NTVA
NORWEGIAN ACADEMY OF TECHNOLOGICAL SCIENCES
A NATIONAL ENERGY STRATEGY
2013 - 2017

NTVA
Norwegian Academy of Technological Sciences (NTVA) is an independent organization founded in 1955.

NTVA's objective is to promote knowledge in technology and the natural sciences, research and business development in order to serve the best interests of Norwegian society.

NTVA is to be the foremost Norwegian forum for factual debate on the importance of technology and the natural sciences for Norwegian value creation and sustainable social development.

NTVA will meet its objective and achieve its vision by the following measures:
• identifying important scientific and technological challenges and breakthroughs
• contributing towards the provision of relevant information on such matters and promoting debate
• identifying and making scientific and technological expertise available in relevant fields
• fostering its Industrial Council as a forum for debate regarding national technology-related policy.
• working together with other Norwegian and international academies and organizations.

In the future NTVA will continue to have an important role as a forum for those working in our priority areas.

Norwegian Academy of Technological Sciences (NTVA)
Lerchendal gård, NO-7491 TRONDHEIM, NORWAY
Telephone: + 47 73 59 54 63
Fax: + 47 73 59 08 30
Email: NTVAmail@ntva.ntnu.no
For information about the NTVA, visit http://www.ntva.no

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1. Scope and framework

NTVA's strategy for energy issues encompasses the entire energy system in domestic and international contexts. The strategy has been prepared by a committee appointed by NTVA, and constitutes the basis for our dialogue with the ministries, research and educational institutes, industry, research institutes, academies and other partners.

The strategy was passed by the Board on 15 May 2013, and is valid for five years (2013 – 2017). However, as both domestic and international energy systems are in a constant state of change it may be necessary to revise the strategy within this five-year period.

After reviewing the international energy situation and Norway's special status, NTVA considers that the unique opportunities in Norway's natural energy resources must be further developed. This will involve the following;

1) *adequate investment must be made in research areas where Norway has a distinct advantage and can potentially bring financial and environmental benefits*
2) *coordination of energy-related research must be prioritized and the entire energy system must be the focus of research activities*
3) *priority must be given to basic research that will provide Norway with a considerable head start in terms of knowledge and innovation.*

2. The Energy Committee – composition and approach

NTVA's Energy Committee was appointed by the Board on 10 December 2010. The following were appointed to the committee; Roy H. Gabrielsen (Committee Chair prior to June 2012), Sverre Aam (Committee Chair after June 2012), Kjell H. Bendiksen, Hans H. Faanes, Einar Hope, Erling Rytter, Knut Åm. Ånund Killingtveit was subsequently admitted to the committee. Hein Johnson, General-Secretary of the NTVA, has acted as committee secretary. The committee can openly communicate with additional associate members in order to provide expertise in the parts of the energy system that are not covered by the appointed members.

The committee has had five meetings and worked on the preparation of a written strategy document between the meetings. This work has been coordinated by the Committee Chair.

3. Terms of reference

NTVA has developed its strategy under the following terms of reference;

1) Challenges linked to international energy and climate change will exert a major influence on the development of society during this century. Future international energy demand is expected to increase significantly as a result of population growth and improvements in

living standards in developing countries. At the same time, according to the IPCC[1], emissions of greenhouse gases have to be reduced by between 10 and 15 per cent if the two-degree target is to be achieved. We are thus faced with two opposing challenges. We must meet international energy demand while at the same time reduce emissions of greenhouse gases to a fraction of their current levels as we approach the middle of the century.

2) There are major imbalances regarding access to and the use of energy between countries and regions at different levels of economic development. Growth in large countries with rapidly growing economies, such as the BRICS countries (Brazil, Russia, India, China and South Africa) will increasingly depend on access to energy. The greatest increases in energy demand are expected to come from such countries, and they will dictate the conditions for the future international energy supply. On the other hand, future energy consumption in OECD countries is anticipated to remain stable, or possibly even decline (IEA WEO 2012)[2].

3) In the short term, the energy demand from less developed countries is limited. However, if such countries are to achieve economic growth, adequate living standards and political stability, secure access to energy at acceptable prices under favourable terms will become a prerequisite.

4) In future climate-friendly scenarios prepared by the IEA, the IPCC and others, major emphasis is placed on energy efficiency, and moving away from the exploitation of fossil fuels towards renewable energy sources, and possibly nuclear power. Emphasis is also placed on the crucial need to establish carbon management technologies by means of using fossil fuels for stationary purposes, since such fuels will represent a major share of total energy consumption. An underlying premise in these scenarios is that it is essential to reduce the transport sector's reliance on fossil fuels, and that increases in transport demand must be taken up by sustainable use of biofuels, electricity, and possibly also hydrogen, provided that a breakthrough is made in relation to hydrogen technology.

5) In the light of recent serious accidents in the energy sector (Gulf of Mexico, Fukushima), international opinion is increasingly concerned with safety, risk and the negative environmental impacts associated with major energy plants and installations. At the same time, issues related to the development of an energy system based on high levels of supply security and output, low prices, and minimal negative impacts on the environment, are high on the political agenda in most countries. Research activities and technological development carried out in the light of these considerations will be given greater emphasis in the future.

6) The recent introduction of high volume renewable energy generation entails considerable challenges linked to the management of the power supply system. A demand has been created for the development of new technical and market-related systems designed to achieve a balance. The storage of electric energy has also become an important issue. Key organizations and commentators are arguing in favour of the cost-effectiveness of international cooperation and the consolidation of power transfer grids with the aim of addressing challenges linked to achieving the required balance.

[1] Intergovernmental Panel on Climate Change (IPCC)
[2] International Energy Agency: "The 2012 edition of the World Energy Outlook"

7) New technologies designed to promote the exploitation of shale gas and shale oil have in a very short time resulted in major changes to the energy system in the USA. The USA has become less reliant on oil and gas imports, and gas is superseding coal as an energy source. A surprising consequence of this has been that Europe is experiencing that coal is superseding gas for electricity generation as a result of declining coal prices. Other parts of the world are now also beginning to investigate the potential of shale gas. This is an example of how a technological breakthrough can result in major changes in the energy system within a short time.

8) As an energy-producing nation Norway has a unique position both in terms of the types and volumes of energy it produces. As part of its energy mix, Norway produces an unusually high share of its energy from renewable sources (approx. 61% in 2010). This is due in large part to its extensive exploitation of hydropower. Norway is also a major net exporter of energy derived from its major reserves of petroleum resources. Norwegian energy exports offer considerable added value to the international energy market because they come from a stable financial and political regime that guarantees reliable supplies.

9) Norway has specific responsibility, potential and self interest in energy-related research and technology development. This responsibility and potential is increasingly now being recognized by the Norwegian authorities concerned with renewable energy and the energy system. There was a considerable increase in the levels of Norwegian research into energy-related issues (exclusive of petroleum) during the period from 2008 to 2010, but this growth has stagnated during the last three years.

In the light of this, it is NTVA's opinion that there is a need for the following;

- Restructuring of the international energy system towards more sustainable and neutral emission energy sources, technologies and systems. This will involve;
  - further development of existing, mature technologies
  - further development of existing but immature technologies
  - innovation and development of radical new (currently non-existent) technologies

- Widespread implementation of energy efficiency measures throughout society, including the development of new transport and urban development projects ("smart cities").

- More sustainable use of conventional and non-conventional fossil energy sources throughout the value chain and particularly in new methods for improved and enhanced oil recovery (IOR/EOR)[3], more efficient combustion engines, and CO_2 management

- Enhancing Norwegian industry's competitiveness in a future low-carbon society.

[3]) Improved Oil Recovery (IOR) and Enhanced Oil Recovery (EOR)

4. Norway's opportunities and responsibilities

Norway's energy resources fall into two categories – those which are based on proven and profitable technologies such as hydropower and oil and gas, and those which require further development before they can become profitable in market terms, such as wave and wind power, osmosis, sea currents, solar energy and geothermal power. Regarding Norway's proven energy sources, it goes without saying that these are due to natural conditions such as geology, geography and topography (its mountainous terrain, water distribution and the geology of the continental shelf). However, Norway is in a unique position as it is able to contribute to the development of alternative and/or renewable sources of energy. This is partly linked to natural phenomena such as the country's elongated coastline, marine currents and such like, and also its access to specific natural resources such as silica and thorium.

Norway also has specific conditions which can contribute to technology development as a result of its expertise in energy-related technologies. It also has the financial resources to fund basic energy research and the development of existing energy technologies.

NTVA's opinion is that the unique opportunities provided by Norway's natural energy resources must be further developed. This will involve the following;

1) *adequate investment must be made in research areas where Norway has a distinct advantage and can potentially bring financial and environmental benefits*
2) *coordination of energy-related research must be prioritized and the entire energy system must be the focus of research activities*
3) *priority must be given to basic research that will provide Norway with a considerable head start in terms of knowledge and innovation.*

NTVA has asked a number of experts to provide brief descriptions of the potential of the various forms of energy available in Norway. These are assessed in relation to the need for research and technology development in these areas (see Section 6). This was to create awareness of current developments in the energy sector and identify specific research challenges.
The following gives the committee's opinions regarding the various issues.

Renewable energy technologies. This is a key strategic area of research in an international perspective. Norway should have a research base that will stimulate Norwegian industry to position itself both as a supplier and subcontractor in the international market. Historically, Norway is in a special position in hydropower. Its experience from the offshore oil and gas sector provides it with research advantages in energy production using marine-based technologies. Norway also has strong traditions in materials production. This can be beneficial in the development of new materials which will be central in the development of new energy technologies.

CCS[4]. The capture, transport and storage of carbon from stationary CO_2 sources of emissions will be crucial if we are to meet our emissions-related challenges. If the international community succeeds in reducing CO_2 emissions we can use considerable volumes of petroleum resources in the energy sector as part of an environmentally friendly future scenario. Norway has special interest in ensuring that the implementation of CCS technologies is successful on an international basis, and thus maximize the value of Norway's remaining petroleum resources. Consequently, Norway should invest more to promote CCS by developing technologies for the storage and/or exploitation of CO_2 for purposes such as increased oil recovery, as well as developing methods for CO_2 capture from onshore industry. International cooperation is an important part of such a strategy.

Energy efficiency. Energy efficiency in all industrial sectors will make a major contribution towards the reduction of greenhouse gas emissions. Norway ought to follow this up, especially in building

[4]) Carbon Capture and Storage

construction and in industry. The development of "smart" energy consumption technologies (Smart Cities, Smart Grids, etc.) fall into this category of initiatives. Furthermore, much development is expected in the international products market, such as the development of more efficient engines and lighting systems.

Emissions from the transport sector. As a result of our high level of domestic renewable energy production, Norway is already in a position to use electric cars (including plug-in hybrids) in densely populated urban centres. Facilities for the charging of electric cars should thus be made more widely available. Norway also has a tradition as a world leader in the development of environmentally friendly ships. This is a field in which Norway ought to make major investments in order to maintain its strong international position. The extensive exploitation of biofuels as part of the energy mix is central in the IEA's analysis of the Nordic countries (Nordic Energy Technology Perspectives). An analysis should be carried out to find out the optimal level of exploitation from the Norwegian and Nordic biofuel resources. This should be based on an overall perspective addressing sustainable energy systems and business development in the relevant sectors. Norway should also be actively engaged in hydrogen technology research in order to monitor the use of hydrogen in the transport sector.

Challenges facing the northern European energy system. The phasing-in of large volumes of renewable energy into the northern European power supply system has presented major challenges. These have been described in Section 3. The challenges related to current imbalances can be met with contributions from a variety of sources. These include:

- increased flexibility in traditional supply technologies such as coal-fired and nuclear power stations
- increased installation of gas-fired power stations
- reinforced grid connectivity across national boundaries
- introducing more flexibility and "smart " systems into the end-user market
- developing new market mechanisms in the power supply system
- exploit hydropower's specific properties such as rapid response production regulation and energy storage
- develop new energy storage technologies
- collaborate in projects in thermal energy supply systems

In this scenario, Norway's strengths lie in hydropower technologies, the development of cable technology for large-scale power transfer, market development in the power supply sector and total energy system modelling. Norway ought to invest in research here in order to contribute towards addressing challenges at a European level. Opportunities will also arise in connection with some of the above areas, and Norway ought to monitor these in order to be in a position to develop new products.

The safe and environmentally friendly exploitation of petroleum resources. Based on domestic market demand, Norway has developed an impressive international supply industry for the offshore petroleum industry. Norway should develop the supply sector within the constraints of the strict requirements for safety and environmentally friendly petroleum production. This will require more publicly funded R&D than is the case today.

International strategic positioning of the Norwegian research community. It is vital for success in terms of research and the country's industry that Norway has research groups that are attractive partners for international research organizations. A robust positioning of the Norwegian research community in the EU's research programmes is an important part of this strategy. Cooperation with research groups in the USA, Japan, China and other countries, must also be part of the strategy to guarantee high quality Norwegian research. Funding for modern laboratories is an important part of this positioning strategy. When it comes to promoting innovation, Norway has a strong tradition for

close collaboration in technological research between state institutions, industry and research groups to promote innovation. This cooperative tradition must be developed further in consortia across national boundaries. Initiatives to promote the recruitment of researchers from the international community should be encouraged.

5. Conclusions and recommendations

In addition to its efforts in basic research which may result in innovative technological breakthroughs, Norway must invest in the following:

- Hydropower, offshore wind power, and other types of renewable energy production in which Norwegian industry has the ability to succeed as a competitive major supplier or subcontractor in the international market
- Energy efficiency combined with "smart" energy systems adapted to the Norwegian climate and installed in new and existing buildings
- Cable technology for large-scale power supply transfer
- The capture, transport, storage and use of CO_2 which can be the basis of long-term value creation based on Norway's petroleum resources
- Energy-intensive, materials production industries in which Norway has strong traditions
- Safe and environmentally friendly utilization of Norway's petroleum resources
- System analyses which provide a comprehensive understanding of the technical, market-related, environmental and socio-economic aspects of the energy system

The entire Norwegian energy-related research infrastructure requires a boost which should include petroleum-related research. An overall comprehensive investment in energy-related research is needed that is administered by the Research Council of Norway. This should involve close partnerships with industry with international ambitions working with energy technology and the use of energy resources. It is important to ensure that the best Norwegian research centres can position themselves strategically in the international market and become key partners in successful international research consortia, especially in the EU. This will require close cooperation between the research community, Norwegian industry and Norwegian state authorities, with a 10 to 20 year perspective.

This must ensure that the research optimizes the following:

- Development of a sustainable Norwegian energy system.
- Sustainable utilization of Norway's energy resources to generate substantial value creation.
- Development of optimal collaborative energy sector cooperation in Scandinavia and Europe.
- Consolidation of the positions held by Norwegian industry and research in relation to essential international restructuring of the energy system.

Our review of the international energy situation and Norway's particular status means that the unique opportunities inherent in Norway's natural energy resources must be further developed. This will involve the following;

- *adequate investment must be made in research areas where Norway has a distinct advantage and can potentially bring financial and environmental benefits*
- *coordination of energy-related research must be prioritized and the entire energy system must be the focus of research activities*
- *priority must be given to basic research that will provide Norway with a considerable head start in terms of knowledge and innovation.*

REFERENCES

1. IEA Energy Technology Perspectives 2012.
2. IEA World Energy Outlook 2012.
3. IEA Energy Technology Perspectives 2012.
4. Renewable Energy Sources and Climate Change Mitigation, IPCC 2011.
5. The European Strategic Energy Technology Plan, Set-Plan, Toward a low-carbon future. Luxembourg Publications Office of the European Union, 2010, ISBN 978-92-79-15667-0.
6. Energy Roadmap 2050. EU COM(2011) 885/2.
7. A Roadmap for moving to a competitive low carbon economy in 2050. EU COM(2011) 112 Final.
8. U.S. Department of Energy – Strategic Plan 2011.
9. Doha amendment to the Kyoto Protocol to the United Nations Framework Convention on Climate Change. Doha, 8 December 2012.
10. *Nasjonal strategi for forskning, utvikling, demonstrasjon og kommersialisering av ny energiteknologi,* (A national strategy for research into, and the development, demonstration and commercialisation of new energy technologies) "Energi21", 2011.
11. *Kartlegging av offentlig støtte i 2012 til forsknings-, utviklings- og demonstrasjonsprosjekter - Klimavennlig stasjonær energiteknologi, CO2 håndtering, miljøvennlig transport og stasjonær hydrogen* (An assessment of state funding in support of research, development and demonstration projects in 2012 – Climate-friendly stationary energy technology, CO_2 management, environmentally-friendly transport and stationary hydrogen), "Energi21", 2013.
12. OG21 - Oil and Gas in the 21st Century. Norway´s Technology Strategy for the 21st Century. OG21, December 2012.
13. *Programplan for RENERGI* (Programme plan for RENERGI). Research Council of Norway) 2010-04-07.
14. *Programplan for RENERGI* (Programme plan for RENERGI), Research Council of Norway) 15/06/2012.
15. Evaluation of the CLIMIT Programme, Oxford Research AS, October 2011.
16. *Årsrapport 2011 Forskningssentre for miljøvennlig energi (FME)* (Annual Report 2011. Centres for environment-friendly energy – FMEs). Research Council of Norway, 2012.
17. *Norge – en foregangsnasjon innen hydrogen* (Norway – a world leader in hydrogen) Action plan 2012-2015. The Hydrogen Council, 9 May 2012.
18. Petromaks II. Provisional programme plan 2013-2022. Research Council of Norway, June 2012.
19. *Økt verdiskaping i naturgasskjeden* (Increased value creation in the natural gas chain – GASSMAKS). Programme plan, Research Council of Norway.
20. DEMO 2000 – Annual Report 2011. Research Council of Norway.
21. *Kunnskap for klima – Strategi for klimaforskning. Rapport fra styringsgruppen for Klima21* (Expertise for climate – A strategy for climate research. Report from the Klima21 Steering Group), February 2010.
22. *Kunnskapsgrunnlaget for ny klimasatsing i Forskningsrådet. Rapport fra Divisjon for energi, ressurser og miljø* (Knowledge base for new climate-related research projects administered by the Research Council of Norway. Report by the Division for Energy, Resources and the Environment). Research Council of Norway, September 2012.
23. *Verktøy for forskning – del 1. Nasjonal strategi for forskningsinfrastruktur 2012-2017* (Tools for research – Part 1. A national strategy for research infrastructure 2012-2017). Research Council of Norway, February 2012.
24. *Energiutredningen – verdiskaping, forsyningssikkerhet og miljø* (An energy analysis – wealth generation, supply security and the environment). NOU 2012:9.
25. *Vi bygger Norge – om utbygging av strømnettet* (We are building Norway – concerning expansion of the electricity distribution grid). Official Norwegian Report no. 14 (2011-2012).

26. *Nasjonal plan for neste generasjon kraftnett. Nettutviklingsplan 2011* (National plan for the next generation electricity power grid. Grid Development Plan 2011.) Statnett, November 2011.
27. *Strategi for NVE* (NVE Strategy) 2012-2016. NVE, February 2012.
28. *En næring for framtida – om petroleumsvirksomheten* (A business for the future – concerning the petroleum sector). Official Norwegian Report no. 28 (2010-2011).
29. *Norsk klimapolitikk* (Norwegian Climate Change Policy). Official Norwegian Report no. 21 (2011-2012).
30. KLIMAKUR 2020. *Tiltak og virkemidler for å nå norske klimamål mot 2020* (Initiatives and instruments to achieve Norwegian climate change targets towards 2020). TA2590/2010.
31. *Lange linjer – kunnskap gir muligheter* (The long view – know-how creates opportunities) Official Norwegian Report no. 18 (2012-2013).
32. *Norge som energinasjon* (Norway as an energy nation) The NHO business panel. NHO, March 2012.
33. *Norsk klimapolitikk – tid for handling. Næringslivets klimahandlingsplan* (Norwegian climate policy – time for action. An action plan from the business sector). NHO, December 2009.
34. *Oslo SmartCity. En rapport om hovedstadens miljøpotensial* (A report into the potential of the Norwegian capital to become environmentally friendly). Oslo Municipality, Bellona and Siemens.
35. *Et kunnskapsbasert Norge* (A knowledge-based Norway). Torger Reve and Amir Sasson, Universitetsforlaget 2012.