SINTEF

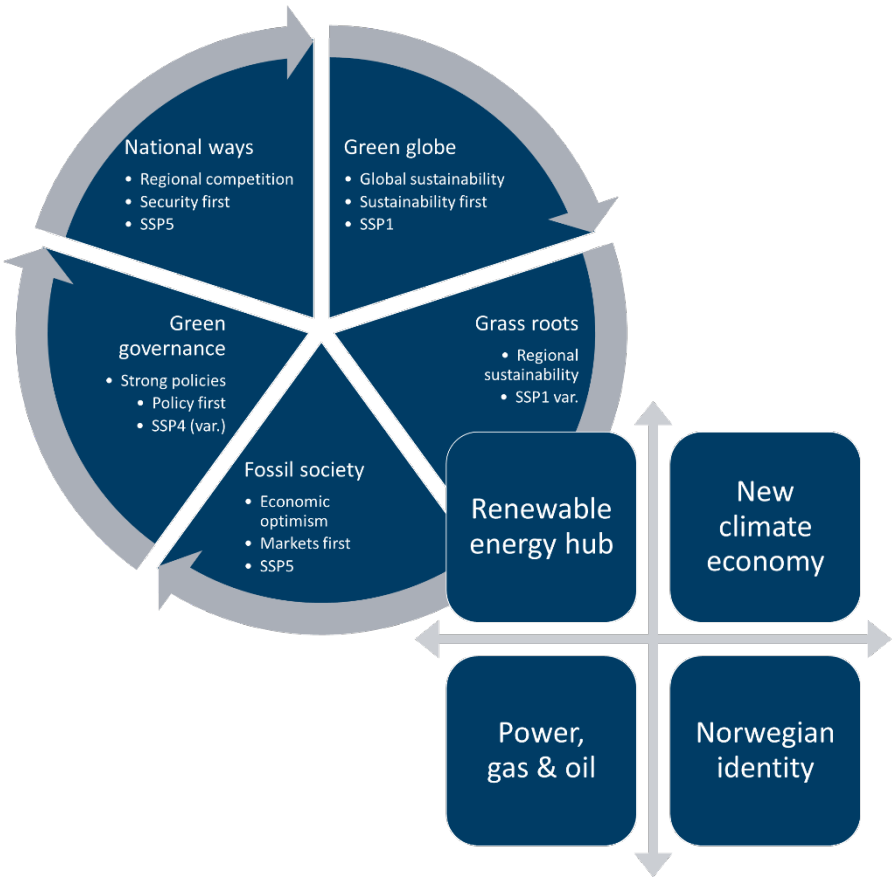
TR A7590- Unrestricted

Report

CenSES energy scenarios

Design process and scenario description

Author(s)
Stefan Jaehnert



SINTEF Energy Research
Production Planning
2016-09-09

SINTEF Energi AS
SINTEF Energy Research
Address:
PO Box 4761 Sluppen
NO-7049
NORWAY
Switchboard: +47 73597200
Telefax: +47 73597250
energy.research@sintef.no
www.sintef.no/energi
Enterprise /VAT No:
NO 939 350 675 MVA

Report

CenSES energy scenarios

Design process and scenario description

KEYWORDS:
Scenarios
Energy system

VERSION
1.1

DATE
2016-09-09

AUTHOR(S)
Stefan Jaehnert

CLIENT(S)
CenSES FME

CLIENT'S REF.
User partner
Research partner

PROJECT NO.
502000135

NUMBER OF PAGES/APPENDICES:
32 + Appendices

ABSTRACT

Abstract heading

Scenarios are a formal way to describe and examine future and uncertain developments, useful to increase knowledge and to give insights for policy development and decision-making. This report establishes a common basis for scenario analyses in the FME CenSES in the form of a set of CenSES energy scenarios.

The established CenSES energy scenarios are developed with a bottom-up approach, with the aim to ensure the engagement of CenSES user partners. The scenarios result from a combination of defined futures, which have a European/global scope and a set of strategies, which have a Norwegian focus.

The five futures are Green globe, Grass roots, Fossil society, Green governance and National ways. These are combined with the four different strategies Norwegian identity, Power Gas & Oil, Renewable energy hub and New climate economy. A set of four apparent and four potential combinations is selected as the CenSES energy scenarios.

PREPARED BY
Stefan Jaehnert

SIGNATURE

CHECKED BY
Marte Fodstad

SIGNATURE

APPROVED BY
Knut Samdal

SIGNATURE

REPORT NO. TR A7590
ISBN 978-82-594-3673-3
CLASSIFICATION Unrestricted
CLASSIFICATION THIS PAGE Unrestricted

SINTEF Energi AS
SINTEF Energy Research

Address:
PO Box 4761 Sluppen
NO-7049
NORWAY
Switchboard: +47 73597200
Telefax: +47 73597250

energy.research@sintef.no
www.sintef.no/energi
Enterprise /VAT No:
NO 939 350 675 MVA

Report

CenSES energy scenarios

Design process and scenario description

KEYWORDS:
Scenarios
Energy system

VERSION
1.1

DATE
2016-09-09

AUTHOR(S)
Stefan Jaehnert

CLIENT(S)
CenSES FME

CLIENT'S REF.
User partner
Research partner

PROJECT NO.
502000135

NUMBER OF PAGES/APPENDICES:
32 + Appendices

ABSTRACT

Abstract heading

Scenarios are a formal way to describe and examine future and uncertain developments, useful to increase knowledge and to give insights for policy development and decision-making. This report establishes a common basis for scenario analyses in the FME CenSES in the form of a set of CenSES energy scenarios.

The established CenSES energy scenarios are developed with a bottom-up approach, with the aim to ensure the engagement of CenSES user partners. The scenarios result from a combination of defined futures, which have a European/global scope and a set of strategies, which have a Norwegian focus.

The five futures are Green globe, Grass roots, Fossil society, Green governance and National ways. These are combined with the four different strategies Norwegian identity, Power Gas & Oil, Renewable energy hub and New climate economy. A set of four apparent and four potential combinations is selected as the CenSES energy scenarios.

PREPARED BY
Stefan Jaehnert

SIGNATURE

CHECKED BY
Marte Fodstad

SIGNATURE

APPROVED BY
Knut Samdal

SIGNATURE

REPORT NO.	ISBN	CLASSIFICATION	CLASSIFICATION THIS PAGE
TR A7590	978-82-594-3673-3	Unrestricted	Unrestricted

Document history

VERSION	DATE	VERSION DESCRIPTION
0.8	2016-06-30	First draft version
1.0	2016-08-30	Final draft version
1.1	2016-09-09	1st feedback from research partners

SINTEF

Table of contents

APPENDICES

Excel sheet - CenSES_energy_scenarios_futures_strategies.xlsx

1 Introduction

As stated in the objective of RA5 [1] in CenSES knowledge to policy- and decision makers shall be provided based on *scenario* studies. Hence, one of the main objectives is to define a number of *CenSES energy scenarios*, including a qualitative and quantitative description.

The *CenSES energy scenarios* to be developed address Norwegian energy and climate policies and consider EU and global policies where relevant. The main target group for the scenario results are policy and decision makers in Norway (in particular CenSES user partners), but also in Europe. These scenarios are based upon the cross-disciplinary knowledge developed in CenSES and include both quantitative and qualitative aspects. The main purpose of the scenarios is to define the scope, boundary conditions, parameter data and framework for the energy system analyses to be carried out in the next step. A bottom-up approach, schematically depicted in Figure 1, has been applied to define the scenarios.

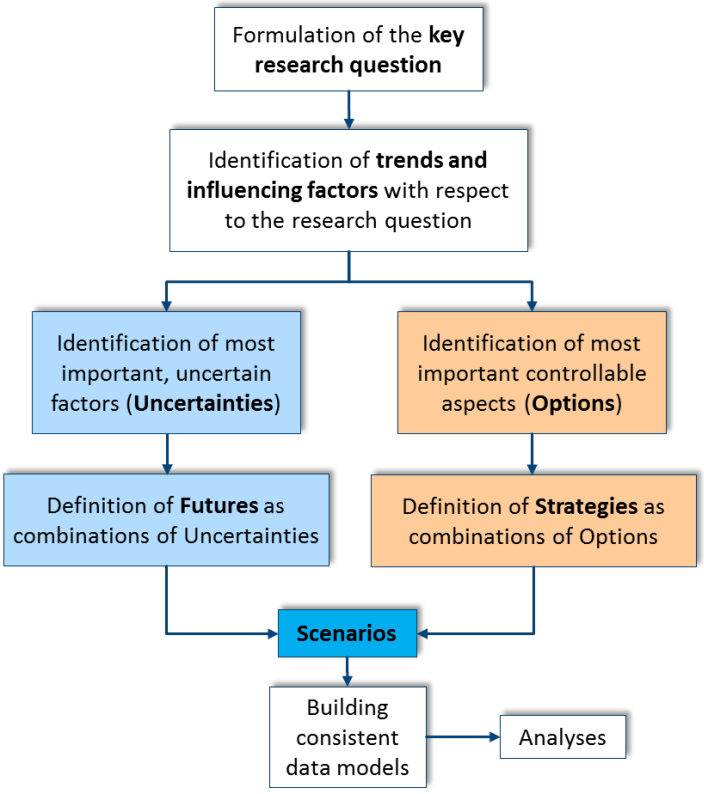


Figure 1: Scenario building process using a bottom-up approach, identifying uncertainties and options in order to form scenarios

2 Methodology

In order to ensure transparency, engagement and efficient communication of assumptions and results across the whole CenSES consortium, a detailed bottom-up approach is proposed for the scenario building. After initially formulating the *key research question*, the construction of relevant scenarios are done by distinguishing between *uncontrollable uncertainties* and *controllable options*, cf. Figure 1. Uncontrollable uncertainties are factors which the decision makers cannot control, but that are important for the development of a sustainable energy system of the future. Controllable options are factors which can be implemented by the decision makers.

This Project Report documents the first step (scenario definition) of the scenario building process and the following analyses. Hence, relevant uncertainties and options will only be described verbally. The following work will focus on the specification and quantification of both uncertainties and options, and may also include revisions such as additions, modifications or removal some uncertainties and/or options.

Any combination of uncertainties will create a possible *future* in which a sustainable energy system will be implemented. The decision makers' choice of one or more options will combine into a possible *strategy* on how to implement a sustainable energy system. This is illustrated in Figure 2. Different *scenarios* will be established by choosing an appropriate set of strategies in combination with different relevant futures.

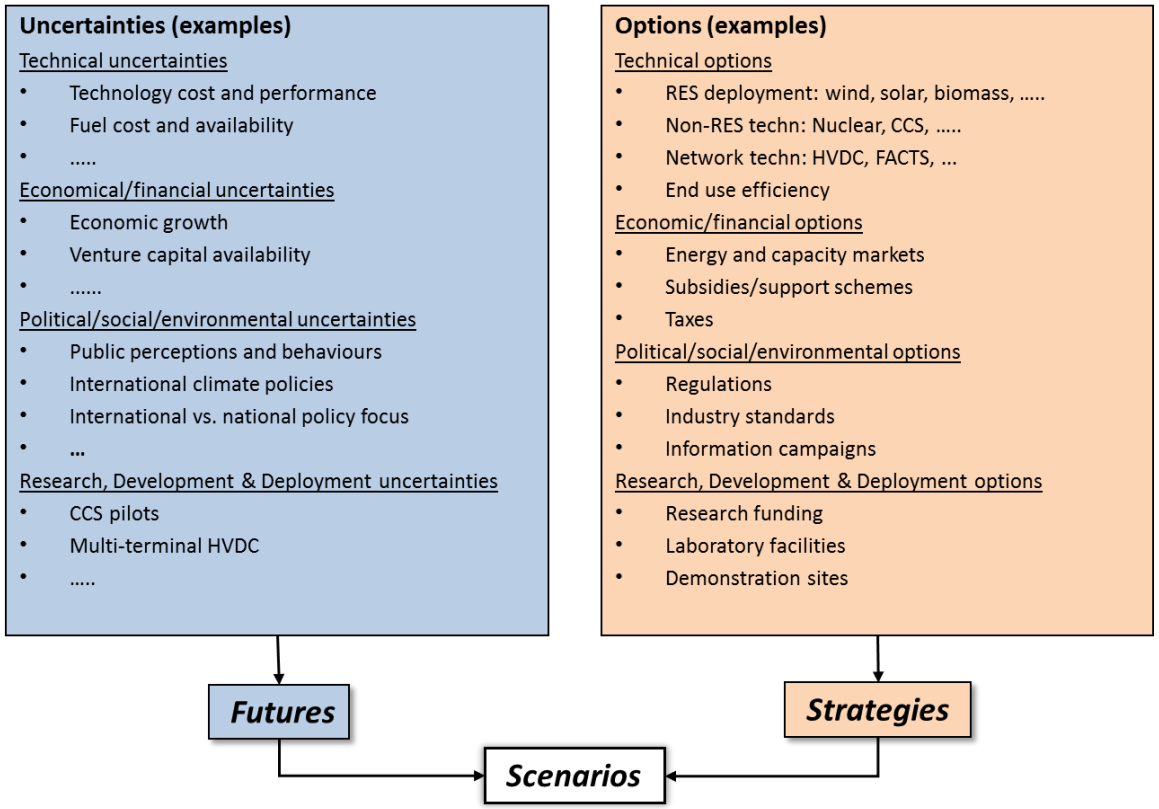


Figure 2: Examples for the construction of Scenarios from Uncertainties and Options

Furthermore, there can be a set of *assumptions*, indicating an uncertainties that do not change between the different futures (or an option that is included in all strategies). In that case, it is no longer an uncertainty but a *fixed condition for all the scenarios*.

The resulting CenSES energy scenarios are neither predictions nor forecasts. It is not claimed that one scenario will be more probable to happen than another, nor that one scenario is more preferred to or qualitatively "better" than others. Rather, each scenario is one alternative image of how the future could unfold, based on a combination of relevant options and uncertainties. The policy recommendations stemming from CenSES' work will be based on further analysis of the scenarios.

Although the main target group of CenSES is Norwegian and Nordic decision makers, the CenSES energy scenarios must have a European perspective to allow for studies with a broader scope. Thus, the initial approach is to define a set of scenarios with European / global futures in addition to a set of Norwegian strategies for the energy system. (Naturally, this first set of scenarios can be modified, expanded or reduced by the scenario team during the progress of work.)

3 CenSES energy scenarios - framework workshop

For the energy scenario, design process in CenSES an initial workshop was held. The objective of the workshop was to:

- Provide a common platform and understanding for the development of CenSES energy scenarios
- Identify the framework for the energy scenarios to be developed:
  - Define the key research question
  - Identify important factors to define different futures and strategies
- Ensure that CenSES user partners provide their input to the scenario building process
- Ensure that CenSES user partners see interesting challenges and can contribute with their expertise within the scenario framework

The outcome of the workshop is the basis for the futures, strategies and resulting scenarios presented in the following. A comprehension of the workshop results can be found in appendix A.1.

4 Research focus

As described in the previous section, our first step is to define a key research question / focus. Within the FME CenSES, a number of premises are set for the scenarios, listed in the following subsection. Furthermore, the key research question and additional important aspects have to be taken into account when developing the scenarios.

4.1 Premises

The premises set by the FME CenSES for the energy scenarios are:

1. The main focus is the energy system.
2. The target group is Norwegian society and industry including policy and decision makers.
3. The target horizons will be 2030 and 2050
4. The main geographic target of the scenarios will be Norway, while interactions with the Nordic area, Europe and globally have to be taken into account

4.2 Key research question

How can Norway contribute to the global reduction of GHG and meet its climate targets for 2030 and 2050, while ensuring value creation within the framework of the energy system? Where can Norway be a leader and contribute to a sustainable value creation based on its particular advantages?

4.2.1 Norway's climate goals

In 2008, a climate agreement was achieved among most of the parties in the Norwegian parliament [4]. The climate goals defined in the agreement have later been updated [5], [6], [7]. Norway has the following climate targets:

- Norway shall up to 2020 take the obligation to cut the emission of greenhouse gasses by 30% of Norwegian emissions in 1990 [4].
- Two-thirds of the emission cuts shall be achieved within Norway, while one-third will be cut through measures outside Norway [4].
- Norway shall be carbon neutral in 2050 [4].
- The Norwegian government suggests to cut GHG emissions by 2030 with at least 40% compared to 1990 [5].
- The energy- and environment committee of the Norwegian parliament opines that carbon neutrality shall be achieved in 2030, due to the successful negotiation of the Paris Agreement (COP21) [7].

4.2.2 Norway's particular advantages

The large amount of natural energy resources is considered to be Norway's main advantage within the framework of the energy system. Among others, these are the fossil resources such as oil and gas and the renewable energy source hydro, but also wind. Due to the mostly remote location of these resources, there already is significant transmission and transport infrastructure already exists, providing large flexibility resources in addition to ensuring transmission of energy.

Furthermore, due to the large offshore and maritime industry sector, including gas & oil extraction as well as fishery and fish farming, Norway has a leading position in offshore and maritime research, development and technologies. Finally, Norway is at the leading edge for the research, development and implementation of CCS in the energy system as well as other emission intensive industry sectors.

5 Scenario framework

A bottom-up methodology for the development of scenarios was applied with the intention to facilitate/incorporate the contribution from the CenSES user partners and ensure a formal documentation of the development process. Due to the rather general research questions and the wide range of the resulting scenarios, this methodology was preferred over a top-down methodology[1].

Within the bottom-up methodology, the resulting scenarios are a combination of defined futures and strategies. As discussed previously the CenSES energy scenarios shall have a Norwegian focus, but also consider European and global developments have to be taken into account. Thus, the scenario development methodology applied here is two-folded. The strategies are developed with a pure Norwegian focus, while the different futures describe possible European and global developments.

5.1 Scenario studies

Recently the climate change research community developed new scenarios, cf. O'Neill et al [8]. Instead of defining scenarios according to their outcome as done previously (2 degree scenario, 4 degree scenarios etc.), now the focus is on the assessment of climate impacts and options for mitigation and adaption. For that a set of shared socioeconomic pathways (SSP) is developed. Van Vurren and Carter [11] present a mapping of scenario from different studies on climate change research and assessment. Within this mapping, the single scenarios are grouped into six different "families" or archetypes of scenarios. UNEP's Global Environmental Outlook [12] draws four different storylines on the environmental development. Beside the environmental stability, a special focus is also set on the social stability of the development. The NorStrat project [10] developed a "Nordic Power Road Map 2050", with the objective to be emission neutral, having an emphasis on the requirements for the future transmission network.

As a basis for the futures of the CenSES energy scenarios, the SSP scenarios developed for IPCC [8], scenario archetypes defined by [11], storylines drawn in [12] and developments done in the e-Highway2050 project [9] are used. The Norwegian strategies are to some extent based on the scenarios in the NorStrat project [10] and further extensive internal discussion.

In the following the drafted futures and strategies are described. A detailed overview of important factors that define uncertainties and options for the futures respectively strategies can be found in [3].

5.2 Futures

A future is a possible development / prospective state of the system. It is the combination of various uncertainties, which mostly comprises EU / global developments that Norwegian society has rather limited or no influence on. The specification of the futures was done in two main steps. At first all of the important factors were listed, which was done during the CenSES scenario workshop and further direct CenSES user partner involvement[2]. Afterwards, this extensive list was structured into different categories.

In the second step, the SSP scenarios [8] were used as a guideline to set up different futures. Finally, the previously identified important factors were categorised within each of the futures, cf. [3]. Each of the futures belongs to one scenario archetype as described by [11]. While there is a good relation between the SSPs and the futures, it is not a strict mapping. For the CenSES energy futures it is decided not to defined as specific reference / base case.

[1] Within a bottom-up methodology, scenarios are created based on the combination of different futures and strategies, taking uncertainties and options as a basis. On the contrary, in a top-down methodology, a set of the most important factors is identified, which then span the scenario space. In case of two factors, this results into 2*2=4 scenarios.

[2] Meeting at NVE February 15th 2016, meeting at Statkraft February 29th 2016

Table 1 shows the five futures that are defined: Green globe, Grass roots, Fossil society, Green governance and National ways. The table also provides the mapping of the defined futures to the scenario archetypes, the SSPs and the storylines described by UNEP's GEO. In addition to the mapping, some general characteristics of the futures is provided. Correspondence with other scenarios defined by the IEA [13] [14], the European Commission [15] and ENTOS-E [16] is also indicated. A description of the defined futures and the according mapping can be found in the following table.

Table 1: CenSES energy futures and according mapping[3]

CenSES energy future	**Green Globe**		**Grass roots**	**Fossil society**	**Green governance**	**National ways**
Economic growth	High in LIC, MIC; Medium in HIC	Medium	Medium	High	High in HIC, MIC; Low in LIC	Low
Technology development	Rapid	Medium	Medium	Rapid	Rapid for high-tech	Slow
Trade	Globalisation	Weak globalisation	Trade barriers	Globalisation	Globalisation	National protection
Carbon intensity	Low	Medium	Medium	High	Medium	High in regions with resources
Energy intensity	Low	Uneven, high in HIC	Medium	High	Medium	High
Policies and institutions	Regional to global efforts	Mixed	Local	Free markets	Multinational cooperation	National governments
Mapping to other studies						
SSP scenarios [8]	SSP1	SSP2	SSP1 var.	SSP5	SSP4 / SSP4 var.	SSP3
UNEP's GEO [12]	Sustainability first			Markets first	Policy first	Security first
Scenario archetype [11]	Global sustainable development	Business as usual	Regional sustainability	Economic optimism	Strong policies (Reformed markets)	Regional competition
World Energy Outlook [13]	450	Current policies			New policies	
Energy Technology Perspective 2015 [14]	2DS	6DS			4DS	
EU Energy Roadmap 2050 [15]		Reference	Energy efficiency	Diversified supply technologies	High RES, Current policy initiatives	
TYNDP 2014 [16]		Slow progress	Green transition	Money rules	Green revolution	

[3] HIC: High-Income country; MIC: Medium-Income country; LIC: Low-Income country;

5.2.1 Green globe

A green revolution is taking place. Society, policy makers and the private sector are aware of and target the challenges due to climate change. There are common efforts on local, regional, national and international level. The focus is no longer on economic growth as such, but rather on societal and environmental sustainability. This leads to value creation based on the development and deployment of sustainable energy technologies. Use of life cycle assessment of various technologies raises awareness of impacts related to resource use, which result in reduced use of resources. The green globe future is based on the following:

- **Energy and Climate Policy:** A global agreement for climate change mitigation is achieved and a global carbon market is established. There is a global trend of reduced fossil fuel consumption per capita, however, Europe still imports a minor share from outside the EU. Common agreements and rules for transnational initiatives regarding the functioning of an internal EU market, EU-wide security-of-supply and the coordinated use of infrastructure for transnational energy exchanges are implemented. There are significant incentives for a sustainable development and a low-carbon society including large funds for R&D.

- **Technological development:** All relevant renewable energy (RES) and demand side management (DSM) technologies have become mature. In addition, both small-scale (decentralised) and large-scale (centralised) storage technologies are mature. Furthermore, CCS technology is mature on a global scale and is deployed in the power sector and the process industry. Electrification of transport, heating and industry is considered to occur both at centralised (private sector) and de-centralised (residential) level. Hydrogen technologies are mature and applied for storage and as an energy carrier in the transport sector.

- **Economic:** The global population growth slow down and the demographic change trend towards 2050 is migration only. Furthermore, GDP growth in the EU is medium, while it is high in developing and emerging countries. This indicates an overall strong economic activity, which has facilitated the successful completion of a global climate agreement. Costs for fossil fuels are relatively low since there is a reduced demand for fossil fuels. On the other hand, CO_2 costs are high due to the existence of a global carbon market (emission trading system).

- **Socio-political perceptions:** Public attitude to the deployment of RES technologies is positive. Due to a successful global climate agreement and generally high focus on climate mitigation and environmental challenges, the public attitude towards nuclear and shale gas as energy sources is negative in Europe. Moreover, a clear shift towards 'greener' behaviours is experienced compared to e.g. present practices (focus and active involvement towards more energy efficiency, focus and active involvement towards more use of sustainable energy by the general public).

5.2.2 Grass roots

There is no intense multinational cooperation and significant regional differences regarding initiatives for climate change mitigation. Climate policy is mainly implemented by local actors. Due to a more regional focus, trading barriers do exist. Hence, the development is driven in the direction of small-scale solutions, leading to a partial decoupling from and less dependence on the transnational energy systems. Furthermore, the grass roots future is based on the following:

- **Energy and Climate Policy:** A global agreement for climate change mitigation does not exist. Still Europe is committed to its target of 80-95% GHG reduction. Furthermore, there are no common agreements for transnational initiatives regarding the functioning of an internal EU market, EU wide security of supply and coordinated use of infrastructure for transnational energy exchanges. Hence, there is no potential for large-scale multinational investments and solutions. On the contrary, most of the focus is on de-centralised solutions dealing with de-centralised generation and storage as well as smart grid solutions at transmission and distribution level. Due to a heterogeneous European landscape of energy strategies, energy dependency from outside EU is medium, and some countries still rely on imports from outside the EU. The energy portfolio outside EU is moderately dominated by fossil fuels. There is a weak European emission trading system.

- **Technological development:** RES and specifically DSM technologies have become mature. Since the long-term development is in the direction of small-scale solutions, predominantly small-scale storage solution technologies are mature. Due to lack of support, CCS technology has not become mature. Electrification of transport and heating is considered to occur at a residential (small-scale) level. There is a significant development for smart-grid technologies.

- **Economic:** Due to coordination and trading barriers, the GDP growth in EU is low to medium. Value creation is based on national industry development. Sustainable energy does not provide profitable business models, but in some of the regions, RES is supported to provide a cheap and reliable energy source. The demographic change in the EU towards 2050 is population growth. Fossil fuel consumption is generally medium to high worldwide, which causes high fuel prices. ETS is primarily controlled by national authorities. Hence, the general supply of CO_2 allowances in the market is high and CO_2 prices in the EU are low. Economic growth worldwide is linked to the use of fossil fuels. This gap correlates with the fact that a global climate agreement was not successful and that the energy policy situation in EU is heterogeneous.

- **Socio-political perceptions:** The public attitude to deployment of local de-centralized RES technologies is positive in Europe. Although political targets are clear and there is a common commitment on sustainability and energy independency, Member States in coordination with the European Commission develop their energy strategies from a national point of view. Attitudes towards nuclear and shale gas are generally negative as these solutions are considered large-scale centralised and non-sustainable energy technologies. A major shift towards 'greener' behaviours is experienced compared to present practices (active involvement towards more energy efficiency and towards more use of sustainable energy by the general public). In general, the public is very active and most of the development occurs on a local de-centralised level.

5.2.3 Fossil society

There is a strong belief in the ability of free markets to deliver social and environmental stability. The private sector, with active government support, pursues maximum economic growth as best path to deliver social and environment improvements. Global challenges are tackled with advanced and complex technical solutions. There is a commodification of common environmental goods, leading to an accompanied cost and trade-off for environmental protection. Furthermore, the globalisation trend intensifies, leading to integrated markets and the removing of institutional barriers. The fossil society future is based on the following:

- **Energy and Climate Policy:** There is no global agreement for climate change mitigation, instead common global achievements are reversed. The future is driven by the success of industrialised as well as emerging and developing economies, becoming more equal. This development is generally based on fossil fuels, leading to an increased consumption and competition for fuel. There are common agreements and rules for transnational initiatives regarding the functioning of an internal EU market, EU-wide security-of-supply and the coordinated use of infrastructure for transnational energy exchanges.

- **Technological development:** Due to missing incentives, there is no significant development for RES, DSM and storage technologies neither small-scale nor large-scale. However, the development for CCS is successful as a technological measure to tackle climate change. Likewise, there is significant R&D in the field of nuclear technologies, including small and large scale as well as nuclear fission. Finally, the growth of the process industries and the transport sector are intensified.

- **Economic:** A very high GDP growth is expected in the EU due to strong market-driven industrial activities, and this supports the trust in market mechanisms as the main instruments for development. The demographic change trend towards 2050 is migration only, as a consequence of the strong market-driven development in the EU and the GDP growth in the emerging and developing countries. Economic growth worldwide is linked to an extensive use of fossil fuels, due to the fact that a global climate agreement was not successful. At the same time, this provides the opportunity for the profitable export of fossil fuels.

- **Socio-political perceptions:** The development of the European energy system is basically market-driven, thus the public attitude towards environmental issues and RES technologies is indifferent in the EU. As the economic growth is based on fossil fuels, the attitude regarding the use of nuclear and shale gas as energy sources is positive. No shift towards 'greener' behaviours is experienced, but present practices are kept (poor involvement towards more energy efficiency or more use of sustainable energy by the general public). In general, the public is passive and everything is left to stakeholders in a market-driven fossil-based energy system.

5.2.4 Green governance

The EU, with active private and partial civil sector support, initiates and implements strong climate policies in a centralised top-down approach. While still emphasizing economic development, large-scale, multi-national solutions are preferred. Sustainable energy solutions are seen as profitable business opportunities, implying their rapid development. Due to the policy support, the private sector has the ability to invest in large-scale solutions. Thus, on the one side, society experiences low energy costs. On the other side, large parts of the society do not profit from the increased value creation, due to an unequal distribution of profits and their exemption from economic growth. This and a scepticism to the top-down approach potentially induces societal instability. In addition, the green governance future is based on the following assumptions:

- **Energy and Climate Policy:** A global agreement for climate change mitigation has been reached. Common agreements for transnational initiatives regarding the functioning of an internal EU market, EU wide security of supply and the coordinated use of infrastructure for transnational energy exchanges in the EU exist. Moreover, there is a strong policy support for large-scale centralised solutions for RES deployment and storage. This facilitates the possibility to realise an offshore grid in the North and Baltic Seas and potential solar energy projects in North Africa. Fuel costs are low since there is a very low demand for fossil fuels. On the other hand, CO_2 costs are high due to the existence of a global carbon market. The high CO_2 cost and policy also lead to a large-scale development and deployment of CCS.

- **Technological development:** Due to the centralised approach, large-scale RES technologies have become mature. Since the long-term focus is on large-scale solutions, predominantly large-scale storage technologies are mature. Likewise, CCS is mature and deployed. Electrification of transport, heating and industry is considered to occur mainly at a centralised level.

- **Economic:** Demographic change trend towards 2050 is based on migration only at EU level. The GDP growth is medium and the economy is policy steered, which has facilitated the successful achievement of a global climate agreement. However, RES technologies are still subsidised and national and European authorities are actively supporting the international initiatives needed for large-scale solutions to be realised.

- **Socio-political perceptions:** The public attitude towards deployment of (specifically large-scale) RES technologies is somewhat negative in the EU, as large parts of the society do not profit from it. In addition, there are bureaucratic barriers for small-scale implementation. The energy strategy is deployed from a top-down approach at EU level with a coordinated trans-national approach based on a strong framework for policy and incentives, supporting the market functioning. Attitudes towards nuclear are positive, and these technologies are preferred instead of de-centralized local solutions. Moreover, only a minor shift towards 'greener' behaviours is experienced in this future compared to present practices. In general, the public is somehow passive and everything is coordinated at high level following a top-down strategy.

5.2.5 National ways

The cooperation of countries weakens and national independence, sustainability, security-of-supply and protection become more important. Governments and the private sector compete for control in efforts to improve or maintain human well-being, only benefitting parts of the society. Thus, there is no ground for a common greenhouse gas reduction commitment. Furthermore, the national focus leads to increasing barriers, reduced trade and economic growth as well as a slowdown in development. Multi-national solutions cannot be achieved any longer. In addition, the national ways future is as follows:

- **Energy and Climate Policy:** A global agreement for climate change mitigation does not exist. The EU has collapsed and there is no European commitment for a GHG reduction. Likewise, there are no common agreements for transnational initiatives regarding the functioning of an internal EU market, EU wide security of supply and coordinated use of infrastructure for transnational energy exchanges. On the contrary, the focus is on national protection, value creation and security of supply. This leads to national centralised and some de-centralised solutions dealing with generation, storage and smart grid solutions. Due to various national energy strategies, there is a competition for fuel and the energy dependency from outside of the EU is high. The energy portfolio outside Europe is moderately dominated by fossil fuels.

- **Technological development:** DSM technologies have become mature. Since the focus is national and on security of supply small-scale solutions, predominantly smart grid technologies have become mature. Due the missing multinational cooperation, CCS technology has not become mature. Generally, there is a low technological development. Electrification of transport and heating is considered to occur mainly at a small-scale level. There is a development of smart-grid technologies.

- **Economic:** The GDP growth in Europe is low, mainly due to the national focus and inhomogeneous economic activity among European countries. The focus is on protecting and developing the national industry sector. Cheap energy sources are required for the economic growth and hence are subsidised. The demographic change trend at EU level towards 2050 is population growth. Fossil fuels consumption is generally medium to high worldwide, which makes fuel prices high. There are a few national ETS and not in all European countries. Thus, there is no significant impact on reduction of CO_2. The supply of CO_2 allowances in the markets is high and CO_2 prices are low. Economic growth worldwide is linked to the use of fossil fuels. This gap correlates with the fact that a global climate agreement was not successful and there are only national energy policies in Europe.

- **Socio-political perceptions:** The development in Europe is national. Due to missing common efforts, the public attitude towards environmental issues and RES technologies is indifferent. To secure national energy supply and economic growth, the attitude towards development and deployment of nuclear and shale gas as energy sources is positive. A minor shift towards 'greener' behaviours is experienced compared to present practices (poor involvement towards more energy efficiency or more use of sustainable energy by the general public). In general, the public is active, however with a national focus.

5.3 Strategies

The strategies are the combinations of various options, which the target group for the analyses can influence. In the context of the CenSES energy scenarios, this mostly comprises decisions with a Norwegian focus. The specification of the strategies was done in two main steps, as for the futures. At first all of the important factors, which can be influenced, were listed and structured afterwards. In the second step, the scenarios defined in the NorStrat [10] project were used as a reference and internal discussions served to define Norwegian strategies.

The defined strategies were based on the research question, which was stated in Section 4.2.

> How can Norway contribute to the global reduction of GHG and meet its climate targets for 2030 and 2050, while ensuring value creation within the framework of the energy system?

Besides determining a framework for the scenario development, the research question addresses two main aspects: reduction of greenhouse gas emissions and value creation. Therefore, the following two main degrees of freedom for the strategies are chosen:

- Strong national climate policy vs. weak national climate policy:
  This dimension describes how strict the national policies for reduction of greenhouse gas emission in Norway are defined in a strategy. Given a strong climate policy, emissions in Norway have to be reduced by 100%. In case of a weaker climate policy, two-thirds[4] of emission have to be reduced with Norway, but a certain share of reduction can also be achieved outside Norway.

- Value creation through energy export vs. Energy consumption and value creation:
  The main focus of value creation can either be exporting energy or extensively developing the industry sector in Norway based on the Norwegian energy resources.

Combining these two dimension results in four different strategies as shown in Figure 3. Available options were categorised within each of the strategies. The resulting four strategies are Norwegian identity, Power Gas & Oil, Renewable energy hub and New climate economy. These different possible Norwegian energy strategies are discussed in the following.

[4] The two-thirds are in line with the Norwegian climate goals [4] agreed upon in 2008.

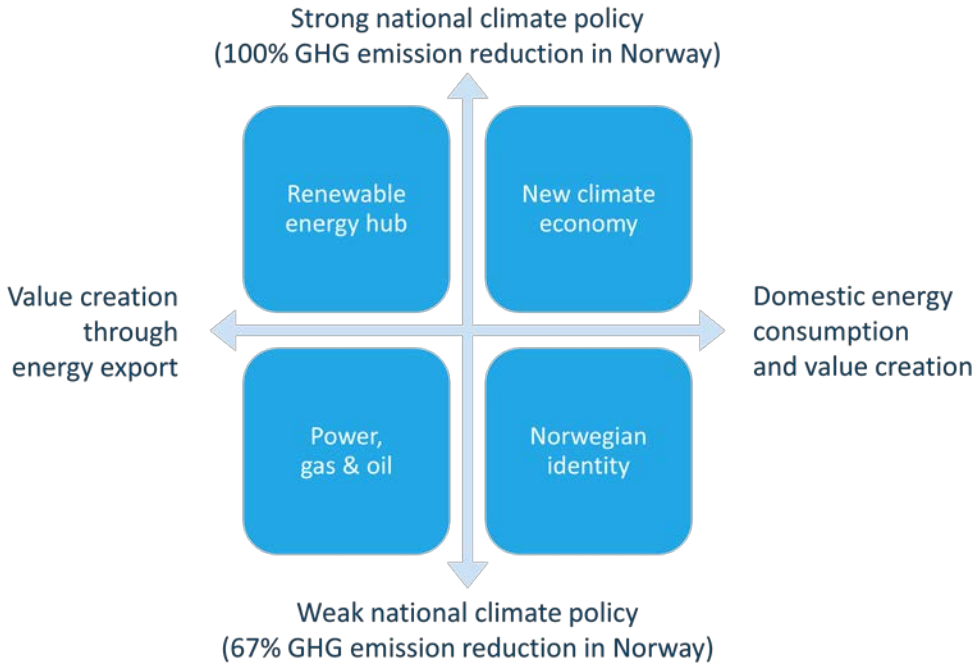


Figure 3: Definition of Norwegian energy strategies

A general overview of the characteristics of the Norwegian strategies can be found in Table 2. A further explanation of the strategies can be found in the following sections.

Table 2: CenSES energy strategies and characteristics

Strategy	**Norwegian Identity**	**Power, Gas & Oil**	**Renewable energy hub**	**New climate economy**
Value creation	National industry / business	Export of energy resources	Export of renewable energy and flexibility	Energy-intensive industry based on RES
R&D	Low funds, directed to security	Technology-neutral	Low-emission directed	Large funds, LCA
Transport sector	Electrification, bio-fuels and fossil fuels	Low-scale electrification, bio-fuels and minor fossil fuels	Large-scale electrification (incl. hydrogen) and bio-fuels	Extensive public transport, electrification (incl. hydrogen), Bio-fuels
Energy exchange infrastructure	Focus on national infrastructure	Expansion all infrastructure	Expansion mostly power exchange	Limited expansion
Norwegian continental shelf	Moderate exploitation new fields	Fast exploitation new fields	Electrification, slow exploitation	Electrification
CCS	None	Small scale	Large scale, incl. Bio	Large scale, incl. Bio
National energy demand	constant	constant	decreasing	increasing

5.3.1 Norwegian identity

The strategy is a combination of domestic utilisation of energy and a rather weak climate policy. Its main objective is to preserve national value creation.

The strategy can be a reaction to a collapse of the EU. As there is no longer a multinational cooperation on common climate efforts, national climate targets are not prioritised, as their value is not obvious anymore. The focus is changed to national value creation, economic / market protection and security of supply within Norway. With increased trading barriers, there is no possibility for profitable export of energy resources, but it is relied on the national private sector for value creation. This implies a radical change of Norwegian policy. Due to the tight integration, specifically of the power sector, a cooperation of the Nordic countries is still necessary.

The existing plans for new RES based generation capacity are implemented, to phase out some of the aging fossil generation capacity and to ensure the security of supply. However, in order to maintain and protect the Norwegian industry sector direct support, as well as support through cheap energy resources, is necessary. This can imply that beside other resources of fossil fuels, nuclear power production becomes important again. In addition, there is no further expansion of exchange / export infrastructure, but rather national back up in order to ensure security-of-supply.

To secure national economic growth, investments in the transport infrastructure is necessary. The transport sector is thereby based on national energy resources, such as bio fuels, hydrogen and electricity as well as conventional fossil fuels. National energy efficiency policies are implemented targeting an efficient utilisation of national resources in order to handle potential limitations. This includes the implementation of large-scale and small-scale DSM.

5.3.2 Power, Gas & Oil

The main objective of this strategy is Norwegian value creation based on the export of national natural energy resources, while also achieving carbon neutrality. However in the framework of a rather weak national climate policy. Hence, reducing emission can include measures in other countries (e.g. through export of renewable energy) in order to offset the carbon footprint in Norway.

There is a continued exploitation of Norwegian energy resources. In addition, significant amounts of renewable energy sources are developed in the Nordic region. This provides the potential for large-scale export of various energy resources to Europe and globally. To ensure value creation, a good access to markets outside of Norway is required, as this is a prerequisite for sale of energy resources at optimal prices. The offshore sector is excluded from Norwegian climate policies. In order to fulfil Norwegian climate targets not only national measures are taken, but also foreign measures to cut greenhouse gas emission.

In order to strengthen the power and energy sector, there is substantial government support including the expansion of energy exchange infrastructure. To efficiently utilise export possibilities, further integration of markets in the European energy sector needs to be promoted.

To secure national economic growth, investments in the transport infrastructure is necessary. There is an ongoing decarbonisation of the transport sector, however with slow pace and mainly in the public transport sector, i.e. fossil fuels still are an important energy source for private transportation.

5.3.3 Renewable energy hub

The strategy combines a strict national climate policy (national carbon neutrality) with value creation based on the export of national (renewable) energy sources.

Large amounts of new renewable generation are deployed in the Nordic region in addition to a significant amount of new flexible capacity in the Norwegian hydropower system. This allows for an extensive export of renewable energy and flexibility to other countries. To ensure value creation, good market access is objected in order to achieve high prices for energy respectively flexibility services. In addition, a significant expansion of infrastructure for exchange (i.e. export) is necessary. Security-of-supply is expected to be ensured through a strong multinational cooperation, relying on the extensive exchange infrastructure.

To facilitate the development of both large amounts of new generation from renewable energy sources and major interconnection infrastructure to the rest of Europe, a combination of support and regulations as well as long-term policy is required. Likewise, a further integration of markets in the European energy sector needs to be followed up (achieving an Energy Union).

The Norwegian climate policies include the offshore sector. In order to achieve a full reduction of greenhouse gas emissions, beside support schemes for RES, tight emission caps are required. This incentivises the development of sustainable technologies such as RES and CCS. However, such tight caps and resulting higher energy prices can lead to shutdown of energy-intensive process industry and gas & oil extraction.

In order to achieve the ambitious domestic reduction of emission, there needs to be a significant development of the transport sector, including both electrification, transition to hydrogen as energy carrier and the utilisation of bio fuels. This transition comprises local, national and international traffic as well as road, rail, maritime and air traffic. Finally, a general policy for a more efficient resource utilisation is required.

5.3.4 New climate economy

The objective of the strategy is national carbon neutrality and value creation based on a domestic utilisation of the own natural renewable energy sources.

There is a shift in the focus of the society from economic growth as premise to societal and environmental sustainability, comprising a strong awareness of climate change. The resulting policies include increasing energy efficiency, electrification of several sectors, increasing research on, and development of, sustainable technologies and promotion of a circle economy which significantly reduces consumption of resources.

To achieve national carbon neutrality, i.e. reduce greenhouse gas emissions to zero, it is relied on the development of a national sustainable private sector delivering sustainable products with extra value. The national energy supply is used for new energy-intensive industry within the country. Value creation is based on export of refined products and an export of new developed sustainable technologies (CCS / maritime). There is a large amount of new RES based generation, which enables a complete phase-out of fossil power generation. At the same time, bio-power production with CCS is deployed in order to be able to achieve additional emission reduction. This can be used to offset for emissions from industry processes that are nearly impossible to avoid. Due to the increased national energy demand, which is in line with the expansion of RES, exchange capacities to the neighbouring countries only need to be expanded marginally.

To better utilise the additional energy from RES, there is major electrification, including hydrogen as energy carrier, of transport as well as residential and industrial demand. In addition new energy-intensive industry is

developed. No carbon offsets are purchased outside Norway, but CCS is applied large-scale in the process industry. Active policy and regulations are used to facilitate the realisation and local utilisation of the large amount of new RES in an environmentally acceptable way. In addition, policies for the efficient utilisation of resources, such as a sharing economy need to be implemented. Among others, this accounts for the transport sector, i.e. less private cars, but more sharing of cars and increased public transport.

5.4 Scenarios

The resulting scenarios are a combination of the defined futures and strategies. Table 3 provides an overview of the resulting scenario space. The table includes a preliminary evaluation of their feasibility and probability in order to do a preselection of the final CenSES energy scenarios. The darker the colour the more realistic the combination is assumed to be. The light grey combinations are assumed to be infeasible.

Norwegian perspective

EU / worlwide perspective

Futures	Strategies	Strategy 1 New climate economy	Strategy 2 Renewable energy hub	Strategy 3 Power, Gas & Oil	Strategy 4 Nordic identity
Future 1	Green Globe	S1	S7	S11	
Future 2	Grass roots	S5	S10		
Future 3	Fossil society	S9	S8	S3	
Future 4	Green governance	S6	S2		
Future 5	National ways			S12	S4

Table 3: Overview of the resulting scenarios

In the following, the selection of potential scenarios is described shortly. The first four scenarios listed are assumed to be most realistic and are suggested to be work with in more detail in the future. The later four are assumed to be interesting, with potentially not uniform futures and strategies.

5.4.1 Apparent scenarios

1. S1: Green globe | New climate economy
   Living the green revolution – There is a global commitment to a sustainable and environmental friendly development, including Norway.

2. S2: Green governance | Renewable energy hub
   Green on the large scale – The development to a sustainable energy system is mainly imposed by strong policies, where the focus is on RES in Norway.

3. S3: Fossil society | Power, Gas & Oil
   Faith in the economy – Globalisation and economic growth continues and intensifies, where Norway uses its chance to benefit based on its fruitful natural energy resources.

4. S4: National ways | Norwegian identity
   Management in the Norway – The collaboration and trade of nations weakens and national security becomes more important, likewise leading to a Norwegian focus and on the Nordic area.

5.4.2 Potential scenarios

5. S5: Grass roots | New climate economy
   Small-scale green economy – While there only is sustainable development based on private and small scale initiatives, Norway achieves a sustainable development in all sectors.

6. S6: Green governance | New climate economy
   Large-scale green economy – While there is a policy-driven sustainable development globally, Norway achieves a comprehensive change to RES and a sustainable industry.

7. S7: Green globe | Renewable energy hub
   Providing the green energy – The global sustainable development is supported by extensive Norwegian renewable energy sources.

8. S8: Fossil society | Renewable energy hub
   Greenify the global economy – The ongoing globalisation and economic growth is backed by significant renewable energy sources from Norway.

6 Summary

This report is a result of the first phase of the scenarios development process. A framework for development and selection of CenSES energy scenarios has been presented and scenarios suggested for further analysis have been defined. These energy scenarios are developed with a bottom-up approach, ensuring the engagement of all user partners.

In the first place, the key research question for the scenarios is defined: *"How can Norway contribute to the global reduction of GHG and meet its climate targets for 2030 and 2050, while ensuring value creation within the framework of the energy system?"* This research question forms the basis for the following process. The scenarios result from a combination of given futures, which have an EU/worldwide scope and chosen strategies, which have a Norwegian focus.

The five futures are *Green globe, Grass roots, Fossil society, Green governance* and *National ways*. These are combined with the four different strategies *Norwegian identity, Power Gas & Oil, Renewable energy hub* and *New climate economy*. Finally, a set of four apparent and four potential combinations is selected as the CenSES energy scenarios.

The next step will be to quantify these scenarios. The quantification will be done for a set of different models, while it will rely on public available data. The final objective is to run a number of analyses targeting the key research question specified during the scenario definition process.

7 References

[1] CenSES, "Revised 4-year plan 2015-2018 RA 5: Scenario development", September, 2015

[2] S. Jaehnert, "CenSES scenario workshop January 7th/8th 2016", Workshop memo, January, 2016

[3] CenSES, "CenSES energy scenarios, futures and strategies", Excel sheet

[4] Ap, SV, Sp, H, KrF, V, "Avtale om klimameldingen", january, 2008, http://www.regjeringen.no/Upload/MD/Vedlegg/Klima/avtale_klimameldingen.pdf

[5] Regjering, "Ny og mer ambisiøs klimapolitikk", Press release, february, 2008, https://www.regjeringen.no/no/aktuelt/ny-og-mer-ambisios-klimapolitikk/id2393609/

[6] Stortinget, " Innstilling fra energi- og miljøkomiteen om norsk klimapolitikk", June, 2012, https://www.stortinget.no/no/Saker-og-publikasjoner/Publikasjoner/Innstillinger/Stortinget/2011-2012/inns-201112-390/

[7] Stortinget, " Innstilling fra energi- og miljøkomiteen om Samtykke til ratifikasjon av Paris-avtalen av 12. desember 2015 under FNs rammekonvensjon om klimaendring av 9. mai 1992 - Komiteens merknader", June, 2016, https://www.stortinget.no/no/Saker-og-publikasjoner/Publikasjoner/Innstillinger/Stortinget/2015-2016/inns-201516-407/2/#a3

[8] B.C. O'Neill et al., "The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century, Global Environmental Change", Available online 12 February 2015, ISSN 0959-3780, http://dx.doi.org/10.1016/j.gloenvcha.2015.01.004.

[9] D. Huertas-Hernando, B.H. Bakken, "Structuring of uncertainties, options and boundary conditions for the implementation of EHS", e-Highway2050 Deliverable D1.2, 24 May 2013. Downloadable from http://www.e-highway2050.eu

[10] Graabak I, Warland L, "A carbon neutral power system in the Nordic region in 2050", Norstrat Deliverable D3.1, SINTEF TR A7365

[11] D.P. van Vuuren, T. Carter, "Climate and socio-economic scenarios for climate change research and assessment: reconciling the new with the old", Climate Change, 2014, pp. 122:415-429

[12] United Nations Environment Programme, "Global Environment Outlook 4 – environment for development", 2007

[13] IEA, "World Energy Outlook 2015", November, 2015

[14] IEA, "Energy Technology Perspectives 2015", May, 2015

[15] European Commission, "EU Energy Roadmap 2050", December, 20111

[16] ENTSO-E, "Ten Year Network Development Plan 2014", October, 2014

A Appendix

A.1 CenSES scenario workshop

Given the different viewpoints of the CenSES user partners attending the workshop, the actual scenario development process was started. To that, the second and third session of the workshop were dedicated to group work containing the initiating of the CenSES energy scenarios. For the group work, the project participants were separated into two groups, each containing CenSES user partners and CenSES researcher.

The group work was divided into the three following subtask:

1. Hva er fokus/kjernespørsmål for scenariene?
   What is the key research focus/question for the CenSES energy scenarios?
2. Viktigste usikkerhetsfaktorer relater til kjernespørsmålet for scenariene, inkludert identifisering av Black Swans.
   What are important factors related to the key research question? What could be Black Swans?
3. Sortering av usikkerheter.
   Sorting and structuring of uncertainties.

Following the work within the two groups, the results were presented and discussed in the full workshop panel.

A.1.1 Key research question

Given the rather general research focus for the CenSES energy scenarios and according premises as stated in the section *Research focus and premises for the CenSES energy scenarios*, the task of the first group work was to specify the key research question.
As an initial starting point following suggestion for a key research question was given:

- How can Norway reach its ambitious climate targets up to 2030 (reduction of emission) and 2050 (carbon-neutral) within a sustainable development, using effective instruments and measures? What are the effects for the energy system, the emissions and the economy?

Throughout the group work, not only one key research question was specified, but a number of important aspects respectively sub questions were raised. In the following the results of both groups are listed

A.1.1.1 Group 1

Sub research question:

- Where can Norway be a leader and contribute to a green/sustainable value creation based on particular advantages?

Prerequisites/preferences:

- Taking 2030 and 2050 targets as given in the research question implies backcasting-type of scenarios, which is ok
  - Though should include a reference path/scenario with extrapolation of current state and policies as a benchmark (even though it is likely to miss on the targets)
  - Some technologies have some high up-front investment costs that they will probably need to be forced into the model solutions to be utilized/analysed
    - Particularly relevant for technologies where Norway has particular advantages and can have increased value creation (natural resources, competence, etc – ex. ships design, energy intensive process industry)

- Should assume very limited availability for buying quotas abroad in 2050 due to strict targets globally. This implies that the 2050 targets are reasonably well defined, but less so for 2030.
- Timing is an interesting issue due to long term investments giving lock-in effects. Ex. analyse the cost by 2050 of a min-cost strategy towards 2030 relative to a more offensive strategy.

Important aspects:

- Only energy and GHG emissions as scares resources, or also other resource scarcities (ex. bio mass, fresh water, mineral resources)
- Economic growth
- Land use, occupant density, collective economy (delingsøkonomi)
- Commercialisation of CCS

A.1.1.2 Group 2

Key research question:

- Hvordan kan Norge bidra til global GHG reduksjon samtidig som mål for 2030 & 2050 blir nådd og samtidig bidra til verdiskaping?
  How can Norway contribute to a global reduction of GHG, while meeting its climate targets for 2030 and 2050 and contributing to value creation?

Further important aspects:

- The global/regional dimension has to be regarded including flexibility mechanisms
  - Flexibility mechanisms can be used to reduced emissions outside Norway
  - How much of reduction potential is left outside Norway after 2030 if all countries reduce emission themselves?
- Economic growth shall be a presupposition for the development of the scenarios
- 2030 and 2050 targets will define the goal of all scenarios
  - The successful achievement of the targets is implied
  - A reference scenarios for fail should be included
- Secure value creation after the oil business
- Energy waste vs. energy use for value creation
- Urbanisation
- Change in behaviour, active consumers
- Electricity for free due to unlimited resources?
- Transport sector also comprises use of area, energy and emissions
  - Beside electrical cars, electric ships are important as this is a strong industry within Norway

A.1.2 Factors

The second part of the group work was dedicated to identifying the trends and factors related to the key research question. The main idea was to find a broad as possible overview, which should include potential Black Swans. These are events, which are defined as:

- Unexpected
- Major effect on the development
- Rationalised by hindsight, as if it should have been expected

The identified factors should be used to form the CenSES energy scenarios. They will help to identify sensitive fields in order to test the robustness of the various strategies. In the following the related factors,

identified by each of the groups is presented in a list. In addition, an initial list of factors provided as an input to the group work part 2 is shown in Figure 3.

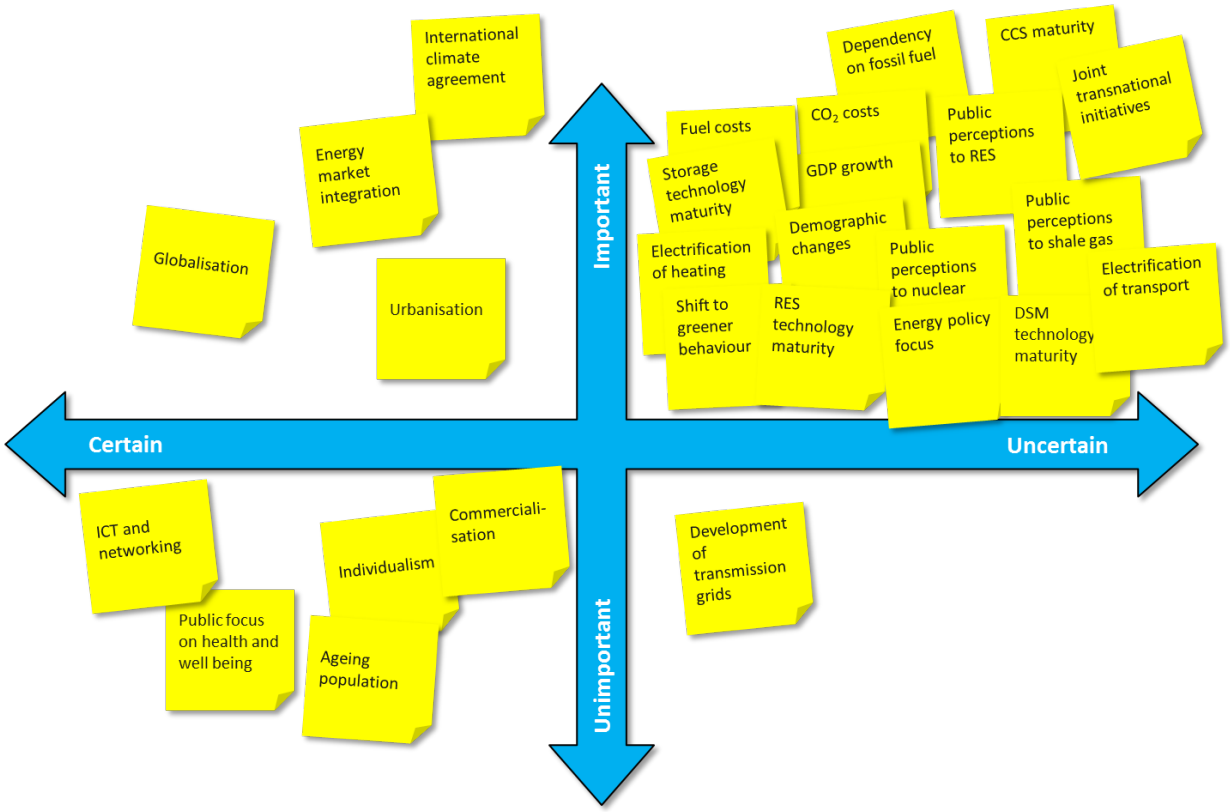


Figure 4: Potential trends and factors affecting the key research question of the CenSES energy scenarios

A.1.2.1 Group 1

Politics
Geopolitics
Middle East, Refugees, Stability
EU future
EU has collapsed
Phasing out of nuclear in Scandinavia and EU
Paris Agreement on Climate Change is met
EU politics for climate and renewable energies
Global phasing out of coal
population growth
National politics
trends
long-term
zero emissions in transport sector
ability to apprehend possibilities
gap between R&D politics, policy towards industry and climate mitigation
Investments in Oil and Gas sector
Access to capital
Local politics
consistency and robustness
Political system able to bring radical (maybe unpopular) changes
transport planning in cities
urbanisation
Decentralisation
Cities and land planning

Society
Behaviour and aspects towards changes and needs for changes
Public wish to restrictions of individual energy use
reduction of flight travels
decreasing use of private car
Public wish towards decision for Oil and Gas

Technology
global technology development/success
Hydrogen as a new industry sector
carbon storage maturity
data storage centre
ICT development
internet of things
maritime industry
research/implementation of results industry/policy towards industry
energy consuming process industry
Progress on Cold Fusion
Limited access to bioenergy in Scandinavia
Small scale energy storage
Effective energy use
Electrification of transport
Commercialisation of offshore wind
Electric cars
Subsea cable costs
Smart grids

Market
Oil sector extend
global/European oil demand
Oil and gas prices
Fuel prices
global CO2 prices
Energy trade
global carbon market
sharing economy
"prosumers"
power market design

A.1.2.2 Group 2

Technology
Virtual communication and use
Reduction of cost for batteries -90%
Electrification of small cars, heavy transport
Electrification of shipping/maritime sector
Off-shore wind
Storage technologies costs
Renewable energies costs
Hydrogen costs
CCS costs power plant/industry
Biofuel for engine from macro algae
Automatization (Robot)

Politics
Climate as a policy driver/collapse of climate policy
Follow-up of the COP21
EU's future
the State as insurance underwriter
Nuclear in Finland, Sweden, Germany
EU ambition for climate
Environmental restrictions for renewable energies
Framework for hybrid vehicles
Open Decision process
Expansion of industry sector in Norway
R&D investments (public sector)
International participation
Electrification of the Norwegian shelf
Expansion of public transport

Market
Capacity mechanism r vs. Energy-only
Global CO2 price
Globalisation vs. Protectionism
Large scale export of wind power from NO/SE
Oil price/oil price back to 120 USD
Development of industry
Prices for power vs effect/network prices
Grid integration/large scale construction of cables from Scandinavia
EU market integration

Society
Changes in consumption habits (Apps) / Water consumption/Demand response
Reduction in oil and gas production/closing down oil industry
Decreased use of resources/sharing economy
Research on Society changes
India the new China
Demography
Urbanisation

Climate
Water availability (more precipitation in Scandinavia)

A.1.3 Structuring

After listing all the potential trends and factors related to the key research question, the last part of the group work addressed the sorting, structuring and weighting of these. At first the factors were sorted into various subtopics, such as:

- Technology
- Economy
- Politics
- Society
- Environment

Thereafter, in order to evaluate if a certain factor is an uncertainty or an option, the ability to influence this factor as seen from the analysis target group (decision makers) should be estimated. Finally, the uncertainty of the various factors should be determined. The resulting overview is provided in the following. The collection and evaluation of the resulting trends and factors will be the basis for the further scenario development process, specifically the draft of the CenSES energy scenarios.

A.1.3.1 Group 1

The result of group 1 for the third part of the group work is shown in Figure 4.

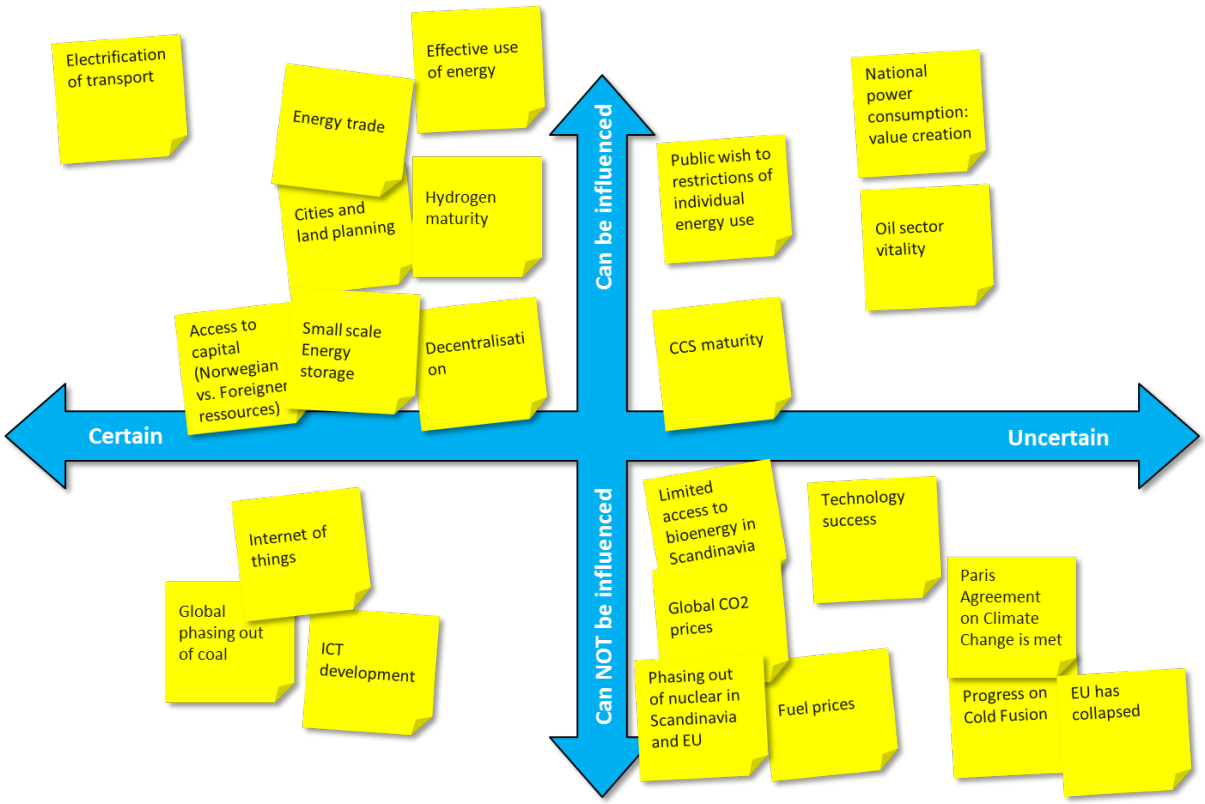


Figure 5: Sorting of trends and factors

A.1.3.2 Group 2

The main result for group 2 contained a suggestion for categorisation of trends and factors.

Within **technology** a classification should be done between **technological development** (can be analysed based on learning curves / sensitivity analyses) and a **technological breakthrough** (new scenarios needed). Furthermore, it should be differentiated between **technology within the energy sector**, where there is a direct effect to the development and **technologies outside the energy sector**, which however can also have a significant effect on the development of the energy sector.

In the main topic of **politics** it should be differentiated between the different levels, **global, national and local politics**. Seen from the point of view of the analysis target group, that has a significant importance for how much these trends or factors can be influence, defining them as uncertainty or option (instrument).

In the case of the **market**, factors should be subdivided into a group of **market design**, which also has a strong connection to politics or policy mention previously. Then there is a big group of external factors, such as prices, demand and supply from outside the scenario/analysis area. Finally, there is a group of **infrastructure** factors providing the basis of the energy system.

Within the topic **society** there is the subgroup of **social acceptance** of and **opposition** to technological development. Furthermore, there is a subtopic of **behavioural development**, addressing the increase reaction/awareness of energy consumers. Finally, there is a general subcategory **development of the society**, including subtopics such as demography, urbanisation etc.

Technology for a better society

www.sintef.no