

Official Norwegian Reports NOU 2018: 17 Summary

Climate risk and the Norwegian economy



Photomontage of photos from Ny-Ålesund, September 2018. Climate change is strongest in the Arctic, and effects are visible in the form of shrinking glaciers. Ny-Ålesund is also an example of transition. A community built around coal mines is now a center for international arctic research and environmental monitoring.

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Summary of a report from a Commission appointed by Royal Decree on 6 October 2017 to assess climate-related risk factors and their significance for the Norwegian economy.

The original report is in Norwegian and was delivered to the Ministry of Finance on 12 December 2018.

Translation from Norwegian. For information only.

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Key Takeaways

- **Climate change means climate risk.** Climate change presents not only physical risk but also transition risk – the risk associated with economic impacts of the transition to a low carbon economy.
- **It is impossible to fully predict the effects of global warming.** The impact of climate change will depend on how rapidly the changes occur, how large the changes are, as well as the adaptability of societies and ecosystems.
- **The possibility of catastrophic climate change cannot be excluded – even if we manage to limit carbon emissions.** If critical tipping points are crossed, this may trigger self-reinforcing processes that cause more warming. From a risk perspective, it is important to consider all possible outcomes, not just the most likely.
- **The only relevant tool for reducing the risk of catastrophic climate change is effective climate policy.** This, together with technology development, is critical to eliminate carbon emissions.
- **The Norwegian economy is highly integrated into the global economy and directly exposed to developments elsewhere.** If already vulnerable states experience major negative effects from climate change, there will be an increased risk of political instability, humanitarian disaster and violent conflict in and between states. Increased migration flows, unstable food prices, supply disruption and changing production and trading patterns will affect both the global and the Norwegian economy. In addition, Norway is exposed through the large international financial holdings of its sovereign wealth fund.
- **An overall assessment of key risk factors indicates that the Norwegian economy is relatively resilient in a scenario with moderate climate change.** Rich countries in the Northern Hem-

isphere are generally less exposed to the direct negative effects of climate change than poorer countries in the South.

- **Compared to the physical risk of climate change, transition risk is manageable.** Effective global climate policy will reduce the value of Norway's remaining petroleum reserves, but this risk is manageable from a national wealth perspective. As a risk-management tool, the Norwegian government should establish scenarios with price trajectories for oil, gas and CO₂, including a scenario reflecting the ambitions under the Paris Agreement. Such scenarios will facilitate better decision making in the public sector, and can be used to stress test Norway's exposure to transition risk.
- **For individual companies, transition risk could be significant and should be better understood and managed.** An increased focus on knowledge, scenario analysis and corporate governance is important for private sector climate risk management.
- **The financial market is a key climate risk management arena.** The transition to a low carbon economy requires large investments, and will thus represent both risks and opportunities to companies. To properly manage downside risks as well as exploit opportunities, financial market participants need to have a proper understanding of climate risk and better reporting is an essential tool.
- **The government should endorse the principles on disclosure and reporting recommended by the Task Force on Climate-related Financial Disclosures (TCFD).** Such reporting will enhance the understanding of climate risk – both within companies and at the investor level.
- **A TCFD-inspired framework for climate risk disclosure should also be implemented at the national level.** Such reporting will serve to enhance transparency and be a basis for better climate risk management and improved decision-making. A potential framework for such reporting is presented in the report.

1 Priorities of the Commission

The global climate is changing, and climate change entails climate risk. Increased climate change awareness has resulted in climate policy measures to reduce greenhouse gas emissions and to help societies adapt to climate change. Since we do not have complete knowledge of the various consequences of climate change, climate policy and climate-related technological developments, we are therefore faced with climate risk. This constitutes the backdrop to the appointment of the Commission, which has been tasked with assessing climate-related risk factors and their significance for the Norwegian economy. Box 1.1 summarises the key features of the report.

The Commission was asked to describe climate risk. The Commission has been instructed to assess:

- Climate-related risk factors and their significance for the Norwegian economy
- How climate risk can be analysed and presented most appropriately
- How private and public sector entities can be provided with an analytical framework for analysing and managing climate risk in the best possible way

The Commission was also asked to propose measures for improved management of such risk. The Commission's report shall serve to advance knowledge of climate risk, but an improved understanding of risk is only of value if it results in better decisions. We have therefore focused on shedding light on how climate risk assessments can be better integrated into existing decision-making processes in the private and the public sector, thus making Norway better prepared for managing climate risk.

The climate is changing and will keep changing. It will take time for temperature increases to stabilise, and it will also take time for the effects of increased temperatures to manifest themselves.

Even if greenhouse gas emissions are reduced in line with the Paris Agreement, we will still have to manage the effects of gradual climate change for a long time. Instead of providing only a snapshot of selected aspects of Norway's climate risk in 2018, the Commission has focused on highlighting key climate risk developments and mechanisms over time.

An economics perspective provides important insights. We have primarily applied the tool of economics in our analysis, as indicated in the mandate of the Commission. This analytical framework provides a good basis for understanding the significance of the climate challenge for political prioritisations, economic development and climate-related risk.

In addition, the Commission has attached considerable weight to adding a risk perspective to its discussions. This implies that key terms, theories and principles from risk theory have been applied both in the Commission's description of climate risk and in its proposals for improved risk management. In particular, we are focusing on tools such as scenario analysis and assessment of vulnerability and resilience. This approach is well in line with international climate risk management developments, in which the use of scenarios and stress testing play a key role.

However, the report does not provide all the answers. The Commission acknowledges, at the same time, that an economics-led approach has its limitations and cannot on its own fully address all climate risk management issues. The climate challenge also raises fundamental ethical issues, such as for example climate burden and climate risk sharing between countries and across generations, including the risk of current generations causing irreversible changes that will make parts of the globe uninhabitable for subsequent generations. Such ethical perspectives are important, and deserve attention in political debate and policy development. These are issues that cannot be resolved from a purely economic theory or risk theory perspective, and therefore fall outside the scope of the discussions and recommendations of the Commission. However, we note that an improved understanding of how climate risk may manifest itself and affect eco-

conomic relationships can have a major impact on the national and international debate on addressing the climate challenge.

There are positive interactions between climate policy and climate risk management. The mandate stipulates that the Commission's focus shall be on climate risk, and the recommendations in the report are therefore centred on the understanding and management of such risk. Although it is not within the mandate of the Commission to propose measures that reduce greenhouse gas emissions, an improved understanding of climate risk may indirectly serve to reduce emissions. An improved understanding of threats and opportunities relating to climate change and climate policy provides a better basis for sound decisions on investments in both the public and the private sector. This may pave the way for a swifter and smoother transition to a low-emission society. In addition to a better understanding of risk being of potential benefit to the climate, a successful climate policy will both benefit the climate and reduce climate risk. An ambitious and effective climate policy is not only the sole tool for alleviating the risk of catastrophic climate change, but may also reduce the uncertainty associated with the transition to a low-emission society.

The Commission has given priority to a broad and general perspective. Climate risk may in principle affect the Norwegian economy in numerous ways. The Commission has chosen to focus primarily on an assessment of potential long-term effects of climate risk on Norway's overall economic prosperity over time, as expressed by its national wealth. This offers the best indication of the long-term effects of climate risk on the basis for welfare. This implies, however, that there has been less scope for detailed risk assessment of various industries, as well as for in-depth discussion of how climate risk may entail economic risk in the context of the many different roles of the State.

Global appreciation of climate risk is emerging. In some areas, access to and use of climate-related knowledge has advanced relatively far, but the Commission has seen a need for establishing a basis for a shared understanding of climate risk at a general level. We emphasise the need for more information, improved reporting and a stronger knowledge base, and we have focused on conveying general

Box 1.1 Key elements of the report

- **Assessment of climate risk:** We describe the climate challenge, discuss what we mean by climate risk and assess climate risk factors for the Norwegian economy.
- **Framework for ongoing monitoring of climate risk:** We recommend a reporting framework for maintaining and accumulating knowledge of climate risk faced by the Norwegian economy.
- **Climate risk management principles:** We recommend a set of general climate risk management principles for both the private and the public sector.
- **Sound decision-making processes that integrate climate risk:** We recommend that a proper understanding of climate risk be better integrated into decision-making processes in both the private and the public sector, with expanded use of scenario analyses as a key measure.
- **Appropriate incentives:** We propose measures to improve the ability of the market to address climate risk, including improved awareness of the link between prevention and the risk of damage.

and universal insights, principles and recommendations. The report does not seek to provide detailed answers to all questions, but adopts a general perspective to establish a solid foundation for enabling both the private and the public sector to pursue a more systematic approach to climate risk. This includes climate risk assessment and reporting on an ongoing basis.

2 The climate challenge we are facing

Anthropogenic greenhouse gas emissions are causing climate change. Population growth and economic development based on fossil energy give rise to greenhouse gas emissions, as the result of burning fossil fuels, industrial processes, agriculture and deforestation. Persistently higher greenhouse gas concentrations in the atmosphere are changing the global climate, and the global mean temperature has thus far increased by approximately 1°C since pre-industrial times. A higher average temperature, altered precipitation patterns, more extreme weather, more acidic oceans and sea level rise are already being observed (see Figure 2.1). If emissions continue, the temperature increase will be more pronounced, and the probability of very severe climate change will increase.

It is impossible to survey all potential impacts of climate change. No existing model can fully describe the workings of the entire physical world and how all physical, chemical, geological and biological processes influence each other. Current societies and ecosystems have taken many millennia to adapt to the world in which they exist, and it is impossible to predict how people and societies will respond when faced with rapid and large changes in their surroundings. Impacts of climate changes will depend on how rapidly they occur, how large the changes are, as well as the adaptability of societies and ecosystems.

Climate change may have serious implications for life on Earth. Climate change is causing major alterations in the basis of existence for marine and terrestrial ecosystems. Climate change will have different impacts on different areas. Some areas are likely to experience a combination of significantly reduced precipitation levels and severe regional warming, while other areas will experience a gen-

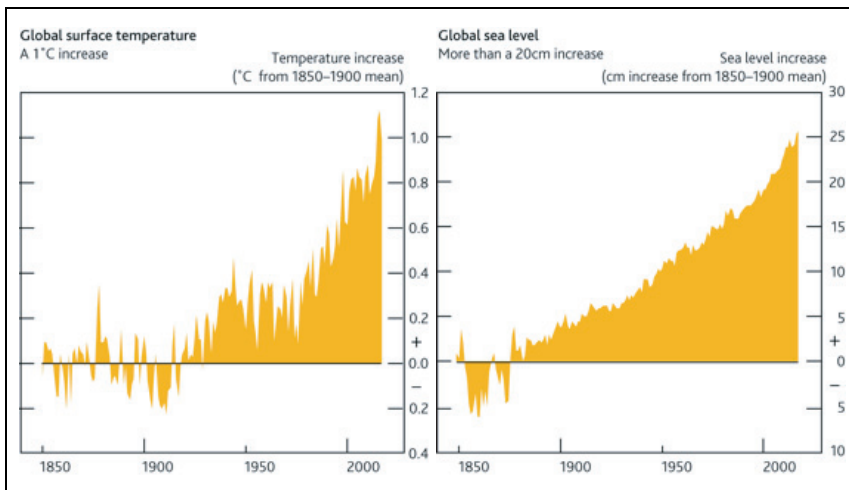


Figure 2.1 Global temperature development and sea level increase

Source: Bank of England.

eral increase in precipitation and extreme precipitation events. The frequency and intensity of extreme weather and climate events is likely to increase.

Catastrophic climate change cannot be excluded. If critical tipping points are crossed, it may trigger self-reinforcing processes that entail major changes. For example, instabilities in the icecaps in Greenland and Antarctica could result in a multi-metre rise in sea level over hundreds to thousand of years if critical thresholds are crossed. The IPCC special report on 1.5°C warming indicates that some tipping points may be crossed between 1.5 and 2°C warming.

The climate in Norway will become warmer, wetter and wilder. The climate in Norway has changed significantly over the last century and will continue to change, as in the rest of the world. The Norwegian climate is expected to become warmer and wetter, and torrential rain episodes may become more intense and frequent. This may result in altered flooding patterns, changed snow patterns and shrinking glaciers. The oceans are likely to become warmer and more

acidic. Rising sea levels will worsen the impact of storm surges. Climate change in the Arctic will also affect weather systems in our latitudes. Continued melting of Arctic sea ice could affect the polar jet stream that largely determines the weather patterns over Norway.

In order to stabilise the temperature increase at a given level, net global greenhouse gas emissions will have to be reduced to zero. Total greenhouse gas emissions over time are the predominant factor in determining the severity of global warming. In order for temperatures to be stabilised, greenhouse gas emissions will have to either cease or be compensated for by greenhouse gases being removed from the atmosphere and stored safely and permanently.

The measures announced until now fall far short of what would be required to reach the target under the Paris Agreement. All countries in the world have through the Paris Agreement agreed to keep global average temperature well below 2°C above pre-industrial levels, and to seek to limit the temperature increase to 1.5°C. However, there is uncertainty associated both with what climate policy will be implemented and with what effect the climate mitigation measures will have. The emission reductions that countries have committed themselves to thus far are not sufficient for reaching the target under the Paris Agreement. If countries only implement the emission reductions reported until now, emissions in 2030 will be on an emission pathway consistent with approximately 3°C warming in 2100. It is uncertain whether it will be possible to stabilise the temperature increase at that level, or whether such warming will trigger self-reinforcing mechanisms in the climate system which will result in further temperature increase – and thus dramatic implications for life on Earth associated therewith.

A fundamental decarbonisation of the global economy is required to reach the Paris targets, and this will also have implications for the Norwegian economy. Climate policy seeks to change stakeholder behaviour through, inter alia, carbon pricing, regulation and stimulation of technological development. Climate-related policy has already contributed to a surge in the development of solar, wind and battery technology. The technological development we are

currently witnessing may, in combination with strict climate policy, bring about major and rapid changes in the global energy markets. Such a restructuring is likely to entail a swift and steep reduction in global fossil energy use and a rapid development of low carbon technologies. Both reduced fossil energy demand and technological developments will impact on the Norwegian economy in various ways.

Considerable uncertainty at many levels means significant climate risk. Future social developments, climate policy developments and technology developments are subject to high uncertainty, and these factors have a major impact on greenhouse gas emissions. Furthermore, there is uncertainty with regard to how sensitive the climate system is to changes in greenhouse gas emissions, and uncertainty with regard to the effects of a given level of warming. Dramatic

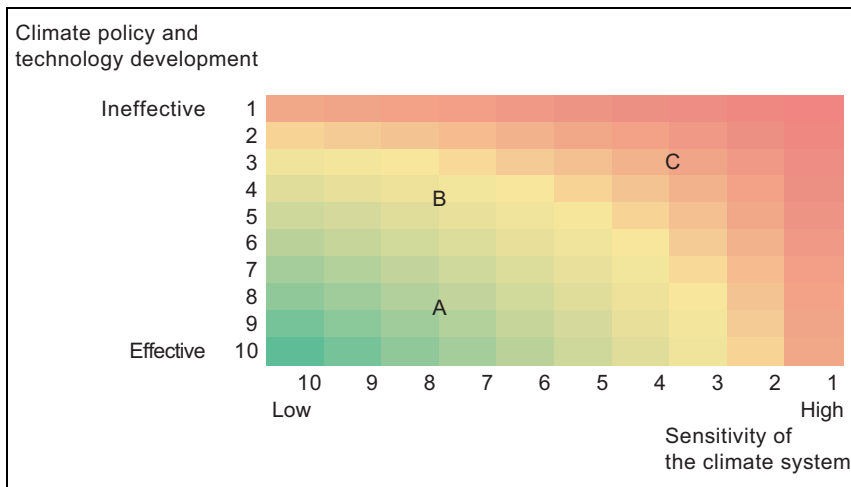


Figure 2.2 Illustration of future climate changes

The figure illustrates how future climate changes depend both on climate policy/technology development, in other words how swiftly the world is able to reduce greenhouse gas emissions, and on how the climate system responds to changes in accumulated greenhouse gas emissions. Green corresponds to minor changes and red to dramatic climate changes. The three future scenarios A, B and C, described in chapter 4, are indicated for purposes of illustration.

Source: Climate Risk Commission.

outcomes cannot be excluded, even if the international community were to succeed in limiting emissions in line with the emission pathways we currently believe are sufficient to reach the Paris target. This implies significant climate risk – which needs to be managed.

3 What we mean by the term climate risk

The term «risk» is associated with uncertainty about events that entail deviations from a planned or envisaged development. These deviations may be negative or positive. A key risk management objective is to withstand negative deviations, and to benefit from the opportunities opened up by positive deviations. Attention will most often be focused on negative deviations, because it will generally be less demanding to adapt to positive than to negative developments and surprises. The magnitude of the risk depends on *how large* the potential implications are, *how likely* it is – under available estimates – that these will occur, and the *strength of the knowledge* supporting the judgment.

Most forms of activity involve having to take risk. Consequently, the challenge is to strike the right balance between the need to create wealth and take risk, on the one hand, and the need to safeguard and protect wealth, on the other hand.

Physical climate risk is risk associated with the implications of physical changes in the environment. Commonly used benchmarks are the current climate or the pre-industrial climate situation. Norway will probably experience increased precipitation, more flooding, more frequent landslips and rising sea level, and these physical changes and the uncertainty associated therewith constitute risk factors. Many of the physical processes happen very slowly, from a human perspective. Even if net global emissions were to be reduced to zero within a short space of time, it may therefore take a very long time for the climate system to arrive at a new equilibrium.

Transition risk is risk associated with the implications of climate policy and technological developments upon transition to a low-emission society. An ambitious climate policy is likely to result in carbon-intensive energy sources such as coal and oil being largely replaced by renewable sources such as sun, water and wind,

but we do not quite know when and how this will happen. This has major implications not only for energy producers such as Norway, but for large parts of society and the economy worldwide in coming years. Figure 3.1 provides a diagrammatic illustration of physical risk and transition risk.

Different stakeholders may base their plans on different expectations. The risk outlook will be different for businesses that are planning for a continuation of the fossil-based energy sector than for businesses that are, for example, investing heavily in renewable energy. Many will be exposed to transition risk associated with changes in climate policy, energy policy and prices, as well as technological breakthroughs in the energy markets.

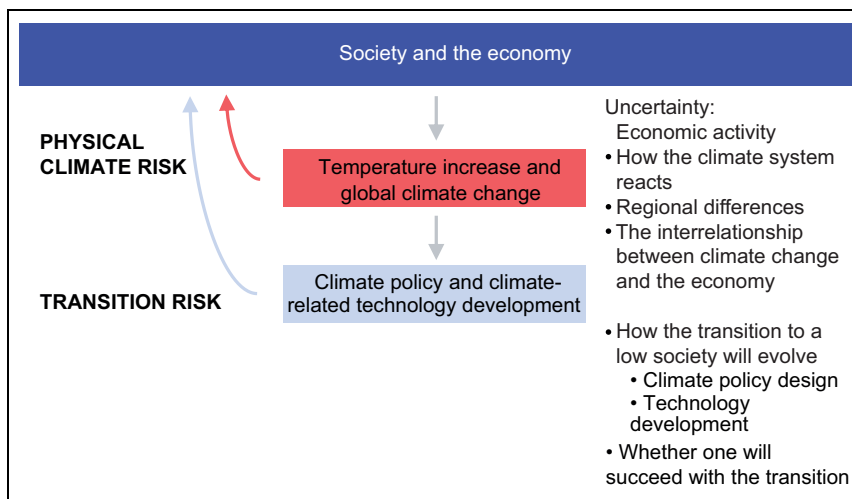


Figure 3.1 Climate risk – key relationships

An interrelationship between society and the economy, climate change, as well as climate policy and technological developments. Economic activity causes climate change, which results in feedback effects on society and the economy (physical climate risk) whilst also giving rise to climate policy and technology development, which again result in feedback effects on society and the economy (transition risk).

Source: Climate Risk Commission.

In risk analysis, uncertainty can in many cases be illustrated by way of scenarios. A scenario outlines a possible future development, based on specific mechanisms, assumptions and forces. In other words, it is not a forecast, but a hypothetical construct. Scenarios are intended to illustrate the potential range of future outcomes. An important function of scenarios is to challenge entrenched perceptions about the future, and thereby contribute to more informed decisions and increased resilience.

A resilient system is better placed to respond to external shocks. The vulnerability or resilience of a system denotes its ability to withstand a shock and nonetheless maintain its structure and functions. These shocks often have their origin in external sources and may be beyond the sphere of influence of those affected, but the vulnerability can be reduced (and the resilience increased) through measures that improve their ability to respond to the events. As an example, a municipal administration cannot in practice influence the global mean temperature or precipitation increases, but the municipal administration may have scope for reducing the vulnerability of the municipality – and thus local implications, such as stormwater, flooding and landslips.

The implications of climate-related events will depend on the resilience of society. The implications of events in the wake of global warming will depend not only on the magnitude of the events, but also on the ability of affected stakeholders and society as a whole to withstand such events. The same will apply to implications of a rapid transition to a world of radically reduced demand for fossil fuels. A more resilient society will face lower climate risk. Hence, measures to increase resilience constitute a key strategy for managing climate risk.

4 Climate risk and the Norwegian economy

The analysis of economic implications of climate change is fraught with difficulty. The existing knowledge base is limited, the available data are inadequate in numerous respects and the analyses carried out are subject to considerable uncertainty. Analyses based on historical experience may be of limited validity if fundamental physical circumstances are materially changed or if key social structures fail. The long time lag between emissions and warming means that implications may be further into the future than would normally be captured by model analyses. Many analyses are based on factors that lend themselves to some degree of quantification, but climate change will also have effects which are difficult to quantify, or which cannot meaningfully be quantified. Scenario analyses are therefore necessary to provide a more comprehensive illustration of the uncertainty.

Three stylised future scenarios shed light on a wide range of potential outcomes:

- *A – Successful climate policy:* This scenario involves a successful climate policy that delivers a swift transition to a low-emission society. No significant self-reinforcing mechanisms in the climate system are triggered, thus implying that the climate changes are moderate and the worldwide economic implications are relatively minor. However, the transition to a low-emission society may be challenging for various stakeholders.
- *B – Late transition:* Scenario B involves late climate policy tightening – following a period of further warming. We are, at the same time, «lucky» – and no self-reinforcing mechanisms in the climate system are triggered. The climate changes and economic implications are considerably more pronounced than in scenario A. There is a higher risk that the Norwegian economy will be indirectly affected by climate changes in other countries as the result of conflict escalation, diminished international cooperation and changes

in global migration patterns. In addition, belated and more severe policy tightening will increase the risk of financial instability.

- *C – Dramatic climate change.* This is a scenario involving political failure and/or the triggering of self-reinforcing mechanisms in the climate system. The economic implications of such catastrophic climate changes cannot be meaningfully quantified. Risk management advice would be of minor use, and the relevant measure is quite simply an effective climate policy that reduces the probability of ending up in scenario C.

Global factors are important to Norway. As a small, open economy holding considerable international financial wealth, Norway is highly dependent on what happens in the wider world. It is therefore necessary to adopt a global perspective in addition to the national one.

Climate change will curb worldwide economic growth. Numerous estimates indicate a global GDP loss as the result of global warming, compared to a benchmark without climate change. The consequences mount steeply with higher temperatures. In aggregate, the effects suggested by the estimates nonetheless seem modest, relative to the effort required to meet the targets under the Paris Agreement and relative to other uncertainties confronting the world economy. However, there are methodological challenges associated with the estimates and a risk analysis needs to adopt a broader perspective. Global averages conceal large differences between countries, and it is difficult to assess what implications major changes in individual countries or regions may have for the rest of the world through, for example, extensive migration. Besides, many of the implications of climate change are so serious as to not lend themselves to quantification, for example destruction of entire ecosystems or loss of entire societies through sea level rise.

Climate change may destabilise international politics. If already vulnerable states suffer major negative implications of climate change, the risk of political instability, humanitarian disaster and violent conflict will increase, both in and between states. The risk of conflict is also fuelled by the potential for climate change to cause shortages of important goods such as clean water. In addition to the possi-

bility that war and conflict may inhibit growth in the world economy, key risk sources for the international economy may be increased migration flows, unstable food prices, supply disruption and changing production and trading patterns. An ever more closely interwoven international community means that regional crises may have greater ripple effects, and events far away can hit harder, faster and in new ways. Effects of climate change may come to dominate political decision-making processes. The institutional capacity of countries may then become so absorbed by immediate damage control as to result in little attention being paid to international cooperation to resolve global problems, including the climate problem.

A successful climate policy may also have geopolitical implications. A new energy system based on renewable energy will change production patterns and the need for cross-border transport of energy. This will create new linkages, dependencies and power dynamics. Petroleum resources are often an important source of power and conflict. A climate policy resulting in a more decentralised energy system and significantly lower petroleum revenues may change power dynamics and have a destabilising effect on certain countries that are currently dependent on such revenues.

The considerable uncertainty with regard to international developments means that the range of potential outcomes for the Norwegian economy is very wide. Over the long time horizon we have adopted, the risk outlook will be dominated by the indirect physical risk associated with how the climate change hits other countries. However, direct physical risk and transition risk may also become important, especially the direct and indirect effects of changes in the value of the petroleum wealth. The time perspective is also important in this regard. The transition risk relates to a – hopefully – limited period of time until transition to a low-emission society has taken place. The physical risk will be increasing for a long time to come, even if one succeeds with climate policy, since it takes time to reduce emissions and it takes a long time from greenhouse gas emissions are eliminated until the climate system arrives at a new equilibrium.

An overall assessment of the key risk factors nonetheless indicates that the Norwegian economy can, all in all, be considered relatively resilient. A moderate level of global warming and climate change will have both negative and positive effects on the Norwegian economy. The implications of major climate change are potentially severe and challenging to envisage. Rich countries in the Northern Hemisphere are generally less exposed to direct negative effects of climate change than are poorer countries in the South. Moreover, rich countries like Norway will by and large have more well-functioning institutions, a higher level of education and a more diversified industrial structure. Higher income levels and flexible labour markets imply a greater capacity for absorbing transition costs whilst transitioning to a low-emission society (see Figure 4.1). Norway seems less vulnerable to climate change than most other countries, and is also held to be one of the best placed countries with regard to adaptability.

Useful insights can be gleaned by addressing climate risk from a national wealth perspective. An appropriate starting point for assessing climate risk for the Norwegian economy in the long run is to estimate how climate risk may affect Norway's overall consumption opportunities over time, and thereby the welfare of current and future generations. National wealth does not include all factors of importance to the welfare of the population (such as the value of leisure), and climate change may also affect factors that only have an impact on national wealth over time (such as ecosystems and biological diversity), but useful insights can be gleaned by adopting a national wealth perspective. Both transition risk and physical risk are relevant in this context. For some parts of the national wealth, for example real assets in the form of buildings, roads and railways, physical risk may be the most relevant. For other parts, such as the value of oil and gas resources and financial wealth, transition risk may be the most important. However, by far the most important component of national wealth is human capital; the value of our manpower, so an important question is how that may be affected by climate risk.

It is likely that moderate climate change will have more of an impact on the composition of Norwegian production, than on its level. Both transition risk and physical risk may affect the com-

position of employment and economic activity in mainland Norway, but it is anticipated that this will have a relatively minor long-run impact on overall economic activity in scenarios in which major climate change is avoided. This reflects the expectation that labour and capital will in the long run have about the same expected return in most industries. The share of the economy accounted for by different industries has changed considerably over the last century, and there is reason to expect that significant changes in the allocation between industries will continue also for the remainder of this century. An adaptable economy, in which manpower swiftly finds its way into new enterprises when needs change, is less exposed to climate risk.

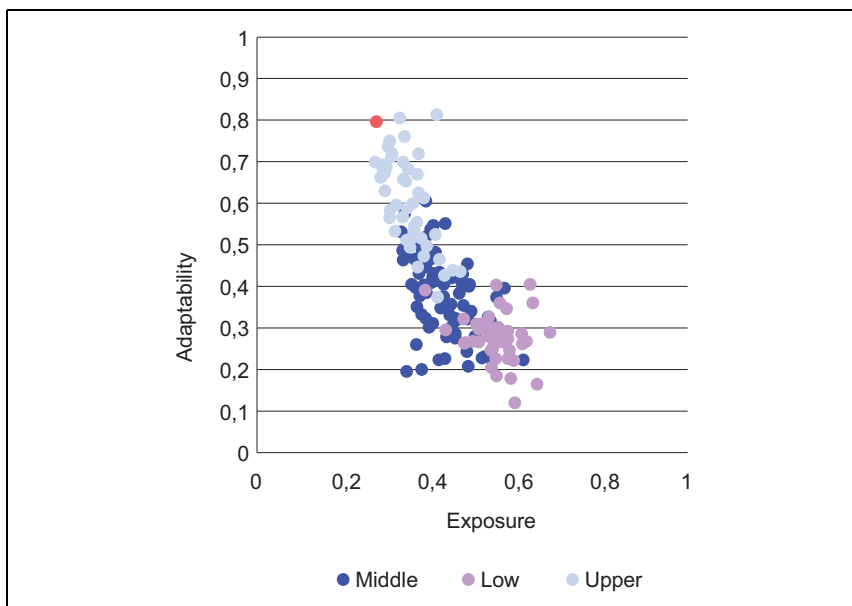


Figure 4.1 Exposure and ability to adapt to climate changes. Countries by level of economic development. Norway is indicated in red.

Source: University of Notre Dame Global Adaptation Index.

However, this is conditional upon the transition costs not being excessive. In the short run, there will be transition costs associated with the transition to a low-emission economy. The transition risk is an important climate risk factor for many businesses. However, if the transition takes place without any impact on general productivity, it will have no impact on the consumption opportunities of the population in the long run. There may nonetheless be scenarios in which transition costs are so high that they affect consumption opportunities over time, for example a development in line with Scenario B above, involving belated, but severe, tightening of climate policy. Such transition costs may potentially be increased through effects on financial markets.

In the case of major climate change, general productivity and productivity growth – also in the Norwegian economy – may be affected. Norwegian businesses benefit, for example, from well-functioning international trade, from research and development of knowledge which is disseminated globally and from other well-functioning international institutions. If key social structures and institutions of the world are weakened, this will also affect the productivity of Norwegian businesses. Other changes as the result of a warmer climate or associated with the transition to a low-emission society may also entail productivity effects. Lower productivity growth will mean reduced consumption opportunities over time and be reflected in national wealth through a reduction in the value of both human capital and real assets.

Industries based on exploitation of non-renewable natural resources need to be analysed separately in a national wealth perspective. These industries tend to be characterised by high economic rent, i.e. higher return than in other industries involving corresponding risk. In Norway, by far the highest economic rent is reaped in the extraction of petroleum. If such an industry is phased out before the economically viable resources have been exhausted, one cannot expect labour and capital to be able to find new uses in enterprises generating equally high returns. This constitutes a potential loss to the economy.

The value of human capital may be affected by migration flows resulting from climate change. One source of climate risk for Norway is changes in global migration patterns, which may have an impact on the composition and productivity of the population. The long-term implications of immigration for economic activity in Norway are highly uncertain, and are largely dependent on whether the immigrants find jobs, as well as their contribution to the productivity of the overall labour force.

Strict global climate policy will, when taken in isolation, reduce the value of the remaining petroleum reserves. If the targets under the Paris Agreement are to be reached, greenhouse gas emissions will have to be reduced steeply towards the middle of this century. Future prices of fossil energy sources are subject to considerable uncertainty, irrespective of which climate policy is adopted by the world. There are also several different potential price trajectories for oil and gas in a situation in which the world is implementing extensive measures to curtail CO₂ emissions. There is nonetheless every indication that implementation of an ambitious climate policy to curb the demand for fossil fuels will entail significantly lower producer prices than a reference pathway involving fewer climate measures. Hence, the difference between an ambitious and a somewhat less ambitious international climate policy may thus be of major importance to the value of Norway's petroleum reserves. However, the State's risk associated with the remaining petroleum reserves has declined considerably over the last few decades, in line with the oil and gas resources having been extracted and the central government revenues having been invested through the Government Pension Fund Global (GPFG), see Figure 4.2.

Lower petroleum wealth may affect other parts of national wealth. How other components of national wealth are affected by reduced petroleum wealth will depend on what are the causes behind the petroleum wealth decline. If a reduced level of activity in the petroleum industry over time results in lower wages in the economy in general, the human capital component of the national wealth may also be

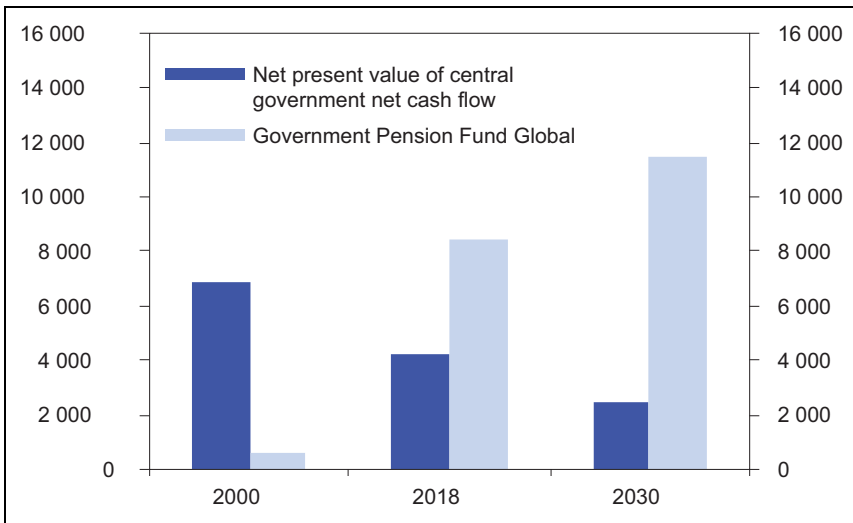


Figure 4.2 Value of the Government Pension Fund Global and the State's petroleum reserves, NOK billion.

Source: Ministry of Finance.

worth less. This suggests higher climate risk than might be indicated by the effect on the value of remaining petroleum resources alone.

Norway's high financial wealth is exposed to climate risk.

The conversion of oil and gas resources in the ground into a broad portfolio of financial assets in the GPFG has served to diversify the risk associated with Norway's national wealth over the last few decades. At the same time as we have observed reduced exposure to the petroleum sector, the accumulation of high financial wealth has brought new sources of risk. Climate risk is one source of risk which it is of particular importance for a large long-term investor to manage. The investments of the GPFG are diversified across a large number of companies in many countries. Over time, the return on the Fund will largely reflect global economic developments. Hence, the same climate-related risk factors that affect worldwide growth will also be relevant risk factors for the Fund.

Increased precipitation and changed energy mix will affect the value of hydropower. Increased precipitation may give rise to increased power generation, at the same time as electrification generally increases power needs. In Norway, warmer weather may, when taken in isolation, result in lower demand for electrical power for heating. In coming years, climate policy is likely to increase the portion of non-dispatchable power from wind and sun in Europe. This would suggest, when taken in isolation, increased value of Norwegian dispatchable hydropower in periods of low wind and sun production. In the long run, it is uncertain what effect a decarbonisation of the European power sector would have on the value of Norwegian hydropower. An ever-increasing share of non-dispatchable power generation, with very low operating costs, will increase the frequency of periods with very low power prices in the European power market. On the other hand, a strict climate policy that reduces the value of petroleum resources may to some extent increase the value of renewable hydro-power resources.

Parts of the fixed capital stock may be subject to increased capital depreciation and maintenance needs. Increased precipitation and stronger wind may result in higher maintenance costs for buildings and roads. Sea level rise along parts of the coastline may result in loss of value or higher costs associated with the relocation of buildings or roads. Adaptations to climate change may curtail such additional costs.

An increasing number of climate-related litigation claims are being brought before courts in different parts of the world. More focus on effects of, and costs associated with, climate change means that stakeholders are seeking to use the judicial system to halt activities which cause emissions or to be compensated for costs and losses resulting from climate change. Two basic types of legal action that may follow in the wake of climate change are tort actions and legal actions that challenge the validity of administrative decisions. Legal actions seeking to influence the substance of a state's climate policy have also been observed internationally.

The risk of tort litigation increases with the extent of damage. Tort action is a legal action in which the injured parties seek

to be compensated for a loss they have incurred directly or indirectly. A typical example from Norway may be compensation for homes destroyed as the result of flooding or landslips relating to climate change, whilst examples from other jurisdictions include legal action brought by government authorities against oil companies to claim compensation for increased infrastructure costs caused by climate change. Tort law in Norway is largely based on legal standards such as «negligence», with the threshold being defined through normative assessments of the acts or omission in question. What is considered to be negligent may be influenced by changes in factual circumstances, changes in the level of knowledge and changes in social expectations as to how certain situations should be dealt with. This implies that a stricter behavioural standard may be applied over time. In addition to serving a restorative purpose, tort law also has a preventive purpose in holding parties accountable. A dynamic development of the legal concepts through case law may thereby also provide incentives for improved response to new risk factors.

Legal actions can be brought against the state, moving for administrative decisions to be declared invalid. The outcome of such actions may be that activities are halted.

Litigation risk may involve large sums. It is difficult to quantify the litigation risk associated with climate change for Norway, but both legal actions to obtain compensation for losses and legal actions to halt activities or restrict the use of a resource may have a considerable financial impact on the parties involved. Even if the claimants ultimately do not prevail in a given legal action, such legal action may in itself have a number of implications for the defendant, both in the form of legal costs and the time and attention devoted to the action within the organisation, and in the form of potential reputational damage and increased uncertainty with regard to future profits.

5 From risk analysis to risk management

Norway is a market economy with a large public sector. There is an interrelationship between the public and the private sector, which implies that there is no sharp distinction between climate risk in the private and the public sector. It is therefore important to adopt an integrated approach to climate risk. Joint climate risk management principles and methods across all sectors – to the extent appropriate – provide the best basis for sound management of such risk for the Norwegian economy as a whole.

Central and local governments have important roles in societal planning. Key roles include decisions on land use and physical infrastructure development. An important question is whether climate change and climate-related risk considerations are accorded sufficient weight in public planning. Central government also carries responsibility for macroeconomic management, which is important for the sound long-term use of society's resources.

Norway has an open economy. This has brought us large welfare gains. However, Norway's open economy also exposes us to risks arising in other countries, including climate-related risk. Norway has little scope for managing such risk. It is therefore important to assess how Norway can strengthen its resilience to said risk. Resilience and adaptability are key aspects of a strategy for addressing climate risk in a sound manner – in both the private and the public sector.

In a market economy, the financial sector is of particular importance. Consequently, a key issue is what it will take for this function to be performed well in the transition to a low-emission society. Climate risk having occurred in other parts of the economy may, at the same time, impinge on the financial sector, for example through changes in the value of investments.

Normally, the market is a good mechanism for ensuring efficient production of goods and services. Market price forma-

tion serves to balance the supply of, and demand for, goods and services. Demand changes cause price changes, thereby signalling how supply should respond. In a well-functioning market, such price signals will result in efficient allocation of production resources in the economy.

However, markets will not function well in certain contexts.

The climate problem is in itself an example of serious market failure; an «externality». The atmosphere is a global public good, with individuals reaping the benefits of free consumption, whilst costs and disadvantages are passed on to the community. This results in excess consumption, which is at the core of the «tragedy of the commons». Various forms of market failure may also inhibit our ability to manage climate risk once it has materialised. It is therefore an important policy priority to identify and correct such market failure, in order to enable market mechanisms to facilitate, in the best possible manner, sound climate risk management in the economy.

The time profile of the climate problem makes it difficult to resolve under the time horizons applied by economic and political stakeholders. Long time lags, cooperation challenges, potential scope, as well as irreversibility, serve to make climate change a challenge different from most other. In order for long-term considerations to prevail, these need to be embedded in regulatory frameworks governing the behaviour of all members of society. This can be challenging.

We recommend a set of general climate risk management principles. The Commission has, from amongst the main climate risk management challenges, placed a special emphasis on various forms of market failure, the long time horizon over which climate risk needs to be assessed, the considerable uncertainty surrounding many aspects of the risk outlook, the fact that many of the assessments rest on a distinctly provisional knowledge base, and the need for uniform and cross-sectoral risk management attaching weight to the importance of resilience when confronted with risk we have little scope for managing. These considerations have led us to formulate a set of general risk management principles for both the private and the public sector, cf. Box 5.1.

Box 5.1 General climate risk management principles

1. **Comprehensiveness:** Use an integrated process in analyses of threats, opportunities and risk factors
2. **Framework:** Address climate risk in the context of other risks and risk frameworks
3. **Appetite:** Desired risk level must be based on a broad assessment of benefit, costs and robustness
4. **Resilience:** Attach weight to resilience in line with the precautionary principle
5. **Incentives:** Clear links should be established between decisions and implications
6. **Standardisation:** Risk assessments should be performed as similarly as possible across various fields
7. **Communication:** Risk management should be based on cooperation, information sharing and transparency

Moreover, the principles form the basis for more specific recommendations. Recommendations for contributing to sound climate risk management decisions can be classified into three categories:

- a. *Thorough analysis:* Global appreciation of climate risk is emerging, so more information, improved reporting and an expanded knowledge base are necessary. A comprehensive risk analysis considers various risk factors in context and shed light on uncertainty. The perspective must be expanded from forecasts with partial sensitivities to using scenario analysis in which several elements are changed simultaneously. For Norway it is of particular relevance to perform stress testing of fiscal policy and the petroleum sector.
- b. *Appropriate incentives:* A key role for policy is to correct market failure and create appropriate incentives, and a predictable and effective climate policy makes an important contribution to reducing climate risk. It provides public and private sector

enterprises with a better basis for establishing their future plans and investment decisions, and facilitates active corporate governance that addresses the long-term nature of climate risk. Furthermore, it gives the financial sector a better basis for performing its role in channelling loans and equity to businesses in the transition to a low-emission society in a sound manner. Misguided investments, poor returns and financial instability are thereby averted. It also paves the way for insurance arrangements to function as they should, and for prevention to be considered in relation to the extent of damage.

- c. *Integrated process*: A sound decision-making process adopts an integrated perspective in which climate risk assessments are conducted as similarly as possible across various fields, climate risk is considered in relation to other risk factors, and climate risk management is integrated into existing risk management frameworks in which the peculiarities of climate risk have been taken into consideration. The process should be broad and transparent to give rise to a joint understanding of risk, make affected parties take ownership of risk level preferences and strengthen the resilience of risk management. In addition, risk management must attach weight to resilience in line with the precautionary principle, in order to address uncertainty and potential surprises that are not captured well by the risk analyses.

6 Climate risk management in the private sector

A focus on knowledge, scenario analysis and corporate governance will be of importance for private sector climate risk management. Expanded knowledge and sound decisions can reduce climate risk. It is likely that the private sector will benefit from drawing actively on climate risk *information and knowledge* since this is a new and important discipline in which new insights are developed at a high pace, *scenario analysis and stress testing* to strengthen the resilience of business models in the face of high uncertainty, and *corporate governance* because the high uncertainty and long time horizon associated with climate risk suggest that owners and lenders should actively address risk that may go beyond the planning horizon of many enterprises.

Different stakeholders are confronted with different climate risks, and must perform different analyses, although based on common principles. Physical climate risk may for example give rise to challenges for insurance providers' pricing of claims risk, the localisation of enterprises in areas prone to flooding and landslips, and the resilience of integrated global supply chains based on limited warehousing. Uncertainty with regard to climate policy and technological developments makes it necessary for the oil industry to consider a range of very dissimilar oil and gas demand scenarios, including a scenario of steep decline in the use of fossil fuels. The potential for a dramatic restructuring of the transport system has implications for a great many stakeholders. Resilience can be strengthened by challenging entrenched perceptions about the future, through the use of tools such as scenario analysis and stress testing.

Climate risk affects the scope and scale of investments. Transition to a low-emission society means that some sectors and businesses are facing increasing demand and mounting investment needs, whilst for other businesses it may be more profitable to devote

a smaller portion of earnings to investments and return a larger portion to their owners. When confronted with increased uncertainty and a distinctly provisional knowledge base, it may be appropriate for businesses to favour investments characterised by flexibility and swift payback over projects which involve a long payback period and which are difficult to modify along the way. Flexibility means increased resilience, and resilience is valuable when faced with risk we have little influence over.

The financial market is a key climate risk management arena for the private sector. Businesses need to consider climate risk when making their investment decisions, and investment funding is often raised in the financial market. The private sector will also use the financial market to adjust its desired exposure to climate risk, with the financial market allocating risk both through hedging arrangements and through diversification across assets. When one market participant reduces its exposure to a risk factor, the risk is reallocated to other market participants. It is therefore an important question whether or not such risk ends up with market participants that are well placed to manage it.

The financial market determines which businesses obtain funding. When businesses seek to raise capital, whether from the banking system or the capital market, they need to convince lenders and investors that their operations are viable also in a future characterised by a different climate and a low greenhouse gas emission regime. Businesses wishing to invest in projects relating to a low-emission economy also need to be able to demonstrate that their projects meet accepted profitability requirements. The transition to a low-emission economy necessitates large investments, and a considerable portion of such investments will be channelled through the financial markets. If financial market participants have a proper understanding of what risk climate change entails for various sectors and businesses, it will enable investors and the financial industry to contribute to restructuring by way of corporate governance, granting of credit, as well as development of new products and instruments.

A dearth of information inhibits the financial market and exacerbates climate risk. It is a prerequisite for well-functioning

capital markets and an effective allocation of capital to investments that prices reflect available and relevant information, including information on climate risk faced by various types of enterprises. High and persistent uncertainty at many levels, with regard to climate change, climate policy as well as energy markets, impairs the ability of the market to price risk. Incorrect pricing of climate risk and incorrect allocation of capital may also increase the risk of financial instability in the longer run. Moreover, we know from experience that when financial imbalances are triggered, the interaction between the financial system and the rest of the economy may result in severe disruption.

The risk of financial instability depends on the timing and speed of the transition to a low-emission economy. Climate change represents a type of structural change that happens gradually and over a long period of time, which should in theory mean that financial market participants have ample time to modify their expectations and portfolios. If expectations concerning the transition to a low-emission society are upset by unforeseen shocks in the form of policy reversals, sudden price formation upheavals or technological breakthroughs, one result will be an increased risk of major market shifts and financial instability. As far as the previously mentioned future scenarios are concerned, financial stability will be less of a concern in scenario A of successful climate policy than in scenario B of later and more severe policy tightening. In scenario C of dramatic climate change, other risk is more dominant, but such risk may give rise to financial market disruption, which may itself exacerbate problems in other arenas.

Companies with high carbon exposure may be vulnerable in the transition to a low-emission society. There are a number of examples of slumping market value of enterprises in sectors experiencing technological shifts and regulatory upheaval. Global financial markets are held to be relatively efficient, thus implying that company valuations will reflect the profitability and uncertainty expectations of investors, including climate change and climate policy implications. Companies with large direct or indirect exposure to fossil energy sources may seem especially vulnerable in a scenario in which climate policy is tightened and the demand for petroleum products declines

significantly more than expected. Those petroleum reserves that are the most expensive to extract can in such cases be expected to be abandoned upon transition to a low-emission society. It is likely that such marginal reserves are of little significance to the current market valuation of oil companies.

Companies based on renewable energy are also exposed to transition risk. Uncertainty with regard to how various energy prices will evolve and which technologies will prevail also represent risk factors for companies focusing on a low-emission society. Rapid technology development and declining costs mean that investments made today may risk being quickly outcompeted by newer and cheaper capacity. Hence, the risk of misguided investments and a «Green Bubble» in renewable energy are also relevant issues when assessing climate risk factors in the financial market.

Climate risk and transition to a low-emission economy necessitate good reporting and corporate governance. It is a challenge that incentives and time horizons are not necessarily concurrent for owners and executives, or for capital owners and managers, whilst it may be challenging for owners to get access to sufficient information about, and control over, how duties are discharged. Such principal-agent problems are a general challenge in financial markets, but may be of special relevance to climate risk in view of the long-term nature of such risk and its potential for generating major structural market changes.

Corporate governance may be of special relevance for industries facing restructuring. In the long run, it must be assumed that strict and effective global climate policy aimed at reducing demand for fossil fuels will result in swifter restructuring of the global petroleum industry than under a benchmark without stricter climate policy. A key challenge for investors is to assess the extent to which such restructuring will take the form of restructuring of existing companies or the gradual downscaling of such companies and the development of new ones. If one is faced with a situation in which oil companies are confronted with reduced access to attractive and profitable projects within their traditional core business, both research and experience indicate that one runs a risk of weaker capital discipline

and lower returns to owners. This means that active follow-up is required on the part of owners in order to ensure that future investments, whether in the traditional core business or in any new business areas, offer adequate profitability. There has been a steep increase in global investor initiatives to address this challenge. These initiatives focus on improved climate risk management, value chain emissions reduction and improved reporting. More transparency surrounding the transition strategies adopted by companies in response to the climate challenge is intended to enhance the scope of investors for imposing discipline on the capital use of companies.

Good corporate reporting on climate risk is of key importance. Statutory requirements and established market standards shall facilitate corporate reporting that provides market participants with relevant information they can base their investment decisions on. Corporate reporting of climate-related risk has thus far been heterogeneous and fragmented. This gave rise to an international effort to examine how companies can report on climate-related risk in a better and more systematic manner. FSB (a cooperation forum for the financial supervisory authorities of the G20 countries) appointed the Task Force for Climate-related Financial Disclosures (TCFD) to develop a framework for the reporting of climate-related risk. The TCFD report was completed in 2017 and has been widely endorsed internationally.

TCFD recommends a framework for reporting of climate-related risk that can help companies identify climate-related threats and opportunities. By including climate-related information in ordinary corporate reporting, one facilitates more informed decisions on the part of investors and others with regard to climate-related threats and opportunities. Reporting on how they factor climate risk into their strategy processes, and on how such risk is identified, measured and managed, may make companies more aware of what risk climate change may pose to their business model. A key recommendation from TCFD is that companies should stress test their business models against reasonable climate policy scenarios, and specifically against a scenario in which the temperature increase is limited in line with the ambitions under the Paris Agreement. Such stress tests may be of considerable value to investors, since companies will have to

show how they are going to make money if the climate policy ambitions are met. The Commission is of the view that the recommendations in the TCFD report can also be of relevance to the public sector.

7 Climate risk management in the public sector

The public sector plays a key role in Norway's climate risk management. The State will in many contexts relieve the private sector of risk through, for example, pension and social security schemes, risk sharing in the tax system, state aid and guarantee schemes. This implies that the State's exposure to, and perspective on, climate risk will differ from those of a private stakeholder. Central and local governments are responsible for societal planning through decisions on land use and the development of physical infrastructure, and are also responsible for macroeconomic management and long-term exploitation of society's resources. The public sector manages large assets that are exposed to climate risk. The central government holds financial reserves through the Government Pension Fund, direct ownership stakes in petroleum resources and facilities, as well as direct holdings in a number of Norwegian companies. Many municipalities hold large assets related to power companies. Besides, special tax regimes for the petroleum and hydropower sectors channel a large portion of future revenues from the said natural resources into the public sector. A key question is whether physical climate risk and transition risk considerations are accorded sufficient weight in public planning, resource management and ownership follow-up.

An inadequate knowledge base and weaknesses in decision-making processes may result in insufficient attention being paid to climate risk. Climate risk is challenging to manage because there is much we do not know, at the same time as a very long-term and broad perspective is needed. Political and administrative decision-making processes may, on their part, be inherently prone to myopia, it may be difficult to apply a risk perspective suitable to resolving challenges across sectors and disciplines, and a lack of overlap between those making the decisions and those living with the implications

thereof may result in insufficient weight being attached to prevention rather than repair.

Effective climate policy is of key importance to climate risk management. An effective climate policy is the sole tool for alleviating the risk of catastrophic climate changes, and is thus of altogether key importance to climate risk management issues.

Climate policy should be effective and predictable to succeed with the restructuring of society and the economy. In order to transition to a low-emission society and adapt ourselves to the effects of climate change, it will probably be necessary to use policy tools more effectively – both in Norway and globally. Late climate policy tightening will mean higher costs and more risk in the transition phase than if climate policy is boosted early, and in a cost effective and predictable manner.

Correction of market failure creates value and eases climate risk management. Lack of correct price signals, lack of information or lack of appropriate incentives on the part of decision makers are examples of market failure that may inhibit our ability to manage climate risk. Too low CO₂ price may, for example, cause global overinvestment in fossil-based industries and excess consumption of fossil fuels, whilst suboptimal incentives and responsibility arrangements may result in prevention not being adequately linked to the extent of damage. An important role for policy is to identify and correct such market failure.

Resilience is often an effective defence against risk. Since one will often be faced with risk one has limited scope for managing, whilst there is at the same time high uncertainty with regard to what will be the impact of such risk, the resilience of society is of great importance when it comes to the implications of climate-related events or the implications of a transition to a low-emission society. This suggests that government authorities should attach weight to policy measures that strengthen the resilience of society, for example through increased use of scenario analyses and stress testing to challenge entrenched perceptions and prepare for a greater range of outcomes.

Scenario planning and stress testing may result in more resilient societal planning. It is challenging to capture how climate change affects the risk outlook. Plans and decisions currently adopted at various administrative levels may have implications many decades into the future, and such plans need to accommodate the requirements implied by future climate changes. The Commission is of the view that central government should establish, maintain and publish a set of scenarios for oil prices, gas prices and CO₂ prices, including a scenario reflecting the ambitions under the Paris Agreement. Such an initiative can make a positive contribution to stress testing for activities that are exposed to the said prices, and may provide a basis for consistent stress testing of climate risk across the public sector. Publication of the scenarios can support private sector risk management and boost confidence in public sector risk management.

The decision-making basis for public sector investments should be strengthened. The Instructions for Official Studies require estimates of financial and administrative implications of planned investments, and the Ministry of Finance has adopted principles and requirements for the preparation of cost-benefit analyses to advance the quality and comparability of such analyses. This framework requires all significant risk factors to be taken into account, but the special characteristics of climate risk lead the Commission to recommend that additional guidance be prepared to ensure that climate risk is actually integrated properly into the decision-making basis for key public sector investment decisions, as well as in public sector financial and administrative management. The development of scenario analyses, stress testing, price trajectories and uncertainty analysis guidelines form part of this effort. Climate risk is a new discipline and our understanding is advancing rapidly. The development of a specific thematic guidance note on how climate risk should be integrated into cost-benefit analyses may include a survey of international best practice on climate risk assessments, as well as an examination of the scope for applying such practice in Norway.

Public finances are exposed to climate risk through the oil price. In order for the State to be well placed to absorb the risk associated with the extraction of petroleum sector resources upon transition

to a low-emission society, public sector budget planning should provide leeway for accommodating a successful climate policy. A strict climate policy will, when taken in isolation, mean lower government revenues than a less ambitious climate policy. However, the risk to public finances posed by oil price changes is held to be manageable, when assessed in isolation and relative to other types of risk faced by the public sector. The oil price assumptions underpinning economic policy in Norway are fairly cautious when compared to forecasts from recognised research centres. Besides, a large portion of the current valuation of petroleum resources relates to revenues over the next decade. Even though an ambitious climate policy targeting the demand side will, when taken in isolation, result in lower producer prices and lower petroleum production volumes than would otherwise be the case, the value of Norway's petroleum resources will therefore not necessarily be substantially lower than in the assumptions underpinning current fiscal policy. Moreover, the fiscal policy framework is tailored to the special challenges Norway is faced with in the management of high petroleum wealth, in both the short and the long run. The fiscal policy guidelines imply that petroleum revenues are not spent until these have materialised and been transferred to the GPFG.

The climate risk faced by the State should be rendered more visible. In order to enhance the knowledge base for assessing how the future outlook for both petroleum-related and other Norwegian industries depends on petroleum prices, technological development, climate policy and climate changes, central government should at suitable intervals, for example in the white paper on long-term perspectives on the Norwegian economy published every fourth year, present the overall climate risk exposure of Norway and the State. Central government should as part of such exercise use the mentioned set of scenarios for oil prices, gas prices and CO₂ prices, including a scenario reflecting the ambitions under the Paris Agreement. Such scenarios may also be used to stress test Norway's petroleum wealth, and the State's stake therein, in the ongoing petroleum wealth reporting in the national budget documents. This will render the sources of climate risk more visible. Unlike classic sensitivity analysis showing isolated price trajectory changes, the scenarios may also cap-

ture the effects of interactions between changes in prices and volumes. Light may also be shed on climate risk associated with the petroleum wealth by examining Norwegian resources from the perspective of a global supply curve. It may also be useful to show various dimensions of the composition of petroleum wealth, for example how the discounted cash flows are distributed over time and what portion originate from fields that have already been developed.

The effect of climate change on overall national wealth is important to clarify implications for future national consumption opportunities. In the development of macroeconomic models for use in designing policy, it would be advantageous to focus on better integration of the overall effects of climate change on the national wealth than is available at present. Furthermore, it would be useful for projections to pay more heed to how technology development, and various scenarios in relation thereto, affect climate risk, public finances and overall national wealth.

It is also appropriate to render climate risk more visible in connection with new petroleum investments. Analyses of development projects that provide indications of the resilience of such projects to changes in assumptions are already being published. An appropriate enhancement of this framework would be to link such resilience assessments to the scenarios for stress testing of the petroleum wealth as a whole. This will provide central government with more active monitoring of developments in the value of the project portfolio on the Norwegian continental shelf and a clearer impression of the risk exposure in the portfolio. However, the decision-making system for petroleum sector investments should not be modified. The companies will still be best placed to assess relevant risk factors, and climate-related risk is one of a great many risk factors that need to be assessed in development projects. More systematic and comparable information on the resilience of new development projects when confronted with climate change may nonetheless strengthen confidence in the decision-making system, whilst at the same time adding new insight into developments in climate risk for overall petroleum wealth.

A high tax level on the continental shelf results in more exposure to climate risk, whilst also meaning high expected

revenues. This is a desired and intended effect of the system: The tax system shall ensure that the extraordinarily high return in the petroleum sector accrues to society. This implies, at the same time, that society will carry the cost of a potential reduction in such return as the result of a successful climate policy.

Within the limits defined by government authorities for their activities, it is important for oil companies to have an incentive, in their ongoing exploration, development and operation, to make those decisions which will maximise the value extracted from the Norwegian continental shelf. One aspect of this is a neutrally designed petroleum tax system. It is outside the scope of the Commission's mandate to assess modifications to the petroleum tax system, but the Commission notes that increased climate-related risk does not in itself suggest that one should deviate from the principle of neutrality. Climate risk is one of many factors that can influence petroleum product price developments, and the tax system cannot distinguish between different sources of price change.

New hydropower opportunities may reduce Norway's overall transition risk. The flexibility of Norwegian hydropower may make it well suited for providing spare capacity in a European energy system in which sun and wind account for a large proportion of overall capacity. Regulatory frameworks facilitating investments in dispatchability and transmission capacity vis-à-vis European energy markets, as well as promotion of a well-functioning market mechanism in which the market's demand for flexibility is reflected in power prices, will serve to reduce transition risk for the Norwegian economy.

Climate risk may give rise to new challenges for macroeconomic stabilisation policy. Accelerating climate change and expanding climate policy measures may increase the incidence of negative supply side shocks, for example in the form of increases in the cost of food, energy or transport. It is generally challenging to address such situations in stabilisation policy, but increased awareness of, and transparency in, various aspects of climate risk will make monetary policy and fiscal policy more resilient. Monetary policy authorities that clarify how they intend to manage new potential supply side

shocks can provide the private sector with a better foundation for its climate risk management.

Climate risk may pose challenges to natural disaster insurance and damage prevention. Increased frequency of extreme weather may make it more difficult for non-life insurance providers to diversify risk, which may potentially make it problematic to obtain insurance on market terms for properties located in particularly vulnerable areas. When the legislative commission evaluating certain aspects of the natural disaster insurance scheme has submitted its report, it would be appropriate to follow up on this by also assessing whether other aspects of the natural disaster insurance scheme are optimally structured, for example whether the principle of uniform premium level irrespective of the risk of natural disaster should be re-examined to provide stronger incentives to invest in damage-prevention measures. Another measure that may strengthen damage prevention is increased information sharing between non-life insurance providers and government authorities. If the industry itself does not agree on a uniform standard for the reporting of damage, government authorities should seek to find data sharing solutions that promote competition between insurance providers, whilst at the same time enabling central and local government to use such data in an appropriate manner.

The important role of municipal administrations in ensuring a climate-ready society should be strengthened. The local nature of climate change puts municipal administrations at the «frontline» of climate change response. Climate change affects many of the responsibilities of municipal administrations, such as where to build, what type of infrastructure should be developed, as well as how to safeguard the life and health of inhabitants. The responsibility of municipal administrations for ensuring a sufficient basis for decision making before plans are adopted thus necessitates suitable impact assessments, as well as risk and vulnerability analyses. Addressing climate change and climate risk is a cross-sectoral effort, encompassing municipalities, counties, cities and directorates. The Norwegian Directorate for Civil Protection (DSB) shall ensure integrated and coordinated natural disaster preparedness. The Norwegian Water

Resources and Energy Directorate (NVE) shall assist in relation to flooding and landslips, and provides assistance with land use planning, mapping, safety measures, warning/monitoring systems and contingency planning. Every fourth year, the Government shall prepare a set of national expectations for regional and local planning. Government authorities should in that context assess whether the quality of municipal land use planning, as well as risk and vulnerability analyses, is adequate, and also whether warning systems are sufficiently rapid and effective.

A climate risk information portal may facilitate climate risk management. It can be difficult to manage climate risk if the information on what climate risk one is confronted with is fragmented or not readily accessible. The public sector can strengthen the climate risk management capacity of both the private and the public sector by making relevant climate risk information readily accessible through a web-based knowledge hub, encompassing both general and detailed climate risk information, specified by geographical areas and individual industries.

Climate risk disclosure for the Norwegian economy should be further enhanced. There is currently an extensive system for calculation and reporting of greenhouse gas emissions accounts and follow-up of international climate commitments under the UN Framework Convention on Climate Change and the Kyoto Protocol. Besides, the Government is required to report annually to the Storting on the status of national climate targets under the Climate Act. It is important to devote more attention to the risk perspective, and the Commission proposes a more comprehensive and systematic reporting on climate risk.

The TCFD framework may also be of relevance in this regard. The TCFD framework appears to be in the process of becoming an internationally recognised reporting standard for companies, and it is appropriate to assess whether that framework can also be adapted and applied to public-sector entities and to the Norwegian economy. This may facilitate more comparable reporting across sectors and countries. We are in Figure 7.1 outlining a potential system-

Governance	Risk description	Risk management measures	Risk measurements and methods
Description of general framework and key principles for managing	Description of climate-related risk faced by the Norwegian economy, and how it may affect key national objectives and strategies	Description of measures aimed at managing climate-related threats and opportunities	Description of how to measure and monitor climate-related threats and opportunities
A. Describe current framework and key principles applied by the Government in managing climate-related risk	A. Describe climate-related threats, opportunities and associated risk in the long, medium and short term for national objectives and strategies	A. Describe potential measures of strengthening resilience under relevant scenarios	A. Describe key climate-related indicators for the country
B. Describe the role of the public administration in the identification and management of climate-related threats and opportunities	B. Describe how climate-related risk affects “overall risk” (e.g. relating to the Norwegian economy)	B. Describe potential measures of managing physical climate risk	
	C. Describe the resilience of overarching objectives, strategies and functions under relevant scenarios and uncertainties	C. Describe potential measures of managing transition risk	

Figure 7.1 Suggested framework for national reporting on climate change.

The framework proposes reporting on climate risk management framework and principles, description of various climate risk factors, measures to manage climate risk, as well as how the risk is measured.

Source: Climate Risk Commission.

Box 7.1 Recommendations for public sector climate risk management

Avert catastrophic climate change:

- a) Government authorities should promote an ambitious and effective global climate policy to avert catastrophic climate change

More information, improved reporting and an expanded knowledge base:

- b) Climate risk knowledge and skill should be developed, with a focus on scenario thinking and stress testing. Government authorities should keep abreast of developments in international climate risk thinking, including assessments of geopolitical risk in relation to climate change and transition to a low-emission society
- c) The TCFD principles on disclosure and reporting should be endorsed. The Commission proposes a TCFD-inspired framework for climate risk disclosure in the public sector and at the national level
- d) Central government should establish and maintain a designated set of scenarios for oil prices, gas prices and CO₂ prices. Central government should conduct stress testing of public finances in relation to climate risk and ensure that fiscal policy is resilient with regard to climate-related shocks and disruptions. Central government should conduct stress testing of Norway's national wealth in relation to climate risk, and should focus on better integration of the overall effects of climate risk on national wealth in the development of macroeconomic analyses and models
- e) Central government should advance the development of a web-based knowledge hub to improve access to climate risk information

Box 7.1 continued

Correct market failure and create appropriate incentives:

- f) Central government should correct market failure in order to improve the scope of markets for managing climate risk, as well as facilitate a versatile economy with well-functioning labour market. Central government should conduct an effective and predictable climate policy
- g) Central government should facilitate new hydropower opportunities, which may reduce Norway's overall transition risk
- h) Central government should consider a comprehensive review of the natural disaster insurance scheme to highlight the link between prevention and the extent of damage
- i) Stimulate businesses to integrate long-term climate risk in the strategic planning

Sound decision making processes with an integrated perspective:

- j) Weight should be attached to general climate risk management principles
- k) Central government should prepare a specific thematic guidance note on climate risk to strengthen the public sector decision making system
- l) Government authorities should stimulate high quality central and local government planning which accommodates climate risk

atic climate risk disclosure framework for the Norwegian economy, inspired by the TCFD framework. It is proposed to report on a regular basis on how climate-related risk is identified and managed. Such reporting will serve to enhance the knowledge base established through the present report over time, as well as transparency concerning the principles and processes underpinning climate risk man-

agement. This can contribute to an improved decision making basis for the sound management of such risk, in both the private and the public sector.

This report lays a foundation which others will have to add to. Climate risk thinking is in an early phase. In view of the time at the disposal of the Commission for completing its report, we have focused on creating a shared understanding of climate risk at a general level and on facilitating knowledge sharing and knowledge building. We emphasise the need for more information, improved reporting and a stronger knowledge base, and we have focused on conveying general and universal insights, principles and recommendations. This means, at the same time, that there is a need for others to take this further, both by evolving the appreciation of climate risk in general and by assessing climate risk in various sectors. Prioritising research on climate risk is one aspect of this. It is our hope that this report can establish a sound basis for more systematic thinking on climate risk in both the private and the public sector.

Appendix: Mandate and proceedings of the Commission

The proceedings of the Commission have been conducted pursuant to a Royal Decree of 6 October 2017, whereby the Solberg Government appointed an Expert Commission to assess climate-related risk factors and their significance for the Norwegian economy. The mandate of the Commission is worded as follows:

«The world's annual greenhouse gas emissions have doubled since 1970, and the stock of such gases in the atmosphere has increased. Norway has ratified the International Climate Change Convention agreed at COP 21 in Paris, whose purpose is to keep the average temperature increase well below 2°C compared with pre-industrial levels, and to strive to limit the temperature increase to 1.5°C. To support the long-term temperature target, the Paris Agreement set a collective emissions target with the aim of reversing the increase in global greenhouse gas emissions as soon as possible in order to achieve balance between man-made emissions and the absorption of greenhouse gases

in forests and seas during the second half of this century (climate neutrality).

Both climate change and measures to counter it affect conditions for and risks associated with economic activity:

- *Higher average temperatures, changes in rainfall patterns, less alkaline seas and higher sea levels may have consequences for water supply, agriculture and settlement, and for production and consumption opportunities in a broader sense. More extreme weather may also alter physical impact patterns.*
- *Measures to counter climate change also have consequences. Technological development, carbon pricing and regulation may alter global market conditions for carbon-intensive goods and services. Transitioning away from fossil energy may trigger a fall in the value of capital and fossil fuel reserves, which in turn may disrupt the activities of enterprises and financial institutions. Revenue and asset valuations may also change in other areas as a result of new policies or the development of new technologies to address climate change. Major changes over a short period of time may present banking and insurance businesses with challenges, and threaten financial stability.*

This recognition has led to increased demand for decision-relevant information on the exposure of financial institutions and other businesses to climate-related risk. Among other things, a task force appointed by the Financial Stability Board has made recommendations including voluntary reporting of climate-related financial risk in businesses and measures to strengthen the capacity of investors and others to assess and price climate-related risks and opportunities. G20 has taken note of the report. Increased knowledge about a country's overall exposure to climate risk can support such voluntary assessment and reporting, and strengthen the informational foundation for aligning policy and instruments to reduce national climate-risk vulnerability and safeguard long-term value creation.

Different countries are affected differently by climate risk, reflecting variations in geography, industry structure, consumption patterns and adaptability. Developments in oil and gas prices and

demand are important factors for Norway, and great emphasis has therefore been given to the uncertainty of future oil revenues in the formulation of economic policy. This is one reason why the state's petroleum revenues are channelled directly into the Government Pension Fund Global and invested in a broadly diversified global portfolio of equities, bonds and real estate. Only the expected real return on the fund capital, estimated at 3 per cent, is spent annually through the fiscal budget. This policy increases the robustness of the fiscal budget and welfare-scheme funding in the face of potential falls in oil and gas prices.

The decline in oil prices since the summer of 2014, and the subsequent downturn in the Norwegian economy, illustrate that oil prices also affect the Norwegian economy through demand for products from the supply industry. This issue was analysed in the Government's white paper on Long-term Perspectives on the Norwegian Economy 2017. An insight gained in recent years is that the adaptive capacity of individual industries has a considerable influence on the socioeconomic consequences of changing market conditions. Nevertheless, further knowledge is needed to enable evaluation of the links between the outlook for petroleum-related and other Norwegian industries and petroleum prices, technological development, climate policy and climate change.

The commission will assess climate-related risk factors and their significance for the Norwegian economy, including financial stability. The commission is asked to:

- Assess how national-level climate risk can be most effectively analysed and described.*
- Identify key global climate-related risk factors, and consider their importance for the Norwegian economy and financial stability.*
- Consider a possible methodology for giving private and public entities, including financial institutions, a technical basis for analysing and managing climate risk in the best possible way.*

In its work, the commission must take into account that the consequences of likely climate change and of the global community's efforts to

counteract or adapt to such change may have different timeframes. Where appropriate, the commission should take into account that the Norwegian economy also faces risks linked to factors other than climate change and changes in climate policy. The commission is asked to emphasise the distinctive characteristics of the Norwegian economy and Norway's industry structure, but also to recognise that such characteristics change over time. It will be natural to investigate how selected other countries approach issues raised by climate-related risk factors. In its work, the commission may also seek specialist input from relevant national and international experts.

The guidelines on fiscal policy and the investment strategy for the Government Pension Fund Global have recently been assessed by other public commissions, and therefore fall outside the scope of this mandate. Further, the commission is not tasked with proposing measures to reduce greenhouse gas emissions, specific measures to facilitate adaptation to climate change, or changes to the petroleum tax system or Norwegian petroleum policy.

The commission is asked to deliver its recommendation by 14 December 2018.»

The Commission has comprised the following members:

- Martin Skancke, MSc (Econ) (Chair)
- Professor Terje Aven
- Research Director Nalân Koç
- Professor Klaus Mohn
- Trude Myklebust, PhD candidate
- Professor Linda Nøstbakken
- Professor Ragnar Torvik

The proceedings of the Commission have been supported by a secretariat. The secretariat has been chaired by Thomas Ekeli of Folketrygdfondet, with the other members being Hege Eliassen, Herbert Kristoffersen and Andreas Marienborg of the Ministry of Finance, Hanne Birgitte Laird and Bent Arne Sæther of the Ministry of Climate and Environment, Carl Gjersem of the Ministry of Trade, Industry and Fisheries, Line Sunniva Flottorp Østhagen of the Ministry of

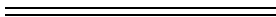
Petroleum and Energy, as well as Katinka Holtmark of the University of Oslo.

Nine meetings of the Commission have been held. A number of individuals have provided the Commission with valuable knowledge on key issues. The Commission has met with Borgar Aamaas, Asbjørn Aaheim, Christa Clapp and Kristin Halvorsen of Cicero, Mirella E. Wassiluk of DNB, Inger Hanssen-Bauer and Cecilie Mauritzen of the Norwegian Meteorological Institute, Patrick du Plessis of NBIM, Stein Lier-Hansen and Øystein Dørum of the Confederation of Norwegian Enterprise (NHO), Anders Bjartnes of the Norwegian Climate Foundation, Per Sanderud of the Norwegian Water Resources and Energy Directorate (NVE), Lars Eirik Nicolaisen and Jo Huseby of Rystad Energy, Jon Vatnaland and Henrik Nissen Sætness of Statkraft, Eirik Wærness of Equinor, Bård Harstad of the University of Oslo, Rick van der Ploeg of the University of Oxford, Per Krusell of the University of Stockholm, Carlo Aall of the Western Norway Research Institute, as well as Haakon Vennemo of Vista Analyse.

In order to solicit additional knowledge and perspectives, the Commission Chair has in addition to the above attended a number of public seminars and conferences, and held meetings with representatives of the Norwegian Directorate for Civil Protection (DSB), DNB, Energy Norway, the Ministry of Finance, the Financial Supervisory Authority of Norway, Finance Norway, the Ministry of Local Government and Modernisation, the Norwegian Association of Local and Regional Authorities, the Agricultural Cooperatives in Norway, the Norwegian Confederation of Trade Unions (LO), McKinsey, the Norwegian Oil and Gas Association, the Confederation of Norwegian Enterprise (NHO), the Norwegian Institute of International Affairs (NUPI), the Norwegian Water Resources and Energy Directorate (NVE), the Ministry of Petroleum and Energy, Oslo Economics, the Office of the Attorney General, the Ministry of Transport and Communications, Statkraft, Statnett, as well as the Ministry of Foreign Affairs.

Besides, the Commission has received written input from a number of stakeholders, which is available on the Commission's website «nettsteder.regjeringen.no/klumarisikoutvalget».

The Commission would like to thank everyone who has contributed to our proceedings with their observations and professional assessments. Moreover, the Commission would like to thank the members of the secretariat for their effort and patience.



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