THE GEOPOLITICAL IMPACT OF CLIMATE MITIGATION POLICIES

How Hydrocarbon Exporting Rentier States and Developing Nations can Prepare for a More Sustainable Future

The Hague Centre for Strategic Studies

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ISBN/EAN: 978-94-92102-55-3

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EXECUTIVE SUMMARY

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At the Paris Climate Conference (COP 21) held in December 2015, 195 countries adopted the Paris Agreement – the first universal, legally binding global climate deal. The signatory parties commit themselves to a global action plan that aims to keep global warming to well below 2°C and to limit the global temperature increase to 1.5°C.

Some countries are expected to be hit harder by climate change than others, and the effects of a transition to a low carbon economy are likely to be borne unevenly. Countries richly endowed in hydrocarbons in particular stand to lose a significant part of their revenue stream if energy transition affects demand for fossil fuels. Many oil- and gas-exporting nations in North Africa, the Middle East, and the region belonging to the former Soviet Union exhibit a relatively high share of oil and gas rents as a percentage of their government budget. Such countries are often referred to as 'rentier states'. If demand for oil and gas were to decrease as a result of successful climate mitigation policies, the financial and social stability of these countries will, *ceteris paribus*, be negatively affected, especially if they fail to reform their domestic economies. This issue was acknowledged at an early stage, as signatory nations of the United Nations Framework Convention on Climate Change committed themselves to reducing the potential adverse effects of climate change mitigation measures.

Therefore, the geopolitical consequences of energy transition are an important factor, to consider when analyzing the effects of climate mitigation policies aimed at reducing greenhouse emissions. This study analyzes, both quantitatively and qualitatively, the effects of existing climate mitigation policies on countries richly endowed with hydrocarbon reserves. Specifically, we assess the conditions under which they could – in the absence of adequate reforms – result in instability and social unrest in Algeria, Azerbaijan, Egypt, Kazakhstan, Russia, Saudi Arabia and Qatar.

These countries were selected as they cover numerous important oil and gas exporting regions of the world in terms of oil and gas shipments via pipeline, as well as via liquefied natural gas (LNG). Moreover, whereas some countries saw their relative importance to the European market decline in recent years (Egypt and Libya for example), others such as Azerbaijan will see their importance grow. That said, the recent offshore natural gas discoveries in Egypt may turn this around in the future. Furthermore, these countries exhibit important differences when it comes to their governance models. Whereas, some countries are genuine autocracies (Saudi Arabia, Qatar, Kazakhstan, Azerbaijan), others such as Russia, Egypt and Libya occupy a middle-position between consolidated democracies and full-scale autocracies. Importantly, some of the selected countries have in the recent past already experienced societal uprisings (Egypt and Libya), causing it to be of interest to include them in this study. Lastly, large differences exist with respect to the financial power of the selected countries. Whereas Saudi Arabia and Qatar are home to large sovereign wealth funds, the same cannot be said about Algeria, Libya and Egypt. Countries such as Kazakhstan, Azerbaijan and Russia occupy a position in between these two groups. The different ability for these countries to financially cope with the dynamic unleashed by climate mitigation policies is therefore interesting to examine.

Although the Paris Agreement holds no specific legal obligations on the part of signatory states to fulfil their pledges, nor is there a legally binding cap on CO_2 emissions in place, it remains imperative that countries live up to their promises if the world is to seriously combat climate change. Realistically, the only way that there can be any kind of enforcement in order to make sure the national policies are implemented is to install a legally binding cap on CO_2 emissions. It is for this reason that this study explicitly looks at the effects that such a legal cap would have on the global energy mix and intra-state stability in rentier states. Following on this, the study also examines the choices made by countries in Sub-Saharan Africa with respect to their future energy mix with the aim of assessing the chances that these countries might avoid some of the choices made by industrialized nations in the past.

In this study we make use of the innovative methodology known as *scenario discovery*. Rather than to predict the future, this method is designed to perform a *what-if* type of analysis of the alternative futures that we may find ourselves in as a result of the consequences of different policy decisions that might be taken over time. In this case the selected timeframes are policy decisions taken towards 2030 and onwards to 2050. In this instance, we made use of System Dynamics (SD) models. Two different models were used: the first model represents the possible development of the global energy mix through supply and demand interaction for oil, gas, coal, nuclear, liquid biofuels, and other renewable energy resources. Using the output from this analysis, the second model assesses the impact of economic developments on the intra-state stability of a country. As a result, one can view the analysis conducted in this study as a kind of 'stress test' of the resilience of rentier states when confronted with the effects of climate mitigation policies.

The analysis generates a number of insights. When it comes to future price levels and overall price dynamics of some of the primary sources of energy distinguished in this study a strong relation appears between the presence of a legal emission cap and the oil price. High oil prices are only possible when a lower demand for oil in capped regions is compensated by higher demand elsewhere in regions not covered by the legal cap. The opposite equally holds true: the ability to meet our CO_2 reduction targets coincides strongly with situations in which the oil price is lower. The reason is simple, as the presence of a legal cap limits the demand for oil by law. A low price of oil however also constitutes a challenge in itself. When the oil price is too competitive compared to renewable energy we witness that it is difficult to achieve a reduction of CO_2 emissions in those areas of the world that are not covered by a legal cap. The incentive to resort to the use of low-priced oil resources in non-capped regions will thus be a critical factor that could undermine and derail efforts to reduce CO_2 emissions. Given that a worldwide legally enforceable cap on CO_2 emissions is unrealistic at this point in time it is imperative that the large-scale availability of inexpensive renewable energy sources, including liquid biofuels, is promoted. Only then, can we disincentivize the use of fossil fuels and achieve a significant reduction in CO_2 emissions in parts of the world not covered by a legal cap. Finally, instances of higher oil price levels appear to all coincide with situations in which the world fails to meet its CO_2-emissions reduction targets.

With respect to the risk of socio-political instability, the study shows that a decline in the import of fossil fuels in Europe will result in a reduction of the mutual import/export dependencies that exist between Europe and the hydrocarbon exporting countries in our immediate neighborhood. In the absence of far-reaching reforms, and if not adequately compensated by a higher energy demand in regions that do not participate in a legal cap, the decline in oil and gas sales causes a higher risk of instability in these countries. Not every country is equally vulnerable to such a downturn however. The level of vulnerability recorded is the highest in the Middle East and North Africa, particularly in Saudi Arabia. Factors of influence in this context are the presence of a relatively large share of young people in the Saudi society that all will need to find suitable employment in the (near) future and the enormously high level of dependence on hydrocarbon exports. Faced with declining export revenues, and a limited share of private sector employment, the government cannot simply resort to creating more public sector jobs. Another factor that may influence the risk of unrest is the discrepancy that exists between the relatively high education levels of Saudi citizens on the one hand and the harsh model of governance in the country on the other. The higher educated a population, the greater their desire for societal participation. If a government is unable to accommodate this, the risk of social unrest is likely to increase. Saudi Arabia's relatively large financial buffers may help to dampen the potential for unrest in the short term, but are unlikely to prove sufficient in the long term.

Countries that are less vulnerable to the oil price scenarios that coincide with successful climate- and energy policies are Russia and Kazakhstan. What plays a role in this context is that both countries have a relatively aged population, and the regime type corresponds well to the older generations in the country. Put differently, young people without jobs are much more likely to resort to public protests than older people who lived through the 1980s and 1990s in Soviet and post-Soviet societies. Furthermore, the Russian and Kazakh economies are more diversified compared to Saudi Arabia. Lastly, both Russia and Kazakhstan are among the countries with the best geographical possibilities for building up an economy based on the export of liquid biofuels that could offset some of the loss in export revenues based on their centrality between the key-markets in Europe, India and China.

A major conclusion is that a lack of attention for the second-order effects of energy transition in the form of heightened instability, in particular in the Middle-East, runs the risk of creating adverse geopolitical consequences in the form of state failure and collapse comparable to the 2011 Arab uprisings. Specific factors that are indicative of a heightened vulnerability are: a high share of resource rents in the GDP in combination with limited financial reserves; a high national debt as a percentage of the GDP or a rapid increase in a state's national debt; a young and/or relatively fast growing population (Middle East and North Africa), a relatively high share of youth unemployment and uncertainty about the continuation of the existing political leadership; a combination of high subsidies and a high domestic energy demand; and the position in international financial markets (risk-aggravating factors are a low credit rating, and difficulties to borrow in international markets). A second major conclusion is that recognizing that countries face this potential time bomb this could undermine their willingness to push for a more ambitious climate policy. Put differently, expect them to try and undermine other countries' efforts at combating climate change.

At the same time, we should anticipate that the incentive for countries to again resort to fossil fuels will increase when prices will decrease as a result of a legal cap on CO_2 emissions in some parts of the world. Countries not covered by the cap may be tempted to increase their use of fossil fuels and countries under the cap system may be incentivized to withdraw. Internationally, this will require lobbying at the highest level to motivate countries to take part in a legal carbon cap system and continued investment in renewable energy with the aim of cutting costs. For that purpose it is of major importance to create *prospects of gain*: both the Netherlands and the EU should be able to demonstrate clearly the economic benefits of decoupling and of a transition towards renewable energy.

A different but related challenge manifests itself in developing countries that face a choice between investing in renewable energy networks or to rely on fossil fuels for their economic growth. A major issue in this context is the need to reduce the high use of biomass in Sub-Saharan Africa, owing to its hazardous health effects and the problems associated with indirect land use change. In the long term it is crucial that a lower use of biomass does not result in a higher reliance on fossil fuel resources. This means that, particularly when viewed through the lens of ensuring coherence in Dutch international policies, the government will have to determine how to deal with public (financial) bilateral contributions to the exploration of new hydrocarbon finds in developing countries.

In the absence of wide-reaching reforms in the countries analyzed in this study, many will face scenarios in which they will struggle to deal with domestic unrest. The biggest risk thereof will manifest itself in the Middle East and North Africa. A silver lining considering energy transition is that, as the name of the phenomenon implies, this is not something that will happen overnight. This means that there are still several decades for countries heavily dependent on the export of fossil fuels to take adequate measures to reduce their vulnerability. This however requires a fundamental reassessment of the nature of the relationship that we have with this part of the world. The crux of the matter is that whereas western nations have an interest in stabilizing the MENA region, the countries in this part of the world have a key interest in reducing their vulnerability with an eye on future regime survival. When reforming the domestic economies of these countries, the focus should be on addressing the factors labelled as critical in this study.

Switching from fossil fuel-based power generation to one based on renewable energy can, on the one hand, mean a significant cost reduction by eliminating wasteful energy subsidies, whilst reducing the burning of otherwise valuable export resources on the other. In the bilateral ties and sectoral dialogues between the Netherlands and countries in the MENA region – the Gulf countries in particular – it is important to stress that doing so represents a significant cost-cutting measure at a time when export revenues are under pressure, and would also allow for the diversification of the economy through the buildup of a domestic renewable energy sector that can compete internationally. For the Netherlands this represents a business opportunity to showcase technological advances in the areas of renewable energy, energy efficiency and clean-tech.

In convincing countries that it is in their interest to do so it is useful to take note of the Chinese experience. The Chinese leadership's growing concern about the impact of climate change – partly fed by growing popular discontent about the level of air pollution – have pushed the country in the direction of an aggressive policy that promotes renewable energy. Today, China is the world leader in domestic investment in renewable energy and associated low-emissions energy sectors, and increasingly, the country has been investing in renewable energy projects abroad with the aim of expanding its renewable sector. Gulf countries with significant sovereign wealth funds, such as Saudi Arabia and Qatar, can learn a thing or two from how China built up such a strong domestic renewable energy sector, followed by a sizeable overseas expansion strategy in frontier markets. If they succeed in building up a domestic renewable energy sector, it would be beneficial as a follow-on step to invest in the energy transition in hydrocarbon exporting countries that are financially less well-endowed and in relative proximity to the European mainland, such as Algeria and Egypt, so that the export of electricity becomes feasible. This would help rentier states around Europe to lessen their dependence on commodity sales to Europe. More importantly, it would dampen the need for domestic energy subsidies and reduce the negative effects that climate mitigation policies will have on these countries. For Saudi Arabia and Qatar, it would result in an ability to collect a return on their investments and to generate additional export revenues allowing these countries to *hedge* against lower oil prices and diminished income from hydrocarbon exports in the future. For Europe, this would mean that – provided the required infrastructure is financed – it can tap into an additional source of renewable energy that is located in relative proximity, whilst the risk of large-scale instability in our immediate neighborhood is reduced.

INTRODUCTION

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At the Paris Climate Conference (COP 21) held in December 2015, 195 countries adopted the Paris Agreement: the first universal, legally binding global climate deal. Under the terms set out in the accord, countries commit themselves to a global action plan that aims to keep global warming to well below 2°C and to limit the increase to 1.5°C, as doing so would significantly reduce the risks and impacts of climate change. With respect to reducing greenhouse gas emissions, the agreement strives to reach a peak in global emissions as soon as possible and to undertake rapid reductions thereafter.[1]

The Paris Agreement introduced the mandatory submission of Nationally Determined Contributions (NDCs) at the nation state level. Although not enough in-and-of themselves, the NDCs, which are to be updated every five years, are a step in the right direction. Every five years governments are to report to each other on the progress achieved and to set out their new ambitions in accordance with the latest scientific and technological innovations. After 55 countries, representing 55% of global emissions, had ratified the agreement, it entered into force on 4 November 2016.[2]

The Netherlands works within its own domestic agreements and frameworks to decarbonize its economy and ensure a greener future. The 2013 Agreement for Sustainable Growth aims to raise the Netherlands' share of renewable energy in the energy mix to 14% by 2020 and 16% by 2023.[3] The 'Energy Report' (Dutch: Energierapport) that was released in January 2016 identifies CO_2 reduction as its primary vehicle to steere the transition in the period 2023-2050. The report states a desire on the part of the Dutch government to reduce greenhouse gas emissions by 80-95% by 2050 in accordance with the agreements made at the European level.[4] In 2015, the share of renewable energy in the Netherlands' energy mix rose from 5.5 to 5.8%. By 2023, it is expected that this share will have increased to 15.8%.[5] By 2050 the government is clear in its ambitions. In the 'Energy Agenda' (Dutch: Energieagenda) that was published in December 2016 the government states that by 2050 virtually all electricity should be generated sustainably; buildings will be heated primarily through geothermal energy and electricity; it expects companies to have adapted their production processes accordingly; households will no longer use gas as a primary source for cooking; and that virtually all cars driving in the Netherlands will be powered through electricity.[6]

For some this level of ambition is not yet enough. In June 2015 a Dutch court ruled that the Dutch state must do more to reduce greenhouse gas emissions. In particular, the government should aim to reduce CO_2 emissions by at least 25% by 2020.[7] The case was brought before the court by Dutch climate organization 'Urgenda'. The Dutch government has since appealed against the verdict.[8]

The impacts of climate change are unlikely to be felt evenly across the world. Some countries are expected to be hit harder than others. By the same token, the effects of a transition to a low carbon economy are expected to be borne unevenly. Although the planet as a whole stands to benefit from climate mitigation in environmental terms, countries richly endowed in hydrocarbon reserves potentially stand to lose a significant part of their revenue stream if the energy transition affects demand. Many oil- and gas exporting nations in North Africa, the Middle East, and the region belonging to the former Soviet Union exhibit a relatively high share of oil and gas rents as a percentage of their government budget. Such countries are often referred to as 'rentier states'.[9] If demand for oil and gas were to decrease as a result of successful climate mitigation policies, the financial and social stability of these countries would, *ceteris paribus*, be negatively affected, especially if they fail to reform their domestic economies. This issue was acknowledged at an early stage, as signatory nations of the United Nations Framework Convention on Climate Change (UNFCCC) committed themselves to reducing the potential adverse effects.[10]

Therefore, the geopolitical consequences of energy transition are an important factor, to consider when analyzing the effects of climate mitigation policies aimed at reducing greenhouse emissions. This study analyzes, both quantitatively and qualitatively, the effects of existing climate mitigation policies on countries richly endowed with hydrocarbon reserves. Specifically, we assess the conditions under which climate mitigation policies could – in the absence of adequate reforms – result in instability and social unrest in Algeria, Azerbaijan, Egypt, Kazakhstan, Russia, Saudi Arabia and Qatar. These countries were selected as they cover numerous important oil and gas exporting regions of the world in terms of oil and gas shipments via pipeline, as well as via liquefied natural gas (LNG). Moreover, whereas some countries saw their relative importance to the European market decline in recent years (Egypt and Libya for example), others such as Azerbaijan will see their importance grow. That said, the recent offshore natural gas discoveries in Egypt may turn this around in the future. Furthermore, these countries exhibit important differences when it comes to their governance models. Whereas, some countries are genuine autocracies (Saudi Arabia, Qatar, Kazakhstan, Azerbaijan), others such as Russia, Egypt and Libya occupy a middle-position between consolidated democracies and full-scale autocracies. Importantly, some of the selected countries have in the recent past already experienced societal uprisings (Egypt and Libya), causing it to be of interest to include them in this study. Lastly, large differences exist with respect to the financial power of the selected countries. Whereas Saudi Arabia and Qatar are home to large sovereign wealth funds, the same cannot be said about Algeria, Libya and Egypt. Countries such as Kazakhstan, Azerbaijan and Russia occupy a position in between these two groups. The different ability for these countries to financially cope with the dynamic unleashed by climate mitigation policies is therefore interesting to examine.

In this context, it should be pointed out that although the submission of NDCs is a mandatory process under the Paris Agreement, there is no legal obligation on the part of signatory states to actually fulfil these national pledges – this remains a national prerogative – nor is there a legally binding cap on CO_2 emissions in place. This means that it remains to be seen how much of the national pledges will ultimately be put into practice. Looking towards the future however, and if the world is serious about limiting the increase in global temperatures to 1.5°C it is imperative that countries live up to their promises. Realistically, the only way that there can be any kind of enforcement in order to make sure the national policies are implemented, is to install a legally binding cap on CO_2 emissions. It is for this reason that this study explicitly looks at the effects that such a legal cap would have on the global energy mix and intra-state stability in rentier states.

Following on this, it is important to look not only at countries richly endowed in hydrocarbons, but also at developing nations that are yet to make the choice between opting for a future based on the exploration and utilization of fossil fuels or, instead, pursuing an energy mix that largely consists of renewable energy sources and hence avoids some of the choices made by industrialized nations in the past. For this reason, the report explicitly looks at the choices made by countries in Sub-Saharan Africa with respect to their future energy mix.

This report consists of six chapters. Chapter 1 kicks off by providing an overview of the outlook for energy transition worldwide. Chapter 2 details the methodology used in this study by explaining the various models that underpin the quantitative analysis. Chapter 3 discusses the initial results based on the model runs conducted with the energy mix- and the intra-state stability model. Chapter 4 delves into the consequences of the oil price crash witnessed between 2014 and today and the responses of hydrocarbon exporting nations. Chapter 5 looks to the future by examining the energy choices made, and about to be made, in Sub-Saharan Africa and the consequences they carry. Finally, Chapter 6 concludes with a number of implications and policy recommendations.

1 THE OUTLOOK FOR ENERGY TRANSITION AND DECOUPLING WORLDWIDE

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There are three main ways to reduce greenhouse gases. First, the overall energy efficiency of the economy can be raised, which corresponds to a 'decoupling' of economic growth and energy demand. Many advanced economies in the world have reached the stage of 'decoupled' economic growth, whereby a growth in GDP is not matched by a corresponding increase in energy demand. In other words, the economy can grow without necessarily increasing the pressure on our planet in terms of a greater demand for energy resources. A second way to reduce greenhouse gas emissions is to increase the share of renewable energy sources in the energy mix. Finally, one can capture and sequestrate greenhouse gas emissions. The first two strategies in particular are aimed at structurally changing the global energy system.[11]

Currently (i.e., in 2014, the latest year for which data is available), renewable energy sources account for 14% of the global total primary energy supply (TPES; Figure 1).[12] By far the largest renewable energy source, representing two thirds of total renewable energy supply presently consists of solid biofuels or charcoal. While hydro energy provides 18% of all renewable energy globally, all other renewable energy sources including wind, solar, and modern biofuels represent only 15% or 2% of the TPES.

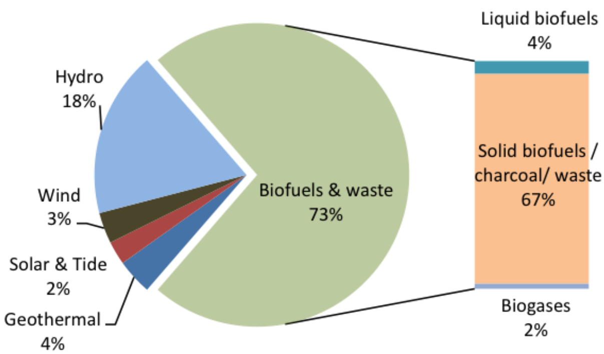

FIGURE 1. WORLD RENEWABLE ENERGY SUPPLY BY SOURCE IN 2014. SOURCE: IEA.

The high share of solid biofuels is explained by their widespread use (i.e., mainly for home heating and cooking) in developing countries, particularly in Africa and Asia.[13] Their use is often associated with negative health effects, and many countries aim to replace them by providing the population with access to electricity and modern fuels. This is primarily why the share of renewable energy sources in non-OECD countries has declined significantly since 1971 (Figure 2). An opposite trend can be witnessed in OECD countries: the share of renewables roughly doubled to 10% between the 1970s and 2014, with significant growth only beginning around 2005. Globally, renewables also added approximately 1.5 percentage points to their share in the TPES in the last few years, yet their share has not changed much since 1971, illustrating the challenges of energy transition on the global level.

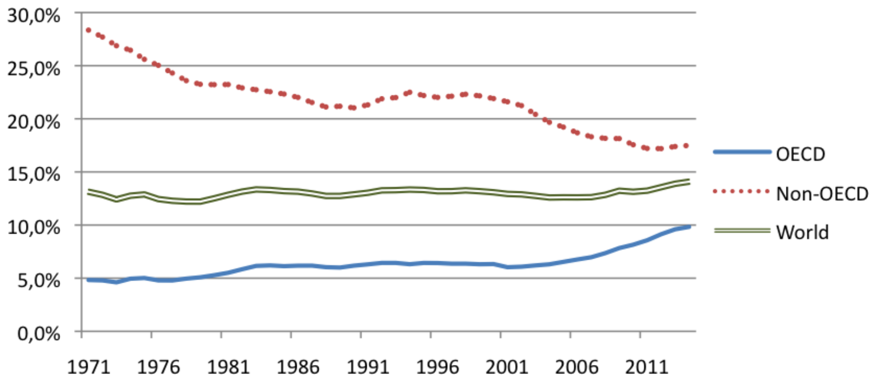

FIGURE 2. SHARE OF RENEWABLE ENERGY SOURCES IN TPES, 1971-2014. SOURCE: IEA.

Over the last 25 years, the most rapidly growing renewable sources of energy in OECD countries were liquid biofuels and solar PV, which grew by 44% per year on average while TPES increased at the rate of 0.6% per annum over the same period.[14]

More recent data shows that 2015 was a boom year for renewable energy. Renewable electricity capacity increased by a record 153 gigawatts, mainly due to additions in wind and solar photovoltaics (PV) installations. For the first time, renewable energy accounted for more than half of the total net annual additions to globally installed power capacity.[15] Global investment in renewable energy reached US$ 286 billion, which also set a new record, exceeding the previous one that had been set in 2011.[16] It was also the first time when investment in modern renewables (excluding large hydro) in developing countries was higher than that in developed countries. China alone accounted for 40% of the global renewable energy expansion. The largest recipients of new investments were solar and wind energy, which received US$ 161 and US$ 110 billion respectively. All other renewable energy sources attracted a combined investment total of US$ 15 billion. What is particulary noteworthy is that this boom in renewable energy had taken place at the time when low fossil fuel prices made traditional hydrocarbons significantly more cost competitive than before. The reasons for this rapid expansion of renewable energy capacity can therefore be attributed to significant cost reductions of some renewable energy technologies on the one hand, in particular solar PV, and to favorable government policies on the other.[17]

There is little doubt that renewable energy will continue to expand in the future. The Paris Agreement on climate change signed by 195 countries in December 2015 provides an additional impetus for such an expansion. Yet, the speed of this growth is highly uncertain and depends on a multitude of factors including the pace of technological progress, prices of competing energy sources, government policies, and public acceptance.

The IEA World Energy Outlook 2016's 'New Policies Scenario', which reflects pledges made by countries under the Paris Agreement, expects that renewable energy sources will grow on average by 2.6% per annum in OECD countries and 2.1% per annum in non-OECD countries between 2014-2040, with solar and wind energy providing most of the growth. This will ensure that the share of renewables will reach 20% of total energy demand by 2040 in both OECD and non-OECD countries. Another, more ambitious scenario, called the '450 Scenario', illustrating a pathway to keep global warming below 2 °C, calls for much more rapid growth of renewables, with their share growing to 32% by 2040 (33% in OECD and 31% in non-OECD countries, respectively).[18] The reality will probably lie somewhere in between these projections.

2 METHODOLOGY

2 METHODOLOGY

In this study we make use of the innovative methodology known as *scenario discovery*.[19] The goal of using this approach is to explore how a system may evolve and what the causes of possibly interesting futures are. Put differently, this method explores what the origins may be of the different kinds of worlds that we may find ourselves in as a result of different decisions taken over time. Due to the complexity of the problem that is analyzed, it is necessary to use simulation models. In this case, we made use of System Dynamics (SD) models.[20] Naturally, these models represent a simplified version of reality. As a result, they are not suitable for predicting the future. Rather, they are designed to perform an analysis of the consequences of different combinations of assumptions and uncertainties. In other words, these models allow for a *what-if* type of analysis of the consequences of predefined choices, parameters or vantage points – in this case with respect to climate mitigation policies.[21]

The full range of assumptions that one can have about a system can be interpreted as a 'mental model'.[22] The simulation models used in this study are thus an internally consistent representation of existing mental models. In cases where there are differences between existing mental models, or where experts agree that they cannot know how the system functions, one can speak about 'deep uncertainty'.[23] By varying the input used for the simulation models it is possible to generate a large bandwidth of 'plausible futures', or possible future worlds that are a result of the input (data, assumptions, uncertainties, parameters, etc.) used. Within the set of plausible scenarios it is then possible to make a selection based on the desirability of each respective scenario. Translated to climate mitigation, assuming we are serious in our desire to combat climate change, this implies that those scenarios in which CO_2 emission reduction targets are met are considered desirable. The uncertainties that lie at the basis of the set of plausible futures thus represent the causes of the 'undesirable' behavior uncovered in the model analysis. More extreme, yet plausible futures, can thus also be used as a way of testing the robustness of existing or policy decisions under consideration.[24] The models in this study are thus used to generate an internally consistent narrative for potentially interesting futures or end states. The models as such act as a tool for generating a narrative, whereby the uncertainty analysis is performed to generate an as large as possible, yet plausible, bandwidth within these narratives. In other words, the analysis would cover the whole range of plausible end states that we can find ourselves in as a result of the set of assumptions, and uncertainties that exist and the decisions that are taken at the outset with respect to climate mitigation.

In this study we chose to combine quantitative and qualitative research methods for a variety of reasons. The complexity of the global energy system and of intra-state stability implies that it is difficult, if not impossible, to come to a complete understanding of the future development of these systems. The use of simulation models, SD models[25] in this case, enables us to make assumptions and uncertainties explicit and to explore the consequences of these assumptions and uncertainties on the future behavior of the system.

Complexity is defined as the existence of feedback loops between the various elements of the system. Instances of such complexity in the global energy system are numerous. The most common examples are that, *ceteris paribus*, whereas a higher price leads to greater supply and a lower demand, a greater supply and a lower demand result in a lower price. Such a system thus consists of two balancing feedback loops. Other examples can be found in the substitution behavior between different primary energy sources, where a high price of energy source A can induce a greater use of energy source B, provided they share similar characteristics. Within a state system an economic downturn can induce instability, the onset of which in turn hampers further economic development. This is thus an example of a self-reinforcing feedback loop. Policies, such as those aimed at climate mitigation, can create additional feedback loops, thus rendering the system even more complex.

Deep uncertainty exists when "analysts either do not know, or decision makers do not agree about: what the (most) suitable conceptual model is to describe the relationship between the most important factors of influence in the long term; what the probability distributions are that are used to portray the uncertainty of important variables and what the parametric values are in the mathematic representation of these conceptual models, and/or, how the desirability of different outcomes should be valued."[26] Examples of deep uncertainty that are of relevance in the context of this study include the cost development of both fossil as well as renewable resources and the development of life expectancy or education levels within societies.

2.1 Setup of the research

In this study we use two different simulation models (Figure 3). The first one represents the development of the global energy mix through the interaction between supply and demand. It includes different scenarios for the development of prices for oil, gas, biofuels, and other renewable energy sources. These price scenarios subsequently act as the input for a simulation model on intra-state stability that can be parametrized for the different oil and gas exporting countries around Europe. In this way, we can assess the impact of different developments in the global energy market on the stability of these countries. Examples of such developments are changes in climate mitigation policies. As a result, one can view the analysis conducted in this study as a kind of 'stress test' of the resilience of rentier states when confronted with the effects of climate mitigation policies.

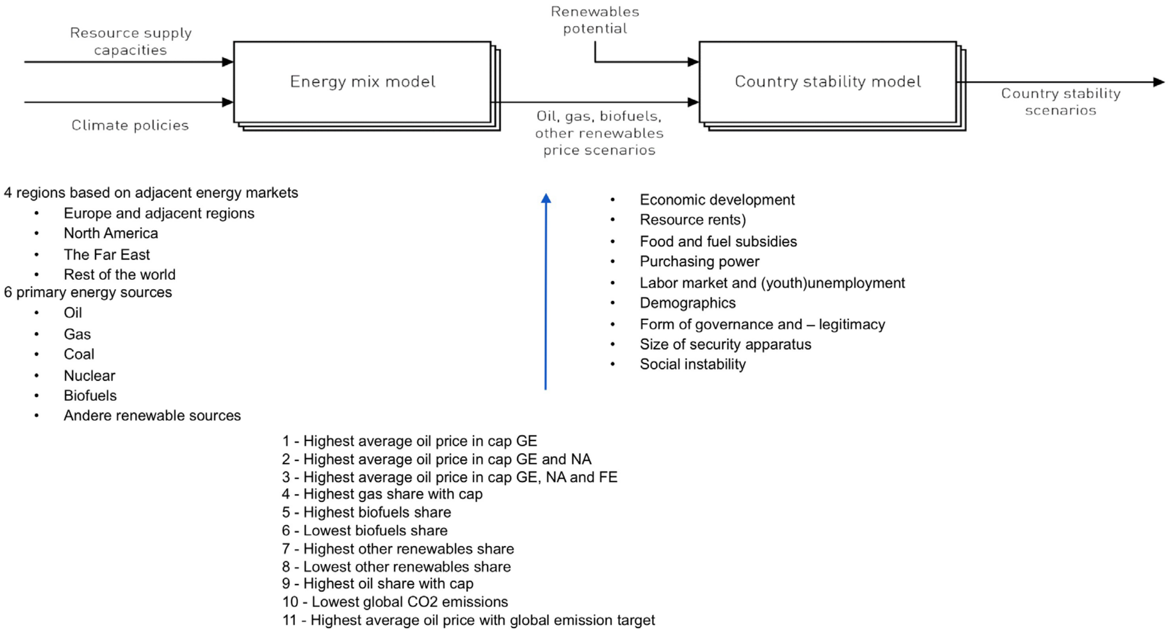

FIGURE 3: THE RESEARCH DESIGN

The energy model is regionalized for four different parts of the world (i.e., Europe and adjacent regions, North America, the Far East, and the rest of the world). Every region has a single price level for each individual energy source. As a consequence, Europe, the Middle East and North Africa, and the countries belonging to the former Soviet Union form one region. These regions are also characterized by the existence of interconnected pipeline networks. Neither in the Far East nor in the fourth region, 'the rest of the world', is there such an interconnected pipeline network. Rather, natural gas is transported via maritime routes, primarily in the form of liquefied natural gas (LNG). The energy model distinguishes between six primary sources of energy: oil, gas, coal, nuclear, liquid biofuels, and other renewable energy resources. By using this model we were able to generate eleven different price scenarios that could be used as input for the intra-state stability model.

The intra-state stability model assesses the impact of economic developments on the satisfaction of the general population in a country. This is also known as the 'greed' aspect of intra-state stability. The other side of the equation, the more ideologically driven cases of instability, is known as the 'grievance' aspect.[27] In this model we explicitly look at the influence of energy prices on resource rents, which in turn influence a country's economic development and carry consequences for the labor market and people's purchasing power. Looking at these aspects in combination with demographic developments, the level of democratization and developments in a country's security apparatus enables us to study changes in social-political stability.

2.2 The energy mix model

The energy mix model consists of six different sub-models.[28] These sub-models pertain to energy demand, supply, the costs of supply, commodity prices, commodity trade and CO_2 emissions. Figure 4 shows how these various sub-models interact.

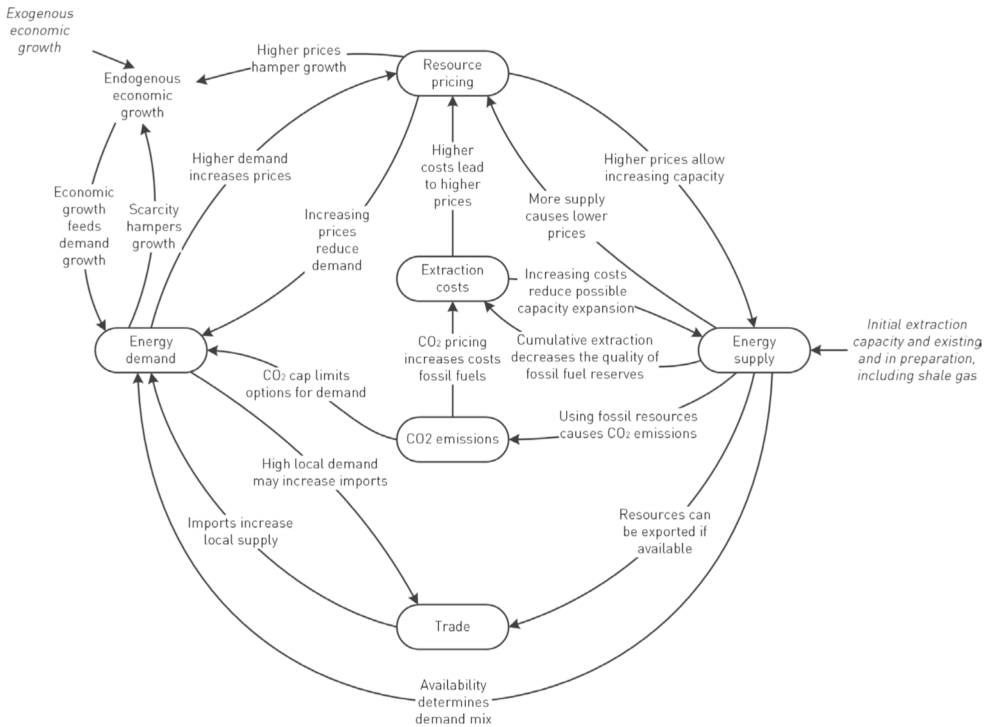

FIGURE 4: THE ENERGY MARKET MODEL

In addition to the above, there are two other important drivers of system behavior that are external to this model. These are exogenous economic growth, primarily driven by non-energy related changes in the productivity, and endogenous effects due to pricing of primary energy sources. Examples of relations between the various sub-models are: an increase in demand causing higher prices; higher prices causing lower demand; a greater extraction capacity for fossil fuels causing higher costs; the total use of different energy resources ultimately determining the level of CO_2 emissions; the regional difference between supply and demand determining the necessity of imports, or the possibility of exports.

An important uncertainty in this particular model is the question whether or not economic costs are incurred when a legal cap on CO_2 emissions obliges countries to render fossil extraction capacity inactive, in other words, to keep some of their fossil fuel resources in the ground. The principal thought behind this is that the potential scarcity that arises as a result could lead to situations where – periodically – there is not enough energy available for the desired level of economic activity. An example thereof is the practice of 'load shedding', or denying districts or industries access to the electricity grid during certain hours of the day.

2.3 The intra-state stability model

The intra-state stability model used in this study is parametrized for seven different countries. These are Algeria, Azerbaijan, Egypt, Kazakhstan, Russia, Saudi Arabia and Qatar (Figure 5). All seven of these countries have, in different shapes and forms, important energy ties to the EU.

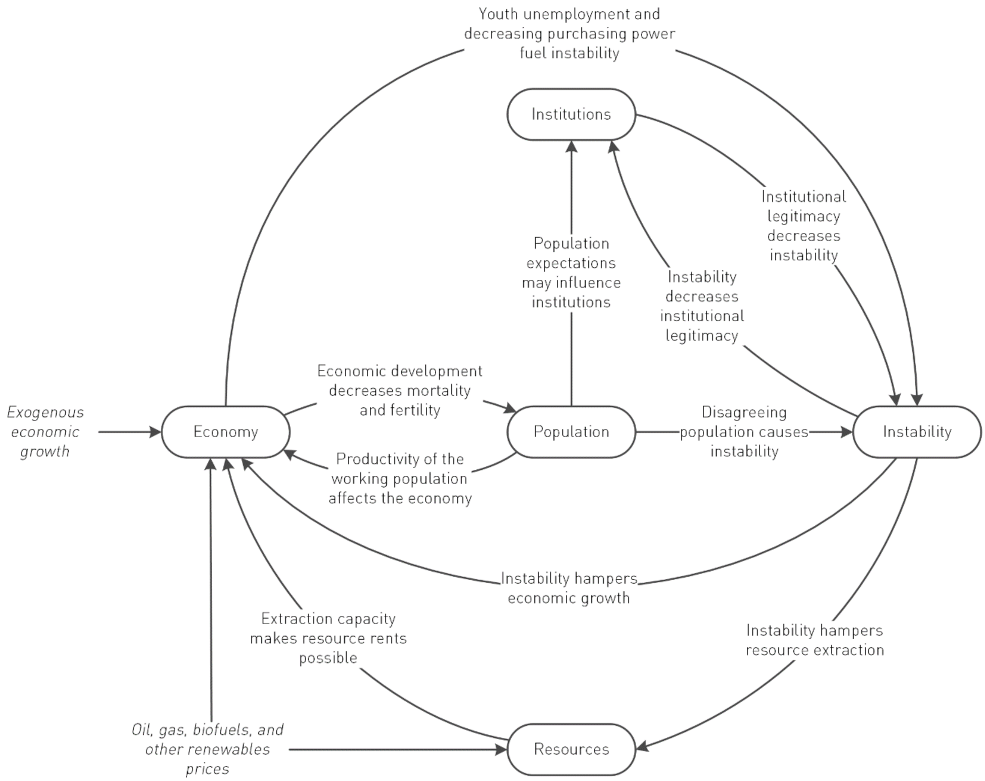

FIGURE 5: THE INTRA-STATE STABILITY MODEL

In this country stability model we make use of five different sub-models. These sub-models pertain to natural resource extraction, economics, demographics, institutions, and instability. The most important exogenous drivers of the model are a country's autonomous economic growth – and derived from the energy mix model – the prices for the different resources produced. Examples of the types of relations between the various sub-models are: income from natural resource production feeding economic growth; more economic growth enabling a greater availability of jobs; economic development possibly reducing the number of children born per family, thereby changing the demographic composition of a country; and increases in instability in turn hampering economic growth.

2.4 Scenarios

In order to select plausible future scenarios from the large number of potentially interesting price dynamics, we made use of eleven selection criteria. A criterion consists of different demands that can be placed on for example prices or CO_2 emissions, or the maximum possible share that a particular energy source can reach within the energy mix under the conditions and parameters that were defined at the outset (Figure 6).

SCENARIO NAME	INDEX
1 - Highest average oil price in cap GE	1
2 - Highest average oil price in cap GE and NA	2
3 - Highest average oil price in cap GE, NA and FE	3
4 - Highest gas share with cap	4
5 - Highest biofuels share	5
6 - Lowest biofuels share	6
7 - Highest other renewables share	7
8 - Lowest other renewables share	8
9 - Highest oil share with cap	9
10 - Lowest global CO2 emissions	10
11 - Highest average oil price with global emission target	11

FIGURE 6: SCENARIOS. GE= GREATER EUROPE. NA= NORTH AMERICA. FE= FAR EAST.

Scenarios 1-3 assume the highest possible average oil price in the event that there is a legally binding cap on CO_2 emissions in place for the different regions in the world. This should be interpreted as follows: when there is an emission cap in a particular region, this shows the impact of a forced reduction in CO_2 emissions in roughly a quarter of the global economy. Since it cannot be ruled out up front that in the future the entire world will have to move towards a legally binding emissions cap, it is relevant to incorporate this possibility into the study. Also, we know that oil and gas exporting countries benefit from higher energy prices. These three scenarios therefore illustrate the situation in which a legal cap would have the least negative impact on the stability of large hydrocarbon exporting countries. The other scenarios (4-11) consider the circumstances in which a particular type of energy either gains the highest or the lowest share in the energy mix. This matters because it allows us to assess the effects that climate mitigation policies have on stimulating particular forms of energy.

3 RESULTS

3 RESULTS

The results of the study can be subdivided into the changes recorded in the energy mix as a result of climate mitigation policies on the one hand, and the impact on intra-state stability on the other. This chapter consists of five sections. Section 3.1 looks at the impact of climate mitigation policies on the oil price, particularly focusing on the dynamics that could be witnessed if and when limits are imposed on carbon emissions. Section 3.2 assesses the development of renewable energy sources within the energy mix in the event of legally imposed caps on CO_2 emissions. Section 3.3 discusses the selection of plausible future scenarios. Sections 3.4 and 3.5 look at the impact of the various price scenarios on the socio-political stability and internal stability of the hydrocarbon exporting countries examined in this study.

3.1 Energy mix – Oil price

Figure 7 displays the full range of oil price dynamics that are the result of two thousand simulations ('runs') with the energy mix model. The distribution of the runs in 2050 is shown on the right hand side.

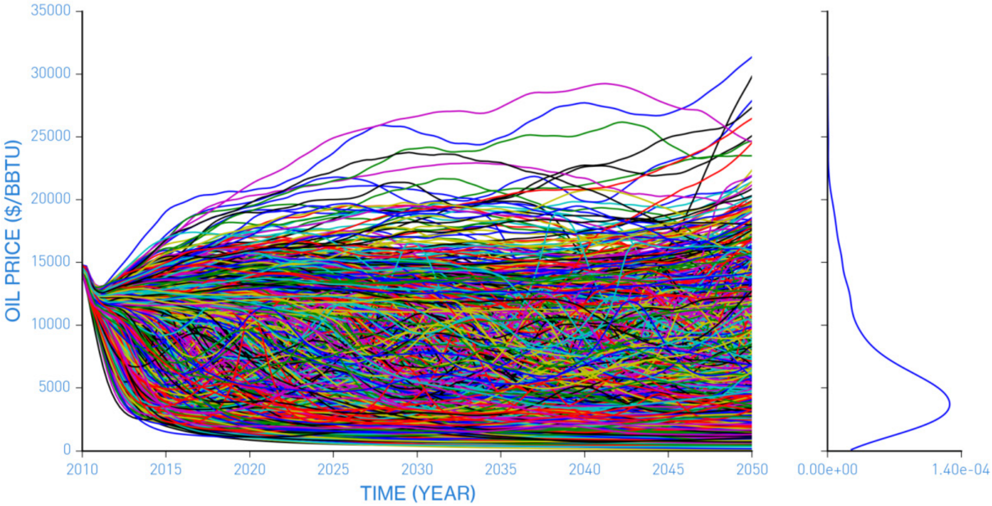

FIGURE 7: OIL PRICE DYNAMICS

Oil price dynamics

A number of conclusions can be drawn. Roughly speaking we can distinguish three types of dynamics. For the first type, an initial dip is followed by either a constant oil price or one that rises slowly from the level recorded in 2010. The second type is a scenario whereby the price continues to drop after the first dip and experiences high levels of volatility between the price level of 2010. The third type is a scenario whereby the price drops after the first dip, has high levels of volatility and subsequently lies significantly below the price level of 2010. The initial dip that is visible in all scenarios is explained by the advent of the US shale revolution.

A second conclusion is that in roughly three quarters of the simulations the price level in 2050 lies below that of the current pricing environment. A quarter ends up having a price level roughly equal to the one witnessed today. Given that this cannot be explained in a probabilistic manner, we will now examine the causes of these different scenario classes.

Oil price dynamics with legal emissions cap

Figure 8 shows the same model runs as those displayed on the previous page (Figure 7). The color corresponds to the geographical area in which a legal emissions cap would be in place.

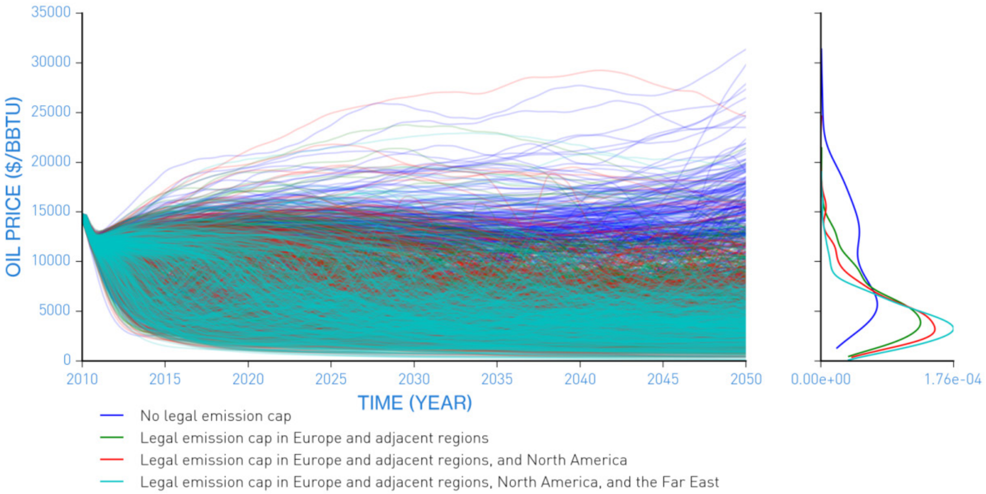

FIGURE 8: OIL PRICE DYNAMICS WITH LEGAL EMISSIONS CAPS IN DIFFERENT REGIONS

Figure 8 shows that if no region has a legal emission cap in place, oil prices either rise slightly or remain around the level recorded in 2010. As soon as one or more regions install a legal emissions cap, oil prices start to decline. If more than one region has a legal emissions cap, this, on average, results in lower oil prices compared to the initial price level. Only in a limited number of runs was it possible to avoid having a lower oil price compared to the 2010 level. A legal emissions cap in one particular region coincides with a higher oil price only if other regions are able to compensate for the lower demand in the 'cap region' by having a higher energy demand themselves. In these instances, the level of CO_2 emissions will ultimately remain high. A large degree of oil price volatility can be discerned in all cap-situations. We do however see that the average price level of volatile scenarios is lower in the case of a legal emission cap.

Oil price dynamics when CO2 targets are met

We also examined the effects on the oil price when proposed emission reduction targets are met. In Figure 9, it is clearly visible that climate goals are not met in situations where the oil price is higher in 2050 than it was in 2010. When the oil price remains roughly at the level recorded in 2010, meeting climate goals is possible only if the energy mix consists of a sufficient share of renewable energy. This conclusion is illustrated by the differences between Figure 9 and Figure 10 below.

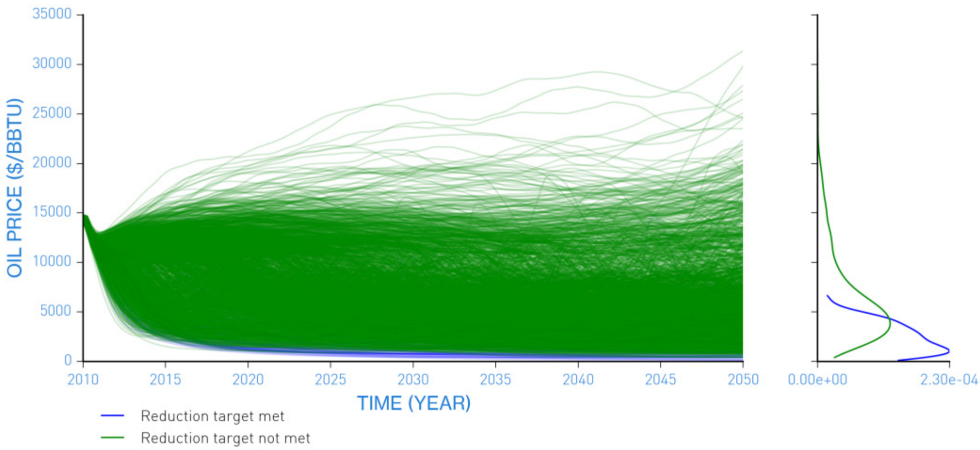

FIGURE 9: SCENARIOS WHEREBY CO_2 REDUCTION TARGETS ARE MET AND NOT MET

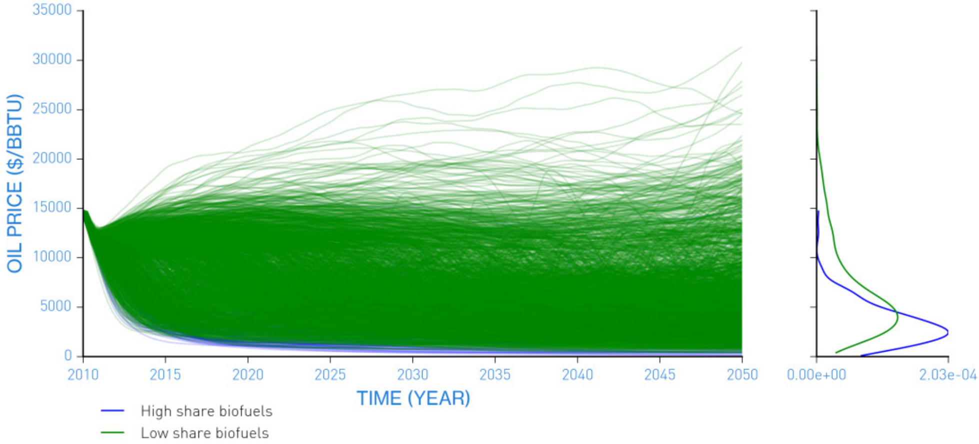

FIGURE 10: SCENARIOS WHEREBY THE SHARE OF BIOFUELS IN THE ENERGY MIX IS EITHER HIGH OR LOW

Figure 9 displays the full bandwidth of scenarios in which CO_2 reduction targets are met as well as instances in which they are not met. Figure 10 shows the full bandwidth of scenarios in which it is possible to have either a high or a low share of biofuels in the energy mix. When comparing Figure 9 and Figure 10, note the blue colored lines at the bottom of both figures. The blue lines in Figure 9 indicating scenarios where CO_2 reduction targets are met match with the blue colored runs in Figure 10, in which the share of biofuels in the energy mix is high. This shows that unless we actively promote this type of fuel we are unlikely to meet our emission reduction targets.

Conclusions on the oil price

On the basis of the analysis in Section 3.1, a number of conclusions can be drawn. First, there are three types of scenarios for future oil price dynamics: a relatively constant or mildly rising oil price; a sharply declining oil price followed by a constant price level; or an oil price with a relatively large degree of volatility. The bifurcation in the oil price between high and low levels is caused by the presence of a legal cap on CO_2 emissions.

The difference between the scenarios shown in this study and those regularly published by institutions such as the International Energy Agency or the US Energy Information Administration is the manner in which the oil price can decline and the absence of an oil price that rises continuously. From historical data we know that the oil price can decline rapidly in a relatively short amount of time and remain at a low price level afterwards for a prolonged period. This is precisely what has happened between June 2014 and today. The low oil prices are caused by the growth in substitution possibilities at higher prices than those that preceded it and the increase in extraction capacity for unconventional energy resources. There is a strong relation between the presence of a legal emissions cap and the oil price. In particular, high oil prices are only possible when reduced demand in a cap region (or cap regions) is compensated by higher energy demand in non-cap regions. At the same time, the ability to meet CO_2 reduction targets coincides strongly with lower oil price levels. The reason is simple, as the presence of a legal cap limits the demand for oil by law. The price pressure exerted by renewables is however less pronounced in these situations.

3.2 Energy mix – Renewable energy

Next to seeing what could happen to the dynamics of the oil price as a result of climate- and energy policies, it is interesting to assess the possible developments for liquid biofuels and other renewable sources of energy. In doing so, this paragraph specifically looks at the bandwidth of the share of renewable energy sources in the energy mix under different policy conditions. In addition, we assess the effects brought about by Dutch, European, and other climate- and energy policies worldwide. We thereby assume, by way of a thought experiment, that the rest of the world will not, as of yet, apply a stringent climate- and energy policy of its own. The reason for doing so is that it is important to know the effects of non-participation of countries in a legal cap system on global CO_2 emissions. Finally, this section turns to discussing the impact of a lessened dependence on fossil fuels on the security of supply.

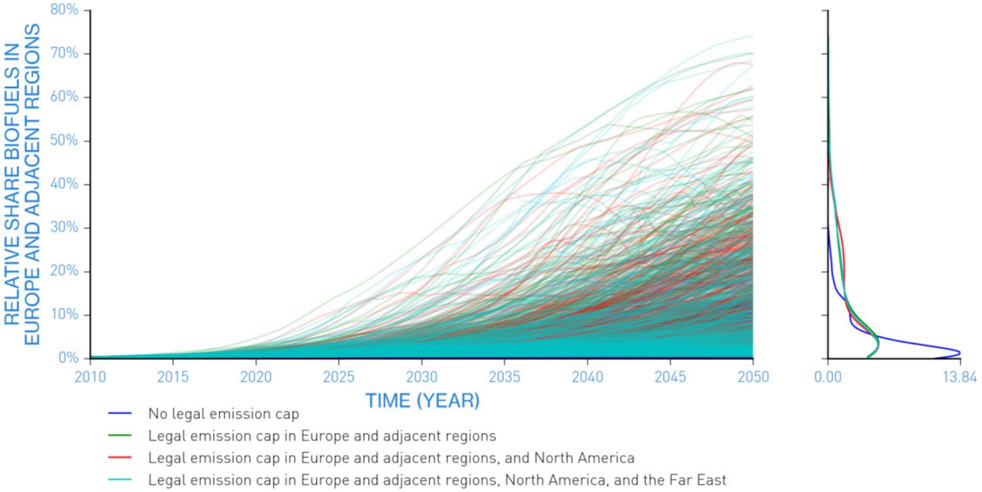

FIGURE 11: RELATIVE SHARE OF RENEWABLE ENERGY IN THE ENERGY MIX IN EUROPE AND ADJACENT REGIONS

Figure 11 shows the total bandwidth within which the share of biofuels can oscillate in Europe and its adjacent regions. Here again, we can see a strong link with the presence of a legal emissions cap. Note that in this context the number of regions in which such a cap exists is in fact not relevant as the only instance in which higher shares of biofuels are not possible occurs when there is no such a cap in the first place. It should however be stressed that high shares of biofuels always coincide with a relatively strong decoupling between economic growth and energy demand. In this particular situation (i.e., the presence of a legal cap and strong decoupling), the total energy demand in Europe decreases. We know that such a situation would put the prices of all the different energy types under pressure. That said, the current level of maturity of biofuels is not up to the level required to firmly affect other types of fuel. Therefore, it will be practically impossible before 2050 to reach a production level of biofuels comparable to the level of oil and gas in the current energy mix.

Impact of a legal cap on CO_2 emissions worldwide

It is realistic to assume that the presence of a legal cap in large parts of the world will not necessarily lead to an overall reduction in energy demand elsewhere (i.e., in those regions not covered by the cap) (Figure 12). This is due to the dampening effect that a legal cap has on energy prices, which in turn reduces the necessity to achieve greater decoupling of economic growth and energy demand in the rest of the world.

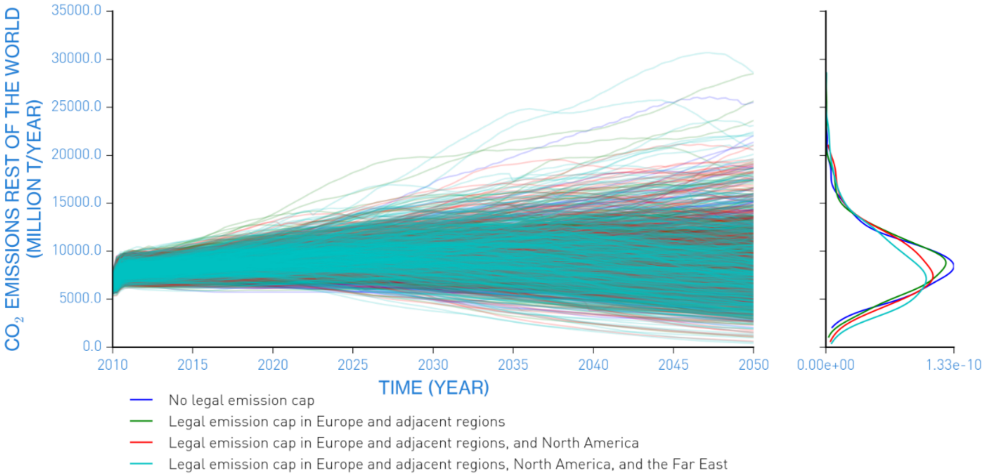

FIGURE 12: CO_2-EMISSIONS IN THE REST OF THE WORLD (MILLION TONS PER YEAR)

Conversely, renewable energy sources will also become cheaper, causing their share in the energy mix to increase, which in turn can reduce the total volume of CO_2 emissions in the world. In our analysis we see that this latter effect indeed can cause CO_2 emissions to be reduced slightly. However, for cases in which the oil price is too competitive for renewable energy we see that no reduction of CO_2 emissions is achieved in parts of the world not covered by a legal cap on CO_2 emissions relative to the situation where no legal cap exists in any of the regions considered in this study. The incentive to resort to the use of low-priced oil resources in non-capped regions will thus be a critical factor that could undermine and derail efforts to reduce CO_2 emissions.

This leads us to conclude that in order to achieve a reduction in CO_2 emissions in the rest of the world, the large-scale availability of inexpensive renewable energy sources, including liquid biofuels, is sorely needed. Only then, can we disincentivize the use of fossil fuels and achieve a significant reduction in CO_2 emissions in parts of the world not covered by a legal cap. The best possible result however will be achieved when a legally enforceable cap exists in all regions worldwide.

Security of supply

A reduction in the share of fossil fuels in our energy mix does not automatically mean that security of supply improves solely due to a lessened dependence on autocratic regimes from which hydrocarbon resources are imported. A number of reasons exist as to why this is not the case.

First, the Netherlands and the rest of Western Europe are relatively densely populated. The consequence of this is that land is relatively expensive, while societal resistance against resource extraction or production is sizeable. For example, witness the protests against the natural gas exploration in the Dutch province of Groningen. The same goes for the production of renewable energy resources and the installation of windmills at sea. Given that the production of oil and gas within the Netherlands is relatively expensive compared to other parts of the world, it can be assumed that if oil and gas demand were to subside significantly, the first production centers that close are those in relatively high cost areas. That in turn means that the relative level of dependency on these resources increases.

For the same reason it should not be assumed that when there is a strong increase in the share of biofuels and other renewable energy resources in the energy mix, these resources will necessarily be produced in the Netherlands or elsewhere in Europe.

Local resistance against windmills on land and the relatively high cost of placing these installations at sea are a factor to consider. What is more, the available space is limited due to the presence of waterways and fishing grounds. At the same time, a higher level of solar irradiance in areas near the equator also means that these parts of the world have a greater potential for renewable energy.

Furthermore, even if the overall expenditure in the economy that is devoted to energy resources decreases as a result of decoupling, the economy as a whole will still remain dependent on energy. If, as a result of decoupling, local energy production becomes less cost-effective and thus a greater share of our energy is imported from abroad, the share of the economy dependent on energy imports as well as our overall level of dependency will increase. This further underlines the importance of for example the strengthening of the EU internal energy market and initiatives such as the Energy Union which aim to foster a greater integration of electricity and gas pipeline infrastructure.

3.3 Selection price scenarios

As described in Section 2.4, out of approximately two thousand model runs we selected those scenarios that would enable us to perform a 'stress test' for extreme, yet plausible energy price scenarios. Given that we know from previous research[29] that traditional oil and gas producing countries are most vulnerable to scenarios with a declining oil price, scenarios 1-3 look at cases with the highest possible oil price on average under conditions whereby a legally enforceable cap on emissions is in place (Figure 13).

SCENARIO NAME	INDEX
1 – Highest average oil price in cap GE	1
2 – Highest average oil price in cap GE and NA	2
3 – Highest average oil price in cap GE, NA and FE	3
4 – Highest gas share with cap	4
5 – Highest biofuels share	5
6 – Lowest biofuels share	6
7 – Highest other renewables share	7
8 – Lowest other renewables share	8
9 – Highest oil share with cap	9
10 – Lowest global CO2 emissions	10
11 – Highest average oil price with global emission target	11

FIGURE 13: OVERVIEW OF SCENARIOS

Scenarios 4-9 look at the highest or lowest possible contribution to the energy mix of different types of energy in 2050. In ascending order, they look at the highest relative contribution of natural gas – often referred to as a transition fuel towards a low carbon economy; the highest and lowest share of liquid biofuels; the highest and lowest share of other renewable energy resources; and finally the highest share of oil in the energy mix under conditions whereby a legally enforceable emissions cap is in place. Scenario 10 is used to see with which energy mix we can reach the lowest level of CO_2 emissions worldwide, and which energy prices correspond to such as scenario. Finally, scenario 11 looks at the highest average oil price in the event that a global emission target is in place.

Oil price scenarios

The selected oil price scenarios contain three scenarios in which the oil price is usually higher than recorded in 2010 (scenarios 1, 2, and 3, Figure 14). The other scenarios (4-11) show a relatively lower price level compared to 2010. What is noteworthy about scenario 11, the scenario that depicts the highest possible oil price when global CO_2-emissions reduction targets are met, is that the oil price is continuously below the price level of 2010. In the long term, the price level is even significantly lower.

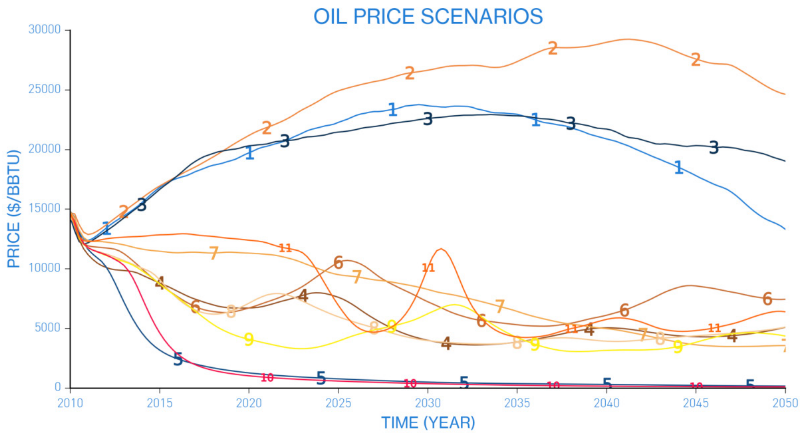

FIGURE 14: SELECTED OIL PRICE SCENARIOS

Higher oil price levels (scenarios 1-3) therefore all coincide with a situation whereby the world fails to meet its CO_2-emissions reduction targets. In these scenarios, demand from the rest of the world compensates for a reduction in oil demand in capped regions.

Other price scenarios

Both the oil price and the biofuels scenarios demonstrate a high degree of volatility (Figure 16 and Figure 15). This has to do with the fact that these fuels can be 'stocked'. When the market suffers from overcapacity, stocks will thus accumulate. Although the development of large scale batteries is moving forward gradually and natural gas can be stored in depleted gas fields, the options for storing electricity and natural gas remain limited compared to oil and biofuels.

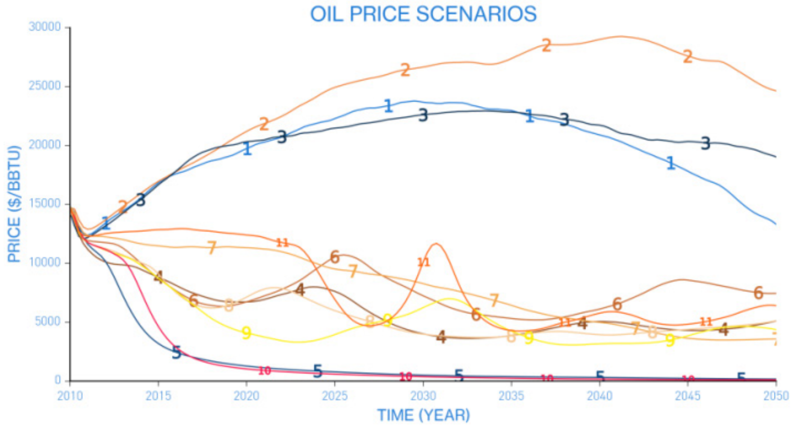

FIGURE 15: OIL PRICE SCENARIOS

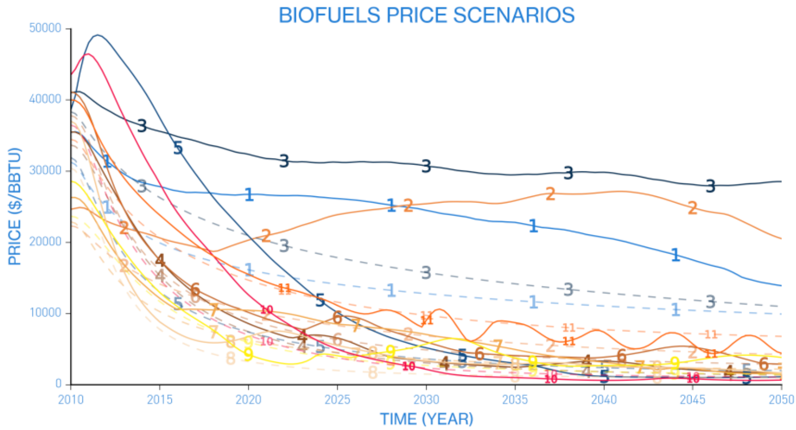

FIGURE 16: BIOFUELS PRICE SCENARIOS

For example, excess capacity of natural gas is often flared, whereas renewable energy sources that connect to the electricity grid are simply switched off in the case of overcapacity.

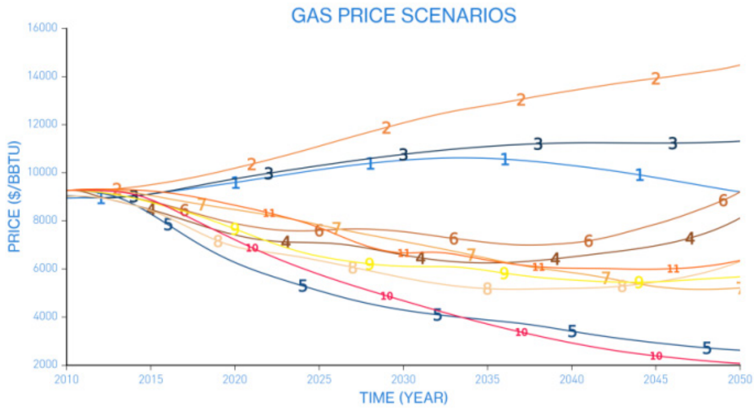

FIGURE 17: GAS PRICE SCNARIOS

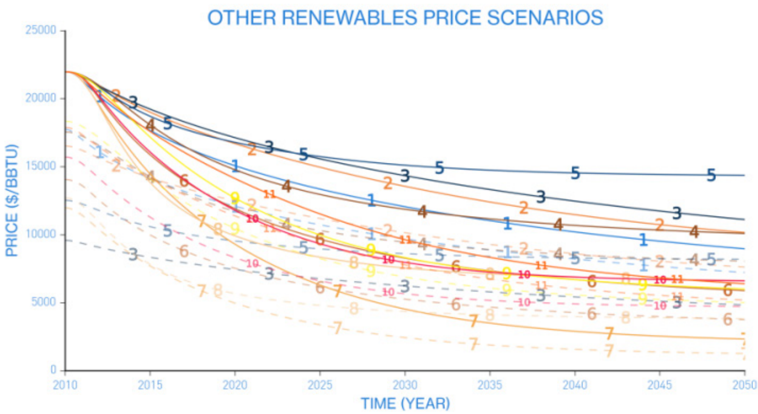

FIGURE 18: OTHER RENEWABLES PRICE SCENARIOS

In this study we assumed that it will be difficult for the price of biofuels to dive significantly below the price of oil. This makes sense when taking into account that biofuels and oil have a comparable functionality. Given that biofuels have an advantage over oil in that they produce only a fraction of the latter's CO_2 emissions, the minimal price of biofuels thus becomes the price of oil minus any costs associated with *carbon pricing*.

Scenarios in perspective

In Figure 19 we have plotted the eleven scenarios used in this study amidst the entire oil price range that was the result of the 2000 model simulations. What is visible is that the eleven scenarios cover virtually all types of energy price dynamics. In other words, the selected scenarios cover the available 'scenario space' relatively well, especially at the beginning of the period (between 2015 and 2020) and at the end (2050).

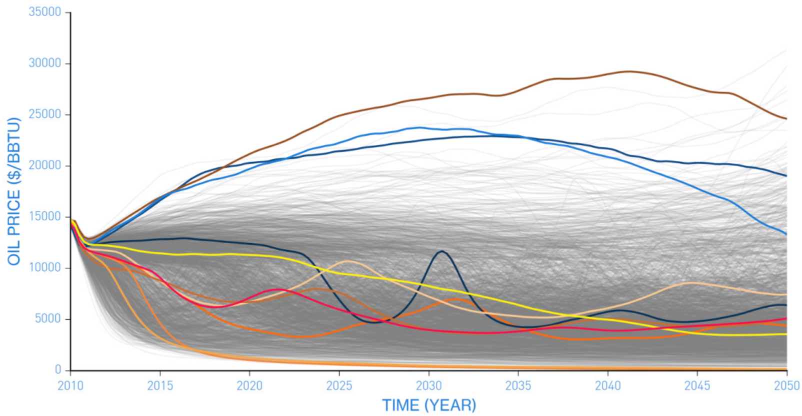

FIGURE 19: THE ELEVEN SCENARIOS IN PERSPECTIVE (OIL PRICE)

When looking at the global level of CO_2 emissions it is even more clearly visible that the eleven scenarios used in this study cover the available scenario space well (Figure 20).

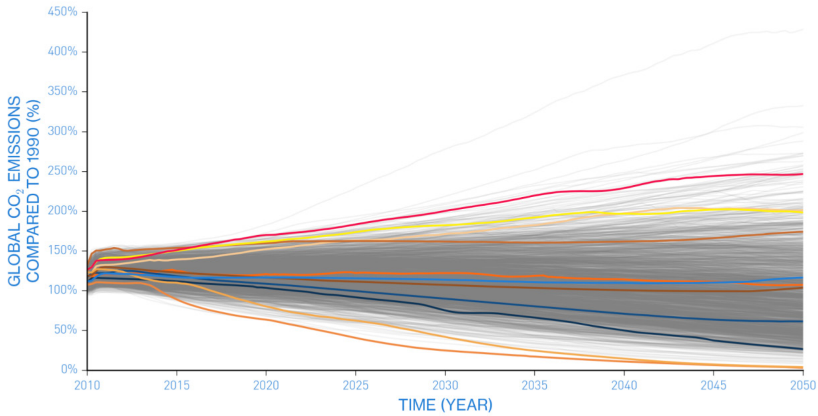

FIGURE 20: THE ELEVEN SCENARIOS IN PERSPECTIVE (CO_2 EMISSIONS)

Only a few cases in which we witnessed a very high level of CO_2 emissions (see the grey lines at the top of Figure 20) – coinciding with a wholly unsuccessful climate- and energy policy – lie outside the bandwidth of the eleven scenarios used in this study. However, given that this study departs from investigating the impact of (successful) climate- and energy policy under the influence of a legally binding CO_2 emissions cap, it is not problematic that this small number of model runs lies outside of the bandwidth of the selected price scenarios.

Looking at the development of energy demand in Europe gives a comparable image as witnessed for CO_2 emissions (Figure 21).

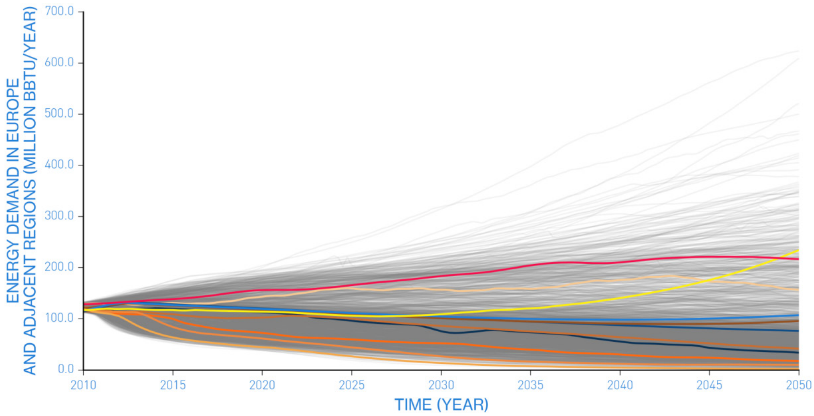

FIGURE 21: ENERGY DEMAND IN EUROPE AND ADJACENT REGIONS

Only those cases with a relatively high energy demand – meaning that the level of decoupling is comparatively small – are not adequately covered by the scenarios used in this study. However, given that these situations strongly correlate with failed climate- and energy policies on reducing CO_2 emissions, again, it is not considered problematic that these cases lie outside of the bandwidth of the eleven price scenarios that were used.

Renewable energy

We now turn to the effects that an increase in energy demand has on the energy mix. In the second phase of this study we use the eleven selected price scenarios as input for a model that assesses the socio-political and intra-state stability within 'rentier states' around Europe.

Before we do so, however, we can already draw a number of conclusions. It is sensible to assume that the costs for biofuels and other renewable energy sources continue to drop when the Netherlands and Europe focus more strongly on utilizing renewable energy for power generation. As a result, biofuels and other renewable energy sources can be expected to become more competitive in the energy mix, which in turn is likely to lead to their greater use in parts of the world where renewable energy sources may not be explicitly supported at the governmental level. This could strengthen the economic position of the Netherlands and Europe by raising their exports of liquid biofuels as well as of relevant knowledge and technologies. The potential for renewable energy sources, both with respect to liquid biofuels and other sources of renewable energy, in the countries studied in this report is highly uncertain. This caveat notwithstanding, the potential for solar energy in these countries is generally estimated to be high, which can be explained by the relatively greater level of experience of these countries with this type of energy compared to liquid biofuels. Also, the geographical location of the rentier states of the Middle East and North Africa contributes to a greater estimate of the potential for solar power.

This uncertainty set aside, the utilization of renewable energy sources can possibly compensate some of the expected loss of revenue due to a diminished return from the export of hydrocarbons. It can do so in two possible ways. On the one hand, renewable energy sources such as liquid biofuels can be stocked and exported, thus possibly contributing to generating valuable export revenues that can offset some of the losses incurred. On the other hand, the utilization of solar power to generate electricity could replace the burning of (expensive) fossil fuel resources for power generation and reduce the need for employing wasteful fuel subsidies, thus freeing up cash that can be used for other purposes.

3.4 Socio-political instability

Previous HCSS research demonstrated that a decline in fossil fuel prices can have destabilizing effects on the internal stability of countries that rely on resource rents to a large degree.[30] A number of different factors can be considered 'critical' in this regard. They can, therefore, potentially serve as *early warning* indicators of socio-political unrest.

Critical factors

First, the natural resources sector, particularly the oil sector, comprises a relatively large part of the economy in most rentier states (measured as % of oil and gas rents in GDP). For the countries under investigation in this study, oil and gas rents account for an even greater percentage of government revenues compared to their contribution to GDP (Table 1).

VARIABLE	OIL RENTS AS % OF GDP (2012)	GAS RENTS AS A % OF GDP (2012)	OIL/GAS RENTS AS % OF STATE BUDGET	EU SHARE OF OIL EXPORTS	EU SHARE OF GAS EXPORTS	REGIME TYPE
Russia	13,9%	2.3%	52% (2012)	79% (2012)	81% (2012)	Anocracy
Algeria	17,1%	5,9%	60% (2013)	72% (2013)	90% (2013)	Anocracy
Egypt	8,0%	3,2%	N/A	56% (2013)	7% (2013)	Anocracy
Qatar	12,1%	12,5%	60% (2012)	N/A	30% (2012)	Autocracy
Saudi Arabia	45,8%	2,4%	90%[86] (2012)	15% (2012)	No exports	Autocracy
Kazakhstan	24,9%	2,2%	N/A	56% (2012)	Net importer	Autocracy
Libya	52,3%	2,1%	96% (2012)	71% (2012)	100% (2012)	Anocracy

TABLE 1: RESOURCE RENTS, EU SHARE OF EXPORTS AND REGIME TYPE[31]

Second, all of the countries we analyze, with the exception of Qatar and Kazakhstan, saw their 'fiscal break even oil price' rise dramatically (Table 2). Especially countries in the Middle East and North Africa started spending a lot more in the wake of the Arab uprisings of 2011 with the aim of preventing similar unrest in their own nations.

	ALGERIA		EGYPT		SAUDI-ARABIA		QATAR		KAZAKHSTAN		RUSSIA		AZERBAIJAN	
	2010	2015	2010	2015	2010	2015	2010	2015	2010	2015	2010	2015	2010	2015
Fiscal Break even oil Price (US$)	85	130	-	-	69.5	106	76	60	68.9	68	116.7	110	33.4	95
Sovereign Wealth Fund (% GDP)	29%	23%	No SWF	Planned	41%	89%	55%	120%	25%	68%	10%	10%	22%	46%
Foreign Exchange Reserves (% GDP)	96%	74%	16%	9%	79%	90%	24%	32%	18%	13%	27%	19%	14%	7%

TABLE 2: FISCAL BREAK EVEN OIL PRICES, SOVEREIGN WEALTH FUNDS AND FOREIGN EXCHANGE RESERVES[32]

Third, large financial buffers enable countries to compensate for losses in export revenues. Financial buffers usually consist of foreign exchange reserves or sovereign wealth funds (SWFs; Table 2). What matters in this context is the relative, rather than the absolute, size of the financial buffers compared to the size of the overall economy. Countries such as Qatar and Saudi Arabia clearly stand out in this regard compared to the other countries in this study. In the long term however, Saudi Arabia does have a problem given the high level of defense expenditure (modernization and the costs associated with the war in Yemen), coupled with the increase in social spending in the wake of the Arab uprisings.[33] Russia, Azerbaijan, and Algeria occupy a notably weaker position compared to Saudi Arabia and Qatar when it comes to the relative size of their financial reserves. The national currencies in Russia, Kazakhstan and Azerbaijan all depreciated considerably in 2014-2016 as a result of the oil price decline. However, such a devaluation does somewhat compensate for a reduction in oil export revenues (see also Chapter 4), as the national budget is denoted in the national currency. Furthermore, a devaluation makes domestic products cheaper, which is beneficial for these countries' export positions. Unfortunately, for many of the countries in this study, little else beyond hydrocarbons is exported. The economic slowdown in China and Russia acts as a knock-on blow for the economies in Kazakhstan and Azerbaijan.

Fourth, in the Middle East in particular, the presence of migrant workers is often used as a buffer mechanism. In case of a recession, work visa for labor migrants are often revoked leading to a slowdown in the rise of unemployment among the local population. Such policies thus have a dampening effect on the potential for social unrest.

A fifth factor that matters is regime type, or the kind of 'polity' by which a country can be classified (see Table 1). Research by the Center for Systemic Peace has demonstrated that full autocracies and democracies are more stable over time than so-called 'anocracies'.[34] Anocracies represent partial democracies whose populations enjoy partial liberties. Countries in Northwestern Europe are all democracies without exception. Saudi-Arabia is an example of a full autocracy, whereas countries such as Russia or Algeria can be qualified as anocracies. The reason for the relative instability of anocracies derives from the fact that partial liberties of the population often lead to a desire for a greater level of liberty in society. What also matters in this context is the level of education of the population. In general, the higher the level of education, the greater the desire for a democratic form of governance.

A sixth and seventh factor relate to changes in employment and purchasing power, particularly youth unemployment and a rise in basic food prices (Table 3).

	ALGERIA		EGYPT		SAUDI-ARABIA		QATAR		KAZAKHSTAN		RUSSIA		AZERBAIJAN	
	2010	2015	2010	2015	2010	2015	2010	2015	2010	2015	2010	2015	2010	2015
Youth Unemployment (% age 15-24)	22.2	25.2 (2014)	26.3	38.9 (2013)	29.8	28.7 (2013)	1.3	1.5 (2013)	6	4.5	16.8	14.5 (2013)	14.6	14.8 (2013)
Change in food prices (% yr on yr)	1.3.	1.4	22.3	8.3.	4	2.2	-0.81	0.9	2.0	3.6	5	20	-1	5.83

TABLE 3: YOUTH UNEMPLOYMENT AND CHANGES IN FOOD PRICES[35]

Table 3 shows that food prices rose by 20% in Russia, 8.3% in Egypt, and 5.83% in Azerbaijan between 2010 and 2015. The combination of economic decline, currency devaluation and rising food prices undermines the purchasing power of the population. All countries experienced a relatively high level of youth unemployment, with the exception of Qatar and Kazakhstan. The issue is particularly salient in Algeria, Egypt, and Saudi Arabia. These countries are thus under tremendous pressure to provide an increasing share of young people with jobs.[36]

Potential for renewable energy

The potential for renewable energy can be seen as a way to compensate losses in income resulting from a drop in oil and gas export revenues. However, it has to be stated up front that the data (Table 4) with respect to the potential for renewable energy is highly uncertain.

COUNTRY	POTENTIAL (BBTU/YEAR)	
	BIOFUELS	OTHER RENEWABLES
Algeria	56472	597482282
Azerbaijan	44866	3592291
Egypt	356	4347958
Kazakhstan	8973 or 30000	123196741
Russia	59821	112123592
Saudi Arabia	0	3329900964
Qatar	0	15901

TABLE 4: RENEWABLE ENERGY POTENTIAL PER COUNTRY[37]

As can be seen from Table 4, the estimates for the potential for biofuels are often very low, at times even lower than the actual production levels of biofuels despite that being theoretically impossible. This discrepancy is due to the fact that liquid biofuels are not well developed, and there is also some level of ambiguity with respect to what *should* and what *should not* be included when speaking about biofuels. That being said, it should be assumed that the total future potential for biofuels is larger than what is indicated in Table 4.

The potential of biofuels notwithstanding, it should be pointed out that their production is not uncontroversial. Biodiesel production in OECD countries increased by 92% from 2000 to 2010.[38] Initially, biofuels were considered an environmentally friendly practice and biofuel programs were heavily subsidized. As a result, large swaths of agricultural land were transformed into land for biofuel crop production. The boom contributed to a steep increase in the non-food demand for crops like soy and corn, and between 2007-2009 biofuels accounted for 20% of the global use of sugar cane, 9% for both oilseeds and coarse grains, and 4% for sugar beet.[39]

However, in the years that followed it became apparent that the promotion of biofuels had a negative effect on food security. Often biofuels are produced from crops that are diverted from existing food production. The effect thereof is that the resultant gap in the food supply is partly filled with the expansion of cropland worldwide, which in turn likely leads to greater carbon emissions through indirect land use change.[40] The IMF and the World Bank assessed that 70%-75% of the increase in food prices during the global food crises of 2008 could be attributed to a growing demand for biofuels.[41] As a consequence, many countries are now reversing their biofuel policies.

For the estimates with respect to solar and wind energy the opposite is true. Often the estimates for the potential are very high. An example of this can be seen in the estimate for Saudi Arabia. Sometimes this is because such estimates are done on the basis of the total solar irradiance on land, as in the case of Saudi Arabia. As a result, this potential should be judged as theoretical, as it does not take into account any practical limitations that may exist on land. Therefore, it should be assumed that the *real* potential is much lower than indicated. Lastly, this overestimation of the potential can also partly be attributed to the relatively high level of maturity found in solar and wind energy technologies. Finally, it should be noted that it is unlikely that Egypt, Saudi Arabia, and Qatar will be able to export electricity to Western Europe as long as this is not cheaper and cannot be transported. This limitation however does not count for the other countries or for biofuels.

3.5 Internal stability

For all countries in the study we subsequently examined whether the 11 price scenarios and two reference scenarios lead to an improvement in internal stability compared to the situation in which the oil price remains at the 2010 level (see Figure 22 for the example of lgeria).

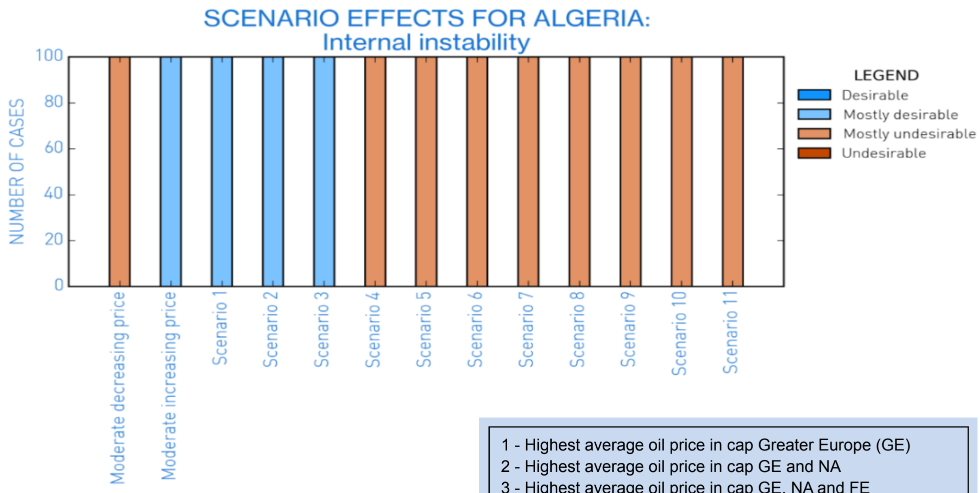

FIGURE 22: SCENARIO EFFECTS FOR ALGERIA

1 - Highest average oil price in cap Greater Europe (GE)
2 - Highest average oil price in cap GE and NA
3 - Highest average oil price in cap GE, NA and FE
4 - Highest gas share with cap
5 - Highest biofuels share
6 - Lowest biofuels share
7 - Highest other renewables share
8 - Lowest other renewables share
9 - Highest oil share with cap
10 - Lowest global CO_2 emissions
11 - Highest average oil price with global emission target

All countries demonstrate a uniform result: only in scenarios with a relatively high oil price did the level of stability increase on average. We know that the three scenarios in which the oil price is relatively high all coincide with a failing of global climate- and energy policies. All other cases in which climate policies are successful lead to a relative increase in instability in all countries investigated. Based on this part of the analysis, however, we cannot (yet) say which countries suffer relatively more or relatively less from this development.

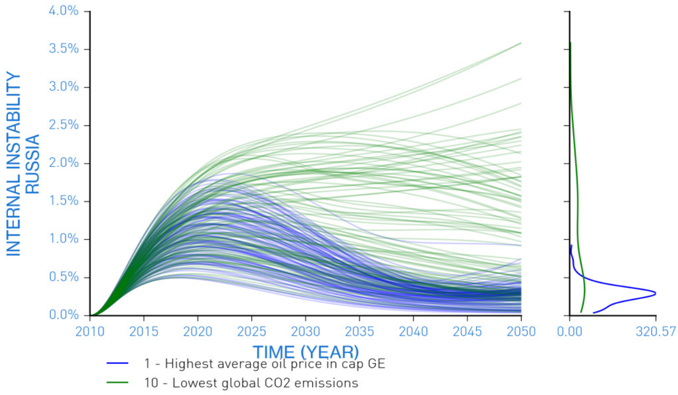

FIGURE 23: INTERNAL STABILITY IN RUSSIA

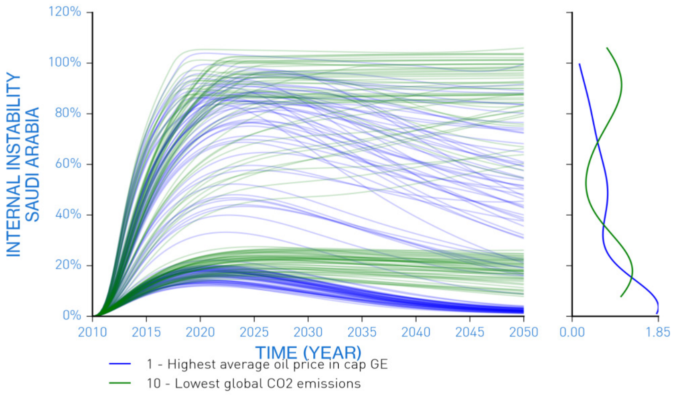

FIGURE 24: INTERNAL STABILITY IN SAUDI ARABIA

Figure 23 and Figure 24 show the possible developments with respect to internal stability in Russia and Saudi Arabia. The blue lines correspond to a scenario whereby the oil price is relatively high (scenario 1), the green lines indicate a scenario with a relatively low oil price on average (scenario 10). It is clearly visible that for both countries the blue as well as the green lines have the same initial bandwidth. This can be attributed to the 'shale effect'[42] and the fact that the impact of climate- and energy policy is unlikely to be significant at the beginning of the period under consideration. When comparing Figure 23 with Figure 24 it can be seen that there are scenarios in which, irrespective of the oil price development, Saudi Arabia could become very unstable. It is however clear that a higher oil price level always leads to less instability. Following on this, it is clear that the relative order of magnitude of instability in Saudi Arabia is larger than in Russia. The primary reason for this difference lies in the fact that Saudi Arabia has an even less diversified economy than Russia does, has a relatively young population and already suffers from high levels of youth unemployment. Furthermore, Saudi Arabia has limited possibilities to develop an economy based on the export of renewable resources, given that connecting the Saudi electricity network to nearby countries is not realistic at this point in time due to the presence of several violent conflicts in its immediate vicinity.

Economic development

The one-sidedness of the Saudi Arabian economy is clearly visible when we compare the possible development of Russia's GDP with that of Saudi Arabia (see Figure 25 and Figure 26).

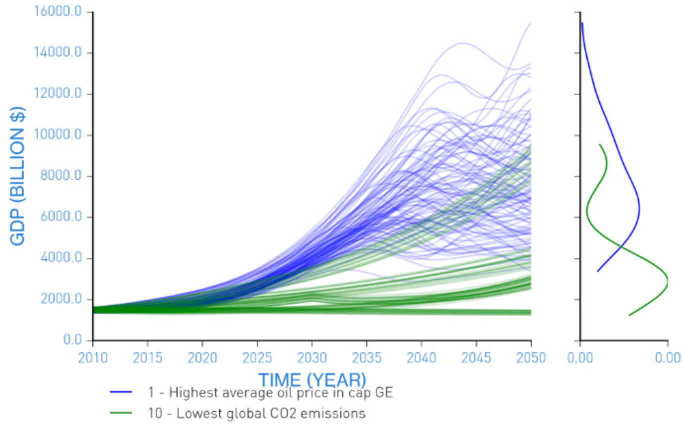

FIGURE 25: DEVELOPMENT OF RUSSIAN GDP

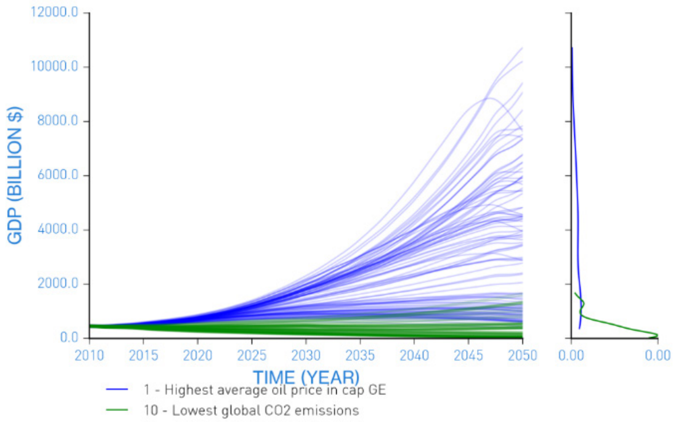

FIGURE 26: DEVELOPMENT OF SAUDI GDP

Economic development in the case of Saudi Arabia remains very strongly linked to the price of oil. This means that unless the Saudi economy is significantly diversified, it will be very difficult for Saudi Arabia to experience economic growth under a scenario in which global climate mitigation policies are successful.

Conclusions on social-political instability

The most important conclusion of the above analysis on the influence of climate mitigation policies on social-political stability in rentier states around Europe is that countries in the Middle East, Saudi Arabia in particular, are highly vulnerable to these policies. That said, this is a development that will only become noticeable in the long term. Factors that play a major role in this context are the relatively young population and the enormously high level of dependence on the export revenues of oil and/or gas. It is however not unimaginable that a large discrepancy between the polity classification and the governance model in a country on the one hand, and the level of education of the population on the other also play an important role. The relatively large financial buffers may help to dampen the potential for unrest in the short term, yet are unlikely to prove sufficient in the long term.

We find that Russia and Kazakhstan are less vulnerable to oil price scenarios that coincide with successful climate- and energy policies. What plays a role in this context is that both countries have a relatively ageing population, and the regime type corresponds well to the older generations in the country. Also the Russian and Kazakh economies are more diversified compared to Saudi Arabia. Finally, Russia and Kazakhstan are among the countries with the best geographical possibilities for building up an economy based on the export of liquid biofuels. That said, the critique against the use of biofuels formulated in Section 3.4 should be borne in mind.

Although the effects of energy transition will primarily manifest themselves in the long term, some of the possible dynamics could already be witnessed over the past two years when average crude oil price declined from US$ 108 to US$ 47 per barrel (bbl)[43], or by 56%, and have since largely stayed within the range of US$ 40-US$ 60/bbl. However, arguably brought about by the US shale oil revolution, which shifted the demand and supply balance in the oil market in favor of consumers, the energy transition should also put a significant downward pressure on fossil fuels including oil products. In this respect studying the impact of low oil prices on oil exporters and the measures they have taken to adjust to new conditions provides an important insight on how these countries might react to the energy transition. For that reason Section 4 takes a closer look at which policy measures major oil- and gas exporting countries have taken to cope with the adverse economic conditions.

4 LEVEL OF PREPAREDNESS: AN ANALYSIS OF THE OIL PRICE CRASH FROM 2014 UNTIL TODAY

4 LEVEL OF PREPAREDNESS: AN ANALYSIS OF THE OIL PRICE CRASH FROM 2014 UNTIL TODAY

Between 2010 and 2015 oil production in the US expanded by 70% and the country became the largest oil producer in the world. OPEC countries as a whole and Saudi Arabia in particular also increased their production in order to defend their market share and to force shale producers out of business. The oil price shock has had a significant negative effect on oil-exporting countries: their export and tax revenues declined substantially. Economic growth has also slowed and in some cases turned into a recession. All oil- and gas-exporting countries have thus been forced to undertake urgent policy measures to counter the negative economic circumstances.

There are some limitations to the analysis conducted in this chapter. Energy transition is expected to be a relatively slow-moving process giving countries much more time to adjust compared to the current oil price shock which took place within a much shorter time frame. Correspondingly, the responses of many countries have focused mainly on short-term measures rather than on long-term plans.

In addition to the countries for which we performed a quantitative analysis (Algeria, Azerbaijan, Egypt, Iran, Kazakhstan, Qatar, Russia and Saudi Arabia, see Chapter 3), we looked qualitatively at Nigeria, Turkmenistan and Venezuela.

Coping measures can be organized into several broad categories, for example:

Macroeconomic and fiscal responses are typically short-term measures, while structural and political measures often have a much longer-term horizon. In some cases government actions can be assigned to several categories simultaneously. For example, the privatization of state-owned companies can be seen as a way to raise government revenues, but it also represents a structural measure intended to increase the effectiveness of such companies and to attract private investment.

All oil-exporting countries have experienced a negative impact of the oil price decline on their government budgetary revenues. Between 2013 and 2015, in all countries with the exception of Egypt and Iran the general government revenues dropped as a percentage of GDP.[44] In the case of Saudi Arabia the drop was 16% of GDP. In Algeria, Azerbaijan and Kazakhstan the decline was also very significant – above 5% of GDP (Figure 27).

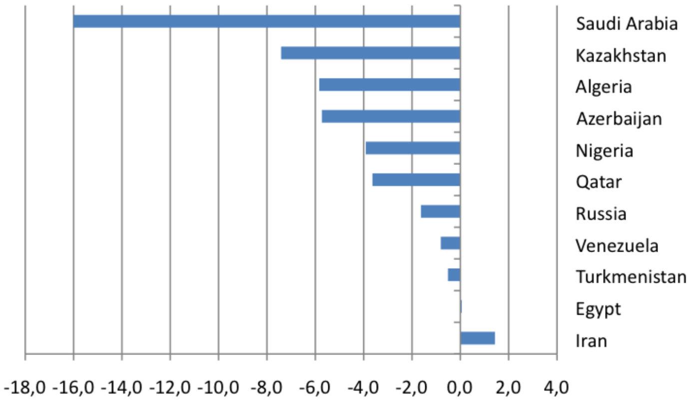

FIGURE 27. CHANGE IN GENERAL GOVERNMENT REVENUE BETWEEN 2013 AND 2015, IN PERCENTAGE POINTS OF GFP. SOURCE: IMF.

To deal with the budgetary problems, all countries had to undertake various measures to bridge the gap between spending and revenues. The most common type of response was a reduction of government spending, in particular, on long-term investment projects (Azerbaijan, Kazakhstan, Russia, Saudi Arabia), energy and water subsidies (Egypt, Qatar, Nigeria, and Saudi Arabia), and public salaries (Algeria, Russia, and Saudi Arabia). Some countries also raised taxes (Algeria, Azerbaijan, Iran, Russia, and Turkmenistan).

Most oil-exporting countries accumulated substantial financial reserves before the crisis (in the form of foreign exchange and sovereign wealth funds) and used them to pay for public sector expenditure when economic circumstances worsened. In some countries these reserves allowed them to pursue the expansion of public spending programs, in particular in Qatar, where infrastructure spending was protected from cuts ahead of the FIFA 2022 World Cup.[45] However, the size of financial buffers varies significantly. In countries such as Kazakhstan, Qatar, and Turkmenistan they can finance 20-30 years of projected budget deficits but in other states such as Venezuela and Egypt they are essentially empty (see also Section 3.4).

One of the macroeconomic adjustment measures that oil-exporting countries used was currency depreciation. Currency depreciation mitigates the impact of oil price declines on budgetary revenue and increases economic competitiveness, yet this comes at the expense of increased inflation and associated declines in the purchasing power of the population. Some countries initially resisted the depreciation (Azerbaijan, Egypt, Kazakhstan, and Nigeria), often using restrictions on currency transactions, but were eventually forced to devalue under the pressure of financial markets. Only countries with very large reserves, Saudi Arabia and Qatar, were able to keep their exchange rate at the same level as in 2014 at the cost of large depletions of their reserves. Another macroeconomic step that many countries had to undertake was an increase in their interest rates – to reduce capital outflows and soften currency depreciation. Devaluation and interest spikes have created a significant risk for the stability of the banking system. To address this challenge, some countries recapitalized banks (Azerbaijan, Algeria, and Russia), purchased non-performing loans from banks (Azerbaijan, and Kazakhstan) and increased the supply of liquidity.

In terms of structural measures, the most ambitious plan was adopted by Saudi Arabia: Vision 2030.[46] It presents a strategy for long-term economic diversification, channeling more money into high-tech sectors and raising the share of Saudis employed in the private sector. The goal of the project is to move Saudi Arabia from its current position of the world's 19th largest economy into the top 15.[47] Instrumental within the Saudi plans is the partial privatization of the national oil company Saudi Aramco and its transformation into a global industrial conglomerate. The ownership of Saudi Aramco and other state-owned companies is transferred to the Public Investment Fund, which will then become the largest sovereign wealth fund in the world. The plans further sets out to diversify the economy away from its reliance on hydrocarbons and localize the oil and gas sector, ultimately raising the share of non-oil exports in non-oil GDP from 16% to 50% by 2030. In doing so, the Saudi government set itself a goal of generating 9.5 gigawatts worth of renewable energy, seeking to localize a significant portion of the renewable energy value chain in the Saudi economy. Energy prices are in the long term to be brought on to the free market level and labor force participation, particularly for women, is supposed to increase.[48] To facilitate this goal, the government will issue tenders for a large-scale solar and wind power program worth between US$ 30 and US$ 50 billion. That said, renewable energy is not the only game in town. The Kingdom is also said to be in the early stages of feasibility and design proposals for the country's first commercial nuclear power stations, with a capacity of 2.8 gigawatts.[49] Although grand in its ambitions, Vision 2030 is scant on details. To achieve its goals, Saudi Arabia would have to significantly open up to global trade, investment, allow foreign visitors and implement international codes of conduct including greater transparency and secular laws. Here Saudi deputy crown prince Muhammad Bin Salman, the man behind Vision 2030, is up against powerful vested forces within Saudi society, including the Saudi clerics and the business interests in his extended family.[50] Time will tell if the prince is able to follow through on his bold promises.

Kazakhstan has also launched structural reforms. On a more practical level, Doing Business reports produced by the World Bank[51] show that it was Kazakhstan that made most significant improvements in the overall business climate for entrepreneurship over the last two-three years, while the regulatory conditions worsened in Qatar, Saudi Arabia and Venezuela.

Has the oil price decline had an impact on the internal political situation and foreign policies of the oil-exporting countries? This question is difficult to answer even with an in-depth analysis of a particular country because these areas are affected by a myriad of factors – most of which not directly related to the price of oil. Some broader measures of democratic governance suggest that there is no uniform trend and countries moved in opposite directions. For example, World Governance Indicators (voice and accountability) indicate that Nigeria has improved its score mainly due to the generally fair and peaceful presidential election in March 2015. However, the situation deteriorated in Azerbaijan, Qatar, and Venezuela. Azerbaijan became increasingly intolerant against dissent resorting to the imprisonment of journalists and activists. In Venezuela, after the opposition won the parliamentary election in December 2015, President Nicolás Maduro declared a state of emergency in May 2016 and the political situation remains tense.

Another indicator, military expenditure, in particular as a share of GDP or government expenditure, also provides an insight on leadership's priorities. Azerbaijan, Russia, and Saudi Arabia show a substantial increase with regard to this indicator between 2013 and 2015.[52] It is not a coincidence that these three were involved in various conflicts in 2015-2016: Nagorno-Karabakh, Syria, and Yemen, correspondingly. In all three countries these military engagements were popular domestically. In Venezuela military expenditure declined significantly owning to the collapsing economy.

Conclusions

This brief review shows that all oil-exporting countries are negatively affected by a decline in oil prices and have had to adopt various fiscal and monetary policies to adjust to a new reality. Their record on structural policies that would promote long-term non-oil economic growth has been limited, although some announced ambitious plans for the future. The impact of the decline in oil prices on oil-exporting countries' politics is quite uncertain. However, it is possible to say that in a relatively short-term perspective (over the last two years), it did not lead to their foreign policy restraint and may, in fact, have had the opposite effect.

5 ENERGY CHOICES IN SUB-SAHARAN AFRICA

5 ENERGY CHOICES IN SUB-SAHARAN AFRICA

When looking beyond the current oil price environment and its effects, one has to focus in particular on the energy choices made by developing countries. After all, for energy- and climate policies to bear fruit it will ultimately matter a great deal as to whether or not developing nations make similar choices as industrialized nations have in the past. For this reason, this chapter takes an in-depth look at the energy choices made by Sub-Saharan African countries and the plans these countries have for the future.

5.1 Current primary energy mix

To meet their energy needs, many economies in Sub-Saharan African countries rely to a large extent on biomass (Figure 28).

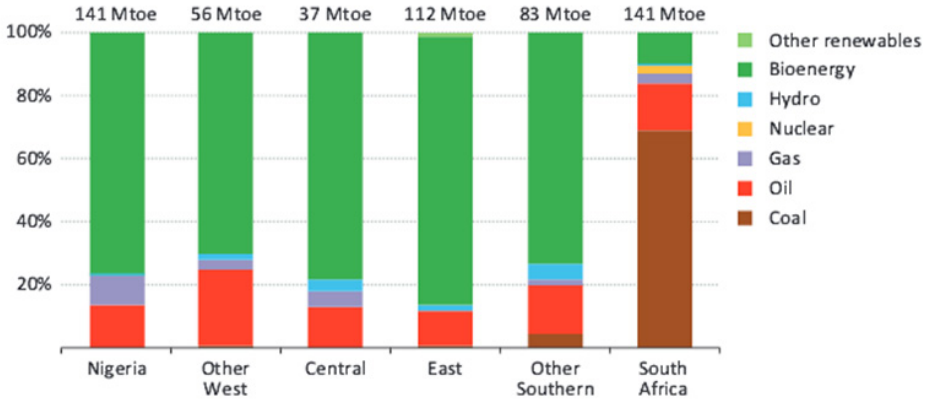

FIGURE 28: SUB-SAHARAN AFRICA PRIMARY ENERGY MIX BY SUB-REGION, 2012. SOURCE: IEA, AFRICA ENERGY OUTLOOK 2014.

However, the share of oil and gas in domestic energy consumption varies greatly across the continent. Nigeria for example relies on oil for 9% of its total energy consumption. For natural gas this figure stands at 5%.[53] In Mali, fossil fuels make up around 21% of the primary energy mix.[54] Ethiopia relies on fossil fuels for 8.3% of its domestic energy consumption.[55] These shares are significantly higher in other countries. Senegal for example relies on oil for 40% of its domestic energy consumption.[56] In terms of its domestic energy consumption, Gambia is 30% reliant on oil products.[57] South Africa heavily relies on coal, which comprises 68% of its domestic energy mix.[58]

Hydroelectric power, although representing only 1% of the overall energy mix in Sub-Saharan Africa, is nonetheless a significant source of energy in several countries. Ethiopia (86%), Central African Republic (56.8%) and Equatorial Guinea (77%) all have high shares of hydropower in their primary energy mix. A new wave of investments in hydro energy is expected in Sub-Saharan Africa, slated to triple the existing capacity by 2040.[59] Although renewable and a clean and reliable source of energy with low operating costs, there are some drawbacks to hydroelectric power. First and foremost, it is expensive to build, as it requires significant up front infrastructural investments. It is true that this can be offset by the low operating costs afterwards, yet for Sub-Saharan African countries the initial capital costs can be prohibitive. Second, the damming of waterways is known to be disruptive to ecosystems. Third, the onset of dry spells could seriously hamper the ability of a hydroelectric power plant to deliver enough power. Power and energy costs are specifically identified with the amount of water that is accessible and the onset of a drought can have a highly disruptive effect.[60]

In some countries, geothermal energy acts as a significant source of energy. One report concludes that "geothermal will play a small role, but relative to total known energy capacity on the continent, it will have significant volume, reaching 28 terawatt-hours by 2040".[61] At present, it is an important source of energy in Ethiopia, Sudan, and Kenya, where in 2014, it made up over half of these countries electricity output.[62]

Biomass however is by far the most used source of energy across the continent, making up 49% of the energy mix in Angola, 62% in Gabon, 70% in Gambia, and 78% in Mali. Other countries with a relatively high share of biomass in their primary energy mix are Central African Republic, Kenya, Mali, Mozambique, Nigeria, Senegal, and Sudan. These countries are largely representative of the composition of the energy mix throughout Sub-Saharan Africa (Figure 29).

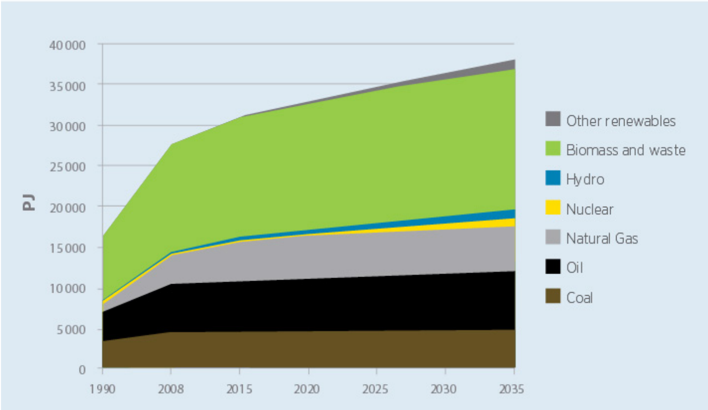

FIGURE 29: TOTAL PRIMARY ENERGY DEMAND FOR ENERGY SOURCES IN AFRICA. SOURCE: IEA, 2010, FROM IRENA-BIOMASS POTENTIAL IN AFRICA.

A 2014 IEA report states that 60% of the energy needs in sub-Sahara Africa are met through bioenergy.[63] What is more, "consumption in the region continues to increase and its growth since 2000 has been greater than that of all other fuels combined".[64] At the same time, the overall share of bioenergy is expected to decline to 47% by 2040.[65]

All countries in Sub-Saharan Africa invest in energy infrastructure in one way or another. In order to further lessen its dependence on oil in its energy mix, Nigeria recently introduced a regulation that makes it mandatory for companies to acquire a minimum percentage of electricity from renewable energy resources.[66] In view of global climate regulations, much funding is geared towards renewable energy. However, not all initiatives are ultimately successful, and nor does investment into renewables automatically equate greening the economy, as, for instance, biomass can also be an important source of local pollution and hazardous to human health when used indoors.

Ethiopia is particularly ambitious, wanting "to become a regional renewable energy hub in East Africa."[67] Kenya is also making significant investments in renewables, chiefly with the help of China.[68] China's involvement in the African renewable energy sector did not originate overnight. The Chinese leadership's growing concern about the impact of climate change – partly fed by growing popular discontent about the level of air pollution – have pushed the country in the direction of an aggressive policy that promotes renewable energy.[69] Today, China is the world leader in domestic investment in renewable energy and associated low-emissions energy sectors, and increasingly, the country has been investing in renewable energy projects abroad with the aim of expanding its renewable sector. Just last year, Chinese foreign investment in renewables grew by 60% to reach US$ 32 billion, including eleven new overseas investment deals worth more than US$ 1 billion each.[70]

Around a third of new generation capacity additions in Sub-Saharan Africa in the period 2010-2015 were installed with Chinese companies acting as the main contractor,[71] equal to the total contribution of the next four largest countries combined. More than half of these additions came from renewable sources, primarily hydro energy, where Chinese companies are dominant. At the same time, Chinese involvement in wind energy in South Africa and Ethiopia is increasing. With respect to solar energy, Chinese companies have hitherto primarily acted as PV suppliers, rather than construction contractors. Primary point of entry for Chinese companies in the Sub-Saharan African market has been South Africa, where Chinese PV manufacturer Jinko Solar has invested in a PV factory with an annual capacity of 120MW.[72]

5.2 Solar energy potential and investments

Given the high number of sunshine hours on average in the Sub-Saharan region, the potential for solar energy is large (Figure 30).

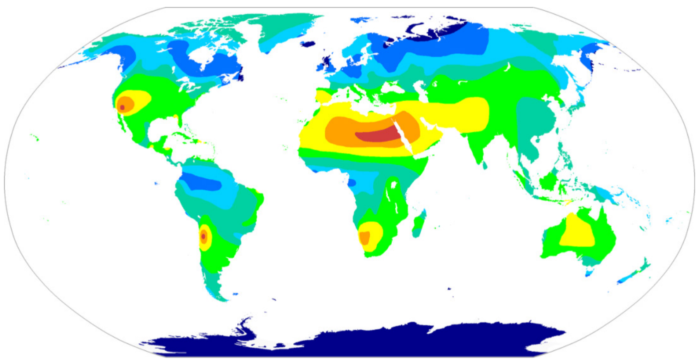

FIGURE 30: ANNUAL SUNSHINE HOURS MAP OF THE WORLD

Indeed, in many countries its potential has already been acknowledged. Nevertheless, at this point solar energy's contribution to the region's energy mix is still negligible. However, should planned investments in solar energy materialize, it could make up 12% of the total energy mix by 2040.[73] At this point, solar energy is significant in countries such as Angola and Mali, in the latter of which it could make up 4% of the energy mix by 2020.[74] South Africa is by far the most important country on the continent when it comes to solar energy production, accounting for 65% (1361 MW) "of the continent's cumulative installed solar PV capacity."[75]

In many countries, solar energy is seen as a source with great potential, and projects aimed at fulfilling the potential have been launched. However, concrete results so far have remained modest. One example is Senegal, which will soon inaugurate a solar power plant north of Dakar that is to provide power to 180,000 local residents.[76] The investment comprises EUR 43 million, partly funded by the French Development Agency.[77] While relatively sizeable for a solar project, its impact on energy consumption will still be rather small overall. Other countries where projects are under way are Botswana[78] and Equatorial Guinea.[79] The continent's largest planned solar project, Desertec, ultimately failed due to costs and political issues.[80] Rather than through large-scale projects, solar appears more suitable for the decentralized provision of electricity, a distribution method particularly useful for rural areas.

5.3 Wind energy potential and investments

Overall, the potential for wind energy in Sub-Saharan Africa is rather minimal. This is chiefly due to issues of cost and relatively low wind speeds recorded in many parts of the continent. Exceptions to the rule are Angola, which aspires to build a windfarm in the southern desert[81], Kenya, where a 310 MW strong wind park is being built at Lake Turkana, and Ethiopia, which currently has 171 installations across the country.[82] Projects are also under way, or have been completed, in Nigeria, Senegal, and South Africa. The projects in South Africa should enable the country to add 8,400 MW to its energy mix by 2030.[83] Sudan is another country with significant potential. Here, the plan is to add 100MW to the grid by 2030.[84]

The variability of electricity generated by wind power makes it a less reliable form of energy as a baseload. According to the IEA, "domestic markets are small and the power grids are not well developed, meaning that variable generation from wind would introduce additional challenges to an already unstable and intermittent system".[85] Also, the costs involved in building wind farms make it a less appealing source of energy for the region.

5.4 Biomass

Biomass is still the most important energy source for countries in Sub-Saharan Africa. Its use is mainly residential and for cooking purposes. At present, it makes up over 60% of total energy use.[86] In Africa as a whole, some 80% of the population is said to rely on biomass for daily purposes.[87] Unfortunately, among renewable energy sources, wood-based energy is considered dirty, inefficient and unsustainable. There is therefore a growing chorus for it to be replaced as quickly as possible by alternative energy sources.[88] On average, the use of biomass is higher in poorer countries. For instance, in Burundi, Rwanda, and the Central African Republic, the share of energy derived from biomass is 90% or higher.[89] Gabon, a country where oil consumption is significant at 29%, also relies on biomass for 62% for its primary energy supply.[90] Similar figures can be found in Gambia.[91] Biomass is also a significant source of energy in large countries. In Ethiopia for instance, biomass makes up 92% of the domestic energy consumption, whilst hydropower is becoming increasingly important as well.[92] In Kenya the percentage is 76%.[93]

Biomass suffers from negative perceptions, being seen as outdated, and is therefore often presented as an "unsustainable source of energy, with its use potentially causing an energy crisis and even desertification."[94] This means that fossil fuels and nuclear energy can be more attractive alternatives.[95] However, others argue in favor of biomass use in Sub-Saharan Africa because of availability, familiarity and price, employment creation, energy security and diversity, climate change mitigation, potential for technological advancement and commercial investment, cleanliness and modernity.[96] Of course, whether these advantages can be reaped depends on how biomass is consumed. This makes it all the more important to make sure that biomass use becomes less onerous for people's health. The promotion of more efficient biomass cooking stoves can reduce the harmful health effects of pollution from indoor smoke. Nevertheless, 650 million people – more than one-third of an expanding population – will still cook with biomass in an inefficient and hazardous way in 2040.[97]

If less harmful ways of consuming biomass can be developed, the potential for its future use is considerable. Bioenergy could sustainably contribute between a quarter and a third of global primary energy supply in 2050. It is the only renewable source that can replace fossil fuels in all energy markets – in the production of heat, electricity, and fuels for transport.[98] Projections suggest that the primary energy mix of sub-Saharan Africa will continue to be dominated by bioenergy. Demand is set to grow by 40%, to reach 490 Mtoe in 2040.[99] At the same time, the overall share of bioenergy in the primary energy mix is set to decline over time, from 61% in 2012 to 47% in 2040.[100]

5.5 Local/decentralized energy generation

Sub-Saharan Africa is far from achieving universal energy access for its citizens. Energy poverty is widespread as a result. National grids often only serve urban areas, and fail to reach into the countryside. At present, only 18% of the rural population in Sub-Saharan Africa has access to electricity, compared to 55% in urban areas.[101] In CAR only 3% of the population is plugged into the electricity grid.[102] On average, electrification rates remain well below 50%. Only South Africa (85%) and Gabon (86%) achieve high figures. The overall electrification rate for Sub-Sahara Africa is 35%, with only 19% coverage in rural areas.[103] The total figure is set to increase to 71% by 2040,[104] with increases to 93% in urban and peri-urban areas and to 46% in rural areas.[105] However, significant efforts are needed to realize these percentages.

The provision of electricity to rural areas proceeds largely in a decentralized manner, with communities relying on off-grid mini-networks. Most of these networks run either on hydro or solar PV. An example thereof can be found in Angola, where the government plans to service 31 communities through mini-hydro installations[106], to be complemented by so-called solar villages.[107] Another example is CAR which is implementing a scheme for micro-hydroelectric power plants[108], and Ethiopia which, with the support of the World Bank, is rolling out off-grid solar lighting systems, being at the forefront of such initiatives in Africa.[109] It is estimated that in Sub-Saharan Africa, by 2040, solar photovoltaics, small hydropower or wind will power two-thirds of mini-grid and off-grid systems in rural areas.[110]

It is by no means a given that off-grid energy supply can be implemented successfully. For instance, in Nigeria, an initiative to install solar mini-grids largely failed as private investors could not be enticed to invest in the project given that electricity is seen as 'charity', i.e. that this should be provided for free by the government in the first place.[111] In Botswana, it was concluded that an extension of the existing national grid pays more dividends, and that off-grid electrification is only appropriate when used in remote villages.[112] In spite of the various initiatives across Sub-Sahara Africa, much of the rural population remains deprived of reliable access to electricity. Cost is a major factor, as the creation of off-grid systems, albeit attractive in some respects, continues to be more expensive than being plugged into a national grid.

5.6 Risks of making the wrong choices

The goal of increasing the use of renewable energy resources can be pursued for two main reasons. There are, first, environmental reasons and, second, the aspiration to create a more shock-resistant economy through diversification. The general trend among Sub-Saharan countries is to move away from non-renewable energy sources. This is done mainly in order to decrease the dependency on one particular resource and to reduce the vulnerability to price fluctuations in the oil market in particular.

Indeed, a number of countries in the region remain highly dependent on energy exports: oil is dominant in Angola, where it makes up 40% of all domestic energy consumption (2012) and 97% of export revenues (2012)[113]; Equatorial Guinea, where oil and gas make up 99% of all export earnings (2011); and Nigeria, where oil constitutes 90% of export earnings (2012).[114] Conversely, some countries exhibit a high energy import dependency. One example is Botswana, where 44.2% of all energy sources are imported (2013).

Most countries in Sub-Saharan Africa have renewable energy promotion schemes in place, often using fiscal incentives or energy savings targets (e.g. using net metering).[115] For some countries turning to renewable energy, this can and has entailed radical change in their economic landscape. Ethiopia for example became virtually energy independent through their investment in hydroelectricity and the country is transforming itself into an energy exporter. However, in this particular case the high dependency on hydro power makes Ethiopia vulnerable to climate conditions such as drought.[116] This is an important reason why the government seeks to further diversify its energy supply and include other renewable energy sources, in particular geothermal energy.[117] Total power sector investment averages around US$ 46 billion per year, with just over half of it in transmission and distribution."[118]

Policies aimed at increasing the share of renewables in the energy mix of Sub-Saharan African countries, or to promote more environmentally-friendly energy sources can come under pressure from discoveries of fossil fuel fields. Various finds have been made in recent years off the coasts of Senegal, Ghana, Angola, and Mozambique, among others. However, low oil prices have curtailed exploration and development activity in oil and gas. What is more, continuing fiscal consolidation in oil-exporting countries is expected to result in further capital expenditure cuts.[119] This means that the chances for these countries to successfully exploit offshore hydrocarbon reserves are hampered in the current low pricing environment. That said, this may change pending a rise in the price of oil.

In Senegal, Texas-based Kosmos Energy and UK-listed Cairn energy are said to want to push ahead to production while oil prices, and industry costs, are still low. However, many Senegalese fear that the country has a lot to lose if it were to go down the road of hydrocarbon exploration. With an economy set to grow at 6% this year underpinned by a strong agriculture sector, the country has been spared by some of the negative effects of the commodity slump that hit many other countries in Africa. With many of the critical decisions yet to be taken, such as what percentage of the revenues will be deposited in a fund for future generations, yet to be taken, there is skepticism about the extent to which Senegal is ready to handle a future revenue stream coming from oil and gas exports.[120]

Despite the low pricing environment, a number of low-income, non-oil commodity exporters are expected to continue to invest heavily in energy and transport infrastructure in a bid to improve the operational environment for growth.[121] One example is Gabon, which has initiated an energy diversification strategy as oil prices started to drop. It attempts to ramp up hydroelectric power in particular.[122] South Africa, the only country in the region that relies heavily on coal, has set itself a target of having approximately two-thirds of all domestic energy use generated through renewables by 2030.[123] A significant continent-wide initiative is the Climate Vulnerable Forum, which includes countries such as the Democratic Republic of Congo, Gambia, Ghana, Kenya, Senegal, and Sudan and aims to phase out the use of oil and coal as part of the energy mix and to rely exclusively on renewables. A pledge to that effect was affirmed in Marrakech in November 2016.[124] There are other encouraging signs. For instance, investment in environmentally-responsible energy such as by the Investor Platform for Climate Action, a group which controls assets worth US$ 25 trillion, can make a difference in shifting funding away from coal, for instance by encouraging divestments away from coal assets and encouraging companies to invest in sustainable infrastructure.[125] Also, the exportation of renewable energy is taking off through the African Powerpool collaboratives (West-African, South African, and East African Power Pools), which seek to integrate regional electricity markets and create common power grids.[126]

An absolute prerequisite for countries to enhance their economic growth is the access of people and companies to the electricity grid.[127] What still remains a problem however is investor risk, in part because many countries lack sufficient institutional policy support for green measures.[128] Partly as a consequence, the private financing of infrastructure that is high-carbon, not climate-resilient, or generally unsustainable still significantly outweighs private investment flows into sustainable infrastructure.[129] Moreover, many Sub-Saharan countries still face difficulties regarding the upkeep (e.g., Nigeria), extraction and optimization of capacity. Nigeria is an extreme example given that it has a 75% loss of energy before it gets the supplies to the consumer.

Conclusions

In conclusion, it is clear that the abundance of biomass and its continuing potential for local use will endure for as long as national grids are not extended into rural areas. This means that the major challenge for Sub-Saharan African countries in the future will be to reduce the hazardous health effects resulting from the use of biomass. On top of providing more efficient biomass cooking stoves, a more sustainable solution should be found in the provision of decentralized electricity generation via off-grid mini-networks that function on the basis of either hydro energy or solar PV.

6 CONCLUSIONS AND RECOMMENDATIONS

6 CONCLUSIONS AND RECOMMENDATIONS

This study has sought to investigate the geopolitical implications of climate mitigation policies that aim to bring about a transition away from fossil fuels and towards a low-carbon economy. The results of our quantitative analysis indicate that in all future scenarios where climate mitigation policies are successful, a relative increase in instability in the countries investigated – Algeria, Egypt, Kazakhstan, Libya, Qatar, Russia and Saudi Arabia – could be recorded. In other words, the second order effects of existing climate mitigation policies can be considerable and, therefore, should be taken into account by policy makers.

Conclusions

Declining imports of fossil fuels in Europe will result in a reduction of the mutual dependencies that exist between Europe and the hydrocarbon exporting countries in our immediate neighborhood. One consequence thereof, in the absence of far-reaching reforms, is a higher risk of instability in the latter countries. In the longer term, this reduced economic dependency will also reduce the influence that the Netherlands, Europe and the Western world more generally have on these countries. The logic is simple: if the importance of the European market decreases relative to other markets, it means that the ability of Europe to exert diplomatic pressure on large hydrocarbon states in the Middle East and in the region belonging to the former Soviet Union recedes. Other players, such as China and India may fill the void. To provide an example, the 'threat' to diversify our supply base and reduce our dependency on Russia therefore becomes a less potent tool in our foreign policy make-up in the case of future disagreements with the Kremlin.

What is worrisome is that if – over time – Europe proved to be the only region worldwide imposing a legally enforceable CO_2 emissions cap while and other countries continued to use consequentially cheaper fossil fuels, this would hamper the competitive position of Europe as a whole. It is, therefore, of the utmost importance that in future climate change negotiations, talks of a carbon price or a legally enforceable CO_2 emissions cap aim at the global level.

A lack of attention for the second order effects of energy transition in the form of heightened instability, in particular in the Middle-East and North Africa, runs the risk of creating adverse geopolitical consequences in the form state failure and collapse comparable to the 2011 Arab uprisings. If these consequences materialized, they would further undermine the possible willingness on the part of countries richly endowed in hydrocarbons to push for a more ambitious climate policy.

Critical factors

A number of factors emerged from the study as 'critical' in terms of their influence in determining as to whether a hydrocarbon exporting country is prone to the destabilizing effects of climate mitigation policies.

The first critical factor are *energy prices*. If in the future the international community decides to install a legally enforceable cap on carbon emissions this may cause a new, much deeper decline of energy prices. Interesting in this regard is the observation that the coal market can be seen as being 'ahead of the curve' in the sense that developments in the coal market show a comparable cycle to those in the oil market. In other words, if prices on the coal market plummet, it is reasonable to assume that the oil market will follow.

Second, when it comes to the *stability* of rentier states, it should be considered to develop a 'score card' for the relative vulnerability of hydrocarbon exporting states. Specific indicators that mark a heightened vulnerability are: a high share of resource rents in GDP in combination with limited financial reserves; a high national debt as percentage of GDP or a rapid increase in a state's national debt; a young and/or relatively fast growing population (Middle East and North Africa), a relatively high share of youth unemployment and uncertainty about the continuation of the existing political leadership; a combination of high subsidies and a high domestic energy demand; and the position in international financial markets (risk-aggravating factors are a low credit rating and difficulties to borrow in international markets). It should be stressed that having a good position in international financial markets and ample financial reserves, as in the case of Saudi Arabia, may provide relief in the short to medium term, yet it by no means makes a country immune to the destabilizing effects of climate mitigation policies and energy transition if significant shortcomings are recorded in regards to the other critical factors.

Recommendations

The analysis conducted in this report leads us to a set of policy recommendation and policy priorities with the aim of promoting desirable scenarios and limiting the negative security effects that result from undesirable scenarios.

In the context of energy transition it is important to pre-empt the arrival of a legally enforceable carbon cap. For the Dutch economy, this can be done by promoting energy efficiency measures and the greening of the domestic economy in order to increase its competitiveness. The ambition of the Dutch government to greatly reduce our dependence on natural gas until 2050 can thus be viewed as a welcome initiative in this regard.

At the same time, we should anticipate that the incentive for countries to again resort to fossil fuels will increase when prices will decrease as a result of a legal cap on CO_2 emissions in some parts of the world. Countries not covered by the cap may be tempted to increase their use of fossil fuels and countries under the cap system may be incentivized to withdraw. Internationally, this will require lobbying at the highest level to motivate countries to take part in a legal carbon cap system and continued investment in renewable energy with the aim of cutting costs. For this purpose, it is of major importance to create *prospects of gain*: both the Netherlands and the EU should be able to demonstrate clearly the economic benefits of decoupling and of a transition towards renewable energy.

A different but related challenge manifests itself in developing countries that face a choice between investing in renewable energy networks or to rely on fossil fuels for their economic growth. A major issue in this context is the need to reduce the high use of biomass in Sub-Saharan Africa, owing to its hazardous health effects and the problems associated with indirect land use change. In the long term it is crucial that a lower use of biomass does not result in a higher reliance on fossil fuel resources. This means that, particularly when viewed through the lens of ensuring coherence in Dutch international policies, the government will have to determine how to deal with public (financial) bilateral contributions to the exploration of new hydrocarbon finds in developing countries. In this context, the 'Energy Agenda' (Dutch: Energie-agenda) of December 2016 states that in order to safeguard coherence in international policies, the government shall have to determine how to assess its public bilateral contributions towards the exploration of new reserves of fossil fuels in light of the remaining / available emission space. [130] This means that the Dutch government should carefully balance its contributions to the development of recently discovered hydrocarbon reserves against those in the sphere of renewable energy, the circular economy and clean-tech. Not only is this defensible from an environmental point of view, but it could also benefit the competitive position of Dutch companies active in these industries in the long term.

In the absence of wide-reaching reforms, many of the countries studied will face scenarios in which they will struggle to deal with domestic unrest. The biggest risk thereof will manifest itself in the Middle East and North Africa. A silver lining considering energy transition is that, as the name of the phenomenon implies, this is not something that will happen overnight. Rather, it is expected that the completion of a transition away from fossil fuels will take several decades. This means that there is still time for countries heavily dependent on the export of fossil fuels to take adequate measures to reduce their vulnerability.

This however requires a fundamental reassessment of the nature of the relationship that we have with this part of the world. The crux of the matter is that whereas western nations have an interest in the Gulf countries remaining stable, the Gulf countries themselves have a key interest in reducing their vulnerability with an eye on future regime survival. When reforming the domestic economies of these countries, the focus should be on addressing the factors labelled as critical in this chapter.

Switching from fossil fuel-based power generation to one based on renewable energy can, on the one hand, mean a significant cost reduction by eliminating wasteful energy subsidies, whilst reducing the burning of otherwise valuable export resources on the other. In the bilateral ties and sectoral dialogues between the Netherlands and countries in the MENA region – the Gulf countries in particular – it is important to stress that doing so represents a significant cost cutting measure at a time when export revenues are under pressure, and would also allow for the diversification of the economy through the buildup of a domestic renewable energy sector that can compete internationally. For the Netherlands this represents a business opportunity to showcase technological advances in the areas of renewable energy, energy efficiency and clean-tech.

In convincing countries that it is in their interest to do so it is useful to take note of the Chinese experience. Gulf countries with significant sovereign wealth funds, such as Saudi Arabia and Qatar, can learn a thing or two from how China built up a strong domestic renewable energy sector, followed by a sizeable overseas expansion strategy in frontier markets. If they succeed in building up a domestic renewable energy sector, it would be beneficial as a follow-on step to invest in the energy transition in hydrocarbon exporting countries that are financially less well-endowed and in relative proximity to the European mainland, such as Algeria and Egypt, so that the export of electricity becomes feasible. This would help rentier states around Europe to lessen their dependence on commodity sales to Europe. More importantly, it would dampen the need for domestic energy subsidies and reduce the negative effects that climate mitigation policies will have on these countries. For Saudi Arabia and Qatar, it would result in an ability to collect a return on their investments and to generate additional export revenues allowing these countries to *hedge* against lower oil prices and diminished income from hydrocarbon exports in the future. For Europe, this would mean that – provided the required infrastructure is financed – it can tap into an additional source of renewable energy that is located in relative proximity, whilst the risk of large-scale instability in our immediate neighborhood is reduced.

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