change, spatial aspects or a bounded time frame. The latter of these implies that climate change expectations have a limited temporal extent, both in looking to the future and in being measured relative to a specific yardstick in the past. There is no fixed idea as to when climatic changes become ‘dangerous’.

There are a number of definitions of dangerous climate change, with the majority focused on crossing a threshold (or a range thereof) leading to large-scale impacts on the biosphere. For example, the Intergovernmental Panel on Climate Change considers dangerous climate change in terms of key vulnerabilities of natural and managed systems, including magnitude, timing, reversibility, likelihood and other aspects of the impacts (IPCC, 2007a, p.64). No IPCC report to date has offered a specific threshold delineating dangerous climate change from acceptable, arguing that defining such thresholds is beyond their remit as it would require value judgements more appropriate for policy-makers than scientists (IPCC, 2007b, p.97). At the same time, although climate change literature often draws on assessment reports by the IPCC, the majority of the studies broadly accept a 2°C global average surface temperature rise as a threshold associated with dangerous interference with the climate system. However even this broad and generally agreed definition undergoes changes as it is transferred from atmospheric physics literature to interdisciplinary academic papers (e.g., on integrated assessment modelling) to policy documents to the mass media. Along the ‘journey’, the definition of dangerous climate change is often simplified, pertinent uncertainties are omitted, and confusion is not infrequent. For example, policy documents often use the terms ‘dangerous’ and ‘acceptable’ climate change interchangeably when discussing the 2°C threshold (Shaw, 2011, p.70). Furthermore, Shaw (2013, p.7) argues that this temperature threshold, as presented in newspapers in particular, does little to facilitate the communication of the
dangerous climate change concept to non-expert audiences, as the associated complexity and uncertainties are not reported.

4.3 A brief history of 2°C and related uncertainties

There are several ‘histories’ on how the 2°C target came into being. The IPCC (2007c, p.105) reports that in 1938 G.S. Callendar used equations to identify a link between the changing climate and greenhouse gas emissions. His calculations showed that the average global surface temperature will increase by 2°C when atmospheric CO$_2$ concentration doubles. On the other hand, Oppenheimer and Petsonk (2005, p.196–197) and Jaeger and Jaeger (2011, p.S16) argue that the 2°C target originated in a series of 1975–79 papers by William Nordhaus. Yet another theory is presented by Randalls (2010, p.599) and Weart (2003, p.203, cited in Shaw, 2011, p.34), who trace 2°C back to a climate sensitivity estimate by Manabe and Wetherald (1967). All these studies directly or otherwise refer to climate sensitivity, although it is not always clear whether it implies the transient climate response (i.e., in the short to medium term) or the equilibrium climate sensitivity (i.e., in the long term).

The US National Academy of Sciences was first to analyse and summarise individual studies on climate sensitivity arriving at the 1.5–4.5°C range (US NAS, 1979). Originally the range referred to doubling only CO$_2$, not CO$_2$-equivalent concentrations. However, as van der Sluijs et al. (1998) report, by the mid-90s studies had become ambiguous on the use of CO$_2$ and CO$_2$-eq., including the 1995 IPCC report that, in its glossary, used both the CO$_2$ and the equivalent CO$_2$ concentrations to define climate sensitivity (van der Sluijs et al., 1998, p.307–308). Another concern was associated with attempts to derive the ‘best estimate’ from the 1.5–4.5°C range. It was assumed to be 3°C up to 1990 and became 2.5°C in the 1990–95 IPCC reports (IPCC, 1990; IPCC, 1995); both ‘best estimates’ are claimed to have a limited scientific credibility (van der Sluijs et al., 1998, p.303–305).

With a 2.5°C ‘best estimate’ climate sensitivity and the mid-range IPCC’95 emission scenario, general circulation models projected that the global mean surface temperature would increase 2°C by 2100 relative to 1990$^6$ (IPCC, 1995, p.322). At that time, increasing scientific evidence contextualised 2°C in terms of baseline surface temperature levels, the rate of climate change and its associated impacts (McCarthy et al., 2001, p.5, Figure SPM-2; Smith et al., 2009, p.2). This new evidence improved the understanding of ‘dangerous’ climate change to such an

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$^6$ The latest IPCC’s ‘best estimate’ of climate sensitivity is 3°C (IPCC, 2007c, p.799), and the temperature increase for a medium scenario is predicted to be ~3.3°C above the pre-industrial level (ibid., p.810). For a more detailed discussion of climate sensitivity see, for example, a series of articles by D.A. Stainforth and colleagues who, in particular, argue that the sensitivity may be as high as 11 K (Stainforth et al., 2005).
extent that the 2°C threshold appeared in policy documents, often with pre-industrial levels as a baseline. The German government was first to ratify the temperature target at the national political level in 1995 (Tol, 2007, p.425); a year later 2°C was recognised by the Council of the European Union (CEU, 1996) and in 2007 officially adopted as the EU’s long-term target (Boykoff et al., 2009, p.54). In 2009 it moved from the European to the global level during the G-8 discussion of that year (Wintour and Elliott, 2009, p.14). Its inclusion in the Copenhagen Accord7 (UNFCCC, 2009, p.5) effectively cemented the notional temperature target in political agendas of more than one hundred countries that signed the Accord, Russia included. As a result, 2°C was consensually endorsed by the governments as the yardstick for characterising ‘dangerous’ climatic changes, regardless of differences in the projected climate impacts across nations. Neither national-level governmental communications nor international negotiations acknowledged uncertainties pertaining to the 2°C target.

Another important source of uncertainty has caused some confusion in both science and policy as to what baseline 2°C should be gauged against: pre-industrial times, 1990, ‘present year’, etc. In addition, it is not always clear from studies and policy documents what future date the 2°C temperature increase relates to. When a date is reported, it can vary from 2020 to 2400 and beyond (BERR, 2000; Ackerman et al., 2009), which causes further questions as to whether the target pertains to stabilising the global mean temperature increase in the medium term, in the long term (even after an overshoot) or never breaching the 2°C threshold. For the purposes of this thesis, 2°C refers to stabilising a global mean surface temperature increase above pre-industrial levels by the end of the twenty-first century, unless otherwise stated.

From a scientific perspective, several pre-Copenhagen Accord studies have questioned the origins of 2°C (Tol, 2007) and its validity as the threshold between ‘acceptable’ and ‘dangerous’ climate change (Oppenheimer and Petsonk, 2005; Harvey, 2007; Allen et al., 2009). Importantly, Tol (2007, p.430), describing the 2°C target as being unjustified and even unjustifiable, is one of the few written works openly critical of 2°C. According to Shaw (2011, pp.162–163), criticisms of 2°C tend to appear in interviews whereas reports and other publications re-affirm this threshold. Although they may list pertinent caveats and uncertainties, the majority of mitigation studies, intended to inform policies, take 2°C for granted. The concept of ‘black-boxing’ may help to explain why 2°C-related confusion and uncertainties have not prevented it from being firmly established in relevant debates. Shaw (2011, pp.32 and 267) argues that the history of an idea is often disregarded if the idea is

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7 The Copenhagen Accord fails to specify the baseline temperature relative to which the ‘below 2°C’ increase is to be held.
established as a ‘fact’ and if this ‘fact’ successfully serves a particular purpose; furthermore, “removing the idea from its social context reinforces the sense of objectivity”. The process of black-boxing is important to acknowledge and understand, as objectivity is a sought-for attribute in decision- and policy-making.

4.4 Target-setting through the interaction between policy and science

Policy-makers typically make recourse to the need for evidence-based policy, with the Copenhagen Accord stating specifically the urgency to “take action [on 2°C] consistent with science” (UNFCCC, 2009, p.5). Amongst other attributes, ‘scientifically derived’ numerical targets provide an ‘objective’ justification for policy decisions. As Porter (1995, p.8) puts it, “quantification is a way of making decisions without seeming to decide”, with quantification helping to frame policy advice and policy action as ‘rigorous’, ‘unbiased’ and ‘authoritative’. Another perceived advantage is that numbers are easy to communicate across nations since “rules for collecting and manipulating the numbers are widely shared” (ibid., p.ix). Similarly, in climate change politics, a numerical temperature target has become more widely accepted than qualitative objectives. Although the concept of ‘dangerous’ is often used in negotiations and reflects a more qualitative framing of climate change, it is typically discussed in conjunction with a numerical objective such as 2°C. The homogeneous 2°C threshold essentially quantifies the more heterogeneous and qualitative characterisations of ‘danger’.

Political feasibility is another important facet of the target-setting and ‘target-maintaining’ processes. Whilst short-term policy measures to reduce emissions may be ‘politically feasible’, such measures cannot necessarily be reconciled with longer-term climate commitments. For example, the UK’s climate change strategy is based on a report by the UK Committee on Climate Change. The Committee’s global scenario, on which the government’s policies are based, assumes greenhouse gas emissions peak in 2016, with CO₂ emissions subsequently declining at ~4% per year (CCC, 2008, p.21). This emission path projects that the 2°C threshold will be exceeded in 2100 with 63% probability (ibid.). Considering current emission trends (Friedlingstein et al., 2010; Peters et al., 2012a), it is highly improbable that global emissions will peak in 2016. However, hypothetically, even if the peak were reached in 2016, the CCC’s 63% chance of exceeding 2°C is incompatible with the UK government’s commitment to make its fair contribution to ensure temperatures “must rise no more than 2°C” (DECC, 2009, p.5, emphasis added), if it is literally interpreted as a commitment to stay below 2°C with a reasonable probability. Such literal interpretation suggests that policies based on the CCC’s scenario are likely to make the 2°C target (and, hence, the commitment itself) impracticable. This raises questions about the internal consistency of policies claimed to be
‘feasible’. Interdependence between the policy-making process and policy-oriented research may intensify ‘a conspiracy of silence’. Policy-makers prefer socio-economic and scientific foundations to justify their policies, and research requires financial and other support from those in power. In the worst case, evidence-based policy might turn into ‘policy-based evidence’ (Marmot, 2004; Choi et al., 2005). The latter would not only impair academic freedom but, more importantly, risk contributing to misguided and potentially dangerous policies.

The feasibility concern is consistent with the ‘cost-benefit’ view of 2°C, whereby 2°C is presented as the optimum target maximising the benefits and minimising the costs of climate change policies (Jaeger & Jaeger, p.S15). Related to this are significant political and social capital and scientific reputations already invested in 2°C. These ‘sunk costs’ are a barrier to accepting a different global climate change target or re-framing the existing target as far more challenging than previously was the case. International climate change negotiations have consistently built on the ‘achievable’ 2°C target since the mid-1990s. Scenarios of low-carbon futures underpinning political action are increasingly informed by the ‘achievable’ 2°C target (Anderson et al., 2008a; IEA, 2008; Labriet et al., 2008). As a result, whilst global emissions continue to rise, politics and science typically reinforce each other’s endorsement of orthodox and incremental mitigation. In so doing, they risk rendering the current framing of the 2°C target obsolete. As the IPCC’s updated ‘reasons for concern’ (Smith et al., 2009) suggest, this threshold no longer represents ‘acceptable’ climate change, but rather, and based on the same logic, a shift from ‘dangerous’ to ‘very dangerous’ climate change.

On the other hand, even if 2°C looks increasingly unattainable without an overshoot, relaxing the climate change target and aiming for higher temperatures instead may not be practical. First, it can be problematic for governments with a strong record supporting 2°C to accept higher temperature scenarios as a basis of mitigation and adaptation policies. Openly acknowledging 3 or 4°C as a ‘likely’ reality risks putting such governments under increasing pressure to instigate immediate and radical mitigation measures. Second, in terms of adaptation policies, projected implementation costs would clearly increase for the higher temperatures (WB, 2010a, p.9). Finally, it is as yet unknown if a 3 or 4°C increase would develop as a transitive stage towards even higher temperature stabilisation, as “feedbacks may add to business-as-usual emissions” (Hansen et al., 2006, p.14293). Related uncertainties and costs make 3 or 4°C unattractive politically, socially and economically, as evidence suggests they are likely to be accompanied by much higher impacts and wider repercussions.
If, despite the re-framing, the 2°C target eventually becomes irredeemably obsolete, it can be revised at a future point. It should be remembered, however, that one of the impediments to a continued adjustment of temperature thresholds is the enthusiasm policy-makers show for unequivocal and non-moving targets. As a former prime-minister of Denmark Anders Fogh Rasmussen phrased it, policy-makers “need fixed targets and certain figures, and not too many considerations on uncertainty and risk and things like that” (cited in Baer and Kammen, 2009, p.12). Because politicians have to assume responsibility for the policy decisions they make, they are likely to favour policy advice with fewer caveats, regardless of whether the targets are national or international.

### 4.5 The 2°C target and early climate negotiations

As discussed above, the 2°C threshold first entered into the political debate in the 1990s (Oppenheimer and Petsonk, 2005; Tol, 2007) and has since permeated politics, the media and science. Importantly, numerous scientific studies have focused on relating 2°C to climate change impacts and feasible emission reduction targets (for example, van Vuuren et al., 2009; Lowe et al., 2010). The 2°C concept has become an objective around which various interests coalesce. Policy-makers and scientists, ecologists and economists, as well as representatives of industrialised and industrialising countries, approach the issue from their respective positions, all of which affect the results of negotiations, but without necessarily changing the ‘pivotal’ and highly persistent 2°C.

The UNFCCC and the accompanying Kyoto Protocol have been the main focus of on-the-record intergovernmental discussions on target-setting. The Framework Convention is a non-committal outcome of more than a decade of debates on the need to contain greenhouse gas concentrations “within the normal range of long-term climatic variation” (Nordhaus, 1977, p.39) that suggests no quantitative targets. By contrast, the Kyoto Protocol focuses on relevant near-term policy, provides specific targets and, in theory, is binding for its signatories. However what is viewed by some as an important ‘first step’ towards stabilising atmospheric concentrations (Grubb et al., 2002; Böhringer, 2003; Oppenheimer and Petsonk, 2005), is denounced by others for its flawed architecture (McKibbin and Wilcoxen, 2002; Nordhaus, 2006; Prins et al., 2010). The main concerns include: arbitrariness of emission reduction targets; setting the targets relative to 1990 rather than to historical emissions; and, focusing on mitigation rather than social-ecological resilience (Sagar and Kandlikar, 1997; Agarwal et al., 1999; Najam et al., 2003 and references therein).
There is no formal link between the Kyoto Protocol and the 2°C threshold, with some studies concluding that the influence of the Protocol implementation on climate is almost negligible (Nordhaus and Boyer, 1998, p.14; Wigley, 1998, p.2288). Arguably, the Kyoto Protocol’s rather lenient emission reduction targets have made it more difficult for the world to stay within a 2°C-related cumulative emission budget. Specifically, the Protocol focuses on endpoint targets without considering either cumulative emissions or the time lag of climatic processes.

Whilst a detailed analysis of Kyoto is outside the scope of this thesis, the absence of long-term emission reductions in the Protocol relates directly to understanding ‘climatic norms’. In an attempt to distil the climate change discussion to something more tangible than “achie[ing] an optimum global climate” (US NRC, 1977, p.ix) and to amend the non-binding nature of the UNFCCC, the Protocol focused on short-term economically and politically feasible emission reduction targets. This move was perceived, by some, as watering down the UNFCCC in favour of industrialised economies (e.g., Najam et al., 2003), with the Protocol making little reference to the direct link between long-term policies, atmospheric stabilisation and ‘dangerous’ climate change. In this regard, the Protocol served to reinforce significant empirical inconsistencies between short-term targets and the long-term 2°C threshold.

4.6 2°C as a boundary object, anchoring device and focal point

In its capacity as a ‘pivot’ of the climate change discussions, the 2°C target exhibits aspects of an ‘anchoring device’ and a ‘boundary object’. Star (1989, p.46, italics in original) explains that a boundary object “both inhabits several intersecting social worlds [e.g., nations and/or stakeholder groups within nations] and satisfies the informational requirements of each of them”, whilst, according to van der Sluijs et al. (1998, p.296), an anchoring device “fixes the scientific basis for the […] policy debate”. Brand and Jax (2007, p.9) argue that boundary objects can often stymie progress in negotiations, as, by accommodating a diversity of visions, they conceal disagreements and inconsistencies.

As an anchoring device, the 2°C target ‘anchors’, at least superficially, climate change politics to science. As a boundary object, 2°C provides common ‘boundaries’ within which different stakeholders engage, both nationally and internationally. However, within such boundaries, the stakeholders do not necessarily reach a consensus. For example, sharing the burden of climate change abatement amongst different countries and sectors remains a contentious issue despite the agreement around 2°C. Since boundary objects “have to satisfy more than one set of concerns” (Star and Griesemer, 1989, p.412), there is a potential for controversy to deepen
Stakeholders seemingly concur on the common objective but often have conflicting interpretations of it. In relation to 2°C, there is a stark difference in how countries in the low latitudes view the threshold compared to nations in the high latitudes: is it ‘unacceptably’ or ‘acceptably’ dangerous (Hare, 2009, p.18)? Similarly, Rahmstorf points to politicians viewing the 2°C target as an ‘ambition’, i.e., although “we aim for two degrees […] it’s OK if we end up at three” (cited in Baer and Kammen, 2009, p.11). At the same time, for others 2°C is an “upper limit” that should not be exceeded, as the potential ramifications are too hazardous to risk (Hansen et al., 2008, p.226; Baer and Kammen, 2009, p.9). Jaeger and Jaeger (2011, p.S22) suggest that, for years, policy-makers have perceived 2°C as a science-based target, whilst scientists have regarded it as a political one.

Baer and Athanasiou (2004, p.2) characterise 2°C as “a compromise target”. Indeed, whilst small island countries advocate a 1.5°C target (Williams, 2009, p.1), current pledges of other nations, including Russia, are more in line with a reasonable probability of 3–4°C warming by 2100 (Lowe et al., 2010, p.8; Rogelj et al., 2010, p.1128; Stern and Taylor, 2010, p.20; Anderson and Bows, 2011, p.41). In this regard, 2°C qualifies as a target stabilising international ‘agreement’, as it satisfies the least expectations of concerned parties. This is corroborated by the Jaeger and Jaeger’s (2011, p.S23) conclusion that 2°C plays the role of a focal point in the climate policy ‘co-ordination game’ and is currently more suitable than alternative targets for motivating action on climate change.

4.7 Conclusion

This chapter shows that, in the last fifteen years, the 2°C threshold have become an important focus of scientific and policy discourse, with it transforming into much more than just a threshold between acceptable and ‘dangerous’ climate change. Each signatory to the Copenhagen Accord claims a stake in the 2°C threshold, and as such its seemingly simple form contains a wealth of diverse and converging interests. In this sense, 2°C can be considered a ‘boundary object’ providing a common basis for collaboration across different groups of stakeholders that interact within countries and at an international level.

Arguably, improved scientific understanding of climate change, evolving uncertainties and rising emissions indicate the need to regularly revisit climate targets and their framing. However, such flexibility is unlikely to gain widespread support from politicians previously equivocal in their commitments to 2°C. Periodically adjusting targets can be especially
problematic at an international level where reaching an agreement is already a protracted and challenging process. When it comes to such a politically sensitive issue as economic growth, politicians and scientists are often prone to emphasising ‘feasibility’ considerations. Consequently, whilst scientific analyses should ideally be detached from short-term political agendas, a ‘conspiracy of silence’ may emerge. Certainly, two decades of political and scientific capital invested in the 2°C target have made it difficult to openly question its practical feasibility and framing.

The chapter concludes that, despite the uncertainties surrounding 2°C and its origins, it is evidently a more appealing ‘focal point’ than existing alternatives. For that reason, the global 2°C target is used in this thesis to define the first stage of the backcasting method and, hence, the resulting scenarios (chapter 8) and suggested mitigation measures (chapter 10). Provided its drawbacks are acknowledged, the target may still serve the purpose of mobilising adequate mitigation action. If a more appropriate and defensible climatic target emerges to replace 2°C, the cumulative emission budgets and associated backcast scenarios can be reworked following the methodological algorithms set out in the next two chapters (i.e., chapters 5 and 6).

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8 Russia is no exception in this case, with economic growth taking precedence over other policy priorities. For example, the doubling of the country’s GDP between 2003 and 2010 was a headline policy of the then-president (Putin, 2003). More recently, Russia’s Ministry of Economic Development has declared its intention to double the national economic growth rate within 10 years (Koroleva, 2013).

9 From physical to social scientists.
PART 2:  EMPIRICAL METHODS
Chapter 5: Research design: scenarios, participatory backcasting and thematic analysis

5.1 Introduction

The previous three chapters discussed politico-economic, cultural and environmental aspects of the climate change and energy debate in Russia and on the international arena. Against this background, this chapter aims to establish and justify methodological boundaries of the thesis, starting with defining the concepts of ‘models’, ‘forecasts’, ‘scenarios’ and ‘pathways’. Although the meanings of these concepts can usually be inferred from the context of publications, it is nevertheless evident that explicit definitions are important for communicating research design and findings. This is particularly pertinent to interdisciplinary studies, where researchers from various areas of knowledge bring in their own baggage of terms and interpretations.

Whilst the backcasting approach has been in use since the 1970s, its application to climate change and other environmental and social problems is a more recent trend. Existing backcasting research can be divided into two main strands — it either covers the theoretical framework underlying backcasting or, else, deals with case studies as specific applications of the approach. There are a number of exceptions, particularly, in the field of participative backcasting (e.g., see studies by Jaco Quist and Philip Vergragt) that combine the two strands, however these studies mostly theorise about participation and inclusiveness rather than about the backcasting approach itself. To bridge the two research strands, this chapter presents a theoretical critique of backcasting in application to climate change, arguing that backcasts offer policy-significant insights and are more appropriate for dealing with the climate change problem than other scenario approaches. The chapter then describes how the backcasting approach is applied specifically within this thesis, including details of the ASK-Russia scenario generator and of the stakeholder engagement process.

The chapter first discusses models and scenarios as representations of the world (section 5.2) and derives an updated definition of backcasting, elaborating on theoretical fundamentals of the approach (subsection 5.3.1). It then goes on to explore the significance of cumulative emission budgets for the climatic change issue (subsection 5.3.2) and climate-related backcasting, providing a comparative analysis of its application to other areas (subsection 5.3.3). Particular characteristics of climate change are discussed in the context of backcasting. The place of backcasting in typologies of futures studies is considered in
subsection 5.3.4, followed by a discussion of the disadvantages and benefits of the approach compared to forecasting. Subsection 5.3.7 describes stages of the backcasting process. The next three sections focus on a review of studies on emission pathways in Russia and specifications of the ASK-Russia tool. The main aspects of stakeholder engagement undertaken within this project are discussed in section 5.7, followed by the penultimate section on the research design used in this thesis. Section 5.9 draws together the main themes of this chapter.

5.2 Models and scenarios as representations of the world

5.2.1 Models

Jordaan and Lategan (2006, p.32) broadly defines modelling as “the process of generating a model as a conceptual representation of some phenomenon”. The output of this process aims to explore and sometimes predict, in an accountable way, the behaviour of a modelled part of the real world. Unless otherwise stated, this thesis defines a model in a more restricted way as an applied technique for representing a phenomenon or a system, usually created and visualised with computer software, and having both quantitative and qualitative elements.

Application of models varies depending on the discipline and on the properties of a studied phenomenon or system. For example, modelling in astronomy may be used to theoretically test the existence of a celestial body when the instrumentation is not sufficiently sensitive to detect it. Atmospheric scientists often model atmosphere-ocean systems to understand the interactions or mechanisms at work between particular aspects and thereby predict behaviour. In the study of society and economics, researchers draw on a range of disciplines to build models that can help to better understand developments of these systems and their components. Clearly, there are important differences between physical and socio-economic phenomena, with the latter presenting a significantly bigger challenge for observation and comprehension in general and for modelling in particular. As Berkhout et al. (2002, p.85) puts it, whilst “the natural sciences make well-founded assumptions of continuity and universality, […] social processes are generative of striking novelty and discontinuity“. The physical environment partly shapes social behaviours, and vice versa. Despite the interconnections, an explicit distinction should be drawn between physical and socio-economic modelling, with the former used for predicting physical reality and the latter for exploring highly stylised future relationships between modelled socio-economic parameters.

By definition, models are unable to fully capture reality, and researchers sometimes introduce more variables and complex interrelationships in an attempt to accurately reflect the world.
Greater precision, however, does not necessarily lead to an enhanced model with either a greater understanding of a modelled world (or part thereof) or improved transparency. Yet, contrary to what some studies suggest (Casillas et al., 2003; Eddy, 2006), modelling does not always present a trade-off between accuracy and transparency. The researcher usually has a choice as to what ‘real-life’ aspects of a model to forgo and what relationships to include. Both transparency and accuracy are necessary for the credibility of models if their outputs are to contribute to policy-making. These aspects are often assigned different degrees of importance depending on the intended audience and the purpose of modelling. For instance, for the non-expert receiver of modelling results a detailed and clear model description matters more than for those familiar with a model’s architecture. As to accuracy, although policy-oriented modelling often involves, for example, macro-level aggregation, such simplifying assumptions should be sufficiently defensible. In any case, it is imperative that all transparency and veracity related assumptions are explicit.

Despite the discussed limitation, modelling is a useful tool for understanding the behaviour of systems and phenomena that cannot be readily observed and predicted. In particular, socio- and techno-economic models that involve explorative scenarios, amongst their other applications, can indicate options and recourses that were previously unnoticed and, thereby, create new ways of thinking and innovative solutions.

### 5.2.2 Scenarios

Future-oriented socio-economic studies widely apply scenario analysis that, in its modern form, was first set out by Herman Kahn in the 1960s. He defined scenarios as “attempts to describe in some detail a hypothetical sequence of events that could lead plausibly to the situation envisaged” (Kahn and Wiener, 1967, p.262). Since then several definitions of the concept have been suggested. This thesis adopts a broad interpretation where a scenario is as an outcome describing a possible future state, in a much simplified *ceteris paribus* world, and explaining how such a future state may transpire or be achieved (adopted from Bishop et al., 2007, p.8). Note that the *ceteris paribus* characteristic is selective, with scenario parameters and relationships between them chosen by scenario developers.

Research on scenarios is extensive, and there are several discrepancies that appear to be ignored in the literature; this brief subsection is an attempt to list and clarify the moot points for the purposes of this thesis. For example, little consistency exists as to how scenarios relate

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10 Bradfield et al. (2005) provides an informative discussion on the history of scenarios and schools of scenario analysis.
to forecasting, in particular, and to modelling, in general; whether a scenario is an independent and comprehensive method; whether it is merely an output of an analysis; or, whether it is a set of ‘inputs’ combining both a storyline and a quantitative component.

One of the difficulties with the notion of ‘modelling’ used alongside scenarios is that researchers tend to operate different meanings of this notion without providing a clear definition. On the one hand, a small number of studies acknowledge that by nature every scenario is a model since it represents a simplified, ‘what-if’ picture of reality (see, for example, Clark and Terrell, 1978, p.301). Importantly, it follows that qualitative components (i.e., narratives) of generated scenarios are also part of a generic concept of ‘models’. On the other hand, Bishop et al. (2007, pp.16–17) argues that modelling is just one of the techniques for developing scenarios, along with backcasting and other approaches, with scenarios being an output of a model. Despite the apparent confusion, there is no contradiction between these two groups of studies, as the first group apply a broad meaning of modelling, whereas in the second case researchers use a stricter definition, i.e., a model as a tool rather than an approach.

The ‘La Prospective’ school of thought also employs a narrow definition of the concept ‘model’, despite viewing scenario generation as an independent method incompatible with quantitative modelling (Godet, 1997; Jouvenel, 1999; both cited in Fontela, 2000, pp.10–11). This viewpoint may be at least partly attributed to conflating models and forecasts, which, again, relates to the problem of misinterpreted definitions.

In climate mitigation research, particularly in recent integrated assessment modelling (IAM) exercises, it is common to use the concepts of ‘scenario’ and ‘model’ in their narrow sense, with a scenario viewed as a ‘storyline’ and a model viewed as an ‘applied tool’ (see, for instance, Energy Modeling Forum, 2011). In IAMs, scenarios are often interpreted as sets of inputs to a modelling environment, i.e., as composite qualitative and quantitative descriptions that guide the research design. By contrast, within this thesis, scenarios are considered in their broader sense, i.e., as outputs of modelling that combine both the storyline (the narrative) and the pathway towards a future.

For climate change it is particularly important to explicitly distinguish scenarios from emission pathways. For the purpose of this thesis, emission pathways describe a series of consecutive

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11 Whilst the cited Energy Modeling Forum report (EMF-25) implies that scenarios are ‘storylines’ that provide inputs to modelling, earlier Energy Modeling Forum publications (EMF-22) regard scenarios in a broad sense (Clarke et al., 2009).
quantitative points that indicate cumulative emissions emitted by a country’s energy system year on year. Consequently, the emission pathways are nested within the scenarios.

A number of researchers argue that scenarios provide a futures study method alternative to forecasts (Peterson et al., 2003, p.360; Kirsch, 2004, p.5), whilst others classify forecasting as a type of scenario study (van Notten et al., 2003, p.429; Börjeson et al., 2006, p.723; Bows et al., 2009, p.22; Durance and Godet, 2010, p.1489). The ‘father’ of scenario development, Herman Kahn, argued that “the scenario is not used as a predictive device” (Kahn and Wiener, 1967, p.263). This thesis applies scenarios as they were originally intended, i.e., for non-predictive normative analyses of future, which corresponds to the stance taken by backcasters, as the subsections below show.

5.3 The backcasting approach

5.3.1 Definition and theoretical framing of backcasting

The backcasting approach was first proposed by Amory Lovins under the name of “backwards-looking analysis” (Robinson, 1982, p.337). The approach originated partly as a response to the inability of forecasts to meaningfully contribute to solving major societal challenges. Backcasting offered a systemic approach to such problems and was, therefore, considered to have scope for embracing real-world uncertainty and complexity. Although Lovins pioneered the backcast, he did not offer a definition for this approach, taking instead a more practical stance and explaining his methodology with a specific example of the US energy system (see Lovins, 1976, for more details). It was not until 1982 that Robinson detailed theoretical aspects of backcasting (Robinson, 1982, p.337) and, in his later study, described backcasting as

“an approach to futures studies which involve[s] the development of normative scenarios aimed at exploring the feasibility and implications of achieving certain desired end-points” (Robinson, 2003, p.841).

As there is no agreed definition of backcasting in the literature and Robinson’s version is relatively comprehensive, it is taken as a starting point for formulating a new definition within the scope of this study. Robinson’s definition emphasises some key features and selected stages of the backcasting process. To begin with, backcasting is indeed an ‘approach’ rather than, more narrowly, a ‘method’. The difference between these concepts is that of scale and generality. Whilst an in-depth discussion about the relationship between the two is outside the scope of this study, it is worth noting that an approach is typically more overarching and less detailed than a method (Oxford Dictionary of English, 2010). Preference for a particular
approach may reflect a deep-rooted philosophical and epistemological creed of a researcher, which determines the future course of the undertaken research and influences the interpretation of results. The choice of a method also reveals attitudes of a researcher but in a less profound way. As will be shown shortly, several philosophical issues underlie backcasting.

Another key element of the backcast noted in Robinson’s definition is scenario generation. The normative nature of scenarios touches on two philosophical decisions the researcher makes consciously or otherwise: a choice between causality and teleology and the attitude to uncertainty. Backcasting starts with defining a strategic objective as a specific desired future state of a system. It then goes on to generate a range of scenarios that stem from the present but, by definition, have to converge on the future objective. In this sense backcasting is teleological, since the pathways generated in the process are to a great extent guided by the future objective, or ‘purpose’. In application to longer-term future studies and modelling, teleology and backcast proponents maintain that behaviour, though “intelligible in retrospect” (Dreborg, 1996, p.820), cannot be causally inferred from historical patterns. Teleology recognises the complexity of behaviour and rejects reductionist forecasts. The advocates of causality, on the other hand, claim that behaviour is an endogenous variable, i.e., it is determined within the model and, therefore, can be predicted based on deterministic assumptions. Interestingly, the backcasting approach does not completely eliminate causality but can use it for solving sub-problems within the backcast. This is facilitated by the iterative nature of backcasting.

As to the researcher’s attitude to uncertainty, it relates directly to the argument about predictability of behaviour and systems (e.g., society or climate), rationality of agents and “the usual continuity suppositions and marginalistic analysis of neo-classical economics” (Dreborg, 1996, p.823). Although backcasts and scenarios are ‘certain’ due to their ceteris paribus settings, they nonetheless help the user to cope with uncertainty by pre-emptively supplying a strategic future target without implausible assumptions often necessary to make forecasts ‘work’. The historical determinism of forecasting, discussed at length by Höjer and Mattsson (2000), is evidently part of the forecasting philosophy based on a reductionist approach to futures studies. Because such an approach attributes events to a limited number of causes, it disregards the inherent complexity and, hence, uncertainties of the real world, even though forecasting studies often attempt to reflect uncertainty by giving probability ranges of the

12 As opposed to, for example, forecasting which is descriptive (positive) rather than prescriptive (normative).
13 Teleology is “the explanation of phenomena by the purpose they serve rather than by postulated causes” (Oxford Dictionary of English, 2010).
14 See also Popper (1960) for a criticism of the beliefs in laws of development, in absolute historical trends, and in the ability of social science to use historical events for predicting future.
projected outcomes. Whilst backcasting also provides a stylised picture of the future, it does not claim any predictive potential. This may be problematic when researchers incorporate forecasting into backcasts. For example, Robinson’s backcasts depend pivotally on forecast energy prices for the next 30–50 years (Robinson, 1982, p.340–341), which, as noted by Anderson (2001, pp.612–613), raises questions about the internal consistency of the backcast.

Ideally, instead of predicting and/or relying on predictions, the backcasting process maps possible pathways towards a desired future state and explores risks, implications, flexibility and resilience of those pathways. Therefore backcasting is essentially an exercise in planning, providing a strategic objective and a range of interim targets seated on the pathways. The process of pathway generation is subject to iteration, revision and adjustment, which potentially prepares the user of backcasting for eventualities and, hence, helps to deal with uncertainty (Mander et al., 2007).

Robinson’s definition of backcasting makes a brief reference to ‘exploring’, which reflects, to some extent, how the approach accommodates changes in a society. It is, however, important to better emphasise the discovery-related nature of the backcast, considering that, further on, his definition expressly engages with “the feasibility and implications” of backcasts. The backcasting approach, being exploratory, encourages creativity that readily challenges current trends and feasibility assumptions.

An aspect not acknowledged in Robinson’s definition is the use of both qualitative and quantitative methods within the backcasting approach. Because backcasting strives to be a systemic approach, narrow specialism has to give way to interdisciplinarity. Historically, backcasting derives from the ‘La Prospective’ approach that, as Valaskakis (1988, p.340) puts it, “can at the same time be very rigorous and very qualitative”.

There are a few other facets of backcasting that could add value to Robinson’s definition. For example, the word ‘end-point’ may be understood as a static objective at a certain discrete point in the future, which may be misleading when considering cumulative emissions. When modelling cumulative greenhouse gas emissions, the final and interim ‘end-points’ would ideally be emission budgets accumulated over a period of time up to the target future ‘state’—which requires a concept more dynamic and continuous than the concept of ‘end-point’ denotes (Bows et al., 2009, p.22). To some extent, interim targets (i.e., interim cumulative

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15 Michel Godet defines ‘La Prospective’ as “a discipline which seeks enlightened anticipation by clarifying actions made in the present through the thoughtful examination of both possible and desirable futures” (Godet et al., 2008, p.8). It was developed by Gaston Berger in the 1960s.
budgets) are more significant than the end-point target/budget per se for achieving a ‘desirable’ future. The rate of emission accumulation determines the rate of climate change (although it is not a one-to-one relationship) and, hence, whether the biosphere has enough time to adapt to the changes.

An alternative definition follows from the above arguments:

Backcasting is an exploratory and interdisciplinary approach for developing normative scenarios and plausible pathways to attain ‘desired’ future states.

An example of such a desired future state may be a ‘below-2°C world’ understood in terms of a global mean surface temperature increase above the pre-industrial level. In this case, the 2°C target is accepted by many governments as a global average of desired futures across different nations, as the previous chapter has explained. However, at regional and local levels the desired objectives vary according to particular circumstances, and downscaled backcasts may provide divergent, though not necessarily conflicting, policy recommendations.

5.3.2 Backcasting and cumulative emission budgets

As the preceding chapter argues, policy reports rarely acknowledge the link between 2°C and cumulative emission budgets. To estimate an increase in the mean global temperature, the amount of infrared radiation that the atmosphere can retain and subsequently emit is calculated based on the concentration of greenhouse gases in the atmosphere. Many major greenhouse gases remain in the atmosphere for a long time (Archer and Brovkin, 2008; Archer et al., 2009) and, hence, as their concentration increases, so does their effect on the surface temperature. For this reason, atmospheric scientists studying anthropogenic climate change use changes in atmospheric concentrations, rather than the amount of greenhouse gases emitted annually, to derive radiative forcing as an indicator of future climatic changes. This indicator, however, was not immediately adopted by the researchers who advised policy makers on formulating national mitigation policies. Although some economists discussed carbon dioxide concentrations already in the 1970s (Nordhaus, 1979), the relative importance, “from a climate perspective”, of cumulative emissions (i.e., ‘stock’) over annual emission flows was acknowledged much later (Holtz-Eakin and Selden, 1992, p.17).

In the early 2000s, policy studies started using cumulative budgets to assign nations responsibilities for anthropogenic climate change (Meyer, 2000; RCEP, 2000). At about the

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16 Note that, due to climate feedbacks and other uncertainties, there is no one-to-one correlation between the temperature changes and atmospheric concentration.

17 Mostly researchers with an economics background.
same time, some UK scientists introduced cumulative emissions, along with radiative forcing indicators, in their research on carbon cycle feedbacks (Jones et al., 2006). However, and despite some studies practically engaging with radiative forcing and cumulative emissions (‘stock’ targets), the global policy debate has been dominated by long-term end-point reduction (i.e., ‘flow’) targets18 (Anderson and Bows, 2011, p.23). Such targets, based on a reduction of annual emissions by some point in the future, typically fail to provide a link between a mean surface temperature change and an atmospheric emission concentration.

There are evident advantages of using cumulative budgets over other types of emission reduction targets in the policy-making process. For example, cumulative emissions are more straightforward and intuitive than either radiative forcing- or ppm molecule amount-based targets, as well as easier to communicate without underplaying the complexity of the concept. Relative emission targets such as per-unit indicators incorporating GDP growth may be misleading, because “in a continually growing economy they would not necessarily […] achieve any absolute reduction in carbon emissions” (Bows et al., 2006, p.12, footnote 14). For targets such as the carbon intensity target adopted by China, there needs to be discussion in the context of economic growth, to provide meaningful emission reductions. Another advantage of cumulative emission targets is that climate change, being a global issue, relates directly to global cumulative emission budgets. For national targets to be meaningful from a climate change perspective, they need to be commensurate with global emission budgets that factor in carbon cycle feedbacks. The distribution of a global emission budget amongst countries—the so-called apportionment regime—also bears important implications for national targets and is discussed in the next chapter.

The important message of cumulative emissions and the urgency of this message for policy purposes suggest that cumulative budgets are a valuable aspect of climate-related backcasting. The intention here is to apply budgets as constraints on the strategic objective of the backcasting process. Because constraints are purposefully built into the approach, backcasting can accommodate cumulative emission budgets and, potentially, raise their profile on the policy arena. However, as the next section shows, to date few backcasting studies have explicitly considered cumulative aspects of either climate change or other complex social-ecological challenges.

5.3.3 A review of recent backcasting studies

This section provides an overview of backcasting studies covering various sectors of the

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18 For instance, the UK’s target of 80% emission reduction by 2050 and Russia’s current pledge of 25% emission reduction by 2020 (in both cases, from the 1990 baseline).
economy and natural environment, and compares them to climate-related backcasting. Analysing backcasts in other areas gives insights as to how backcasting may apply to climate change and emissions. This comparative analysis is preliminary and by no means exhaustive.

Table 7 summarises a number of recent policy-relevant studies selected through the keyword search on the Scopus database. The keywords ‘backcast’, ‘backcasting’ and ‘backcasting scenarios’ have predominantly yielded sustainability-focused studies with the topics including greenhouse gas emissions, waste, resource depletion, noise pollution, limited well-being and development, and malnutrition. To understand how frequently backcasting is used sector-wise, the topics are grouped into the main economic sectors – primary, secondary and tertiary. The primary sector of the economy covers basic production (mining, agriculture, forestry and fishery); the secondary sector includes the production of goods (construction, manufacturing and crafts); and the tertiary sector usually refers to the production of services (transport, banking, education, health and so on) (Rost, 2007).

Some sectors, such as transport, cover a complex array of interrelated issues including air pollution, soil erosion and land-take (see the third column of Table 7) and, hence, demonstrate multiple cumulative aspects. However, despite the evident cumulative dimension of the environmental and social issues, its nature is fundamentally different from that of climate change. In the case of climate, it is not only the annual amount of greenhouse gases emitted in a particular end-point year (e.g., 2050) that matters, but also their accumulation at every point in time before the ‘end-point’ target. By contrast, most other issues within the reviewed backcasting studies are relatively insensitive to their interim states, i.e., before the ‘end-point’ has been reached. There are several other substances displaying cumulative aspects with similarity to greenhouse gases, e.g., nuclear waste, DDT, mercury and other cases of bioaccumulation. These examples have a shared characteristic of a long decay period and a long-term negative impact, with the interim accumulation pattern being determinative for intermediate, end-point and ‘beyond’ states of the system. Yet, climate change differs markedly from the bioaccumulation examples in terms of its global nature, complexity and uncertainty. An environmental issue similar to climate change in its irreversibility is species extinction that usually starts locally; however, the main differences highlighted for bioaccumulation cases pertain here too.

As elaborated in the third column of Table 7, each of the listed issues has its own imperfect cumulative ‘analogue’ to climate-related emission budgets. Similarly, there are non-cumulative analogues (i.e., end-point, or flow, targets in a particular year), for example, annual pollution as
opposed to an absorptive capacity of an environment. In climate policy, cumulative budgets remain subordinate to annual end-points, whilst in other sustainability-related areas it is common to plan and implement policies based on a cumulative value (‘stock’) instead of, or in addition to, the long-term value in a particular year (‘flow’). A potential explanation is that the limits of other environmental issues have been historically better understood than those of the climate system. In addition, the cumulative framing of climate change around 2°C requires deep changes in contemporary society—a situation challenging to admit and act on.

The cumulative nature of most environmental and social issues in the reviewed studies does not necessarily imply that they have potential critical thresholds “at which a tiny perturbation can qualitatively alter the state or development of a system” (Lenton et al., 2008, p.1786). Critical thresholds partly account for the importance of pathways and interim targets when dealing with climate change. The decay of the Arctic summer sea-ice and the Greenland ice sheet, the dieback of the boreal forests and the collapse of the Indian Summer Monsoon are examples of such climatic discontinuities. Because of the uncertainty involved, the timing and ramifications of climatic critical thresholds are ‘unknowable’. Hence, not only do such thresholds emphasise the gravity of climate change compared to other issues, but there is also no meaningful way to forecast beyond those thresholds because of unknown potential changes in the system – neither magnitude, nor the direction of the changes is knowable with any reasonable level of certainty. However, what is known is that exceeding cumulative emission budgets sooner rather than later is likely to increase the probability of discontinuities. The interrelationship of backcasting, critical thresholds and cumulative aspects makes climate change unique compared to other sustainability matters.

The last two columns of Table 7 summarise both the general characteristics of the backcasting approach and the targets in the reviewed studies. Quantitative studies listed in the table tend to be less participatory than their qualitative counterparts. All of the studies discuss some form of a ‘final target’, although it is not always explicit, for example, when represented within a ‘vision’. Interim targets are either not provided at all or approached qualitatively, as a ‘roadmap’, with no timeframe suggested. Some researchers classify roadmapping and similar exercises as a “conceptual approach” (Quist et al., 2011, p.884) to backcasting as opposed to a more technical “backwards-looking analysis” (ibid.). Because implicit or absent final and interim targets are not easily measurable, the question arises as to how strategic such targets are in terms of both backcasting and policy-making. The last column in Table 1\(^\text{19}\) shows that

\(^{19}\) Note the difference between the third and the last columns of the table that summarise the cumulative nature of the issues and that of the backcasting approach in each study, respectively.
only one of the reviewed studies acknowledges and explicitly identifies cumulative aspects of the backcast issue.

Table 7. A comparison of recent backcasting studies in application to areas that have potential cumulative aspects and critical thresholds

<table>
<thead>
<tr>
<th>Example of a study</th>
<th>Focus of a backcasting exercise</th>
<th>Environmental and social issues with potential cumulative aspects [critical thresholds or lock-in]</th>
<th>Qualitative / quantitative method(s)</th>
<th>Backcast targets: final, interim and cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary sector</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Secondary sector</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Partidário, 2002)</td>
<td>Chemical industry (paint production) sustainability[a]</td>
<td>Various. E.g., waste and emissions [e.g., saturation of a particular environment with wastes]</td>
<td>Qualitative: more than 70 stakeholders involved in workshops, interviews and questionnaires, at all stages of the research.</td>
<td>The final target sustainable industrial coatings by 2050. Interim targets presented as a six-stage pathway. No cumulative aspects to the targets.</td>
</tr>
<tr>
<td><strong>Tertiary sector</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(JRC, 2008)</td>
<td>Transport sector sustainability[b]</td>
<td>Various. E.g., air / soil pollution, noise [e.g., saturation with a pollutant]</td>
<td>Quantitative: a specific method is not reported. No stakeholders involved.</td>
<td>Two visions up to 2050; no explicit interim targets and no cumulative aspects to the targets.</td>
</tr>
<tr>
<td>(Bows et al., 2009)</td>
<td>Aviation sector</td>
<td>Cumulative emissions [climatic discontinuities]</td>
<td>Qualitative: a spreadsheet scenario tool. Qualitative: stakeholder input used iteratively.</td>
<td>The final target cumulative (emission budgets). Interim targets represented as pathway from ‘today’ to 2030.</td>
</tr>
<tr>
<td>(Green and Vergragt, 2002)</td>
<td>Household ‘functions’: sustainable food, clothing care, shopping, energy use</td>
<td>Various. E.g., nutrition, energy consumption, waste [various critical thresholds, e.g., no-return health damage due to malnutrition; exhausted absorptive capacity of a particular environment]</td>
<td>Qualitative: workshops and focus groups to build scenarios and to assess impacts and consumer acceptance. Stakeholders involved insufficiently at the assessment stage.</td>
<td>The final target a factor 20 environmental efficiency improvement by 2050. Interim targets and pathways not discussed.</td>
</tr>
<tr>
<td><strong>Intersection of sectors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Anderson et al., 2008b)</td>
<td>Energy system</td>
<td>Cumulative emissions [climatic discontinuities]</td>
<td>Quantitative: a spreadsheet scenario tool. Qualitative: stakeholders to verify end-points, pathways and multi-criteria assessment.</td>
<td>The final target cumulative (emission budgets). Interim targets represented as pathway from ‘today’ to 2050.</td>
</tr>
</tbody>
</table>
As Table 7 shows, the number of studies generating backcast emission scenarios to inform the policy-making process is relatively low. Much of the research on emission scenarios is a result of predictive modelling, i.e., forecasting and ‘what-ifs’ (see section 5.3.5 for a distinction between the two). Since there is a degree of perceived ‘rivalry’ between backcasting and forecasting, the focus of the next sections is mainly on these two approaches to climate change related futures studies.

### 5.3.4 Backcasting and forecasting in typologies of futures studies

Classifications of approaches used in ‘futures’ studies abound. For example, van Notten et al. (2003, p.429) groups scenarios based on their general characteristics in terms of the project goal, process design and scenario content. Backcasting emerges under the first category and is contrasted with forecasting based on the vantage point, i.e., the starting point of a scenario. The study also defines backcasting scenarios as “prescriptive” and “anticipatory” (ibid.). Dreborg (2004, pp.19–20) suggests three modes of thinking about the future: predictive, eventualities and visionary. Each mode is assigned a formal methodology, with forecasting (or, more broadly, predictive modelling) pertaining to the first mode and backcasting to the third. Börjeson et al. (2006, p.723) argues that “the scenario user’s need to know what will happen, what can happen, and/or how a predefined target can be achieved” is a suitable criterion for tagging a particular approach as predictive, explorative or normative. The authors (ibid., pp.725, 729) then allocate backcasting to the latter category, whilst forecasting belongs to predictive approaches.

Evidently, there is a general agreement about the place of both forecasting and backcasting in
typologies related to futures studies. Forecasting is typically described as a predictive tool in many respects ‘wedded’ to the present, whilst backcasting is perceived as a transformative approach designed to envision futures and ways of achieving them. The two approaches are intended for different purposes, and the subsections below will argue that backcasting is more suitable for generating emission scenarios to inform policy.

5.3.5 Critique of backcasting

The backcasting approach has a number of perceived disadvantages that become prominent only in certain contexts. For example, unlike forecasts, the backcast is not a predictive tool, i.e., it is not meant to tell what the future is going to be. Instead, backcasting is used to “indicate the relative implications of different policy goals” (Robinson, 1982, p.337). Therefore the two approaches are designed for very different purposes.

Backcasting involves normative scenarios and pre-specified end-points. As a result, it has been criticised for being political and based on subjective values rather than ‘objective science’; this contrasts with the claims of forecasts to be positivist, and as such, more objective. Although in most cases the starting point for both backcasting and forecasting is societal value, the ‘subjectivity’ criticism refers to how a future is ‘achieved’ rather than to what motivates the futures study. Since the backcast is best applied to politically important and controversial problems, it cannot be entirely detached from value-driven processes. At the same time, explicitly acknowledging the subjectivity and values underpinning a backcasting is good practice and is far removed from the hidden assumptions in forecasting, making the latter “ultimately a product of deeply entrenched belief structures and cultural traditions” (Anderson, 1998, p.328). Transparency and stakeholder engagement are two ways of reducing (or testing) subjectivity, and the backcasting approach is amenable to both. Forecasting is underpinned by assumptions on the direction of trends and on likely future relationships between variables in the model. Backcast pathways, however, may part with historical trends if this is necessary for attaining specific objectives.

In addition to being called ‘political’, normative scenarios were deemed incompatible with the laissez-faire approach. Valaskakis (1988, p.342) notes that “backdoor socialism” was a common label for normative futures studies in the US in the 1980s. Backcasting and predictive tools were deemed mutually exclusive up until the 1990s, when the former proved to be flexible enough to accommodate strengths of the latter, in the same vein as teleology can accommodate causality. Dreborg (1996, p.824) and Höjer and Mattsson (2000, p.613) suggest

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20 Therefore criticisms of the ‘predictive capacity’ of backcasting are meaningless.
that the forecast can potentially complement the backcast in the short term when dealing with sub-problems of a futures study or when there is a need to demonstrate that sustaining current trends would result in undesirable outcomes. This chapter argues that it is ‘what-if’ scenarios, rather than forecasting, that can complement backcasts. Both forecasts and ‘what-ifs’ belong to the category of predictive futures studies (Börjeson et al., 2006, p.725), with the main difference being that forecasts embody the most likely future conditions (based on only marginal changes to the status quo) whereas what-if studies build on researcher-specified conditions. In both cases, an end-point future is an exogenous output of a model. This should not be confused with backcasting where ‘what-if’ type questions are often used to pre-set such a future.

Another issue, noted by Börjeson et al. (2006, p.729), is that backcasting may disregard high short-term costs of implementing the pathway towards the desirable future state. The backcast, however, proves a valuable tool if attaining a long-term target is preferred over an immediate gain, with forecasting more suitable for predicting short-term phenomena. Therefore an approach largely depends on the research purpose and a chosen time frame, with backcasts, being iterative, likely to be more successful at exploring policy target implications in the longer term.

Since backcasting builds on a medium- to long-term objective, both the objective itself and the pathways towards it may considerably change over time. As Anderson (2001, p.615) puts it, backcast-derived policy recommendations are “intrinsically sub-optimal” and need to be “iteratively tuned to match strategic objectives”. Provided this ‘learning’ aspect of backcasting is acknowledged, it remains an essential approach that is both normative and exploratory.

### 5.3.6 Benefits of backcasting when dealing with complex problems

The exploratory, problem-solving and flexible nature of backcasting is particularly suitable for dealing with societal problems that are complex, multidimensional and often unbound by a specific time frame. Backcasting embeds a systems perspective and generally requires a grasp of both technology and society to analyse “the political and social underpinnings of economic and technological decisions” (Valaskakis, 1988, p.340). In this sense, the backcasting approach improves the systematic interdisciplinary understanding of social and environmental constraints, commensurate with particular desired futures. Such understanding is necessary if

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22 Therefore, misinterpreting backcast-generated scenarios as fixed futures is unjustified.
the transformation of a carbon-intensive “techno-institutional lock-in” (Unruh, 2000, p.818) is to take place.

Being relevant for complex societal challenges, backcasting is therefore highly policy-oriented. At the same time, backcasting is not just a blind tool of policy-makers but is likely to challenge half-hearted political targets. To determine feasible and ambitious ‘rules’ for attaining a desired future state, backcasting may involve stakeholders. Whilst forecasting can also lend itself to expert formulation, the way the stakeholder input is used distinguishes the two approaches. Backcasting is likely to apply expert judgements to veer away from the past trends, if they are unfavourable for a specified desirable future objective. By contrast, forecasting often uses stakeholder engagement to identify likely future developments.

‘Likely future developments’ of the socio-economic system may be a problematic concept as the system is assumed to have a set of properties constant over time. This may hold true for basic physical laws but not for complex adaptive systems with a large number of interacting agents, regardless of the timeframe. Two examples of such systems are society and climate, and their most ‘constant’ characteristic is that they display unpredictable emergent properties. The study of complex adaptive systems originates from the systems theory (Hartvigsen et al., 1998, p.427) and is broadly defined as “the study of systems limited in their predictability” (Levin, 2002, p.17). Due to their emergent properties, such systems are ‘complex’ rather than ‘complicated’ (Snowden, 2002, pp.105–106), whereas forecasts are often based on the assumption that these two attributes are the same, i.e., that the system can be deconstructed into distinct, non-overlapping parts and that cause and effect can be easily separated. This assumption is at the core of reductionism. By contrast, backcasting deals with emergent properties by providing a range of possible pathways, rather than a likely future development, with stakeholders playing an important role in bringing the system back on ‘track’, i.e., on a chosen pathway. In addition, the flexibility and iterative dimensions built into backcasting are more attuned to absorbing or responding to change.

In general, details of stakeholder participation vary based on, amongst other criteria, stakeholders profile and the degree of their involvement in a project (Carney et al., 2009). The criteria are largely determined by the purpose of the research and would ideally differ depending on whether backcasting or forecasting is applied. For example, one of the main aims of backcasting is to illustrate the pathways of systemic-scale change. To this end,

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23 See, for example, Juarrero (1999) for a contextual discussion on separating cause from effect in dynamical systems.
stakeholder engagement can facilitate the dissemination of results (Quist et al., 2011) by channelling the ‘transformation’ message through stakeholder networks. As to the dissemination of results, involving stakeholders may be more important for backcasts than for forecasts, as forecasting is less strategic as a planning tool for three main reasons. First, the main proclaimed advantage of forecasts (their predictable potential) reduces with time making it less than useful as a strategic tool. Second, forecasts do not provide a ‘plan’ in the form of pathways towards a desired future. Third, in many cases forecasting is little more than a theoretical exercise due to assumptions often abstracted from physical reality (Anderson, 2001, p.609), whereby the resulting dissemination and implementation is superfluous or, even, dangerous in terms of the impacts forecast-based policies may have on the society, economy and environment. In summary, given the ‘pros’ and ‘cons’ of the forecasting and backcasting approaches, backcasting is evidently more suitable for achieving the aim and research objectives of this thesis.

5.3.7 Stages of backcasting

Backcasting starts with defining a ‘desirable’ future state and proceeds to model transitions to that state from the present. Following Gomi et al. (2011, p.853), the backcasting process can be divided into two broad phases: ‘static’ and ‘dynamic’. During the first phase, the researcher specifies a desirable future and describes the past and present states of the system, both qualitatively and numerically. This phase of backcasting is ‘static’ as it is mostly descriptive and does not require any modelling, although it may define relationships between variables. During the second, dynamic, phase, the researcher explores how to transition to the desired future from the present state, through the generation of pathways and testing their consistency and feasibility.

Figure 5 provides a more detailed outline of the backcasting process. On the scheme, stages 1 and 3 are adjacent as they are both future-oriented, with the first stage framing the strategic objective of the backcasting exercise and the third stage detailing desirable future states compatible with the objective. These two stages are ‘interrupted’ by stage 2 because the data- and assumption-intensive process per se technically starts from this stage. The logic behind the sequence of and connections between other stages is straightforward. The backcasting process is iterative, which helps to verify feasibility of a desirable objective and devise appropriate transition paths. This subsection maps out a generic backcasting algorithm, whilst the details

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24 Despite the benefits of stakeholder engagement, it may entail prohibitive costs and a heavy administrative burden, extend a project implementation timeline, and eventually give trivial results (see a detailed discussion in US NRC (2008)).

25 The philosophical standing taken in this thesis, that the main purpose of stakeholder engagement is to facilitate strategic planning, is sometimes referred to as “functionalist” (Renn, 2008, pp.296, 303).

26 This contrasts with Gomi et al. (2011, p.853) claiming that “the first phase requires a static model”.
of its implementation within this research project are described and analysed in the rest of this thesis.

The starting point for devising the first stage is conditional on the existing and future socioeconomic needs and available resources, but it typically offers a more ambitious policy outcome than any currently implemented measures do. The distribution of greenhouse gas emissions over time (i.e., the rate of spending an emission budget) is essential for stabilising the global temperature at a particular level. Because many greenhouse gases remain in the atmosphere for a long period after being emitted, it is important that medium- to long-term reduction targets incorporate interim emission budgets to ensure early reductions and thereby reduce the risk of overshooting the strategic objective.

At the second stage, the researcher gathers information about the past relationships and trends and the current conditions in a system. An important function of the second stage is to explore driving forces, resources and constraints that may facilitate or limit pathways towards the desired future state. Although stage 2 of the backcast aims to report a detailed picture of historical trends, there is no attempt to search for patterns—extrapolate from the past data, other than in the short term. Such an attempt would be incompatible with the teleological nature of backcasts rejecting the determinism of forecasting, as discussed above.

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27 This has been done, for example, by the Committee on Climate Change for the UK's 2050 greenhouse gas emission reduction target.

28 Höjer and Mattsson (2000, p.620) analyse three different ways of describing historical patterns—cycles, time-series correlation and invariance. Although the list is by no means exhaustive, these are the most ubiquitous tools of the forecasting methodology.
The third stage of backcasting describes future end-points, i.e., desired future states of the system, compatible with the overarching objective (e.g., staying within given cumulative emission budgets). There may be an almost infinite number of futures that correspond to the same emission budget; therefore, one of the tasks at this stage is to identify criteria for short-listing a manageable and informative range of future states. There is, however, no strictly established procedure for achieving this apart from a few tentative guidelines. An obvious criterion would be the technical feasibility of a future, mostly determined by technological and resource constraints. Political feasibility also plays an important role, which is why it is essential to tailor the backcast to national socio-political and cultural circumstances. Stakeholders can provide an invaluable input at this stage of backcasting by offering their visions of potential desirable futures for the system as a whole or for different elements of it. The third stage cannot be completed in isolation from subsequent stages of backcasting that may involve similar selection criteria. The stages from now onwards retain a tentative status until the iteration process determines the consistency and feasibility of both future states and pathways towards them.

Whilst stage 1 of the backcasting process is strategic, the fourth stage can be described as ‘tactical’ since it discusses how to achieve specified future states. The main purpose of pathways is, therefore, to show ways towards the desired future states. Although pathways are usually rooted in the current trends, they may have to depart from them in the medium- to long-term to reach the desired objective, especially if it is radically different from the past state of the system. Transformations challenging systemic inertia on a large scale may require a departure from current trends already in the short term. In particular, in climate change policy and science such a departure will be required to assist in escaping the carbon lock-in of economies.

Stage 5 ensures the pathways generated through the backcasting process are relevant and consistent. To begin with, pathways should be consistent with the strategic objective set out at the first stage of backcasting, for example, be commensurate with given cumulative emission budgets. Keilman (1985, p.1473) regards the process of complying with such a constraint as ‘external consistency’, which requires that “certain output variables have to satisfy externally specified restrictions”. On the other hand, internal consistency, according to Keilman (ibid.), occurs when output variables are consistent with each other.

At stage 6 the researcher evaluates relative feasibility and implications of the generated pathways and desired future states. The implications may refer to a broader context of
sustainability and governance, in addition to the narrow area addressed by the backcast scenarios. The final stage of backcasting generates one of the key outputs that later feeds into the discussion on feasibility, governance and other aspects of low-carbon transitions. Stakeholders and experts may contribute valuable insights to assessing various aspects of feasibility and implications of pathways and scenarios. Furthermore, there is vast research on criteria and benchmarks for assessing impacts of policy options.

5.4 A review of studies on emission pathways in Russia

This section summarises and analyses the main characteristics of several studies on Russia’s greenhouse gas emissions. The articles and reports have been selected based on one criterion: they should produce and discuss future emission pathways for the energy system or the economy of Russia. Most of the studies are published in the Russian language.

Table 8 below shows that the reviewed studies have several common features. For instance, forecasting dominates the modelling exercises, with elements of backcasting incorporated in a few studies. Climate change impacts, cumulative emissions and the economic crisis are hardly considered, whilst most of the modelling is focused on energy-related CO$_2$ with non-CO$_2$ and non-energy greenhouse gases omitted from the analyses. Input-output tables appear to prevail as a basis of top-down models; however, the studies fail to acknowledge weaknesses of the input-output approach in the context of Russian economy. In particular, the volatility of prices and major economic restructuring in the 1990s may render the results of input-output modelling inadequate.

Whilst Table 8 may not be exhaustive, it is evident that many studies have drawbacks sufficient to make them unsuitable for advising policy-makers. Therefore, there is a strong need for novel approaches to explore Russian emission pathways and targets. Such approaches should, first, reveal a more plausible depiction of reality and, second, be able to envision and inform step-change in Russia’s climate policy. The first aspect may be realised by drawing on interdisciplinary methods, including an explicit involvement of stakeholder expertise. The second aspect unfolds if researchers are forthright about the actual state of the climate and its potential implications for the priorities of government. This thesis takes account of both aspects to suggest alternative sets of policies that may lead to a low-carbon future in Russia.

As discussed earlier in this chapter, the backcasting approach has evolved as an alternative to forecasting, with a twofold purpose. First, the backcast aims to break away from past and
current trends, assuming they are incompatible with desirable future states. Second, it avoids relying on predictions of economic variables, for example, future costs of energy and technologies (i.e., monetised variables commonly used in optimisation and input-output models). Therefore the preference for backcasting narrows down the range of available quantitative and qualitative modelling tools; for instance, it significantly reduces the use of time-series analyses and least-cost optimisation\(^\text{29}\). Instead, it offers scope for applying “explanatory models” (Börjeson et al., 2006, p.734) that are more suitable for generating explorative scenarios rather than predictions. The next section discusses the ASK-Russia scenario generator and argues that, being both flexible and transparent, this scenario tool provides an appropriate quantitative modelling environment for the purposes of this thesis.

\(^{29}\) Although there have been attempts to combine optimisation and backcasting (see, for example, Strachan et al., 2008), this appears to go against the very nature of the backcast. In particular, Börjeson et al. (2006, pp.728–729) classify normative studies that use optimisation as ‘preserving’, in contrast to ‘transforming’ normative studies using backcasts.
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Table 8. A review of emission scenario studies for Russia

(Note: where possible the last column describes the most ambitious scenarios within each set)

<table>
<thead>
<tr>
<th>Model and source</th>
<th>Top-down (TD) or bottom-up (BU)</th>
<th>End year</th>
<th>Modelled emissions</th>
<th>Forecasting (F) or backcasting (BC)</th>
<th>Recent economic crisis considered</th>
<th>Cumulative emissions considered</th>
<th>Main mechanisms / incentives of changes in carbon and energy intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGYPAL-GEM – simple simulation model (Bashmakov, 2009a)</td>
<td>TD</td>
<td>2050</td>
<td>CO₂</td>
<td>F</td>
<td>In 2 out of 6 scenarios</td>
<td>No</td>
<td>Energy efficiency, CCS, bio, nuclear, hydro and heavy reliance on renewables – the only scenario with slightly decreasing emissions (starting from ~2043). C price: €30-50/tCO₂e.</td>
</tr>
<tr>
<td>MESAP/PlaNet – simulation model (Teske and Tchouprov, 2009; Tchouprov, 2010)</td>
<td>TD + BU</td>
<td>2050</td>
<td>Energy-related CO₂</td>
<td>F with elements of BC&lt;sup&gt;a&lt;/sup&gt;</td>
<td>No</td>
<td>No</td>
<td>Phasing out nuclear energy; realising full energy efficiency potential; emphasis on renewables (incl. sustainable biofuels). Global carbon trading system assumed; $50/tCO₂ in 2050. CCS not included.</td>
</tr>
<tr>
<td>TIMES –optimisation model (Fiodorov et al., 2009)</td>
<td>BU</td>
<td>2025 and 2030</td>
<td>Electricity and heat-related CO₂</td>
<td>F</td>
<td>In several scenarios</td>
<td>No</td>
<td>Proportions of CCS, renewable and nuclear energy are unclear. C price increases from $15 to 25/tCO₂ in 2013-25.</td>
</tr>
<tr>
<td>Dynamic linear optimisation model (Nekrasov and Siniak, 2007)</td>
<td>TD (+ BU)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2030</td>
<td>CO₂</td>
<td>F</td>
<td>No</td>
<td>No</td>
<td>Nuclear power increases from 21.7 in 2000 to 68 GW in 2030 (~40-45% of power stations). RES generate 12.5% of energy in 2030, if nuclear is not capped, and ~80% (calculated based on the text) if nuclear is capped.</td>
</tr>
<tr>
<td>MENEK-EKO –optimisation model (Malakhov, 2010; Malakhov and Dubynina, 2010)</td>
<td>TD + BU&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2030</td>
<td>CO₂, CH₄, N₂O, other GHGs</td>
<td>F in two scenarios and BC in one</td>
<td>No</td>
<td>No</td>
<td>Carbon ‘charge’ is used in the third scenario, but magnitude unclear. CCS, renewables and nuclear not discussed. Prices are used instead of physical units (i.e., a ‘classic’ input-output model).</td>
</tr>
<tr>
<td>Simple simulation model (Novikova et al., 2009)</td>
<td>TD</td>
<td>2020</td>
<td>CO₂</td>
<td>F</td>
<td>No</td>
<td>Yes, in all scenarios</td>
<td>The largest share of renewable energy sources is 6.6% of generated energy. GDP energy intensity is the main factor driving emissions down in the scenarios.</td>
</tr>
<tr>
<td>SRES-based scenarios (RosHydromet, 2008a)</td>
<td>TD + BU</td>
<td>2100</td>
<td>CO₂, CH₄, N₂O, other GHGs</td>
<td>F</td>
<td>No</td>
<td>No details provided</td>
<td>No details provided.</td>
</tr>
<tr>
<td>World Bank’s model (Safonov, 2000)</td>
<td>TD</td>
<td>2012</td>
<td>CO₂</td>
<td>F</td>
<td>No&lt;sup&gt;d&lt;/sup&gt;</td>
<td>No</td>
<td>No details provided.</td>
</tr>
<tr>
<td>Model</td>
<td>Type</td>
<td>Year</td>
<td>Emissions</td>
<td>Included in Scenarios</td>
<td>Bottom-Up</td>
<td>Notes</td>
<td></td>
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<td>-------</td>
<td>------</td>
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<td>------------</td>
<td>-----------------------</td>
<td>------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>WEM – World Energy Model (IEA, 2007)</td>
<td>TD + BU</td>
<td>2030</td>
<td>Energy-related CO₂ emissions</td>
<td>No</td>
<td>No</td>
<td>No details provided.</td>
<td></td>
</tr>
<tr>
<td>IIASA’s GAINS optimisation models (Cofala et al., 2008)</td>
<td>TD + BU</td>
<td>2030</td>
<td>CO₂, CH₄, N₂O, SO₂, NOₓ, PM</td>
<td>F</td>
<td>No</td>
<td>“…both through structural changes in the energy system (fuel substitution, energy efficiency improvements) and through end-of-pipe measures (e.g., carbon capture).”</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

a Backcasting was inferred by the author from the following statements: “The Energy [R]evolution Scenario has a target to reduce energy related CO₂ emissions to a maximum of 10 Gt […] by 2050” (Teske and Tchouprov, 2009, p.11). “By 2050 the average per capita emission should be between 1 and 2 tonnes of CO₂.” (ibid.)

b It is unclear from the text of the article if bottom-up elements are present, however a schematic representation of the model includes a “Database of energy technologies” (Nekrasov and Siniak, 2007, Fig.1, p.24)

c Top-down with bottom-up elements for the most energy-intensive industries

d The economic crisis was not considered, because the study was submitted / published before the crisis started

e A combination of econometric software and bottom-up simulation programmes
5.5 Specifications of the ASK-Russia scenario tool

The original scenario generator, ASK, was developed by the Tyndall Centre for Climate Change Research for constructing UK decarbonisation scenarios (Bows et al., 2010). The approach was subsequently modified to explore emissions from China (Wang and Watson, 2008, 2009) and is also being used to develop emission pathways for the shipping sector. For this thesis, the tool has been adjusted to embed the geopolitical and national circumstances of Russia and to accommodate the specifications of available data. ‘ASK-Russia’ has the advantage of being simple and transparent and requires the researcher to remain an integral and informed part of the modelling process at all times. On the other hand, it uses a relatively high level of top-down aggregation, relies on external projections of certain inputs (e.g., population and GDP growth) and, to a degree, is constrained by the limited functions of the software (Microsoft Excel).

The purpose of the scenario exercise, stakeholder input and the constraints of the research project determine the scope of the modelling of Russia’s energy system. Depending on the availability of data, the scope may be expanded to cover the whole economy of Russia and, hence, non-energy greenhouse gases. As regards the temporal scope, the model is static, with discrete (as opposed to continuous) time represented as one-year steps.

The model distinguishes seven economic sectors: households, industry, services, agriculture, transport, energy production and ‘miscellaneous’, where ‘industry’ is subdivided into energy-intensive industry, other industry and construction. Transport is similarly divided into domestic aviation, international aviation bunkers, rail, road, domestic navigation and international marine bunkers. The sectoral disaggregation is determined by the access to data and the plausibility of assumptions. As Figure 6 shows, supply-side, technology and demand-side data and assumptions are the main inputs of the model, including indicators of sectoral activity, emission factors, final energy demand, efficiency potentials, population and the number of households. A cumulative emissions budget compatible with a ~2°C global mean surface temperature increase above pre-industrial (see chapter 6 for details) is the key constraint specified within the scenario tool and complemented with constraints on fossil fuel reserves, uranium reserves, renewable energy potentials and so on. The main outputs of the scenario generator are carbon emission pathways and the energy intensities/efficiencies of, for example, the economy as a whole, the grid and various sectoral parameters.
5.6 Divergence from the original ASK tool

The original ASK spreadsheet was built to represent past, present and ‘what-if’ states of the UK’s energy system. In the context of this thesis the tool has been adjusted at three levels: modifications attributable to the differences between the UK’s and Russia’s energy systems; modifications related to data availability for Russia’s energy system; and, formulae adjusted to remedy inaccuracies in the original version of the tool. This section refers to rows and columns in spreadsheets “The all new scenario generator for foe final” (the original ASK scenario generator) and “ASK-Russia_20130818” (the scenario generator used in this thesis) and needs to be read simultaneously with consulting the two spreadsheets.

5.6.1 Modifications attributable to the differences between the UK’s and Russia’s energy systems

a) ‘Demand Data’ tab:
First, no electricity is used within the 'Energy Industry Transformation' sector in ASK-Russia, although electricity did contribute to electricity generation in the original ASK (row 154). Second, nuclear energy use in the original ASK’s 'Energy Industry Transformation' rows is equal to zero, however it is present in the 'CHP Plants' row in ASK-Russia (row 201).

b) ‘Yearly’ tabs:
In the original ASK, column E containing the total of fuels used for non-electrical energy

---

30 As a reminder, in this case ‘what-if’ type questions are exploratory rather than predictive.
consumption does not include heat for the Road, Shipping and Miscellaneous sectors (e.g., cell E41), whilst it does for other sectors. In addition, ASK-Russia contains data on heat within the 'Miscellaneous' sector, unlike in the original ASK.

Within the Energy Industry, the only major divergence from the original ASK is that heat (column R) is manually set to zero in all 'yearly' tabs, as it is zero in the 'Demand Data' tab, whilst in ASK-Russia the heat in the Energy Industry is relatively high and would distort the results, were it not included. Therefore, in ASK-Russia column R is set to draw on the 'Demand Data' tab.

'Grid Total' in the original ASK (cell K60) does not include electricity supplied for Miscellaneous industry. Even though it is close to zero in the ASK-Russia spreadsheet as well, it is nonetheless included.

In column G, calculations of carbon dioxide emissions in each ‘yearly’ tab, an original ASK comment on how to calculate non-electrical energy emissions in each sector (e.g., cell G5 in the ASK-Russia) is, "Sum of the coal emission factor multiplied by the coal amount, gas emission factor multiplied by the gas amount and oil emission factor multiplied by the oil amount. Adjusted from net calorific value to gross using percentages laid out in the 'key parameters' sheet". The original formula in that cell is as follows:

\[
\begin{align*}
\ &= \text{Coal Amount} \times \text{Coal Emission Factor} \times (1+\text{Coal Conversion To Gross Calorific in baseline year}) \\
&+ \text{Oil Amount} \times \text{Oil Emission Factor} \times (1+\text{Oil Conversion To Gross Calorific in baseline year}) \\
&+ \text{Gas Amount} \times \text{Gas Emission Factor} \times (1+\text{Gas Conversion To Gross Calorific in baseline year}) \\
&+ \left(\frac{\text{Heat Amount}}{\text{Heat Efficiency of CHP Gas Total in baseline year}}\right) \times \text{Gas Emission Factor} \times (1+\text{Gas Conversion To Gross Calorific in baseline year})
\end{align*}
\]

Considering that Russia already in the baseline year has several kinds of CHP plants, whilst the original ASK only considers gas CHP, the last part of the formula is modified into:

\[
\begin{align*}
\ &= \text{Coal Amount} \times \text{Coal Emission Factor} \times (1+\text{Coal Conversion To Gross Calorific in baseline year}) \\
&+ \text{Oil Amount} \times \text{Oil Emission Factor} \times (1+\text{Oil Conversion To Gross Calorific in baseline year}) \\
&+ \left(\frac{\text{Heat Amount}}{\text{Heat Efficiency of Gas CHP in baseline year}}\right) \times \text{Gas Emission Factor} \times (1+\text{Gas Conversion To Gross Calorific in baseline year}) \\
&+ \left(\frac{\text{Heat Amount}}{\text{Heat Efficiency of Coal CHP in baseline year}}\right) \times \text{Coal Emission Factor} \times (1+\text{Coal Conversion To Gross Calorific in baseline year})
\end{align*}
\]
(1+Coal Conversion To Gross Calorific in baseline year)
+(Heat Amount / Heat Efficiency of Oil CHP in baseline year) * Oil Emission Factor *
(1+Oil Conversion To Gross Calorific in baseline year)

There are also relatively minor contributions from biofuel and nuclear CHPs in Russia, but
they are assumed to be zero-carbon, and life-cycle emissions of power stations are excluded
from the analysis. In scenario tabs described below, a similar formula is used in the original
ASK, with only coal CHP and gas CHP included in calculations. In ASK-Russia the formula is
amended with oil CHP.

c) ‘Scenario’ tabs\textsuperscript{31}:
The energy for heat specified in column R of the 'Baseline year' tab does not appear at all in
scenario tabs of the original ASK spreadsheet. The heat-related numbers are low there
however, whilst in ASK-Russia they are as high as 125 Mtoe in 2009 (about a third of the total
final consumption in that year), and their omission would greatly underestimated the annual
energy consumption by Russia’s economy.

To allocate the heat amongst different fuels, the IEA’s Energy Balances (2006)\textsuperscript{32} were used.
For the ASK-Russia tool, only the fuel mix for 2009 was calculated, as this is the baseline year
feeding into all scenarios. The main fuel source for heat is natural gas (67.4%), followed by
coal (19.2%). Oil and renewables (mostly hydro) are 5.8 and 5.3% respectively, whilst nuclear
is 0.2%.

The IEA Energy Balances provide a breakdown of 'Heat Generated' into 'CHP Plants' and
'Heat Plants'. Assuming the ratio between the two types of plants holds in each sector, the
2009 heat data were distributed in the scenario tabs accordingly. Table 9 below details the heat
energy fuel mix and the proportion of CHP vs. Heat Plants in 2009.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Total heat output, ktoe</th>
<th>Fuel share in total heat output</th>
<th>Share of CHP vs. Heat Plant for different fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>CHP</td>
</tr>
<tr>
<td>Coal</td>
<td>32030</td>
<td>22.7%</td>
<td>49.3%</td>
</tr>
<tr>
<td>Oil</td>
<td>7877</td>
<td>5.6%</td>
<td>20.5%</td>
</tr>
<tr>
<td>Gas</td>
<td>90900</td>
<td>64.4%</td>
<td>45.8%</td>
</tr>
</tbody>
</table>

\textsuperscript{31} Tabs referring to scenario years in ASK-Russia (e.g., tabs ‘2015 trends’, ‘2050 cherry’, ‘2030 plum’ and so
on) are collectively called ‘Scenario’ tabs in this chapter.

\textsuperscript{32} For other sources of data used in the ASK-Russia scenario generator, see Appendix A.
An additional assumption was made whilst working with the IEA Energy Balances: no data for 2000, 2005 and 2009 were available in the category 'Heat output-main activity producer heat plants' and it was assumed that it equals the heat output in 1995, to avoid an anomaly in the energy for heat data.

An example of how the heat energy from the 'Baseline Year' tab in ASK-Russia was allocated to scenario tabs can be found, for example, in cell AQ5 in the '2015 trends' tab:

Gas CHP In 2015 = Total Heat Output In 2009 * Share Of CHP In Total Heat Output For Gas * Share Of Gas In Total Heat Output = 49.8 Mtoe * 45.8% * 64.4% = 14.7 Mtoe

Similar calculations apply to the columns with non-electrical energy fuels. In this case, the 'Heat Plant' portion of the 2009 heat output, as opposed to the 'CHP' portion, is added to each cell in columns AV–AZ. That is the first part of the formula in each of these cells, except 'Renewables ONSite', since they do not generate any energy for heat (according to the 2009 heat energy breakdown).

The allocation of the heat energy has required an 'Oil CHP' column to be added to ASK-Russia, as its share in heating is not trivial (see Table 9 above: 20.5% of oil-source heating comes from oil CHPs). A further modification relates to the 'Key Indicators' tab where 'Proportion of heat vs. electricity' for CHP has been introduced (row 90), assuming that it is similar to other CHP plants (40%). Three more rows are added to the same tab: 'CHP oil electricity portion', 'CHP oil heat portion' and 'CHP oil total' (rows 45–47), and assumed to be as equal to coal CHP proportions.

### 5.6.2 Modifications related to data availability for Russia’s energy system

a) ‘Households’ tab:

The 'Final Energy Consumption by End Use' table in the original ASK contains data on space heating, water, lighting, appliances air conditioning. The only related information on Russia is available for 2005. The source providing the data argues that no such statistics are collected in Russia (Bashmakov, 2009b), and the estimates appear to be very approximate. At least 2–3 data points in different years are needed to be able to extrapolate and interpolate them, hence the table in ASK-Russia was not filled in. However, as there are no dependants in any other
tabs leading from these data in the original ASK, the output is not affected.

b) ‘Shipping Calculations’ tab:
In the original ASK this tab is used to explore the sectoral emissions in detail, even though it has no dependent cells elsewhere in the spreadsheet. Due to data availability, it was not possible to do similar calculations for Russia and bunker fuels were used instead.

5.6.3 Formulae adjusted due to potential inaccuracies in the original version of the tool

a) Conversion from net to gross calorific values:
In the ‘Scenario’ tabs of the original ASK, cell T5, carbon dioxide emissions from non-electrical energy are calculated with the following formula:

\[
\text{= Coal Amount} \times \text{Coal Emission Factor} +
\]
\[
+ \text{Coal CHP / CHP Coal Heat Proportion} \times \text{Coal Emission Factor} +
\]
\[
+ \text{Oil Amount} \times \text{Oil Emission Factor} +
\]
\[
+ \text{Gas Amount} \times \text{Gas Emission Factor} +
\]
\[
+ \text{Gas CHP / CHP Gas Heat Proportion} \times \text{Gas Emission Factor}
\]

The formula is similar to those used in emission calculations in the ‘Yearly’ tabs apart from conversions to gross calorific values. In ASK-Russia, the conversions have been included in the ‘Scenario’ tabs as well as in the ‘Yearly’ tabs, with the formula changing to:

\[
\text{= Coal Amount} \times \text{Coal Emission Factor} \times (1+\text{Coal Conversion To Gross Calorific Value}) +
\]
\[
+ \text{Coal CHP} \times (1+\text{Coal Conversion To Gross Calorific Value}) / \text{CHP Coal Heat Proportion} \times \text{Coal Emission Factor} +
\]
\[
+ \text{Oil Amount} \times \text{Oil Emission Factor} \times (1+\text{Oil Conversion To Gross Calorific Value}) +
\]
\[
+ \text{Gas Amount} \times \text{Gas Emission Factor} \times (1+\text{Gas Conversion To Gross Calorific Value}) +
\]
\[
+ \text{Gas CHP} \times (1+\text{Gas Conversion To Gross Calorific Value}) / \text{CHP Gas Heat Proportion} \times \text{Gas Emission Factor}
\]

b) Division vs. multiplication:
In the ‘Scenario’ tabs in the original version of the spreadsheet, carbon dioxide emissions from electricity are calculated according to the comment, similar to the one in ‘Yearly’ tabs apart from more generic ‘terms’:
“1. For coal at w% efficiency with transmission and distribution losses at p% all multiplied by the coal emission factor
2. Oil at y% efficiency with transmission and distribution losses at p% all multiplied by the oil emission factor
3. CCGT at t% efficiency with transmission and distribution losses at p% all multiplied by the gas emission factor
4. Biomass co-fired with CCS gives a carbon sink, therefore this is removed from the overall figure”

In accordance with the comment the formula in, for example, cell T6 is:

\[
\begin{align*}
&= \text{Coal Power Stations} / (\text{Coal PS Efficiency} \times \text{Electricity Transmission}) \times \text{Coal Emission Factor} + \\
&\quad + \text{Coal CHP} / \text{CHP Coal Electricity Portion} \times \text{Coal Emission Factor} + \\
&\quad + \text{Gas CCGT} / (\text{Gas CCGT Efficiency} \times \text{Electricity Transmission}) \times \text{Gas Emission Factor} + \\
&\quad + \text{Gas CHP} / \text{CHP Gas Electricity Portion} \times \text{Gas Emission Factor} + \\
&\quad + \text{Coal Co-Fired With Biomass} / (1 - \text{Percentage Biofuel To Coal}) / (\text{Electricity Transmission} \times \text{Efficiency of Co-Fired Biofuel}) \times \text{Coal Emission Factor} - \\
&\quad - \text{Coal BioCCS} \times \text{Percentage Biofuel To Coal} / (\text{Electricity Transmission} \times \text{Efficiency of Coal BioCCS}) \times \text{Biomass Emission Factor}
\end{align*}
\]

It is evident from the formula that the original ASK divides CHP amounts by the electricity portions instead of multiplying. However, in a simple numerical example, if a gas CHP produces 100 ktoe of energy in total and the electricity portion is 45%, then dividing gives ~222 ktoe, which means the electricity portion is twice as high as the total. A calculation where 'Coal Co-Fired with Biomass' is divided by (1 - Percentage Biofuel to Coal) gives similar results. It follows that the formula should contain the product of the two instead, which has been done in ASK-Russia. A revised formula is:

\[
\begin{align*}
&= \text{Coal Power Stations} / (\text{Coal PS Efficiency} \times \text{Electricity Transmission}) \times \text{Coal Emission Factor} + \\
&\quad + \text{Coal CHP} \times \text{CHP Coal Electricity Portion} \times \text{Coal Emission Factor} + \\
&\quad + \text{Gas CCGT} / (\text{Gas CCGT Efficiency} \times \text{Electricity Transmission}) \times \text{Gas Emission Factor} + \\
&\quad + \text{Gas CHP} \times \text{CHP Gas Electricity Portion} \times \text{Gas Emission Factor} + \\
&\quad + \text{Coal Co-Fired With Biomass} \times (1 - \text{Percentage Biofuel To Coal}) / (\text{Electricity Transmission} \times \text{Efficiency of Co-Fired Biofuel}) \times \text{Coal Emission Factor} - \\
\end{align*}
\]
- Coal BioCCS * Percentage Biofuel To Coal / (Electricity Transmission * Efficiency of Coal BioCCS) * Biomass Emission Factor

5.7 Stakeholder engagement in backcasting

5.7.1 The definition of stakeholders

This thesis uses a participative backcasting approach, whereby scenario-generation is aided by stakeholder engagement. As Lonsdale and Goldthorpe (2012, p.2) acknowledge, the term ‘stakeholder’ is problematic, being broad enough to cover anyone affected by climate change. However no narrower and, at the same time, sufficiently inclusive term has been found to describe the interviewees who have contributed to this research project; hence the term ‘stakeholder’ is preferred here to other terms and denotes external contributors, i.e., those recruited outside the research group of the author of this work. The general rationale for involving stakeholders in this thesis is to broaden the knowledge base of the project by drawing on specialist expertise about different parts of the modelled energy system. In particular, stakeholders are to help to ground scenario assumptions and narrow the ranges of input variables, as well as providing a reality check for the scenarios developed. Bryman (2001, p.447) names such a cooperation of methods “multi-strategy research” with qualitative findings facilitating and complementing quantitative analysis.

5.7.2 Interviews vs. alternative methods of stakeholder engagement

In a broad sense, a research interview is “a form of conversation in which the purpose is for the researcher to gather data that address the study’s goals and questions” (Savenye and Robinson, 1996, p.1056). Being flexible but not entirely unguided, semi-structured interviews are deemed appropriate for this thesis as they make the task achievable for an interviewer with little experience. Whilst the project also involves offline electronic interaction, interviewing is preferred to other means of stakeholder participation. This subsection intends to justify why suitable alternative qualitative methods such as questionnaires, focus groups and the Delphi technique are not used in this research.

A questionnaire is a series of written questions to which respondents provide answers (Bell, 1999). The researcher considers questionnaires to be unsuitable for selected expert participants due to potential difficulties with prompting such interviewees to complete an impersonal set of questions. Furthermore, interviews are more directly participative and flexible than questionnaires and can, therefore, be adjusted and individualised depending on the situation, which may help to obtain richer answers from respondents. The flexibility of
semi-structured interviews is yet more important considering that selected stakeholders represent different sectors of the economy and require highly tailored questions.

Collective stakeholder participation methods—such as focus groups, group interviews and workshops—generally involve open questions discussed by ‘interviewees’ in groups (Bryman, 2001, p.110). The researcher has estimated that these methods are more difficult to administer than individual interviews in terms of both expenses and organisation, when engaging elite stakeholders. Given financial and time constraints of the PhD project, collective stakeholder participation methods are not used within this thesis.

The Delphi technique is an established method for involving expert stakeholders. Skulmoski et al. (2007, p.1) defines it as “an iterative process to collect and distil the anonymous judgments of experts using a series of data collection and analysis techniques interspersed with feedback”. As this technique is typically used with experts in one area or industry, there are time and participation constraints on involving a large number of stakeholders from the same sectors. With the Delphi method being iterative, it may prove difficult to convince elite stakeholders to respond to more than one round of the re-circulated feedback.

There are many other qualitative methods of engaging stakeholders, for example, a qualitative research diary (e.g., Bryman, 2001, p.137) and participant observation (ibid, pp.163, 291). However, these methods are intended for collecting the information coming from observing stakeholders’ behaviour, sentence structures and figures of speech, whilst this project is designed to use the direct meaning of stakeholders’ responses. At the same time, participant observation of both visual and audio non-verbal signals has played a role in the interviewing process as part of the researcher’s reflective practice, rather than as a direct input into the backcasting exercise. A reflective diary has been used to ensure the quality of the research and to document the learning path of the researcher.

5.7.3 The process: selecting, recruiting and interviewing stakeholders

For the purposes of this thesis, the stakeholder engagement comprised two stages. The first stage involved semi-structured telephone interviews of industry and policy experts permanently based or spending much of their working time in Russia (see Appendix B for a topic guide), whereas the second stage involved semi-structured in-person interviews of policy experts based in the UK. During the first stage, the intention was to link the categories of key stakeholders to the sectoral disaggregation in the backcasting tool. The first category was to

33 The Delphi study has been applied to backcasting before. See, for instance, M. Hoejer, Transport telematics in urban systems—a backcasting Delphi study, Transportation Research, D3 (6) (1998) 445–463.
include representatives of Russia’s economic sectors: industry, transport, buildings, energy production and agriculture. The second category was to consist of relevant governmental officials from the Ministry of Industry and Trade, Ministry of Transport, Ministry of Economic Development, Ministry of Energy and Ministry of Agriculture. Finally, non-governmental sector representatives were to constitute the third stakeholder category including observers, researchers, NGO employees and activists.

The pilot-stage recruitment process started with an Internet search of industry experts regardless of their interest in energy and carbon reduction issues. Official recruitment emails were sent to thirty-five contacts (see Appendix C for a version of such an email in English), eliciting four email responses, two of which came from the researcher’s own networks. Follow-up emails yielded yet another email response that, however, did not result in an interview as the respondent did not answer further emails, whilst follow-up calls did lead to one interview. Not counting the interviews with the researcher’s former colleagues, only one interview out of five has resulted from the initial recruitment efforts. A number of additional contacts were obtained during the pilot interviews, and this ‘snowballing’ technique was used to increase the recruitment rate during the second stage of stakeholder engagement.

The original intention was to include at least one representative from each sector (and stakeholder category) to ensure a broad coverage of industries and policy issues; however, the initial approach, based on recruiting industry experts with no evident interest in climate change issues, largely failed. This outcome in itself may offer some insight on priorities amongst Russia’s industries. A modified recruitment approach, at the second stage of stakeholder engagement, involved contacting experts already interested in the decarbonisation of Russia, whilst their belonging to a certain industry was a secondary criterion. It should be acknowledged that such selection may have yielded a bias in stakeholder input.

At both stakeholder engagement stages, every interviewee was sent the Information Sheet and the Consent Form in either Russian or English, depending on their language preference. Interview questions and prompts were not sent to a respondent lest they limited the scope of the forthcoming interview. The questions served as guidance for the researcher and were adjusted before and during each interview. Not only was the adjustment based on the respondent’s background, but also on all previous interviews, to incorporate learning and ask further details about moot areas. Interviews were audio-recorded after respondents gave their consent.
Both stakeholder engagement stages were meant to be part of the iterative process moulding the backcast scenarios. The pilot interviews however yielded little information relevant for scenario generation and specific inputs to the ASK-Russia tool. There were two main reasons for their limited value for the scenarios. Firstly, interview questions had been formulated and the interviews conducted before the preliminary scenarios were ready. This was the original intention, with interviews expected to provide input at an early stage, so that the researcher could then use the stakeholder contribution for developing scenarios. However, this strategy proved self-defeating. The topics chosen for the pilot interviews were relatively broad (see Appendix B), albeit tailored to each interviewee’s area of expertise, and failed to provide a sufficient and relevant focus.

Secondly, a different group of stakeholders should have been targeted to maximise the value of stakeholder engagement for the scenario exercise (see chapter 9 for more detail). Consequently, the researcher used interview findings from the pilot interviews for augmenting the general context of the thesis rather than for triangulating the scenarios. At the same time, the pilot questions and prompts were modified to better incorporate the aim of the backcasting exercise to generate contextualised scenarios. The second stage, consisting of in-person expert interviews, thereby provided the main ‘reality check’ for the scenarios as well as adding to the contextual framing of the research.

The experience with stakeholder engagement (the pilot stage, in particular) described in this section provides a number of lessons for designing a more effective research process. First, a more specific, scenario-focused, topic guide is necessary to gain scenario-relevant insights from interviews. Second, a more easily accessible group of stakeholders is likely to yield a larger sample of interviewees. These two ‘lessons’ were implemented during the second stage of stakeholder engagement. In relation to the second ‘lesson’, the researcher deliberately moved away from attempts to employ a ‘representative sampling’ approach towards using a ‘convenience sampling’ approach (Bryman, 2001, pp.323–325). Given limited financial and time resources of the project and its focus on the modelling part of the work, a relatively small sample of interviewees was recruited and interviewed. If project constraints allow, an additional lesson for future research would be to try ‘theoretical sampling’ (ibid.), with the intention to reach theoretical saturation, i.e., a state when the contribution of every additional interview provides marginal insight (Fontana and Frey, 2000; Silverman, 2010). Additionally (and, again, contingent on project resource constraints), engaging stakeholders from early stages onwards would help to incorporate their input as part of designing the research process itself (as opposed to only discussing the results of this process).
5.7.4 The pilot stage: telephone interviews with industry and policy experts

Five pilot interviews were undertaken over the telephone between March and June 2012, as Table 10 details. The interviewees’ professional background varied widely and included buildings-sector researchers, an aviation-sector entrepreneur and policy experts. Four of the respondents were Russian, whilst one was a foreigner with fluent Russian language skills. Three interviews were conducted in English and two in Russian. Predictably, policy experts offered general and overarching insights, suitable for the contextual framing of the thesis, whilst industry experts gave more specific interviews. Both groups provided limited insight for technical and quantitative scenario assumptions.

Table 10. A summary of pilot interviews with industry and policy experts

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Professional background</th>
<th>Respondent’s residence at the time of the interview</th>
<th>Interview date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Buildings-sector researcher</td>
<td>Western Europe</td>
<td>09/03/2012</td>
</tr>
<tr>
<td>2</td>
<td>Aviation-sector entrepreneur</td>
<td>Russia</td>
<td>26/03/2012</td>
</tr>
<tr>
<td>3</td>
<td>Buildings-sector researcher</td>
<td>Eastern/Central Europe</td>
<td>17/04/2012</td>
</tr>
<tr>
<td>4</td>
<td>Policy expert (research/NGO)</td>
<td>Northern Europe</td>
<td>29/05/2012</td>
</tr>
<tr>
<td>5</td>
<td>Policy expert (consulting/business)</td>
<td>Russia</td>
<td>27/06/2012</td>
</tr>
</tbody>
</table>

The researcher has written summaries, rather than verbatim transcripts, of the pilot interviews (see Appendix D for a sample summary). Each interview covered four broad topics (see Appendix B) that directed the ‘flow’ of the interview in the following order: 1) the present situation in the Russian economy and/or interviewee’s sector; 2) past trends in and effects of the financial downturn on the economy and/or interviewee’s sector; 3) a future ‘desired’ state of the energy system in 2020 as an interim target and in 2050 as the end-point target; 4) potential pathways towards the desirable future state of the energy system. This subsection gives examples of findings from the pilot interviews. The reason these are reported here, i.e., in the chapter on research design rather than in the chapters on research results and discussion thereof, is because the pilot interviews have informed the content and structure of the background chapters in this thesis without affecting its main conclusions.

Respondent 4 offered ideas on Russia’s climate and energy legislation, dividing it into two ‘streams’: “either purely climate or something else but synergistic with mitigation” (pers. comm. 29/05/2012). The responded listed the Climate Doctrine, the Climate Action Plan, the Joint Implementation decrees and gas flaring regulations as the first type of legislation. The second type covered the Energy Efficiency Strategy, the Pact on Renewables and a number of other directives. The interviewee added there was also a working group discussing a national emissions trading scheme, although such a scheme in the Russian context appeared, to the
interviewee, unlikely. Whilst respondent 4 was in favour of a carbon tax (ibid.), respondent 2 disagreed and advocated an emissions scheme similar to the EU Emissions Trading System (pers. comm. 26/03/2012).

Respondent 5 complemented this information with their own interpretation of the regulations, noting that the title of the Climate Doctrine does not even contain the word ‘change’, “the Doctrine is about ‘climate’ not ‘climate change’” (pers. comm. 27/06/2012). The respondent also pointed to the order of tasks set out in the Doctrine and the Energy Efficiency Strategy stating that, “action is not among the first priorities at all” (ibid., italics based on the respondent’s stressing the word). The same interview offered an idea for a scenario storyline, anticipating that the country will be compelled to act, because “fossil fuels will soon become unexportable” (ibid.).

Respondent 5 argued that, “regions [i.e., provincial areas in Russia] are busy surviving, they are not worried about climate change at all” (pers. comm. 27/06/2012). This statement was partly corroborated by the unresponsiveness of Russia-based contacts outside Moscow and St. Petersburg. Even when they were willing to help, such potential interviewees confessed they had little knowledge of decarbonisation in either their industry specifically or in Russia generally. It should be acknowledged that the dearth of respondents from the rest of the country biases the results towards opinions concentrated in the most affluent part of Russia. All five interviewees spoke about a general limited interest in decarbonisation and the widespread ignorance of climate change within government circles. In general, the content of responses was similar to a range of published reports and legal documents. The nature of causality was, however, debatable; in particular, it was unclear whether the interviews independently confirmed those documents, which would be valuable for triangulation, or rather drew on them consciously or otherwise (being familiar with them).

5.7.5 The second stage: in-person interviews with policy experts

The second stage of the stakeholder engagement process consisted of four face-to-face interviews and involved policy experts rather than industry representatives and governmental officials. The majority of potential interviewees identified for the second stage recruitment focused on Russia’s fossil fuel industry and the EU-Russia energy security issues. These two broad issues are clearly of most relevance to UK-based experts on Russia (compared to other subject matters, for example, Russia’s transport, agriculture, etc.). With their expertise spanning from economic geography to technology and innovation to ‘Weak State’ environments, the breadth of the expertise was deemed sufficient for providing valuable
insights to this project, as politico-economic and governance issues cover much of the relevant context. As Table 11 shows, two experts were part of the ‘younger’ generation socialised in their discipline during Russia’s modern history, i.e., in the past 10–20 years. The other two interviewees belonged to a more ‘senior’ generation with much of their expertise developed during the existence of the Soviet Union. It was hoped that this difference would further diversify the interviewees’ responses.

Table 11. A summary of in-person interviews with policy experts

<table>
<thead>
<tr>
<th>Expert</th>
<th>Expertise</th>
<th>Expertise developed during...</th>
<th>Interview date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Technology and innovation</td>
<td>...Russia’s modern history</td>
<td>23/04/2013</td>
</tr>
<tr>
<td>2</td>
<td>Political economy</td>
<td>...Russia’s modern history</td>
<td>09/05/2013</td>
</tr>
<tr>
<td>3</td>
<td>Economic geography</td>
<td>...the Soviet times</td>
<td>21/05/2013</td>
</tr>
<tr>
<td>4</td>
<td>Natural-gas markets</td>
<td>...the Soviet times</td>
<td>13/06/2013</td>
</tr>
</tbody>
</table>

The interview techniques slightly varied each time in terms of adhering to the questions and prompts or following the interviewee when an interesting and relevant digression emerged. Fontana and Frey (2000, p.86) describe the use of different interview techniques as “tactics” facilitating a flexible conversation and a more diverse interview output. Despite the flexibility, the interviews did not take the form of an informal conversation, and respondents themselves asked no questions until prompted. The questions and prompts were adjusted in parallel with developing the ASK-Russia tool, with results from each subsequent interview feeding, in turn, into the final scenario storyline or the context of the thesis.

Reflecting the research objective of this thesis, two topic groups of different scope were identified to be discussed during in-person interviews. The first topic group had a narrow focus on presentation and framing, consistency and feasibility of the scenarios. The second topic group had a broad focus on (both existing and potential) decarbonisation triggers and Russia’s socio-political context. Although each interview started with the first topic group (in particular, the presentation of scenarios), the two groups were not discussed sequentially or in a linear fashion. For example, questions about consistency and feasibility of the scenarios led to the discussion of more complex issues related to the Russian context and potential triggers for decarbonisation. The scenario summaries and interview questions were slightly updated after each interview to incorporate salient comments from previous interviews (see Appendix E for a version of scenario summaries used for the in-person interviews).

One of the main criteria for interview material to be reported as findings is its relevance to the research questions. Further conditions are whether it confirms or contradicts information
obtained in the literature or other interviews, and whether it provides new and unexpected insights. For the purposes of this chapter, the initial idea was to report findings from the in-person interviews following the UKCIP’s five “dimensions of change” (UKCIP, 2000, p.18) including economics, demography, technology, governance and values. However, the very first interview demonstrated that these categories were too simplistic to accommodate rich data provided by the experts, which was confirmed throughout the course of the fieldwork. Based on audio records of the in-person interviews and on the researcher's accompanying notes, it became evident that they contained valuable but unsystematic information, often characteristic of semi-structured interviews. Consequently, the researcher took a decision to transcribe the in-person interviews (see Appendix F for a sample transcript) and conduct a simplified version of thematic analysis, in order to analyse and report the findings.

5.7.6 Thematic analysis

Thematic analysis, in its current form, was developed by researchers in the field of psychology (see, for instance, Smith and Osborn, 2003) and is widely used as a qualitative method for analysing rich and often unstructured data for commonly occurring themes. The method is broadly defined as “a method for identifying, analysing and reporting patterns (themes) within data” (Braun and Clarke, 2006, p.79). There are no hard and fast rules as to how thematic analysis should be conducted, although a typical analysis usually includes the following six stages: transcribing and reading the data, generating initial codes, searching for themes, reviewing themes, naming themes and producing an analytical report (ibid., p.87). Just as the backcasting approach, the process of thematic analysis is iterative rather than linear. The main results of the thematic analysis undertaken within this thesis are reported in chapter 9 and further discussed in chapter 10.

5.7.7 An analytical and reflective lens for stakeholder engagement

Prior to and during the stakeholder engagement process, the researcher considered issues of anonymity and confidentiality, the interview method, recording, transcribing, as well as translating, the analysis method and the interviewer’s personality.

Anonymity and confidentiality are two main ethics considerations pertinent to the interviews conducted within this study. In terms of its influence on the framing, anonymity affects the way the results are reported and interpreted; for example, no respondent’s background, that can identify them, is revealed within this thesis to protect their anonymity. Similarly, confidentiality precludes the publication of full transcripts and audio records. Whilst these two considerations, at least in theory, help interviewees to give more detailed and genuine answers,
the recording process itself may make them feel more restricted than when talking off record.

The transcription method also affects the interpretation of the interview results. In this study, the researcher wrote summaries for the pilot interviews (see Appendix D for a sample summary) and verbatim transcripts for the second stage of expert interviews (see Appendix F for a sample transcript). Although some valuable insights from the pilot interviews may have been lost, the limited timeframe of the project did not allow for a more detailed transcription, as their input in the scenarios was less useful than that of the in-person interviews.

A semi-structured approach to interviewing yields a large amount of chiefly unstructured information, which influences the choice of an analytical framework. For example, qualitative rather than numerical methods are more appropriate for analysing such interview outputs. For the purposes of this thesis the interview material is mainly used to inform scenario-related context, assumptions and results. In so doing, the researcher adopts a “pure empiricist” (Silverman, 2010, p.133) approach “uninterested in the theoretical bases of research design” (ibid.). In other words, the researcher draws on the content of the stakeholder input in a ‘functional’ way, as opposed to seeking to uncover additional layers of meanings and interpretations and to explain those through a particular theoretical framework.

The interview material gathered for this thesis can be analysed deductively or inductively. In the first case the data are generalised and categorised early on, whilst in the second case generalisations are suspended until further clues and data emerge. A deductive approach is more consistent with the substance of this thesis for three reasons. First, the research questions had been defined before the interviews were analysed and even conducted. Second, the research questions are not ‘blue-skies’ but were shaped by an existing practical issue, namely climate change mitigation issues in Russia. Third, the researcher, being Russian and regularly keeping up to date with Russian reports, news and interpretations thereof, had a priori expectations of certain general patterns to transpire in the interviews.

There is a degree of personal influence of the interviewer on the answers elicited from interviewees. This is to be expected, as the interviewer/researcher is not just an invisible tool aiming to obtain purely ‘objective’ knowledge during an interview. Hence, the concept of the “interview as a negotiated accomplishment” (Fontana and Frey, 2000, p.91) appears befitting the stakeholder engagement experience described in this thesis. In this sense, the interviews were intentionally flexible and reflective, despite being later analysed in a functional, empiricist way.
An additional layer of the author’s subjectivity comes from translating the main themes and quotes from the interviews into English. To account for potential inaccuracies, different versions of the translation could be supplied if they affected the interpretation, although this particular issue did not arise in relation to the interviews conducted for this project.

5.8 Research design

This section brings together the different methods and research instruments discussed in this chapter, with Figure 7 presenting a stylised diagram of the research design, i.e., a snapshot of the complex and multi-dimensional process of the research conducted within this thesis. The methods used in this study are grouped into two overarching categories of secondary and primary research. The secondary research strand includes analysis of statistical data, a theoretical critique of backcasting in application to climate change and the analysis of pertinent policies and related context, feeding into the ASK-Russia scenario generator and the backcast scenarios. The main source of primary data is a series of semi-structured interviews subjected to a simplified thematic analysis that informed both the context of the study and the backcast scenarios. Key results of the thematic analysis and outputs of the scenario exercise are combined to inform suggestions for decarbonising Russia’s energy system and associated policy insights. Only one instance of iteration is shown in Figure 7—between the secondary and primary strands of research—although the entire research process was recursive and non-linear (see some examples in chapter 9).

Figure 7. The research design: the relevant methods and relationships between them as applied in this thesis
5.9 Conclusion

As part of the global climate change negotiations, various national and supra-national authorities, including Russia, have repeatedly affirmed the commitment to the 2°C target (as chapter 4 showed). However, the majority of existing and planned policies are based on long-term emission targets in a particular year, as opposed to cumulative emission budgets. The thesis views climate change as a very specific problem, distinct from other environmental and social challenges, in its simultaneous characteristics of urgency, uncertainty, scale and irreversibility (or lock-in). This chapter highlights the importance of cumulative emissions for understanding the chronology of mitigation. With a range of emission pathways and interim targets facilitating mitigation action in the short term, backcasting is pitched as an approach to strategic planning particularly relevant for the purposes of this thesis.

In many countries, and Russia is no exception, annual end-point targets have come to dominate the climate change policy arena. However, having little direct correlation with the global temperature increase, they may result in misleading policy action; hence, the combination of backcasting and cumulative emission budgets is an important step towards science-based climate and energy policy. Greenhouse gases typically accumulate in the atmosphere over decades and centuries. Backcasts are able to accommodate this cumulative aspect of climate change in the strategic objective and ensure it permeates throughout backcasts through the ongoing iteration process. The backcasting ‘algorithm’ set out in the literature and summarised in this chapter underlies the research design of the thesis and provides a structure for the subsequent chapters.

Within the backcasting approach, the chapter elaborates on the stakeholder engagement process undertaken by the researcher, including the stages of selecting, recruiting and interviewing stakeholders for both the pilot stage (telephone interviews) and the second stage (in-person interviews). The ASK-Russia scenario generator outlined in this chapter is as an ‘explanatory’ and ‘explorative’ tool essential for the backcasting exercise. The next four chapters cover the six stages of backcasting implemented in this thesis, starting with chapter 6 on the strategic objective of the scenario exercise.
PART 3: RESULTS OF THE
SCENARIO EXERCISE
6 Chapter 6: The strategic objective: Russia’s carbon emission budgets

6.1 Introduction

The first stage of backcasting requires an overarching objective, placing a constraint on results of the scenario exercise. Chapter 4 has made the first step towards formulating such an objective within the framework of this thesis, by explaining the reasoning behind 2°C as a global climate change target. The question is now how 2°C can be translated into national emission target/s and, subsequently, into specific changes that the national energy system would need to undergo in order to achieve the target/s. For such national targets to be science-based and retain the link to global climate change, they use cumulative emission budgets. If the atmosphere is regarded as a global commons, the process of emitting greenhouse gases may be likened to drawing on a finite resource. This thesis focuses on energy-related carbon dioxide only, therefore this gas is assigned the role of a ‘finite resource’, with each country’s emissions contributing to the depletion of the ‘resource’ and thereby spending a global cumulative emission budget.

To make a global temperature target meaningful in the national context, this chapter derives a range of cumulative emission budgets for Russia, focusing on two calculations methods. Both methods start with choosing and justifying a global temperature target (see Chapter 4 for a detailed account). The first method then establishes a probability, or range thereof, with which this global temperature target should not be exceeded and a global cumulative emission budget compatible with the chosen probability. Allocating a global budget amongst countries and regions is the next step, which involves a comparative analysis of different fairness principles and corresponding allocation parameters. Finally, each country’s cumulative budget share is calculated based on the chosen principles and parameters. Emission pathways can then be generated, with the emission budgets as a constraint. For comparison, the second calculation method relies on, first, generating future emission pathways of a particular country replicating other nations’ pathways within an ‘allowed’ cumulative budget. These emission pathways are then used to calculate cumulative budgets for that particular country. For example, emission peak dates and reduction rates for Annex 1 countries to stay within a cumulative budget, compatible with staying under 2°C global temperature increase, can be applied to Russia’s annual emissions in a chosen baseline year out to 2050. The resulting annual emissions are then summed to obtain Russia’s 2013–2050 cumulative budget.

34 Thereafter used interchangeably with ‘emissions’.
The chapter starts with a discussion on what probability of staying below a global 2°C target is appropriate in the Russian context (section 6.2), followed by the justification of a corresponding Annex 1 emission budget range (section 6.3). Sections 6.4, 6.5 and 6.6 then consider equity principles and allocation parameters for determining Russia’s share in the cumulative budgets of Annex 1. Existing literature on Russia’s cumulative emissions is reviewed next (section 6.7), followed by alternative emission budget calculations (section 6.8). Section 6.9 discusses a timeframe for the backcast scenarios, and the subsequent section concludes.

6.2 Climate change probabilities and targets

Governmental climate-related documents are an obvious source of a carbon constraint for national emission pathways, with additional guidance provided by international climate change agreements. Russia’s Climate Doctrine (2009) and Climate Action Plan (2011) fail to mention either temperature or emission targets the country could aim to comply with. Russia’s pledge to ‘reduce’ emissions by 15–25% relative to 1990 by 2020 means an increase in actual emissions with respect to the current level. Given the Russian government has not explicitly incorporated an ambitious quantitative framing of climate change in its domestic legislation or guidelines, it is necessary to review its international commitments, if any. Here, Russia, along with many other of the world’s leading nations, has made a direct, explicit and quantitative obligation associated with the 2°C threshold. Moreover, it has repeated this commitment on several occasions since subscribing to it for the first time in 2009. For the purpose of this thesis, the Russian government’s commitment to this quantitative framing of climate change is taken at face value and in good faith. The following analysis therefore builds on Russia’s commitment first formulated in the Copenhagen Accord:

“We agree that deep cuts in global emissions are required according to science, and as documented by the IPCC Fourth Assessment Report with a view to reduce global emissions so as to hold the increase in global temperature below 2 degrees Celsius, and take action to meet this objective consistent with science and on the basis of equity.” (UNFCCC, 2009, p.5, emphasis added).

The official documents of the subsequent Conference of the Parties in Cancun reiterate the aim to “establish clear objectives for reducing human-generated greenhouse gas emissions over time to keep the global average temperature rise below two degrees” (UNFCCC, 2011). Although neither the Copenhagen Accord not the Cancun Agreements are legally binding, the latter are full-fledged decisions of the Conference of the Parties (Werksman, 2010), which goes some way to restoring confidence in the multilateral negotiations. More recently, the 2°C
commitment has been re-confirmed in the G-8 Camp David Declaration, with Russia being one of the signatories:

“We agree to continue our efforts to address climate change and recognize the need for increased mitigation ambition in the period to 2020, with a view to doing our part to limit effectively the increase in global temperature below 2ºC above pre-industrial levels, consistent with science.” (Group of Eight, 2012, §13, emphasis added)

Building on the approach developed by Tyndall Centre Manchester (Anderson et al., 2009; Anderson and Bows, 2011), the language of these statements can be reasonably interpreted as a resolution to ensure a very low chance of exceeding the 2ºC threshold. If the IPCC likelihood terminology (see Table 12 below) is applied to translating the qualitative commitment into a quantitative probability, where ‘very unlikely’ means <10% probability and ‘exceptionally unlikely’ means <1% probability, it is appropriate to conclude that the Copenhagen commitment implies at least a ‘very unlikely’ chance of exceeding 2ºC. Some analyses, however, suggest that keeping the temperature rise below 2ºC is virtually unachievable and increasingly so given the recent global emission trends (New et al., 2011).

**Table 12. A likelihood scale for the IPCC Fifth Assessment Report (Mastrandrea et al., 2010, Table 1, p.3)**

<table>
<thead>
<tr>
<th>Term</th>
<th>Likelihood of the Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtually certain</td>
<td>99-100% probability</td>
</tr>
<tr>
<td>Very likely</td>
<td>90-100% probability</td>
</tr>
<tr>
<td>Likely</td>
<td>66-100% probability</td>
</tr>
<tr>
<td>About as likely as not</td>
<td>33 to 66% probability</td>
</tr>
<tr>
<td>Unlikely</td>
<td>0-33% probability</td>
</tr>
<tr>
<td>Very unlikely</td>
<td>0-10% probability</td>
</tr>
<tr>
<td>Exceptionally unlikely</td>
<td>0-1% probability</td>
</tr>
</tbody>
</table>

### 6.3 Annex 1 emission budget range

Literature gives a range of global cumulative budgets consistent with a relatively low probability of staying under 2 degrees Celsius, in line with the IPCC likelihood terminology. For example, Meinshausen et al. (2009, p.1161) suggest a 2000–2049 carbon budget of 886 GtCO₂ with a probability range 8–37%. A 360 GtC (1,321 GtCO₂) 21st century budget is discussed by Macintosh (2010, p.2968) in the context of potentially stronger and earlier carbon cycle feedbacks.

This thesis draws on Anderson and Bows (2011) who use Macintosh’s calculations to explore the share of Annex 1 countries in the global carbon dioxide budget. The CO₂-plus budgetary
regime is applied where global deforestation emissions and historical, i.e., pre-2000 emissions, are considered “a global overhead” (Anderson and Bows, 2011, p.29). They are subtracted from a global budget before it is allocated between Annex 1 and non-Annex 1 countries, with Russia being included in the former. Despite the economic collapse in the 1990s, Russia is still a relatively industrialised country, a major emitter of greenhouse gases and a global supplier of fossil fuels. It has the capacity to influence the global emission budget both through national and international policies; hence, it is reasonable to still consider Russia as part of the Annex 1 group and apply a corresponding budget constraint.

Table 1 in Anderson and Bows (2011, p.35) summarises the main aspects of scenarios and cumulative budgets explored in their study. For the purposes of this thesis, scenarios C+2 and C+6 can be discarded immediately because they fail to stay within the allocated budget range. Given recent emission trends (Peters et al., 2012b, p.2), the scenarios where non-Annex 1 countries peak in 2020 can be treated as overly optimistic, which eliminates scenarios C+1 and C+4, leaving C+3 and C+5 to provide lower and upper boundaries of a budget range. A range of Annex 1 budgets, rather than a single budget, helps to account for uncertainties in climate-carbon cycle feedbacks and provide flexibility for scenarios. C+3 gives 313 GtCO₂ to Annex 1 countries with a 37% probability of exceeding 2°C (with 742 GtCO₂ remaining for non-Annex 1 nations), whilst a C+5 Annex 1 budget totals 363 GtCO₂ with a 52% probability of exceeding 2°C (with 949 GtCO₂ for non-Annex 1). In these two scenarios, Annex 1 nations do not fully decarbonise by the middle of the century. Instead, they reduce carbon emissions by 98% in the first case and by 95% in the second case by 2050 relative to 1990.

6.4 Emission budget apportionment based on equity principles

The next step is to calculate Russia’s share of the chosen Annex 1 budget range. There have been more than a dozen different apportionment regimes suggested over the last decade based on, for example, historical responsibility, equity, or a basket of greenhouse gases. By far, the ‘Contraction & Convergence’ approach has been the most widely used in studies on emission modelling and scenarios. Theoretically, the ‘Contraction & Convergence’ approach has a number of advantages; however, a remaining global cumulative emission budget, compatible with the 2°C temperature increase above pre-industrial levels, in fact leaves little to apportion amongst nations. For example, Annex 1 countries are already “in emission debt”, if their 20th-century emissions are considered in an egalitarian apportionment regime (Anderson and Bows, 2011, p.29).

35 In application to cumulative emissions, this thesis uses terms ‘allocation’, ‘apportionment’ and ‘burden sharing’ interchangeably.
The discussion on emission burden sharing between countries and regions can be approached in two different ways. Deductively, it starts with general fairness (or, equity) principles and proceeds to more specific allocation parameters to be operationalised in the ‘real world’. Inductively, the first consideration is how the apportionment can be achieved in practice, which involves the analysis of precedents and empirical data, followed by the identification of patterns to form a high-level theory. In accordance with its policy-oriented and pragmatic stance, this thesis adopts a deductive approach, with equity principles being a starting point of the argument. Climate change is expected to negatively affect livelihoods in poorer parts of the world, thereby aggravating existing income inequalities. Informing climate mitigation action by equity considerations may help to avoid political conflict and facilitate social cohesion.

As Winkler et al. (2002) point out, even amongst industrialising countries with similar levels of development various burden sharing principles are more favourable for some and less so for other nations. Likewise, Annex 1 countries would benefit differently depending on the emission apportionment, which is ultimately a zero-sum game. Country-wise differences are compounded by the way equity principles are applied. For example, one of the early comprehensive studies on climate justice distinguishes between allocation-, outcome- and process-oriented implementation of the principles (Rose et al., 1998, p.29). More recent research highlights deontological and welfarist approaches based on whether consequences of an allocation are taken into account (Mattoo and Subramanian, 2012, p.1084).

Table 13 summarises the equity principles used in this thesis, drawing on allocation-based implementation parameters from Rose et al. (1998). The other two groups of parameters are not considered for two main reasons. Firstly, the three outcome-based and the first of the process-based criteria require modelling of potential welfare losses and, hence, are relatively speculative. This reasoning is supported by, for example, Jansen et al. (2001, p.7) who state that the allocation-based implementation has the advantage of relying, in large part, on measurable data. Secondly, the remaining final process-based criteria depend on premises not borne out by empirical evidence: “the international negotiations process is fair” and “the market is fair” (Rose et al., 1998, p.30). In their review of Rose et al.’s work, Ringius et al. (1999) add the polluter-pays principle that is also included here as an important equity consideration. The final column of Table 13 details specific budget allocation parameters used in this chapter to facilitate the translation of equity principles into operational emission apportionment algorithms.
Table 13. Equity principles, their interpretation and specific cumulative emission budget allocation parameters applied in this thesis (adopted from Rose et al., 1998, p.30; Ringius et al., 1999, p.10)

<table>
<thead>
<tr>
<th>Equity principle</th>
<th>Alternative name (if available)</th>
<th>General interpretation</th>
<th>Specific budget allocation parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egalitarian</td>
<td>Equal-per-capita</td>
<td>Every individual has an equal right to pollute or to be protected from pollution</td>
<td>Population in a particular year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cumulative population over a number of years</td>
</tr>
<tr>
<td>Sovereignty</td>
<td>Grandfathering principle</td>
<td>All nations have an equal right to pollute or to be protected from pollution; current level of emissions constitutes a status quo right</td>
<td>Per capita annual CO₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total annual CO₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per capita cumulative CO₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total cumulative CO₂</td>
</tr>
<tr>
<td>Ability-to-pay²</td>
<td>Principle of capacity</td>
<td>The greater the current ability to pay the greater the mitigation effort</td>
<td>Per capita gross national income</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total gross national income</td>
</tr>
<tr>
<td>Polluter-pays²</td>
<td>Principle of guilt</td>
<td>The economic burden is proportional to emissions (eventually including historical emissions)</td>
<td>Per capita annual CO₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total annual CO₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per capita cumulative CO₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total cumulative CO₂</td>
</tr>
</tbody>
</table>

Notes: a The budget apportionment is proportional to a budget allocation parameter. 
  b The budget apportionment is inversely proportional to a budget allocation parameter.

There are two points worth highlighting when calculating the emission apportionments based on the four equity principles. The first point relates to per-capita budget allocation parameters that are only considered for three principles out of four. To obtain a per-capita parameter, total budget allocation parameters, such as gross national income (GNI), annual emissions and cumulative emissions, are divided by population, which would be meaningless for the egalitarian principle (as a per-capita indicator in this case would need population to be divided by, again, population). The second point is relevant for the ability-to-pay and polluter-pays principles, where apportionment calculations involve extra steps to account for their ‘inverse’ nature. For these principles, the allocated budget share is inversely proportional to a budget allocation parameter.

A sample allocation algorithm for the per-capita basis sovereignty principle with 2000 as a baseline year is explained below:

Step 1: For each country in Annex 1, divide its annual CO₂ emissions in 2000 by its 2000 population.
Step 2: Sum up all emissions per capita from Step 1. E.g., it is 364.5 tCO₂ per person for Russia in 2000. A resulting number is meaningless on its own, but is a necessary step for further calculations.
Step 3: Calculate each country’s share in the output of Step 2. E.g., it is about 2.8% for Russia, which is the share of the Annex 1 emission budget Russia is eligible for. The sum of all shares adds up to 100% by definition.

Step 4: Multiply the output of Step 3, e.g., 2.8% for Russia, by the total Annex 1 budget range consistent with a reasonable probability of staying below 2°C.

To calculate an inverse principle, for example, the per-capita polluter-pays allocation with 2000 as a baseline year, two more steps are necessary after Step 3 above:

Step 4: Divide 1 by the output of Step 3 to calculate the ‘inverse emissions per capita’ value for each Annex 1 country. For example, it equals 36.3 for Russia and, again, cannot be interpreted directly but is necessary for calculating relative per-capita emissions.

Step 5: Sum up all ‘inverse emissions per capita’ values from Step 4. Again, the resulting number is only used as an interim calculation.

Step 6: Calculate each country’s share in the output of Step 5, which will give a nation’s slice of the emission budget inversely proportional to the nation’s per capita emissions. E.g., it is 1.7% for Russia.

Step 7: Multiply the output of Step 6 by the total Annex 1 cumulative budget range.

Following these allocation algorithms, cumulative emissions apportioned to Russia have been calculated on the basis of various allocation parameters, with 2000 as a baseline year (Table 14). Columns ‘Min’ and ‘Max’ correspond to the budgets with a 37% and 52% probability of exceeding 2°C respectively. For instance, Russia’s 21st century budget range as a result of the egalitarian distribution is around 10.2–11.8 GtC (37.3–43.2 GtCO₂), as shown in columns two and three. To calculate the share of the budget Russia has used up since 2000, the UNFCCC historical emissions data for 2000–2010 are summed up after the international aviation and shipping data are added for the same period36. Russia’s cumulative carbon dioxide emissions over 2000–2010, including international bunker emissions, total about 4.6 GtC (16.8 GtCO₂), which, deducted from Russia’s 21st century carbon budget, gives a range of 5.5–7.1 GtC (20.2–26.1 GtCO₂) to emit for the rest of the century. If the annual emission rate stays similar to that in the 2000s, the country will spend its remaining budget by 2021–2024. If Russia’s remaining carbon budget is to last until the middle of the century, its average annual emission rate should be about 3.5 times lower than it was over 2000–2010.

36 International bunker emissions have constituted 0.5–0.6% of Russia’s total annual CO₂ emissions over the past two decades.
The egalitarian principle calculations leave some room for Russia to continue emitting in the current decade. The remaining emission budget range for 2011–2050 is also positive for the total annual CO$_2$ sovereignty principle and the GNI-per-capita ability-to-pay principle. The other four budget allocation parameters result in a negative budget implying that Russia spent its 21st century budget allocation between 1990 and 2011 and is already in a cumulative emission ‘debt’.

Table 14. Cumulative carbon emission budget ranges for Russia based on four equity principles with 2000 as a baseline year (own calculations based on Anderson and Bows (2011, table 1, p.35), the World Bank Databank and the UNFCCC Online GHG Emissions Database)

<table>
<thead>
<tr>
<th>Equity principle</th>
<th>21st c. emission budget range, GtC (GtCO$_2$)</th>
<th>Remaining emission budget range for 2011–2050, GtC (GtCO$_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Egalitarian</td>
<td>10.2 (37.1)</td>
<td>11.8 (43.1)</td>
</tr>
<tr>
<td>Sovereignty: annual CO$_2$ per capita</td>
<td>2.4 (8.6)</td>
<td>2.7 (10.0)</td>
</tr>
<tr>
<td>Sovereignty: total annual CO$_2$</td>
<td>8.7 (31.8)</td>
<td>10.1 (36.9)</td>
</tr>
<tr>
<td>Ability-to-pay: GNI per capita</td>
<td>6.4 (23.6)</td>
<td>7.5 (27.3)</td>
</tr>
<tr>
<td>Ability-to-pay: total GNI</td>
<td>0.2 (0.6)</td>
<td>0.2 (0.7)</td>
</tr>
<tr>
<td>Polluter-pays: annual CO$_2$ per capita</td>
<td>1.5 (5.4)</td>
<td>1.7 (6.3)</td>
</tr>
<tr>
<td>Polluter-pays: total annual CO$_2$</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

6.5 Variation in the equity-principle-based emission budgets

Whilst the calculations in Table 14 are for 2000, it is by no means straightforward to substantiate the reasoning behind the choice of a baseline year. One approach is to select a year deemed ‘representative’ of a country’s typical socio-economic situation. In Russia’s case, such ‘typical’ conditions are challenging to identify due to dramatic changes its economy underwent in the past. Experts define 1999–2006 as a period of relative stability in Russia with a reference to high global oil prices, the weak rouble and some political steadiness (Skorobogatov, 2006; Ekman, 2009, p.19). *Ceteris paribus*, this makes 2000 a reasonable baseline year, considering that it is also the starting point of the 21st century carbon budget.

For comparison, Table 15 provides emission allocations with 1990 and 2010 as baseline years, when the earliest and the latest data are available for most allocation parameters. As regards 1990, although ‘Annex 1 nations’ as a concept had not officially existed before the UNFCCC was adopted in 1992 and was about half its 2010 size (in terms of the number of nations) until 1998, it is assumed as a nominal grouping for the 1990 baseline calculations. The calculations underlying Table 15 show that, regardless of the baseline year, Russia’s remaining 21st-century...
cumulative emission allowance is negative, unless the country’s share in Annex 1’s 313–363 GtCO\(_2\) budget range exceeds 5.4–4.7\% (not shown in the table below).

Table 15. Shares of Annex 1’s 21st century carbon budget allocated to Russia with 1990, 2000 and 2010 as a baseline year (own calculations based on Anderson and Bows (2011, table 1, p.35), the World Bank Databank and the UNFCCC Online GHG Emissions Database)

<table>
<thead>
<tr>
<th>Equity principle and allocation parameter</th>
<th>1990 baseline</th>
<th>2000 baseline</th>
<th>2010 baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egalitarian</td>
<td>12.6%</td>
<td>11.9%</td>
<td>11.1%</td>
</tr>
<tr>
<td>Sovereignty: annual CO(_2) per capita</td>
<td>4.0%</td>
<td>2.8%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Sovereignty: total annual CO(_2)</td>
<td>16.7%</td>
<td>10.2%</td>
<td>11.3%</td>
</tr>
<tr>
<td>Ability-to-pay: GNI per capita</td>
<td>5.4%</td>
<td>7.5%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Ability-to-pay: total GNI</td>
<td>0.1%</td>
<td>0.2%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Polluter-pays: annual CO(_2) per capita</td>
<td>1.2%</td>
<td>1.7%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Polluter-pays: total annual CO(_2)</td>
<td>0.002%</td>
<td>0.004%</td>
<td>0.003%</td>
</tr>
</tbody>
</table>

Note: The polluter-pays (by total annual CO\(_2\)) result is low due to the economic collapse in the 1990s.

Given that carbon dioxide is a long-lived greenhouse gas and will continue affecting the climate long after it was produced (Archer and Brovkin, 2008; Archer et al., 2009), cumulative emissions may potentially serve as a basis for emission apportionment. Similar to other budget allocation parameters, the choice of a baseline needs to be justified. In particular, a period over which the accumulated emissions are taken into account may include the last few decades, the 20th century, or even since the industrial revolution. The further into the past, the higher data measurement uncertainty would be manifest. Moreover, country borders changing over time create additional difficulties for the territorial apportionment of emissions. Russia as an independent state, with its current borders, emerged in the early 1990s, which explains 1990 as the starting point for the historical cumulative emissions in Table 16. The 1990–2000 baseline covers Russia’s past emissions up to the beginning of the 21st century carbon budget, whereas the third column extends the baseline period to include the latest available emission data.

Table 16. Russia’s shares of Annex 1 21st century carbon budget with 1990–2000 and 1990–2010 as a baseline period for cumulative emissions allocation parameters (own calculations based on Anderson and Bows (2011, table 1, p.35), the World Bank Databank and the UNFCCC Online GHG Emissions Database)

<table>
<thead>
<tr>
<th>Equity principle and allocation parameter</th>
<th>1990–2000 baseline</th>
<th>1990–2010 baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sovereignty: cumulative CO(_2) per capita</td>
<td>3.1%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Sovereignty: total cumulative CO(_2)</td>
<td>12.3%</td>
<td>11.5%</td>
</tr>
<tr>
<td>Polluter-pays: cumulative CO(_2) per capita</td>
<td>1.6%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Polluter-pays: total cumulative CO(_2)</td>
<td>0.0038%</td>
<td>0.0039%</td>
</tr>
</tbody>
</table>

It is evident that Russia’s slice of a cumulative emission pie varies depending on an equity principle and a baseline year (Table 15 and Table 16). The variation in budget shares helps to identify relatively stable and ‘representative’ allocation parameters. With climate change being a long-term process unfolding over decades, low volatility is essential to ensure the
apportioned budget stays relevant in the future. The deviations of the 2000- and 2010-based budget shares from the 1990 one are summarised in Table 17. Total GNI is by far the most variable allocation parameter, followed by GNI- and CO$_2$-per-capita. The egalitarian principle is relatively stable, which is intuitively clear from corresponding historical data. Overall, the 2010-based allocation results are slightly closer to 1990 than the 2000 results are, except for the egalitarian principle. As to the 1990–2000 and 1990–2010 cumulative baselines, they are compared to each other (rather than to 1990) and not included in the table. The variation amongst the cumulative emission-based allocation parameters is relatively low, falling between -6.6% and 3.3%.

Table 17. Variation in the size of Russia’s carbon budget for the four equity principles calculated with 1990, 2000 and 2010 as a baseline year (own calculations based on Anderson and Bows (2011, table 1, p.35), the World Bank Databank and the UNFCCC Online GHG Emissions Database)

<table>
<thead>
<tr>
<th>Equity principle</th>
<th>Variation in the budget size relative to the 1990-based shares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egalitarian</td>
<td>2000</td>
</tr>
<tr>
<td>Sovereignty: annual CO$_2$ per capita</td>
<td>-30.8%</td>
</tr>
<tr>
<td>Sovereignty: total annual CO$_2$</td>
<td>-38.9%</td>
</tr>
<tr>
<td>Ability-to-pay: GNI per capita</td>
<td>40.9%</td>
</tr>
<tr>
<td>Ability-to-pay: total GNI</td>
<td>73.5%</td>
</tr>
<tr>
<td>Polluter-pays: annual CO$_2$ per capita</td>
<td>47.4%</td>
</tr>
<tr>
<td>Polluter-pays: total annual CO$_2$</td>
<td>83.1%</td>
</tr>
</tbody>
</table>

6.6 The egalitarian equity principle: justification and caveats

From the methodological viewpoint, a low sensitivity to assumptions is an important consideration for scenario work. Whereas population is not the only parameter that has proven relatively resilient to changes in Russia’s economy and energy system since 1990, it has additional advantages over the cumulative emissions and total annual CO$_2$ parameters. From the ethical perspective, the egalitarian principle emphasises each citizen’s right to and responsibility for emitting greenhouse gases; therefore, after a budget is allocated, a growing population will see a diminishing national per capita budget. Importantly, from the political perspective, a survey of COP-15 participants by Hjerpe et al. (2011) indicates that a per-capita allocation of emission mitigation efforts is one of the four principles with wider support by the respondents. It is unclear whether the wider support is due to a relative transparency or the ethical appeal of the per-capita allocation method.

Another parameter assumed to be reflective of welfare and equity is a gross national income (GNI). Although a carbon budget proportional to a total or per capita GNI may partly
capture the level of development, this indicator is generally a poor measure of well-being (Daly and Cobb, 1990, pp.62–69) and, hence, the fairness of the ability-to-pay budget allocation is questionable. In addition, to sustain the credibility of a scenario tool, a less volatile indicator needs to underlie the emission apportionment. Compounding the GNI volatility is a necessity to compare cross-country and time-series data, where uncertainty originates from reducing nation-specific currencies and inflation rates to a ‘common denominator’.

Along with population, historical emissions are more stable than GNI-based indicators in terms of the baseline variation, as the analysis above shows. A further advantage is associated with the importance of cumulative CO\(_2\) for climatic changes. However, ‘polluter-pays’ budget allocations leave Russia in emission debt already by 2010, which renders this indicator impractical for the purposes of this thesis.

Hence, for the purposes of this thesis, the egalitarian, i.e., per-capita allocation, is more appropriate for a carbon budget apportionment than other equity principles. Note that some equity considerations do inform Anderson and Bows’s (2011) emission budget calculations that this chapter draws on, even though their study is predominantly based on the principle of practicality. This principle is evidently more resilient than other allocation principles when challenged on feasibility grounds. A question for further analysis is how far the practicality principle can be stretched.

To provide a balanced perspective, equity-related and practical limitations of the egalitarian allocation method are explored by Raymond (2006). The three main drawbacks are: population growth encouragement (before a cumulative budget is allocated); inequalities based on other criteria such as living in warm vs. cold climates or in urban vs. rural areas; and, high costs in terms of financial transfers from countries with high per-capita emissions to those with low per-capita emissions. Raymond (2006) suggests that a combination of the egalitarian and other allocation methods is more likely to achieve a multilateral agreement.

Similarly, Neumayer (2000) argues that a per-capita allocation should be augmented to include historical emissions, which is implemented by Bode (2004) in the form of a specific allocation function combining ‘Contraction & Convergence’ with the historical responsibility criterion. In a more recent study, Vazhayil et al. (2011) consider resources to mitigate in addition to per-capita and historical emissions, thereby integrating the ability-to-pay, polluter-pays and egalitarian principles. Although Neumayer (2000) puts forward several valid reasons for such
complex apportionment rules and attempts to refute the main arguments against them, the author ventures into a philosophical and moral discussion that is outside the scope of this work. For that reason and for the sake of practicality, historical emission ‘debt’ is not included into the emission allocation here.

6.7 Russia’s cumulative budgets in the literature

A literature search has returned only one source that explicitly estimates cumulative emission budgets for Russia commensurate with a relatively low probability of exceeding 2°C. Table 18 summarises the calculation results from Mattoo and Subramanian (2012), who apportion a global budget of 750 GtCO$_2$, with a 67% chance of staying below 2°C, amongst fifty countries that were responsible for around 94% of global carbon dioxide emitted in 2008.

The lower bound of the egalitarian budget range in this chapter is similar to the ‘equal-per-capita’ budget from Mattoo and Subramanian (2012). Their ability-to-pay allocation is also close to the calculations in this chapter for the same equity principle, regardless of the baseline year. Similarly to the ‘polluter-pays’ budgets here that leave Russia in cumulative emission debt for any baseline year, Mattoo and Subramanian’s (2012) ‘historic responsibility’ scenario provides the lowest budget (0.4 GtC, or 1.5 GtCO$_2$). By contrast, their budgets under the ‘80-20 cuts’ and ‘preserving future development opportunities’ scenarios are higher than any calculations in this chapter. Mattoo and Subramanian (2012) also quantify implications of burden-sharing proposals from other studies, although resulting cumulative emissions fail to comply with the global budget of 750 GtCO$_2$.

Table 18. Russia’s 2010–2050 cumulative carbon budgets under alternative scenarios from Mattoo and Subramanian (2012, p.1093)

<table>
<thead>
<tr>
<th></th>
<th>Equal per capita</th>
<th>Historic responsibility</th>
<th>Ability to pay</th>
<th>80-20 cuts</th>
<th>Preserving future development opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>GtCO$_2$</td>
<td>18.7</td>
<td>1.5</td>
<td>6.1</td>
<td>40.1</td>
<td>65.8</td>
</tr>
<tr>
<td>GtC</td>
<td>5.1</td>
<td>0.4</td>
<td>1.7</td>
<td>10.9</td>
<td>17.9</td>
</tr>
</tbody>
</table>

6.8 Alternative budget range calculations

Table 19 summarises alternative emission budget calculations based on the emission peak dates and emission reduction rates for Annex 1 from Anderson and Bows (2011), with Figure 8 below showing resulting emission pathways. The study’s assumptions about non-Annex 1 nations and the global budget constraint necessitate the 2007 emission peak for Annex 1 (ibid.). Whilst the UNFCCC inventory shows that the 2007 peak is consistent with historical
emissions averaged across Annex 1 (UNFCCC, 2012), the same assumption for Russia’s emission peak fails to reflect the country’s past emission trajectory. For this reason, 2018 is chosen as an illustrative peak year, as explained in the next paragraph.

To account for the carbon dioxide that Russia emitted up to 2010 and provide a five-year transition period before an emission peak, the country’s emissions are assumed to grow at the 2006–2010 average rate (0.5% pa) between 2011 and 2017 and then to plateau for one year, peaking in 2018. These assumptions, combined with 8% and 10% annual emission reduction rates from the C+3 and C+5 scenarios (ibid.), result in a 7.5–8.4 GtC (27.5–30.8 GtCO₂) cumulative budget for Russia in 2011–2050. According to the calculations, the energy system will not be fully decarbonised by the middle of the century, with emissions in 2050 reaching 15.5 MtC (56.7 MtCO₂) per year (at a 10% reduction rate) and 31.4 MtC (114.9 MtCO₂) per year (at an 8% reduction rate). With the higher emission reduction rate (10%), annual emissions drop below 1 MtC (3.66 MtCO₂) per year in 2077, whereas an 8% annual reduction achieves this level as late as 2092, with corresponding cumulative budgets of 7.6 and 8.8 GtC (27.8 and 32.2 GtCO₂) over 2011–2100.

Table 19 and Figure 8 demonstrate differences between the pathways with two emission peaks (2007 and 2018) and two annual emission reduction rates (8% and 10%). It is evident from Figure 8 that the calculations employ an unlikely assumption that emissions will drop immediately after peaking, and the allowed carbon budget will be spent earlier if emissions plateau and/or decline gradually after the peak.

The alternative 2011–2050 cumulative budget range with a 2018 emission peak is 1.27–1.98 GtC (4.65–7.25 GtCO₂) higher than the egalitarian principle calculations with a 2000 baseline (see the first row of Table 14). The difference is non-trivial, with its upper end comparable to Russia’s cumulative carbon emissions over 2006–2010. Evidently, staying within the egalitarian budget to uphold the inherent value of the equity principle (i.e., following the first calculation method) is a relatively more challenging task.

Note also that neither calculation method used in this chapter ‘credits’ Russia for the emission drop that occurred on its territory in the 1990s (see section 2.3 of the next chapter for the statistics). The main reason for this is that these emission reductions happened as a result of an economic downturn following the collapse of the USSR rather than due to intentional mitigation policies.
Table 19. Alternative 2011–2050 carbon budget calculations for Russia (own calculations based on Anderson and Bows (2011, table 1, p.35) and the UNFCCC Online GHG Emissions Database)

<table>
<thead>
<tr>
<th>Emission peak and reduction rate assumptions</th>
<th>Cumulative budget 2011–2050, GtC (GtCO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C+3: peak in 2007, 10% post-peak reduction</td>
<td>2.80 (10.25)</td>
</tr>
<tr>
<td>C+5: peak in 2007, 8% post-peak reduction</td>
<td>3.74 (13.69)</td>
</tr>
<tr>
<td>C+3: peak in 2018, 10% post-peak reduction</td>
<td>7.50 (27.45)</td>
</tr>
<tr>
<td>C+5: peak in 2018, 8% post-peak reduction</td>
<td>8.41 (30.78)</td>
</tr>
</tbody>
</table>

![Graph showing stylised carbon emission pathways](image)

**Figure 8. Stylised carbon emission pathways for Russia’s energy system based on alternative cumulative emission budget calculations** (Note: for the pathways peaking in 2018, the graph shows Russia’s historical emissions up to 2010)

### 6.9 A timeframe for the backcast scenarios

Meinshausen and colleagues maintain the 21st century is a suitable timeframe for generating emission scenarios, with 2100 being sufficiently removed from today to be able “to determine which emission scenarios will probably lead to a global surface warming below 2°C” (Meinshausen et al., 2009, p.1159). Research, however, shows that the 2°C threshold is likely to be exceeded between 2045 and 2060 “under a high-end, roughly business-as-usual scenario” (New et al., 2011, p.9), which makes the middle of the century a meaningful endpoint for working with carbon budgets.

In Anderson and Bows’s (2011) work, Annex 1 countries spend the whole of their 21st-century budget by 2050 when the probability of exceeding 2°C is relatively low (e.g., 37%). In higher probability scenarios where staying below 2°C is less likely, Annex 1 nations can emit beyond 2050 and reach zero annual emissions by ~2090. *In theory*, a full decarbonisation by 2050 is not necessary for Russia unless there is a risk of exceeding the budget otherwise and if there are no major feasibility issues with early emission reductions. Another point to be noted is that for C+ scenarios, Annex 1 emissions are assumed to peak in 2007 (see table 1 in
Anderson and Bows, 2011, p.35). Although historical data have not yet invalidated this assumption, Annex 1 emissions resumed their growth after reaching their lowest point in 2009. There is a risk that the available budget range is being depleted more rapidly than if the emissions had continued to drop or stayed level after 2007. The precautionary principle suggests that there is a need, at least, for Annex 1 countries to decarbonise earlier, which makes a full decarbonisation of Russia’s energy system by 2050 a necessary and reasonable aim.

A further consideration is the final year of the scenario tool used in this thesis, which in this case is 2050. If annual emissions are not brought down to zero by 2050, they will continue to accumulate thereafter and may eventually exceed the budget, without it being indicated on the tool’s summary tabs. This may or may not be significant, depending on how low annual emissions are in the years preceding 2050. For example, for the alternative budget calculations above, post-2050 cumulative emissions amount to around 0.4 GtC (1.5 GtCO\textsubscript{2}) by 2100, which is comparable to Russia’s annual emissions in the 2000s.

### 6.10 Conclusion

The first stage of backcasting presupposes an overarching strategic objective, and, given the importance of cumulative emissions for the climate, any such target-setting exercise should derive a range of budget constraints for emitting nations. However, despite the proliferation of studies on burden sharing, Russia’s share of a remaining 2°C cumulative budget has received limited attention to date. A notable exception is a recent study by Mattoo and Subramanian (2012) who derive 2010–2050 budgets for Russia amongst other high-emitting countries.

This chapter defines the first stage of backcasting, for the purposes of this thesis, as a range of carbon emission budgets consistent with staying below the dangerous climate change threshold. The chapter arrives at a set of emission budgets for Russia in two different ways. Both methods build on Anderson and Bows (2011) and start with a discussion of the probability of exceeding the 2°C temperature threshold as an overarching global constraint. The first method then takes Annex 1 cumulative budgets from the literature and applies a range of equity principles to derive Russia’s share of the cumulative emission budget. The main challenge relates to the choice of an allocation method and a baseline year for the budget allocation parameter. After analysing a number of existing allocation principles, the chapter concludes that the egalitarian, or per-capita, principle is appropriate for calculating Russia’s emission budgets for this backcasting exercise.
The second method applies Annex 1 emission reduction rates to Russia’s annual emissions. The sum of resulting annual carbon dioxide emissions over 2011–2050 gives the country’s emission budget range. A starting year for Annex 1 reduction rates to be applied in the Russian context is open to discussion. This method does not explicitly rely on a specific allocation principle; however, by drawing on Anderson and Bows (2011), it adopts their ‘pragmatic’ principle with egalitarian elements. Importantly, with both budget calculation methods building on the analysis by Anderson and Bows (2011), the non-Annex 1 emission constraints these budgets entail are extremely demanding, despite a later emission peak and a larger remaining carbon budget, along with a much larger population than in Annex 1. If these constraints are relaxed, the Annex 1 countries have little to no cumulative budget to spend.

The researcher adopts the first budget calculation method (with the egalitarian principle and a 2000 baseline) as it is more contextual and allows flexibility in the emission peak year and reduction rate, compared to the second calculation method. Accordingly, the strategic objective of the backcast is to generate scenarios characterising an evolving energy system for Russia in 2011–2050 within the 5.5–7.1 GtC (20.2–26.1 GtCO₂) cumulative emission budget range, which is commensurate with a relatively low probability of exceeding 2°C global mean surface temperature increase. To explore driving forces, resources and constraints that may facilitate or limit low-carbon transition pathways, the next chapter analyses past and present states of Russia’s energy system (which corresponds to the second stage of backcasting as presented on Figure 5 in chapter 5).
Chapter 7: The past and present states of Russia’s energy system

7.1 Introduction

There are three broad types of constraint placed on scenarios in this thesis: emission budgets commensurate with a given probability of the 2°C objective; a momentum in both the energy system and in the socio-economic environment; and, the ‘feasibility’ of implementing the scenarios. The previous chapter has elaborated on the first type of constraint, in accordance with the first stage of backcasting, developing a range of emission budgets for the strategic objective of the scenario exercise. This chapter expands on the second and touches on the third type of constraint, by describing and analysing past and current trends in Russia’s energy system and related economic, demographic and technological aspects of the re-developing economy. This chapter corresponds to the second stage of backcasting.

As explained in Chapter 5, scenario exercises attempt to understand the relationship between stability and change, which makes the analysis of major developments and trends an essential task. At the same time, by definition, no systemic change is attributable to a single trend or ‘driver’, with circular causality and feedbacks inherent to socio-economic transitions. This presents a challenge for any written work that is necessarily linear. Another challenge the researcher faces is the data-intensive nature of the second stage of backcasting. Consequently, the task includes but is not limited to: defining appropriate boundaries for the large amount of data needed; dealing with unavailable or unreliable data; and, structuring available data in ways that are coherent and intelligible for both the backcaster and the user of the scenarios. This chapter highlights energy- and emission-intensive sectors of the Russian economy, as well as the sectors and elements thereof, for which interesting (e.g., rapidly decreasing or increasing) trends are evident. To give a sense of perspective, the chapter provides examples from Russia’s recent and more distant past as well as comparisons to current situations in other countries.

The structure of this chapter broadly follows the “main dimensions of change” identified by the UK Climate Impacts Programme in their review of the literature on scenarios and futures. The UKCIP (2000, p.18) discusses the following five aspects common to the studies they reviewed: the composition and rate of economic growth; demography and settlement patterns; the rate and direction of technological change; the nature of governance; and, social and political values. As the final two aspects have already been considered in the background...
chapter on Russia’s policies and governance (Chapter 3), this chapter focuses on the first three ‘dimensions’ in the order suggested.

7.2 The composition and rate of economic growth

7.2.1 GDP, sectoral value-added and international trade

Analysis of economic indicators is important for understanding some of the drivers behind energy and emission dynamics. Russia was amongst the top ten countries in the world by both nominal and purchasing-power-parity GDP in 2011 (IMF, 2012), whereas in terms of the affluence of its citizens the country ranked as low as 54th (WB, 2012). Yet, at the mean value of 12,995 USD per person per year at current 2011 prices, it was at the top of the ‘upper middle income’ country category (ibid.). The relative affluence (at the mean) of the Russian population is predominantly due to a rapid economic growth the country experienced in the early 2000s that to some extent compensated for a series of economic crises in the 1990s (Figure 9).

![Figure 9. The 1990–2011 GDP growth rates in countries with the highest absolute annual GDP PPP in 2011 (%) (WB, 2012)](image)

It should be noted that the mean may be a misleading indicator of the country’s average income if the income distribution is skewed. For example, in 2008 the mean disposable income of Russia’s households was 198,276 roubles (7,976 USD) per household at current 2008 prices, whereas the median disposable income was 141,420 roubles (5,689 USD) (OECD,

37 The 2008 disposable income indicators have been converted from roubles to US dollars at the 2008 exchange rate: 1 USD = 24.8594 RUB (see Appendix A for data sources).
Although these indicators are not directly comparable to the mean income per person in the previous paragraph, the gap between the mean and median household incomes suggests there are few high-earning households and a large number of low-earning households in Russia. The per-capita income distribution is likely to show a similar tendency. Russia’s Gini index of 41.7 in 2011, ranking 52nd in the world (CIA, 2013), further substantiates the relatively high inequality of income distribution in the country.

A nation’s income (‘gross domestic product’), energy consumption and emissions typically move together, at least until a decoupling is achieved through decarbonisation and energy efficiency. Figure 10 shows that, although total primary energy consumption per capita in Russia has changed in the same direction as the other two indicators, it has been much less volatile. Furthermore, per-capita CO$_2$ exactly traces per-capita GDP in the 1990s, whereas starting in the early 2000s the two indicators are to some extent decoupled. However, the simultaneous decrease of all three indicators during the recent economic crisis demonstrates that they are still interrelated.

![Figure 10. Per-person indicators: total primary energy consumption, GDP and CO$_2$ emissions in Russia in 1990–2009 (tCO$_2$/cap, thousand constant 2008 USD/cap and toe/cap)](image)

The share of services in GDP was steadily expanding from about 40% in 1992 to about 61% in 2009. The share of energy intensive industry decreased, although not uniformly, with high-value added manufacturing processes taking the hit and with the resource extraction share of

---

38 An example of high inequality of income distribution is a Gini index of 63.1 in South Africa in 2005, whilst low inequality of income is reflected in a Gini index of about 23.0 in Sweden in 2005 (CIA, 2013).

39 The difference between the latest, i.e., 2009, per-capita GDP value on Figure 10 (8,239 USD/cap) and the number cited at the beginning of this chapter (12,995 USD/cap) is explained by a number of factors, including their units being measured in constant 2008 prices vs. current 2011 prices respectively and the two-year gap between the two datapoints.
GDP increasing, which is reflected in the dynamics of Russia’s international trade (see Figure 12 and Figure 13). The shares of other GDP-contributing sectors have remained relatively stable over the past two decades.

Note that there are a number of methodological issues in the data collection and grouping by the International Energy Agency (IEA) that may fail to reflect the relative importance of certain sectors in Russia. For example, according to the IEA’s data classification originally designed for the OECD countries, ‘Fossil Fuel Extraction and Processing’ is part of the category ‘Intensive Industry’. However, to account for Russia’s national circumstances (compared to those of the OECD), it would be reasonable to incorporate the fossil fuel sector data within the ‘Energy Industry’ category instead. In this case the ‘Energy Industry’ group would better reflect its high share of gross value added in Russia’s GDP, as well as its significant contribution to the national emissions. For comparison, following the IEA’s classification, the energy industry constitutes 3–5% of annual GDP on average over the 1992–2009 period, whereas, with the extraction and processing industry included, the average share in GDP is about 15% (own calculations based on data from RosStat (2012)). It is also difficult to separate out the ‘Processing of Fossil Fuels’ category from the data provided by Russia’s Federal State Statistics Service, because it is listed as part of the ‘Manufacturing & Processes’ category.

Table 20. Sectoral gross value-added as a share of Russia’s GDP in the 1990s and 2000s (%) (own calculations based on data from RosStat (2012))

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry – energy-intensive</td>
<td>29.9</td>
<td>22.9</td>
<td>17.9</td>
<td>11.9</td>
<td>9.8</td>
</tr>
<tr>
<td>Construction</td>
<td>4.7</td>
<td>7.3</td>
<td>5.9</td>
<td>5.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Commercial and public services</td>
<td>40.4</td>
<td>45.8</td>
<td>50.1</td>
<td>55.4</td>
<td>60.7</td>
</tr>
<tr>
<td>Agriculture and forestry</td>
<td>4.0</td>
<td>4.6</td>
<td>5.0</td>
<td>4.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Energy industry</td>
<td>5.0</td>
<td>4.3</td>
<td>4.1</td>
<td>3.5</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Note: no pre-1992 sectoral GVA data was found

In addition to its significant role in Russia’s GDP, the resource extraction industry (particularly fossil fuel industry) contributes a disproportionately large share of the federal budget revenue. Figure 11 shows that in 2006, 2008 and 2011 it formed nearly half of the total revenue stream. One of the main reasons the share of the oil and gas revenue in the federal budget doubled in 2004 relative to the previous year, and more than quadrupled compared to the average share in the 1990s, is a comprehensive tax reform undertaken in 2000–2004. The dramatic increase was predominantly due to the more ‘efficient’ taxing of the oil sector. Progressive export tariffs and the linking of extraction tax to global oil prices resulted in
channelling up to 81% of the oil rent to the federal budget in the late 2000s (Gurvich, 2010, pp.7–8). At the same time, the budget revenue from natural gas stayed as low as 38% of the rent over the same period, to a large extent due to differences in taxing the two branches of the extraction sector (ibid.). Oil-related taxes formed 92% of the total taxes for natural resources, with natural gas constituting about 7% (own calculations based on data from FNS (2012)). In terms of the bigger picture, the average ratio of gas and oil revenue to the country’s GDP increased from around 1% in the 1990s to 9.6% in the late 2000s (see Table 21).

Figure 11. Oil & gas revenues as a proportion of the total revenue in Russia’s federal budget (%) (Institut Ekonomicheskogo Analiza, 2010; FNS, 2012; Illarionov, 2012)

Table 21. Total federal budget revenue, oil & gas revenue and revenue other than oil & gas as a share of Russia's GDP (%) (Institut Ekonomicheskogo Analiza, 2010; Illarionov, 2012)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total federal budget revenue (per cent of GDP)</th>
<th>Oil &amp; gas revenue (per cent of GDP)</th>
<th>Revenue other than oil &amp; gas (per cent of GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>14.1</td>
<td>0.3</td>
<td>13.9</td>
</tr>
<tr>
<td>1995</td>
<td>16.2</td>
<td>0.4</td>
<td>15.8</td>
</tr>
<tr>
<td>1996</td>
<td>15.5</td>
<td>0.7</td>
<td>14.9</td>
</tr>
<tr>
<td>1997</td>
<td>13.8</td>
<td>1.4</td>
<td>12.4</td>
</tr>
<tr>
<td>1998</td>
<td>11.5</td>
<td>1.4</td>
<td>10.1</td>
</tr>
<tr>
<td>1999</td>
<td>12.7</td>
<td>1.4</td>
<td>11.3</td>
</tr>
<tr>
<td>2000</td>
<td>15.4</td>
<td>1.4</td>
<td>14.0</td>
</tr>
<tr>
<td>2001</td>
<td>17.8</td>
<td>1.6</td>
<td>16.2</td>
</tr>
<tr>
<td>2002</td>
<td>20.3</td>
<td>3.0</td>
<td>17.3</td>
</tr>
<tr>
<td>2003</td>
<td>19.6</td>
<td>3.0</td>
<td>16.5</td>
</tr>
<tr>
<td>2004</td>
<td>20.1</td>
<td>6.3</td>
<td>13.8</td>
</tr>
<tr>
<td>2005</td>
<td>23.7</td>
<td>10.0</td>
<td>13.7</td>
</tr>
<tr>
<td>2006</td>
<td>23.3</td>
<td>11.0</td>
<td>12.4</td>
</tr>
<tr>
<td>2007</td>
<td>23.4</td>
<td>8.7</td>
<td>14.7</td>
</tr>
<tr>
<td>2008</td>
<td>22.5</td>
<td>10.6</td>
<td>11.8</td>
</tr>
</tbody>
</table>
With about three quarters of Russia’s annual oil production in the 2000s exported (Korzhubaev et al., 2011, Fig.1, p.17), a large proportion of the budget revenue comes from international trade. As Figure 12 shows, the composition of Russia’s exports is heavily skewed towards mineral products, with their share expanding from 42.5% in 1995 to 72.1% in 2011. At the same time, the export of machinery and transport more than halved during the same period; whereas, the import thereof increased from 33.6% in 1994 to around 50% of total imports in the late 2000s (see Figure 13). In absolute terms, Russia’s 2011 exports totalled 503,130 and imports 298,450 million USD at the then-current prices (RosStat, 2012).

![Figure 12. The composition of Russia’s exports between 1995 and 2011 by share in total exports (%)](image1)

![Figure 13. The composition of Russia’s imports between 1995 and 2011 by share in total imports (%)](image2)
An increasingly large share of fossil fuels in Russia’s exports and in the federal budget revenue exposes the economy to a number of potential external shocks. Firstly, sudden fluctuations in regional and global energy prices, being unpredictable, leave little time for Russia’s economy to adapt when a price dip occurs. This vulnerability was aggravated after the taxation system reform in the early 2000s. Linking oil extraction tax to global oil prices exposed the major budget revenue stream to the volatility of international oil markets. Secondly, the demand of Russia’s import partners for its fossil fuels, although less volatile and relatively more predictable than energy prices, is still out of Russia’s control. Compared to price volatility, such demand decreases may be more fundamental and prolonged or even permanent (on a human timescale), for example, due to the performance of importers’ economies or the diversification of their energy sources.

The dependence of Russia on fossil fuel importers has major repercussions for “the security of demand” (Bradshaw, 2012, p.209) and, hence, the macroeconomic stability in the country. The competitiveness of the Russian economy and, more generally, the country’s role in the world are evident in and contingent on the diversification of exports towards high-value added goods and services. Over the past decade, however, the government has interpreted the process of diversification as expanding the number of ‘reliable’ import partners. For instance, Korzhubaev et al. (2011, p.16) argue that one of the main aspects of Russia’s recent export-related policies has been the reduction of oil transit via the Eastern Europe and the Commonwealth of Independent States replaced by alternative routes to Western Europe. At the same time, although about 80% of Russia’s oil is still exported to the ‘Atlantic Ocean’ market, the share of exports to the Pacific Ocean countries (in particular, China) has been steadily growing (ibid., p.18).

7.2.2 Energy use country-wide and in GVA-producing sectors

Whilst Russia’s energy exports have increased dramatically in the 2000s, the change in domestic energy consumption has been a modest 0.1% per year (see Table 22). Some decoupling of total final energy consumption from the GDP growth is evident in the falling energy intensity of the economy by 1.9% per year in the 1990s and by 4.5% per year in the 2000s. This trend can in part be explained by the economic restructuring Russia underwent after the collapse of the USSR. As Table 20 above has illustrated, the share of energy-intensive industry contributed about a third to the country’s total GVA in 1992 and shrank to less than 10% of the total GVA by 2009. At the same time, the contribution of commercial and public services grew from 40.4% in 1992 to 60.7% of the country’s GVA in 2009. Interestingly, Hayes et al. (2012, p.12) arrive at a different conclusion regarding Russia’s GDP intensity in
the 2000s, arguing that when the country’s GDP is adjusted for inflation, there is no change in the energy intensity. A possible explanation is discrepancies in data underlying calculations. Similarly to this thesis, Hayes et al. (2012, p.12) use the energy data from the International Energy Agency; however, their GDP and GDP deflators are sourced from the World Bank, whereas this thesis draws on Russia’s Federal State Statistics Service.

Table 22. The main trends in the Russia’s economy: mean annual change in primary energy demand, total final energy consumption, GDP, imports, GNP and the energy intensity of the economy in 1990–2000 and 2000–2009 (%) (own calculations based on data from RosStat (2012), IEA (2011a) and UNFCCC (2012))

<table>
<thead>
<tr>
<th>Unit: per cent (annual change)</th>
<th>1990–2000</th>
<th>2000–2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary energy demand</td>
<td>-5.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Total final energy consumption</td>
<td>-5.8</td>
<td>0.1</td>
</tr>
<tr>
<td>GDP</td>
<td>-3.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Import</td>
<td>9.3</td>
<td>12.1</td>
</tr>
<tr>
<td>GNP (GDP + Import)</td>
<td>-5.2</td>
<td>6.6</td>
</tr>
<tr>
<td>Economy energy intensity</td>
<td>-1.9</td>
<td>-4.5</td>
</tr>
</tbody>
</table>

As Table 23 details, the industry (including construction but excluding the energy sector) has been the largest energy consumer, although its share decreased from just under 45% to a third of Russia’s total primary energy demand between 1990 and 2009. It is currently closely followed by the households sector whose share remained relatively stable at the time, even though its absolute energy demand decreased from 183 to 109 Mtoe (IEA, 2011a). The services sector and transport consumed around 78 and 85 Mtoe respectively in 1990, decreasing to 46 and 66 Mtoe correspondingly by 2010 (ibid.). The share of the energy industry in total primary energy demand doubled between 1990 and 2010, although in absolute terms it grew by only a fifth of the 1990 level (ibid.). The sectoral energy consumption did not increase or decrease uniformly, with most sectors dwindling over the 1990s and recovering in the 2000s. The subsections below provide further information about the residential, transport and energy sectors.

Table 23. Shares of energy consumed and CO$_2$ emitted by sector in 1990, 2005 and 2009 (%) (own calculations based on data from RosStat (2012), IEA (2011a) and UNFCCC (2012))

<table>
<thead>
<tr>
<th>Sector</th>
<th>1990</th>
<th>2005</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of E</td>
<td>% of CO$_2$</td>
<td>% of E</td>
</tr>
<tr>
<td>Household</td>
<td>25.1</td>
<td>22.9</td>
<td>27.8</td>
</tr>
<tr>
<td>Industry – energy-intensive</td>
<td>23.7</td>
<td>25.6</td>
<td>24.4</td>
</tr>
<tr>
<td>Industry – other</td>
<td>15.9</td>
<td>15.9</td>
<td>6.0</td>
</tr>
<tr>
<td>Construction</td>
<td>3.8</td>
<td>3.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Commercial and public services</td>
<td>6.6</td>
<td>7.1</td>
<td>8.7</td>
</tr>
<tr>
<td>Agriculture and forestry</td>
<td>4.1</td>
<td>4.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Domestic aviation</td>
<td>1.3</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Sector</td>
<td>2009</td>
<td>2010</td>
<td>2011</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>International aviation</td>
<td>1.2</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Rail</td>
<td>0.8</td>
<td>0.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Road (freight and passenger)</td>
<td>7.1</td>
<td>6.3</td>
<td>9.7</td>
</tr>
<tr>
<td>Domestic shipping</td>
<td>0.6</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>International shipping</td>
<td>1.2</td>
<td>1.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1.8</td>
<td>1.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Energy industry</td>
<td>6.8</td>
<td>7.6</td>
<td>14.1</td>
</tr>
</tbody>
</table>

*Note: the most energy-consuming sectors are in italics.*

In terms of its GDP energy intensity, Russia is amongst ten of the world’s most energy intensive economies alongside the Middle East’s oil-exporting nations (EIA, 2012). Yet, by energy use per person, Russia ranks between 23rd and 26th—depending on the calculation method—in the world at 4.6 toe/cap in 2009, being comparable to the Republic of Korea and the Netherlands (IEA, 2012a). According to the IEA (ibid.), Russia’s 1990 total primary energy consumption per person was 5.9 toe/cap, whereas other experts (Sinyak, 1991) estimate the USSR’s 1990 energy use to be 5.04 toe/cap. Russia’s per-capita energy use decreased between 1990 and 1997 reaching 4.1 toe/cap, the lowest value in Russia’s modern history. It then steadily grew up to 4.9 toe/cap in 2008 when the financial crisis occurred, at which point the energy consumption dropped to 4.6 in 2009 and recovered to the pre-crisis level a year later.

As no publicly available pre-1990 data for Russia were found, a number of early literature sources on the USSR were used to provide a historical perspective. The energy consumption per person in the Soviet Union was 3.0 toe/cap in 1973 (UN-Habitat, 1991, p.34), 4.47 toe/cap in 1985 (ibid.) and 4.6 toe/cap in 1987 (U.S. Congress: Office of Technology Assessment, 1991, p.9). It is unlikely that this number had been higher than 5.9 toe/cap during the Soviet times; hence, the 1990 remains the peak of Russia’s primary energy consumption per person. Despite being a ‘peak’, it is still lower than the current per-capita energy use in the most developed countries, for example, Canada’s 7.4 toe/cap in 2011 (IEA, 2012a).

Figure 14 illustrates the primary energy demand fuel mix across all sectors over the past two decades. The energy demand was nearly 1,100 Mtoe in 1990, falling to about 670 Mtoe in 1998, the lowest point in the country’s modern history. It gradually increased afterwards reaching 775 Mtoe in 2009. Since the collapse of the Soviet Union, the fuel mix has undergone some changes, with the largest drop in the share of coal (from 17.9% in 1990 to 12.7% in 2009) and the largest increase in the share of natural gas (from 30.8% in 1990 to 38.1% in 2009). The contribution of energy from renewable sources and waste grew from 2.4% to 2.8% over the same period, largely due to the expansion of large hydroelectric power.
The share of electricity in the total final energy consumption steadily grew from 8.6% in 1990 to 14.5% in 2008, slightly decreasing to 13.9% in 2009 (IEA, 2011a). As Figure 15 shows, the 2009 electricity supply fuel mix was similar to that in 1990, with the most noticeable change coming from the oil share decrease. Nearly half of all electricity in 2009 was supplied by natural gas, whilst the rest was almost equally distributed between coal, nuclear and hydroelectricity, whose shares slightly increased since 1990.

**Figure 15. Russia’s electricity output in 1990 and 2009, including combined heat and power (%) (BP, 2011; IEA, 2011a)**

The share of electricity (vs. heat) produced by combined heat and power (CHP) plants increased from 36.2% in 1990 to nearly 50% in 2009, although it did not grow steadily but
fluctuated slightly over the years (IEA, 2011a). The proportion of heat (vs. electricity) produced by CHP plants declined correspondingly. Overall, between 1990 and 2009, the energy used for heat decreased both in absolute terms (threefold) and as a share of total energy production (from 45% to 27%) (ibid.). Most of the heat in Russia in 2009 was produced from natural gas (64.4%) and coal (22.7%), as Table 24 shows, with slightly more heat produced by heat plants than CHP plants for both types of fossil fuel. The dominance of natural gas over coal was partly due to the former being cross-subsidised (IEA, 2011b; IMF, 2013).

Table 24. Heat energy fuel mix and the proportion of CHP vs. heat plants in 2009 (ktce and %) (own calculations based on IEA (2011a))

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Total heat output, ktoe</th>
<th>Fuel share in total heat output</th>
<th>Share of CHP vs. heat plant for different fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>CHP</td>
</tr>
<tr>
<td>Coal</td>
<td>32,030</td>
<td>22.7%</td>
<td>49.3%</td>
</tr>
<tr>
<td>Oil</td>
<td>7,877</td>
<td>5.6%</td>
<td>20.5%</td>
</tr>
<tr>
<td>Gas</td>
<td>90,900</td>
<td>64.4%</td>
<td>45.8%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>328</td>
<td>0.2%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Biofuel and waste</td>
<td>2,819</td>
<td>2.0%</td>
<td>29.6%</td>
</tr>
<tr>
<td>Renewables</td>
<td>7,159</td>
<td>5.1%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Total supplied</td>
<td>141,113</td>
<td>100.0%</td>
<td>42.7%</td>
</tr>
</tbody>
</table>

7.2.3 Emissions country-wide and in GVA-producing sectors

As Figure 16 illustrates, in 2010, Russia was the fourth of the world’s largest emitters, after China, the United States and India, producing around 1.6 Gt of carbon dioxide. In terms of production-based emissions, Russia has been amongst the top five emitting countries throughout its modern history despite the major economic downturn in the 1990s. Table 25 shows the trends in the mean CO$_2$ emission growth rate in Russia since 1991. There was a significant drop in the early 1990s, with the largest annual reductions occurring in 1992 (17.9% lower than 1991) and in 1994 (11.5% lower than 1993). The 2000s saw a gradual emission increase, on average, apart from 2009 when the reduction was a high as 5.1% compared to the previous year due to the economic crisis. In 2010, Russia’s carbon dioxide emissions increased by 4.4%.
Figure 16. Countries with the largest absolute annual CO₂ emissions in 2010 (Mt CO₂) (Olivier and Peters, 2010; Olivier et al., 2011; UNFCCC, 2012)

Table 25. Annual mean growth rate of carbon dioxide emissions in Russia, including international aviation and marine emissions (% per year) (own calculations based on data from UNFCCC (2012))

<table>
<thead>
<tr>
<th>Period</th>
<th>Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991–1995</td>
<td>-8.7%</td>
</tr>
<tr>
<td>1996–2000</td>
<td>-1.3%</td>
</tr>
<tr>
<td>1991–2000</td>
<td>-5.0%</td>
</tr>
<tr>
<td>2001–2005</td>
<td>0.7%</td>
</tr>
<tr>
<td>2006–2010</td>
<td>1.0%</td>
</tr>
<tr>
<td>2001–2010</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Amongst the countries and groups thereof with the highest annual CO₂ emissions, Russia ranks second, after China, in terms of the carbon intensity of GDP (see Figure 17). Several characteristics of the national economy may be responsible for Russia’s high carbon intensity, including a large share of heavy and energy-intensive industries, a protracted cold season, long distances and inefficient infrastructures. Politically, there have been few incentives for the country’s industries and economic actors to decrease either their energy use or emissions.

Figure 17. GDP PPP carbon intensity of the largest emitters in 2011 (tCO₂/thousand constant 2005 USD) (EIA, 2012)

In the mid-1990s, the carbon intensity of Russia’s GDP was about 15–20% higher than that in 1990 (see Figure 18). This was predominantly due to the steeper GDP decrease compared to...
that of the energy use in the economy in the 1990s, which is evident from Figure 10 above. However, overall, between 1990 and 2009 Russia’s GDP carbon intensity decreased. Much of the decline in the energy and emission intensity of GDP over the past two decades is explained by the decline in industry and a subsequent economic restructuring towards the services sector. A partial switch from coal and oil to natural gas and hydroelectricity in Russia’s energy supply fuel mix (BP, 2011; IEA, 2011a) also accounts for a share of the reduced emission intensity. Particularly between 1998 and 2008, whilst the country’s gross domestic product nearly doubled, energy-related CO₂ emissions ‘only’ grew by 12% (Novikova et al., 2009, p.114) indicating a partial decoupling of the GDP from carbon dioxide. Table 23 details the changes in carbon dioxide emissions of Russia’s economic sectors.

![Graph showing changes in GDP, CO₂ emissions and energy intensity of the Russian economy relative to 1990 (%) (IMF, 2008; BP, 2011; IMF, 2012)](image)

**Figure 18. Changes in GDP, CO₂ emissions and energy intensity of the Russian economy relative to 1990 (%) (IMF, 2008; BP, 2011; IMF, 2012)**

### 7.3 Demography, settlement patterns and infrastructure

#### 7.3.1 Population and settlement patterns

As of 2011, Russia had the 9th largest population in the world, although at about 142 million people its population was nearly ten times smaller than that of China (IMF, 2012). Figure 19 shows annual population growth rate for each of the ten countries with the largest populations. In contrast to the other top nine countries, the number of people in Russia has decreased for much of the time since 1990, except during a period of relative economic
stability between 2005 and 2009. The overall decrease has been 5.3 million people over the past two decades.

The number of people in Russia decreased by about 0.1% per year in the 1990s and by 0.4% per year in the 2000s (Table 26). At the same time, the number of households decreased faster than the population in the 1990s and increased faster in the 2000s. Over the 1990–2000 period as a whole, the country’s population dropped by about 0.2% a year, whereas the number of households experienced an annual increase of 0.02%. Evidently, the dramatic socio-economic change of the 1990s reflected in the population statistics only a decade later. The decreasing population and smaller household size resulted from a number of factors, including social and economic difficulties and the active ‘Westernisation’ of the culture and attitudes. In particular, young people started to postpone creating a family until after advancing their careers (Demin et al., 1997). This trend was intensified by deteriorating childcare institutions (ibid.) and the weakening of employee bargaining power (Barsukova, 2000). The Western culture of individualism and a ‘nuclear family’ (Demin et al., 1997) are also reflected in the decreasing household size. Both the demographic changes and a growing affluence (see ‘Consumer expenditure per person’ in Table 26) are likely to have implications for energy consumption in the medium to long term.

Figure 19. Population change on previous year in the top ten countries with largest populations in 2011 (IMF, 2012)

It is unclear from the data source why Pakistan shows a sharp increase in its population in the late 2000s.

---

40 It is unclear from the data source why Pakistan shows a sharp increase in its population in the late 2000s.
Table 26. Trends in the residential sector: mean annual change over a period indicated (%) (own calculations based on data from RosStat (2012))

<table>
<thead>
<tr>
<th>Unit: per cent (annual change)</th>
<th>1990–2000</th>
<th>2000–2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of households</td>
<td>-0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Population</td>
<td>-0.1</td>
<td>-0.4</td>
</tr>
<tr>
<td>Energy consumption per person</td>
<td>-2.6</td>
<td>-2.3</td>
</tr>
<tr>
<td>Energy consumption per household</td>
<td>-2.3</td>
<td>-3.1</td>
</tr>
<tr>
<td>Energy consumption per consumer expenditure</td>
<td>-1.9</td>
<td>-10.6</td>
</tr>
<tr>
<td>Consumer expenditure per person</td>
<td>-0.7</td>
<td>9.3</td>
</tr>
</tbody>
</table>

With an increase in the number of households and depreciating Soviet housing, stock renewal rates become particularly important. According to the national statistics office, about 5% of families in Russia are registered as in need of housing (RosStat, 2012). Other sources suggest this figure could be much higher with average per-person residential area in Russia (20.7 m²/cap in 2005) being below that in both developed and transitional economies, for example, the USA (70 m²/cap), Germany (50 m²/cap) and China (27 m²/cap) (Barbasov, 2008, p.1). Barbasov (ibid.) argues that the housing stock renewal rates of 50 million square metres per year (or about 0.33 m² per person per year) are currently three times lower than required by international standards, although there is little detail to clarify what the standard entails. Although the contribution of the construction industry to the country’s GDP increased from 4.7% in 1992 to 5.8% in 2009, the sector was unable to keep up with a growing need for new residential floor area. In fact, the expansion of commercial and public sectors is likely to have accounted for much of the growth in the construction industry.

The majority of Russian citizens live in cities and other urbanised areas. According to the World Bank (2012), historically there was a gradual increase in the share of urban population in Russia from 54% in 1961 to 73% in 1990. Between 1990 and 2009 the share of urban population fluctuated around 73% (ibid.). The urban housing stock by type of ownership and type of building may have important implications for the implementation of emission- and energy-related policies and investment decisions. Although the availability of such data is limited, Table 27 provides a snapshot of the breakdown and compares it to the situation in the Western Europe. Given that conglomerate housing and condominiums in Russia are typically tower-blocks, 80% of urban housing is high-rise. It is unclear from the table what proportion of the buildings belongs to the state; however, the Russian Federal State Statistics Service estimates that, in 2011, 76% of all housing was in private ownership (RosStat, 2012).
Table 27. Urban housing in Russia by type of ownership compared to the average indicators in Western Europe (%) (Glazunov and Samoshin, 2006, p.18)

<table>
<thead>
<tr>
<th>Type of housing</th>
<th>Russia (total)</th>
<th>Moscow</th>
<th>Western Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private single-family house</td>
<td>20</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Condominium / co-operative</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Commercial apartment building</td>
<td>-</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>Municipal apartment building</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Conglomerate housing</td>
<td>70</td>
<td>90</td>
<td>-</td>
</tr>
</tbody>
</table>

7.3.2 Energy and emissions in the residential sector

As Table 26 above has shown, the per-capita and per-household energy consumption in Russia’s residential sector gradually decreased between 1990 and 2009. Similarly, residential carbon intensity fell by about 40% from 1.1 tC/cap in 1990 to 0.7 tC/cap in 2009, or from 3.0 to 1.8 tC/household over the same period (own calculations based on data from IEA, 2011b; IEA, 2012a; UNFCCC, 2012). Despite decreasing energy use both per person and per household (Table 26), Russia’s residential sector remains one of the most energy-intensive in the world. Table 28 shows that, amongst 12 largest economies, only France currently exceeds Russia in residential energy use per unit of floor area. By contrast, in the commercial sector Russia’s energy use ranks as “moderately high” (Hayes et al., 2012, p.86). Note that the calculations have been adjusted for climatic differences in terms of both heating and cooling days.

Table 28. Energy use per unit of floor area in the residential and commercial sectors in 12 of the world’s largest economies, adjusted for climatic differences (adapted from Hayes et al., 2012, p.16)

<table>
<thead>
<tr>
<th></th>
<th>Energy use in residential buildings</th>
<th>Energy use in commercial buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Btu/f²</td>
<td>kJ/m²</td>
</tr>
<tr>
<td>France</td>
<td>11.7</td>
<td>133</td>
</tr>
<tr>
<td>Russia</td>
<td>11.6</td>
<td>132</td>
</tr>
<tr>
<td>Germany</td>
<td>11.4</td>
<td>129</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>10.6</td>
<td>121</td>
</tr>
<tr>
<td>United States</td>
<td>10.5</td>
<td>119</td>
</tr>
<tr>
<td>Canada</td>
<td>10.2</td>
<td>116</td>
</tr>
<tr>
<td>European Union</td>
<td>9.4</td>
<td>106</td>
</tr>
<tr>
<td>Italy</td>
<td>8.8</td>
<td>100</td>
</tr>
<tr>
<td>Japan</td>
<td>7.7</td>
<td>88</td>
</tr>
<tr>
<td>Australia</td>
<td>6.9</td>
<td>79</td>
</tr>
<tr>
<td>China</td>
<td>6.1</td>
<td>69</td>
</tr>
<tr>
<td>Brazil</td>
<td>4.3</td>
<td>49</td>
</tr>
</tbody>
</table>

Data on final energy consumption by end-use in Russia’s household sector are scarce. A study by the Center for Energy Efficiency—known as ‘CENE’—apparently provides the only available estimates to date (Table 29). The table shows that heating and hot water, with around 60% and 25% of the total end-use energy respectively, are the largest end-use categories. For
comparison, UK’s space and water heating were about 60% and 15% respectively in 2011 (DECC, 2012). In Russia, three quarters of the energy in both of these end-uses are supplied by heat and about a fifth by natural gas. Electricity provides just over 9% of the total end-use energy of the residential sector, with electric appliances drawing on about half of that electricity and with lighting using about a third. As Bashmakov et al. (2008) note, the use of electricity and gas for heating grows due to failures in centralised supplies and is typically higher in regions with decentralised heating. Electricity and gas use in general increases in summer when centralised hot water supplies are cut off for a two- to three-week-long maintenance. Note the difference between the row ‘Heating’ and the column ‘Heat’ in Table 29, with the former being an end-use (i.e., demand-side) category and the latter being a supply-side option produced to satisfy part of the demand for heating.

Table 29. End-use energy consumption in the households sector in 2005 (Mtoe) (Bashmakov et al., 2008, p.83)

<table>
<thead>
<tr>
<th>Unit: Mtoe</th>
<th>Coal</th>
<th>Petroleum products</th>
<th>Gas</th>
<th>Other solid fuels</th>
<th>Electricity</th>
<th>Heat</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>2.47</td>
<td>-</td>
<td>12.05</td>
<td>0.76</td>
<td>0.79</td>
<td>46.68</td>
<td>62.94</td>
</tr>
<tr>
<td>Hot water</td>
<td>0.36</td>
<td>0.18</td>
<td>5.71</td>
<td>0.18</td>
<td>0.36</td>
<td>20.34</td>
<td>26.94</td>
</tr>
<tr>
<td>Cooking</td>
<td>-</td>
<td>0.73</td>
<td>9.42</td>
<td>-</td>
<td>0.57</td>
<td>-</td>
<td>10.72</td>
</tr>
<tr>
<td>Lighting</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.81</td>
<td>-</td>
<td>2.81</td>
</tr>
<tr>
<td>Appliances</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4.84</td>
<td>-</td>
<td>4.84</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2.83</td>
<td>0.91</td>
<td>27.18</td>
<td>0.94</td>
<td>9.37</td>
<td>67.02</td>
<td>108.25</td>
</tr>
</tbody>
</table>

7.3.3 Energy infrastructure

When it comes to implementing energy- and climate-related policies, the distribution of the population across the country has a major influence on the national infrastructure. Two-thirds of Russia’s population live to the west of the Ural Mountains, i.e., on just a quarter of the country’s total area (Morozova et al., 1998). The urban population is disproportionately concentrated in the two federal cities, Moscow and St. Petersburg, and there is a big gap between these two cities and the next tier of cities in terms of economic development and ‘connectedness’ (Hill and Gaddy, 2003, pp.19–24). More than a third of Russia’s population live in cold and very cold cities, which has no analogues in other countries (ibid., p.40). For comparison, in Canada, with average winter temperatures in some regions similar to those in Russia, more than 95% of the population are concentrated in the country’s warmest regions close to the USA border (Statistics Canada, 2013).

A long cold season in populated areas of the country highlights the importance of secure and reliable energy supply in Russia. A conventional energy supply chain includes some or all of the following elements: primary energy resource extraction; transportation links to deliver the
resource to power plants; refineries, power plants and other energy-transforming technology; capacity and technology for storing primary energy resources and power; and, transmission and distribution lines to deliver power to networks and end-users. Specific characteristics of Russia’s energy supply chain suggest a number of potential threats to maintaining the conventional energy system. The rest of this section will expand on issues such as deteriorating capital stock and long distances.

One of the most significant problems facing Russia’s economy in general and its energy system in particular is a large proportion of ‘used up’ capital stock and equipment, combined with a low rate of stock renewal. Nureev (2010) estimates that, whilst in 1970 and 1980 about 70% and 64% of all equipment respectively was less than 10 years old, in 2000 almost 60% was older than 16 years. Table 30 summarises the estimates based on data from Russia’s Federal State Statistics Service. Although more recent data are unavailable, the trend suggests that the situation is unlikely to have improved.


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0–5</td>
<td>40.8%</td>
<td>35.5%</td>
<td>29.4%</td>
<td>10.1%</td>
<td>4.7%</td>
</tr>
<tr>
<td>6–10</td>
<td>30.0%</td>
<td>28.7%</td>
<td>28.3%</td>
<td>29.8%</td>
<td>10.6%</td>
</tr>
<tr>
<td>11–15</td>
<td>14.0%</td>
<td>15.6%</td>
<td>16.5%</td>
<td>21.9%</td>
<td>25.5%</td>
</tr>
<tr>
<td>16–20</td>
<td>6.9%</td>
<td>9.5%</td>
<td>10.8%</td>
<td>15.0%</td>
<td>21.0%</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>8.3%</td>
<td>10.7%</td>
<td>15.0%</td>
<td>23.2%</td>
<td>38.2%</td>
</tr>
<tr>
<td>Average age (years)</td>
<td>8.4</td>
<td>9.5</td>
<td>10.8</td>
<td>14.3</td>
<td>18.7</td>
</tr>
</tbody>
</table>

For most elements of the energy sector, including heat and power generation and distribution, the average depreciation of plant and machinery is around 46%, with 15% having been fully amortised yet still in operation (Popov, 2012, p.8). Tarasiuk and Akimova (2010, p.9) argue the equipment used in Russia’s oil and gas industry has the highest level of ‘wear and tear’ amongst industrial sectors: 60% as opposed to 50% on average. The oil and gas stock renewal coefficient is about 1%, which is lower than the average across the industry (ibid.), despite the strategic importance of the oil and gas sector. This is likely to have serious implications for the fossil fuel extraction in the short- to medium-term and subsequent knock-on effects on Russia’s international trade, federal budget revenues and the social welfare system supporting much of the population.

A number of stop-gap measures have been implemented, for example, extending the lifetimes of capital stock through maintenance. For instance, as a recent report by the Russian Ministry of Energy (2010, p.53) explains, it is technically possible and economically sensible to extend
the service life of a nuclear power plant. Investment-wise, it is more cost-efficient to maintain an existing nuclear plant than to build a new one. Technology-wise, improvements to the nuclear fuel cycle allow first-generation plant units to extend the initial 30-year operational lifetime by 15 years. Table 31 provides data on currently operational nuclear power stations in Russia and their initially-planned and extended decommissioning. Without the 15-year extension, 18 plant units with combined installed capacity of 11.2 GW (i.e., nearly half of the existing capacity) would have already been decommissioned. Even with the extended service life, 11 plant units (4.8 GW) are to go offline by 2020. This would include shutting down the Bilibinskaya, the only operational nuclear power plant to the east of the Ural Mountains.

Table 31. Operational nuclear power stations in Russia as of 2010 (Ministry of Energy, 2010, pp.53–54)

<table>
<thead>
<tr>
<th>Nuclear station name (location)</th>
<th>Plant unit number</th>
<th>Installed capacity (MW)</th>
<th>Year operation commenced</th>
<th>Initial year of decommissioning</th>
<th>Year of decommissioning after a 15-year extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leningradskaya (Sosnovy Bor)</td>
<td>1</td>
<td>4,000</td>
<td>1979</td>
<td>2005</td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1,000</td>
<td>1976</td>
<td>2010</td>
<td>2025</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1,000</td>
<td>1979</td>
<td>2011</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1,000</td>
<td>1980</td>
<td>2012</td>
<td>2027</td>
</tr>
<tr>
<td>Kolskaya (Poliarnye Zori)</td>
<td>1</td>
<td>1,760</td>
<td>1976</td>
<td>2001</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>440</td>
<td>1975</td>
<td>2002</td>
<td>2027</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>440</td>
<td>1979</td>
<td>2004</td>
<td>2027</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>440</td>
<td>1981</td>
<td>2011</td>
<td>2027</td>
</tr>
<tr>
<td>Kalininskaya (Udomlia)</td>
<td>1</td>
<td>3,000</td>
<td>1974</td>
<td>2006</td>
<td>2031</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1,000</td>
<td>1980</td>
<td>2016</td>
<td>2031</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1,000</td>
<td>1984</td>
<td>2021</td>
<td>2031</td>
</tr>
<tr>
<td>Kurskaya (Kurchatov)</td>
<td>1</td>
<td>4,000</td>
<td>1972</td>
<td>2001</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1,000</td>
<td>1976</td>
<td>2002</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1,000</td>
<td>1979</td>
<td>2004</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1,000</td>
<td>1981</td>
<td>2011</td>
<td>2026</td>
</tr>
<tr>
<td>Novovoronezhskaya (Novovoronezh)</td>
<td>3</td>
<td>1,834</td>
<td>1971</td>
<td>2001</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>417</td>
<td>1971</td>
<td>2002</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1,000</td>
<td>1980</td>
<td>2010</td>
<td>2026</td>
</tr>
<tr>
<td>Smolenskaya (Desnogorsk)</td>
<td>1</td>
<td>3,000</td>
<td>1975</td>
<td>2002</td>
<td>2027</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1,000</td>
<td>1980</td>
<td>2016</td>
<td>2031</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1,000</td>
<td>1990</td>
<td>2020</td>
<td>2035</td>
</tr>
<tr>
<td>Balakovskaya (Balakovo)</td>
<td>1</td>
<td>4,000</td>
<td>1981</td>
<td>2001</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1,000</td>
<td>1985</td>
<td>2005</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1,000</td>
<td>1988</td>
<td>2010</td>
<td>2026</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1,000</td>
<td>1993</td>
<td>2015</td>
<td>2026</td>
</tr>
<tr>
<td>Rostovskaya (Volgodonsk)</td>
<td>1</td>
<td>1,000</td>
<td>1990</td>
<td>2001</td>
<td>2026</td>
</tr>
<tr>
<td>Beloyarskaya (Zarechny)</td>
<td>3</td>
<td>600</td>
<td>1980</td>
<td>2010</td>
<td>2026</td>
</tr>
<tr>
<td>Bilibinskaya (Bilibino)</td>
<td>1</td>
<td>48</td>
<td>1975</td>
<td>2005</td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>12</td>
<td>1975</td>
<td>2005</td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>12</td>
<td>1975</td>
<td>2005</td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>12</td>
<td>1976</td>
<td>2006</td>
<td>2020</td>
</tr>
</tbody>
</table>
The length and efficiency of energy transmission and distribution (T&D) are important aspects of energy supply security, bearing in mind long distances and the relatively low density of end-users in Russia. There are 2.6 million km of transmission and distribution lines in the country (Ministry of Energy, 2012a, p.107). For comparison, the length of the UK’s transmission and distribution lines is 825,000 km (Parliamentary Office of Science and Technology, 2007). Interestingly, in per-person terms the length of T&D lines in Russia and the UK are similar (about 0.018 km/cap and 0.013 km/cap respectively), despite the population densities being markedly different. In 2011, transmission and distribution losses were about 11% of total electricity supplied to Russia’s national grid (Ministry of Energy, 2012a, p.124), and in absolute terms the losses increase as centralised T&D infrastructure is developed further, although they may fall in relative terms. As much as 98% of electricity in Russia is currently supplied via a centralised delivery model (ibid., p.162). Distributed power generation is one of the ways to reduce reliance on the centralised supply and potentially cut T&D losses, which depends on the share of transmission lines in the losses and on the efficiency of new capacity coming online, amongst other factors. Such a dramatic change in the electricity delivery model would require the country to invest significantly in local energy production infrastructure and, more challengingly, to dismantle institutional and social structures that come with the current energy system.

Inefficiencies and disruptions in the supply of Russia’s energy would affect not only domestic consumers but also those in countries dependent on energy imports from Russia. This consideration is particularly relevant for energy sources other than electricity since Russia only exports about 2.3% of its total electricity generation (Teske and Tchouprov, 2009, p.33). By contrast, fossil fuels are important for energy users both within the country and elsewhere, as the discussion in Section 7.2.1 of this chapter has shown. The bulk of fossil fuel energy sources in Russia are transported via pipelines and by rail. In terms of its length and capacity, Russia’s pipeline system is the second largest in the world after the United States, with just under 160 thousand km for transporting natural gas and with more than 50 and 20 thousand km for transporting oil and petroleum products, respectively (Korzhubaev and Suslov, 2008, pp.2–4). Most of the existing pipelines have been built in the past 20–35 years and have 55–70% depreciation (ibid.). The pipeline network in Eastern Siberia and the Far East is not well developed, hence oil and petroleum products (and, to a lesser extent, gas cylinders) for these regions, as well as for exports to Asia, are delivered by rail (ibid.).

\[41\] Imported electricity is as low as 1% of Russia’s total electricity generation (Teske and Tchouprov, 2009, p.33).
7.3.4 The transport sector and mobility trends

Rail is the most actively used mode of freight transport in Russia. The comparison between Figure 20 and Figure 21 shows that the use of freight rail (measured in billion ton-km) dwarfed the use of all other transport modes over the past two decades. In the 1990s, there was a reduction in the use of all transport modes, particularly noticeable in international shipping which dropped from 508 freight ton-km in 1990 to 60 freight ton-km in 2005 (Figure 20). Whilst most transport modes regained some or all of the loss in the 2000s due to the recovering economy, the road passenger transport never bounced back. During and after the 2008 crisis, there was a significant dip in the use of most modes of transportation except international shipping that slightly increased.

Figure 20. Transportation of passengers and freight by mode of transport in Russia in 1990–2009, excluding rail freight (ICAO, 2007; RosStat, 2012; WB, 2012)
Notably, the use of aviation was the only transport mode that exceeded its early levels, although no pre-1993 data are available for this mode. The latest data indicate that the domestic aviation use in 2011 more than doubled compared to 1993, whereas the international aviation use increased by as much as 6.6 times over the same period (ICAO, 2007; RosStat, 2012). These trends are, in part, related to the growing affluence levels of the Russian population and a faster pace of life, with aviation becoming a preferred mode of transport for coping with long distances, as well as high growth rates in the aviation sectors of other countries linked to Russia through international flights. Coincidentally, the use of passenger railway stayed relatively level until a decrease after the 2008 economic crisis, whilst road passenger transport was gradually decreasing between 1990 and 2009 (Figure 20).

As Table 23 above has shown, road transport was consistently one of the highest emitting and energy consuming sectors of the economy between 1990 and 2009. It alone constituted about 11.4% of total Russia’s energy use and 9.6% of the country’s carbon dioxide emissions in 2009, which exceeded the combined shares of Russia’s energy use (5.7%) and emissions (5.6%) attributed to all other modes of transport that year. The energy consumption of and emissions from rail transportation were much lower at 1.4% and 1% respectively, despite the intensive use of rail freight (Figure 21). This is reflected in the particularly low energy and carbon intensities of rail transport compared to other modes of transport (Table 32). Both rail energy intensity and rail carbon intensity increased between 1990 and 2009, especially in passenger rail probably due to a reduced number of people using it. Note that the energy intensity increase was higher than the increase in carbon intensity indicating de-coupling, to an extent. No other sectors showed considerable de-coupling between energy and emissions. In
international aviation the energy and carbon intensities decreased significantly compared to 1993/1995, whereas international shipping experienced a large increase. Road passenger and aviation consistently stood out as the most energy and carbon intensive modes of transport in 1990–2009.


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AVIATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOMESTIC AVIATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy intensity (ttoe/billion passenger-km)</td>
<td>-</td>
<td>107</td>
<td>178</td>
<td>130</td>
<td>99</td>
</tr>
<tr>
<td>Change relative to 1993 [1993=100]</td>
<td>-</td>
<td>105</td>
<td>176</td>
<td>128</td>
<td>98</td>
</tr>
<tr>
<td>Carbon intensity (MtC/billion passenger-km)</td>
<td>-</td>
<td>0.091</td>
<td>0.152</td>
<td>0.111</td>
<td>0.085</td>
</tr>
<tr>
<td>Change relative to 1995 [1995=100]</td>
<td>-</td>
<td>100</td>
<td>167</td>
<td>122</td>
<td>93</td>
</tr>
<tr>
<td>INTERNATIONAL AVIATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy intensity (ttoe/billion passenger-km)</td>
<td>-</td>
<td>295</td>
<td>255</td>
<td>113</td>
<td>92</td>
</tr>
<tr>
<td>Change relative to 1993 [1993=100]</td>
<td>-</td>
<td>74</td>
<td>64</td>
<td>28</td>
<td>23</td>
</tr>
<tr>
<td>Carbon intensity (MtC/billion passenger-km)</td>
<td>-</td>
<td>0.253</td>
<td>0.218</td>
<td>0.096</td>
<td>0.079</td>
</tr>
<tr>
<td>Change relative to 1995 [1995=100]</td>
<td>-</td>
<td>100</td>
<td>86</td>
<td>38</td>
<td>31</td>
</tr>
<tr>
<td>RAIL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy intensity (ttoe/billion passenger-km)</td>
<td>22</td>
<td>25</td>
<td>30</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>114</td>
<td>134</td>
<td>166</td>
<td>167</td>
</tr>
<tr>
<td>Energy intensity (ttoe/billion freight ton-km)</td>
<td>2.4</td>
<td>4.0</td>
<td>3.6</td>
<td>3.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>167</td>
<td>150</td>
<td>139</td>
<td>127</td>
</tr>
<tr>
<td>Carbon intensity (MtC/billion passenger-km)</td>
<td>0.020</td>
<td>0.020</td>
<td>0.024</td>
<td>0.028</td>
<td>0.027</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>102</td>
<td>124</td>
<td>140</td>
<td>135</td>
</tr>
<tr>
<td>Carbon intensity (MtC/billion freight ton-km)</td>
<td>0.002</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.002</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>149</td>
<td>139</td>
<td>117</td>
<td>103</td>
</tr>
<tr>
<td>ROAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROAD FREIGHT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy intensity (ttoe/billion freight ton-km)</td>
<td>54</td>
<td>69</td>
<td>77</td>
<td>73</td>
<td>99</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>129</td>
<td>143</td>
<td>135</td>
<td>184</td>
</tr>
<tr>
<td>Carbon intensity (MtC/billion freight ton-km)</td>
<td>0.048</td>
<td>0.062</td>
<td>0.068</td>
<td>0.064</td>
<td>0.088</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>129</td>
<td>143</td>
<td>136</td>
<td>185</td>
</tr>
<tr>
<td>ROAD PASSENGER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy intensity (ttoe/billion passenger-km)</td>
<td>119</td>
<td>90</td>
<td>100</td>
<td>151</td>
<td>237</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>76</td>
<td>84</td>
<td>127</td>
<td>199</td>
</tr>
<tr>
<td>Carbon intensity (MtC/billion passenger-km)</td>
<td>0.102</td>
<td>0.077</td>
<td>0.086</td>
<td>0.129</td>
<td>0.203</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>76</td>
<td>84</td>
<td>127</td>
<td>200</td>
</tr>
<tr>
<td>SHIPPING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOMESTIC SHIPPING</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy intensity (ttoe/freight ton-km)</td>
<td>22</td>
<td>13</td>
<td>16</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>62</td>
<td>75</td>
<td>65</td>
<td>92</td>
</tr>
<tr>
<td>Carbon intensity (MtC/billion freight ton-km)</td>
<td>0.019</td>
<td>0.012</td>
<td>0.014</td>
<td>0.013</td>
<td>0.018</td>
</tr>
<tr>
<td>Change relative to 1990 [1990=100]</td>
<td>100</td>
<td>62</td>
<td>75</td>
<td>65</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td>2007</td>
<td>2009</td>
<td>2010</td>
<td>2011</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Energy intensity (toe/freight ton-km)</td>
<td>18</td>
<td>14</td>
<td>37</td>
<td>86</td>
<td>60</td>
</tr>
<tr>
<td>Change relative to 1990 (1990=100)</td>
<td>100</td>
<td>83</td>
<td>210</td>
<td>490</td>
<td>341</td>
</tr>
<tr>
<td>Carbon intensity (MtC/billion freight ton-km)</td>
<td>0.016</td>
<td>0.013</td>
<td>0.033</td>
<td>0.076</td>
<td>0.053</td>
</tr>
<tr>
<td>Change relative to 1990 (1990=100)</td>
<td>100</td>
<td>83</td>
<td>210</td>
<td>490</td>
<td>341</td>
</tr>
</tbody>
</table>

Note: The energy and carbon intensity of passenger and freight rail was derived by dividing the total energy use and emissions in rail transport by the passenger and freight turnover, as no energy use and emission data for these two categories separately were found.

### 7.4 Energy-related technological change

Many of the energy security threats and constraints described in the sections above, for example, depreciated or fully amortised capital stock and the volatility of global energy prices, can be opportunities for modernising elements of the existing energy system and developing new, low-carbon, infrastructures. These opportunities are complemented by Russia’s high potential for energy efficiency and renewable energy sources. The implementation of a mix of supply- and demand-side policies, including the adaptation of modern technologies and capital stock renovation, requires considerable investment. Investing in new supply-side technologies in particular is often high-risk, if high-return, since most of them are not fully mature and some are ‘immature’.

In Russia, this is aggravated by the worsening investment climate (Nureev, 2010, pp.15–17) and low spending on research and development (R&D) in this area. Hayes et al. (2012, pp.15–16) estimate that the government’s per-capita spending on energy efficiency R&D was 0.77 USD/cap in 2010—the second lowest out of the 12 researched countries. In terms of R&D investment in the manufacturing sector, “regardless of the origin of funding”, Russia came last at 0.1% of the country’s GDP (ibid., 2012, p.26). Not only is the R&D spending low, but also much of prospective investment in Russia’s energy sector is likely to fund fossil fuels. Popov (2012, p.9) calculates that 1,300–1,800 billion USD, or about 60% of total energy investments in Russia out to 2030, will finance the coal, oil and gas sectors (at least, in the absence of a substantially changed policy arena).

#### 7.4.1 Energy efficiency

Although Russia is one of the world’s leaders in the development of combined heat and power technology (Popov, 2012), other energy efficiency initiatives are under-developed, which suggests its technical energy efficiency potential is relatively high. Bashmakov et al. (2008) estimate that Russia could save just under 300 Mtoe by implementing energy efficiency measures, including the elimination of natural gas flaring (Table 33). Amongst the categories of total primary energy supply, the technical energy efficiency potential of heat generation is
more than a third of the total potential. Within the total final energy consumption, the highest potentials are in the residential and manufacturing sectors, followed by transport. For comparison, these potentials amount to 30–50% of Russia's total energy consumption in 2005. As an example, Table 34 suggests how the nation’s energy efficiency potential can be realised between 2010 and 2020.

Table 33. Energy savings through technical energy efficiency measures in Russia (Mtoe) (Bashmakov et al., 2008, p.14)

<table>
<thead>
<tr>
<th>Unit: Mtoe</th>
<th>Coal</th>
<th>Crude oil</th>
<th>Petroleum products</th>
<th>Gas</th>
<th>Other solid fuels</th>
<th>Electricity</th>
<th>Heat</th>
<th>TOTAL</th>
<th>Compare to 2005 consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total, including the elimination of natural gas flaring</td>
<td>58.34</td>
<td>2.50</td>
<td>34.65</td>
<td>192.09</td>
<td>6.92</td>
<td></td>
<td></td>
<td></td>
<td>294.49</td>
</tr>
<tr>
<td>Elimination of natural gas flaring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12.09</td>
<td>12.09</td>
</tr>
<tr>
<td>Total primary energy supply</td>
<td>58.34</td>
<td>2.50</td>
<td>34.65</td>
<td>180.00</td>
<td>6.92</td>
<td></td>
<td></td>
<td></td>
<td>282.40</td>
</tr>
<tr>
<td>Electricity generation</td>
<td>23.87</td>
<td>0.00</td>
<td>2.53</td>
<td>64.88</td>
<td>1.73</td>
<td></td>
<td></td>
<td></td>
<td>83.01</td>
</tr>
<tr>
<td>Heat generation</td>
<td>23.31</td>
<td>0.46</td>
<td>7.38</td>
<td>71.02</td>
<td>3.47</td>
<td>1.82</td>
<td></td>
<td></td>
<td>107.45</td>
</tr>
<tr>
<td>Fuel production, transformation, transmission and distribution</td>
<td>2.15</td>
<td>2.04</td>
<td>0.17</td>
<td>5.92</td>
<td>0.07</td>
<td>10.08</td>
<td></td>
<td></td>
<td>41.29</td>
</tr>
<tr>
<td>Total final energy consumption</td>
<td>9.01</td>
<td>0.00</td>
<td>24.57</td>
<td>38.18</td>
<td>1.65</td>
<td>19.52</td>
<td></td>
<td></td>
<td>60.72</td>
</tr>
<tr>
<td>Agriculture and forestry</td>
<td>0.02</td>
<td>1.53</td>
<td>0.08</td>
<td>0.04</td>
<td>0.73</td>
<td>0.50</td>
<td></td>
<td></td>
<td>2.90</td>
</tr>
<tr>
<td>Fishery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mining</td>
<td>0.00</td>
<td>0.14</td>
<td></td>
<td>0.37</td>
<td>0.60</td>
<td>0.12</td>
<td>0.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>8.41</td>
<td>1.19</td>
<td>9.86</td>
<td>1.40</td>
<td>7.72</td>
<td>12.90</td>
<td></td>
<td></td>
<td>41.49</td>
</tr>
<tr>
<td>Construction</td>
<td>0.00</td>
<td>0.20</td>
<td>0.01</td>
<td>0.01</td>
<td>0.25</td>
<td>0.04</td>
<td>0.50</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>0.00</td>
<td>0.00</td>
<td>21.29</td>
<td>14.95</td>
<td>0.00</td>
<td>1.67</td>
<td>0.39</td>
<td>38.30</td>
<td></td>
</tr>
<tr>
<td>Municipal utilities</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.36</td>
<td>0.34</td>
<td>0.72</td>
<td>3.61</td>
<td></td>
</tr>
<tr>
<td>Services sector</td>
<td>0.01</td>
<td>0.02</td>
<td>3.12</td>
<td>0.01</td>
<td>4.60</td>
<td>7.44</td>
<td>15.20</td>
<td>36.31</td>
<td></td>
</tr>
<tr>
<td>Residential sector</td>
<td>0.57</td>
<td>0.18</td>
<td>10.16</td>
<td>0.19</td>
<td>3.82</td>
<td>38.50</td>
<td>53.42</td>
<td>108.24</td>
<td></td>
</tr>
<tr>
<td>Non-energy-use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45.73</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: “Numbers in italic are for total energy inputs to power and heat generation. Final energy consumption and those numbers are not additive due to the fact that both sectors have positive energy outputs – correspondingly power and heat, which are used by final consumers” (ibid.)

Table 34. Estimated realisation of energy efficiency potential in Russia between 2010 and 2020 (Fiodorov et al., 2009, p.14)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total energy</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Million toe per year</td>
<td>Share of total energy efficiency potential</td>
</tr>
<tr>
<td>2010</td>
<td>55–58</td>
<td>63%</td>
</tr>
<tr>
<td>2015</td>
<td>135–140</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>250–275</td>
<td></td>
</tr>
</tbody>
</table>

7.4.2 Renewable energy

In terms of risks to energy security, the supply chain for renewable energy sources typically contains fewer elements than that for conventional fuels. For example, onsite renewables facilitate the development of a de-centralised model of energy supply, reducing the need to
build long-distance transmission lines or to transport fossil fuels and uranium from extraction sites to power stations. At the same time, some renewable energy sources may involve other risks, for instance, intermittent power supply of solar and wind energy, if operating in isolation, or assuming a passive grid. Even if the energy efficiency potential is realised, there will be a need to use a mix of existing and new energy sources to satisfy the nation’s energy demand during the transition to a low-carbon economy.

Table 35 summarises recent estimates of Russia’s renewable energy potential. Evidently, non-intermittent renewable energy sources (geothermal, small-scale hydropower and biomass) have the highest economic potential adding up to 250 Mtoe together. Wind and solar energy, although having some of the highest technical potentials compared to other renewables in Russia, may be difficult to harvest cost-efficiently. The economic potential of energy sources is usually calculated based on current wholesale energy prices, although in the absence of reliable data, alternative methods may be used (see, for example, Bezrukikh et al., 2007, pp.17–18). Numerous uncertainties are associated with calculating both technical and economic potentials; consequently, such estimates vary greatly and should be used with caution (Slade et al., 2011). In addition, it is often unclear from the studies whether they account for longer-term impacts of climate change on the potential of renewable energy sources.

Table 35. Renewable energy potential for producing electricity and heat in Russia (Mtoe/year) (Bezrukikh et al., 2007, p.67; Fiodorov et al., 2009, p.16; Kobyshева, 2012, p.490)

<table>
<thead>
<tr>
<th>Unit: Mtoe/year</th>
<th>Technical potential</th>
<th>Economic potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal</td>
<td>11,868</td>
<td>114</td>
</tr>
<tr>
<td>Small-scale hydropower</td>
<td>126</td>
<td>70</td>
</tr>
<tr>
<td>Biomass</td>
<td>140</td>
<td>69</td>
</tr>
<tr>
<td>Wind</td>
<td>2,216</td>
<td>11</td>
</tr>
<tr>
<td>Solar</td>
<td>9,676</td>
<td>3</td>
</tr>
<tr>
<td>Low-grade heat</td>
<td>194</td>
<td>53</td>
</tr>
<tr>
<td>Bio-waste</td>
<td>92</td>
<td>54</td>
</tr>
<tr>
<td>TOTAL</td>
<td>24,221</td>
<td>374</td>
</tr>
</tbody>
</table>

7.5 Conclusion

This chapter describes and analyses a small portion of data collected for the backcasting exercise. Only the more prominent trends and patterns are covered here, with much of the data remaining in the ASK-Russia spreadsheet. The chapter explores past and current trends in Russia’s energy system and economy seeking empirical evidence to support low-carbon transitions. In the past two decades, some of the variables have undergone dramatic changes, for example, the shares of energy-intensive industry and of services in the country’s GDP, as well as some exports and imports. In addition, a number of variables, e.g., the freight turnover
of rail and road transport, have experienced a rapid and substantial decline in the 1990s and an equally large increase in the 2000s.

Despite such trends being relatively unambiguous over certain periods of time, it is uncertain whether they will be sustained over a significant number of years in the future, which may render extrapolations meaningless. Yet, although there are few clear patterns in historical data on Russia, and no systematic data for Russia separately from other Soviet republics are available before 1990, the importance of trends should not be underestimated. Regardless of their limited extent, the trends can indicate potential opportunities for or barriers to decarbonisation. For example, an increase in the use of aviation transport is likely to interfere with demand-side energy policies, whilst the growth of the services sector may be beneficial for reducing the energy intensity of the economy.

Building on the detailed picture of past and current trends summarised here (stage 2 of backcasting), chapter 9 will explore ‘desirable’ future states of Russia’s energy system in 2050 and pathways towards them (stages 3 and 4 of backcasting), expanding on what trends are likely to challenge or facilitate low-carbon transition. Before that, the next chapter (chapter 8) will introduce the process of scenario iteration and the contribution of stakeholders thereto, including their comments on the consistency, relevance and feasibility of the backcast scenarios. Chapter 8 will essentially narrate how and why the scenarios had changed before they acquired their final shape reported in chapter 9.
8 Chapter 8: The research’s journey: the iterative process of refining the backcast scenarios

8.1 Introduction

This chapter merges two final stages of backcasting (stages 5 and 6) and the main aspects of iterations that the backcast scenarios underwent throughout the project. Chapter 5 has explained that the fifth stage of backcasting ensures the backcast scenarios are relevant and consistent, whilst the sixth stage evaluates relative feasibility and potential implications of the generated scenarios and desired future states. This is achieved through engaging both internal peer-reviewers and external experts, as this chapter shows. The internal peer-review process has predominantly focused on technical details of the scenarios, whereas the external stakeholder engagement has yielded more general comments on scenario framing and context, thereby providing a ‘reality check’ for the scenarios. For this purpose, the choice of external stakeholders as ‘engaged actors’ amongst the Russian-policy community (rather than the scenario-studies community) has been deliberate.

In reporting the iterations of and adjustments in the backcast scenarios—one of the main outputs of the thesis—this chapter essentially narrates the ‘journey’ of the research project. Clearly, the actual research journey was inevitably messier than the final text of this chapter (or, indeed, of this thesis), whence the challenge of assembling the written work originates. The iteration process has been ongoing, and in many instances it is difficult to determine the chronological order of ideas arising from internal peer-reviews, comments of expert interviewees and the researcher’s own thinking process. For want of a non-linear written structure, the chapter is organised as follows. After the introduction, Section 8.2 details how early and relatively more quantitative stages of the iteration process contributed to the development of backcast scenarios. Scenario-focused insights from in-person expert interviews are reported in section 8.3, followed by section 8.4 on expert insights with broader implications for mitigation. Section 8.5 concludes the chapter.

8.2 Early and relatively ‘more quantitative’ stages of the iteration process

Even prior to the thematic analysis of the in-person interviews, it was evident that most of the interview material related to the storylines, the context and other qualitative characteristics of the backcast scenarios. Therefore, before reporting insights from the interviews, this section describes relatively more technical aspects of the iteration process. Although early stages of
the technical iterations chronologically preceded the in-person interviews, the interview material did shape the final version of the scenarios, which is shown in this section.

Table 36 summarises the early version of the backcast scenarios and the TRENDS pathway presented at the third-year review meeting. The researcher originally developed two backcasting scenarios building on earlier work by Anderson et al. (2005). In scenario CHERRY, energy consumption was assumed to double, whereas in scenario MELON it was halved by 2050. At that stage two more scenarios were work in progress. In particular, PLUM was to focus on high penetration of nuclear energy, to incorporate a number of short- to medium-term promises made by the Russian Government. The fourth scenario, KIWI, was to highlight the possibilities of a zero-nuclear low-carbon future, given concerns about the cost of nuclear infrastructure and rapidly decreasing uranium reserves. A non-backcasting ‘what-if’ pathway TRENDS originally extrapolated the 2000–2009 tendency in energy demand (as opposed to that in energy supply). The early version of the TRENDS curve had a polynomial shape, i.e., increasing with time faster than a linear shape but slower than an exponential one.

| Table 36. A 2050 snapshot of the two backcast scenarios and the TRENDS pathway developed at earlier stages of this research project (version 30/08/2012) |
|-----------------------------------------------|-----------------------|-----------------------|
| **TRENDS** | **CHERRY** | **MELON** |
| Annual GDP growth | 5.1% | 3.4% | 2.1% |
| Dominant sectors in terms of: 1. GVA 2. total energy consumption 3. annual CO₂ emissions | 1. services, non-intensive industry, energy industry 2. household, intensive industry, energy industry 3. road transport, international aviation | 1. services, non-intensive industry 2. household, intensive industry 3. household; intensive industry |
| Final energy consumption (Mtoe) | 1,805 | 882 | 219 |
| CO₂ emissions (MtC/yr) | 1,510 | 30 | 77 |
| Number of households (million) | 63.3 | 56.9 | 56.6 |
| Energy use per person | -2.3% pa reduction as per trends | -2.8% pa | -4.9% pa |
| Supply mix | All fossil fuels (without CCS); nuclear; renewables; biofuels | Fossil fuels with CCS and bioCCS; large proportion of nuclear and renewables; hydrogen; biofuels | Fossil fuels (no CCS), particularly gas; nuclear in grid as today; large proportion of biofuels |
| Emission mitigation policies | Following current trends: rapidly growing demand and supply | Little done on demand side; and dramatically decarbonising supply, developing CCS and nuclear | Decreasing demand and partly decarbonising supply |
| Transport | Following current trends | Decarbonising transport fuels to a very large extent | Decarbonising transport fuels to a moderate extent |
| Transport fuels | Oil, natural gas | Oil, biofuels, hydrogen | Oil, gas, biofuels |

Note: the table format adopted from (Anderson et al., 2005, Table A, p.20)

The third-year review meeting resulted in a number of changes to both the ‘what-if’
(TRENDS) and backcast (CHERRY and MELON) pathways. In particular, a 5.1% GDP growth in TRENDS out to 2050 raised questions as to how realistic it would be in a relatively industrialised country. Accordingly, the growth in energy consumption and emissions was deemed too high. The internal peer-review suggested that the finite nature of fossil fuel energy resources and existing infrastructural lock-in might be a barrier to extremely high growth rates of the economy- and energy-related variables. Following the discussion, the researcher revised the TRENDS pathway introducing more defensible assumptions and elaborating on the ‘big picture’, i.e., an emission gap between the extrapolated trends and the backcast scenarios. Subsequently, the original polynomial TRENDS curve became less steep, approaching a linear shape similar to existing reference cases from scenario literature (see chapter 8 for details of the updated TRENDS pathway).

The original backcast scenarios (CHERRY and MELON) drew comments on both their presentation and substance. To make the scenario more transparent and comparable to other scenarios and to the baseline year, internal peer-reviewers requested information on the split between electrical and non-electrical energy and on the structure of primary rather than final energy consumption. An additional suggestion on scenario presentation was to provide flexibility between coal- and gas-based carbon capture and storage depending, for example, on the geopolitical situation, technological progress and fossil fuel reserves.

Substance-focused recommendations related to (in the order of increasing importance) allowing time for transition before an emission peak, providing ‘imperfect analogues’ to scenario assumptions and contextualising the scenarios. Allowing time for a low-carbon transition from the current state of the energy system would make scenarios more feasible and realistic, which is particularly relevant to policy-oriented research. In the original version, both backcast scenarios peaked in 2010, the year when the latest data for the scenario tool were available. The peer-reviewers suggested that the researcher should test how the backcast scenarios would change if the transition started later, for example, with current trends continued until 2015. The immediate discontinuity of the original scenarios from trends was deemed improbable. After a series of revisions following internal peer-reviews and the in-person interviews, the researcher decided to not only introduce a transition period but also differentiate the peak years of the scenarios. In the final version, emission pathways of the four backcast scenarios peak in 2013, 2015, 2020 and 2025 as the previous chapter (chapter 8) has explained.
According to the third-year review panel, ‘imperfect analogues’ would help to imagine and present a vivid picture of what a desirable low-carbon world might look like. For example, scenario CHERRY with a doubling energy use could be compared to the historical energy consumption growth in industrialised nations (e.g., Germany after the war), to precedents in Russia’s past and to currently industrialising nations (e.g., China, India and Bulgaria). Similarly, scenario MELON with a halved energy use could have intensity indicators analogous to, for instance, Sweden. This would then help to understand whether insights from Russia’s case can be applied in similar countries. The researcher introduced the ‘imperfect analogues’ accordingly based on economy-related similarities with other countries and with Russia’s past. The analogues were then presented to experts in face-to-face interviews alongside other scenario characteristics. Table 37 shows a truncated version of characteristics of the backcast scenarios discussed with interviewees during the second stage of stakeholder engagement. The general impression from the interviews was that the ‘imperfect analogues’ row provided more questions than answers. This was particularly problematic for the experts who considered Russia unique in some or many aspects, despite the interviewees themselves using plenty of ‘imperfect analogues’ without being prompted. Based on the stakeholder input and additional internal peer-review, the researcher removed the ‘imperfect analogues’ from the scenario summary.

Table 37: Part of the scenario summary table presented to experts during the first two in-person interviews (VERSION 5, 10/04/2013)

<table>
<thead>
<tr>
<th>Scenario group description</th>
<th>Service-based re-industrialisation</th>
<th>Manufacturing-based re-industrialisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A post-industrial economy through ‘de-industrialisation’ and re-orienting economic activities towards services</td>
<td>An economy based on restored and renovated light and heavy industries; producing a large share of products domestically</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sectors with the largest GDP share</th>
<th>Scenario A</th>
<th>Scenario B</th>
<th>Scenario C</th>
<th>Scenario D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legend: Share in the GDP in 2050: (H) 60–80%; (M) 30–50%; (L) 5–20%</td>
<td>agriculture and forestry (L) construction (L)</td>
<td>services (H) highly efficient mining and processing (L) construction (L)</td>
<td>highly efficient mining and processing (H) agriculture and forestry (L) construction (L)</td>
<td>highly advanced and consumer-goods manufacturing (H) services (M) construction (L)</td>
</tr>
</tbody>
</table>

| Precedents as ‘imperfect analogues’ | USSR (1974, focus on agriculture), India, US | Latvia (a ‘Baltic Tiger’-style economic growth) | USSR (1974, focus on industries), Iceland, Canada, New Zealand | Japan, Germany, S. Korea, UK, US |

Finally, the third-year internal peer-review suggested the researcher contextualise the backcast scenarios through, firstly, describing the past and current state of Russia’s energy system and,

42 Note that, for the purposes of stakeholder engagement, the names of scenarios were denoted with letters rather than fruit names. Scenario A corresponds to ‘Plum’, B to ‘Cherry’, C to ‘Melon’ and D to ‘Kiwi’ (see chapter 8 for details).
secondly, elaborating on and justifying scenario storylines. The researcher had previously adopted a highly numerical framing, and as a consequence the original scenarios resembled a ‘maths game’ with little qualitative information. The following paragraph from the third-year report illustrates the original approach to scenario generation showing that, despite the occasional use of such terms ‘assumption’, ‘transition’, ‘storyline’ and ‘carbon budget’, the context and scenario narratives were missing.

“In the CHERRY scenario the doubling of energy consumption by the middle of the century is achieved by multiplying the baseline electricity, non-electric energy and CHP in the spreadsheet by 200% in 2050. The *assumption* is that 20% of this reduction (relative to 2009) happens in 2015 and 80% in 2030. In the MELON scenario, the energy consumption is halved by 2050, i.e., the baseline amount is multiplied by 50% in the corresponding scenario tab. It is assumed that 20% of this reduction relative to 2009 happens in 2015 and 80% in 2030. For scenario emissions to stay within the *carbon budget*, the fossil fuel consumption is gradually reduced in both scenarios across the following three categories: non-electrical energy, combined heat and power (CHP), and electricity from the grid. For example, in MELON, coal consumption for non-electrical energy is brought down to zero by 2050 and substituted with energy from renewable sources. For the *transition*, in 2030 the amount of coal decreases 80% compared to the baseline; in 2015 it is 20% below the baseline – all replaced by renewable energy sources instead. The oil undergoes a 20% reduction in 2015, 80% in 2030 and 90% in 2050, relative to the baseline, as a 100% reduction in oil use by 2050 is deemed impossible, particularly, for the transport sector. This is compensated by the increase in biofuel consumption. No changes are made to the amount of gas consumed for non-electrical energy, apart from halving it compared to 2009 as per the original *storyline* of the MELON scenario.” (Sharmina, 2012, pp.10–11, emphasis added)

The suggestion to contextualise the scenarios had anticipated the second stage of backcasting, subsequently covered in chapter 7 to develop an understanding of changes in Russia’s energy system and identify technical and resource constraints. The background chapters analysed some political, cultural and socio-economic lock-ins, which this chapter explores further based on stakeholder input. As a result, the backcast scenarios transformed from a ‘maths game’ into more contextual storylines (see chapter 8) refined through internal peer-review and suggestions of the expert interviewees. An important starting point of this transformation was the third-year review panel’s recommendation to devise two types of scenario based on heavy industry vs. hi-tech re-industrialisation. This helped the researcher to clarify the ‘top line’ thinking on the storylines, and the final version distinguishes between services-based *de-
industrialisation (scenarios Plum and Cherry) and manufacture-based re-industrialisation (scenarios Melon and Kiwi), with the manufacture-based scenario group covering the original suggestion on hi-tech vs. heavy industry. Both the internal peer-review process and expert interviews were instrumental in developing the scenario storylines, whilst the expert opinion also provided a reality check on both quantitative and qualitative elements of the backcast scenarios. The next two sections summarise key findings from the in-person expert interviews, with some of the emerging themes focusing on the backcast scenarios and others having broader implications for governance and policy insights.

8.3 Scenario-focused insights from the stakeholder engagement

Following the methods of semi-structured interviewing and thematic analysis set out in chapter 5, the researcher used some of the stakeholder input to adjust the scenario storylines. This section reports whether and how the adjustments took place. Interview findings from the thematic analysis are grouped, in this and the next sections, into four aspects including presentation, consistency, feasibility and decarbonisation triggers. Although some of the reported findings are narrow and scenario-specific, many relate to broader implications for the decarbonisation process as well as for policy implementation and governance issues in general. Not all comments of the expert interviewees were taken on board for two main reasons. Firstly, a number of suggestions, if implemented, would lead to a greater level of detail in the four scenarios. Not only would this risk cluttering the storylines but also (by making the storylines too specific) reduce the flexibility in mitigation-related suggestions arising from the scenario exercise. Secondly, although one key aim of the interviews was to encourage imaginative thinking about potential low-carbon futures for Russia’s energy system, most interviewees’ comments were firmly grounded in the past and current trends (as a quote from expert 4 following this paragraph shows). Whilst this fulfilled the second key aim of stakeholder engagement to provide a reality check for the scenarios, there was clearly tension between the two aims that had to be resolved subjectively by the researcher.

“I just find it very difficult to imagine any scenario in Russia where mining & processing in Russia is not going to be very, very prominent.”

(expert 4, pers. comm. 13/06/2013)

8.3.1 The presentation and framing of the scenarios

The first group of insights from the interviews covers the framing, or formulation, of the backcast scenarios (e.g., justifying scenario characteristics and structural logic) and their presentation (e.g., defining, explaining and adding more detail). In terms of the framing,
expert 1 suggested to improve the logic and defensibility of the scenarios with ‘a tree of
factors’ that would feed into the conceptual framework of the thesis. Clearly defined
categories from the tree of factors would be combined to yield a large number of scenarios,
exhausting all possible combinations of scenario characteristics. This suggestion was,
independently, supported by one of the internal peer-reviewers. The other two expert
interviewees gave no such suggestion, whilst one more expert was explicitly against it:

“And what’s the point of that, that’s useless. Again, [a scenario is] a heuristic, plausible
efficient. […] You cover four plausible enough bases.”

(expert 2, pers. comm. 09/05/2013)

Following a number of internal-peer-review discussions, the researcher decided to continue
with the scenarios as heuristics exploring a number of interesting and plausible futures in a
particular context, in line with the definition of scenarios as a normative rather than
descriptive tool (chapter 5). However the researcher did use expert 1’s advice to link scenario
characteristics to the conceptual framework of the thesis (as section 3.1 in chapter 8 explains)
and to back up certain scenario characteristics with literature on drivers of greenhouse gas
emissions (see section 3.3 in chapter 8). Whilst these changes did not affect either the analysis
or the findings, they improved the clarity and presentation of the scenarios.

Another important suggestion from the interviewees on the formulation of scenarios related
to the place of Russia in the global context. All four experts commented on the limited global
dimension in the scenario summary, i.e., it was unclear what happens to the rest of the world
in the envisioned futures. The interviewees’ questions regarding the international context
converged on a discussion about a future shape of the Russian economy and the country’s
place in the world:

“[…] you’re talking about Russia, and it seems like you’re taking it out of everything else
that’s going on, so it seems like the only global variable you’re talking about is 2 degrees
Celsius, right? […] I guess it would also be important in terms of production… I mean
other global variables are also important; they will have certain influence on what’s
going on in Russia and other countries. Russia is not alone in this world.”

(expert 1, pers. comm. 23/04/2013)

“[…] there are still these question marks about what is Russia’s role in the global
economy. Is it a place that makes things? Is it a place that just produces resources? If it’s a
service economy, is that the service economy only producing services for the domestic
market?”

(expert 3, pers. comm. 21/05/2013)

The experts’ comments on Russia’s current and future role in the world reflected a contemporary debate in
the relevant literature (see, for example, Kheshgi et al., 2012, p.482).
By contrast, only one interviewee explicitly suggested that scenarios may need to elaborate on possible implications for Russia’s ‘regions’, i.e., areas other than Moscow and St. Petersburg, although this linked to the more prominent and politically-important issue of ‘effective occupation’ raised by experts 3 and 4 (see the next section):

“The regional consequences of your different scenarios are not really explored in detail here, but I think you’re kind of hinting at it in terms of population [and settlement patterns].”

(expert 3, pers. comm. 21/05/2013)

After considering the experts’ recommendations on the international context, the researcher concluded that a nearly infinite range of futures for the rest of the globe could be envisaged for the four backcast scenarios. It was deemed impractical to either list them all or define criteria for selecting more suitable ‘futures’ for the rest of the world, as it was unlikely to affect the overarching conclusions of this thesis. Hence, instead of adding the global context as an explicit variable to the scenario summaries, the researcher refined existing scenario categories to better reflect Russia’s role in the world. As section 3.2 in chapter 8 explained, sectors with largest GDP share, factors of economic growth and main outputs in the scenario table indicate the shape of the economy based on the country’s relative competitive advantages in 2050, whilst aspects of governance and values and, to some extent, transport and settlement patterns suggest whether the economy is open or closed, local or global. Additionally and importantly, an international dimension had framed the scenario exercise from the outset, in the form of a global carbon budget compatible with the 2°C threshold.

Other comments on the presentation of the scenarios involved defining specific terms (e.g., multi-level governance Types I and II), clarifying the baseline to which economic and energy changes related, and zooming in on certain scenario aspects. In particular, the experts suggested adding more information about the dynamics of energy consumption and energy intensity; explaining what happens to the current housing stock in Russia in future; distinguishing between financial and IT services in the service-oriented scenarios; adding high-value added goods (rather than services) to more scenarios; and, discussing what happens to oil and gas in each storyline. The researcher defined terms and clarified the baseline as requested, but decided that most of the suggested additional detail would provide little value to the scenarios for the purposes of this thesis, being either of little consequence, implied elsewhere in the scenario categories, or, in some cases, inconsistent with the rest of a particular storyline.
8.3.2 The consistency and feasibility of the scenarios

In terms of the consistency within each scenario, the experts commented on the combinations of economy/energy and governance more than on any other aspects of the scenarios. This was likely due to the policy-oriented expertise of the interviewees and their busy schedule that left little time for analysing the rest of scenario summaries in detail. Scenarios Melon and Kiwi raised most questions about internal consistency. Expert 1 argued that, although scenario Melon seemed more feasible than others, there were no right conditions for it to be achieved through top-down capitalist expansion, unless it involved a benevolent dictator or an enlightened monarchy (pers. comm. 23/04/2013). Scenario Kiwi, according to expert 2, looked “distinctly illiberal” rather than decentralised; for example, it could be an autarky where Russia would be fully self-sufficient and closed to the rest of the world (pers. comm. 09/05/2013). Furthermore, expert 2 suggested that the dominance of government investment was more plausible in conjunction with suppressed consumption and limited freedoms (ibid.).

The experts’ comments on consistency led to a discussion on the feasibility and plausibility of the scenarios. For example, scenario Melon was unanimously perceived by the interviewees as similar to today’s Russia and involving only incremental change by 2050, hence more plausible. The other three scenarios raised feasibility-related questions for different reasons. For example, both experts 2 and 3 stated that high growth in scenario Cherry is unlikely to be accompanied by low energy demand:

“[…] if that were to happen over 40 years, that would be an example of a miracle in terms of economic history.”

(expert 2, pers. comm. 09/05/2013)

Upon reflection the researcher adjusted the 2050 energy demand in scenario Cherry from ‘low’ to ‘medium’, in line with the recommendation, although the adjustment was made to ensure consistency with the rest of the scenario storyline, rather than on feasibility grounds. More specifically, the economic structure envisaged in scenario Cherry was relatively energy-intensive, which was evident in at least two characteristics of this scenario (see Table 39 in chapter 8). Firstly, mining and processing and the construction industry were amongst the top three GDP-contributing sectors; and, secondly, all modes of transport were assumed to be well developed and extensively used. These two aspects of the storyline suggested that Cherry’s economic structure would be more likely characterised by ‘medium’ than ‘low’ energy demand.
In relation to the feasibility of scenario Plum, expert 1 argued that the de-urbanisation aspect rendered it implausible:

“…when you talk about de-urbanisation, I would expect people moving back to agriculture and to [subsistence] farming, which is completely unrealistic. This means that the whole human kind is going to be degrading so much that it would just go back to pre-medieval ages I’d say. Everything that is created, will be forgotten. [...] you cannot just get rid of technology. Society is co-evolving with technology, these are artefacts that are produced by society and they are getting embedded in the social structure…”

(expert 1, pers. comm. 23/04/2013)

As a general comment on the opinion above, a shift back to agriculture as the main economic activity is not impossible (albeit unlikely), for example, following a series of natural disasters and/or economic shocks. However, and particularly in relation to scenario Plum, de-urbanisation does not necessarily imply technological ‘retrogression’. The scenario storyline specifies that the IT-focused services sector dominates the economy, whilst the share of agriculture is relatively low⁴⁴ (Table 39), which implies that much of the services sector’s value-added is generated in a highly decentralised way, for example, individually or at multiple IT clusters in rural locations.

Expert 4 saw a different problem with the feasibility of scenario Plum (and scenario Kiwi) due to the assumption on de-centralised governance:

“…you’ve got a couple of your scenarios which got devolved power, and I am not a very cynical person in character, but I think devolving is an incredibly difficult thing in the Russian state, and anyone who wanted to do it, ended up not doing very much. Because if you start devolving, it would start breaking up in a number of states.”

(expert 4, pers. comm. 13/06/2013)

By contrast, expert 1 stated that the current, centralised, governance structure could not possibly continue for long (pers. comm. 23/04/2013). This opinion was directly or otherwise corroborated by the other three interviewees, including expert 4 – seemingly contrary to the expert’s quote above on the difficulty of devolving power in Russia. The apparent contradictions and, at the same time, consistency of some responses related to broader (as opposed to scenario-specific) and more complex themes that emerged during the interviews, including the weakness of the state, the ‘social contract’ and other unique (or otherwise) characteristics of Russia. The discussion of these complex themes and controversies is provided in the next section of this chapter and, partly, in chapter 10.

⁴⁴ Although at 20% of GDP in 2050, Russia’s agricultural sector in scenario Plum is significantly larger than that of most countries in the baseline year (i.e., in 2009).
8.4 Insights from stakeholder engagement related to broader implications for mitigation

8.4.1 Russia’s case: unique or common?

Amongst complex ideas expressed by the experts, the idea of Russia being one-of-a-kind was the main source of conflicting opinions. Although the researcher’s questions and prompts did not include this theme, it emerged in every in-person interview and was usually discussed alongside barriers to and triggers for decarbonising Russia:

“I don’t think Russia is peculiar. I think we’re all human beings and we respond to incentives. [...] I find it very difficult to speak in terms of mentalities and cultures. [...] to me, the simple thing is human beings, whether you are in the Arctic, whether you’re in China, whether you’re in Russia, whether you’re in Latin America or live in the woods of the Amazon, respond to incentives.”

(expert 2, pers. comm. 09/05/2013)

“I always have this debate with Russian friends who are always telling me Russia is different, nowhere is like Russia. And I say, well, it’s not really like that, there are more universal processes, and Russia is not immune to them. But in my own work [...] I have really struggled about where to stick Russia. [...] There is and was no analogue for Russia. And it comes back to the Hill/Gaddy argument that this is a failed industrial economy. We don’t have other historical examples of a failed industrial economy of this scale. [...] There ARE no analogues.”

(expert 3, pers. comm. 21/05/2013)

“You know Russia is never going to be as stable as Germany, America or UK.”

(expert 4, pers. comm. 13/06/2013)

Whilst the sample of expert opinions was too small to draw a general conclusion, they were in agreement with the researcher’s own observation that Russia is comparable to other nations in some aspects and unique in many others. In particular, Russia is facing universal barriers to decarbonisation (explicitly highlighted by expert 3 as ‘inertia’ and implied by the other three interviewees) and likely to respond to incentives (which was noted by experts 2, 3 and 4). For instance, the government (both in the Soviet Union and, less extensively, in Russia) used incentives to pursue their strategic agenda of ‘effective occupation’—the term emerged during an interview with expert 3, whereas experts 2 and 4 referred to it indirectly—in relation to encouraging Soviet/Russian citizens to settle in the country’s remote regions.

45 Such incentives often included a one-off relocation allowance, a northern and/or a far-eastern allowance added to monthly wages and salaries, an annual travelling allowance for visiting family in the western parts of Russia, a multiplier for the length of service in remote regions (which essentially meant an early retirement with a full-scale state pension) and so on.
At the same time, all interviewees pointed, sometimes obliquely, to a number of distinct characteristics of the country. Another emerging theme was that these characteristics were often misinterpreted. For example, a theme of ‘state incapacity’ (in relation to pervasive inefficiencies in policy implementation) surfaced in all four interviews as a long-standing problem in Russia that gave rise to conflicting interpretations both within and outside the country. For example, whilst expert 2 pointed out that conflicting interpretations exist, expert 4 actually demonstrated the contradiction in their own answers to interview questions:

“The Russian state is so weak! I often get frustrated with journalists and academics who make out of Putin some sort of dreadful dictator, like he is really powerful. I think the man says something and it’s probably ignored by the time it gets to the Kremlin walls! This is the state that for hundreds of years had a great deal of difficulty in implementing policies.”

(expert 2, pers. comm. 09/05/2013)

“I agree […] about the ‘strong’ state argument, and I actually wrote a short book where, if I didn’t use the word ‘weak’ state, I certainly used similar words.”

“[…] with every Russian energy saving person you meet […], and all of them say the same thing, which is if only central government will pay serious attention to this for like 10 minutes, everything will change. And I think that’s true.”

(expert 4, pers. comm. 13/06/2013)

8.4.2 Potential decarbonisation triggers

The experts agreed that Russia’s current politico-economic paradigm had no capacity to deliver low-carbon policies, as numerous implementation issues had demonstrated before (see chapter 2). At the same time, the interviewees portrayed this impediment to decarbonisation as an opportunity—with the current ‘system’ being unstable and, hence, susceptible to change—which added further complexity to the issue. Similarly, other characteristics of Russia were discussed as both barriers and potential triggers. The existence of a social contract “based on […] funnelling down [resource] rents” (pers. comm. 09/05/2013), in particular, both ensured the population’s support for the current system and was “inherently unstable and unsustainable” (pers. comm. 21/05/2013). Subtly linked to the social contract and its instability, was the idea of ‘people against the system’ that was explicit in interviews 1 and 3 and implicit in the other two interviews:

46 The two quotes are taken from the beginning and the end of the interview with expert 4, in the order presented here.
“[…] Russian people are inherently anarchic. All these myths about a strong authority and everything, this is a big myth, […] Russian people hate any authority at all, whatsoever.”

(expert 1, pers. comm. 23/04/2013)

“You can see that in the Soviet period – being able to work within and around the system. And the fact that that did that stopped the system from collapsing, that's the ultimate irony. Because if they worked the way the system wanted them to work, the whole thing would have collapsed long ago.”

(expert 3, pers. comm. 21/05/2013)

A major heat wave in Russia in 2010 was mentioned as one example where people organised themselves when the 'system' failed to cope with the emergency. Expert 2, however, argued that it was a local and short-term organisation of the 'civil society' or, rather, community, which would be insufficient to instigate major changes. As Expert 3 noted,

“…the history of Russia tends to be more shock therapy than gradualism […] although if you think about the circumstances by which the Soviet system collapsed it was through a series of public protests in Moscow that actually occupied a very small area and overthrew a huge country.”

(expert 3, pers. comm. 21/05/2013)

This seemed to support the view that radical change (e.g., rapid and large-scale mitigation and/or adaptation) may be possible in Russia, considering the country’s economic and political situation, as well as its tumultuous past. Indeed, historically Russia’s government was prone to large-scale ‘experimentation’ and risk-taking—activities considered important for innovation (Watson, 2012, p.103), in addition to the population’s entrepreneurial skills manifest in people working around the ‘system’.

Expert 3 saw parallels between the current situation and the 1980s, in terms of both Russia riding the energy sector and “the heavy-handedness of the government in dealing with protests” (pers. comm. 21/05/2013). The interviewees unanimously suggested that, not being a resilient politico-economic regime, Russia is susceptible to both internal and external shocks; for example, a sharp increase in the domestic price of energy and/or a drop in the global oil price could trigger a breakdown of the ‘social contract’. However, as expert 2 argued, it would be too naively optimistic to expect a turn for the best after a ‘shock’ to the current system—“just by looking at history, in Russia or in other countries, sometimes things can keep on getting worse and just not getting any better” (pers. comm. 09/05/2013). Amongst the more gradual ‘triggers’ for change, expert 2 suggested that there needs to be sufficient demand for

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47 Russia’s propensity for ‘experimentation’ is further strengthened by the government’s generally limited concern about public policy failure.
the rule of law that could come from civil, political and business potential agents of change (ibid.).

8.5 Conclusion

As chapter 5 explained, the backcasting process is iterative, which helps to verify feasibility of a desirable objective and devise appropriate low-carbon transition paths. External experts may contribute valuable insights to assessing various aspects of feasibility and consistency of pathways and scenarios. This chapter has illustrated the process and outcomes of iterative adjustments in the backcast scenarios generated within this research project. It is evident that the iteration process was multi-dimensional and involved the researcher’s own thinking, internal peer-reviewing and interviews with external experts, amongst other interrelated activities. The chapter deliberately shifts focus from, predominantly, stakeholder engagement input, given that the other two scholarly activities (own thinking and peer-reviewing) are traditionally less formalised in backcasting studies. In participative backcasting, the rationale for covering all three activities is their formative role in a research project’s journey.

This chapter demonstrates that the research has undergone a significant transformation since its inception in 2009. In particular, although a two-stage stakeholder engagement process was envisaged from the beginning of the project, the type of stakeholders chosen for the pilot stage did not fulfil the purpose of contributing to the backcast scenarios (as chapter 5 explained). After the initial recruitment process, five pilot interviews were conducted providing limited input for the scenarios. Following a suggestion by internal peer-reviewers, the researcher involved expert stakeholders later in the project to obtain their feedback on results of the scenario exercise. Other changes related to the project’s subject matter and presentation, rather than its research design. For example, based on the external expert input and additional internal peer-review, the researcher removed ‘imperfect analogues’ from the scenario summary and provided more in-depth and coherent scenario characteristics.

The iteration process, in general, and the expert interviews, in particular, provided a wealth of material shaping both the scenarios and the context of the research. The thematic analysis of the interviews yielded insights on the consistency of the backcast scenarios, triggers to and levers for decarbonisation, the uniqueness and comparability of Russia, the incapacity of the state, the social contract, effective occupation and the idea of ‘people against the system’. The stakeholder input helped to improve the clarity and consistency of the scenario storylines and to situate mitigation-related recommendations, arising from the scenario exercise, within a broader context. Some of the interview material proved contradictory, illustrating the
complexity of the issues discussed and the difficulty of resolving these issues in practice.

Building on the detailed picture of past and current trends summarised in chapter 7 (stage 2 of backcasting), the next chapter will explore ‘desirable’ future states of Russia’s energy system in 2050 and pathways towards them (stages 3 and 4 of backcasting), expanding on what trends are likely to challenge or facilitate low-carbon transition.
9 Chapter 9: Desired future states of the energy system and transitions towards each future

9.1 Introduction

This chapter explores ‘desirable’ future states of Russia’s energy system in 2050 and pathways towards them, covering the third and fourth stages of backcasting. The word ‘desirable’ encapsulates the strategic objective of the backcasting exercise derived in Chapter 6. As a reminder, the strategic objective is to generate scenarios characterising an evolving energy system for Russia in 2011–2050 within the 5.5–7.1 GtC (20.2–26.1 GtCO$_2$) cumulative emission budget range, which is commensurate with a relatively low probability of exceeding 2°C global mean surface temperature increase. To implement the strategic objective, the ASK-Russia tool is used as a modelling environment. Results of the modelling and assumptions behind the generated scenarios are explained in this chapter.

The previous chapter (Chapter 7) listed three main constraints that should be taken into account in low-carbon scenario exercises and, importantly, when implementing low-carbon options in the ‘real world’. One of them is inertia in the energy system and socio-economic environment. The existing system contains both ‘lock-in’ trends and incipient “key elements of future paradigms” (Wilby and Wigley, 1997, p.271), and this chapter analyses which scenarios may be adversely or favourably affected by the past and current trends. In this way, the ‘desirable’ futures and pathways take into account elements of the existing energy system discussed in the previous chapter: economic and demographic trends, infrastructural constraints, and the technical potential of energy efficiency and renewable energy. Russia’s socio-political context explored in chapter 3 is also considered here when developing the scenario storylines. An evident connection between the real-world trends and ‘desirable’ futures in the storylines is a low-carbon transition, described as part of pathways towards the futures.

The structure of this chapter is as follows. After the introduction, section 9.2 provides a summary of the four backcast scenarios, including their main characteristics in 2050 and annual emissions in 1990–2050. Section 9.3 then explains why particular scenario characteristics are brought together in a particular order, followed by section 9.4 on ‘undesirable’ futures and on trends enabling or challenging the transition to such futures. Decarbonisation options used in the scenarios are described in section 9.5. Section 9.6 elaborates on each of the four backcast scenarios, and section 9.7 concludes.
9.2 Cross-scenario results: summary

Scenarios are heuristics exploring interesting aspects of potential futures and, when developed with the backcasting approach, tend to be highly numerically intensive. Combining the breadth of parameters with the limited time and resources available within a PhD, four backcasting scenarios were constructed for this thesis. The intention was to have an even number of backcast scenarios with neutral names to avoid the ‘middle tendency’ and ‘name bias’ effects, when the scenario user is influenced by the ‘good’ or ‘bad’ keywords. The scenarios were originally presented to stakeholders under the letters A, B, C and D for the reasons of practicality and neutrality. These letter labels were deemed practical since no single distinct characteristics was sufficient to illustrate each scenario and, as a consequence, any headline descriptor would be simplistic. The argument for ‘neutrality’ was to highlight that there was no obviously preferable scenario amongst the four as they would all eventually converge on a ‘desirable’ future (defined in chapter 6). However, the researcher later renamed the scenarios Plum, Cherry, Melon and Kiwi to make them easier to distinguish and remember visually. To preserve the ‘neutrality’ of the scenarios, only fruit names with no negative connotations were chosen. Indeed, the fruit names are arguably more neutral than the letter names since letter ‘A’ may be perceived as superior to all other letters, ‘B’ as preferable to ‘C’ and ‘D’, and so on.

Two types of pathways have been generated with the ASK-Russia tool. The first type, a ‘what-if’ extrapolation, continues recent historical trends in energy consumption for a given period, whilst the second type, a range of backcast scenarios, is carbon-optimistic and pushing the boundaries of the socio-economic and technical feasibility to stay within the designated emission budget constraint. The ‘what-if’ pathway TRENDS is necessary for factoring in a transitional period from the current state of the energy system towards a decarbonisation path as the backcast scenarios follow the TRENDS trajectory until their respective emission peaks. The second type follows the backcasting approach, where the starting point is a desirable state of the energy system in 2050. Along each backcast trajectory, there is the baseline year and three future points (see Table 38) at which the country’s energy system is described in detail in the ASK-Russia spreadsheet. Interim year 1 differs amongst the four backcast scenarios, depending on their respective storylines (see section 9.6 of this chapter). The first interim year is chosen to provide a transition period for the energy system before emissions peak, whilst the second scenario year (2030) is approximately halfway between the baseline year (2009) and the endpoint of a pathway. To plot annual points over 2010–2050, the CO₂ numbers are interpolated between the three scenario years, and between the baseline and emission peak years.
Table 38. The baseline year and three future points on the backcast pathways

<table>
<thead>
<tr>
<th>Points on the backcast pathways</th>
<th>Scenarios</th>
<th>Plum</th>
<th>Cherry</th>
<th>Melon</th>
<th>Kiwi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline year</td>
<td>2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interim year 1 (emission peak year)</td>
<td>2013</td>
<td>2015</td>
<td>2020</td>
<td>2025</td>
<td></td>
</tr>
<tr>
<td>Interim year 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endpoint year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2050</td>
</tr>
</tbody>
</table>

Table 39 details the main characteristics of the four backcast scenarios as a range of desirable futures in 2050. The structure of the table loosely follows the UKCIP’s key “dimensions of change” (UKCIP, 2000, p.18). The final two rows of the table summarise measures and outcomes thereof that, according to the scenario storylines, take the country to the ‘futures’ described in the table. Section 9.3 of this chapter explains the logic of the scenario structure and the terminology used in the table.

Table 39. The main characteristics of the backcast scenarios in 2050

Legend: (T) 100%; (H) 60–80%; (M) 30–50%; (L) 5–20%

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Plum</th>
<th>Cherry</th>
<th>Melon</th>
<th>Kiwi</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 GDP and energy dynamics</td>
<td>Low growth Low energy demand</td>
<td>High growth Medium energy demand</td>
<td>Medium growth Medium energy demand</td>
<td>High growth High energy demand</td>
</tr>
<tr>
<td>2 Sectors with the largest GDP share in 2050</td>
<td>Services (H) Agriculture and Forestry (L) Construction (L)</td>
<td>Services (H) Highly efficient mining and processing (L) Construction (L)</td>
<td>Mining and processing (H) Agriculture and forestry (L) Construction (L)</td>
<td>Highly advanced and consumer-goods manufacturing (H) Services (M) Construction (L)</td>
</tr>
<tr>
<td>4 Main outputs [the ‘quantity’ of value added]</td>
<td>High value-added services Low value-added goods</td>
<td>High value-added services Medium value-added goods</td>
<td>Low to medium value-added goods</td>
<td>High value-added goods</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td>Governance, social and political values</td>
<td>Short-term decarbonisation achieved through...</td>
<td>Medium- to long-term decarbonisation achieved through...</td>
</tr>
<tr>
<td>---</td>
<td>-----------</td>
<td>----------------------------------------</td>
<td>-----------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Freight, but not passenger, transport used extensively. International shipping used extensively to support agricultural and forest exports. Public transport developed better than private. Main modes: shipping, rail, road.</td>
<td>Multi-level governance Type I: levels multiple but limited, multi-task, non-overlapping and stable</td>
<td>Reduction in road transport energy consumption through less and slower travel. Improved agricultural and forestry practices. Biofuel replacing coal (L).</td>
<td>Economy restructured away from energy-intensive manufacturing. New housing stock complying with strict energy efficiency standards. Onsite renewable energy. Non-energy CO₂ reduced through economic restructuring.</td>
</tr>
<tr>
<td></td>
<td>Both passenger and freight transport used extensively. International aviation and shipping used extensively for both importing goods and travelling. Both public and private transport well developed. Main modes: shipping, aviation, rail, road.</td>
<td>A centralised approach: state-led democracy</td>
<td>Reduction in road transport energy consumption through energy efficient vehicles. Existing nuclear and hydro-power stations used to their full capacity. Biofuel replacing coal and oil (T).</td>
<td>New, mostly high-rise, housing stock complying with strict energy efficiency standards. Wide-spread combined heat and power (CHP). New nuclear power plants built, including CHP. Onsite renewable energy. Non-energy CO₂ reduced through the use of alternative feedstock. Coal CCS and/or gas CCS.</td>
</tr>
<tr>
<td>7</td>
<td>Public transport developed better than private. Main modes: shipping, rail, road.</td>
<td>Multi-level governance Type II: levels innumerable, task-specific, overlapping and flexible</td>
<td>Non-energy CO₂ reduced through the use of alternative feedstock. Biofuel replacing coal and oil (T).</td>
<td>Electrification of transport. Onsite renewable energy. Wide-spread combined heat and power (CHP). New nuclear power plants built. Non-energy CO₂ reduced through the use of alternative feedstock. BioCCS.</td>
</tr>
<tr>
<td>8</td>
<td>For the purposes of the cross-scenario summary, Figure 22 illustrates the scenario emission curves between 2011 and 2050 as well as historical emissions in 1990–2010. After significant</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

48 The energy system of individual backcast scenarios is described in section 9.6 of this chapter, after a justification of why certain scenario characteristics are brought together and an explanation of the TRENDS
reductions in fossil fuel use, three out of four scenarios only just stay within the remaining carbon budget with cumulative emissions around 7 GtC (25.6 GtCO₂), i.e., at the upper end of the 5.5–7.1 GtC (20.2–26.1 GtCO₂) budget range. The fourth scenario, Kiwi, has the latest peak (2025) and exceeds the budget constraint at 7.3 GtC (26.7 GtCO₂) despite a dramatic reduction in energy and non-energy emissions between the peak and 2050 as well as negative emissions after 2030. This scenario allows a temporary overshoot; however, if negative emissions continue beyond the final year of the model (2050), the cumulative budget of the scenario will gradually decrease to the ‘allowed’ level. Note that only one scenario out of four assumes negative emissions for reasons explained in section 9.5.2 of this chapter.

To stay within the budget constraint, a later emission peak typically results in a steeper post-peak pathway. For example, scenario Cherry has an emission peak in 2015 (compared to Melon’s 2020 and Kiwi’s 2025), and subsequently slopes downwards at a more gradual rate than Melon and Kiwi. Scenario Plum is, to some extent, an exception with emissions peaking in 2013 and an annual reduction rate of 13% until 2030 being higher than Cherry’s 10% per year (see Table 40). Scenario Kiwi displays the most dramatic post-peak reduction rates. Note that, although its emission reduction rate between 2030 and 2050 appears high in percentage terms, it is low in absolute terms. Kiwi’s largest emission reductions in absolute terms happen between the peak and 2030, as is the case in the other three scenarios. This is largely due to a high technical potential of biomass in Russia (see the preceding chapter), which makes it a relatively feasible option in the short and medium terms. Issues related to how feasible the backcast scenarios are technically and socio-economically are explored in the discussion chapter (chapter 10).

Note that the TRENDS pathway is followed by the backcast scenarios up to their respective emission peak years.
Figure 22. Highly stylised plots of Russia’s annual emissions in 1990–2050: the TRENDS pathway and four backcast scenarios, with 1990–2010 being historical emissions (MtC/yr)

Table 40. Emission peak dates, annual emissions and emission growth/reduction rates for the low-carbon pathways in 2009 and in the interim scenario years

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Peak year</th>
<th>2009 (MtC/yr)</th>
<th>2030 (MtC/yr)</th>
<th>2050 (MtC/yr)</th>
<th>Emission growth/reduction rate to an interim year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRENDS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual emissions</td>
<td>461.5</td>
<td>452.1</td>
<td>628.1</td>
<td>809.7</td>
<td>0.7%</td>
</tr>
<tr>
<td>Emission growth/reduction rate to an interim year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.2% - 1.3%</td>
</tr>
<tr>
<td><strong>PLUM (peak in 2013)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual emissions</td>
<td>461.5</td>
<td>445.9</td>
<td>127.5</td>
<td>63.1</td>
<td>0.7%</td>
</tr>
<tr>
<td>Emission growth/reduction rate to an interim year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-13.3% - 3.6%</td>
</tr>
<tr>
<td><strong>CHERRY (peak in 2015)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual emissions</td>
<td>461.5</td>
<td>452.1</td>
<td>108.9</td>
<td>39.8</td>
<td>0.7%</td>
</tr>
<tr>
<td>Emission growth/reduction rate to an interim year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-10.0% - 5.2%</td>
</tr>
<tr>
<td><strong>MELON (peak in 2020)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual emissions</td>
<td>461.5</td>
<td>504.4</td>
<td>71.8</td>
<td>4.1</td>
<td>0.7%</td>
</tr>
<tr>
<td>Emission growth/reduction rate to an interim year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-21.5% - 15.4%</td>
</tr>
<tr>
<td><strong>KIWI (peak in 2025)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual emissions</td>
<td>461.5</td>
<td>562.9</td>
<td>1.2</td>
<td>-20.7</td>
<td>0.7%</td>
</tr>
<tr>
<td>Emission growth/reduction rate to an interim year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-239.4% - 1149.8%</td>
</tr>
</tbody>
</table>

Notes: * Except the TRENDS pathway, which has no emission peak as such.

9.3 Characteristics of the backcast scenarios

9.3.1 The structure of the backcast scenarios: origins and reasoning

Scenarios are heuristics exploring a number of the most interesting and plausible futures in a particular context. Scenarios should be reasonably different in their essential characteristics to be of interest to the scenario user. As explained previously, the logic of the scenario structure in this thesis (see Table 39 above) broadly follows the UKCIP’s five “dimensions of change”
commonly found in socio-economic scenario studies (UKCIP, 2000, p.18). The categories the UKCIP report identifies are demography and settlement patterns, the composition and rate of economic growth, the rate and direction of technological change, the nature of governance, and social and political values (ibid.), in this order. Whilst it is unclear from the report whether the order and specific content of the five categories is important, they have been adapted to match the research design of this thesis. This section justifies changes in the original five categories and explains why particular scenario characteristics are brought together in a particular order.

Several criteria are used to adjust the UKCIP's dimensions of change, with priority given, firstly, to categories with the most immediate and significant impact on emissions and, secondly, categories relatively easy to quantify. Thirdly, the structure of both the original ASK tool and ASK-Russia, largely shaped by the first two criteria, restricts modelling to specific variables (as chapter 5 explained). Fourthly, the most prominent and interesting trends (see Table 43 in section 9.4.5 of this chapter) help to identify variables that the decarbonisation process should target. Finally, the feasibility and, hence, implementation timeframe of various decarbonisation options helps to prioritise the dimensions of change. For example, it is reasonable for scenarios to initially focus on exploring combinations of technical and behavioural change necessary for a low-carbon transition. Such combinations would indicate how institutions and policies may need to be adjusted to achieve the socio-technical change, given the political and cultural contexts.

These criteria, guiding the modification of the UKCIP’s categories, suggest that the scenarios in this thesis are ‘socio-technical’ or ‘techno-economic’, rather than ‘socio-economic’. For example, the first two criteria, listed in the previous paragraph, are commonly used for assessing environmental impacts through the IPAT identity \[^{49}\] (Impact = Population x Affluence x Technology). In such assessments, governance and values are rarely considered explicitly, and the focus is on demography, economy and technology, as is the case for the scenarios developed in this thesis.

For the purposes of this chapter, the first two UKCIP categories—demography and economy—have been swapped and expanded. Demographic and settlement indicators are, to some extent, easier to quantify than economic and technological indicators, as there are fewer interrelations and changes occur more gradually. Nonetheless, the economy category takes

\[^{49}\] For the purposes of this thesis, ‘Affluence’ in the IPAT identity (Impact = Population x Affluence x Technology) is assumed to be measured by per-capita GDP, and ‘Technology’ is represented as the carbon or energy intensity of GDP (Chertow, 2001).
priority as it covers all GVA-producing sectors, thereby introducing energy use and emissions in the economy. This is consistent with the focus of the ASK-Russia tool. The economic sectors contributing to GVA indirectly, i.e., the households and transport sectors, are included in the demography and settlement category. This is a straightforward decision for the households but not for transport. Transport and mobility partly affects and depends on variables from a number of categories, for example, GDP growth (the economy category), technological progress (the technology category), behaviour and attitudes of people (the values category) and the structure of political power (the governance category). Yet, settlement patterns and infrastructure—both often driven by the government’s investment—are evidently the main factors impacting transport development. Note that the ‘infrastructure’ variable is also considered in the demography category.

The following subsections explain the context around key characteristics of the backcast scenarios. The subsection ‘The composition and rate of economic growth’ not only provides definitions of economic variables but also explains how they determine the role of Russia in the world, which goes beyond the UKCIP’s dimensions of change. The subsection ‘Demography, settlement patterns and infrastructure’ reviews literature on whether and how related variables affect emissions. The categories on values and governance are covered together in the same subsection. The technology category is re-named ‘Decarbonisation options and outcomes’ in this chapter, as these are directly dependent on what is technologically feasible. The decarbonisation topic is covered later in this chapter, after the analysis of trends and transitions.

9.3.2 The composition and rate of economic growth

The first four substantive rows of Table 39 contain the main economic characteristics of the backcast scenarios. The ‘GDP and energy dynamics’ row qualitatively describes the mean annual growth and energy use of Russia’s economy in 2050, with ‘low’, ‘medium’ and ‘high’ indicating how these variables compare to those in the baseline year (2009). ‘Low’ is about a third lower than in 2009, ‘medium’ is similar to 2009 and ‘high’ is about a third higher than in 2009. The GDP and energy dynamics are consistent with the structure of the economy in 2050, indicated in the second row of Table 39, where three sectors with the largest GDP shares are listed for each scenario in a descending order, by their GDP share. These GDP shares are ‘illustrative cases’ from the ranges consistent with the scenario storylines (Table 41). In other words, in a given backcast scenario, the ASK-Russia tool uses an ‘illustrative case’ for each sector out of an assumed range of sectoral sizes. Table 41 shows each sector’s share of the country’s GDP in 2050 assumed in the backcast scenarios. Both ranges (the third column
of the table) and illustrative cases used in the spreadsheet (the final column of the table), as well as the actual structure of the economy in the baseline year (in the final five rows of the table) are included. The table ascribes the remaining GDP to other sectors after the allocation to the top three sectors.

Table 41. GDP shares of economic sectors assumed in the backcast scenarios in 2050 and the actual structure of the economy in the baseline year (2009)

Legend: Share in Russia’s GDP in 2050: (H) 60–80%; (M) 30–50%; (L) 5–20%

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Sector</th>
<th>Share in GDP: range (%)</th>
<th>Share in GDP: an illustrative case (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario Plum</td>
<td>Services (H)</td>
<td>30–80</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Agriculture, forestry (L)</td>
<td>5–20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Construction (L)</td>
<td>5–20</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Industry &amp; other sectors</td>
<td>0–30</td>
<td>10</td>
</tr>
<tr>
<td>Scenario Cherry</td>
<td>Services (H)</td>
<td>30–80</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Industry (L)</td>
<td>5–20</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Construction (L)</td>
<td>5–20</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Agriculture &amp; other sectors</td>
<td>0–30</td>
<td>5</td>
</tr>
<tr>
<td>Scenario Melon</td>
<td>Industry (H)</td>
<td>30–80</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Agriculture, forestry (L)</td>
<td>5–20</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Construction (L)</td>
<td>5–20</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Services &amp; other sectors</td>
<td>0–30</td>
<td>10</td>
</tr>
<tr>
<td>Scenario Kiwi</td>
<td>Industry (H)</td>
<td>30–80</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Services (M)</td>
<td>30–50</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Construction (L)</td>
<td>5–20</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Agriculture &amp; other sectors</td>
<td>0–5</td>
<td>0</td>
</tr>
<tr>
<td>Baseline year (2009)</td>
<td>Services</td>
<td>n/a</td>
<td>60.7</td>
</tr>
<tr>
<td></td>
<td>Industry</td>
<td>n/a</td>
<td>25.9</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>n/a</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>Agriculture, forestry</td>
<td>n/a</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>n/a</td>
<td>3.0</td>
</tr>
</tbody>
</table>

The third row of Table 39 details the main factors of economic growth (also known as ‘primary factors of production’) appropriate for each scenario storyline. A ‘factor of economic growth’ is an input into the production of goods or services. Such inputs are not exhausted during the production process unlike, for example, fuel and raw materials, however they can deteriorate over time (Deardorff, 2006). This thesis distinguishes between four factors of economic growth: capital, labour, human capital (including, or sometimes also known as, technology, know-how, knowledge and entrepreneurship) and land (including renewable natural resources, for instance, soil fertility). ‘Capital’ includes durable goods produced as a result of investment and used in creating other goods or services. Its main difference from ‘land’ is that ‘capital’ needs to be produced before it can become a factor of production. ‘Human capital’ is defined as “the stock of knowledge and skill, embodied in an individual as a result of education, training, and experience, that makes him or her more productive” (ibid.). It is often known as ‘skilled labour’, but differs from ‘labour’ in its superior level of skill and a higher wage.
Whilst factors of economic growth indicate the ‘quality’ of value added, the row ‘Main outputs of the economy’ in Table 39 represents the ‘quantity’ of value added. Deardorff (2006) defines value added as “the value of output minus the value of all intermediate inputs, representing therefore the contribution of, and payments to, primary factors of production”. Intermediate inputs, for example, raw materials, are expended during production, as opposed to primary factors of economic growth.

The factors of production and main outputs of the economy in each scenario correspond to a scenario economic structure. Although the relative importance of the factors across the scenarios is typically quantified as ‘factor intensity’, it is described qualitatively in Table 39 and reflected in the order of the factors in the third row. The factor price and quantity used determine, to a large extent, the value added of an output. This thesis assumes that, relative to one another, long-term factor prices out to 2050 remain similar to those the baseline year; in other words, whilst absolute prices of factors of economic growth may change over time, the relative factor prices are assumed to continue.

Particularly, in Russia, land has a low factor price compared to other factors of production, whereas capital and labour have medium factor prices, and human capital has a high factor price. However there is a distinction between value added and the international competitiveness of the economy’s outputs. For example, although Russia’s agricultural exports may have low value added domestically, they are likely to be expensive and competitive on the international market in future as a consequence of scarcity caused by climatic changes.

The economic role of Russia in the world is outlined in the rows 1 to 3 of Table 39: sectors with largest GDP share, factors of economic growth and main outputs. In addition, the global context is reflected in the aspects of governance and values and, to some extent, transport and settlement patterns (rows 4 to 6 of Table 39). This demonstrates the importance of these scenario characteristics as part of the storyline and broader context, as opposed to a more narrow focus on energy and emissions. In this way, rows 2–4 indicate the shape of the economy based on the country’s relative competitive advantages in 2050, whilst rows 5–7 suggest whether the economy is open or closed, local or global. As a reminder, another essential part of the global context is Russia’s cumulative emission constraint derived from a global 2°C budget, with the rest of the world assumed to share in the required mitigation effort (chapter 6).
9.3.3 Demography, settlement patterns and infrastructure

Changes in demography-related scenario characteristics in 2050 (rows 5 and 6 of Table 39) are described in relation to the ‘baseline’; i.e., each baseline indicator refers to statistics in 2009, rather than to so-called ‘business-as-usual’ developments of the indicator in the future, in contrast to what is frequently assumed in reference cases of scenario studies. Assumptions on long-term future continuity of past and current trends are difficult to justify. This is especially pertinent to Russia and other transitional economies with low availability of data and an absence of clear recent trends (as section 0 of this chapter explains). Despite limited data, a large number of variables relate to demography, settlement patterns, transportation and infrastructure. To select characteristics appropriate for the scenarios, the criteria outlined in section 9.3.1 were used. For this task, even relatively short-lived trends, in want of longer-lasting ones, may be helpful in selecting the most interesting variables. An additional condition is that the characteristics need to be consistent with the evolving storylines; this is achieved through a series of iterations (see the next chapter for a description of the iteration process).

In addition to the discussed criteria, helpful pointers may come from literature on drivers of greenhouse gas emissions. Studies in this field routinely apply tools of econometrics—a combination of economics, statistics and mathematics—to uncover relations between variables. However, results of econometric modelling are sensitive to assumptions and sometimes criticised for showing spurious correlations between variables, and it is worth keeping in mind these drawbacks.

A review of relevant, albeit limited, literature suggests that demographic and geographical variables considerably affect emissions, despite being less researched than economic variables. In particular, Neumayer (2004, pp.38–39) argues that the more spread out are a country’s population, agriculture and, hence, the transportation system, the more energy this country consumes. This effect is found to be statistically significant. A cold climate and the availability of renewable energy are even more substantively important for the level of emissions (ibid.). The non-negligible effect of these variables suggests that they need to be considered in policy-relevant scenarios. However, because some of these variables have the opposite effect on emissions and because many other factors are at play, it is by no means straightforward to anticipate the resultant effect.

Energy consumption of households is another important demographic variable. In practice-theory research (see, for example, publications by the Lancaster University’s Department of Sociology), a ‘household’ is a common unit of analysis, being arguably a more meaningful unit
than a ‘person’ in terms of both the energy and carbon footprints and acceptance of or resistance to change. For instance, Rosa and Dietz (2012, p.583) review a large number of studies and conclude that a significant proportion of household energy consumption is insensitive to the size of a household, although in transitional economies, more (and, presumably, smaller) households often mean increased energy use per household. In addition, their review of empirical evidence suggests that growth of the number of suburban households is likely to result in more commuting and more personal vehicles (ibid.). In addition to these insights informing the scenario generation, this thesis assumes that small families and solo living are more appropriate for scenarios with high-rise buildings and a high concentration of the urban population, and vice versa, i.e., bigger and fewer households correspond to low-rise buildings.

At a more profound level, scenario studies often imply that larger households are consistent with community values, whilst smaller households correlate with individualistic values. Although this may well be the case in certain regions, this thesis refrains from explicit value-related assumptions. Fixed assumptions about governance and its influence on other scenario characteristics and on emissions may also be problematic and are, hence, excluded from this thesis. The next subsection explains the reasoning behind the researcher’s decision.

### 9.3.4 The nature of governance, social and political values

In its review of socio-economic scenarios, the UKCIP (2000, p.17) states that “technology [dimensions] are […] dependent on social values and regulation”. This thesis argues that, if this is the case and if, in addition, values shape behaviours, then placing governance and values at the foundation of scenarios may restrict the scope of technological and behavioural change in a backcasting (i.e., exploratory) exercise. This would, in turn, limit options for a low-carbon transition, particularly in the short-term. The intention is, instead, to work backwards in three stages. At the first stage, backcast scenarios should be generated to explore how technology and behaviour can contribute to decarbonising the energy system. At the second stage, the researcher analyses the barriers to the decarbonisation process that are due to existing aspects of governance and values or to other various current trends. At the third stage, the researcher suggests what changes to current socio-political context (i.e., governance, values and other ‘trends’) are necessary for enabling a low-carbon transition. This chapter covers the first two stages, whilst chapters 9 and 10 explore the third stage, although a comprehensive analysis of governance and values is beyond the scope of this thesis.
Although particular values and aspects of governance can be, to some extent, inferred from the storylines, this thesis avoids framing scenario characteristics in the form of dichotomies. Such characteristics—community values vs. consumerism, local vs. global, autonomy vs. interdependence, economic vs. environmental, authoritarianism vs. democracy—are common in scenario studies using a twin-axis approach (IPCC, 2000a; UKCIP, 2000; Berkhout et al., 2002). This approach has a number of disadvantages. Firstly, scenarios containing some of the characteristics may be perceived as more desirable than others, whereas the intention of backcasting is that they all have a desirable long-term future. Secondly, the twin-axis approach implies that particular values and governance characteristics correspond to certain elements of scenarios, as in the example above on community values and the size of households (see section 9.3.3 of this chapter). Such approach risks losing some of the richness and depth of scenarios. Thirdly, as explained in the previous paragraph, by locking scenarios into the simplistic and rigid assumptions on governance and values, the two-axis approach restricts the potential of technological and behavioural change.

The scenario summary in Table 39 shows that a variety of governance regimes can lead to desirable, low-carbon futures. Empirical evidence validates this statement, to some extent. Rosa and Dietz (2012, p.584) argue that, despite the opinion that democracies are more likely than authoritarian states to care about the provision of public goods, “forms of governance are generally not significant predictors of greenhouse-gas emissions,” *ceteris paribus*.

Some studies on ‘varieties of capitalism’ suggest that a country’s interpretation and implementation of capitalism can affect its capacity for generating emission mitigation technologies (see, for instance, Mikler and Harrison, 2012, pp.199–200). In particular, co-ordinated market economies (e.g., Germany and Japan) are likely to be more successful than liberal market economies (e.g., the US) at tackling climate change (ibid.). This thesis does not explicitly assign particular types of either capitalism or other economic systems to scenario-specific governance regimes. Nonetheless, a number of keywords from the scenario storylines may indicate that the two scenarios with a centralised approach to governance (Cherry and Melon) are more likely to represent co-ordinated market economies. At the same time, the multi-level governance scenarios (Plum and Kiwi) do not exclude either co-ordinated or liberal types.

Arguably, a benevolent dictator concerned about climate change might have a higher chance to decarbonise the energy system in each scenario quickly. If, however, the same governance regime (e.g., a benevolent dictatorship) were assumed in each scenario to achieve a desirable
future, it would reduce the diversity and richness of the scenarios. Therefore this thesis draws on a range of governance characteristics.

In Table 39, the closest to a ‘climate-focused benevolent dictatorship’ is state-led environmentalism, followed by another centralised regime – a managed democracy similar to the situation in Russia in the 2000s. Note, however, that ‘state-led environmentalism’ does not necessarily imply centralised power, although ‘a managed democracy’ probably does. Two unquestionably decentralised regimes are labelled multi-level governance of Type I and Type II. Hooghe and Marks (2001, p.4) describe Type I governance as having a large but limited number of levels with non-overlapping jurisdictions, relatively stable over time and performing many tasks in their particular territorial jurisdictions. Type II presents innumerable polycentric levels of governance, task-specific, often overlapping territorially and flexible (ibid.). Type I may sometimes be described as ‘federalism’ and is a widespread form of governance globally, with Canada, the European Union and, to some extent, Russia as examples. Type II is less clear-cut and typically occurs in “densely populated frontier regions in North America and Western Europe”, with relevant institutions most advanced in Belgium, Germany and the Netherlands (Hooghe and Marks, 2001, pp.10–11). Evidently, some of these regimes and corresponding socio-political values may require much effort and time to develop in the Russian context. For this reason, scenarios need to incorporate a transition period to diverge from ‘undesirable’ trends and establish pathways to a low-carbon future.

9.4 Diverging from ‘undesirable’ pathways and futures

9.4.1 The TRENDS pathway

Until their respective emission peaks, all of the backcast scenarios follow the TRENDS trajectory with emissions growing at 0.7% annually, given that realistic pathways to ‘desirable futures’ ought to build on existing foundations, at least, in the near term. It is therefore reasonable to explore TRENDS and a number of references pathways from literature in some detail. Figure 22 (in section 9.2) shows that there is a widening gap between the backcast scenario pathways and the TRENDS trajectory after the scenarios peak. The 2011–2050 cumulative budget of TRENDS is about 24.7 GtC (90.4 GtCO₂), which is more than triple of the upper end of the allowed budget range.

periods appear too short for trends to establish themselves. The 1990s trends are discarded due to the instability of the political, economic and social situation at the time making emission drivers volatile. By contrast, the first decade of the 21st century was, overall, relatively stable in terms of Russia’s economic performance and the population’s well-being. For this reason, the researcher has used the 2000–2009 tendency in sectoral energy consumption for developing the TRENDS trajectory.

Figure 23 shows how extrapolated energy use in each sector changes between the baseline year and 2050. Evidently, the energy industry and international aviation have the highest annual energy growth rates, followed by the services sector and road transport. The primary energy supply in TRENDS in 2050 is 919 Mtoe, which is about twice as high as that in 2009. More than 90% of primary fuels are hydrocarbons heavily dominated by coal (see Figure 24 below). Coal—the most abundant fossil fuel resource in Russia (Nekrasov and Siniak, 2007, pp.26–29)—is assumed to meet the growing energy demand in the future. A different fuel mix would clearly change the resulting annual and cumulative emissions of the pathway. Annual carbon dioxide emissions in 2050 are around 810 MtC/yr (2.96 GtCO₂/yr), i.e., nearly double the 2009 level (see Table 40 above), with a 2011–2050 emission budget of 24.7 GtC (90.4 GtCO₂) (see Table 42 below).

Figure 23. Final energy demand by sector in TRENDS in 2009–2050 (Mtoe)
TRENDS is non-contextual extrapolation containing little qualitative information, i.e., no narrative accompanies the pathway in terms of political, socio-economic, cultural and technological aspects. Whilst energy consumption trends are extrapolated *ceteris paribus*, this in itself may be a problematic assumption. For example, an expanding fossil fuel industry implies Russia’s entrenched role as an exporter of natural resources in the 2050 world. However, although existing fossil fuel resources are sufficient to meet increasing energy consumption, it is debateable whether international demand for Russia’s hydrocarbons will increase at the same rate as in the 2000s. In addition, developing the available resources would require significant investments in new infrastructure, which is not entirely *ceteris paribus*. Along similar lines, the growing energy use may be incompatible with a static structure of the electricity grid, given that most existing power stations are to be decommissioned by 2050 (see chapter 7). In essence, the TRENDS pathway extrapolates a limited number of variables and deliberately assumes away relationships between them. This is a widespread assumption in reference, or ‘business-as-usual’, cases developed in scenario literature.

### 9.4.2 Reference scenarios: SRES, BP, Greenpeace and IEA

**The IPCC: Special Report on Emissions Scenarios (SRES)**

Amongst the SRES scenarios (IPCC, 2000a), the A1FI marker best satisfies the main attribute of a reference case—approximating the real world emission pathway. According to Raupach et al. (2007, p.10289), “the actual emissions trajectory since 2000 was close to the highest-emission scenario in the envelope, A1FI”, although the real world emission growth rate was even higher than that in A1FI. Raupach et al.’s study was published in 2007 and the global annual emission growth rate they used, 3.3% over 2000–2005, accelerated to 5.9% in 2010 (Peters et al., 2012b, p.2).

The A1FI illustrative scenario for ‘REF’ countries (Eastern and Central Europe and the Former Soviet Union) provides data with a 10-year interval, with the rest of the emissions
interpolated in the ASK-Russia tool. From the SRES spreadsheet on the REF region, it follows that Russia historically emitted more than other ‘REF’ nations, in proportion to its population, thereby inordinately drawing on the common carbon budget. In 2000, Russia’s population share was 34% of the total REF population, whereas its cumulative emissions over 2000–2010 were 49% of REF’s, and its annual emissions in 1990, 2000 and 2010 constituted 53, 44 and 45% of REF’s respectively. To plot Russia’s emissions with the data provided in the SRES, the country is assumed to henceforth emit in proportion to its population, bearing in mind equity and personal responsibility considerations.

The British Petroleum: “Energy Outlook 2030”

In the BP’s reference case, the only information about emissions available from the text is that “the growth of global CO$_2$ emissions from energy averages 1.2% p.a. over the next twenty years (compared to 1.9% p.a. 1990–2010)” (Finley, 2012, p.35). To calculate the carbon budget of this scenario for the purposes of this thesis, the 1.2% growth rate is applied to Russia’s historical emissions starting from 2011.

Another assumption relates to the timeframe of the BP’s scenarios. The ‘Energy Outlook’ end-point year being 2030, the same emission growth rate is assumed until 2050. It is worth repeating that the actual global CO$_2$ emission growth in 2010 was 5.9% per annum, despite the economic crisis (Peters et al., 2012b, p.2). Although it dropped to about 3% per year in 2011 (Peters et al., 2012a, p.4), global carbon dioxide emissions are unlikely to decrease in the foreseeable future without stringent mitigation action or widespread economic slowdown (Anderson and Bows, 2011, p.41). Hence, the BP’s reference case probably overestimates the ‘real-world’ global cumulative emissions budget.

Greenpeace: “Energy [r]evolution”

For its ‘Energy [r]evolution’ project, Greenpeace has developed a separate family of scenarios for Russia. For the reference case, this thesis adopts emission growth rates from Teske and Tchouprov (2009, p.42). For instance, the 2050 energy emissions constitute 92% of the 1990 level, i.e., in the future the emissions continue growing but never reach their 1990 peak. To calculate a carbon budget, the emissions are interpolated between decadal data points provided by Greenpeace up to 2050.

The researcher has attempted to gauge the resulting emission pathway against additional information available in the report. In particular, in the report’s Reference Scenario, Russia’s CO$_2$ emission from energy will grow by more than a fifth by 2050 (Teske and Tchouprov,
2009, p.36). It is however unclear what baseline year is implied, and hence the information is of little use.

**The IEA: “Energy Technology Perspectives 2012”**

The International Energy Agency describes its 6DS scenario as an extrapolation of current trends (IEA, 2012b), which makes it a classic ‘reference case’. Emission data are provided for Russia, amongst other countries and regions, at a 5-year interval up to 2050, and the researcher has interpolated numbers between these data points.

It is unclear whether the IEA’s Energy Technology Perspectives and other reference cases consistently include international aviation and shipping emissions in their scenario outputs. If this is not the case, the bunker fuel emissions up to 2050 will need to be added, to be consistent with the TRENDS scenario assumptions.\(^\text{50}\)

### 9.4.3 Medvedev’s pledge

At the 15th Conference of the Parties to the UNFCCC in 2009, Dmitry Medvedev, then president of Russia, stated that the country is ready to reduce CO\(_2\) emissions 25% below the 1990 level by 2020 (Medvedev, 2009). Although, in 2012, Russia refused to participate in the second commitment period of the Kyoto Protocol, the pledge has been included in a recent draft decree on ‘The Level of Greenhouse Gas Emissions’ (Draft Decree of the President of Russia, 2013). To calculate what this ‘commitment’ means in terms of a carbon budget, CO\(_2\) emissions in the ASK-Russia tool are set at 75% of the 1990 level in 2020 and interpolated between the 2010 historical emissions and 2020.

If the CO\(_2\) emissions are assumed to stay at the 2020 level (i.e., 25% below 1990) afterwards, the resulting cumulative emissions over 2011–2022 are about 5.8 GtC (21.2 GtCO\(_2\)), which exceeds the lower end of the carbon budget range. The upper end of this century’s budget is exceeded in 2025 with cumulative emissions totalling 7.3 GtC (26.7 GtCO\(_2\)). It means that Russia’s current commitment is likely to result in spending the country’s entire 21st-century carbon budget by 2025. If the country continues to emit at the 2020 rate until 2050, its 2011–2050 cumulative emissions will be as high as 20.2 GtC (73.9 GtCO\(_2\)), which is almost three times greater than the upper end of its ‘allowed’ budget range. Therefore, the pledge is inconsistent with the signed international agreements on the 2°C target. Rather, it is in line

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\(^{50}\) Shell International BV has developed another well-cited family of scenarios (Shell, 2008). However it is not used in this thesis, as Shell provides no non-mitigation scenarios. Although Shell’s ‘Scramble’ appears more suitable than the other storyline, ‘Blueprints’, it still implies mitigation measures by stating that in 2050, “the world needs around 15% less energy than if it had not acted” (Shell, 2008, emphasis added).
with reference, or business-as-usual, pathways and is likely to be insufficient to avoid dangerous climate change.

9.4.4 Comparing the backcast scenarios with Medvedev’s pledge and the reference pathways

In Table 42, the scenarios are sorted by their 2011–2050 cumulative emission budgets. The only pathway that implicitly includes mitigation policies is ‘Medvedev’s pledge’; however its results are only marginally different from the non-mitigation pathways. Furthermore, if the optimistic assumption about staying at the 2020 level until 2050 is relaxed, ‘Medvedev’s pledge’ will result in a budget that exceeds that of some reference cases. For example, if the annual emission growth rate of 1.6% between 2011 and 2020 is maintained post-2020, the resulting 2011–2050 cumulative emissions are 24 GtC (87.8 GtCO₂), which is greater than the budgets of all but one non-mitigation cases.

Table 42. The comparison of non-mitigation reference scenarios and ‘Medvedev’s pledge’ to ASK-Russia’s TRENDS scenario

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Medvedev’s pledge</td>
<td>5.8 (20.9)</td>
<td></td>
<td>7.3 (26.3)</td>
<td></td>
<td>20.2 (72.7)</td>
<td></td>
</tr>
<tr>
<td>IEA’s ETP 6DS</td>
<td>5.9 (21.2)</td>
<td>Lower end of the budget range exceeded in 2022</td>
<td>7.5 (27.0)</td>
<td>Upper end of the budget range exceeded in 2025</td>
<td>22.2 (79.9)</td>
<td></td>
</tr>
<tr>
<td>BP’s reference case</td>
<td>5.7 (20.5)</td>
<td>Lower end of the budget range exceeded in 2022</td>
<td>7.2 (25.9)</td>
<td>Upper end of the budget range exceeded in 2025</td>
<td>22.5 (81.0)</td>
<td></td>
</tr>
<tr>
<td>Greenpeace’s reference case</td>
<td>5.7 (20.5)</td>
<td></td>
<td>7.5 (27.0)</td>
<td></td>
<td>23.6 (85.0)</td>
<td></td>
</tr>
<tr>
<td>SRES A1FI</td>
<td>5.9 (21.2)</td>
<td></td>
<td>7.6 (27.4)</td>
<td></td>
<td>25.6 (92.2)</td>
<td></td>
</tr>
<tr>
<td>Cf. ASK-Russia TRENDS</td>
<td>5.7 (20.5)</td>
<td>Lower end of the budget range exceeded in 2022</td>
<td>7.3 (26.3)</td>
<td>Upper end of the budget range exceeded in 2025</td>
<td>24.7 (88.9)</td>
<td></td>
</tr>
</tbody>
</table>

The TRENDS scenario exceeds the budget range constraint almost simultaneously with the reference scenarios and has a comparable cumulative budget, as is evident from Figure 25. The TRENDS 2011–2050 carbon budget is 24.7 GtC (88.9 GtCO₂), which is only exceeded by that of the SRES A1FI reference case. The TRENDS budget goes over the lower end of
the 21st-century budget range constraint in 2022 at 5.7 GtC (20.5 GtCO₂); and the upper end in 2025 at 7.3 GtC (26.3 GtCO₂). On average, the 2011–2050 cumulative emissions of the reference scenarios are three to four times higher than Russia’s remaining carbon budget. The gap in absolute terms is 15.7–17.3 GtC (57.5–63.3 GtCO₂) over the same timeframe. The lower (upper) end of the budget range is consistently exceeded around 2021–2023 (2024–2026) across all reference cases and Medvedev’s pledge.

Figure 25. ‘Reference’ emission pathways for Russia from literature and the TRENDS emission pathway in 2011–2050 (MtC/yr)

9.4.5 Transitions: enabling and challenged trends

This subsection highlights the trends that should be built upon or discontinued if decarbonisation is to take place. The word ‘trends’ is used here nominally as there are few clear patterns in historical data on Russia, and no systematic data for Russia separately from other Soviet republics are available before 1990 (as chapter 7 showed). Despite the limited data, the importance of ‘trends’ cannot be overestimated. Table 43 summarises changes over time in the key variables pertinent to the backcast transitions. The rows of the table roughly correspond to the UKCIP’s ‘dimensions of change’, with the ‘Main exports and imports’ variables added to characterise Russia’s role in the world. Depending on the type of variable, some changes can be traced quantitatively (e.g., sectoral dynamics, changes in mobility and urbanisation), whilst others can only be described as a narrative (e.g., values and governance). It is evident from the table that, in the first case, a ‘trend’ is a sustained move in a particular direction over a relatively short period of time, whereas for the second type of variable, ‘trends’ are systemic characteristics unlikely to change noticeably over the years.
The first two columns show that, in the past two decades, some of the variables have undergone dramatic changes, for example, the shares of energy-intensive industry and of services in the country’s GDP, as well as some exports and imports. A number of variables, e.g., the use of rail freight and road freight, have experienced a rapid and substantial decline in the 1990s and an equally large increase in the 2000s. Despite such trends being relatively unambiguous over certain periods of time, it is uncertain whether they will be sustained over a significant number of years in the future, which may render extrapolations meaningless. As noted in subsection 9.4.1, the choice of a trend from a particular period is a fundamental assumption for extrapolating and, hence, for modelling the transitions. The second column of Table 43 shows trends over the whole period where data are available to illustrate the instability of the trends. However the signs in the last four columns refer to trends in the 2000s for reasons explained in subsection 9.4.1.

The last four columns of Table 43 indicate what trends are likely to enable (+) or challenge (−), and be challenged by, low-carbon transitions in the backcast scenarios. No trends are disruptive for all four scenarios at the same time, and, by design, no scenario goes against all the trends considered in the table. This is intentional, since a scenario challenging all trends is unlikely to be feasible. The analysis in the table highlights what scenarios go mostly against trends and where particular difficulties in implementation may arise. For example, scenario Melon is least disruptive for current trends, closely followed by scenario Cherry. Scenario Kiwi is likely to face more difficulties in implementation than other scenarios.

Not only the quantity of ‘difficulties’, i.e., the number of (−) in a scenario column, but also their quality matters. Many trends and characteristics of the system are particularly difficult to reverse, for example, the dramatic decline of manufacturing, the dominance of mineral resources in exports, and the weakness of civil society. There are a number of reasons why the departure of the backcast pathways from certain trends is likely to be challenging. Firstly, such fundamental changes as economic restructuring and modernisation of infrastructure require large upfront investments, long-term strategic planning and steadfast implementation of policies. Secondly, there are external factors the country has no immediate influence on, for example, the international context (demand on Russia’s fossil fuels from other countries, international regulations, intensified international trade using aviation and so on) and climatic

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51 As a reminder, the analysis in chapters 2 and 7 has shown how investment, long-term planning and policy implementation offer challenges in the Russian context.

52 In many respects, Russia is a price taker on the global energy market, which is partly explained by the country’s refusal to participate in a number of international energy-related treaties and cartels (Bradshaw, 2012, p.217).
changes. Finally, some ‘trends’ and characteristics, including a weak civil society, appear particularly ingrained in the fabric of Russia’s culture.

Table 43. Scenario categories and key ‘trends’ over the past two decades enabling (+) or challenging (-) the transition to a low-carbon energy system (own analysis based on data from IEA (2011a), RosStat (2012); also see references in chapters 2 and 7)

<table>
<thead>
<tr>
<th>Scenario descriptors</th>
<th>Key ‘trends’ in Russia</th>
<th>Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Plum</td>
</tr>
<tr>
<td><strong>Sectoral composition and dynamics (1992–2009)</strong></td>
<td>Share of energy-intensive industry decreased from 30% to 10%</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Share of services grew from 40% to 61%</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Share of construction fluctuated between 5% and 7%</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Share of agriculture/forestry stable at 4–5%</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Share of other industry fluctuated between 15% and 19%</td>
<td>-</td>
</tr>
<tr>
<td><strong>Main exports and imports (1995–2009)</strong></td>
<td>Share of mineral products in exports increased from 43% to 67%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Share of machinery &amp; transport in exports decreased from 10% to 6%</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Share of agricultural &amp; forestry products in exports stable at 6–7%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Share of machinery &amp; transport in imports increased from 34% to 43%</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Share of agricultural &amp; forestry products in imports decreased from 30% to 21%</td>
<td>+</td>
</tr>
<tr>
<td><strong>Demography and settlement patterns (1990–2009)</strong></td>
<td>Urban population dominant: 73%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Domestic migration away from the periphery towards the capital cities</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Number of households marginally increased</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Household size marginally decreased</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Urban housing by type: 80% high-rise, 20% single-family (in 2006)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Transport</strong></td>
<td>Road passenger use halved in 1990–2009</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Road freight use halved in the 1990s but re-gained in the 2000s</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Rail passenger use fluctuated and halved in 1990–2009</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Rail freight use halved in the 1990s and re-gained in the 2000s</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Domestic aviation use more than doubled in 1993–2011</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>International aviation use increased 6.6 times in 1993–2011</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Domestic shipping use dropped 75% between 1990 and 2005</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>International shipping use in 2005 almost 10 times lower than in 1990</td>
<td>-</td>
</tr>
<tr>
<td><strong>Governance and values</strong></td>
<td>Centralisation of political power (traditionally)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Paternalistic government (traditionally)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A weak civil society (traditionally)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Increased individualism and decreased community values (since 1990)</td>
<td>-</td>
</tr>
</tbody>
</table>
9.5 Decarbonisation options and outcomes

9.5.1 Short-term options: energy demand reduction and biofuels

The last two rows of Table 39 present desirable outcomes of decarbonisation policies, classified into short-term options and medium- to long-term options. In the short term, the main low-carbon options are reductions in energy use in various sectors, on the demand side, and the substitution of hydrocarbons with biofuels, on the supply side. All of the scenarios use the country’s technical energy efficiency potential fully, thereby saving around 290 Mtoe (see Chapter 7 for references and numbers on the sectoral breakdown of the estimated potential). In addition, energy consumption in certain sectors decreases in line with the storylines due to lower use of particular transport modes (in the short term) and economic restructuring (in the longer term, apart from Scenario Plum where the economic structure is similar to that in the baseline year, i.e., 2009). This is illustrated by the ‘final energy demand’ charts for each scenario in section 9.6 of this chapter.

On the supply side, domestic bioenergy replaces various types of fossil fuels, with the biomass technical potential estimated to be 140 Mtoe/year (Bezrukikh et al., 2007, p.67). There are four levels of using the technical potential in the backcast scenarios labelled in Table 39 as (T) 100%, (H) 60–80%, (M) 30–50% and (L) 5–20%, where (T), or ‘total’, stands for a fully realised potential. Note that, for other renewable energy sources, no labels and percentages are used to indicate a realised share of potential. The combined technical potential of other renewables in Russia is estimated at around 24,000 Mtoe/year (Bezrukikh et al., 2007, p.67; Fiodorov et al., 2009, p.16; Kobysheva, 2012, p.490), which is nearly 30 times higher than the energy use in TRENDS in 2050. The use of biomass as a transition energy source partly explains why the stylised scenario trajectories in Figure 22 decline steeply after their respective emission peaks. In scenarios Cherry and Kiwi the decline happens even despite increased energy use relative to the baseline year, through realising the total technical potential of bioenergy.

9.5.2 Medium- to long-term options: renewable energy and a mix of other options

Short-term demand- and supply-side options are established as part of the mainstream infrastructure in the medium term and beyond. In addition to the existing demand-side options, scenario Plum and partly scenario Cherry involve economic restructuring away from energy-intensive sectors towards services. On the supply side, many of the existing power stations start going offline. In all scenarios, the structure of energy supply is further diversified
to include renewable energy sources other than biomass for electricity, heat and transport fuels. All four scenarios rely on renewable energy as a major supply-side option in the medium to long term. The two scenarios with medium energy demand in 2050 (Cherry and Melon) have to resort to either nuclear energy or CCS to stay within the carbon budget. The high-energy demand scenario (Kiwi)—with the most delayed emission peak out of the four—assumes nuclear power, CCS and bioCCS, as well as undergoing widespread electrification of transport.

In general, medium- to long-term options cover many ‘immature’ technologies that are currently at the R&D stage or waiting to be deployed through large-scale demonstration projects. Evidently, such options (for example, carbon capture and storage) cannot be transition technologies. In scenarios with CCS (Melon and Kiwi), the introduction of this technology is assumed after 2030. To accommodate such factors as a geopolitical situation, investment climate and fossil fuel reserves, the scenarios are deliberately flexible between coal CCS and gas CCS. Whilst two out of four scenarios use CCS, only one of them (Kiwi) relies on negative emission technologies with CCS-equipped power plants co-firing fossil fuels with biomass (often abbreviated as ‘BECCS’ or ‘bioCCS’).

The deployment of CCS and other immature technologies in the future will require additional infrastructure, from re-equipping existing power plants to building new ones to adjusting the transmission capacity of the grid and pipelines. In addition, there are still significant uncertainties over the technical performance of “full-scale power plant CCS” (Hammond et al., 2011, p.983), “water, sequestration, and pore-space competition” and regulatory challenges (Court et al., 2012, p.571), issues of risk perception and societal acceptance of the technology (Mander et al., 2011, p.6366), and commercial and financial feasibility concerns (Kheshgi et al., 2012, p.565).

An important but often overlooked concern is upstream emissions associated with such technologies. For example, Hammond et al. (2013, p.114) estimate that carbon capture and storage is likely to reduce emissions of power stations by 70% on a life-cycle basis, rather than the previously assumed “over 90%” (Hammond et al., 2011, p.983). Russian gas has particularly high upstream emissions due to a large amount of fugitive emissions and long transmission distances (Hammond et al., 2013, p.113). Other Russian fossil fuels are also likely to be more emission-intensive on a life-cycle basis than hydrocarbons originating in more developed countries. Although this thesis does assume reduced efficiency when CCS (or
bioCCS) is employed in the backcast scenarios, life-cycle emissions are not factored in. It is clear, however, that it would make the carbon budget constraint yet more challenging.

Whilst biomass can potentially mitigate upstream emissions of CCS technologies (Hammond et al., 2013, p.114), its production is associated with a number of other uncertainties and wider sustainability issues (Thornley et al., 2009; Slade et al., 2011). Besides, the four backcast scenarios already draw on the technical bioenergy potential to a significant extent for uses other than bioCCS (for example, transport, onsite micro-generation and/or power plants). For these reasons, bioCCS is limited to one scenario (Kiwi) that would have otherwise missed the budget constraint by a greater amount.

The issues discussed help to devise a qualitative ‘hierarchy’ of mitigation measures and technologies for the purposes of this thesis. The ‘hierarchy’ is not meant to be an in-depth account, but a highly stylised ranking of available options based on their potential for short-vs. long-term deployment. In particular, the decarbonisation options in Table 39 (rows 8 and 9) are listed in the order preferred within the ‘hierarchy’. Accordingly, negative emissions are only used as a last resort, i.e., if other options are insufficient to stay within the cumulative budget constraint. Note that the wave and tidal energy sources are not used as more mature renewable energy technologies have a sufficiently technical potential for meeting Russia’s energy demand in the scenarios.

By 2050, regardless of the differences in the energy demand, economic growth rate, decarbonisation options and other contextual characteristics, three out of four scenarios stay within the allocated cumulative CO₂ emission budget. The fourth scenario overshoots the budget constraint in 2050 and would require a continued use of, as yet, untested negative emission technologies to return to the allowed budget range (and assuming the overshoot does not trigger further emission and climate feedbacks). The following section provides general context and main characteristics of each scenario.

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53 There are quantitative studies exploring what mitigation options and combinations thereof are preferable according to a set of criteria (see, for instance, Bowen et al., 2009)
9.6 Scenario-specific results

9.6.1 Scenario Plum

Scenario Plum is a low economic growth and low energy demand\(^{54}\) scenario. Russia in 2050 is a post-industrial economy built through ‘de-industrialisation’ and re-orienting economic activities towards services. The transition occurs through a series of economic crises (following the economic recession in the late 2000s) that are used as a springboard for economic and social reforms. The services industry, agriculture and forestry sectors are well developed and produce high-value added services and low-value added goods. The services industry focuses on information and communication technologies with ‘value’ created remotely and in a decentralised mode. Manufacturing decreases dramatically while construction rates in rural areas grow to accommodate the de-urbanising population. The construction sector innovates to support agriculture and settlements on melting permafrost. Settlement patterns are more spread-out, the pace of life is slow compared to the baseline year, and households become more self-sufficient. Political power is devolved to multiple but limited levels of governance, whose tasks and geographical jurisdictions are non-overlapping and relatively stable.

The 2011–2050 emission budget of scenario Plum is around 7.0 GtC, marginally smaller than that of scenarios Cherry and Melon, and 0.4 GtC below the budget of scenario Kiwi. The emission pathway of scenario Plum peaks earlier than the other scenarios, in 2013, at 445.9 MtC/yr and declines at 13.3% per year out to 2030 (see Table 40). Figure 22 shows that there is a rapid drop in emissions early on in this scenario as it starts with a series of economic crises followed by structural breaks in energy demand. The storyline involves a relatively difficult transition economically, although, as mentioned above, it is quickly taken under control and used for reforms.

The most energy consuming sectors in 2050 are the residential sector and services, whereas the energy intensive industry’s energy use is halved compared to that in 2009 (Figure 26). The 2050 primary energy supply is around 320 Mtoe (Figure 27), which is 1.6 times lower than that in the baseline year. Fossil fuels (without CCS) still satisfy a large proportion of energy demand compared to other scenarios; however, the scenario stays within the budget because the total energy use is low. Electricity supplies 57 Mtoe in 2050, with approximately equal

\(^{54}\) As a reminder, the ‘low’, ‘medium’ and ‘high’ terms qualitatively describe the mean annual growth and energy use of Russia’s economy in 2050, indicating how these variables compare to those in the baseline year (2009). ‘Low’ is about a third lower than in 2009, ‘medium’ is similar to 2009 and ‘high’ is about a third higher than in 2009.
shares supplied from the grid and from onsite energy sources (Figure 28). There is no combined heat and power in this scenario after the existing CHP stations are decommissioned. Most of the electrical energy comes from renewables (88%) and biomass (11%).

Figure 26. Final energy demand by sector Scenario ‘Plum’ in 2009 (the baseline year), 2013 (the emission peak year), 2030 and 2050 (Mtoe)

Figure 27. Primary energy supply by fuel in Scenario ‘Plum’ in 2050 (%)

Figure 28. Electrical energy supply by source and by fuel in Scenario ‘Plum’ in 2050 (%)

9.6.2 Scenario Cherry

Scenario Cherry is a high economic growth and medium energy demand scenario. Russia in 2050 is a post-industrial economy built through ‘de-industrialisation’ and re-orienting economic activities towards services. The transition occurs through high, ‘Baltic Tiger-type’ economic growth and partial liberalisation. Similarly to scenario Plum, the economy is service-
oriented but with a different flavour. The services sector heavily dominates, with industry moderately developed and little agriculture – an economic structure similar to today’s Russia – producing high value-added services and medium value-added goods. The services industry focuses on information and communication technologies with ‘value’ created in large, centralised hubs and clusters modelled after the Silicon Valley. The urbanisation rate is high and households are predominantly concentrated in high-rise buildings, with some low-rise buildings in rural areas. Melting permafrost drives settlements south. The centralisation of power is reminiscent of Russia’s current ‘managed democracy’.

Similarly to scenario Plum, this scenario stays within the carbon budget range with cumulative 2011–2050 emissions of 7.0 GtC. Annual emissions peak in 2015 reaching 452.1 MtC/yr and decline at an annual rate of 10% (see Table 40). The emission level in 2050 is 39.8 MtC/yr. It is evident from Figure 22 and Table 40 that the emission pathway of scenario Cherry has the most gradual decline out of the four backcast scenarios. Yet, a 10% emission reduction per year is more challenging than anything achieved in real life to date, which shows that even a very early emission peak would require unprecedented decarbonisation.

Figure 29 shows sectoral final energy demand in 2050, with the energy-intensive industry and services remaining the most energy-consuming economic sectors since 2009. Primary energy supply in the final scenario year is 463 Mtoe, compared to 543 Mtoe in the baseline year. More than 50% of primary energy comes from renewable (non-biomass) energy sources and about a third comes from biomass (Figure 30). Nuclear power stations provide 10.5% (48.4 Mtoe) of primary energy – a gradual increase from 6.2% (36.2 Mtoe) in 2009. Nuclear energy (including nuclear CHP) plays an important role in the electricity fuel mix, supplying about a fifth of it in 2050 (Figure 31). Around 35% of electrical energy in 2050 is produced with CHP and a quarter – onsite.

![Figure 29. Final energy demand by sector Scenario 'Cherry' in 2009 (the baseline year), 2013 (the emission peak year), 2030 and 2050 (Mtoe)](image)
9.6.3 Scenario Melon

Scenario C is a medium economic growth and medium energy demand scenario. Russia in 2050 is an economy based on restored and renovated light and heavy industries, including highly efficient mining and processing. A large share of products is manufactured domestically. The transition occurs through top-down (state-led) capitalist expansion, with three out of four factors of production (labour, capital and land) used intensively. The industries are situated in proximity to raw materials and/or energy sources; the share of services is low. The population is spread across the country and concentrated around industrial sites; the new housing stock is predominantly high-rise. Melting permafrost is dewatered to maintain fossil-fuel mining and agriculture. The pro-environmental government takes a centralised approach to governing the country.

The scenario’s 2011–2050 emission budget is 7.1 GtC, about 43 MtC below the upper end of the budget range constraint. However the 2050 annual emissions in this scenario reach 4.1 MtC and are still decreasing, which reduces the chance of breaching the budget constraint after 2050. The emission trajectory peaks in 2020 and declines thereafter at 21.5% per year until 2030 (Table 40), a reduction rate that relies on the rapid deployment of CCS technologies.

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55 As a reminder, it is the 21st-century emission budget calculated to be spent between 2011 and 2050 (chapter 6).
after the emission peak year, along with economy-wide energy efficiency and conservation in the residential and transport sectors, as well as reductions in non-energy CO$_2$ through the use of alternative feedstock. With the Melon pathway peaking later than Cherry (2020 as opposed to 2015), the emission trajectory has a steeper slope to stay within the budget range. The reduction rate becomes less dramatic (15.4%) between 2030 and 2050, as is the case in other scenarios.

There is a significant reduction in the energy consumption of the services sector in 2050 compared to the baseline year (Figure 32). At the same time, the energy-intensive industry’s energy use increases, in accordance with the economic structure in the storyline. As Figure 33 shows, primary energy in 2050 is significantly dominated by renewable energy (59.2%) and biofuels (21.2%). Bioenergy is only used for non-electrical energy, whilst the fuel mix of the grid consists of renewable energy (other than biomass) and fossil fuels with carbon capture and storage (Figure 34).

![Figure 32. Final energy demand by sector Scenario ‘Melon’ in 2009 (the baseline year), 2013 (the emission peak year), 2030 and 2050 (Mtoe)](image)

![Figure 33. Primary energy supply by fuel in Scenario ‘Melon’ in 2050 (%)](image)
Scenario Kiwi is a high economic growth and high energy demand scenario. It illustrates the most highly stylised (and hypothetical) decarbonisation pathway that would be necessary to meet the carbon budget constraints laid out in chapter 6. Russia in 2050 is an economy based on restored and renovated light and heavy industries, producing a large share of products domestically. The transition occurs through a bottom-up capitalist expansion, with the economy moving away from taxing labour towards taxing capital and, hence, developing labour- and human capital-intensive, high value-added manufacturing (including crafts, modularity and re-manufacturing). Construction rates are high to accommodate new polycentric networks of cities with sprawling suburbs. The construction sector innovates to support settlements on melting permafrost. Political power is devolved to a large number of governance levels that are task-specific, overlapping and flexible.

The 2011–2050 cumulative emission budget of this scenario is 7.4 GtC, resulting in a temporary overshoot of the budget constraint. The emission trajectory follows the TRENDS pathway until around 2025 and peaks shortly thereafter at 562.9 MtC/yr. It subsequently declines at an annual reduction rate of 240% (Table 40) through aggressive decarbonisation. Such an extreme reduction rate in emissions emphasises the hypothetical nature of this scenario. It is difficult to envisage (let alone implement) a politico-economic regime that would introduce the dramatic and rapid emission reductions required here. For this reason and despite being consistent with the scenario narrative above, the ‘Type II’ governance model is also highly hypothetical in application to this context.

The nearly vertical post-peak emission trajectory and negative emissions introduced no later than in 2030 (Figure 22) is the only way to approximate the carbon constraint. Although this scenario exceeds the upper end of the allowed budget range by 230 MtC, if emissions are absorbed at the same rate after 2050, the trajectory will be within the budget constraint by
2060. More bioCCS could achieve this earlier, however that would require importing biomass since the technical potential of domestic bioenergy is fully realised.

Figure 35 demonstrates how high the energy use of certain sectors will be if they follow the TRENDS pathway until 2025. The energy industry, services and energy-intensive industry particularly stand out in this respect. Even in 2050, after 25 years of dramatic emission reductions, the primary energy supply (663 Mtoe) is 120 Mtoe higher than in the baseline year. More than two thirds of the primary energy is provided by biofuels and other renewable energy sources, with nuclear energy and bioCCS supplying the rest (Figure 36). Electricity penetration in this scenario is relatively high: more than a quarter of the 2050 final energy supply is electrical compared to 15% in 2009. About 60% of electricity comes from the grid, and 12% is generated with combined heat and power (Figure 37). The fuel mix of electrical energy is similar to that of the primary energy supply.

![Figure 35. Final energy demand by sector Scenario ‘Kiwi’ in 2009 (the baseline year), 2013 (the emission peak year), 2030 and 2050 (Mtoe)](image)

![Figure 36. Primary energy supply by fuel in Scenario ‘Kiwi’ in 2050 (%)](image)
This chapter describes how four heuristic backcast scenarios have been constructed that capture a breadth and diversity of interesting and informative heuristics and that can be appropriately developed within the resource constraints of a PhD project. A variety of economic structures, settlement patterns, decarbonisation options and governance regimes can lead to ‘desirable futures’, defined here as futures with a reasonable chance of avoiding dangerous climate change. Although the UKCIP, in its review of socio-economic scenarios, considers governance and values “foundational and independent determinants of future change” (UKCIP, 2000, p.18), this chapter argues that setting these as fixed assumptions at the beginning of a backcasting exercise would restrict the scope of available technological and behavioural options. This would defeat the very purpose of backcasting which is, by definition, exploratory. For this reason, the chapter has considered, first and foremost, how technology and behaviour can contribute to decarbonisation in the four scenarios, followed by a brief analysis of aspects of governance, socio-political values and other ‘trends’ that may hinder or facilitate a low-carbon transition.

In the short term, decarbonisation options in the four scenarios vary little, being mainly limited to biomass, energy demand reduction and energy efficiency. Politically, extensive and rapid deployment of bioenergy is likely to be more suitable for scenario Cherry with its ‘managed democracy’. In this sense, harvesting biomass can be perceived as more of a ‘stopgap’ measure compared to other low-carbon options, i.e., less thought-out and more Soviet-style by its grand scale. Political regimes in other scenarios would probably have more careful (in terms of biodiversity) and less sweeping policies than growing enormous quantities of biomass in the short term. Using this option in scenario Kiwi with its conscientious approach to decarbonisation would require a change in political and social values in the medium term, if not earlier.
In the long term, all four scenarios rely on renewable energy as a major supply-side option. The two scenarios with medium energy demand in 2050 (Cherry and Melon) adopt either nuclear energy or CCS to stay within the carbon budget. The high-energy demand scenario (Kiwi) develops nuclear power, CCS and bioCCS, as well as widespread electrification of transport. By 2050, regardless of the differences in the energy demand, economic growth rate, decarbonisation options and other contextual characteristics, three out of four scenarios stay within the allocated cumulative CO$_2$ emission budget. The fourth scenario overshoots the budget constraint, despite a dramatic emission reduction rate after the emission peak, and would require a continued use of speculative negative-emission technologies post-2050 to return to the allowed budget range. On balance, the four backcast scenarios demonstrate that the identified budget constraint is extremely tight and challenging to meet, if Russia continues on its current emission trajectory for more than a year or two. Emission reduction rates required, even in the early-mitigation scenarios, are well in excess of anything seen currently or achieved in the past through mitigation policies.

The discussion chapter (chapter 10) will integrate the analysis in this chapter with insights from the background chapters and stakeholder interviews conducted by the researcher. The feasibility (and ‘desirability’) of the storylines and the low-carbon transition pathways is also the subject of chapter 10.
PART 4: DISCUSSION AND CONCLUSIONS
10  Chapter 10: Discussion and concluding remarks

10.1  Introduction

This chapter integrates the scenario analysis with insights from the background chapters and expert interviews to contextualise the challenges facing Russia in mitigating emissions in accord with its international commitments to the 2°C target. In this regard, the chapter demonstrates how the thesis has delivered on its aim of deriving cumulative emission budgets for Russia and generating associated low-carbon pathways in the context of both a re-developing economy and international climate change goals. This aim has been achieved through three key research objectives: 1) to assess the political and economic background in Russia in relation to climate change science and international climate change negotiations; 2) to generate national medium-term emission scenarios for Russia’s energy system; and, 3) to suggest alternative sets of measures as to how 2°C emission pathways for Russia’s energy system could be implemented.

After the introduction, section 10.2 of this chapter discusses climatic changes, impacts and adaptation in Russia; nationally and globally relevant climate targets represented by the 2°C threshold and associated cumulative emission budgets for Russia; and, related socio-political and techno-economic contexts. Section 10.3 elaborates on interdisciplinary and methodological aspects of the thesis, recounting the main reasons for using participatory backcasting and the ASK-Russia scenario generator. An analysis of the backcast scenarios and alternative sets of decarbonisation measures are presented in section 10.4. Sections 10.5 and 10.6 explain the limitations and original contributions of this thesis, respectively, followed by concluding remarks.

The first, context-related, research objective is primarily addressed in section 10.2, although its importance is reflected throughout the discussion chapter (starting from the physical-geography characteristics of Russia’s climate and finishing with the limitations and originality of this research). The second objective, covering the generation of national emission scenarios and pathways, is the focus of sections 10.3 and 10.4. The final objective—measures for implementing 2°C pathways—mainly belongs to section 10.4; however, being interrelated with the first two research objectives, it emerges throughout this chapter.
10.2 The national and global context of this thesis

10.2.1 Climatic changes, impacts and adaptation

Against the backdrop of accelerating emissions and increasing global mean surface temperature, some changes to Russia’s climate are already evident, as chapter 2 demonstrated. The average temperature increase in Russia between 1907 and 2006 suggests that future climatic changes are likely to be more rapid there than the global average change. Moreover, climate change impacts are expected to intensify over the 21st century and inevitably affect the country’s development path. This is particularly important for countries with an inhospitable environment that typically locks them into climate-specific infrastructures. Russia’s territory includes some of the harshest conditions in the world for living and working. In the face of these difficulties, the population and institutions have adapted to their environment over decades of relatively stable climatic conditions. Consequently, if the scale or the pace of climate change exceeds that of adaptation, the repercussions may be far-reaching and damaging. Despite such palpable risks, there is no adequate adaptation strategy in place; effectively, adaptation in Russia is still at the research and planning stage. Climate change risks are, to some extent, considered in various programmes for the development of economic sectors and provinces, but there is no comprehensive and clear set of policies at either national or regional levels. Preventing severe repercussions of climate change would require step-changes in the drafting and then delivering of appropriate legislation.

The low level of commitment to addressing the issue of adaptation is exacerbated by the absence of an adequate mitigation strategy at the international level. Unless major emitting nations dramatically reduce their emissions within the coming decade, a ‘4°C world’ by 2060–2100 appears evermore likely. This is associated with an estimated 6–16°C temperature change across Russia. Such high temperatures have not only profound implications for impacts and adaptation within Russia, but risk triggering global climatic discontinuities (for example, through methane released from thawing permafrost). Given such potentially cascading risks, anything short of immediate and internationally co-ordinated action is likely to result in substantial and irreversible change across both the Russian territory and much of the globe.

10.2.2 The 2°C target and cumulative emission budgets in the Russian context

Despite uncertainties surrounding 2°C and its origins, this thesis demonstrates that it is evidently a more appealing ‘focal point’ for global mitigation action than existing alternatives (chapter 4). The Russian government, alongside many other national and supranational
authorities, has repeatedly affirmed the commitment to the 2°C target (chapters 4 and 6). This thesis adopts a literal interpretation of the commitment, taking it at face value and in good faith. For these reasons, the global 2°C threshold is used here to define the first stage of backcasting (chapter 6) and, hence, the resulting scenarios and decarbonisation measures. Provided its drawbacks are acknowledged, the target may still serve the purpose of mobilising adequate mitigation action. To achieve that, the 2°C concept needs to be re-framed, in line with the latest science, emphasising that 2°C is a threshold associated with ‘dangerous’ and ‘very dangerous’ climatic repercussions at the local (or regional) level as opposed to the global, ‘averaged’ level.

If the Russian government chooses to mitigate in line with the global 2°C target, it would need to adapt, at least, to climatic changes associated with a local ~3–4°C increase, although a precautionary approach would require more demanding adaptation. On the other hand, if the Russian government chooses to aim at avoiding the impacts of a local 2°C temperature rise, the mitigation efforts would obviously need to aim at keeping the temperature increase in Russia below this threshold. This would be a very ambitious target, bearing in mind that an estimated average warming for the Russian territory for the past century is already 1.29°C compared to 0.75°C globally (RosHydromet, 2008a, p.36). If the country’s influence on the international climate negotiations is sufficiently strong, the potential consequence of adhering to this more ambitious local target is twofold. Firstly, a proactive stance of the Russian government may catalyse international discussions for a lower than global 2°C target. Secondly, Russia could focus its adaptation strategy on less severe climate impacts; however, given potentially devastating impacts in case mitigation fails, the level of adaptation may need to be sufficient to prepare for such risks.

This thesis takes a conventional interpretation of 2°C as a global (rather than local) target acknowledging that less stringent decarbonisation is likely to result in the need for more substantial adaptation. With the ‘global’ 2°C threshold adopted as a strategic objective, a range of cumulative emission budgets for Russia are derived, commensurate with a suite of probabilities of staying below the dangerous climate change threshold (assuming other nations take commensurate mitigation action). The strategic objective of backcasting within this thesis is to generate scenarios characterising an evolving energy system for Russia in 2011–2050 within the 5.5–7.1 GtC cumulative emission budget range, corresponding to a relatively low (37–52%) probability of exceeding 2°C global mean surface temperature increase above pre-industrial. This cumulative budget range does not ‘credit’ Russia for the emission collapse that
occurred in the 1990s, given it was due to an economic downturn rather than intentional mitigation action.

Despite the proliferation of studies on emission burden sharing, Russia’s share of a remaining 2°C cumulative budget has received limited attention to date. The importance of deriving nationally appropriate cumulative budgets is in translating a global threshold of 2°C into national emission targets and, subsequently, into specific changes that the national energy system would need to undergo in order to achieve the targets. Furthermore, the cumulative budget approach (i.e., ‘stock’ targets) is contrasted with using annual end-point (‘flow’) targets commonly used in the climate-related policy arena. However, having little direct correlation with the global temperature increase, annual end-point (‘flow’) targets are likely to result in misleading policy action; hence, for national mitigation policies to be science-based and retain the link to global climate change, they need to draw on a cumulative-emission-budgets approach. For these reasons a national emission budget commensurate with a given probability of the global 2°C objective is one of the three key constraints placed on scenarios in this thesis. The other two constraints are momentum in both the energy system and the socio-economic environment, and the associated feasibility of implementing the scenarios.

10.2.3 Socio-political techno-economic contexts: potential barriers, triggers and ‘levers for change’

The analysis of national developments shows that within Russia’s ruling establishment there is much resistance to pro-active mitigation and adaptation. The government’s position is characterised by a number of interrelated geographical, political and economic factors. A frequently cited reason for inaction is the country’s relatively high natural adaptive capacity, alongside other physical-geography characteristics including large forest carbon sinks and extensive fossil fuel reserves. The latter is not openly declared as an ‘excuse’ not to mitigate, but rather underlies both the sluggish development of renewable energy sources and Russia’s influence on importers of its fossil fuels. Arguably, wielding control on the international arena and thereby preserving the superpower status is an essential part of the government’s geopolitical ambition. Related to geopolitics are economy-focused arguments against decarbonisation. In particular, the government has expressed concern that Russia’s mitigation action may give an immediate competitive advantage to other high-emitting economies-in-transition who have no binding emission targets. Amongst the top echelons of power, little credence is given to the view that decarbonisation could benefit the country’s economic and geopolitical position in the long run.
Evidently, the economic-growth-focused priorities of the Russian government do not align with the 2°C emission budget range (chapter 6). In addition, as both the literature review and stakeholder engagement within this project demonstrated (chapters 2 and 9), limited transparency, unclear attribution of responsibilities and other aspects of the legacy of bureaucracy continue to stall effective policy implementation. The ‘state incapacity’ can in part be explained by the specifics of Russia’s policy-making process, the analysis of which points to the most powerful politico-economic actors in the country. Kroutikhin (2008, p.25, 27) suggests that, for at least a decade, the power dynamics in Russia have been defined by the interaction of oligarchs, ex-KGB officers and St. Petersburg technocrats; and balancing the interests of the three factions has resulted in diluted policies and poor implementation. Because of these factional struggles, long-term energy planning to date has largely failed, for example, the energy strategies out to 2020 and 2030 and other energy and industry development programmes are “just collections of possible scenarios” (ibid., p.29). It is questionable whether any of the three factions is likely to introduce or facilitate low-carbon policies, considering that much of their power comes from the oil and gas industry.

Broader analyses provide a different interpretation of powerful actors in Russia. In particular, Gustafson (2012, p.483) identifies three main power groups benefitting from the oil and gas sector: the state, shareholders and consumers. The idea of a ‘social contract’ that has emerged during the in-person expert interviews corroborates the insights from literature on the funnelling down of resource rents. The ‘no-change’, or business-as-usual, political course suits most actors because it promises relative stability (Usova, 2012, p.10). It is likely that only if the system fails to satisfy one or more of the power groups, the decarbonisation process can gain momentum. However, the decline of the current system is a necessary but not sufficient condition. The literature review and the expert interviews suggest that the emphasis is on what could trigger the decline of the existing system, rather than on more ‘positive’ triggers (i.e., those establishing foundations for a low-carbon transition), although they are often difficult to separate.

Potential triggers are numerous and exist at different levels. Despite the intention of the government and of other power groups to preserve the status quo at both domestic and international levels, the advent of climate change suggests that the era of fossil fuel consumption may be hastened, together with Russia’s energy supremacy. The current situation is “inherently unstable and unsustainable” (pers. comm. 21/05/2013), and Russia’s politico-economic regime is increasingly susceptible to both external and internal shocks. For example, a sharp increase in the domestic price of energy and/or a drop in the global oil price could
trigger a breakdown of the social contract. One of the expert interviewees suggested that, as history shows, seemingly small-scale events can trigger a large-scale change in Russia (pers. comm. 21/05/2013).

Related to the issue of potential triggers, is the uncertainty about what power group/s could emerge as ‘levers for change’, i.e., for ushering in a low-carbon transition. A widespread viewpoint, both outside and within Russia, is that the Russian ‘managed democracy’ is likely to have more control over domestic affairs than other political systems do. This thesis argues that, even if the Russian leadership starts prioritising climate change (which is not the case, contrary to the official and nominally legislated discourse), the long-standing issue of ‘state incapacity’ will hinder effective decarbonisation policies.

Similarly, the second power group (‘shareholders’) representing Russia’s big business is an unlikely ‘lever for change’. Firstly, a close connection between this power group and the government implies they have overlapping interests and priorities. For example, Nureyev (2010, pp.18–19) describes the ‘power vs. assets’ phenomenon as pervasive in Russia’s vertically integrated industrial groups, where an individual’s position in the governmental power structure determines the value of assets the individual owns. Secondly, the political power of businesses in general is fragile (Fuchs, 2005, p.799) and, hence, a sustained business-led initiative towards decarbonisation seems improbable, without appropriate legislation being in place and enforced. This is indirectly confirmed by rare climate-focused interactions between the government and businesses where the two groups shift the responsibility for low-carbon development to each other (RIA-Novosti, 2013). What business can do is require greater transparency and accountability of the government or, in other words, increase the demand for the rule of law. However, as suggested by one of the expert interviewees, it is small and medium enterprises, not the big business, that are interested in the rule of law, and their share of Russia’s private sector is low (pers. comm. 09/05/2013).

The third power group, representing Russia’s population, is a potentially powerful actor emerging from what is a relatively weak civil society. Gustafson’s identifying this group as ‘consumers’ (2012, p.483) implies a strengthening of consumerist values as a result of the west’s influence (chapters 7 and 9). Assuming that consumerism is not the only western value adopted in Russia, growing awareness of climate change issues is likely to lead to stronger public support for renewable energy and energy efficiency measures, as is the case in the UK (Parkhill et al., 2013), for example. Whilst the direct influence of the civil society and other non-governmental actors remains low, they increasingly appear more likely than the ruling
elite as effective and timely ‘levers for change’. It is likely that the population would act as an intermediary—rather than an implementer—informing the government and other decision-makers of policy priorities. Although currently ‘dormant’ as a political actor, Russia’s population may be a powerful force, if triggered to action, as numerous incidents in the country’s history show. The combination of potential ‘triggers’, a shifting agency and opportunities for re-industrialisation may create a springboard for a low-carbon modernisation.

Some of the unique characteristics of Russia, highlighted in the literature review, the analysis of relevant statistics and the expert interviews (chapters 2, 3, 7 and 9), provide opportunities for not only undermining the current system, but also building a new, low-carbon system. For example, the country’s dilapidated energy infrastructure will need to be replaced in the next 10 to 20 years regardless. Similarly, modernisation is one of the government’s declared priorities. These opportunities, however, may instigate policies with competing objectives, unless the decarbonisation agenda is considered from the start. Moreover, if one of the ‘triggers’ leads to a breakdown of the social contract, both the population and the government are likely to have other priorities. Therefore, as decarbonisation is not currently seen as an immediate concern, it is important that it is at least viewed as a significant and strategic ‘co-benefit’. To this end, there is a need to inform the national climate- and energy-related debate, based on the latest climate change science and in accord with international climate targets. Exploratory backcast scenarios, in particular, can indicate mitigation options and recourses that were previously unnoticed and, thereby, create new ways of thinking and strategic, innovative solutions.

10.3 Interdisciplinary and methodological aspects of the thesis

10.3.1 Participatory backcasting for strategic planning

A review of emission scenario literature on Russia (chapter 5), whilst not exhaustive, has shown that many studies have drawbacks sufficient to make them unsuitable for advising on the decarbonisation policy agenda. Consequently, there is a strong need for new approaches for framing and developing Russian emission pathways and targets. If such novel approaches are to respond to the 2°C agenda, they need, first, to reveal a more plausible depiction of reality and, second, to envision and embed step-changes in Russia’s climate policy and delivery. The first aspect will require the synthesis of a breadth of interdisciplinary methods, including substantial stakeholder expertise. The second aspect unfolds if researchers respond objectively to the explicit commitments of the Russian government and international community and are forthright about the actual state of the climate and its implications, in order to inform Russia’s policy priorities. The backcast scenarios in this thesis take account of
both aspects to demonstrate alternative sets of decarbonisation options that could lead to a low-carbon future in Russia.

This thesis has derived a new alternative definition of backcasting as an exploratory and interdisciplinary approach for developing normative scenarios and plausible pathways to attain ‘desired’ future states. Chapter 5 demonstrated how the iterative and innovative framing of backcasting is more appropriate for addressing system-level climate-related issues than conventional modelling and forecasting assessments, at least in the context of this study. Climate change has a range of characteristics that make it distinct from other environmental and social challenges. Multiple elements of the climatic system, positive feedbacks, numerous unknown consequences, a breadth of geographical and temporal impacts, uncertainty about critical thresholds and, hence, about the cumulative budgets – all have implications for policy-oriented emission studies.

By its very nature, climate change is challenging to translate into well-defined policy objectives. Furthermore, because climate science is evolving, and timeframes involved can be from decades to centuries, the pathways towards strategic objectives are necessarily flexible and adaptive. The teleological aspect of backcasting is better suited to accommodate dynamism and complexity than are more reductionist approaches. By extension, backcasts may be applicable to futures studies of other complex phenomena, in particular, social and economic behaviour in the face of rapid systemic transformations (for example, political and financial crises or even swiftly introduced reforms). Backcasting provides an important tool for strategic planning and, particularly, for exploring the framing of low-carbon transitions.

Both the review of methods literature and the backcasting exercise conducted within this thesis have shown that backcasting deals with emergent properties by supplying a range of possible pathways, rather than a likely future development (provided by forecasting). In participative backcasting, interim targets and stakeholders provide a reality-check for bringing the system back on ‘track’, i.e., on a chosen pathway. In addition, the flexibility and iterations built into backcasting make it attuned to absorbing or responding to change. Chapter 9 detailed how an interdisciplinary two-way interaction of the backcast scenarios and interviews formed “the on-going process of analysis” (Coffey and Atkinson, 1996) within this research project. This iterative process comprised internal peer-review, external expert interviews and the researcher’s own thinking, with emerging ideas shaping the context of the research, the backcast scenarios and decarbonisation measures.
10.3.2 The ASK-Russia tool

As discussed in chapter 5, the backcasting approach has evolved as an alternative to forecasting, with a twofold purpose. First, backcasting aims to break away from past and current trends if they are incompatible with desirable future states; and, second, it reduces the reliance on predictions of economic variables, for example, future costs of energy and technologies. Therefore the preference for backcasting narrows down the range of available quantitative and qualitative modelling tools; in particular, it significantly reduces the use of time-series analyses and optimisation models. Instead, it offers scope for applying “explanatory models” (Börjeson et al., 2006, p.734) that are more suitable for generating explorative and heuristic, rather than predictive, scenarios. The ASK scenario generator—originally developed by researchers in the Tyndall Centre for Climate Change Research at the University of Manchester—provides an appropriate quantitative modelling environment, being both flexible and transparent.

For the purposes of this thesis, the original, UK-focused, ASK tool was modified to accommodate geopolitical and national circumstances of Russia as well as data available. The ASK-Russia tool differs from the original ASK at the following three levels: modifications attributable to the differences between the UK’s and Russia’s energy systems; modifications related to data availability for Russia; and, finally, formulae adjusted to remedy any potential inaccuracies in the original version of the tool. The backcast scenarios generated with ASK-Russia demonstrate, together with Tyndall scenarios for China (Wang and Watson, 2008), that the ASK scenario generator is sufficiently flexible to be applied in non-UK contexts. The quality of an adapted scenario tool is conditional on, amongst other factors, the availability of national statistics and other country-specific data. For example, most energy-related data for ASK-Russia came from the International Energy Agency’s (IEA) energy balances, complemented with numbers from Russia’s Federal State Statistics Service and other sources.

The ASK-Russia tool (and the backcast scenarios generated with it) is one of the foremost elements of the research design in this thesis for reasons explained in chapter 8. To reiterate, in its review of socio-economic scenarios, the UKCIP (2000, p.17) states that “technology [dimensions] are […] dependent on social values and regulation”. This thesis argues that, if this is the case and if, in addition, values shape behaviours, then placing governance and values at the foundation of scenarios may restrict the scope of technological and behavioural change in a backcasting exercise. This would, in turn, limit options for a low-carbon transition, particularly in the short-term. The intention is, instead, to work backwards in three stages. At the first stage, backcast scenarios were generated with the ASK-Russia tool to explore how
technology and behaviour can contribute to decarbonising the energy system. At the second stage, the researcher analysed the barriers to the decarbonisation process that are due to existing aspects of governance and values or to other various current trends. At the third stage, the researcher identified potential ‘triggers’ that could transform the current socio-political context (i.e., current governance and values) and enable a low-carbon transition. In summary, although the research proceeded in a nonlinear fashion, with many activities happening simultaneously and/or iteratively, the foundations of this process were laid by the scenario generator and its specifications, including a range of cumulative emission budgets for Russia as the main constraint for the backcasting exercise.

10.4 An analysis of the backcast scenarios: feasibility issues, limited mitigation options and decarbonisation as a co-benefit

A review of non-mitigation pathways from literature and a simple extrapolation of past trends make it clear that staying on the current trajectory is inconsistent with the 2°C target, as chapter 8 showed. Even the pathway following Russia’s pledge of a 25% emission reduction by 2020 relative to 1990 is insufficient for staying within the 2°C budget range. The backcast scenarios generated in this thesis demonstrate that staying within a carbon budget constraint commensurate with ‘avoiding dangerous climate change’ is a formidable task that requires step-changes to both energy demand and supply. In the short term, decarbonisation options in the four scenarios vary little, being mainly limited to energy demand reduction, energy efficiency and biomass partly substituting fossil fuels, although to a different extent and in different parts of the economy (consistent with the associated scenario storylines). As an example, scenario Plum assumes that road transport energy use is reduced through less and slower travel, agricultural and forestry practices are improved, and biofuel replaces coal. Scenario Cherry assumes that road transport energy consumption is reduced through energy efficient vehicles, existing nuclear and hydro-power stations are used to their full capacity, and biofuel replaces all coal and oil that have not been reduced via energy efficiency and savings.

In the long term, the only major supply-side option that the four scenarios share is onsite renewable energy. The two scenarios with medium energy demand in 2050 (Cherry and Melon) adopt either nuclear energy or CCS to stay within the carbon budget. The high-energy demand scenario with the most delayed peak (Kiwi) assumes nuclear power, the successful large-scale demonstration and deployment of negative emission technologies (bioCCS) and widespread electrification of transport in order to stay within the budget constraint. Here, negative emissions are used as a last resort, according to the ‘hierarchy’ of mitigation options (chapter 8) based on the extent to which they could be deployed in the short and/or long
term. Technical, commercial and wider environmental uncertainties associated with CCS and bioCCS technologies render them ‘speculative’ in the foreseeable future. By contrast, Russia’s large energy efficiency potential makes demand-side measures a preferred short-term option, whilst the country’s considerable renewable energy resources can be harvested within the next decade and thereafter (chapter 7), although there are uncertainties in estimating the potentials. Bioenergy as a supply-side option is a special case in this regard as the technical potential of domestic biomass in Russia is significant and can be deployed relatively quickly. Consequently, it could be used as a transition energy source, provided uncertainties in the resource estimates and wider ecological concerns are considered.

With a range of short- and long-term mitigation options deployed, the scenarios demonstrate that the budget constraint is challenging even if Russia’s emissions peak immediately, i.e., in 2013, overturning an average annual 2001–2010 emission growth rate of 0.5%. If the peak occurs in 2015, an unprecedented reduction rate of at least 10% per year will be necessary to stay within the allowed budget range. If the emission peak is delayed until 2025, approximating the budget constraint will require a nearly vertical emission pathway and significant negative emissions soon after the peak. Scenarios with late emission peaks eventually make the budget constraint (after 2050), conditional on the scale of the deployment of carbon capture and storage. Yet, until this ‘excess’ carbon dioxide is removed from the atmosphere, it will continue affecting the climate and intensifying the impacts of climate change. Moreover, if major irreversible feedbacks are triggered, CCS and bioCCS may become inadequate and even unavailing. The precautionary principle, together with the multiple uncertainties associated with negative emissions, would suggest that starting the decarbonisation process early is critical.

On the other hand, although early mitigation may be beneficial for the climate, issues related to the feasibility of mitigation make the decision on timeframe of relevant measures less straightforward. For example, scenario Kiwi ostensibly has the most challenging decarbonisation pathway (see Figure 18 and Table 32 in chapter 8), with emissions falling at 240% per year after the peak. This reduction rate relies on the deployment of all options considered in the ‘hierarchy’ in order to make the budget constraint. A possible advantage of this scenario is that major emission reductions start after 2025, thereby providing an opportunity to prepare during earlier years for a radical transition later. However, it would clearly be infeasible to stay on a business-as-usual trajectory until 2024 and then suddenly decarbonise; therefore, preparations for such dramatic reductions would need to start sooner rather than later. This scenario is not a viable mitigation pathway as it relies on a number of
implausible assumptions, including a rapid and widespread deployment of negative technologies already in the next decade. In this sense, scenario Kiwi is a theoretical exercise illustrating the potential implications of delaying emission reductions necessary for staying within the 2°C budget range.

In the short term, scenarios Plum and Cherry are likely to be more challenging than Kiwi, with rapid emission reductions starting in 2014 and 2016 respectively, despite their post-peak annual reduction rates of 13% and 10% being much lower than Kiwi’s. Scenario Melon is close to the middle of the scenario range, with its emissions starting to decline in 2021 at 22% per year and slowing down to about 15% per year after 2030. Whilst these are less challenging reduction rates than scenario Kiwi requires post-2025, they are well in excess of anything achieved or, indeed, deemed possible so far. Such radical emission reductions would involve significant material changes to the energy system, including (in the short term) residential energy demand reduction in both old and new housing stock, reduction in international transport energy use and biofuel replacing coal and oil. In the long term, scenario Melon entails considerable amounts of onsite renewable energy, reductions in non-energy CO₂ through the use of alternative feedstock, and the deployment of coal CCS and/or gas CCS.

Although these backcast scenarios, in particular, and decarbonisation measures, in general, may be feasible—if challenging—technically, their economic and social feasibility (and desirability) is likely to present additional constraints, at least, within the current socio-economic paradigm. Accordingly, this thesis argues that it is necessary to, first, create technically feasible pathways and then challenge potentially obstructive aspects of governance and values, including institutional and behavioural lock-in (as explained in section 10.3.2 of this chapter). In scenario literature some mitigation options, including the centralised vs. distributed energy generation, are often assumed to correspond to particular governance regimes. However, this thesis intentionally moves away from such assumptions. The scale of decarbonisation (national vs. regional/local) varies between different scenarios depending on storyline aspects other than governance. For instance, onsite energy generation is present in all scenarios, whereas combined heat and power is deliberately limited to the two scenarios where the population is spread across the whole country in 2050: Cherry with a ‘managed democracy’ and Kiwi with a ‘multi-level governance’ regime.

Another example is that, politically, extensive and rapid deployment of bioenergy is likely to be more suitable for scenario Cherry with its ‘managed democracy’. In this sense, harvesting biomass can be perceived as more of a ‘stop-gap’ measure compared to other low-carbon
options, i.e., less thought-out and more Soviet-style by its grand scale. Political regimes in other scenarios would probably have more careful (in terms of biodiversity) and less sweeping policies than growing enormous quantities of biomass in the short term. Using this option in scenario Kiwi with its conscientious approach to decarbonisation would require a change in political and social values in the medium term or earlier. Yet, even if such a change does occur, it is difficult to envision (let alone implement) a politico-economic regime that would introduce the dramatic and rapid emission reductions required in scenario Kiwi.

In practice, both technical and socio-economic constraints on mitigation suggest that a range of policies (i.e., a ‘portfolio’ approach) will likely be more feasible than a single across-the-board mitigation mechanism. According to the results of the scenario analysis (chapter 8), in order to stay within the carbon budget, no single decarbonisation option alone is sufficient, although some options are indispensable. In particular, it is clear that a reduction in energy consumption by itself is insufficient to deliver an economy that remains within the available carbon budget. It is also evident that reduced energy consumption is an essential contributor to climate change mitigation, even without changing the fuel mix. For example, compared to the TRENDS pathway in the same year, the energy demand reduction in 2030 ranges from 369 Mtoe in scenario Plum to 236 Mtoe in scenario Kiwi, whilst in 2050 it ranges from 563 to 325.7 Mtoe (in the same scenarios, respectively). In general, all four scenarios rely on combinations of a limited number of decarbonisation options, albeit to a varying extent and at different times. The choice of mitigation options is relatively flexible only if emission reductions start early. Although the apparent scarcity of choice in scenarios with post-2020 peaks may be worrying for those concerned about mitigation, it provides an opportunity for decision-makers and other stakeholders to focus, taking advantage of such apparently limited ‘resources’ as public support, time and investment.

10.5 Limitations and scope for further research

Research projects, by their very nature, have numerous limitations. Objectively, research is limited by financial, human and time resource constraints. Subjectively, its quality depends on that of secondary and primary data sources (e.g., data quality and disaggregation), of the research design, analysis and so on. Consequently, a researcher needs to identify boundaries not only for their research project but also for its limitations. This section only focuses on the following three limitations, or possible extensions, to this thesis: accounting for climate change impacts in mitigation scenarios; applying a case-study approach to Russia; and, suggesting detailed policy recommendations based on the scenarios.
The scenarios generated within this thesis primarily explore mitigation options and associated feasibility aspects. Yet, climate change impacts and adaptation are increasingly likely to assume socio-economic and political significance, particularly as decarbonisation is delayed. According to the analysis in chapter 3 (Table 6), if appropriate adaptation strategies are put in place, Russia’s agriculture is likely to become more competitive on international markets with moderate climatic changes as this sector deteriorates in countries that lead in agricultural exports and/or have large populations to feed. To reflect that, one of the Plum scenario descriptors states that “international shipping is used extensively to support agricultural and forest exports”. Ideally, a similar characteristic would need to accompany all scenarios with well-developed agriculture and forestry as well as scenarios assuming considerable quantities of biomass. Other sectors of Russia’s economy likely to be significantly affected by climatic changes (and considered in the backcast scenarios) are the construction industry and transport. These impacts are partly reflected in the ‘settlement patterns’ descriptors, e.g., in one scenario the construction industry innovates to support settlements on what used to be permafrost, whereas in another scenario the settlements retreat to below-permafrost latitudes.

The backcast scenarios, however, reflect climate change impacts only partly and qualitatively. Further research could introduce impacts, vulnerabilities and adaptation more explicitly and comprehensively. One straightforward improvement to the scenario generator would be to account for spare capacity of the energy system. For example, a typical capacity margin in Russia’s electricity sector is a 12 to 22% spinning reserve “kept on standby in case of unforeseen failures in power” supply (Ministry of Energy, 2010, p.47). This figure is likely to increase with intensifying climate change impacts, unless alternative storage technologies become available. To ensure the supply security of the whole energy system (including the electricity sector), the spare capacity may need to be larger. Importantly, when the spare capacity is accounted for, it is even more challenging to meet the budget constraint, especially if national energy demand is not reduced.

The second potential area on which further research could focus is exploring to what extent Russia can be viewed as a case study. This thesis has investigated Russia’s possible mitigation pathways in their own right. By contrast, a case study approach would attempt to infer patterns that can be generalised to draw lessons for how low-carbon policies and practices can be introduced in similar contexts. This thesis suggests that, although Russia clearly has many distinctive features, some aspects are not so unique and may indeed be representative of similar issues and opportunities elsewhere. At the beginning of this project the researcher expected that similarities would extend to transitional economies and/or former Soviet
republics. However, based on the contextual analysis around the backcast scenarios (including the analysis of policy documents, media coverage and other grey literature, and the expert interviews), a tentative finding has emerged that Russia is a more likely case study for the Gulf countries. The most obvious similarity is an extractive and energy-intensive economy. For instance, the International Energy Agency (2013) in its report on four quick mitigation ‘fixes’ argues that Russia and the Middle East nations share two of the four ‘fixes’: phasing out fossil fuel subsidies and reducing upstream methane emissions. In terms of shared socio-political aspects, the civil society is weak as is the state, with vast inefficiencies in policy- and decision-making processes. The ‘state incapacity’ is accompanied by the existence of a ‘social contract’ implemented through considerable fossil fuel subsidies. It is likely, however, that Russia and the Gulf nations have as many differences as similarities, and future research could explore how useful a case study Russia would present in this case.

The third potential avenue for research is to suggest policy recommendations based on the scenarios developed. To provide context for the scenarios, this thesis has analysed, to some extent, Russia’s policy environment related to climate change and energy. In particular, several weaknesses and opportunities in the country’s current governance framework have been identified. However, the implementation of the suggested radical changes to the country’s energy system requires a more in-depth analysis of how the policy-making process works in Russia. Such policy analysis and recommendations could, for example, be framed from a political economy perspective, with governance aspects of the scenario storylines being a starting point of the analysis.

10.6 Originality and contribution

This thesis delivers three broad outputs that attest to the originality of the work. The first and most immediate research output includes scenario storylines and quantitative snapshots of Russia’s energy system that serve as a basis for suggesting changes the energy system would need to undergo to switch to and stay on a 2°C pathway. The emission scenarios take into account the country’s socio-economic and political context, as well as the globally- and nationally-relevant carbon budget constraint. To this end, the researcher’s analysis of climate-related issues in Russia has been published as a peer-reviewed journal article. The review presents an original and important synthesis of a breadth of literature to analyse the politico-economic situation in Russia with regard to international climate change negotiations, related domestic policies, societal attitudes and climatic change impacts on Russia’s territory (Sharmina et al., 2013).
The second key output of the thesis is an updated and augmented scenario generator, ASK-Russia, tailored to Russia's economy-energy system and incorporating national statistics. Russia-focused emission studies tend to cluster around highly aggregated top-down models. The dearth of bottom-up economic-engineering tools implies that many aspects of the country's energy system remain overlooked. This output relates to the methodological and theoretical framework developed within the project, which concludes that: a) backcasting is a teleological and strategic planning approach that rejects reductionism in futures studies; b) as a planning tool, backcasting emphasises interim targets and pathways towards the ‘strategic objective’; and, c) interim targets and pathways are essential due to unique cumulative aspects of the climate change issue.

The methodological contribution points to the third key output of the thesis: cumulative emission budgets developed here for Russia to make a global temperature target meaningful in the national context. This is in contrast with using annual end-point (i.e., ‘flow’) targets that have come to dominate the policy arena despite having little direct correlation with the global temperature increase. Hence, the combination of backcasting and cumulative emission budgets is an important step towards science-based climate and energy policy. Prior to this study, cumulative emission budgets for Russia were only derived in scenario literature once, focusing on a single budget, rather than a range of budgets, for each allocation principle.

10.7 Concluding remarks

This chapter has provided a synthesis of the secondary and primary research material covered within this PhD project. The thesis draws on a number of disciplines, bringing together bottom-up energy system modelling from engineering and physical sciences, as well as stakeholder and expert interviews from social sciences. Using contextual and participatory backcasting, this thesis derives Russia’s cumulative emission budgets and generates associated low-carbon pathways in the context of both a re-developing economy and international climate change objectives. Whilst the scenario exercise does not lead to an unequivocal conclusion that a particular pathway is preferable (e.g., a service-oriented de-industrialisation vs. a hi-tech re-industrialisation), it demonstrates that staying within a carbon budget constraint commensurate with ‘avoiding dangerous climate change’ is a formidable task that requires step-changes to both energy demand and supply. The scenarios help to explore what particular changes to Russia’s energy system are necessary, within the specific geographical, technological and socio-political context.

56 The analysis and conclusions are dependent on the assumptions made within the scenario exercise.
The backcast scenarios generated within this thesis are ambitious and extremely challenging. With significant changes on both demand and supply sides, an annual post-peak emission reduction rate of at least 10% is required to meet the cumulative budget constraint, despite the dramatic fall in Russia’s emissions in the 1990s. The scenarios indicate that, if emission reductions start sufficiently early, the country’s decision-makers have a range of relatively technologically mature options at their disposal. However, even with early reductions, to attain a low-carbon energy system in 2050 in accordance with the cumulative emission constraint, all of such ‘mature’ options would need to be employed. In particular, in the short term, decarbonisation options in the four scenarios vary little, being mainly limited to energy demand reduction, energy efficiency and biomass partly substituting fossil fuels, although to a different extent and in different parts of the economy. Short-term mitigation is facilitated by Russia’s large energy efficiency potential and a significant biomass potential. In the long term, mitigation draws on the country’s considerable renewable energy resources.

If, however, the emission peak is delayed until 2020–2025, staying within the budget constraint will require a rapid and widespread deployment of CCS and negative-emission technologies characterised by significant technological and financial uncertainties. Scenario Kiwi, particularly, is a useful theoretical exercise showing that staying within the 2°C budget range is not a viable option unless mitigation starts early (and, preferably, immediately). In addition, until this ‘excess’ carbon dioxide is removed from the atmosphere, it will continue affecting the climate and intensifying the impacts of climate change. Whilst the suggested mitigation pathways with emissions peaking early are demanding, they are potentially less challenging and destabilising than failing to mitigate and subsequently adapting to climate change impacts of a 6–16°C temperature rise across Russia. The precautionary principle, together with the multiple uncertainties associated with negative emissions, would suggest that starting the decarbonisation process early is critical.

The mitigation options suggested draw on the contemporary debate (or, rather, rhetoric)—within Russia’s political, economic and academic establishments—about the urgent need to replace decaying infrastructure, modernise the country’s economy and reduce its energy intensity. However, the analysis of Russia’s policy landscape shows that mitigation- and adaptation-related issues are relatively low on the governmental agenda. Whilst some relevant legislation is in place, it has proven inadequate for responding to existing and imminent challenges associated with climate change. In addition, the process of policy implementation in Russia has historically been slow and inefficient, even in such a strategically important area as energy. To devise and deliver a coherent programme of mitigation and adaptation, the
existing legislation (for example, the Climate Doctrine and the Renewable Energy Decree) will need specific long-term and interim objectives, clear responsibilities of relevant institutions, a risk management framework and alternative ways of achieving the objectives. In addition, it is important that the domestic policies are aligned with international targets and commitments. Integrating both global and national dimensions of climate change will help to ensure consistent and evidence-based policies, foster synergies and abate conflicts.

To facilitate a transition to a decarbonised system, mitigation may need to be viewed initially as an essential co-benefit, complementing other policies and measures in the short term. For example, legislation on land, agriculture and forests, water and, particularly, energy could explicitly account for climate-related issues or even be integrated. Such policies could be directly linked to Russia’s national priorities, in particular, creating a more stable investment environment, attracting highly skilled labour force and reducing dependence on the global demand for fossil fuels (and thereby improving the security of energy demand for Russia). Although some of these ‘priorities’ may not be regarded as such by the current government, the decarbonisation process does not necessarily happen solely as a consequence of the government’s actions. It could be taken up or, at least, prompted by non-governmental actors, which is why it is important to understand the governance system (i.e., where agency and power reside) in Russia.

The analysis of Russia’s political and economic background has helped to identify weaknesses and opportunities in the country’s current governance framework. The semi-authoritarian policy regime in Russia can, ostensibly, more readily impose climate-related policies, with a historically passive civil society further facilitating the top-down approach. On the other hand, the weakness of the civil society and a low level of interest in climate change issues amongst the population are a handicap when it comes to long-term national priorities. For example, the culture of ‘passive observation’ evident in the evolution of the main Russian environmental advisory body, RosHydromet, can partly explain the country’s climate change inaction. Yet, the climate-related track record of the government has demonstrated that non-governmental actors are more likely than the ruling elite to emerge as ‘levers for change’. The level of awareness and concern amongst the Russian population, albeit comparatively low, is growing steadily. The engagement of the public is likely to intensify as climate change impacts become increasingly prominent. This thesis concludes that, in the absence of meaningful government-led climate policies, civil society actors may need to use the country’s dilapidated energy infrastructure, the depletion of large easily accessible oil and gas fields, obsolete manufacturing capacity and the recent economic crisis to instigate mitigation action within the current
decade. It is likely that the population would act as an ‘intermediary’—rather than an ‘implementer’—informing the government and other decision-makers of policy priorities.

Cutting across issues of governance, values and technological progress, is the fundamental question unresolved for both those within and outside the country: what is Russia’s place in the world? This question has emerged, directly or otherwise, in the backcast scenarios and literature sources as well as—unprompted—in all of the interviews. This thesis concludes, tentatively, that global leadership towards a sustainable (defined here as ‘low-carbon and climate-resilient’) future may provide an answer.

Along with other big emitters, Russia has a pivotal role in influencing the future direction of international climate change mitigation and adaptation. Not only is Russia a major emitter of greenhouse gases and a global supplier of fossil fuels, but also it remains a major force in international politics, and its diverse territory is both vulnerable and resilient to the impacts of climate change. This unique confluence of circumstances leaves Russia with a challenging dilemma. The country can choose to acquiesce to short-term political and economic considerations, adopt weak mitigation measures and face potentially devastating impacts. Or it can apply its considerable attributes and powers to instigate an epoch of national and global action to secure a sustainable future. Whilst the former will see Russia subsumed into the international malaise on climate change, the latter may both quench the nation’s “thirst for greatness” and fill the void of climate leadership.
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## Appendix A. Secondary sources of data used for populating the ASK-Russia tool

<table>
<thead>
<tr>
<th>Sector</th>
<th>Tab in the ASK-Russia tool</th>
<th>Source</th>
</tr>
</thead>
</table>
- Number of households in 1989, 1994, and 2002 from the Domoscope journal (table 5.4, page 125)  
- Number of households in 2010: the GosKomStat online database updated in April 2012  
- Consumer expenditures from the World Bank Databank - The 2005 final energy consumption by end-use from Bashmakov et al. 2008 ‘Resource of energy efficiency in Russia: scale, costs and benefits’ |
- 2002–2009 sectoral GVA from the GosKomStat online database updated in April 2012  
- Energy consumption, electricity consumption and non-electricity consumption from IEA 2011 Energy Balances 1990–2010  
- 2002–2009 sectoral GVA from the GosKomStat online database updated in April 2012  |
- 2002–2009 sectoral GVA from the GosKomStat online database updated in April 2012  
- Sectoral deflators averaged over 2003–2011 from the GosKomStat online database  
- The 1992–2006 USD/RUB exchange rates from the ESDS International and the UN Common Database  
- The 2007–2009 USD/RUB exchange rates from the Oanda website |
| Transport    | ‘Demand Data’, ‘Transport’  | - Total and international aviation passenger-km in 1993–2004 from UN ‘2007 Common Database Civil Aviation Data’. Domestic aviation passenger-km calculated as the difference between total and international.  
- Railway data: passenger-km and freight ton-km 1990–2009 from the World Bank’s World Development Indicators (edition: April 2011)  
- Implied emission factors from the UNFCCC Online Greenhouse Gas Emissions Database  
- Net calorific values, make up of the grid, heat fuel mix, heat energy fuel mix and share of CHP vs. heat plants from IEA 2011 Energy Balances 1990–2010  
- Historical CO2 emissions 1990–2010 from the UNFCCC Online Greenhouse Gas Emissions Database |

- ‘Key Indicators’
- ‘Output Summary’
Appendix B. A topic guide for pilot interviews (in English)

**PROJECT:** Russia’s emission pathways and cumulative emission budgets

**DOCUMENT:** Topic guide for the first stage of stakeholder engagement (semi-structured telephone interviews)

1. **GENERAL INFORMATION ABOUT THE INTERVIEWS**

**AIM**
The aim of the interviews is to obtain expert stakeholder input into backcasting-based scenario generation for the energy system in Russia.

**OBJECTIVES**
The specific objectives of the stakeholder engagement are to obtain stakeholder input into trends and assumptions in the following areas:
1. The past and present states of the energy system, i.e., cause analysis.
2. The future desired state of the energy system (in 2020, as an interim target, and in 2050).
3. Potential pathways towards the desirable future state of the energy system.

**DEFINITION(s)**
A ‘stakeholder’ in the context of this study is an expert, who has an overview of a particular sector of the Russian economy or of the economy as a whole in terms of energy production and consumption.

**KEY STAKEHOLDERS**
Sectoral experts (industry, transport, buildings, energy production, agriculture)
Governmental officials (Ministry of industry and trade; M. of transport; M. of economic development; M. of energy; M. of agriculture)
Non-governmental sector representatives (observers, researchers, NGOs, activists)

**METHODOLOGY**
The stakeholder engagement will consist of a series of semi-structured telephone and/or face-to-face interviews. The interviews may be followed by a focus group or additional interviews at a later stage of the research.

**SIZE OF THE SAMPLE**
The potential sample size is 10-15 interviewees with at least one stakeholder from each sector and each ministry listed previously, as well as from the non-governmental sector.

**STAKEHOLDER ENGAGEMENT SCHEDULE**
The stakeholders will be involved during the third year of the PhD project to inform the initial methodology, and potentially during the fourth year to review the results and analysis and interpretation of these results.

**FEEDBACK RULES**
The stakeholders will individually receive a summary of their respective interviews. Those interested in the later stages of the project will be updated about the results of the project.

**ANONYMITY**
Every effort will be taken to avoid disclosing the information that may identify participants.

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57 The other stages of backcasting—testing consistency and feasibility of pathways—are discussed during the second set of interviews.
2. STRUCTURE OF THE INTERVIEWS

I. INTRODUCTION
5 min
Aim: to introduce myself, my affiliation and the purpose of the interview

- Thank interviewee for taking part in the research.
- Introduce myself and Tyndall Centre.
- Explain purpose of research: I would like to talk to you about …
- Explain the format of the interview, its length (40 min) and that it will be recorded, if they don’t mind.
- Explain importance of interviewee saying what they think, there are no right or wrong answers, all opinions valid and helpful.
- Ask to sign the consent form.
- Any questions so far?

II. MAIN PART
30 min
Aim: to discuss the main topics outlined in the objectives of this topic guide

[Advice: use requests for factual or descriptive information as opening questions.]

Topic 1: The present situation in the economy / interviewee’s sector.
Topic 2: Past trends in and effects of the financial downturn on the economy / interviewee’s sector.
Topic 3: The future desired state of the energy system (in 2020, as an interim target, and in 2050).
Topic 4: Potential pathways towards the desirable future state of the energy system.

III. CLOSING
5 min
Aim: to summarise the interview and close

- Can we please summarise key areas?
- Is there anyone else that the interviewee thinks I should interview?
- Does the interviewee have any questions for me?
- What happens next: I will email the summary of the interview to the interviewee.
- Check out the willingness of respondents to be re-interviewed at a later stage of the project (in about 6-8 months).
- Thank the interviewee for their time.
Appendix C. A recruitment letter for pilot interviews (in English)

What?
I am a PhD Researcher at the University of Manchester working on a project related to Russia’s energy-related greenhouse gas emissions and climate change policies. I am looking to recruit experts with the knowledge of Russia’s energy system or elements of it (in particular, the aviation industry) to participate in a one-off telephone interview.

How?
In this research, I am interested in your views on Russia’s energy system, greenhouse gas emissions and climate policies from the viewpoint of the aviation industry. For this purpose I would need you to take part in an interview which would last approximately 40 minutes.

When?
The interview will be conducted over the phone at the day and time most suitable for you. More information will be available on request if you agree to take part in this research.

Who?
Maria Sharmina, PhD Researcher, University of Manchester
Tel.: +44 (0) xxx xxx xxxx
Fax: +44 (0) xxx xxx xxxx
E-mail: xxxxxxxxxxxxx@xxxxxxxx

Please contact me using the details above if you would like to participate in this research or seek any further information.

I look forward to hearing from you,
Maria
Appendix D. A summary of a telephone interview with the aviation sector entrepreneur (in Russian)

Interview date: 26/03/2012
Person interviewing and summarising: Maria Sharmina
Date of summarising: 30/03/2012

1) Можете ли авиационная отрасль в принципе достичь нулевых выбросов углерода, если мы допустим, что у нас достаточно для этого времени? (например, до конца века)

*Interviewee*: теоретически возможно, с помощью биотоплива. В России данное топливо пока не применяется в связи с высокими инвестиционными затратами, хотя эксперименты проводились. Нужно помнить, что тяжело организационно перейти на биотопливо, т.к. это повлечет изменение многих отраслей, и в первую очередь, сельского хозяйства.

2) При оптимистичном прогнозе, насколько низко могут упасть эмиссии отрасли парниковых газов к 2050 году?

*Interviewee*: вопрос, скорее, должен звучать обратно: какова будет цена на нефть к тому времени и будет ли она приемлема для осуществления воздушных перелетов? Я считаю, что будущее за биотопливом или за совершенно новыми технологиями. Например, если человечество откажется от скоростных перемещений и перейдет на воздушные шары и дирижабли.

3) Какие еще технологии могут способствовать снижению эмиссий парниковых газов в отрасли, помимо Вами упомянутых выше?

*Interviewee*: существуют организационные мероприятия, например, более простые схемы захода воздушного судна; улучшение аэродинамики самолета — т.е. меры, направленные на сокращение использования топлива скорее, чем выброс CO₂.

4) Какие политические меры или реформы могут способствовать снижению эмиссий парниковых газов и каким образом?

*Interviewee*: EU ETS в данный момент является наиболее эффективным способом добиться чего-либо. Для этого нужна инициатива правительства. Проблема системная и должна решаться экономическими способами, которые всегда устраивают «сверху». Системно этим заниматься бизнес неспособен. Пример: правительство Китая тоже пришло к созданию аналогичной системы — углеродного рынка. С созданием EU ETS [и углеродных рынков в других странах], энергоэффективность становится важна для конкуренции на внешних рынках.

6) Что, по Вашему мнению, является основными препятствиями и ограничительными условиями на пути к низкоуглеродному будущему в России?

*Interviewee*: Проблемы такого уровня у нас в стране обычно решаются от первого лица [государства]. Если что-то долго не решается — значит, первое лицо против по какой-либо причине. И ждать будут до последнего момента. Пример: упущеная возможность продать китайские квоты. Сейчас аналогичная ситуация в отношении производителей (и не только авиапроизводителей). Пока проблема не игнорируется — внимание со стороны правительства уделяется — собираются совещания, выслушиваются различные мнения. Некоторые чиновники пытаются довести ситуацию до состояния торговой войны. В данный момент невозможно сказать, какое решение правительство примет.
1) Do you think aviation in Russia can in principle become a zero-carbon industry, assuming enough time is allowed for a low-carbon transition (for example, by the end of the century)?

*Interviewee:* it’s possible hypothetically, with the deployment of biofuels. In Russia, this type of fuel is not used yet due to high investment expenditures, although some experiments have taken place. You need to remember that it’s challenging to switch to biofuels system-wide, because it would result in changing many other industries and, first of all, the agricultural sector.

2) Optimistically, how fast and low do you think emissions in Russia’s aviation industry can drop by 2050?

*Interviewee:* the question should perhaps be re-phrased as follows: what will be the price of oil by that time, and will it be affordable to fly planes? I think the future is in biofuels or some completely new technologies. For instance, people might give up high-speed planes and choose to fly by hot-air balloons and dirigibles.

3) What other technologies do you think may facilitate the de-carbonisation of the aviation industry, in addition to the ones you’ve already mentioned?

*Interviewee:* there are administrative measures, for example, more simple/short approaches to landing, improvements to aircraft dynamics and so on, i.e., measures targeting fuel efficiency rather than CO₂ emission reductions.

5) What political measures or reforms could facilitate emission reductions and in what way?

*Interviewee:* the EU ETS is currently the most effective way of achieving anything in this area. Here, we need the government to lead the way. This is a systemic problem and needs economic solutions that are always top-down. Businesses are unable to achieve that at a systemic level. For example, China’s government has decided to launch a similar system – a carbon market. With the establishment of the EU ETS [and carbon markets in other countries], energy efficiency becomes an important aspect of international competitiveness.

6) What, in your opinion, are the key barriers to and constraints on Russia’s low-carbon development?

*Interviewee:* it’s the head of state who deals with such high-level problems in our country. If a problem is not being tackled, it means the head of state is against this for some reason. And they [the big political and economic players] will be waiting until the very last minute. One example was the wasted opportunity to sell Kyoto quotas. The situation is similar in relation to manufacturers (and not only aircraft producers). Currently, the problem is not ignored completely – the government is paying attention – meetings are organised, opinions are listened to. Some officials are trying to turn the situation into a trade war. It’s currently impossible to predict what decision the government will take.
Appendix E. A version of low-carbon scenario profiles used in face-to-face interviews with policy experts

**PROJECT**: Russia’s emission pathways and cumulative emission budgets  
**DOCUMENT**: Low-carbon scenario profiles for the second stage of stakeholder engagement (semi-structured in-person interviews)

**CONTEXT**
Regardless of the differences in the energy demand and economic growth rate, all four scenarios stay within the allocated cumulative CO$_2$ emission budget aiming to stay below the 2°C temperature increase by 2050. The subsequent paragraphs provide general context for each scenario, and the main scenario characteristics are compared in the table below.

**SCENARIO A**
Scenario A is a low economic growth and low energy demand scenario. Russia in 2050 is a post-industrial economy built through ‘de-industrialisation’ and re-orienting economic activities towards services. The transition occurs through a series of economic crises (following the economic recession in the late 2000s) that are used as a springboard for economic and social reforms. The services industry, agriculture and forestry are well developed and produce high-value added services and low-value added goods. Manufacturing decreases dramatically while construction rates in rural areas grow to accommodate the de-urbanising population. The construction sector innovates to support agriculture and settlements on melting permafrost. Settlement patterns are more spread-out, the pace of life is slow compared to today, and households become more self-sufficient. Political power is devolved to local authorities.

**SCENARIO B**
Scenario B is a high economic growth and low energy demand scenario. Russia in 2050 is a post-industrial economy built through ‘de-industrialisation’ and re-orienting economic activities towards services. The transition occurs through high, ‘Baltic Tiger-type’ economic growth and liberalisation. Similarly to Scenario A, the economy is service-oriented but with a different flavour. The services sector heavily dominates, with industry moderately developed and little agriculture – an economic structure similar to today’s Russia – producing high value-added services and medium value-added goods. The urbanisation rate is high and households are predominantly concentrated in high-rise buildings, with some low-rise buildings in rural areas. Melting permafrost drives settlements south. The centralisation of power is reminiscent of Russia’s current ‘managed democracy’.

**SCENARIO C**
Scenario C is a medium economic growth and medium energy demand scenario. Russia in 2050 is an economy based on restored and renovated light and heavy industries, producing a large share of products domestically. The transition occurs through top-down (state-led) capitalist expansion, with three out of four factors of production (labour, capital and land) used intensively. The industries are situated in proximity to raw materials and/or energy sources; the share of services is low. The population is spread across the country and concentrated around industrial sites; the new housing stock is predominantly high-rise. Melting permafrost is dewatered to maintain fossil-fuel mining and agriculture. The pro-environmental government takes a centralised approach to governing the country.

**SCENARIO D**
Scenario D is a high economic growth and high energy demand scenario. Russia in 2050 is an economy based on restored and renovated light and heavy industries, producing a large share
of products domestically. The transition occurs through a bottom-up capitalist expansion, with the economy moving away from taxing labour towards taxing capital and, hence, developing human capital- and labour-intensive, high value-added manufacturing (including crafts, modularity and re-manufacturing). Construction rates are high to accommodate new polycentric networks of cities with sprawling suburbs. The construction sector innovates to support settlements on melting permafrost. Political power is devolved to regional authorities.

Table: The main features of the four scenarios (VERSION 6, 18/05/2013)

<table>
<thead>
<tr>
<th>Scenario A</th>
<th>Scenario B</th>
<th>Scenario C</th>
<th>Scenario D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GDP and energy dynamics</strong></td>
<td>• low growth</td>
<td>• high growth</td>
<td>• high growth</td>
</tr>
<tr>
<td></td>
<td>• low energy demand</td>
<td>• low energy demand</td>
<td>• high energy demand</td>
</tr>
<tr>
<td><strong>Sectors with the largest GDP share in 2050</strong></td>
<td>• services (H)</td>
<td>• services (H)</td>
<td>• highly advanced goods</td>
</tr>
<tr>
<td>(H) 60–80%</td>
<td>• agriculture and forestry (L)</td>
<td>• highly efficient mining and processing (L)</td>
<td>manufacturing (H)</td>
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<td>(M) 30–50%</td>
<td>• construction (L)</td>
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<td>(L) 5–20%</td>
<td><strong>Main factors of economic growth</strong></td>
<td><strong>Main outputs</strong></td>
<td><strong>Settlement patterns</strong></td>
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<td>• human capital</td>
<td>• high value-added services;</td>
<td>• de-urbanisation</td>
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<td><strong>Main factors of economic growth</strong></td>
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<td><strong>Transport</strong></td>
<td>• de-urbanisation</td>
<td>• high value-added goods</td>
<td>• freight, but not passenger,</td>
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<td>• less and slower travel</td>
<td>• high urbanisation</td>
<td>transport used extensively</td>
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<td>• settlements spread out</td>
<td>• more travel</td>
<td>so is international aviation and shipping for both importing goods and</td>
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<td>• residential sector dominated by low-rise buildings</td>
<td>• settlements below permafrost latitudes only</td>
<td>travelling</td>
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<td>• fewer and larger households, with shared utilities</td>
<td>• buildings mostly high-rise, with some low-rise rural buildings</td>
<td>• both public and private transport well developed</td>
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<td>• main modes: shipping, aviation, rail, road</td>
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<td><strong>Settlement patterns</strong></td>
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<td>• urbanisation as today</td>
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<td>• more travel</td>
<td>• travel as today</td>
<td>• private transport developed better than public</td>
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<td>• settlements below permafrost latitudes only</td>
<td>• new housing stock of three types: high-rise buildings concentrated around industrial sites, rural low-rise houses, and suburban houses</td>
<td>• main modes: road, rail</td>
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<td>• buildings mostly high-rise, with some low-rise rural buildings</td>
<td>• number and size of households as today</td>
<td>• freight and passenger transport used extensively, with the latter used for leisure rather than commutes</td>
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<td>• more and smaller households</td>
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<td>• international aviation and shipping used extensively for trade and travelling</td>
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<td>• main modes: road, aviation, shipping, rail</td>
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58 This study distinguishes between four factors of production: capital, labour, human capital [including, or also known as, technology, know-how, knowledge and entrepreneurship] and land [including natural resources].
<table>
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<tr>
<th>Governance</th>
<th>multi-level governance Type II: devolving power to local authorities</th>
<th>a centralised approach: managed democracy</th>
<th>a centralised approach: state-led environmentalism</th>
<th>multi-level governance Type I: devolving power to regional authorities</th>
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| **Short-term decarbonisation policies** | • reduction in car use  
• improved agricultural and forestry practices  
• imported biomass | • reduction in car use  
• existing public transport used to its full capacity  
• so are existing nuclear and hydro-power stations  
• domestic biomass | • residential energy demand reduction  
[austere]  
• reduction in international transport use  
• imported biomass | • residential energy demand reduction  
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• domestic and imported biomass |
| **Medium-to long-term decarbonisation policies** | • economy restructured away from energy-intensive manufacturing  
• new housing stock complies with strict energy efficiency standards  
• onsite renewable energy | • new, mostly high-rise, housing stock complies with strict energy efficiency standards  
• wide-spread combined heat and power (CHP) | • solar energy imported from neighbours in the south  
• CCS  
• onsite renewable energy | • nuclear energy: electrification of transport  
• wide-spread combined heat and power (CHP)  
• bioCCS  
• offshore wind and marine energy |
Appendix F. A sample transcript of a semi-structured in-person interview with a policy expert

Interview date: 21/05/2013
Person transcribing: Maria Sharmina
Date of transcription: 30/07/2013
Notes:
2) The times in square brackets indicate the time on the audio-recording.
3) The researcher’s questions in this transcript are often abbreviated.

E3 (seeing the researcher holding the ‘Siberian Curse’ book): It’s not a book that a geographer would have written, it’s how an economist might approach it. Partly because there are tons of environmental determinism. But I think it’s an interesting way of measuring what we might have achieved with the radical consequences of state socialism, that you have these industries and people in places which wouldn’t be supported by a market economy. The tendency of economists is to think they’ve been put in the wrong place. Well, they weren’t in the wrong place under the Soviet system. I think the idea of shutting down very large cities is really wrong, fanciful and has not happened. In some parts people have left, there is a lot of inertia in the system. There is a lot of sunk costs in infrastructure. [01:32]

R: How likely is it that this might happen?

E3: It’s happened on the extremes, it’s happened in the Far North, and I see you are making much of this issue of the permafrost and whether people will be living on the permafrost. One of the things they’ve discovered with the census results, over the last two censuses [02:00], that there are quite a lot of places where there were settlements with no people. So there has been a consolidation of the population, withdrawal of the population from the more extreme locations. And it’s happened in the Russian far east where the population has declined, but what’s happened there is, in the Soviet period there was a steady flow of people out of European Russia into these areas, young people. They were either sent there when they graduated from university, or they went there because there were higher wages, benefits, holidays and so forth. All of that stopped. So those who went there in the late 80s got trapped and they’ve been there ever since if they couldn’t get out. If they could get out – in the early 90s as quickly as they could. But what has happened is the population has been far more static in the Russian far east and it’s aged, it’s aging now in the same way as the European Russia is. [03:00] So that’s adding to the demographic decline. So you can see that early on that out-migration lead to a very substantial reduction in these marginal areas, now it’s the ageing of the population and the fact that there is no influx of younger people to have families in those areas. So you have a more elderly population in these more peripheral regions.

R: What do you mean by static population?

E3: There is no in-migration and out-migration, so a relatively stable population

R: Because of the distances partly?

E3: Well, there are no incentives. It’s very difficult for example for oil companies working on Sakhalin to recruit people in Moscow. If they can’t pay them enough, they won’t come. Why would you leave Moscow and go and live in Sakhalin? You can’t even attract them from Vladivostok to go there, it’s not an easy thing to do. [03:52]
R: Just going back to the scenarios, do you think it’s likely that the government might provide incentives for the population to go back to the Western part, as the book suggests? I.e. to shrink the country.

E3: [05:00] The government’s policy is the opposite. The question is this notion of ‘effective occupation’ – we have a product called [removed to protect identity]. They continue to have programmes to try and promote the development of the Far East and Trans-Baikal. And even now there’s a ministry for the re-development of the Far East.

R: What stakeholders are interested in this?

E3: Obviously, the people in the Far East are interested. For example, [Viktor Ivanovich] Ishaev who is now a minister who was the presidential representative, and previous to that the governor of Khabarovsk, but he is an old Soviet-era politician, he is not very dynamic. But there is a sense in which the population of the Far East have settled back down [06:00] to a more realistic size, and it’s concentrated in the southern border regions, which is what you would expect of an economy developing under market rules. So it kind of now mirrors somewhere like British Columbia or Western Canada where you have this concentration of the population in the southern regions.

[06:43] In terms of policies it still seems to me that they are concerned about this strategic issue about ‘effective occupation’. They look across the border and see the 19 million Chinese in the bordering regions of China. [07:00] So there’s things like a ‘Power Siberia’ pipeline, which they’ve announced they are going to build at the cost of 8 million dollars a kilometre, which given that it’s 4 thousand kilometres long, it’s a very long pipeline and an awful lot of money. 48 billion dollars. My Russian colleague in Japan says, it’s basically scam, it’s for the people to make money out of corruption.

[07:30] So there’s continuing government policies, but people I think are not showing great willingness, and the problem is these big resource projects, they don’t employ a lot of people once they are built. So the manufacturing economy... What will people do in the Russian far east, what will they make? In a resource-based economy, still mainly capital-intensive, not labour-intensive [08:00] I don’t know it depends... The regional consequences of your different scenarios are not really explored in detail here, but I think you’re kind of hinting at it in terms of population. But they do mean different things. The Russian government gave up quite some while ago the idea of trying to equalise living standards. It wants to promote economic growth. So the priority is more about promoting growth in regions where growth seems to want to happen rather than equalising across regions.

R: The q. about the presentation of scenarios.

E3: Well, I am used to this kind of scenario building thing [09:00], I mean I do it myself. But I just thought the one scenarios that was missing was the one most likely. Which is medium growth and high energy. But I have a couple of questions. When you say ‘low growth, low energy’, are you looking at energy intensity as a measure? Lower growth and lower energy demand from the current situation? Because the current situation is extremely inefficient.

R: It’s all compared to today.

E3: One of the concerns I have is that, does ‘low’ mean falling energy consumption? [10:03] Because you can improve your intensity where your growth is more rapid than your energy consumption, but that doesn’t necessarily imply an absolute reduction in energy consumption. Intuitively I think that more service-oriented modernisation-type scenario – with modernisation will
come increased energy efficiency. Therefore the absolute amount of energy consumed will decline. So if you have falling energy consumption plus moderate growth, you have quite dramatic changes in intensity, even without substantial economic growth. [11:00] Either side, which is the denominator here? What is driving the change in intensity? The intensity could be driven by efficiency gains or it could be a combination of that and growth. I guess it wasn’t clear in my mind. When you read the numbers in terms of the inefficiency of the Russian economy, clearly there already have been substantial reductions in energy consumption, but I wouldn’t say there have been substantial improvements in efficiency. There haven’t been. There have been the losses of the sectors of the economy that consume a lot of energy like making tanks and missiles and things. But most of the economy and the building stock remains horribly inefficient.

[11:52] When you’re talking about sectors with largest GDP share, I mean your resource sector, ‘highly-efficient mining and processing’, the energy sector itself is not here [12:00]. Why is that? It’s generating 50% of government revenue at the moment.

R: Well, it depends on what you consider the energy sector, whether the extraction industry is classified as part of it.

E3: It’s national exportable surplus. It’s that oil and gas are major exports of Russia.

R: The energy sector in my view is the energy consumed within Russia, not the energy [and emissions] that’s exported [NOTE: does this relate to territorial vs. consumption-based emissions?]

E3: But energy is itself an industry.

R: Which is called the ‘Extraction Industry’ here

E3: But it doesn’t figure in the sectors with large GDP share

R: It does in scenarios B and C

E3: [13:02] But mining and processing is different from the energy sector, in terms of industrial classification, I wouldn’t... Well, I think it’s one way of treating it, but I think it’s this ‘modernisation paradox’ that Pavel Baev talks about, that Russia needs to modernise, but it can only modernise by generating revenue, and the only way it can generate revenue is by exporting energy, and the only way it can sustain exporting energy is by investing more in the energy sector. So the energy sector itself and the role of the energy sector, its place in the economy is critical towards these things. Because of the changing geography of energy production in Russia, the depletion of accessible fields, [14:00] they have to invest more just to stand still. Which means even to meet domestic requirements for energy they need to invest more. That’s a major incentive to be more efficient, to get rid of things like flaring and improve efficiency so that you can sustain your exportable surplus. But in true Soviet style, Putin says, right, we must continue to produce 10 bn barrels of oil a day. The cost of maintaining that level of production is going to go up. The energy invested to maintain that production will go up because the production itself will move further east and offshore. So the role of the energy sector and the extent to which the energy sector is a brake on the economy, I think, is critical. [15:00] I think it’s just separating out the energy sector. I mean we’ve got the Energy Strategy to 2030, you could look at that. There’s also the Russian scenarios that were done by the World Economic Forum, which might be helpful as well. Because what happens in the energy sector and the global prices of oil is so important to driving Russian economic growth that it is not separate and identifiable

R: I used the classification by the IEA where the energy sector is different from the mining and processing industry, and the energy sector acc. the IEA does not produce much GDP...
E3: But the IEA is reflecting the economic structure of the OECD economies. Even though there are statistics for non-OECD countries, it has an internal bias towards OECD [16:00]. In a sense, Russia is not a classic resource-rich economy because it’s got a large industrial sector, but that industrial sector has shrunk, and the service sector—as you’ll know there is a huge argument about measuring the size of the service sector in Russia—it’s just an observation… When it comes to things like main outputs, there is this continuing desire to deepen the amount of processing, which is an obsession from the late Soviet period that Russia should not be exporting unprocessed raw materials, it should be exporting products, refined products rather than crude oil, for example. To add value, yes… And the success or not of being able to do that is critical. [17:00] You’ve got your different scenarios… One of the assumption to talk through about production being for the domestic market. At what is ever Russia is a place where international companies invest in production to export to elsewhere?

R: Well, it doesn’t seem very likely today.

E3: Which sets it apart from most economies. It’s historical. There are some parallels, for example, the automotive industry is an interesting one to look at because the Russians have obviously learnt a lesson. The domestic industry was basically rubbish and some foreign countries have invested in [18:00] the remnants of that domestic industry. But they, essentially through the tariff barriers and whatever, are causing companies to set up what we call ‘trans-plant’ activities in Russia, initially to assemble but now to manufacture cars for the Russian and CIS markets. So they are using trade policy in a well-understood way because it’s exactly what Americans did to stop the Japanese exporting cars to America which cost American auto-workers jobs; they made the Japanese companies locate their plants in the United States to service American markets. So now Japan produces cars in America which it exports elsewhere. But the thing about Russia is that the productivity of the labour market, the age structure of the labour market, the availability of future labour and so forth – there are still these question marks about [19:00] what is Russia’s role in the global economy? Is it a place that makes things? Is it a place that just produces resources? If it’s a service economy, is that the service economy only producing services for the domestic market? For example, is Moscow going to become an international financial services centre play a role for a wider region or just Russia? I don’t think any of these questions are really resolved yet, and I just don’t see the government policy—top-down modernisation through creating state companies—is the answer to anything.

R: They probably don’t prioritise long-term.

E3: Well, no, because they […] to get as much as they can from oil and gas and stick it in offshore.

R: Just going back to my questions here. So you said the most feasible scenario is absent here, with medium growth and high energy consumption? [20:30]

E3: I guess the question is what you mean by the dynamics of energy consumption. What I mean by ‘high’ is that you don’t get the efficiency savings, and your scenario C is probably closest to that, which you’re calling ‘medium growth, medium energy demand’. It begs the question of what are these ‘low’, ‘medium’, ‘high’ relative to? Are they relative to where they are now, are they relative to global standard where we would expect, for example, an economy with the GDP/cap of Russia to be [21:00] in terms of its energy intensity, and we know that its energy intensity is much higher than what we’d expect given its GDP.

R: I need to clarify the baseline.

E3: Yeah, I mean, why, why four scenarios?
R: The odd number is so there’s no scenario in the middle, which is usually the ‘favourite’. And it’s four because two would be two few, etc.

E3: You’re absolutely right, because what tends to happen is we have a good scenario, a bad scenario and one in the middle, which is ‘bumping along’. And it always seems to me that, in the numerous scenario-building exercises I’ve been, it tells you as much about the people doing the scenarios. They kind of hope that Russia won’t be as bad as they think it is, and that’s the good scenario [22:00]. They kind of think, well, it can’t be as bad as it might be, and that’s the bad scenario. And then they realise that actually the reality is just a mess, and that’s the middle scenario, and that’s the one that’s most likely. But putting the fourth one kind of destabilises it.

R: …explaining re desirable futures and backcasting

E3: It’s very unusual to have Russia and scenarios associated with everything [ever to be?]. Good luck.

R: [23:18] So which scenario do you think the most unrealistic one, the least feasible?

E3: Scenario B I think, ‘high growth, low energy demand’

R: Just because of these two aspects?

E3: No, it’s kind of implying a successful modernisation scenario, and I just don’t see that happening. [Reading] Centralised approach: managed democracy. I mean the relationships between the governance assumptions and the economic outcome [pause] are interesting. If you say ‘high growth, low energy’, it’s potentially the most positive scenario here, depending on what you’re interested in. [24:00] But that’s dependent on a centralised approach and managed democracy, which is essentially what we have at the moment. But it’s not delivering that and it’s got no capacity in the future to deliver that. Whereas multilevel governance devolving power Type I vs. Type II… What’s the difference between I and II?

R: Type I is similar to the EU

E3: Well, that should create crisis! And Type II is more fragmentation. It’s just something for you to consider, I guess, what you see as a relationship between your assumptions about governance and your assumptions about growth.

R: Well, that’s one of the questions, how consistent they are. [25:00]

E3: You’ve got ‘centralised approach: state-led environmentalism’ that’s actually [scenario] C, whereas I would say that centralised approach, managed democracy and state-led environmentalism is probably what we have now.

R: Do you think it’s helpful to provide examples of countries that have or had (in the past) similar pathways and use them as ‘imperfect analogues’?

E3: It’s an interesting one because I always have this debate with Russian friends who are always telling me Russia is different, nowhere is like Russia. And I say, well, it’s not really like that, there are more universal processes, and Russia is not immune to them. But in my own work and the book I’ve just finished [26:00] [title deleted here to preserve the anonymity], I have really struggled about where to stick Russia. In the end, I wanted to have a separate chapter, which was about post-socialist economies because I think since 1990 the transition they have gone through is different from the rest of the world. They’ve gone through the collapse of the socio-economic system, the
political system, the imposition of some form of market economy and some form of democracy. And that’s had dramatic impacts on a relationship between energy, economy and society. But when you put Russia in together with the 20-27 transition economies, Russia is again an outlier because Russia is so big and is the major supplier of resource, of energy, to most of these economies, not all of them, but most of them. So Russia is not like the post-socialist economies of Central Europe because the post-socialist economies of Central Europe have the prospect of EU membership, which was critical to them in their transition. [27:00] So they had a model, an analogue they were looking at. They had no choice because if they wanted to become part of the European Union, they had to adopt European Union institutions and legislation. So the analogue was already made, take it or leave it. There is and was no analogue for Russia. And it comes back to the Hill/Gaddy argument that this is a failed industrial economy. We don’t have other historical examples of a failed industrial economy of this scale. The Soviet Union as a super power, a major industrial economy; within the Soviet Union, Russian Federation was dominant. In a sense, it’s a collapse of an industrial economy that we see. I can’t think of an analogue. It’s not like the 1930s – the scale of the restructuring, [28:00] the speed, all of it, politically a very different context. This notion of the ‘triple transition’ that they had to go through. They all went thought it in some ways. Triple transition – from plan to market, from the authoritarianism to democracy, and another one is to do with a closed economy to an open, global economy. It’s a term that [unclear] is used in the 90s. There ARE no analogues. And the problem is that the West thought that it could just take its standard model of market democracy and impose it on Russia and it would work, and of course it didn’t.

R: the argument about ‘good enough incentives’

E3: [29:05] Yeah but it’s not a tabula rasa, it’s not a blank map. People are already in the wrong place doing the wrong thing. There is a degree of path dependence that is an impediment. This is something that transition economists never understood. You model maybe a pinhead, but this is the largest country in the world, you’ve got 140 something million people. And what Clifford [Gaddy] is essentially saying that a lot of these people are in the wrong place doing the wrong thing. But they can’t and won’t move. At the end of the day this is a process that will take generations. What will happen is that all the people in these areas will die and there’ll be no one else to replace them. The settlements will die off, and the country will shrink. One of the Russian geographers I worked with in the past talks about an ‘archipelago’, there’ll be islands of settlements [30:00], surrounding areas will be sparsely populated. And in the transition process you’ll find people basically stuck, they’re there until they die. They’ve got nowhere to go, they can’t afford to move, they’ve got their social networks where they are. It’s a difficult process and it’s still ongoing. Largely unspoken about really. Because these people are incredibly resilient, and this is their home, so why should they leave. But when they go, there’s no one to come and to take over. That’s posed lots of questions which we’ve never really had to deal with before. You know, mining towns, we’ve had booms and busts, but this is on a continental scale. It’s not finished, I don’t think. And I think the seeds of discontent are still very much there.

R: Do you think there is not cultural argument [31:00] e.g. adopting a Chinese model?

E3: I kind of dispute the idea that people are all the same, at one level. This is just saying that culture is not important, the economics and human greed essentially will always [unclear]. I don’t think that’s true. For example, Vladivostok is a European city, it’s not Asian. You get there and, certainly in 1995, just like any other Soviet city, it’s the homogenisation of the landscape. And also of the culture. Another Russian friend of mine, a cultural geographer, was always saying that there IS no cultural geography [32:00] in Russia, all Russians are essentially the same. It doesn’t differ in the way it does the United States where there is a big difference between the north and the south. Well, I couldn’t detect whether that’s true that all Russians are the same. It it’s a question of incentives, then how does that explain kleptocracy and the level of corruption that’s developed in Russia. It’s a huge problem, it’s endemic.
There's no reason to think that Russians are more or less prone to be good entrepreneurs. Within the rules of the game they can manipulate the rules to their benefit. Maybe it IS an incentive mechanism, maybe the rules aren't right, I don't know. You'd thin if you only have to pay a 13% tax, you'd pay it... You can see that in the Soviet period, of being able to work within and around the system. And the fact that that did that stopped the system from collapsing, that's the ultimate irony. Because if they worked the way the system wanted them to work, the whole thing would have collapsed long ago. And now we have the system that have the trappings and the appearance of being capitalist but as to the Chinese model, I don't know, I can't see that kind of imposition of central authority working again in Russia.

R: What triggers do you think might work?

E3: I think the history of Russia tends to be more shock therapy than gradualism in the sense that... One of the things that interested me in the 90s, and also in the late 80s when it was starting to fall apart, was... If you think about the circumstances by which the Soviet system collapsed it was through a series of public protests in Moscow that actually occupied a very small area, overthrew a huge country. And some of the symbolic things that happened along the way that matter [35:00], obviously, arresting Gorbachev was a bit of a mistake. But if you think back to Eltsin [unintelligible 7 seconds]. I think that the financial crisis in 98 was very significant because that stopped a lot of the things that had been happening prior to that, which were propping up the old system. I think Putin was exceptionally lucky in his first two presidencies, he rode a wave of petro-dollars. All went horribly wrong in 2008. But the problem now is that the oil price has moved up too quickly. It doesn't seem to me that there's actually been a shock that required fundamental reform, there's the appearance that things are ok, Potemkin villages in terms of, well, we continue to grow until the next shock. It IS muddling through, and our own politicians are just as bad [36:00] ... But along the way, as long as enough people are making money, as long as year on year they are better off or no worse off, then it's a kind of social contract that exists. There was a form of social contract in the Soviet system, it was a social contract in China in terms of sustaining economic growth and improvements to living standards. I think there is a similar social contract in Russia: as long as we are better off but certainly not worse off, then we'll put up with whatever crap is going on in Moscow. [37:00] It's when things threaten that stability, that things go wrong, and there's growing tension. And I think that there are underlying issues in the Russian economy now which I see as parallels to the 1980s in the Soviet Union, which is the system is inherently unstable and unsustainable

R: For example?

E3: This whole issue of the energy sector, particularly the fact that the cost of maintaining energy production and an exportable surplus is going to go up, and the squeeze on that exportable surplus. It will happen for one or two reasons, and what is happening or is probably going to happen is a combination that domestically Russia will struggle to sustain oil production, but if there's a significant fall in the price of oil and gas, which may well be at the end of this decade, then Russia is in real trouble. [38:00] I don't think Putin should have run for the third term.

R: That could be something that would trigger real changes?

E3: [38:27] So I think there are triggers internally. Internally, it's like a patient suffering from slow internal bleeding that people don't know about, sooner or later it will kill you. But at the moment it's the appearance that everything is alright. [Unclear] an external shock, which means that the Russian economy is not resilient. And we saw that in 2008 when Putin said we won't be affected by the financial crisis. It turned out that Russia was affected more than any other G-20 country. So I don't think it's a resilient political economy [39:00], there's a problem in the relationship between politics and economics. And how it changes is, again there're parallels with the late Soviet period when the
system could only survive if it was reformed but it was incapable of reforming itself. We've come again to that paradox now.

R: Do you think the civil society could play any role at all?

E3: Well, a bit like Gorbachev’s perestroika, it could turn out to be the hair that breaks the camel's back. Talking about triggers, for example, the heavy-handedness of the government in dealing with protests could be a trigger. It comes back to my observation that actually in Moscow [40:00], key sites that triggered huge social change. But you could see a scenario around something like gay rights, where there’s a demonstration, the police or the special forces go over the top, a lot of people get killed, that could be a trigger.

R: So, on the one hand there are these small triggers that can cause really big changes, and on the other hand there is an undercurrent of people who are relatively stable.

E3: Yes, this emergent middle class, if they are content, they turn a blind eye to [unclear] goes on because actually each year they are doing better, fine. But if it gets to a point where they feel... I think there are generational issues here. It’s not so much the life chances of those who've been through the 90s, it’s their children. What prospects do THEY have? [41:00] Because corruption is... Things like the school system and the health system are so corrupt, there is no sense of it being a meritocracy. And people just get fed up with that. ... [42:17] You could argue that part of the problem here is the quality of the opposition, they can't agree among themselves. I think that’s part of the issue that by default it’s a one-party state.

E3: [43:05] I have a question about... Why have you got this imported biomass?

R: In the scenarios with a strong agricultural sector, there is a potential conflict between demand for land for both agriculture and biomass.

E3: But you've got a huge forestry industry and a huge forestry sector, so why do you need to import it? If you take the impacts of climate change on Russia, your agricultural zones are shifting further south.

R: Well, that's another issue that growing biomass can be considered part of the agricultural sector, so trying to separate them...

E3: [44:00] Because Russia and European Russia are exporting wood pellets, they also have biofuels, biomass based on waste from wood pulp. So there is a large biofuel resource in Russia that is not competing with agricultural land. As to the Far East, the problem is going to be the productivity of the forest, it’s already being badly managed, and a lot of species are not commercially valuable, but it might be valuable from a biomass perspective. The problem is to manage it in a sustainable fashion, because if the productivity is low, the amount that’s going to be cut each year is going to be lower. ... [45:00] Well, sitting on so much gas, I think you're much better off with carbon capture and storage. It's technologically doable and done, it's scaling up its commercial viability, but Russia has got a lot of depleted oil and gas fields where you could store that. ... I just don't see it happening in the Russian context that they actually take seriously the life-cycle emissions, but I am not convinced that biomass is something that’s going to be imported. I see its potential for exports. [46:00] It’s the scenario where there is non-settling on permafrost. It’s already happening as the oil companies are shifting away from permanent settlements to work camps. And as they move further north, they are not going to put up permanent settlements [unclear], and the more southerly fields deplete, they'll move people out.

R: Do you have any more comments?
E3: It's not right or wrong, it's your interpretations and the extent to which they are defensible. You know we've already talked about it, when you put the main outputs and value added, it comes back to this fundamental question about the future role of the Russian economy in the global system: what does Russia do? We have the same problem in this economy [47:00], what do we do? We don't make things any more, we buy things from people, but how do we earn money? [...] [48:00] Russia used to be a deficit economy, [...] and now Russia is looked at as a major emerging market, a large retail market, Russia is brand-conscious, they create their own brands in Russia that are globally successful. But it comes back to the fundamental question what is the role of Russia in the global economy, what is generating this income? It's still got its feet firmly in the resource sector, which means that they are susceptible to volatility because they haven't got a resilient political economy. When I talk with students about oil crises, they are talking about the high price of oil. I often say, be careful what you wish for. If you think a $100 a barrel world is difficult [49:00], a modern $50 a barrel world will be as difficult if not more. Because most of the oil-exporting states now rely on the price considerably higher than $50 a barrel to balance the budget, so a prolonged period of $50 a barrel or lower will be a real problem for Russia, it will destabilise Russia, it will destabilise Saudi Arabia. Is that something we really want to see? So it's a question of what is a reasonable price. And of course the other problem with low-cost fossil fuels is that they are very difficult for renewables to compete. So as an energy-consuming economy, we might think that low costs of fossil fuels are good, but they could be too low.

R: [50:00] How likely do you think is a future where the Russian economy is self-sufficient and will have no need to interact with the global economy?

E3: I think it's unlikely. It's a large continental economy. Look at the United States for example, but the United States attracts far more foreign investment than Russia does. In a global economy, very few economies are that... China has to export to generate income, and it imports a lot. I don't think it would be a healthy thing for Russia to be isolated like that and I don't think it can be. It comes back again to this question of what does Russia do? If Russia is generating rents from exporting resource, those rents are circulating through the economy and driving consumption, the goods which are being consumed are not all produced in Russia. In fact, if you look at the structure of imports into Russia, it's all retail goods. [51:00] Either it's high end or it's in the local market, say in the Far East, whereas low end, textiles, would come from China or South East Asia, but it's not produced in Russia. It's the same problem that we have in Europe that the cost of domestic production is too high, labour costs are too high. One of the other factors to think about it what happens to domestic energy prices under different scenarios. Because subsidised energy costs is a critical problem for Russia and its WTO membership. It is not price of petrol at the pump because that's fairly liberalised, but they still have heavily subsidised energy costs. And under different scenarios [52:00] whether or not it's feasible to liberalise domestic energy costs, because if you don't liberalise domestic energy costs you're not sending a price signal that drives efficiency, so how do you gain efficiency under your different scenarios? [...] The most effective way of driving efficiency is to push up the price of the commodity, to charge more for energy services. But it comes back to the social contract. When GazProm said we're going to spend $40 billion to export gas to China [...] because we're not making money in the domestic market. Well, they are but they are not making a huge amount of money. So maybe this issue of domestic energy prices is another key category to look at [53:10]. It can be a simple dummy variable, liberalised electricity costs, yes/no. Well, partially because at the moment industry is paying more than domestic consumers, it's a kind of cross-subsidy, but even then it's not at a price that's high enough to drive efficiency... Otherwise I'd be very interested to see what comes out the other end!