Discussion Paper

From Riches to Rags?

Stranded Assets and the Governance Implications for the Fossil Fuel Sector

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Executive Summary

With the Paris Agreement, the international community has agreed to limit global warming to 1.5 or 2 degrees Celsius. This goal sets a limit to consumption of fossil fuels: around one third of the oil reserves, half of the gas reserves and over 80% of the global coal reserves will need to stay in the ground. This puts many assets in the fossil fuel sector at risk of *stranding,* that is, of unanticipated devaluation. Decarbonisation will potentially result in many fossil fuel reserves failing to yield the expected revenue because of the decreasing demand and prices for fossil fuels. This entails major risks for **businesses, investors and governments.**

Developing countries whose economic and social progress is disproportionately dependent on fossil fuel extraction may suffer particularly severe consequences: a dramatic decline in export and domestic earnings from fossil fuels could impair growth and reduce government revenue, which under certain conditions may jeopardise social and political stability. To contain the costs incurred through stranded assets, states will have to tackle the monumental tasks of low-emission diversification and address important questions concerning management of the fossil fuel sector. **Development cooperation should use its capacities** in the fields of economic and development planning, fossil fuel governance and climate policy in order to take on these challenges.

Economic policy and national development plans

Balancing development and climate action requires a strategic vision for the socio-economic development of countries most at risk. In this regard, reducing path dependencies that support high-risk, high-carbon development models is essential. The following measures are of great importance for developing countries:

- **Incorporate climate-policy requirements in the public macroeconomic and development planning:** Revenue from the fossil fuel sector can be invested for climate-friendly and long-term purposes. Countries can also reduce the risks of stranded assets by assuming lower fossil fuel prices and extraction rates in their macroeconomic development and investment planning.
- **Climate-compatible diversification:** It is preferable to invest in low-emission and thus sustainable assets – such as education – than to invest in developing the value added chain of fossil fuels.
- **Nationally Determined Contributions (NDCs):** The NDCs should take into account the planning processes and strategies of all sectors of the economy – and involve the fossil fuels and finance sectors more closely in particular.

Fossil fuel governance

Development cooperation has a major role in supporting optimal utilisation of revenue generated by the fossil fuel sector and the preparation of the sector for a global transition. There are the following entry points:

- **Sustainable sector strategies:** Devising a sustainable sector strategy requires a careful and comprehensive analysis of fossil fuel extraction costs and of expected revenue.
- **Thorough assessment of new investments:** Established producers should thoroughly (re-)assess plans to invest in fossil fuel extraction. In the emerging producer countries, it is important to prepare now and to take appropriate decisions concerning extraction rates, infrastructure development and institutional capacities to embark on low-carbon, low-risk paths and avoid future hard transition shocks.
- **Shadow prices:** Applying shadow prices helps to account for the probable future costs of greenhouse gas emissions in investment planning.
- **Support effective revenue management and emission mitigation approaches:** Managing revenues effectively and reducing emissions from fossil fuel production help to maximise its development benefits in the 2-degree world.

Align fossil fuel and climate governance at international level

The perspectives of the fossil fuel sector and of climate governance need to be brought together to promote a climate-compatible, low-risk transformation of the global economy in order to prevent negative geopolitical consequences. There are numerous forums for international dialogue appropriate for this purpose. The following steps could support the alignment of fossil fuel and climate governance:

- **Tackle contradictions between climate and fossil fuel governance:** The conflict between a fixed carbon budget and unfettered fossil fuel extraction needs to be resolved in international political processes, so that national strategies can bear fruit.
- **Address the issue of fairness:** There should be a high-profile public debate on climate justice regarding historical responsibilities and different transition capacities in the context of stranded assets.
- **International climate politics:** Clear climate-policy signals by the UN Framework Convention on Climate Change and country groups such as the G20 remain of essence to enable low-risk transition processes.
- **International development politics:** Stranded asset risks should be considered in development policy processes at UN level (e.g. SDGs, UNEP Green Economy & Finance Initiatives) and in ODA donor forums (e.g. OECD, multilateral development banks, G7).
- **Bilateral and regional initiatives:** Bilateral and regional initiatives such as North-South or South-South partnerships should take up the issue of stranded assets.

1 Introduction

After years of stagnation, the successful climate conferences of Paris in 2015 and Marrakesh in 2016 have revived global climate governance. The agreements reached, in particular the global commitment to limiting the temperature increase to 1.5-2 degrees Celsius, will – provided that they are fully implemented – have massive implications for the fossil fuel sector. The era of fossil fuels such as oil, gas and coal as a source of energy will foreseeably (have to) end, more rapidly and comprehensively than many people currently realise.

Against this background, this paper aims to provide greater insight into the subject of stranded assets in the fossil fuel sector. Stranded assets are assets that lose value, or generate new liabilities, before they reach the end of their (planned) economic life (IRENA 2017). For fossil fuels, this means fuels that can no longer be burned or extracted. Equally, the production capital invested cannot be used any longer and is therefore devalued – the assets have stranded.

In this paper, assets primarily refer to fossil fuel resources (oil, gas and coal) that need to be left in the ground because they would otherwise jeopardise compliance with the 1.5- or 2-degree target specified in the Paris Agreement as a binding limit for man-made global warming.

To shed light on the foundations and context of this challenge, we will first explore the links between climate change and extractive fossil fuels. In doing so, we will examine how the fossil fuel sector contributes to climate change, looking at the results of the climate conferences in Paris and Marrakesh and the Nationally Determined Contributions (NDCs). This paper will then analyse in detail the possible impacts of stranded assets on national economies and budgets, on fossil fuel enterprises, and on investors. Based on this analysis, it will propose entry points for international cooperation and topics for further research.

The starting point for entry points for international cooperation is the fact that we can only tackle the climate challenge by embarking on a comprehensive transformation towards a decarbonised global economy as soon as possible. The fossil fuel sector can contribute to this process. However, this will require a change of direction.

2 Links between Climate Change and Extractive Resources

This section will illustrate both how the extractive resources sector contributes to global warming and how this sector is adversely affected by climate change. This analysis forms the basis for the mitigation and adaptation options available. The climate impact of the extractive sector and its economic relevance make rapid action in both fields imperative – especially in regard to establishing sustainable economies in developing countries.

2.1 The Impact of Fossil Fuel and Mineral Resource Sector on Climate

A look at the sectors contributing to global warming makes the significance of extractive resources apparent.

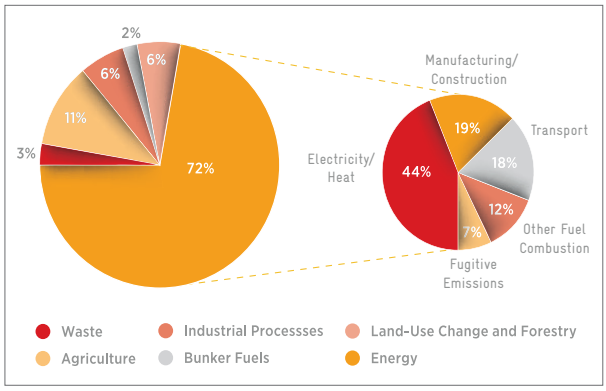


Figure 1: GHG emissions by sector, based on data from the World Resource Institute. Source: IRENA 2015

Besides transportation, particularly industrial production and the energy sector contribute to the worldwide direct GHG emissions. These sectors still rely primarily on the extraction and combustion of fossil fuel resources such as coal, oil and gas as well as on the processing of mineral resources. The latest IPCC Assessment Report states the following:

> "Emissions of CO_2 from fossil fuel combustion and industrial processes contributed about 78% of the total GHG emissions increase from 1970 to 2010, with a similar percentage contribution for the increase during the period 2000 to 2010. [...] Increased use of coal has reversed the long-standing trend of gradual decarbonisation (i.e., reducing the carbon intensity of energy) of the world's energy supply." (IPCC 2014)

The contribution of fossil fuels to global GHG emissions continues to increase rapidly (Figure 2). At the same time, extraction of fossil fuels itself often also produces secondary gas emissions. These secondary gases, notably methane, additionally and substantially affect the greenhouse effect.

The climate impacts set limits for future extraction and combustion of fossil fuels. The inherent challenges are outlined in section 3.

There are principal differences between GHG emissions resulting from the extraction of fossil fuels and those resulting from the extraction of mineral resources. Extraction and utilisation of oil, gas and coal produce substantial GHG emissions both *upstream* (during extraction) and *downstream* (during utilisation, mainly combustion, of the resources).

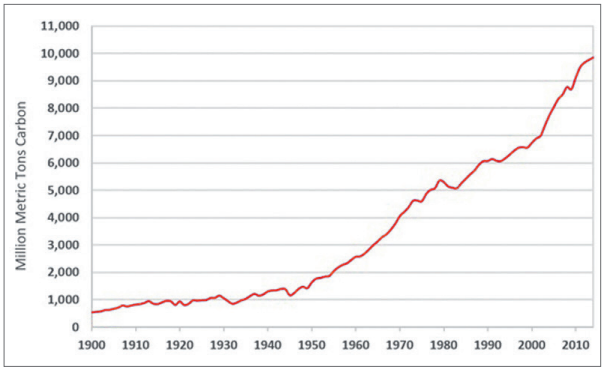


Figure 2: Worldwide GHG emissions from combustion of fossil fuels. Source: EPA 2017

Extraction and utilisation of mineral resources produces GHG emissions during industrial extraction and – depending on how they are used – during subsequent further processing. A classic example would be production of aluminium from bauxite. While mining bauxite ore produces comparatively low GHG emissions, the main share of GHG is emitted during the highly energy-intensive electrolysis to aluminium. The electricity required for this process is itself usually generated using fossil fuels.

However, the major relevance of mining activities for climate change implies high mitigation potential through deployment of innovative technology. A Cambridge University study provides an example:

> "Direct and indirect industry-related GHG emissions grew from the equivalent of 10.4 gigatonnes of carbon dioxide ($GtCO_2eq$) in 1990 to 15.5 $GtCO_2eq$ in 2010, reflecting the steady growth in world production trends for extractive industries, manufacturing and services. However, much attention is currently focused on ways of improving energy efficiency within the primary energy sector. Energy intensity could be reduced by up to 25% through widespread deployment of the best available technologies. Additional reductions in energy intensity of up to 20% could be realised through innovation, before technological limits are reached." (Bourgouin 2014)

The technological options the study refers to are mainly the electricity savings achievable through energy efficiency measures and the use of renewable energies. It remains to be seen whether more complex technologies such as carbon capture and storage (CCS), which at this point have not been commercialised yet, will offer further sustainable savings potential.

Beyond the direct climatological consequences of resource extraction, the extractive sector causes further, indirect climate damage. Such damage may include:

- Disruption of local and regional water cycles, potentially draining swamps and releasing methane to the atmosphere
- Deforestation with the inherent direct CO_2 emissions and the loss of carbon sinks provided by wooded areas

Managing this, at times massive, adverse impact on the environment and climate caused by the extractive sector requires comprehensive strategies. With regard to sustainability goal 13 "Climate Action", in its report *Mapping Mining to the SDGs: An Atlas,* the Columbia Center on Sustainable Investment states the following:

> "Mining companies can contribute to addressing climate change by reducing their carbon footprint and by engaging in dialogue with stakeholders to enhance adaptive capacities and integrate climate change measures into policies and strategies.[...] To move away from coal will necessitate not only the development and adoption of new technologies, but also support to countries heavily dependent on coal to enable the transition to cleaner technologies, energy sources and alternative employment opportunities." (Columbia Center on Sustainable Investment et al. 2016)

Section 4 will examine corresponding options for international cooperation in more detail.

2.2 From Paris to Marrakesh to Bonn (COP21 to COP23)

To understand the links between the fossil fuel sector and climate change, the agreements reached at the last climate conferences in Paris and Marrakesh need to be examined more closely. On its website, The German Federal Ministry for the Environment (BMUB) has published the following statement on the significance of the agreements reached:

> "On 12 December 2015 in Paris, history was made: at the international Climate Change Conference, also referred to as COP21, the Paris Agreement was signed. After many years of intense negotiations, all nations have subscribed to the obligation to change the global economy for the good of the climate. This is an historical step – the previous regulations of the Kyoto Protocol had obligated only a number of industrialised nations to reduce emissions." (BMUB 2016)[1]

[1] Here and in the following – a translation of the original website in German.

COP21 made climate policy a global issue – both in terms of the causes of climate change and in terms of action to counter it. The Kyoto Protocol, originally valid until 2012 and extended until 2020, had codified undertakings to reduce greenhouse gases only for the ANNEX-B nations (industrialised and transition countries corresponding to the UNFCCC ANNEX-I nations) (UNFCCC 2017). With the Paris Agreement, all nations have now committed to pursuing concrete climate targets. This is of particular significance because the share of greenhouse gases emitted by industrialised nations has dropped while the share (of emissions) by emerging and developing countries continues to grow:

> "In 1990, industrialised countries were responsible for roughly 60% of global emissions, today they are still responsible for about a third, and in 2030 around three quarters of annual global emissions will be attributed to developing countries." (BMUB 2016)

The rapidly growing share of emissions by developing and emerging countries underscores their global responsibility. This does not, however, imply that the industrialised economies can lean back and rest their efforts. They continue to bear great historical responsibility regarding their emitting of greenhouse gases and, furthermore, should regard assisting the developing and emerging countries in combatting climate change as a matter of self-interest. There is no other way to implement the transformation processes towards a low-carbon economy at a global level.

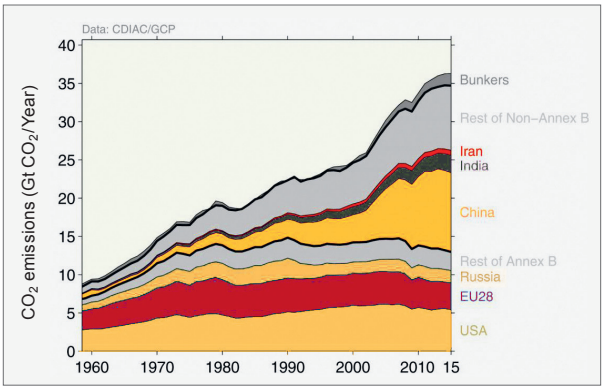


Figure 3: Progression of CO_2 emissions 1960–2014 by country. Source: Global Carbon Budget 2016

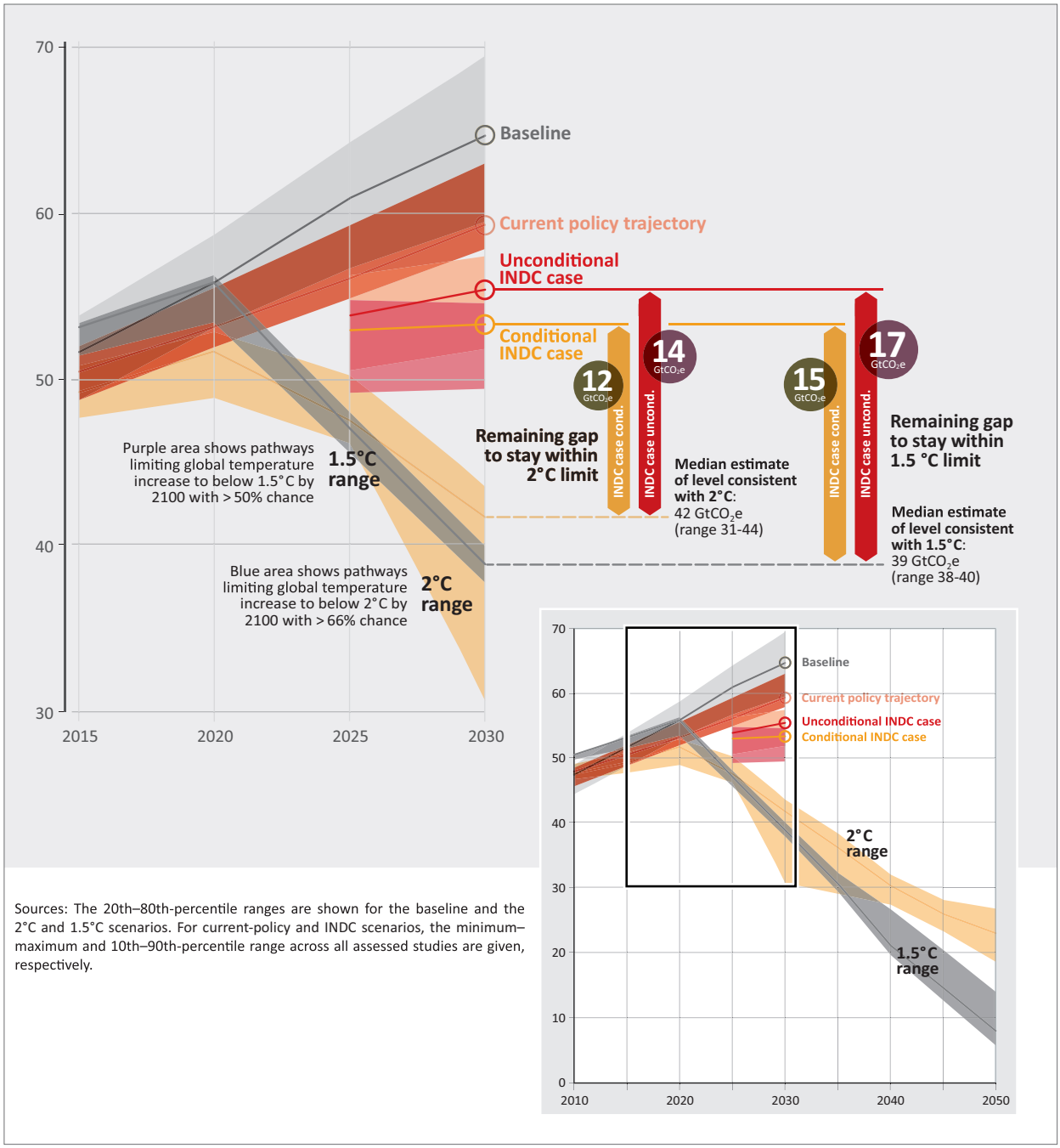
2.3 Target: 1.5-2 Degrees Celsius

Besides the global joint commitment to combating climate change, a clear planetary limit has been codified in the Paris Agreement. Rise of the global temperature needs to be limited to no more than 2 degrees Celsius, ideally to 1.5 degrees Celsius. Otherwise, it will render overcoming the consequences of the greenhouse effect enormously difficult, if not utterly impossible for both the current and subsequent generations. This paper is based on the presumption that a comprehensive transformation is indispensable to achieve this target.

In 2014, a total of 52.7 billion tonnes of CO_2e were emitted worldwide. Currently, the cumulated national mitigation pledges submitted would allow keeping emission levels at 54 billion tonnes in 2030 (as opposed to the baseline assumption of around 65 billion tonnes). However, achieving the 2-degree target will require greenhouse gas emissions in 2030 to total no more than 42 billion tonnes (median of estimated values). As for the 1.5-degree target, the current (I)NDCs[2] fail to meet its requirements by a huge margin, even when assuming a probability of reaching the target of only 50% (see Figure 4)[3] The entire *de facto* carbon budget globally available in this context is estimated at around 1,000 billion tonnes over the period from 2011 to 2030, assuming a 66% probability of achieving the 2-degree target (UNEP 2016). These figures are based on the fact that the Earth's atmosphere is already one degree warmer than it has been during the pre-industrialised era.

[2] Because not all nations have ratified the Paris Agreement or converted their Intended Nationally Determined Contributions (INDCs) to Nationally Determined Contributions (NDCs) yet, the abbreviation (I)NDCs is used referring to both types of contributions.

[3] More details will be made available in the IPCC's special report on the 1.5-degree target, expected to be published before COP23.



Sources: The 20th–80th-percentile ranges are shown for the baseline and the 2°C and 1.5°C scenarios. For current-policy and INDC scenarios, the minimum–maximum and 10th–90th-percentile range across all assessed studies are given, respectively.

Figure 4: Worldwide GHG emissions in various scenarios. Source: UNEP 2016

2.4 Nationally Determined Contributions (NDCs)

Besides the political agreement on a target of 1.5 and 2 degrees respectively, one of the greatest successes of the recent climate negotiations in Paris and Marrakesh is the establishment and consolidation of the instrument of *Nationally Determined Contributions (NDCs)*. These strategies detail every country's future contributions to combating climate change. Each country drafts its own NDC and submits it to the international community for approval. An NDC needs to contain country-specific action during the implementation phase of 2025 to 2030. Countries can update and amend their NDCs until 2020.

NDCs only account for the GHG emitted within the respective country, in accordance with the usual approach in the context of international climate negotiations. With respect to the fossil fuel sector, this means that only the emissions that result from resource extraction or consumption within the state's borders are accounted for in a national emission inventory. Consequently, only these emissions are subject to mitigation strategies, including NDCs. Emissions caused by combustion of exported fossil fuels in another country are therefore not included in the NDCs of the resource producers.

Nonetheless, these strategies are of key significance for risk mitigation in producing countries: the substantial risks in these countries are fundamentally connected to high domestic consumption and socio-political path dependencies. Additionally, NDCs have macroeconomic implications due to their holistic nature. They can assist decisively in the modification of high-risk economic models in resource-rich countries and thus mitigate the risks of stranded assets (see the discussion of domestic consumption and infrastructure risks as well as of low-emission diversification in section 3.1). It is further safe to assume that NDCs will become a new, key field of action in current and future development cooperation (see section 4).

The first assessments of submitted NDCs have been performed by Climate Action Tracker, a consortium of research institutes. At the time of writing (October 2017), only climate action (i.e. (I)NDCs, other pledges and existing policy) by Costa Rica, Ethiopia, Gambia, India, Morocco and Philippines was rated compatible with the goals of the Paris Agreement. The entirety of the remaining analysed NDCs (including for example those of the European Union, Canada and Australia) has been classified as "insufficient". Promoting ambition until 2020 is thus an important task and should be viewed as an opportunity by development policy actors. Due to its relevance for climate policy illustrated above, the extractive sector and its transformative contributions could be incorporated more in NDC processes in future (see section 4 for courses of action).

3 Stranded assets

Climate change and the declining prices for renewable energies have challenged the oil, gas and coal industries. The sector has entered an era of increased risk, as fossil fuel dominance on the global energy market appears to be under threat. Projections based on the 1.5- or 2-degree target and on the corresponding carbon budget point to the risk of stranded assets. Companies whose business models rely on the extraction of fossil fuels and states in possession of major reserves run the risk of not being able to fully use their assets. This concept is increasingly being debated by the fossil fuel sector.

As already mentioned, stranded assets are assets that devaluate, or generate new liabilities, before they reach the end of their (planned) economic life (IRENA 2017). Actors can put assets to use in different ways. While a business lists its assets on the company balance sheet, the use of national assets for economic development of a state can be observed in national budget planning and political strategies.

The most common assumption behind assets stranding is that the declining demand, as a consequence of decarbonisation, leads to declining prices. Thus, some projects may become economically unattractive while ongoing extraction may generate less profit, decreasing the value of the corresponding assets (CPI 2014). The following developments could cause this dynamics:

1. Technological Progress

Renewable energies, such as wind and solar power in particular, have undergone rapid development over the last twenty years. Fostered by the energy transition in Germany and by the latest changes on the vast Chinese energy market, in many regions today, renewable energies produce electricity at prices per kilowatt-hour that can (almost) compete with fossil fuels. At the same time, the benefits of climate action for national economies are increasingly being recognised. Energy efficiency reduces the energy intensity of production and can slow down the increase in energy demand resulting from economic and population growth. Another factor is the growing market share of hybrid and electric vehicles, which could reduce demand for diesel and petrol. Low-emission transport systems offer additional benefits, for instance, the improvement of air quality or more efficient mobility in urbanised areas.

2. Global Climate Governance

As section 2 illustrates, the conferences in Paris and Marrakesh have taken the international climate policies forward. The 1.5- or 2-degree target and the evident need to thus decarbonise the economy impact the future of fossil fuels. If the agreements are enforced and mitigation ambition increases, adverse economic effects on the fossil fuel sector are inevitable. Potential tools for initiating and promoting low-carbon transition include greenhouse gas emissions taxes and/or the definition of national carbon budgets (combined with an emissions trading system).

At the same time, there is the possibility that the resources will be extracted at a faster rate as producers expecting a future decline in demand or price may wish to liquefy their assets as soon as possible. Affected actors need to assess how much profit their assets can still generate. The answer to this question largely depends on the point along the cost curve at which the respective projects currently are (Figure 5).

In the fossil fuel sector, these challenges are widely recognised and there is awareness that the fossil fuels market needs a change. Many affected actors, particularly

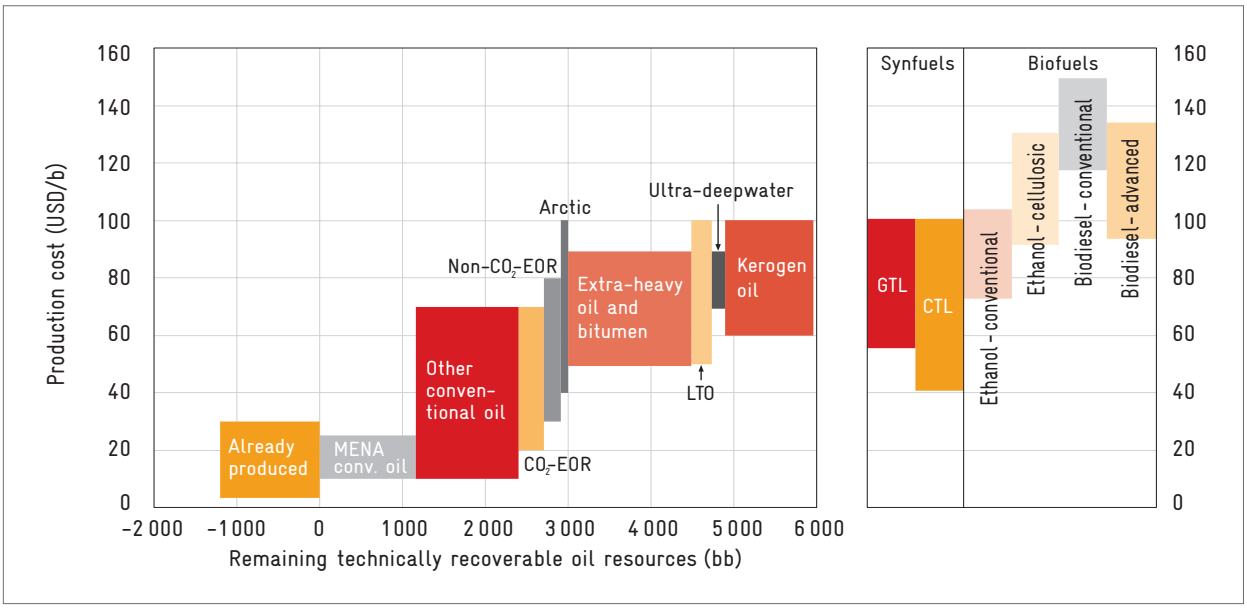


Figure 5: Production costs of crude oil for various resource categories. Source: IEA 2013.

the major corporations, have devised strategies for handling the risks specific to the sector, such as fluctuating oil prices. For example, the possibility of *peak oil demand*[4] is considered. Demand for coal has already fallen behind expectations. These considerations need to be adjusted to the 2-degree target by taking into account the corresponding global GHG budget.

Figure 6 below shows the climate consequences of utilising fossil fuels from known reserves, with a separate indication of the developing countries' reserves.

The red line indicates the global CO_2 potential of the existing untapped fossil fuel reserves. Approximately 80% of these reserves need to remain in the ground in order to achieve the less ambitious 2-degree target. Conversely, it would theoretically be possible to burn the majority of the currently known fuel reserves of developing countries without jeopardising even the more ambitious target of 1.5 degrees (green line).

If we are to meet the global climate goals, between 34 and 49% of the oil reserves, 49 to 52% of the gas reserves and 77 to 78% of the known coal reserves need to remain in the ground, according to different calculations (IRENA 2017). Abandoning the extraction of coal provides the greatest climate benefit and, compared to other fossil fuels, entails lower financial losses. Devaluation of oil assets, on the other hand, entails the greatest financial risk (CPI 2014). Nevertheless, over the next twenty years, USD14 trillion will likely be invested in extraction of fossil fuels, that is, in new extraction sites, mines and transport infrastructure (Oil Change International 2016).

One approach is to estimate how many reserves can be extracted in an economically optimal way (extraction at lowest possible cost) and how these are distributed among the regions. This indicates that achieving global climate goals would require Middle Eastern countries, for example, to leave the majority of their oil and gas reserves in the ground, 38 and 61% respectively (McGlade and Ekins 2015). However, this estimate assumes a global market, which exists to a certain extent only for oil; gas and coal trade is far less globalised (CPI 2014). Because trade relationships and infrastructures are heterogeneous and specific to particular resources, producers would be affected to different degrees depending on where decarbonisation occurs and what new energy mixes are.

How economies will be affected also depends significantly on the precise combination of actions taken to achieve the 2-degree target (CPI 2014). Action taken may affect demand (e.g. GHG taxes or cutting consumption subsidies) or affect supply (e.g. restrictions on extraction). Furthermore, such action may be national (stringent NDCs) or international in nature (global carbon price or consumption cap). The

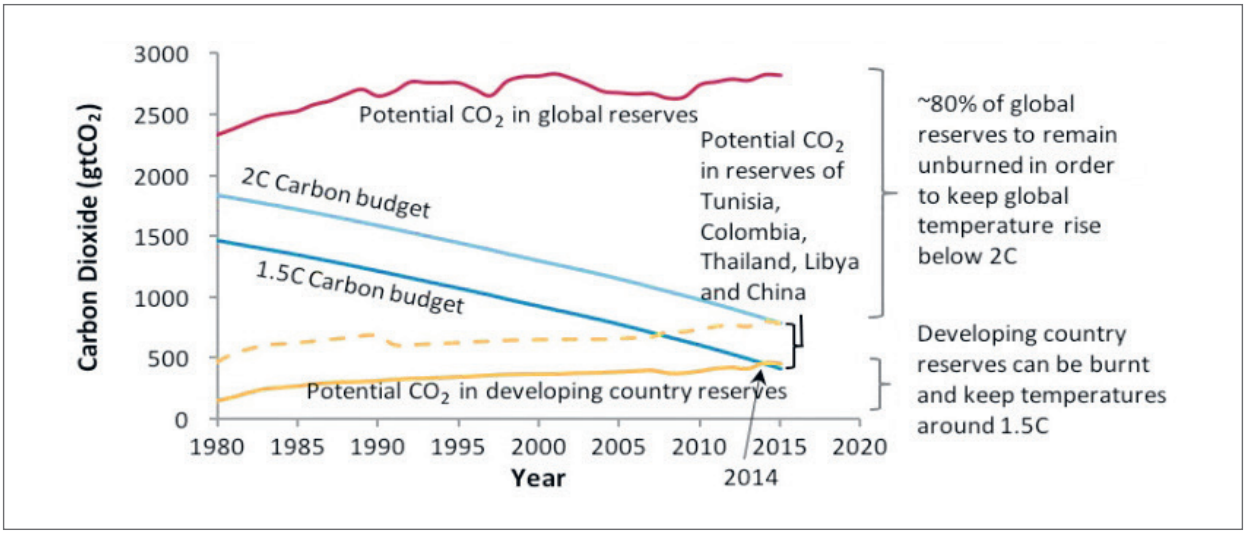


Figure 6: Carbon reserves globally and in developing countries along with carbon budgets. Source: Columbia Center on Sustainable Investment 2016

[4]Formerly, the term "peak oil" referred to an extraction peak, that is, to the supply side. More recent publications, however, speak of the time at which oil demand may reach its maximum – "peak oil demand". In its latest Energy Outlook, BP predicted this point of time to be around the year 2042 (Blas 2017, Brogneaux et al. 2017, Ollagnier 2017).

feasibility at the political level as well as the stakeholders to be involved vary accordingly. All of this affects the value of assets stranded and distribution of burden (CPI 2014).

The uncertainty regarding climate policies and decarbonisation progress has given rise to a debate on whether, and to what extent, the risk of stranded assets will manifest and on how such risk will be distributed. One way to handle uncertainty is to examine scenarios. Such examinations frequently focus on the following two options (ESRB 2016, IRENA 2017, Manley et al. 2017): **1)** the "soft" scenario: gradual and continuous decarbonisation allowing stakeholders in the fossil fuel sector to prepare, for example by gradually divesting; or **2)** "shock" scenarios: drastic and sudden climate protection measures (or catastrophic climate change in the absence of measures) that increase the magnitude of stranded assets. This helps to illustrate the advantages of a "soft" transition, which leads to comparatively low financial loss. As a result, in September 2017, 340 non-government organisations signed the Lofoten Declaration demanding an organised withdrawal from fossil fuel production under the leadership of and with the dedicated support by high-income producing countries (The Lofoten Declaration 2017).

The research here focuses on the consequences of continuously declining demand and prices entailed by progressive decarbonisation, so that the global fossil fuel consumption can stay within the limits necessary to achieve the 2-degree target. There is a wealth of evidence indicating that shock scenarios cause greater economic harm, albeit with a different distribution of losses (ESRB 2016). The corresponding market tendencies are assumed as a consequence of political decisions to decarbonise. This study will not present all *possible* scenarios and their inherent risks for the extraction of fossil fuels. Rather, it will outline the effects global climate-friendly developments could have on the fossil fuel sector.

The role of price assumptions

Oil prices are highly volatile and difficult to predict. Predictions regarding stranded assets depend significantly on resource price assumptions which therefore are among the greatest factors of uncertainty.[5] There is a variety of scenarios, each of them depending among other things on the nature of climate action and on technological progress. It is possible, for example, that oil prices may rise as a result of supply restrictions. In this case, the stranding of assets is caused by the assumed extraction restrictions, not by lower prices. A so-called pork cycle may also emerge: oversupply and decline in prices reduce investments, in turn leading to shortages in supply and an increase in prices (cf. CPI 2014, Helm 2015).

The value-at-risk method is an attempt to factor in the likelihoods of developments (example: Dietz et al. 2016). Another expedient method of accounting for price volatility and uncertainty is sensitivity analysis, that is, analysis of investment decisions under various price scenarios. This allows taking into account non-energetic use of oil or the development of oil substitutes, for example. In sum, there is a distinction between **a)** predictions of the most likely changes to demand, price and thus assets; or **b)** the implications of effectively restricting the use of fossil fuels to a level compatible with the 2-degree target. This study focusses on the latter.

[5] Interview with James Leaton (Carbon Tracker Initiative) on 17 July 2017.

Merely warning of asset devaluation will not provide a sufficient impulse for a low-carbon transformation (see Helm 2015). It remains essential to strive for ambitious climate and energy policies in order to achieve the global climate targets. There are also a wide range of purely economic reasons that favour climate-friendly developments (OECD/IEA and IRENA 2017). The primary concern is thus how to minimise the emergent burdens and distribute them fairly. Questions that need to be addressed include how to mitigate transition risks, what political obstacles need to be overcome and what justice issues arise. A low-risk transition will require complex political decisions and negotiations; but with the necessary political will, these are not unmanageable. The extractive sector plays a key role in the working towards viable solutions, as does development cooperation.

The impacts of stranded assets on different actors will vary substantially. To identify entry points for development cooperation, in the following, we will look at implications of asset stranding for 3.1 governments and national budgets, 3.2 the fossil fuel enterprise and 3.3 investors (see summary in Figure 7).

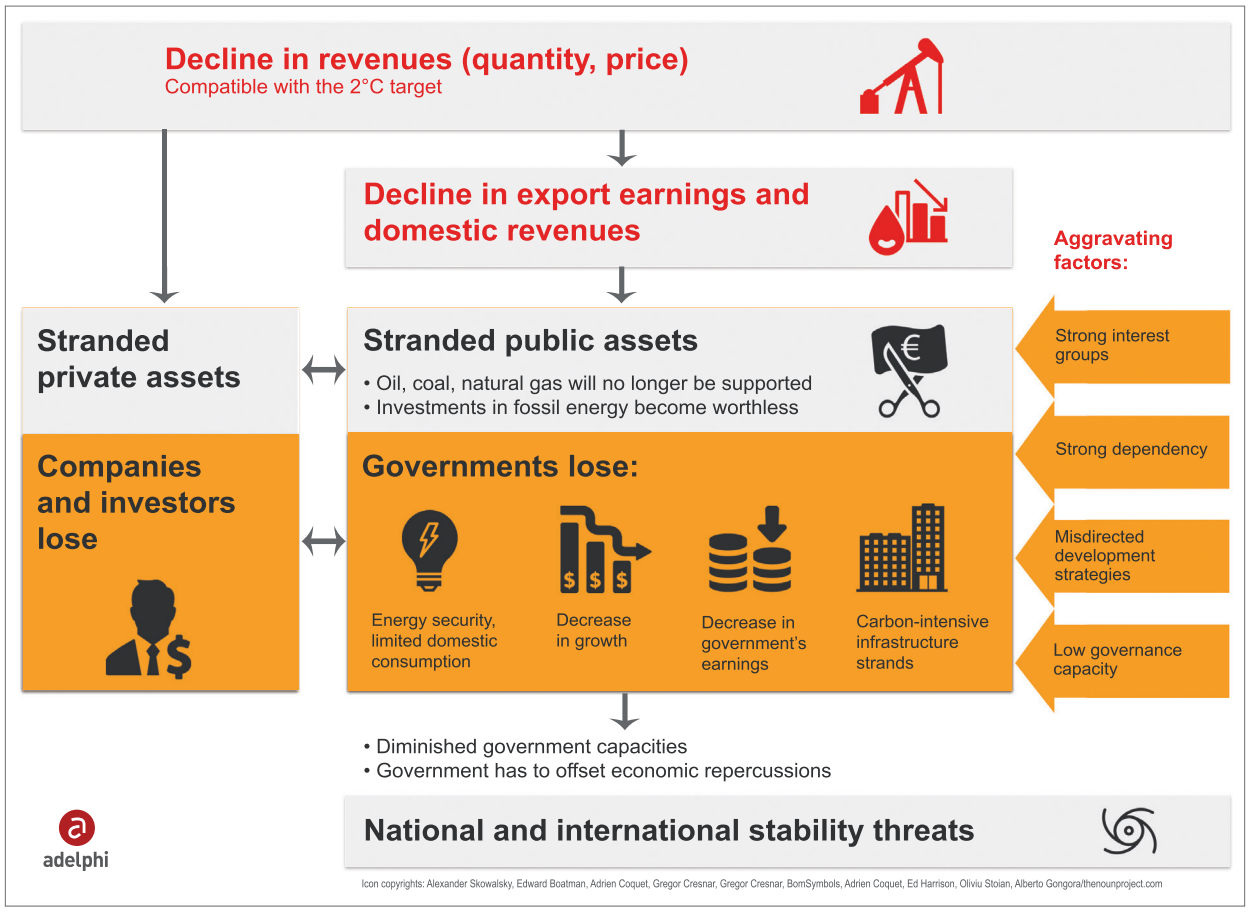


Figure 7: Overview of effects on various actors if fossil fuel revenues decline and assets strand. Source: adelphi

3.1 Impacts on Governments

This section will illustrate how fossil-fuel rich nations may be affected by devaluation of fossil fuel assets. This includes both effects on the national economy and other effects on welfare or state capacity. As not only the explicitly valuated assets are relevant for a society's wealth and political planning, a broad definition of asset stranding seems appropriate, i.e. of unexpected asset devaluation (see above)[6]

Over the course of history, seeking an optimal use of resource reserves to promote development and welfare improvements has often proven difficult (Venables 2016). A limited worldwide GHG budget will make this even more difficult. For example, it would impose further time and capacity constraints on the exporting countries, compared with the case of continuous extraction until depletion of the reserves. Some states consider the fact that the use of fossil fuels needs to decline to a certain extent. However, the national development plans more often than not fail to fully incorporate this insight. This may be due to the fact that the economic risks and long term socio-political consequences of a business as usual use of fossil fuels are not necessarily apparent. Fossil fuel rich countries will face these risks over the mid to long term because – unlike a business corporation – their capacity to dispose of these assets is very limited (CPI 2014, Manley et al. 2017). Furthermore, overarching strategic considerations and the need to prevent economic disruptions may force governments to bail out fossil fuel businesses if they become insolvent.

Not all countries rich in fossil fuels will be affected equally. The severity of impact depends not only on available reserves but rather on the extent to which current and future economic development depends on them. As fossil fuel reserves are intertwined with national economies and development strategies in manifold ways, a potentially high impact results from the following:

- Decline in export revenue;
- Restrictions to domestic consumption;
- Pronounced difficulties to reduce economic dependency on fossil fuels.

We can use a range of different indicators to operationalise the vulnerability to stranded assets. Manley et al., for example, identify a group of "fossil fuel-rich developing countries" that may be severely affected: as we can see in Table 1, these are developing countries in which fossil fuel production comprises 10% or more of the gross domestic product (GDP) or in which the identified reserves comprise 25% or more of the total wealth (incl. produced, intangible, foreign and natural assets) (Manley et al. 2017). However, economic dependency and resilience can also be measured with a much larger number of variables (see Peszko 2016).

[6] Unlike the assets of a business corporation, a nation's assets also include resources that are not (yet) given a specific monetary value. In many cases, there is an implicit assumption that such resources can be exploited for economic gain, e.g. that they will cover the increasing demand for energy for decades to come. The longer-term the perspective, the more difficult it becomes to attach a value to a nation's fossil fuel reserves and to determine the implications of non-extraction.

Country	Region	Fossil fuel production value (% of GDP)	Fossil fuel reserves (% of total assets)
Turkmenistan	Central Asia	63	-
Iraq	MENA	28	-
South Sudan	Sub-Saharan Africa	28	-
Kazakhstan	Central Asia	23	-
Iran	MENA	20	55
Azerbaijan	Central Asia	29	72
Uzbekistan	Central Asia	32	61
Yemen	MENA	22	-
Equatorial Guinea	Sub-Saharan Africa	31	-
Angola	Sub-Saharan Africa	27	66
Libya	MENA	15	-
Gabon	Sub-Saharan Africa	24	45
Russian Federation	Europe	19	41
Venezuela	Latin America & Caribbean	14	42
Indonesia	Asia-Pacific	14	37
Chad	Sub-Saharan Africa	12	42
Ecuador	Latin America & Caribbean	12	26
Algeria	MENA	10	32
Nigeria	Sub-Saharan Africa	11	40
Malaysia	Asia-Pacific	14	24
Vietnam	Asia-Pacific	12	25
Myanmar	Asia-Pacific	11	-
Bolivia	Latin America & Caribbean	12	46
Timor-Leste	Asia-Pacific	177	-

Table 1: Fossil-fuel rich developing countries. Source: Manley et al. 2017

3.1.1 Mechanisms

Decline in Export Revenue

Revenue from exporting fossil fuels that falls behind expectations creates stranded assets. Fossil fuel exports present a major source of income for many countries. They comprise a substantial share of the GDP and – provided taxation or state controlled production – of the national budget. Declining export rates adversely affect economic growth and national budgets.

Restrictions on Domestic Consumption

Fossil fuel assets are also used to achieve economic progress domestically. For some countries, this may be of greater economic significance than the export of fossil fuels. For example, coal exports of Vietnam or India are declining (Chatham House 2017) but their strategies reveal the role of coal in meeting domestic energy demand: India plans to double coal-based electricity generation by 2040 (GoI 2017); Vietnam's 2011 projections for future coal use have been corrected in 2016, but the country still intends to meet 42% of its electricity demand in 2030 with coal (Ha-Duong Minh 2016). At the same time, the national economies of those countries with major fossil fuel reserves are usually more carbon-intense and less energy-efficient (see Figure 8 as well as Friedrichs and Inderwildi 2013).

A decarbonisation of the national energy supply could be a result of political decisions or of competition from low-emission alternatives. Fossil assets would strand because their economic use would become either impossible or

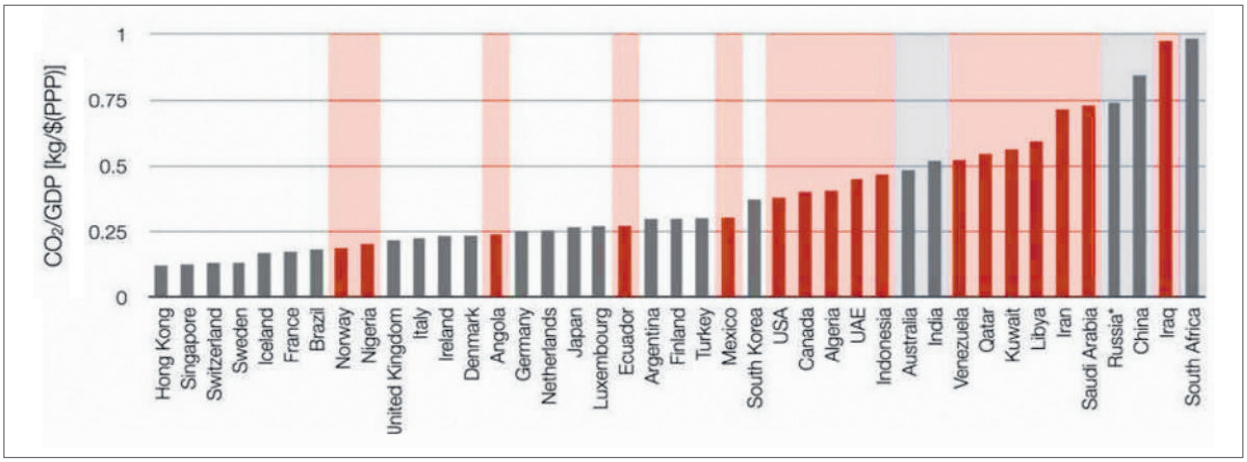


Figure 8: Carbon intensity of various national economies in 2008 (emissions per unit of GDP). Source: Friedrichs and Inderwildi 2013

less profitable, especially if these assets have already been factored into decisions, implicitly or explicitly, by national entities or domestic private businesses. A lack of political coherence or cross-sector targets for decarbonisation, for example, may expose some sectors to transition risks and asset stranding.

Challenges for Diversification

The higher risk for fossil fuel dependent nations is also due to the barriers domestic availability of fossil fuels and associated political and economic structures create for a timely and cost-efficient transition to a low-carbon economy. It is likely true for both industrialised and developing countries that a transition to a global low-carbon economy is possible and rational from an overall economic perspective, but political shortcomings, path dependencies, vested interests and the unequal distribution of social burdens get in its way (OECD 2017b, GCEC 2014). Figure 9 shows the positive effects of climate policy on economic growth to be expected in the G20 nations by 2021 and 2050, if action is taken in combination with the economic reforms recommended by the OECD. Among other things, this illustrates the positive effect of innovation and investment incentives. In this scenario, the average added economic growth for the G20 surpasses the decline in growth caused by higher energy prices, stranded assets and regulatory intervention (red bars). If the benefits from avoiding climate damage are accounted for, the positive growth effect until 2050 increases by approximately another 30%.

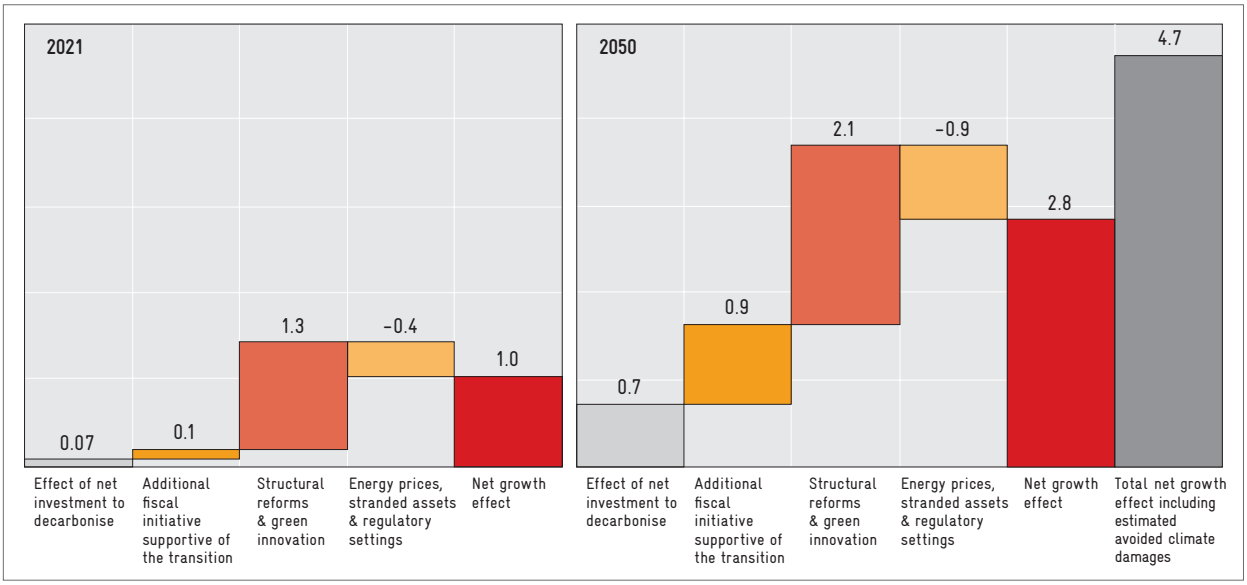


Figure 9: Positive growth effects of decisive low-emission transition on G20 nations (50% probability of achieving 2-degree target). Source: OECD 2017b

However, it is easier for high-income industrialised countries to achieve diversification and a transition to a low-carbon economy (Arent et al. 2017). These countries possess a much broader range of economic resources upon which to base a transition (e.g. innovation potential, technical and social infrastructure, diversified revenue and exports) and better socio-political conditions for managing a changing economy (e.g. steering and institutional capacities, modes to promote social acceptance).

In addition, the fossil fuel rich countries also need to overcome greater political economy obstacles. In the countries with major fossil fuel reserves, the political, economic and social actors of the extractive sector and the often closely associated energy sector shape strong dependencies.[7] State subsidies to the sector and its elites reinforce these as well as social dependencies on fossil fuels (de Jong et al. 2017). Planning deficiencies solidify the expectation among businesses and in politics that business as usual will continue furthermore reducing the likelihood of a transition.

A comprehensive planning perspective is crucial. Otherwise nations risk being insufficiently prepared for a necessary transformation. Income from fossil fuel exports and domestic energy supply are significant factors in political planning – both for the overall economy as well as for individual sectors. For example, development strategies often assume certain growth rates, government spending and availability of energy at certain prices as a basis for devising political action plans (CPI 2016). However, these policies can become obsolete or difficult to fund if these conditions no longer apply.

3.1.2 Consequences

Decrease in Growth

Whether caused by internal or external factors, fossil fuel sector losses would often noticeably affect the national economies simply due to its large GDP share (see Table 2 for a list of countries in which fossil fuels make up more than 3% of the GDP, data source: World Bank). Growth rates and investments would decline. Currency value, trade balances, national debt and creditworthiness would also suffer adverse effects. The weakened extractive sector would also affect its adjacent sectors. Due to its comparatively low labour intensity, a decline in employment within the fossil fuel sector would be noticeable primarily at the local level (Malmeuss and Alfredsson 2017). Such consequences have already been observed in the wake of the latest oil price slump since 2014 (BBC 2016, Politico Magazine 2016).

Country	Oil, natural gas and coal rents (% of GDP 2015)
Libya	50.7
Kuwait	39.1
Iraq	28.6
Iran	23.5
Saudi Arabia	23.3
Oman	23.0
Turkmenistan	18.9
Republic of Congo	18.2
Equatorial Guinea	16.4
Venezuela	14.6
MENA	13.6
Azerbaijan	13.2
South Sudan	12.1
UAE	11.9
Algeria	11.7
Qatar	11.3
Angola	10.7
Gabon	10.0
Russia	9.1
Brunei Darussalam	8.5
Trinidad and Tobago	7.5
Kazakhstan	6.9
Chad	6.8
Papua New Guinea	5.7
Norway	5.3
Bahrain	5.0
Uzbekistan	4.7
Mongolia	4.0
Egypt	3.4
Ecuador	3.3
Nigeria	3.3
Bolivia	3.2

Table 2: Countries whose oil, gas and coal rents exceed 3% of their GDP (2015). Data source: World Bank 2017c

[7] For an example and detailed analysis of how the mining and energy industries as well as the political elites and trade unions strengthen the dependency on coal in South Africa, see Baker 2015.

Decline in Government Revenue

A country's actions are of course affected by economic developments. However, it is worth examining in greater detail how government income might be affected by the devaluation of fossil fuel assets. This depends on the extent to which the fossil fuel reserves are publically owned, how effectively the government generates income from the sector and how such income is used. The majority of fossil fuel production worldwide is state-controlled (50 to 70%). In many cases, the extraction and processing companies of fossil fuels as well as those handling domestic energy supply are owned by the government, with minor shares held by private business (CPI 2014). Governments also sometimes hold shares in privately run corporations. Figure 10 shows the shares in production of different fossil resources under state control.

Governments also benefit from extraction of fossil fuels by collecting various taxes or by granting licences (IMF 2014). They further generate income from production contracts, which for example guarantee the government shares in production.[8] Figure 11 shows that the lion's share of predicted revenue in the oil sector up to 2050 (87%) is government earnings, with 75% of total revenue generated by taxes and royalties. Therefore, the risk for national budgets from stranded assets is high: around USD 10 trillion could be lost by states between 2015 and 2035. This does not take into account revenue that governments would generate from the sale of fossil fuels to their own citizens up to 2035 – which is estimated to amount to a further USD 9.5 trillion (CPI 2014, see Figure 12).

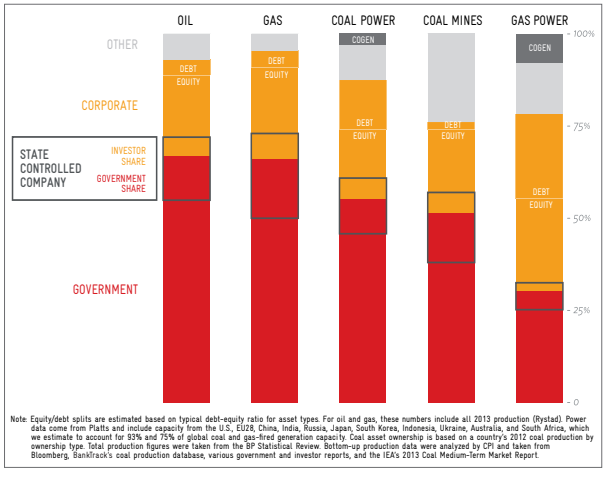


Figure 10: Shares of governments and corporate investors in fossil fuel production. Source: CPI 2014

[8] See case studies for more details.

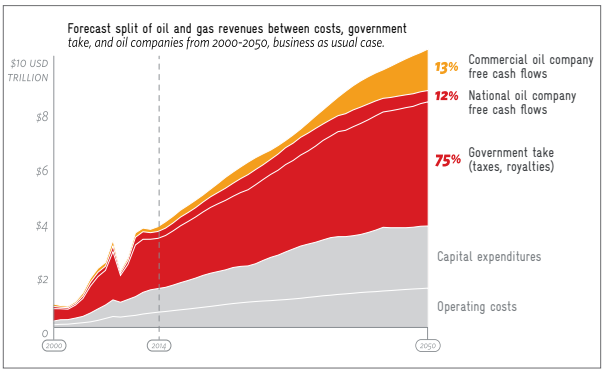


Figure 11: Break-down of projected oil sector revenue up to 2050. Source: CPI 2014

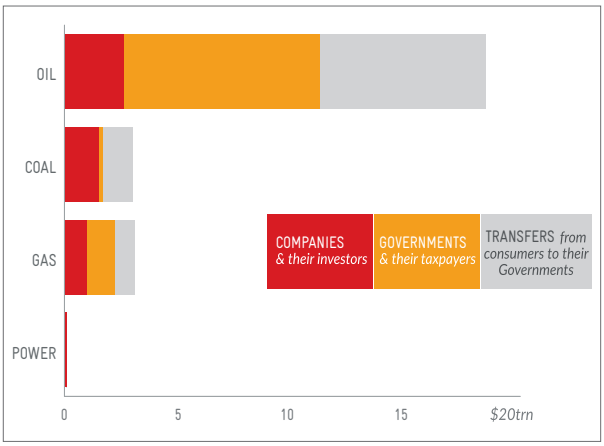


Figure 12: Value at risk (2015 to 2035) for governments and businesses, by type of fossil fuel. Source: CPI 2014

Government losses from stranded assets are highly likely to affect welfare spending, subsidies and public institution funding. Pensions, social security systems, and public services such as providing security, healthcare, education and municipal services may come under pressure. As the comparatively high share of fossil fuels in government income in producer countries is often coupled with low state capacities, the effects on these countries could be severe. Similar developments have already affected a number of African nations during the latest slump in oil prices. In October 2015, Angola announced it would cut public spending by 50%, equally funds for healthcare and waste management were reduced. Several observers associate these cuts with the outbreak of yellow fever in 2016, which began in a poor district of Luanda (Agbo 2016, George and Onuah 2017, Kazeem 2016).

Case Study Mexico

Mexico is one of the world's top ten oil producers and exporters. However, production has been declining since the mid-2000s. While oil sales had steadily comprised more than one third of national revenue since the mid-2000s, this share dropped to around 13% in 2015 (Albarrán 2016). The share of energy in exports dropped from more than 20% to 5% in 2014 (World Bank 2017a, 2017c). The share of total fossil fuel exports in GDP is at 5% (Chatham House 2017). Automotive industry exports have surpassed fossil fuel exports by far (IEA 2016b). At the same time, tax reform successfully increased income from sources other than oil (SIE 2017; OECD 2017a). Approximately USD 93.4 billion in investments planned until 2025 would not be required (i.e. not needed capital expenditure or capex) under the 450-ppm scenario; this amounts to 37% of all investments in oil. Mexico is thus one of the five countries with the highest potentially unprofitable investments (CTI 2015).[9]

Mexico generates its energy primarily from fossil fuels, placing additional strain on export capacities (93% as of 2014, EIA 2016). Final consumption has increased by 15.8% from 2004 to 2014, with strong growth in the ten years leading up to 2008 and a slight decline since 2009. The share of natural gas is increasing and comprises the main source of electricity, but overall oil products are dominant (IEA 2017a). Energy intensity has dropped only slightly since 1990, but still remains under the G20 average (Climate Transparency 2017). The Mexican transport sector grows fast and makes up the greatest share of final energy consumption in the country (IEA 2016b).

To meet its energy challenges, Mexico introduced an extensive energy reform package and opened the sector to international investors (by means of auctions). This required a constitutional reform. The regulating authorities can now grant licences to private investors at various phases of the process. How these regulations are implemented will affect, among other things, future infrastructure investments. According to IEA, the reform will increase extraction rates, so that one billion additional barrels can be produced in 2040 (see Figure 14) (IEA 2017a). The state company Petroleros Mexicanos (PEMEX) lost its monopoly position and was reformed to improve its competitiveness; this proved urgently necessary in a time of low oil revenue. In 2015, PEMEX posted a loss of USD25 billion and already cancelled a number of expensive investment projects (IEA 2016b).

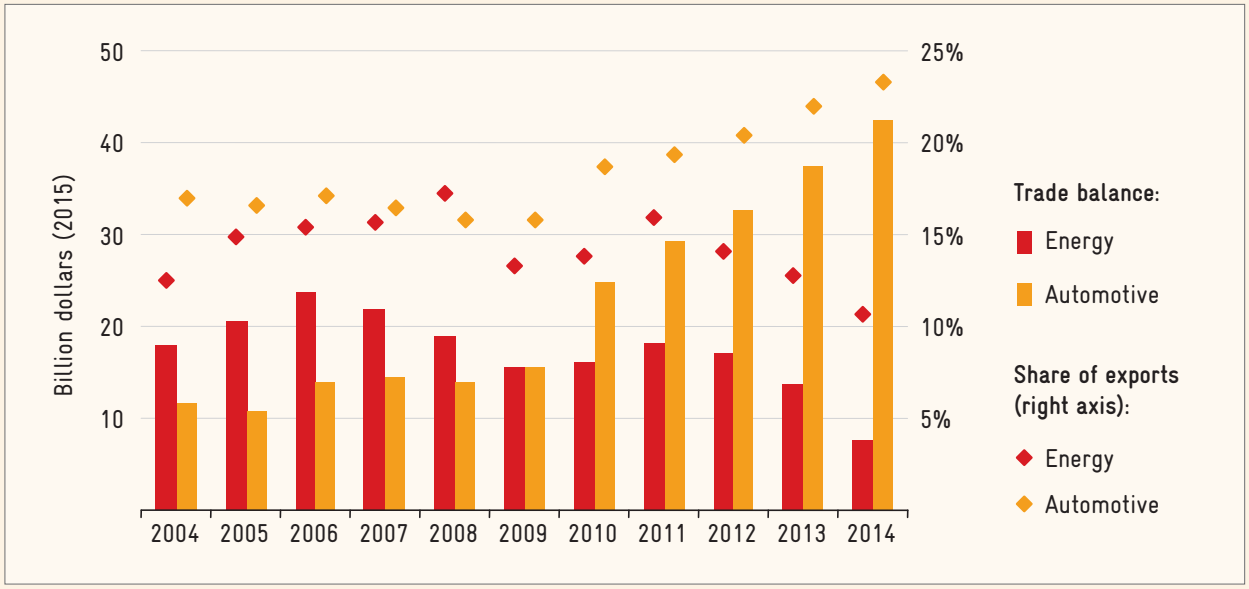


Figure 13: Trade in energy and automotive sectors in Mexico. Source: IEA 2016b

[9] The study assumes that compliance with the targets stipulated as part of the 450-ppm scenario will render a number of fossil fuel investments made unprofitable due to the required limits on burning fossil fuels (assuming an energy-related carbon budget of 593 billion tonnes CO_2 from 2015 to 2035). These investments are referred to as *not needed capex*. Certain price and market developments are assumed to estimate the sales volume achievable with climate-compatible fossil fuel extraction. These sales are compared to the already planned total investments (projects under development and projects already underway). This allows calculating superfluous investments. To obtain country data, supply cost curves are used (cf. CTI 2015).

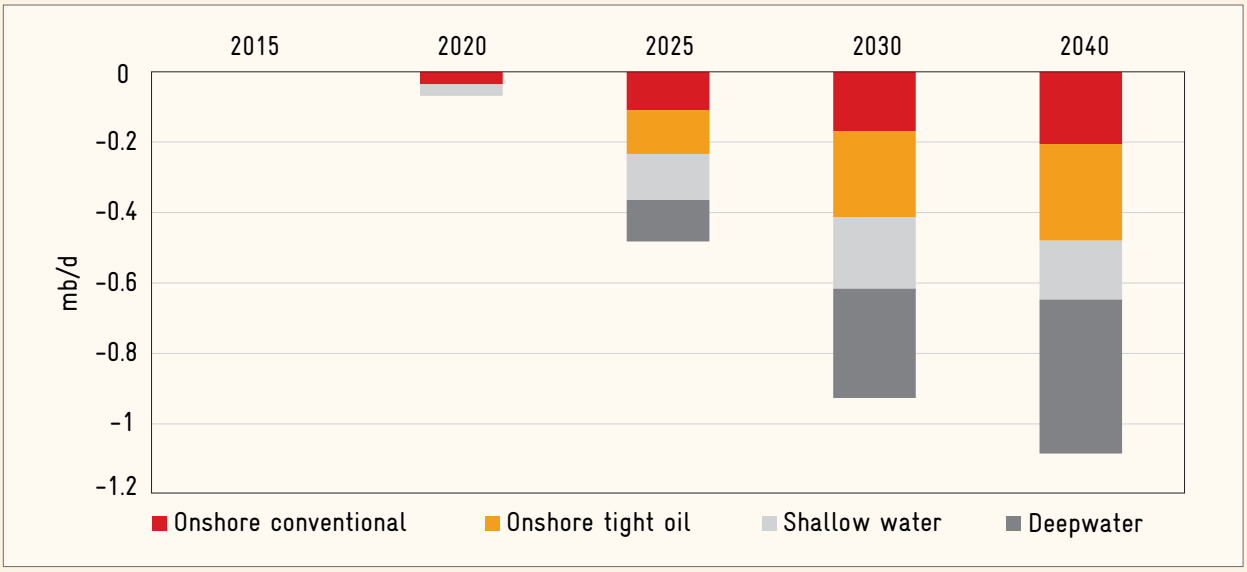


Figure 14: Expected losses in Mexican oil production without reforms as compared to full realisation of reforms, in millions of barrels per day, by type of extraction. Source: IEA 2017a

The energy reforms included a gradual phase-out of subsidies for petrol and diesel, while electricity prices are still set by the government. Consumption subsidies dropped from USD 18.5 billion in 2012 to USD 2.5 billion in 2014 (Climate Transparency 2017). In early 2017, the high fuel prices led to civil unrest. However, President Peña Nieto justified the cuts, citing the necessity to stabilise the economy (Peña Nieto 2017). The recently introduced subsidies for solar roofs are expected to substantially reduce government electricity subsidies (García 2017).

Mexico pursues an ambitious climate policy. So far, 67% of greenhouse gas emissions have come from the energy sector, where the sub-sectors power generation and transport have the largest shares. The Energy Transition Law (2015) confirms the targets for clean energy (25% by 2018, 30% by 2021, and 35% by 2024) and introduces corresponding instruments. Furthermore, there is a consumption tax on fuel and a carbon tax with an average rate of USD 3.5 per tonne of CO_2, though it should be noted that natural gas is exempted. There are also plans for an emissions trading system (Climate Transparency 2017). The current share of renewables (5%) and their growth rates remain low, however.

Conclusions

- Despite oil revenue still making up a major part of the national budget and large amounts of investments at risk, dissolution of the strict PEMEX monopoly and adjustment of the energy consumption incentives were important steps towards risk reduction. Increasing PEMEX's efficiency counteracted the combination of low production rates and low prices.
- The progress made in diversifying Mexican exports and national revenue likely renders the consequences of devalued fossil fuel reserves more manageable than they would have been only a decade ago. Increased tax revenue from other sectors further supports this assumption. However, it must be noted that the future of the automotive industry, which generates high export volumes, is also uncertain.
- Supporting renewable energies and ambitious climate targets promotes a low-carbon transformation. However, the structures and investment trends in the transport sector remain of concern. Possible courses of future action include increased emphasis on sustainable urban and spatial planning, including prioritising transport modes other than motorised individual transport.

Consequences for Energy Supply

Energy access remains a major challenge in many regions of the world: households, businesses and providing infrastructure (schools, hospitals etc.) all require energy. It is estimated that 620 million people in Sub-Saharan Africa are currently lacking access to electricity (IEA 2014). Developing natural gas reserves in countries such as Mozambique or Tanzania could provide long-term improvements. Progress beyond satisfying basic needs due to industrialisation, urbanisation and rising living standards at present also means higher fossil fuel consumption. Countries with major fossil fuel reserves also often grant substantial energy subsidies that distort market prices and encourage excessive consumption, in turn eliminating incentives for businesses to innovate (IEA 2017b).

It is, however, becoming increasingly recognised that development does not automatically lead to increasing emissions and low-carbon paths may offer a better alternative (GCEC 2016, OECD/IEA and IRENA 2017, Northrop et al. 2016). In this respect, co-benefits of low-emission energy systems such as improved air quality, less environmental harm and benefits of efficient energy use play a big role. For instance, considering co-costs and co-benefits raises the question of whether coal can really be seen as a cheap domestic energy source. Smaller oil and gas producers might even be able to compensate their extraction emissions through low-emission policies in other sectors.[10] However, fossil fuel rich developing countries will require support to tackle the initial transformation costs and require access to resources other than their own fossil fuel assets. It is of foremost importance to initiate the transition as soon as possible and manage it with necessary foresight in order to limit asset stranding (see below).

[10] Interview with Valerie Marcel (Chatham House), 17 July 2017.

Case Study Indonesia

Indonesia has major fossil fuel reserves, worth about 280% of its GDP and 37% of all national assets (Manley et al. 2017). In 2015, fossil fuel exports amounted to almost 10% of GDP and made up more than 20% of the overall export volume (World Bank 2017a). Indonesia is the world's largest exporter of coal, and its export volume is increasing rapidly. Natural gas exports have been declining since 2010 because domestic consumption increased while production declined (EIA 2015). Conversely, the relative economic significance of oil exports has diminished over the last decades. Over the last ten years, oil production has gone down by around 25%; Indonesia already became a net importer in 2004 (Ordenes 2017). While the initial government focus was on redirecting funds from consumption subsidies to infrastructure, it has now shifted to increasing production (Gordy 2015).

The national company Pertamina controls 30% of the oil and roughly 13% of the gas production, most of the oil and gas refineries and the entire production for the domestic market. The company is still investing heavily in production (Climate Transparency 2017, Singgih 2017). According to IRENA, more than 80% of potentially stranded assets in Indonesia are in energy source production (upstream). CTI lists almost USD 92 billion of capex investments that would not be needed in the 450-ppm scenario.[11] For coal and natural gas, this amounts to 62 and 54% of the total investments respectively (CTI 2015).

Private businesses with oil and gas production-sharing contracts (PSCs) contribute to government revenue through taxes and the predefined government share of extracted oil and gas. Since 2015, PSCs are awarded in competitive tender rounds.[12] In 2013, around 20% of the government revenue came from the extractive sector (Prichard et al. 2016). This revenue, however, was almost entirely outweighed by subsidies to fossil fuels which in 2014, totalled around USD 32.5 billion. The subsidies have contributed to the rapid spread of privately owned motor vehicles (ADB 2015, IEA 2016a). At present,

[11] Cf. footnote 9 for notes on methodology.

[12] A reform planned: so far, businesses with a PSC are reimbursed for exploration and production (32% of national income in 2014). In future, they will instead receive a specified share in production; the intention is to make investing in the industry more appealing (Ordenes 2017).

almost 40% of all energy is consumed by the transport sector; this is also where the greatest future increase is to be expected (APERC 2016). In 2015, subsidies were reduced from 3% to 1% of the GDP, as the government came under pressure due to low oil prices. Low energy prices, at the same time, made it politically easier to implement subsidy cuts (IEA 2016a).

Energy consumption may rise from 163 to 980 Mtoe in the period from 2011 to 2050. The domestic energy supply is unstable and cost-intensive; reasons for this include lack of exploration, production and transport capacities. Supplying energy to both centres of economic growth and to remote regions is a challenge (Tharakan 2015). Only roughly 80% of the population have access to electricity, almost 40% are forced to rely on biomass for energy supply (Climate Transparency 2017). Indonesia relies increasingly on coal (about 45 GW coal power capacity are under construction or in planning), although last year, the government postponed the construction of more than 7 GW of additional capacity (Shearer et al. 2017). Every year 100,000 Indonesians die a premature death as the result of air pollution caused, among other things, by the current energy system (Wright 2016).

As a result of efforts to strengthen the economy and attract investors, government spending on infrastructure has increased substantially (despite budget cuts in 2016, infrastructure funds amounted to USD 22.9 billion compared to only USD 5.5 billion in 2009) (OBG 2016). The future development of energy production, consumption and exports, and thus development of the country's risk profile, depend on government investments and reforms, which are required or planned in a wide range of fields (Climate Transparency 2017, OECD 2017b).

Indonesia is still undergoing an economic and political transition. The intensity of regional and religious conflicts has decreased. The fragility index shows a largely positive trend over the last ten years (FSI 2017). The country is an important member (and seat) of ASEAN and a member of the G20. However, competitiveness, investment levels and human capital remain limited (German Federal Ministry for Economic Cooperation and Development BMZ 2017a) and corruption is still an issue (90th among 176 according to transparency International 2017). The quality of institutions offers potential for improvement (cf. Doing Business 2017 and WB Governance Indicators).

The NDC level of ambition is rated medium with respect to the 2-degree target (CAT 2016). Climate aspects are reflected in some sector strategies (OECD 2017b). Along with land use emissions, the energy sector is a cause for concern: while coal is gaining importance as a cheap and abundant energy source, the conditions for renewables (share: 8.5%) are poor. Better investment conditions, government support and a high carbon price would be favourable (Climate Transparency 2017).

Conclusions

- Substantial investments are either planned or to be expected as energy consumption continues to increase rapidly. Because it is an abundant domestic resource, coal plays a major role in planning. The corresponding investments are at high risk of stranding. A rapid reassessment is necessary here.
- The significance of fossil fuel exports has diminished considerably. However, they still present an important source of government revenue, as does taxation of fossil fuel extraction. Cutting energy consumption subsidies has achieved important progress toward risk reduction. However, investing further in oil production may bring about new risks. Such investments should therefore be planned under conservative assumptions.
- A better option would be to improve governance of the fossil fuel sector, in order to increase the obtained revenue. Additionally, low-emission options for the transport sector could be explored, fully accounting for environmental and social benefits, for instance improved air quality, to slow down the increase in domestic consumption.
- The climate targets, energy power consumption trends and energy exports are likely to create contradiction. The plans for achieving the climate targets do not offer sufficient detail on how to address these conflicting developments.
- Overall, conditions for economic progress can be improved substantially. This can offer an opportunity for continuing diversification, instead of deepening the dependency on oil and coal.

Case Study Mongolia

Mongolia has large metal and mineral as well as fossil fuel resources. Mongolia's actual extractable reserves amount to more than 1,170 megatonnes of anthracite, 1,350 megatonnes of soft lignite and 35 megatonnes of oil; known natural gas resources currently cannot be extracted (BGR 2016).13 Mongolia's total exports came to almost 70% from metals and minerals (primarily copper and gold). Fossil fuels made up around 20% of Mongolia's total exports (Chatham House 2017). Government revenue from the extractive sector is substantial (averaging approximately 28% from 2010 to 2015); the share of coal has been relatively low compared with copper, varying over recent years (see graph; MEITI 2016).

Product	Volume USD	Share of total exports (rounded)
Metals and minerals	3.2 bn.	70 %
Copper	2.4 m.	52 %
Gold	402 m.	9 %
Iron and steel	253 m.	6 %
Others	145 m.	3 %
Fossil fuels	932 m.	20 %
Coal	558 m.	12 %
Oil	374 m.	8 %
Total exports	4.6 bn.	100 %

Table 3: Mongolian exports. Source: Chatham House 2017

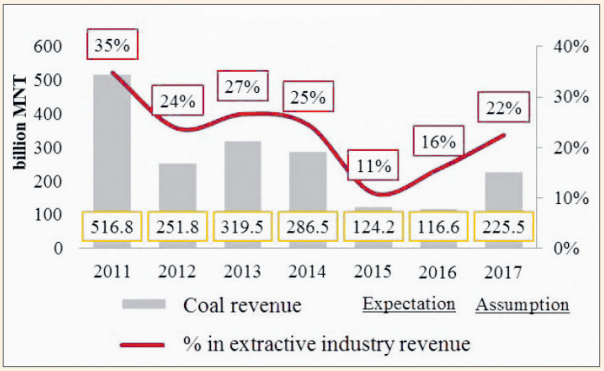


Figure 15: Share of the coal industry in Mongolia's government revenue. Source: MEITI 2016

The largest export market is China (around 92% of total exports). Due to its dependency on the extractive sector and almost a single export market, Mongolia's economy is vulnerable to economic fluctuations (GTAI 2017). In addition, China's decarbonisation plans have developed rapidly over recent years; expenditure on coal imports has declined significantly since 2012 (Chatham House 2017).

Fossil fuels, soft lignite in particular, are not exported in their entirety. Energy demand has increased rapidly since 1990, partly because of the growing mining industry and population growth in Ulaanbaatar. Around 65% of the extracted coal is used for generating electricity and heat. 70% of electricity and 90% of heating energy are obtained from coal (MEGD 2014). However, energy production is highly inefficient and results in, often heavy, air pollution. There is major potential for renewable energies (wind, water, solar) but their share in electricity generation so far lies at only 3 to 4% (MEGD 2014, EBDR 2017).

According to the latest estimates by Germany Trade and Invest (2017), the volume of investments planned in the field of fossil fuels currently totals around USD 7 billion. In December 2016, the government begun seeking investors for an expansion of the Tavan Tolgoi coal mine and its local infrastructure again (investments of USD4 billion).

[13]According to the BGR's definition, reserves are "proven volumes of energy commodities economically exploitable at today's prices and using today's technology" (BGR 2016, 169). Rated globally, Mongolia's soft lignite reserves rank eighth and its anthracite reserves rank fifteenth (BGR 2016).

So far, developments around the mine have been unsteady: since 2011, several investment plans have failed. In the meantime, declining prices have even forced Mongolia into an unfavourable cash-for-coal deal with a Chinese aluminium producer (Schmücking et al. 2016). Construction of an oil refinery (investment: more than USD 1 billion) and construction of a coal power plant (investment: USD 1 billion) on the Tavan Tolgoi deposits are under preparation. Construction of a coal power plant is also currently underway on the Baganuur deposits (investment: USD1 billion). In addition, two wind farms have been planned, with a comparatively low investment volume of USD 245 million.

The largest foreign investor, the European Bank for Reconstruction and Development (EBRD), published its Mongolia strategy in June 2017. It recommends strengthening of the non-extractive sector, supporting sustainable mining and improving infrastructure (including in the energy sector). The bank further intends to support value generation from responsible mining. At present, 66% of the bank's operating assets lie in the field of natural fuel resources (EBRD 2017).

Mongolian key climate strategy is the National Action Programme on Climate Change. It was issued in 2011 as part of the Millennium Development Goals and contains strategies for climate protection and adaptation (Nachmany et al. 2015). Mongolia's parliament furthermore passed the Green Development Policy in 2014. This policy forms the foundations for the NDC, which pursues a 14% reduction of greenhouse gas emissions by 2030 compared to BAU. Key components are increasing energy efficiency and a greater share of renewables in electricity generation (20% by 2020, 30% by 2030).

Conclusions

- Mongolia has undergone a resource boom, making the sector enormously important. So far, however, evidence – including the example of Tavan Tolgoi – shows that governance of the sector is highly inconsistent and insufficiently developed. This stops the country from reaping the potential economic benefits of the coal sector. The concentration of exports on the Chinese market is a further risk factor. To a certain extent, declining coal prices already cause asset stranding: profit expectations are lower, investments have been cancelled and contracts were signed at poor conditions.
- On the other hand, the relative significance of copper for the economy reduces fossil fuel risks. Here too, however, governance issues and susceptibility to price fluctuation persist.
- Risk assessments for the coal industry in view of the 2-degree target and matching planning within the sector should be supported. This goes hand in hand with supporting good governance in the extractive sector overall. New investments need to be thoroughly assessed.
- Climate-related risks that arise from the inefficient energy systems for national budget and economy should be addressed as soon as possible by exploring sustainable energy options and by identifying investment and political barriers to their implementation. Both energy efficiency and renewables offer huge economic and social benefits. Additional leverage could be achieved by better integrating the NDC into all policy fields.

Stranded Public Investments and Infrastructure Assets

Investments in the Extractive Sector

The impact on emerging producers of fossil fuels (countries that have been producing for less than 10 years) serves as an illustrating example for the stranding of investments. Some of these producers are already engaged in the export of fossil fuels and would be affected directly by decreasing demand or prices as described above. However, new investments in exploration and extraction that might not pay off in view of the climate policy developments may entail even greater disadvantages. Yet, even in established producer countries, the planned extractive sector investments are likely too high, as illustrated in Figure 16 below (public and private investments).

Investments in Other Sectors

Stranded assets potentially occur not only in energy production but also in those industries that consume energy. Thus, public investments in high-emissions infrastructure may strand when its use prematurely ends or is restricted as a result of transformation. This includes power supply, transport, industrial production, buildings and urbanised land (CPI 2016, IRENA 2017). This aspect is highly significant because developing countries are currently investing heavily in infrastructure that will determine the emission paths and energy demand for years to come. The reserves available to emerging producers may be an incentive to invest in high-emission infrastructure. Subsidised energy prices can increase social dependency further. Figure 17 illustrates that assets in the energy production, electricity, building and industrial production sectors will strand far less if early climate action is taken (REmap) in comparison to delayed policy action.

Stability Impacts

Because many of the fossil fuel rich countries have substantial fragility levels, the additional economic pressure may lead to further instability, even on a regional scale. This is why the potential geopolitical consequences of fossil fuel devaluation cannot be dismissed. The end of the fossil-fuel era could challenge domestic stability even in reform-friendly countries such as Mexico, Brazil or Colombia (Bordoff 2016).

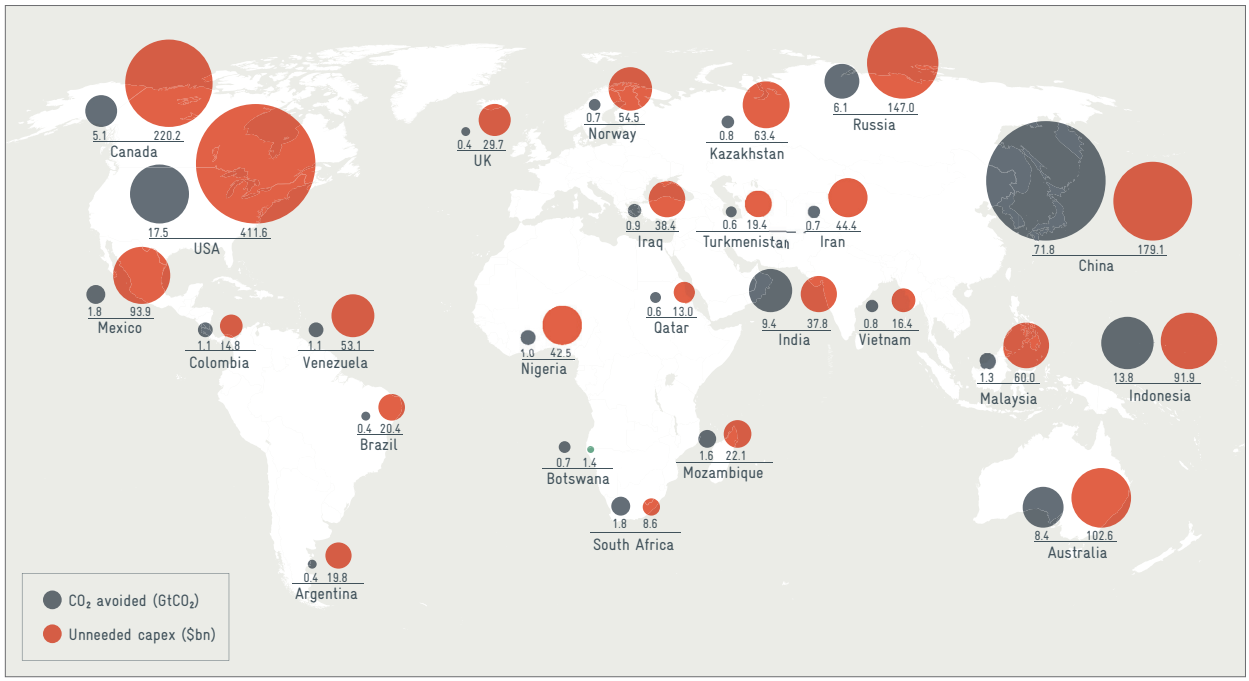


Figure 16: Unneeded capex in fossil fuel sector until 2025 in the 450-ppm scenario. Source: CTI 2015

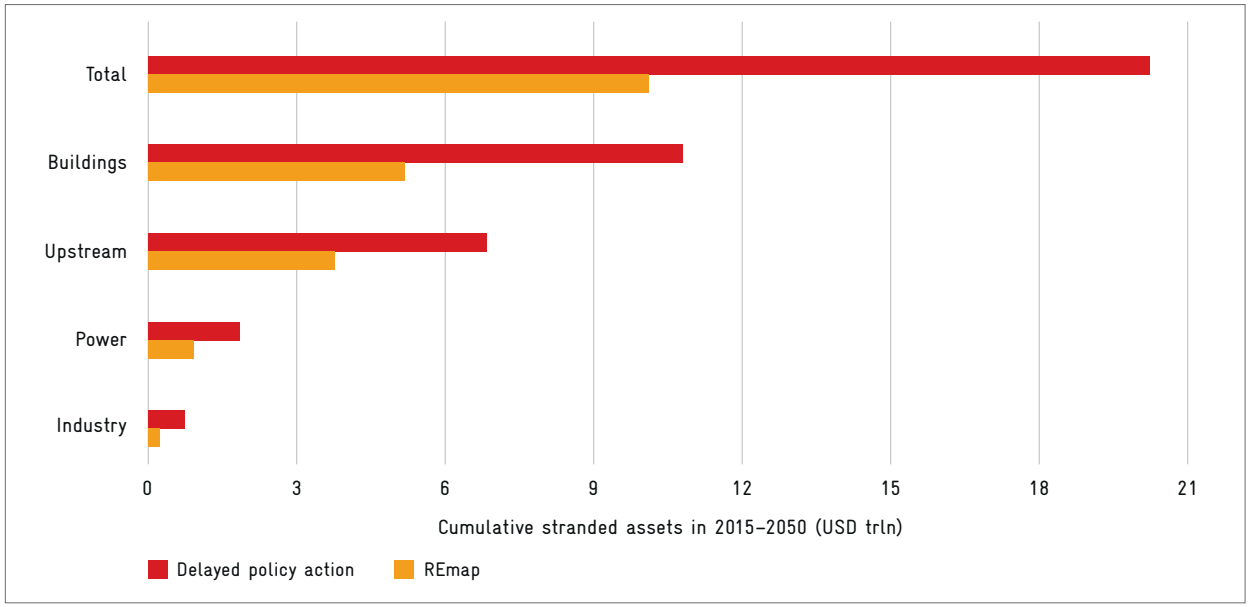


Figure 17: Comparison of potentially stranded assets in various sectors under an early action scenario (REmap) and a delayed policy action scenario. Source: IRENA 2017

The resilience of social structures rests upon appropriate interplay of authority, legitimacy and capacity (Rüttinger et al. 2015). All of these may be weakened by declining government revenue and economic recession, as this entails poorer standards of living, lower purchasing power and a diminishing capability of the state to perform its functions. Political power structures and systems are particularly affected if their social contract, and thus legitimacy, depends on extensive privileges for elites and patronage relations as well as from subsidised consumption funded by oil revenue (Richert and Mamel 2017, de Jong et al. 2017).

A state may also face declines in social welfare or be forced to cut domestic security and defence budgets. This in turn can result in a reduced capacity to combat crime and violence, weakening state authority. Public steering functions may also be affected if public administrations that often are already under strain because of lacking capacity face additional funding problems. Particularly urgent crises emerge, necessary long-term reforms might be neglected and investments slashed (e.g. in the field of education), even though this further weakens the national economy.

Shifts in trade dependencies can also reduce international political influence of some producers. If key regional players are among them, this may affect regional stability (Richert and Mamel 2017). Transboundary consequences are possible, especially in fragile contexts. If regions already struggle with security issues, such as the Middle East with the civil wars in Syria and Yemen, these risks are especially high. Declining oil and gas prices have already led or contributed to instability in countries such as Nicaragua or Venezuela. Additional research on the potential impact on stability is needed, including on the role of the fossil fuel revenue decline and associated regime destabilisation in past and current conflicts.

The potential consequences of a collapse of state structures for a region are illustrated by the current situation in Libya. Libya is one of the main transit countries for migrants. It has become a hotspot for human traffickers, where conditions for refugees and migrants are inhumane (Bachstein 2017, Oxfam 2017). At the same time, migration pressure may even increase: many migrants, for example, come from Nigeria (see case study). This has a severe impact on European migration policy. The scope for action is thus extremely limited, as it is extremely difficult to support the country due to the absence of nationwide established government structures.

Case Study Nigeria

Nigeria has huge oil and gas reserves. Since the 1970s, fossil fuels have consistently accounted for over 80% of total exports (World Bank 2017a). Nigeria is often cited as an example of the so-called resource curse because the nation has not succeeded in converting the abundant oil revenues to sustained societal wealth (Gbahabo and Oduro-Afriyie 2017). Oil production has also brought about massive socio-economic problems: the pollution of the Niger delta is infamous (UNEP n.d.). Despite fossil resource richness, 60% of the population have no access to electricity and more than 85% of power consumed is supplied using biomass and waste (GIZ 2015).

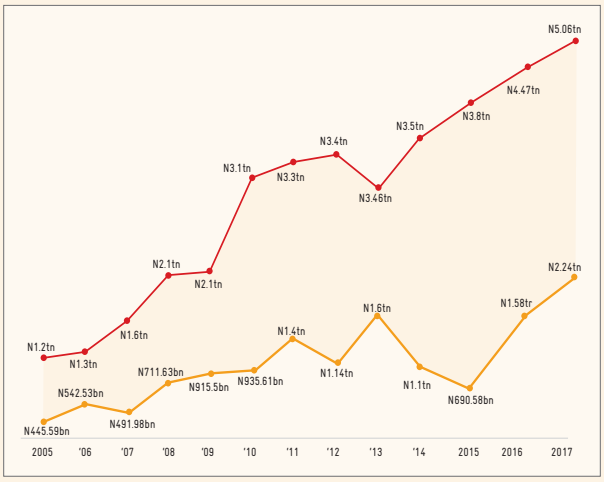


Figure 18: Current government spending and investment in Nigeria. Source: BudgIT 2016

National budget planning is tied to highly volatile oil revenues (Prichard et al. 2016). The decline in oil prices since 2014 and the reduced extraction rates due to the insurgences in the Niger delta had severe economic consequences, pointing at what potential revenue losses may bring in future. Growth rates declined rapidly (see Table 4).

Year	GDP growth rate
2013	5.4 %
2014	6.3 %
2015	2.7 %
2016	-1.6 %
2017	1.2 % (projected)

Table 4: GDP growth rates in Nigeria over recent years. Data source: World Bank 2017c

Inflation and unemployment as well as the exchange rates went up, while foreign currency reserves depleted due to lower export revenue. The debt service costs increased and oil price, exchange rate and oil production assumptions needed to be adjusted substantially since 2014 (EY 2016, Ofoegbu 2015).

This financial pressure also forced the government to reform the fuel subsidies in 2016, which accounted for massive expenditure since the late 2000s (IISD 2016). For 2017, around 40% of government revenue is expected to come from oil, assuming USD 42.50 per barrel. The 2016 and 2017 budgets allow for greater deficits and attempt to counteract recession. The plans include higher investments than in previous years, with a particular focus on transport and energy supply infrastructure in 2017. In times of high oil prices have, however, public investment levels did not necessarily grow at the same pace as the recurrent public expenditure (Ajikobi 2017, BudgIT 2016, EY 2016). In addition, since 2014, the government has been making efforts to improve revenue from other sources (primarily tax revenue, which is very low) (Gbahabo and Oduro-Afriyie 2017; PWC 2014). Approximately USD 42.5 billion of capex until 2025 is not needed under the 450-ppm scenario. This includes 22% of the oil sector capex (CTI 2015).[14]

The comprehensive Petroleum Industry Bill intends to reform and improve sector governance (EITI 2017, Okere 2017). In July 2017, the Nigerian government confirmed the new National Petroleum Policy as part of these reforms. The policy considers a potential end of the oil era and seeks to identify options for diversification as a means to reduce oil dependency. A focus on moving further along the value chain is a key issue. The policy intends to build up petrochemistry and refinery industries, cut extraction costs and attract private investors. However, experts warn that the policy lacks detail and that its implementation will face political resistance, for example, from enterprises (George and Onuah 2017). The strategy may also reinforce path dependencies based on the oil deposits. Investments in developing this value chain run a significant risk of stranding. Diversification efforts should consider low-carbon sectors to a greater extent.

[14] Cf. footnote 9 for notes on methodology.

Nigeria is one the world's least energy-efficient countries. The energy infrastructure is underdeveloped; to an extent that around 50% of electricity is produced by inefficient diesel and oil generators. Nigeria has the second-largest volume of gas flaring worldwide. The national company Nigerian National Petroleum Corporation (NNPC) has announced its engagement in energy supply and is seeking investments of USD15 billion for three thermal power stations. The country plans to significantly expand the use of its natural gas reserves (Eboh and Ahiaba 2017; Kaletovic 2017).

Nigeria is a fragile country with weak state institutions and an unstable economy. Development progress is overshadowed by inequality (Chatham House 2017, FSI 2017, BMZ 2017b). Nigeria also has a very young population which, especially in rural areas, is suffering under high unemployment rates and lack of prospects (Akande 2014, Gbahabo and Oduro-Afriyie 2017). Specific threats include Boko Haram in the north-east and the instability in the Niger delta, which are connected to poverty in the rural regions. The attacks in the Niger delta specifically target the oil industry. Although an amnesty programme that also offered the militant groups economic opportunities achieved some progress, it was subjected to budget cuts in 2015 (Onuoha 2016). Stabilisation is unlikely without long-term government efforts to develop these regions. However, unabated dependency on oil exports may result in constraints of government action capacity.

In its NDC, Nigeria focuses primarily on energy-efficiency measures, including a reduction of gas flaring, its use in gas power stations to replace inefficient generators and on cutting distribution losses. The country further intends to develop renewable energies and emphasises the benefits of decentralised solutions. The cost of action is superseded by the economic benefits. Implementation will require international support (Nigeria 2015). The "Vision 20:2020" planning strategy also includes climate aspects and first steps towards low-carbon diversification. It is evident, however, that the economic model of fossil fuel exports is not being questioned. Adjustment of the NDCs in the international review mechanism is an opportunity for more critical examination of this issue, which can then be incorporated into an overarching climate-compatible strategy.

Conclusions

- Nigeria faces high stranded asset risks because it continues to rely on fossil fuels and its economic model is economically and politically unstable. The latest oil prices collapse illustrates the substantial economic impact.
- There are first signs of better budget planning and forced corrections to price assumptions and to public spending (including for fossil fuel subsidies). However, further planning needs to continue pursuing these approaches and ensure that potential revenue increases are not merely used to increase recurrent expenditure. Instead, such revenue should be reserved for investments in low-carbon diversification; the existing but currently small sovereign wealth fund may be a suitable mechanism for this.
- The country has great potential for economically viable climate policies that improve resource efficiency. Low-hanging fruits to reap substantial economic benefits include combating large energy inefficiencies and gas flaring.
- Efforts to reform the oil and gas industry are visible. However, these pursue value chain development, which itself potentially entails new risks. Greater efforts should be made to prepare the fossil fuel sector for a global transformation, stressing the urgency of the already initiated reforms.
- A midterm overarching economic vision should be a foundation for discussing the sector's importance to fulfil development requirements and tackle inequality. This should consider what would benefit the majority of the population (e.g. with respect to agriculture, telecommunications or the manufacturing industry).

3.1.3 Diversification: Options from a Climate Perspective

The subject of sustainable diversification in fossil rich countries brings together perspectives of both the fossil fuel sector and climate policy. The concern in this is the possible limits to the use of fossil fuels. This illustrates that climate and resource policies can generate synergies and that a holistic approach to international cooperation is required (see section 4).

To create a sustainable set of national assets, states can invest revenues in profitable diversification or consider savings via, for example, a sovereign wealth fund. The former can aim at increasing not only financial and material assets but seek to build up sound (economic) institutions or a competitive educational system. A sovereign wealth fund allows saving revenue from the fossil fuel sector for future use, and facilitates diversified investments and thus a step-by-step reduction of fossil fuel sector dependence (UNFCCC 2016).

For instance, Norway and the Arab states of the Persian Gulf have established sovereign wealth funds that are worth billions. However, not all sovereign wealth funds are equally successful and their investments are also at risk of stranding (Manley et al. 2017). The Government Pension Fund of Norway, for example, replenished by oil revenue, has decided to pull investments out of the coal sector and monitors climate-related risks comprehensively. This is not a common approach yet (Guardian 2015, Norges Bank 2017). Poor revenue management can strengthen dependencies on fossil fuel reserves and exports. In addition, many of the sovereign wealth funds maintained by developing countries comprise only a fraction of the reserves' value.

Even without taking into account climate considerations, the countries dependent on fossil fuel reserves have the task to employ these assets for wealth generation and to increase and diversify national assets overall. Fossil fuels are a finite resource and their extraction often entails high social and environmental costs. First and foremost, however, mere export of raw materials is a less attractive economic model than an industrialised, energy-efficient, knowledge-based economy (UNFCCC 2016). Overcoming the former, through good governance of the extractive sector and by investing in structural economic reforms, is by no means a novel political goal. But a worldwide GHG budget alters the available options for reducing dependence on fossil fuel exports.

For example, a value added diversification, that is, expanding fossil fuels industry and corresponding capacities to increase domestic value added, may prove an economic dead end in view of the risks described. But options for diversification are manifold; many

Country	Fossile fuel reserve value (USD billion)	SWF funds (USD billions)	Proportion of SWF funds to reserves
Azerbaijan	331	72	21.7 %
Kazakhstan	1,033	71	6.9 %
Algeria	467	25	5.4 %
Russian Federation	7,347	288	3.9 %
Uzbekistan	221	6	2.7 %
Gabon	65	<1	0.2 %
Nigeria	1,024	1	0.1 %

Table 5: Value of sovereign wealth funds maintained by selected countries compared with their reserves.[15] Source: Manley et al. 2017

[15]The calculation of the reserves assumes constant production rates over the years that the reserves will last and a discount rate of 4% (for price assumptions and further details, cf. appendix to Manley et al. 2017).

measures to support diversification are of cross-cutting nature (improving infrastructure, investment climate, and economic stability) (UNFCCC 2016). Assessments of the available options need to include the full range of possible national assets and of human development benefits of low-emission diversification.[16]

Conversely, it is hardly controversial that global climate targets can be achieved only through comprehensive restructuring of the global economy, which needs to be initiated as soon as possible in order to reduce economic costs of climate change, but also of air pollution (IRENA 2016; OECD 2017b; OECD/IEA and IRENA 2017). This, however, implies disadvantages for some actors, fossil fuels producing states among them. So, even though there is little doubt that climate-compatible economies are possible and preferable, especially in the long run, this insight per se does not define specific options and challenges for individual countries.

This topic is being addressed in the Just Transition debate as part of the UNFCCC in the *"Forum and work programme on the impact of the implementation of response measures":* in 2016, the Secretariat drafted a technical paper that examines the diversification concept as a possible answer to potential adverse economic effects of climate action on developing countries (UNFCCC 2016). An expert workshop was also held on this topic in September 2016. The paper states that the experience of development institutions with diversification policies should be put to use in the climate context (UNFCCC 2016).

Some states whose economies are heavily dependent on fossil fuel revenue, among them the United Arab Emirates, have already reacted by investing major sums in renewable energies, particularly in large-scale solar power plants. Saudi Arabia too presented its ambitious Vision 2030 and formulated a National Transformation Plan that aims to reduce dependency on oil reserves, strengthen private sector and attract more foreign investors (Bordoff 2016; Luomi 2015; IMF 2016).

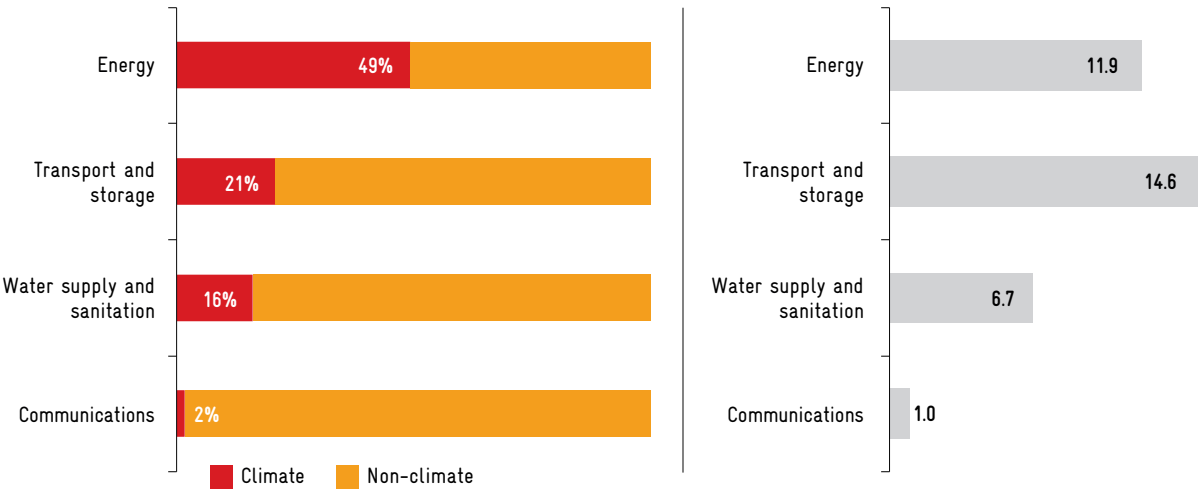
This paper has so far illustrated that, beyond the effects of global fossil fuel price volatility on exporters, the issue at hand is their comprehensive economic dependency on employing their fossil fuel reserves. This shows that transformation strategies are necessary. Swift action as well as integrated and carefully balanced planning is required while accounting for economic development needs, employment and other social factors. At the same time, one should not dismiss the positive effects of transformation to a low-carbon economy, as discussed above in the context of diversification challenges and consequences for energy supply. It is essential that these often underestimated benefits are adequately incorporated into overall economy planning (see section 4).

The developing countries will require substantial international support that accounts for respective national circumstances in order to pursue a continuous transformation (see Table 6 for an overview of subject fields and strategies). Upon signing the Paris Agreement, it was decided and reiterated that, starting in 2020, developing countries will receive at least USD100 billion in climate finance annually – from public and private sources.

[16] Interview with James Cust (World Bank) and David Manley (Natural Resource Governance Institute), 18 July 2017.

	Strategies	Infrastructure needs		Technologies
Transport	Improve carbon intensity of vehicles Shift to more efficient transport modes Avoid carbon intensive mobility when possible	Passenger	Charging infrastructure for electric cars and fueling infrastructure for hydrogen cars Intelligent Transport Systems Smart grids Rail Mass rapid transit systems (light rail, metro, bus rapid transit lanes)	Electric cars Advanced biofuels and biojet (algae) for air and maritime transport Hydrogen aircrafts Batteries
		Freight	Hinterland rail infrastructure	Electrification of trucks Advanced biofuels, hydrogen for shipping Investment in agriculture research (yields)
Energy	Decarbonise the power sector Electrification of end-uses Energy efficiency	Energy and power generation	Renewable energy (wind, solar, thermal energy, tidal, waves) Smart grids Infrastructure for CO_2 transport and storage	Energy storage (thermal cycle, power to gas, batteries) Tidal, thermal energy CCS (large-scale demonstration)
		Buildings	Retrofitting of the building stock Energy-efficient new build Heat supply	Zero energy or positive energy buildings Alternative material for steel and cement
Heavy industries	Energy efficiency in industrial processes Material efficiency Capture of emissions		Energy efficiency in industrial processes Infrastructure for CO_2 transport and storage	CCS (large-scale demonstration of industrial CSS applications) Hydrogen in steel making
Land use	Improve carbon sequestration by land Minimise emissions from food production, including livestock	Negative emissions	Infrastructure for CO_2 transport and storage	CCS Direct air capture and storage BECCS (deployment at commercial scale) Biochar Ocean liming
		Agriculture	Restoration of degraded grassland	Research on yields improvements Innovative agricultural practices to improve productivity

Table 6: Examples of infrastructure and technology required for transition to a low-emission economy. Source: OECD 2017b



Note: This graph is based on data reported to the OECD Development Assistance Committee by the following MDBs: the African Development Bank, the Asian Development Bank, the European Bank for Reconstruction and Development, the European Investment Bank, the Inter-American Development Bank, the Islamic Development Bank and the World Bank Group (WBG), which also includes the International Finance Corporation. Climate-related components of projects are those that target mitigation, adaptation, or both mitigation and adaptation, based on the joint MDB Climate Finance Tracking Methodology. MDB commitments include concessional and non-concessional support.

Figure 19: Share of climate-related infrastructure investments by multilateral development banks (in USD billion, 2013–2015 average). Source: OECD 2017b

The focus on climate finance, however, appears to be too narrow. The goal should rather be to make all public and private development investments climate-compatible and to offer profit-maximising actors enough incentives to engage in climate-compatible business models. For development cooperation, this means ensuring that all projects and funding pledges need to take into account their climate effects if they are to support a comprehensive transformation. Figure 19 by the OECD shows climate-related shares of infrastructure financing by multilateral development banks (OECD 2017b). International development institutions are particularly well-positioned to promote innovative concepts and respond to current global trends and should tap into their potential.

3.2 Impacts on Fossil Fuel Companies

If the climate targets are to be achieved, the Paris Agreement needs to have a strong influence on portfolios and future action of the fossil fuel industry. HSBC, the United Kingdom's largest bank, calculated that corporations such as Shell, BP, Eni, Total or Statoil stand to lose between 40 and 60% of their market value, as they will not be able to exploit their reserves as planned. Potential financial losses from stranded assets amount to more than USD 2 trillion (Walton 2016).

Despite the risk of high losses, the currently low oil price and increasing price volatility, the major oil corporations continue investing billions in the exploration of new reserves – almost USD 166 billion in 2015 and 136 billion in 2016. A recent analysis by the Carbon Tracker Initiative (CTI) shows that, under a 2-degree scenario, one third of the BAU production capex up to 2025, roughly USD 2.3 trillion, should not be invested. Among the 69 largest oil and gas companies, the share of investments at risk of stranding varies from 10 to 60% (CTI 2017). The coal industry is subject to greatest divestment trends (see 3.3). The two largest mining corporations BHP Billiton and Rio Tinto have been continuously pulling out their thermal coal investments in order to reduce the impact of a price decline on their profits. Rio Tinto, for example, recently sold a major share of its coal business to a Chinese company for USD 2.45 billion (Biesheuvel and Williams 2017).

The oil and gas industry shows similar, though weaker trends. In a poll by EY, 60% of the oil and gas executives stated to plan divestments within the next two years (EY 2017). An example is Shell, Europe's largest oil corporation. According to CTI, until 2025 30 to 40% of Shell's capex could be stranded. Pressure from shareholders caused the company to diversify its portfolio: Shell's New Energies division is investing in renewable, low-carbon energy, for example, in wind power.[17] Shell was the first major oil corporation to publish its vision of achieving the 2-degree target and of the necessary steps for that. Shell still, however, continues to refute analyses that predict losses in fossil fuels assets resulting from climate action. The corporation instead advocates compensating carbon emissions by means of shifting from coal to natural gas and through carbon capture and storage (CCS), even though this method is not yet available at industrial scale. Shell does not intend to reduce its net emissions to zero within the next decades, despite its 2-degree scenario, and has not changed its stance substantially (Shell 2016).

In a Chatham House paper experts voice a warning, especially addressing the international oil industry: companies needed to transform their businesses to avoid a short, brutal demise within the next 10 years (Stevens 2016). A diversification of portfolios in favour of green energy was inevitable. The investments in renewables by oil, gas and coal corporations are presently still comparatively low, but are likely to increase in future in comparison with fossil fuel investments.

The Oil and Gas Climate Initiative (OGCI)[18] pursues the goal of minimising the sector's greenhouse gas emissions. Its members produce around a fifth of the world's oil and gas and include the CEOs of corporations like BP, Shell or Statoil.[19] In November 2016, the members pledged investments of one billion dollars to fund projects in the following fields: a low-emissions roadmap, carbon capture and storage, utilisation and storage technologies (CCS) and the reduction of methane emissions. However, these funds and topics can only be a part of the efforts necessary to limit the temperature rise to 2 degrees. Action by the oil and gas corporations must and will play an important part in a climate-compatible transformation. But this will require a much more determined change on a much broader scale. The necessary technological and economic innovations cannot be achieved otherwise, which would jeopardise the industry's future.

There is some involvement of fossil fuel companies in broader climate initiatives. Shell and GE Oil and Gas, for example, are members of the Energy Transition Commission, a cross-sector initiative of energy corporations, banks, research and international organisations, who explore action required to achieve a global transition to low-emission pathways, based on the findings of the Global Commission for Economy and Climate. Shell and Total SA participate in the Business and Climate Forum, one of the prominent platforms for private sector exchange on climate topics.

[17] These and more examples of action by leading international oil and gas corporations are outlined in the Tiki Toki Timeline on a platform implemented by CCSI (May 2016).

[18] Website: Oil and Gas Climate Initiative.

[19] Compared with the rest of the sector, Statoil already applies more stringent emissions standards and pursues a more ambitious technology strategy (Statoil 2017).

3.3 Impacts on Investors

The stakeholder group of investors includes banks, financial investors, industrial corporations from different sectors and institutional investors such as pension funds, insurance companies and private investors. The distinction between investors and companies is by no means clear-cut. Accordingly, fossil fuel corporations and their downstream and upstream industries often act as investors. Nonetheless, investors are affected differently by stranded assets. The risks that come with stranded assets can entail far-reaching consequences for financial markets and are highly complex and difficult to predict. Furthermore, the risks for institutional investors like pension funds directly affect social welfare (Bowen and Dietz 2016). Investor groups also differ in their capacity to analyse portfolio risks and in their flexibility regarding investment decisions or portfolio changes.

Investments in fossil fuel power stations take time to generate returns. The same is true of exploration and extraction of oil, natural gas and coal. In the European Union, almost one third of coal-fired thermal power stations are more than 30 years old, another 61% are over 20 years old. The more rapidly climate regulation evolves and the higher the investment in climate-friendly technologies, the greater the risk of stranding for investments in fossil fuel power stations and infrastructure. The faster the costs for renewables drop, and grid integration and storage development progress, the faster also the loss of value for investments in fossil fuels. The economic turmoil around the major German energy corporations RWE and EON, which led to partial breakdown of the respective group structures, exemplify such developments. Even though utilisation of oil and gas will not stop in the near future, a gradual decline in demand is expected. Small shifts in demand can thus cause major price fluctuation and price volatility (Bordoff 2016).

According to economists, stranded assets in fossil fuels are a factor that must not be underestimated in investment decisions (Wolf 2016). An Oxford University study even predicts that practically any investment in new fossil power plant capacities or associated infrastructure starting in 2017, the "2-degree capital stock", is a loss (Pfeiffer et al. 2016). Any further power plants would have to be emission-free to avoid a complete loss of value, i.e. stranding. The question is no longer if, but rather when fossil fuels and power plants will be entirely devalued, causing losses and divestment.

Investors therefore need to motivate businesses and nations to disclose these risks in order to avoid potentially unprofitable investments (Fugere 2016). In fact, the technical risks within the fossil fuel sector are well-known and largely incorporated in investment calculations. The growing political, regulatory and reputational risks involved in extraction of fossil fuels are thus far less well understood and rarely included in revenue forecasts (Maennling and Toledano 2016). These risks would be easier to track if taxes and other payments to countries made by the fossil fuel industry were transparent and investor balance sheets were publicly available. This would support investors and governments in better assessing potential risks of fossil fuel price fluctuations and dealing with these risks – not annually but over the long term. Greater transparency also simplifies legal regulation of and investment decisions in the fossil fuel sector. Over the long term, this would make the risk of stranded assets more visible to investors who would – for economic reasons – focus less on fossil fuels as a consequence.

Greater transparency and the disclosure of the climate effects on business operations and profitability would have a positive impact on the global economy. One of the most prominent political initiatives in this respect is the Financial Stability Board's Task Force for Climate-related Disclosures. The Task Force recommends measures for corporate risks disclosure in its final report, published in 2017. It is constituted by top-level executives led by Michael Bloomberg, the former mayor of New York City (TFCRFD 2016). Standardised information on climate-related risks does not only assist investors and creditors in making informed decisions but also allows public supervisory authorities to identify potential systemic risks. The task force therefore advocates a standardised legal framework.

Investors can demand that businesses examine the risk of stranded assets and take corresponding countermeasures. Their privileges as shareholders and their possibility to withdraw capital give them leverage to shape corporate strategies. Accordingly, the Investor Platform for Climate Actions classifies existing investor initiatives by four approaches: "measure" (assess climate risks for portfolios), "engage" (support better disclosure and management of risk), "reallocate" (invest in climate-compatible enterprises) and "reinforce" (promote climate-friendly investor action) (IPCA 2016).

The shareholders of oil and gas corporations like BP, Shell and ExxonMobil are indeed exerting substantial pressure. More than 150 of BP's and Shell's investors, for example, demanded that the corporations examine their business model in light of the 2-degree target. These corporations have the largest carbon footprint of those listed on the London Stock Exchange (Carrington 2015). ExxonMobil had to answer to shareholders holding almost USD 300 billion of the company's capital (Chestney and Houreld 2016). Meanwhile, the withdrawal of capital continues, due to the growing risk of devaluation of investments in fossil fuels and to ethical reservations and fiduciary duties of investors. Investors today acknowledge the risk of further divestment and of stranded assets brought about by a low-carbon transformation. The latest estimates for capital withdrawn in 2014 amount to USD 50 billion. In the following year, the figure was USD 2.6 trillion (Baron and Fischer 2015).

At the same time, the market for green bonds is growing rapidly. In 2016, its value was estimated at USD81 billion, almost twice as much as in 2015. In early 2017, France successfully launched the first green government bond, following Poland's leadership (Climate Bonds Initiative 2017).

Political decision-makers can build on these approaches. On the one hand, political support is required to facilitate improved investment decisions and bring investment flows of capital in line with global climate targets. On the other hand, politics can help ensure that capital withdrawal does not cause shock waves.

Prominent Divestment Decisions

For some time now, there has been a topical divestment debate in the coal sector. Numerous non-government organisations as well as institutional investors are pushing to stop coal mining (slogan: "leave it in the ground") and coal power funding. There was already some success. Divesting institutions include insurance companies such as AXA and Allianz, pension funds (e.g. the California state pension fund), universities (e.g. Stanford and Yale), churches (the Church of England), cities (Copenhagen, Oslo, Berlin) and healthcare entities (the British Medical Association) (Fossil Free 2017). Recently, Ireland has become the world's first country to completely divest from fossil fuels. A law prohibiting Irish government investments in oil, gas or coal is expected soon (Darby 2017).

3.4 Conclusion on Stranded Assets

The above analysis of the implications of stranded assets for governments, investors and business illustrates that stranded assets present a risk for many stakeholders, ultimately constituting a risk for economies as a whole. The topic therefore directly touches upon the wealth and progress of many societies. The challenges posed by stranded assets are also characterised by a highly complex political economy. Continuing business as usual in this field would be negligent at numerous levels, so the subject needs to be explored in further detail.

Fairness and justice considerations are of utmost importance, in particular concerning the historical responsibility for climate change by the industrialised nations, who have major leverage on extraction trends by reducing fossil fuel consumption. For all producing countries, it is essential that revenue is employed to realise sustainable, low-emission diversification strategies.

To keep the costs incurred by stranded assets low, investments in exploration and extraction of fossil fuels need to be increasingly reduced, based on long-term planning, and investments already made need to be given up in an rational manner. The resulting negative impact on national economies needs to be mitigated. The producing countries face the enormous task of low-emission diversification and need to address important questions concerning management of the fossil fuel sector. Section 4 describes possible entry points for development cooperation and further research in this respect.

4 Action Areas, Next Steps and Topics for Further Research

How can development cooperation address the challenges posed by stranded assets? What support do developing and emerging countries need for the necessary transition efforts? The problem of stranded assets illustrates the importance of coherent strategies for development cooperation in fossil fuel rich countries. Projects that fail to integrate the climate imperative entail risks and increase the costs of the inevitable transition over the long term. High investments in the extractive sector, carbon intensity and dependence on fossil fuel exports increase the risks for economies. Linking the transition processes across various sectors can create considerable synergies.

International cooperation can address the risks of stranded assets through action at the following levels:

- Bilateral cooperation: advising governments and transfer of knowledge and technology[20]
  - For national development strategies
  - For governance in the fossil fuel sector
  - For climate governance
- International political dialogue

The sections below first outline specific options in bullet points. These are followed by a supporting and contextualising argument.

4.1 Bilateral Cooperation: Advising Governments, Transfer of Knowledge and Technology

4.1.1 Economic Policy and National Development Plans

The following approaches are available to development cooperation:

- Advisory services to help adapt the role of fossil fuel assets for a national economy and for government revenue to climate policy conditions
  - Use revenues from the fossil fuel sector for climate-friendly and long-term aims instead of merely covering recurrent expenses, particularly regarding revenues new fossil fuel production sites, as vested interests are comparatively less powerful. A fund model like that of Norway, which targets long-term, high-impact projects, could prove beneficial.
  - Adjust the revenue forecasts for the fossil fuel sector, especially by assuming lower fossil fuel prices and lower extraction rates
  - Identify and continuously track non-energy value chains of fossil fuels to support climate-compatible development of the sector while maintaining security of supply ("leave no one behind")
- Support inter-ministerial coordination mechanisms to climate-proof national development strategies, when politically viable and reasonable, for example, by engaging with the national planning ministry or – if in charge of the NDC process – the ministries for environment, mining and energy. In particular, the ministries of finance and the economy should be involved because ministries of climate or the environment often have less political influence.
- Support low-emission diversification
  - Prioritise low-emission diversification options in bilateral cooperation, particularly investing in other assets (especially education and human capital) instead of developing the fossil fuel value chain
  - Invest in low-emission and sustainable infrastructure (including power supply, buildings, transport, urban development). This approach implies an examination of all infrastructure investments or – from a development cooperation perspective – of infrastructure-related support provided.
- Support transition of national economies
  - Assess the economic and social benefits of low-emission policy options and make these visible via research cooperation and exchange of best practices (an example is the Mitigation Action Plans and Scenarios (MAPS) programme)
  - Use the Sustainable Development Goals (SDGs) processes as a framework and impulse for action, because in many countries (e.g. Mexico) the SDGs generate significant momentum and commitment by many national actors[21]
  - Advise on implementing green fiscal measures and carbon pricing, including subsidy reforms
  - Advise on the use of adequate, conservative price trends and assessments, sensitivity analyses and shadow carbon prices[22] for investment decisions in fossil fuel sector

[20] The key statements essentially apply to financial cooperation as well.

[21] Combating climate change and its consequences is in fact one of the SDGs (goal 13).

[22] Shadow prices reflect the (social) costs and benefits of using a commodity that are not incorporated in the commodity's market price. In the context of GHG emissions, shadow prices are used to incorporate the climate effects. From a government perspective, shadow prices make sense because they improve social welfare (de Bruyn et al. 2010). For businesses, they are a method of handling the uncertainty that comes with technological progress and political developments: it is assumed that the prices of emissions will increase, even if how they will do so remains unknown (CDP 2016). Experts estimate the optimum shadow price of greenhouse gases to be exponentially higher than the prices used in the EU's primary pricing instrument, the emissions trading system.

Balancing development and climate needs requires a **strategic vision for the socio-economic development of the respective country.** To minimise risks, this vision should reflect the global sustainability agenda and its associated processes. The 17 Sustainable Development Goals are particularly important but attention should also be given to approaches like Green Economy, Green Growth and Social and Planetary Boundaries,[23] which were developed at international level and offer guidelines on how to align development and environment goals. Path dependencies that support high-risk, high-carbon development models should be prevented or reduced. Instead, fossil fuel policy should be embedded in an overall strategy aiming to support development and a social transformation. Foresight and long-term planning for a gradual transformation are far less costly than a forced, sudden policy change that could strand large investments.

Accounting for climate policy requirements in macro-economic and development planning facilitates a more accurate estimation of the costs and benefits of various options. For example, the environmental costs of extraction and the costs of air pollution from burning fossil fuels can be included alongside the risk of stranded assets. It is also important to consider how costs are distributed among various groups and over time. Transition costs often accrue primarily in the early phases and amortise over the mid to long term. Strategic planning of development cooperation and economic policy consulting could pay more attention to these aspects.

NDC processes should integrate the fossil fuels and financial sectors, for example, by involving finance and business actors and by making climate opportunities (and threats) for a country's key development issues (e.g. urbanisation process management, access to power) more visible. NDC pledges should be reflected in the strategies and planning processes of all sectors, so that public investments, at least, do not undermine these pledges. Policy makers should use windows of opportunity, such as the design of major investment and collaboration programmes and the NDC five-year submission cycle.

Section 3.1 illustrated that, in order to prepare for global decarbonisation trends and mitigate impacts on their economies, fossil fuel exporters can reduce their dependence on fossil fuel assets through **diversification strategies** (i.e. by increasing different asset types, both tangible and intangible). However, these strategies and the corresponding investments should be climate-compatible and provide ways to establish low-emission business models. This means diverting priorities from tangible, high-carbon assets to intangible assets, investing in education and knowledge building. Examining the entire value chain of fossil fuels can support diversification efforts.

4.1.2 Fossil Fuel Governance

Development cooperation in the area of extractive sector governance offers the following options:

- Raise fossil fuel sector awareness (i.e. responsible public authorities and businesses) of macroeconomic risks of business as usual and of the need to integrate climate aspects into macroeconomic goals
  - Exchange on measures to make climate risks for business portfolios more transparent
  - Promote dialogue of civil society and private sector (such as, for example, the regional *Iniciativa diálogo minero* in Latin America). Development cooperation could be an impartial mediator.
- Critically examine planned and future investments and plan further development of the sector conservatively
  - Apply shadow prices of the respective GHG emissions in investment planning
  - Assess the stranding risks of investments in building knowledge and institutional capacities in the fossil fuel sector and ensure these match diversification goals
- Provide technical support for reducing extraction-related emissions (e.g. using renewables, avoiding of flaring[24]).
- Build capacities and train auditors for the climate-compatible best practices in fossil fuel mining[25]
- Provide good governance training and capacity building to improve revenue management and use, fostering efficacy and efficiency

[23] See Raworth 2017 for more details.

[24] To this end, the World Bank initiated Zero Routine Flaring by 2030. For more information, see also Schulz et al. 2015, Schulz and Leckebusch 2013.

[25] The Oil and Gas Climate Initiative mentioned in section 3.2, for example, pursues improving of extraction efficiency, advancing CCS and limiting methane emissions (OGCI 2016). For further courses of action, see also Sachs et al. 2017.

Public fossil fuel governance can contribute considerably to tackling climate change and reducing major transition risks. This does not mean that the extraction of fossil fuels must be abandoned immediately. Rather, **the development benefits of fossil fuel resources need to be optimised in view of the 2-degree target.** This requires careful consideration and complex international negotiation and coordination (see the statements on aspects of fairness in section 4.2). Furthermore, the costs and expected revenues of extraction, and thus profitability of investment decisions in the fossil fuel sector, need to be assessed carefully. This applies in particular to public spending because a high share of production is publicly owned and governments invest heavily in the sector. Even where this is not the case, there is the risk that fossil fuel companies go bankrupt and need to be bailed out for strategic reasons and to prevent economic disruption.

The **strategic vision for the extractive sector should be embedded in national development goals** (see also section 4.1.1). This is a crucial basis for decisions on the pace and direction of sector development. In emerging producer countries, this implies using the existing scope for decision-making on sector development and status, for example in terms of extraction rates, creation of infrastructure and institutions, revenue utilisation (see also section 4.2 regarding the New Petroleum Producers Discussion Group). In established producing countries, the existing vision should be thoroughly (re-)assessed. Particularly new investments in fossil fuel extraction should be examined critically as technological advances and climate policy developments can seriously impact the fossil fuels market.

Clearly, decisions on the role of the fossil fuel sector remain at the exclusive discretion of each country. However, development cooperation could foster an inclusive debate to encourage decisions based on a sound assessment of opportunities and threats of various options and on comprehensive consultation of actor groups. Not only from a climate-policy but also from a broader economic and development perspective, the assumption does not necessarily hold that major fossil fuel reserves should always be used extensively. The extractive economic model entails a multitude of difficulties and problems risking the opportunities of alternative models are missed.

4.1.3 The Role of Climate Policy Cooperation and Technology Transfer

Climate cooperation should engage with extractive industries actively. Any climate strategy in a country rich in fossil fuel reserves will ideally also be a strategy for the fossil fuel sector. Climate-related cooperation should:

- Aspire an open debate on the limits and opportunities in view of the national development goals
- Support improved climate performance of the extractive sector and of other sectors to reduce emissions overall, particularly if fossil fuel revenues are key for development
- Provide expertise on transition technologies, efficiency measures for the fossil fuel sector and alternative technologies (renewables, storage technology, grid management) to overcome transformation barriers
- Advance research on alternative resources for non-energy uses and identification of possible substitutes

4.2 International Political Dialogue

To support a climate-compatible transformation of the global economy as well as to avoid extractive industry shocks and the associated geo-political consequences, international processes need to **bring together the perspectives of the fossil fuels sector and of climate governance.** The global scope of climate change and of international trade correlations imply that this needs to happen **at international level:**

- What conflicts arise between the global climate targets and business as usual of the global resource cycles?
- What risks and costs does this entail?
- What are the possible solutions?
- What are the fairness implications, in other words, who wins and who loses?

National strategies can only be designed sensibly if multilateral frameworks and processes support positive, low-risk dynamics. This makes **clear political signals at international level** essential. It applies not only to climate policy (which, with the Paris Agreement, achieved progress but has to go a long way to implement the 2-degree target) but also to development policy. What role do fossil fuels play in international regimes and how can this be compatible with the goals of sustainable development? The role of international development cooperation in terms of fossil fuel governance and management should also be critically examined. What does the 2-degree target mean for fossil fuel extraction support? The conflict between a fixed carbon budget and unfettered fossil fuel extraction needs to be resolved.

A key question in this regard is which extraction is still 'allowed'. Should this be judged based on the cost curve or should particularly poor countries with new, minor reserves receive 'permits' – and if so, what criteria should apply for such decisions (cf. discourse on right to development)? The **debate on fairness is important and should be conducted prominently**[26]**,** an effort that the development ministries in the donor countries can support.

International dialogue could take up these issues in the following forums dealing with development and sustainable energy:

- UN development forums: SDG process, Finance for Development, UNEP Green Economy & Finance Initiatives, UN Principles for Responsible Investment (UNPRI)
- ODA donor forums: OECD, MDBs (including using their diversification experience), Sustainable Energy for All, G7 & G20 energy initiatives

Presently, stranded assets are primarily an expert topic, receiving few media attention. However, the implications of the 2-degree target could be widely discussed in the **fossil fuel sector.** Two international level forums could be stood up:

- For the subject of fossil fuels, a project task force in the *OECD Policy Dialogue on Natural Resource-based Development* could offer a suitable forum for compiling and focusing scientific expertise and for formulating recommended action.
- A corresponding subject group in the *Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF),* which could also seek ways to appropriately involve stakeholders from the oil and gas sector.

In addition, bilateral and regional initiatives could promote exchange on the subject, such as

- North-South or South-South partnerships
- The *New Petroleum Producers Discussion Group* (chaired by Chatham House), that could deal more thoroughly with the implications of the 2-degree target, as the member nations are potentially affected substantially and must be included in such a dialogue.

Overall, **international climate policy** could observe the fossil fuel sector more closely during and beyond the climate conferences. To increase emphasis on the geo-political perspective, international cooperation could engage with foreign and defence policy which also pursue climate diplomacy.

Finally, disclosure of climate-related risks could be supported in the **private sector.** International development cooperation could take this factor into account in collaborations with private sector, in particular in the financial sector, and also help to increase political pressure at an international level. These efforts can expand upon the work of the Task Force on Climate-related Financial Disclosures of the Financial Stability Board and G20 Green Finance Working Group. Furthermore, cooperating with the many investor initiatives (Investor Platform for Climate Actions, Carbon Disclosure Project etc.) can be worthwhile. Economic policy forums such as the World Economic Forum are already investigating the low-emission transition and climate change risks for the private sector. As such, important approaches for dialogue on fossil fuels may be found here, too.

[26] For fairness implications of stranded assets, cf. Caney 2016.

4.3 Topics for Further Research

Following this paper's examination of potential effect mechanisms, the issues below are among those requiring further research:

- **(De-)stabilisation of nations and regions.** The mechanisms of potential destabilisation as a result of decline in revenue require more detailed analysis. Erosion of patronage systems in particular could contribute to conflict among elites. Insights could be gained by analysing present and past conflict in which the decline of extractive revenue was a factor, and by investigating cases of structural change that occurred without destabilisation. Such analyses would supply important findings for achieving 'soft' transition. The stabilising effects of holistic and well-planned transition strategies could also be investigated.
- **Discussion of fairness in regard to fossil fuels.** Stranded assets are a controversial topic. Which nations and population groups can or must relinquish revenue from extraction of fossil fuels? For example, extraction of fossil fuels could continue for significantly longer in the least developed nations and support development goals, if the extraction in the industrialised and emerging countries were decisively and rapidly limited (Caney 2016). Under what conditions can such obligations be enforced upon countries and to what extent is global governance and national control over private sector decisions feasible or realistic? Yet, the consequences of unfettered climate change far outweigh the losses of stranded assets – and all the more so for the least developed nations (cf. climate justice debate).
- **Concrete options for integrating primary resource extraction into the NDCs.** At present, the NDCs are a core instrument of climate governance and link the national efforts to the global 2-degree target. How can the NDC processes and the fossil fuel sector be integrated? Currently, the emissions caused by the fossil fuels exported are not accounted for in the extracting country's NDC. What interrelations are there between export and domestic consumption of fossil fuels and what are the implications for climate policy decisions? For example, could a climate policy that reduces domestic consumption and provides incentives for better planning in the fossil fuel sector have positive effects on the utilisation of fossil fuel revenue? What mechanisms and measures could achieve this? These questions can provide a starting point.
- **Climate-compatible diversification through use of fossil fuel revenue.** Here, it is necessary to systematically sort the existing experiences and models in order to offer specific options and highlight obstacles. One example (and potentially a case study) could be the establishment of an off-shore wind energy industry in Aberdeen, Scotland – a city that previously relied heavily on fossil fuel extraction and suffered from the recent decline in prices. To examine the subject of stranded assets, it could be specifically analysed how fossil fuel revenue can be exploited for climate-compatible diversification.
- **Share perspectives on fossil fuels employed outside of the energy sector.** Using fossil fuels for purposes outside of the energy sector carries potential for the future and considerable efforts are being made. However, this still remains a side issue in the discussion surrounding stranded assets. Additionally, there is a lack of underlying data because in most countries, the respective data gathered are insufficient. But analysing this share in the use of fossil fuels to produce more detailed forecasts could be useful in devising strategies for future extraction and (alternative) use of fossil fuels. Further research is therefore required.

5 About the Authors

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