

Work Programme (for period 2010-2013) for the Large-scale
Programme Clean Energy for the Future (RENERGI)

*(preliminary version in English – without all tables in chapter
7)*

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1. Summary

This work programme establishes the formal framework and focus of the Large-scale Programme Clean Energy for the Future (RENERGI) and provides guidelines for R&D players seeking funding under the programme.

Calls for proposals for funding for R&D projects will be based on the content of this work programme, together with the national budget, the appurtenant allocation letters from the funding ministries and the annual analysis of the programme's project portfolio.

Primary objective

The primary objective of the RENERGI programme is to develop knowledge and solutions as a basis for ensuring environment-friendly, economically efficient and effective management of Norway's energy resources, a highly reliable energy supply and internationally competitive industrial development related to the energy sector. Research activities shall also seek to find solutions to global energy and climate challenges as well as the political challenge inherent in Norway's role and responsibilities as a leading player in the global energy sphere.

The programme encompasses two different time perspectives, with secondary objectives set out for each of these separately:

5-10 year perspective:

- New technologies, systems and solutions that facilitate energy restructuring by improving the efficiency of energy use, making energy more accessible and improving system security and flexibility, both in Norway and internationally.
- Environment-friendly energy systems that reduce emissions of greenhouse gases and other air pollutants, improve land use, etc.
- New, internationally competitive goods and services related to the energy sector.
- Knowledge and analysis as the basis for the authorities' and industry's long-term energy strategies, public debate and design of public policy instruments.
- Internationally competitive research groups in high-priority fields that collaborate extensively with international specialist environments and various types of users.

20-30 year perspective:

In such a long-term perspective there is great uncertainty attached to the research results that can be achieved, the potential impact of the research on the actual situation that emerges and how the results can be used in that context. Nevertheless, the objectives for a 20-30 year perspective will encompass the same elements as the objectives for a 5-10 year perspective. Research activities are intended to create a foundation for social development based on a high degree of innovation in which the development of the energy sector is consistent with ambitious environmental goals.

Important secondary objectives in this context include:

- Energy systems and management that can be adapted to comply with the next generation of climate agreements and the EU's long-term objectives for security of supply, the environment, renewable energy, etc.
- Energy policy that paves the way for value creation in the energy sector and enables the energy-related supplier industry to continue to play an important role in the Norwegian economy.

As one of seven Large-scale Programmes at the Research Council of Norway, the RENERGI programme is designed to realise objectives set out in the Government white paper on research, Climate for Research, and the strategy of the Research Council, In the Vanguard of Research. A major part of research activities on environment-friendly energy at the Research Council are consolidated under the RENERGI programme, which encompasses long-term basic research, competence-building, applied research and technology development. The programme will be a key instrument for implementation of the Energi21 national R&D strategy for the energy sector.

The RENERGI programme is targeted towards Norwegian companies and research and educational institutions that can advance the development of the energy sector. Collaboration between various industry players is vital in both a national and an international context.

The RENERGI programme was launched in 2004 and will run for a 10-year period, concluding in 2013. This work programme applies to the last four years of the programme, during which priority will be given to dissemination of research findings, implementation of research-based technologies and solutions, and qualification and testing of technologies with a view to pilot projects, demonstration and commercialisation.

2. Background

2.1 Strategic perspectives

The national and international focus on energy-related concerns such as climate change and security of supply is greater than it has been in many years. Interest in the impact of climate change has risen dramatically in Norway and abroad in the years since the programme Clean Energy for the Future (RENERGI) was first launched, and this has in turn led to a major shift in the principles underlying the activities of the Norwegian energy authorities, the Norwegian energy sector and the supplier industry at large.

At the national level, much of this shift has been incorporated into the broad-based political agreement on climate policy achieved in the Storting in 2008. The agreement provides a clear framework for Norwegian energy, transport and research policy, and identifies the challenges Norway is facing. The agreement sets a goal of achieving carbon neutrality by 2030 and establishes climate targets to be met by 2020. Investments in research have increased substantially as a direct result of the agreement. There is a clear expectation that research will help to *solve the problems* caused by climate change as well as make it possible to *exploit the opportunities* inherent in this by providing a foundation for new industrial activity and new value creation based on technology and research. This is important both for ensuring maximum utilisation of Norway's renewable energy resources and – equally crucial – for developing new technology that is designed to solve global challenges facing the energy sphere and an international market, where the demand for effective solutions will increase rapidly in response to ambitious international goals to reduce greenhouse gas emissions.

In addition to the Storting's agreement on climate policy, the RENERGI programme will take its direction from the national R&D strategy for the energy sector – Energi21. Furthermore, the establishment of Centres for Environment-friendly Energy Research under the recently introduced centre scheme has spawned new, dynamic research constellations that will help to bolster efforts in key areas. The national strategy for climate research – Klima21 – will also have an impact here. Effective coordination between the RENERGI programme, the Energi21 and Klima21 strategies and the FME

centres is essential to ensuring efficient use of resources and obtaining constructive results.

At the international level, the EU works to facilitate the coordination and prioritisation of R&D activities to meet stipulated objectives for the energy research field.

Research activities under the RENERGI programme extend across the entire energy value chain: energy production, transport and use, and the energy system. Research on low-carbon transport also lies within the scope of the programme. These are among the most important research areas to address if advances are to be achieved in the field of climate change. The FME centres and the RENERGI programme together serve as the most important research policy instrument for the authorities in this area.

The RENERGI programme will foster innovation and create new opportunities within an area of strategic importance for Norway at large. The programme has been given a broad scope and seeks to achieve a high national and international profile. The work programme was revised in 2009 to reflect recent shifts in areas of concentration in the energy sphere and to adapt the direction of the programme to the focus given in:

- The broad-based political agreement on climate policy achieved in the Storting in 2008
- The Government white paper on research, *Climate for Research*
- The Research Council's strategy for 2009-2012, *In the Vanguard of Research*
- The mid-term evaluation of the Large-scale Programme initiative as a funding instrument
- The Energi21 national R&D strategy for the energy sector

While energy research is an essential component of Norway's long-term energy policy, its relevance is not limited to the energy sector alone. It also plays an important role in national policy for the research, industrial, transport and environmental sectors. This becomes even clearer in light of the challenges posed by climate change, as solutions must be cross-sectoral, and developments in one sector will influence developments in another. Strategic cross-sectoral thinking is crucial, also within the field of energy research. This is apparent in, for example, the transport sector, where the introduction of new solutions such as electric vehicles will have implications for the stationary energy supply in terms of energy production, grid capacity and control of the energy system. Another example is the use of biomass to produce biofuels to replace fossil fuels in the transport sector or as bioenergy for use in the stationary sector. The trend is clear: energy streams are merging, changing the framework for energy research and changing the understanding of what constitutes effective solutions in an overall perspective.

Targets and guiding principles for the strategic focus of the RENERGI programme

Various aspects of the framework and targets for publicly-funded energy research are set out directly or indirectly in a number of official documents and plans, including:

The white paper on research (Report No. 30 (2008-2009) to the Storting) underlines the importance of energy research in relation to two strategic objectives: "Meeting global challenges" and "Industry-oriented research in strategic areas".

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With regard to global challenges, the white paper states: "Norwegian research policy will contribute to meeting global challenges, with a particular emphasis on the environment, climate change, oceans ... and energy research." With regard to industry-oriented research, energy is named as one of five strategic areas. The white paper encourages the further development of the supplier industry and sets specific targets for renewable energy and raising energy efficiency (an increase of 30 TWh in the period 2001-2016) and bioenergy (an increase of 14 TWh by 2020).

An important component in determining the direction of the RENERGI programme in the coming years is found in the white paper's emphasis on energy-related problems as an integral part of major global challenges and Norway's ability to help to tackle these through energy research. The Norwegian R&D community and business sector have been key players in the development of solar energy internationally, and broad-based energy research activities are intended to foster development in other areas as well.

The strategy for the Research Council of Norway (2009-2012) highlights the importance of enhancing the quality and capacity of Norwegian research by, among other measures, increasing focus on basic research in fields with major innovation potential, such as environment-friendly energy.

The National Transport Plan (Report No. 16 (2008-2009) to the Storting) presents transport policy objectives and strategies for the period 2010-2019, during which the transport sector is to substantially reduce its greenhouse gas emissions. The implementation of a number of proposed measures, including a CO₂ tax on fuel and the accelerated introduction of low and zero-emissions vehicles, will require new knowledge and technology.

EU objectives influence Norwegian priorities, and the EU's 20-20-20 targets, together with a number of pan-European guidelines, will have implications for Norway's future energy and research policy. *The EU Renewable Energy Directive* (2009/28/EC) was approved in 2008. The aim of the directive is to establish a common framework for promoting the use of energy from renewable sources. Each Member State is to contribute to meeting the 20 per cent target for the overall share of energy from renewable sources in the EU, as well as a mandatory 10 per cent target for energy from renewable sources in the transport sector, both by 2020. The directive is also relevant for the EEA, and will therefore have an impact in Norway.

The EU Energy Performance of Buildings Directive proposes among other things a requirement to draw up a roadmap charting the path from today's buildings to zero-emissions buildings. These objectives will serve as political guidelines for the administration of public research funding.

Renewable energy and increased energy efficiency have been identified as the most important means of solving global climate challenges while ensuring adequate access to energy. Virtually all activities under the RENERGI programme promote these both by seeking to develop technological solutions for global markets and by participating in international research cooperation to share knowledge and spread technologies and solutions.

2.2 Scientific perspectives

Norway has an abundance of traditional energy resources, primarily hydropower, oil and gas, compared to many other countries. Pressing environmental problems, particularly relating to greenhouse gas emissions, make it imperative to step up efforts to develop energy production based on new, renewable energy sources such as wind energy, solar energy and bioenergy. In addition to promoting optimum use of Norway's own energy resources, the international market for new energy solutions will open up promising business opportunities for export-oriented industry, service companies and other companies in Norway. Research and development are crucial to achieving sustainable energy production and use and to providing a foundation and support for fledgling and well-established industrial activities alike. History shows that energy research is of major significance for Norway's energy supply and business sector. Examples of this include:

- Technical, system-related and environmental knowledge about hydropower developed jointly by the Norwegian research community and the industry.
- Production of solar cells and materials for the solar industry based on Norwegian industrial and research expertise in silicon.
- Social science research groups' heavy involvement in implementing market reforms in the Norwegian power sector in the 1990s.

Expanding Norway's established competence base will better equip the country to meet current and future challenges. Improved exploitation of new, renewable energy sources, increased energy efficiency, power generation with carbon capture and storage¹, and development of international framework conditions that help to reduce greenhouse gas emissions are all areas in which research can lead to progress and Norwegian efforts will make a difference.

3. Objectives of the programme

Achieving the Government's overarching goals is a challenging task for the Research Council because research is expected to generate results of many types. Although the emphasis placed on research activity varies in research, energy, environmental and industrial policies, there is nonetheless a general agreement and a widespread expectation that research will create new opportunities in the long term.

The target groups for activities under the RENERGI programme are users of the research findings. Long-term basic research is primarily targeted towards other researchers, while applied research is targeted towards the authorities, the business sector, the public administration and the public at large.

The following objectives have been drawn up for the RENERGI programme, in response to public policy objectives and the inherent potential of the research itself.

¹ The purview of the CLIMIT programme.

Primary objective

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- Energy policy that paves the way for value creation in the energy sector and enables the energy-related supplier industry to continue to play an important role in the Norwegian economy.

When specifying objectives and designing strategies in such a long-term perspective, research efforts will have to be adaptable to changes in the needs of society and in framework conditions, and include:

- Knowledge-building in fields relevant to the exploitation of Norwegian energy resources and energy efficiency.

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- Recruitment to research groups.
- Establishing good cooperation between research groups, the business sector and other users.
- Broad-based participation in international research programmes.
- Encouraging innovation and a long-term perspective in the business sector.

The RENERGI programme has initiated and will continue to apply foresight processes to identify new research needs and opportunities, and the programme will be adapted accordingly.

4. Priority research tasks

4.1 Strategic priorities

The objectives of the RENERGI programme provide a natural starting point for determining the thematic priority areas for the programme. These largely correspond to the priority R&D areas defined in the Energi21 strategy, which was designed to be a broad-based, collective R&D strategy for the energy sector. An effort has also been made to ensure that research activities are in keeping with the overall strategy for the Research Council and relevant national strategies.

Long-term objectives and stable framework conditions are being given high priority under the RENERGI programme. At the same time, the programme must maintain the flexibility required to adapt to changing needs and opportunities over time. Such flexibility will also be crucial when designing funding instruments. For example, it may be best to promote long-term competence-building in one area, while promoting industrial innovation in another. Furthermore, it is important to be able to offer funding to particularly high-quality projects with good potential for value creation, even when these lie outside the scope of the defined thematic priority areas.

The RENERGI programme is to provide public funding to the thematic priority areas on the basis of identified needs and opportunities. Financial resources must therefore be administered in a way that ensures that public funding generates research that would not otherwise have been possible. There is an intrinsic challenge here when it comes to balancing this with the ability and willingness of the business sector to provide research funding; it is just as important that the programme seeks to create new opportunities by facilitating cooperation between public and private players. In certain cases, such cooperation – combined with public funding – may result in projects of greater scientific merit and with a longer timeframe than would have otherwise been possible. Differences between branches of industry, technological maturity, the degree of basic research being conducted and the amount of researcher training are all elements that will play a role when determining which thematic priority areas to select, how much of the public funding to allocate and which instruments to employ. The trend towards increased international research cooperation may also be of key importance when setting priorities for the use of national funding.

The establishment of the Centres for Environment-friendly Energy Research (the FME scheme) has given national efforts in the field of energy research a more concentrated

focus. Activities under the RENERGI programme will support and help to further develop the centres to enable them to fulfil their intended national role.

During the final phase of the programme period, priority will be given to implementing research findings and allocating a greater amount of funding to qualification and testing projects for research-based technologies. This will enhance coordination with public funding instruments administered by Enova, Transnova and Innovation Norway.

In order to boost Norway's standing as an energy nation, special focus should be given to promoting publicly funded research in certain areas. These include:

- Areas in which *Norwegian research groups have specialist expertise and a strong position*. These research groups must be internationally competitive and possess the resources for further developing their position. Although research is becoming increasingly international, this should encompass areas in which Norwegian users are particularly well-equipped to collaborate with international research groups and utilise research findings.
- Areas in which the *Norwegian business sector and other user groups have the required expertise* to exploit research findings with a view to enhancing value creation in Norway at large. In this context, Norwegian companies means companies that have strong ties to Norway, through Norwegian ownership or a presence in the country, and that have special expertise or a strong market position that provides a sound basis for research activities.
- Areas in which *Norway's energy resources* put the country in a unique position in a long-term perspective. Norway enjoys significant natural advantages, with a variety of energy resources including hydropower, wave energy, energy from ocean currents and wind energy. Research can make it possible to use these resources as a foundation for value creation, either in the form of energy production or as related technology.
- Areas in which the public authorities have a need for greater expertise to take decisions on Norwegian views in international climate policy and develop framework conditions and instruments. The aim is to facilitate the country's transition to more environment-friendly energy consumption and adaptation to international agreements.
- Areas in which the Norwegian energy system, along with its production methods, traditions and climate-related issues, generates *research needs specific to Norway*.
- Areas in which there are particularly *pressing environmental challenges* related to the exploitation of Norwegian energy resources, both in terms of national environmental policy and in relation to fulfilling international commitments.

4.2 Thematic priorities

The thematic priority areas have been adapted to correspond largely with the priority R&D areas in the Energi21 strategy. Transport has also been designated as a thematic priority area under the programme.

The following thematic priority areas have been identified for the RENERGI programme:

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- Raising energy efficiency: buildings and industry
- Renewable energy production: hydropower, wind power, solar energy and marine energy
- Energy systems: planning, modelling and infrastructure
- Alternative energy carriers: hydrogen, natural gas and biogas
- Low-carbon heating and cooling
- Low-carbon transport: biofuels, electric transport and hydrogen
- Energy markets and energy policy

The RENERGI programme extends across a wide array of fields, and there are significant differences between the thematic priority areas in terms of user interest, public interest, developments in the market and demand, etc. The programme encompasses technological, natural science and social science research.

Many research questions will include topics from more than one thematic priority area. Importance is attached to establishing a framework that encourages projects addressing questions from several thematic priority areas. The programme also seeks projects that incorporate technological and social science-related research questions.

Please refer to Chapter 10 for a more detailed description of the various thematic priority areas.

5. International cooperation

Participation in international cooperation within the framework of the programme is aimed at achieving two main objectives:

- Strengthening Norwegian research groups through collaboration on projects with leading international players.
- Promoting the interests of Norwegian research groups in the international arena for research on environment-friendly energy.

International cooperation must be structured to safeguard Norwegian interests and value creation. Collaboration with leading international research groups will enable Norwegian researchers to acquire the knowledge needed to enhance Norwegian competitiveness and will foster the internationalisation of Norwegian technology.

Globalisation and needs related to solving global challenges may also hold new insights on how to use Norwegian research resources optimally to achieve targets quickly and efficiently.

The internationalisation of research has given rise to new arenas for cooperation and new sources of funding.

The EU Seventh Framework Programme for Research and Technological Development envisions better integration between research policy and research funding and seeks to build strong ties between the most prominent research groups in Europe. This has more profound implications for Norwegian research than previous framework programmes, in terms of the number of players involved as well as the structure and internationalisation of Norwegian research.

The European Strategic Energy Technology Plan identifies priority technologies on which European energy research is to focus. Research activities under the RENERGI programme must be coordinated with the plan.

In addition to research conducted within the EU framework, important activities are being carried out under the auspices of *the Nordic countries, the International Energy Agency (IEA) and under bilateral agreements* with a number of countries.

In a national context, it will be fruitful to use the programme's instruments systematically in certain thematic areas to develop world-class research groups – both to enhance the level of expertise in industry-oriented and applied R&D, and to improve quality in strategic research. Formal international cooperation on projects requires that participating players set aside a defined amount of resources, personnel and funds for the individual project.

6. Communication and dissemination activities

The RENERGI programme will actively use communication and dissemination of research findings as a tool in achieving its objectives. The business sector and the research community comprise the primary target groups for communication activities, followed by the authorities and the public at large. Communication activities will make use of a variety of different arenas and channels to draw attention to the programme's activities, as well as to facilitate dialogue with, disseminate research findings to and serve in an advisory capacity for the various target groups.

Communication activities under the RENERGI programme will primarily be dedicated to conveying the following overall points:

- Increasing privately and publicly-funded research efforts is crucial to identifying measures for dealing with climate challenges in both the short and the long term.
- Research activities under the RENERGI programme develop knowledge and solutions as a basis for ensuring environment-friendly, economically efficient and effective management of energy resources, a highly reliable energy supply and internationally competitive industrial development.

The use of communication instruments and channels is specified in the programme's communication strategy, which is revised on an annual basis and conforms to the Research Council's overall strategic communication activities and procedures.

Guidelines have been drawn up for activities relating to communication, dissemination of information and the media, including how the programme should stipulate dissemination requirements for researchers, how the programme should present its findings in a unified manner, how the programme board can fulfil its advisory role vis-à-vis the authorities and the public at large, and how to deal with the media.

As part of its communication activities, the RENERGI programme will promote good, professional, well-prepared relations with journalists and the media at the regional, national and international levels.

7. Budget

The budget for the RENERGI programme is presented in the figure below. Allocations have increased from NOK 114 million in 2004 to NOK 363 million in 2010. The total budget for the period 2004-2009 was approximately NOK 1 billion.

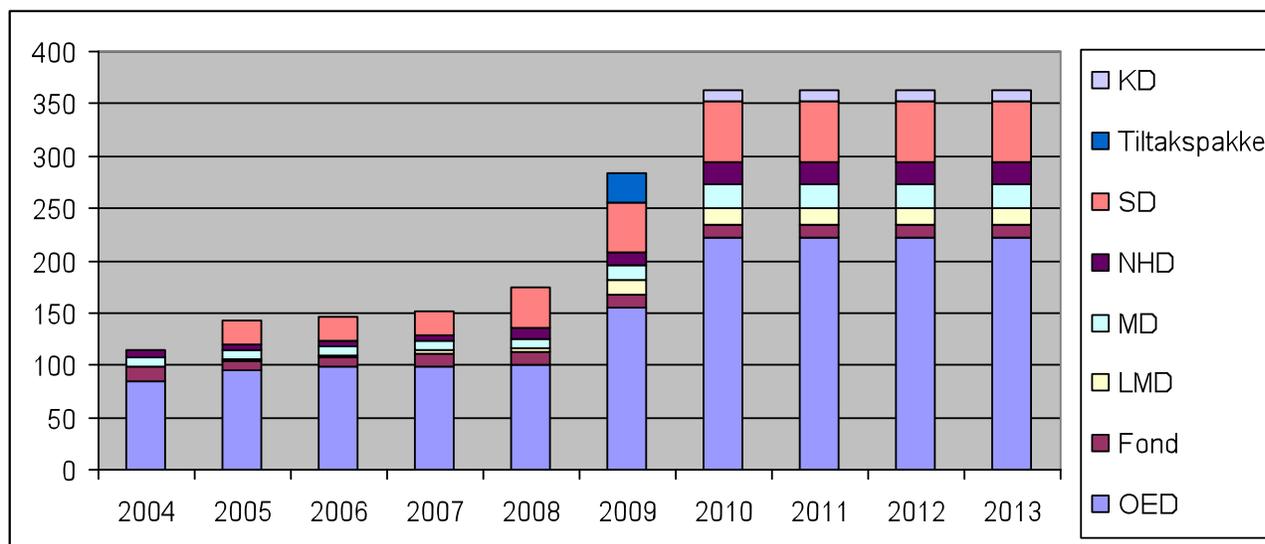


Figure 7.1 Development of the RENERGI programme budget from 2004-2010 (in NOK million). Zero-growth budget for the period 2010-2013.

More tables in Norwegian version..

If allocations remain at the 2010 level, the RENERGI programme will have a total budget of approximately NOK 1.5 billion for the period 2010-2013. Some NOK 900 million of this amount is allocated to projects that are already underway. As of spring 2010, the programme has around NOK 500 million available for allocation to new projects (funding for programme administration included here). Assuming zero-growth, the programme will set out priorities on the basis of this amount for the last phase of the programme, which concludes in 2013.

Efforts will be also be made within the framework of the programme to ensure that decisions regarding future funding for the field are taken within a broad-based scientific context. The RENERGI programme will cooperate with the Energi21 strategic body in various budget processes to promote focus on R&D topics that are time-critical for the energy sector and areas in which Norwegian players have long-term ambitions.

In the 2004-2009 period, the RENERGI programme allocated about 40 per cent of available funding to Knowledge-building Projects with User Involvement, about 40 per cent to User-driven Innovation Projects, and about 20 per cent to Researcher Projects.

During the final four years of the programme period, the programme will give priority to implementing research findings and allocating a greater amount of funding to qualification and testing projects for research-based technologies. In spring 2010, the programme issued a call for proposals for market-oriented User-driven Innovation Projects involving pilot testing/testing of research-based technologies. The aim is to provide support to projects that will lead to realisation of the technologies for market introduction or investments in larger-scale pilot/demonstration facilities. Greater priority will be given to this type of project, given that it fulfils an identified user need.

The programme will also focus greater priority on dissemination of research findings.

8. Coordination with other related instruments at the Research Council

The RENERGI programme shares an interface and arenas for cooperation with several programmes at the Research Council:

- In the area of broad-based innovation projects, the BIA programme covers production processes relating to solar energy, construction and raising energy efficiency in industry.
- In the area of nature-based industry, the NATUROGNAERING programme addresses upstream bioenergy and first-generation bioenergy processes, while the RENERGI programme addresses downstream bioenergy and second-generation bioenergy processes.
- In the area of nanomaterials, the RENERGI programme covers basic and applied research on materials technology for solar cells, while the NANOMAT programme covers related nanotechnology. In the area of hydrogen, the RENERGI programme covers the entire value chain, while the NANOMAT programme covers processes in which nanotechnology is a key component.
- In the area of maritime activities and offshore operations, the MAROFF programme covers maritime transport and service and installation vessels.
- In the area of petroleum research, there is cooperation with the PETROMAKS programme on subsea energy supply and geothermal energy.

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- In the area of climate research, there is an interface with the NORKLIMA programme on the framework conditions for climate and energy policy and impacts of climate change on the energy sector.
- In the area of oceans and coastal areas, there is cooperation with the HAVKYST programme on environmental conditions relating to marine energy: wind energy, wave energy and energy from ocean currents.
- Cooperation with the NORGLOBAL, CHINOR and INDNOR programmes will increase in the effort to enhance bilateral cooperation activities.

The RENERGI programme also has clear collaboration with six of the eight Centres for Environment-friendly Energy Research. (The other two centres deal with CCS and collaborate with the CLIMIT programme.) The RENERGI programme will support the centres in their efforts to realise their objectives, ensure effective cooperation between the programme and the individual centres, and will set priorities to strengthen the centres scientifically and strategically. The six FME centres are:

- The Centre for Environmental Design of Renewable Energy (CEDREN)
- The Bioenergy Innovation Centre (CenBio)
- The Norwegian Centre for Offshore Wind Energy (NORCOWE)
- The Norwegian Research Centre for Offshore Wind Technology (NOWITECH)
- The Norwegian Research Centre for Solar Cell Technology
- The Research Centre on Zero Emission Buildings – ZEB

The programme also collaborates with the Division for Science to enhance national research infrastructure within the area of renewable energy production, which is of strategic importance for Norway at large.

The public sector is an important partner for cooperation as well:

- *The SkatteFUNN scheme.* This tax deduction scheme for R&D-related costs has given the business sector the incentive to boost its R&D activity. The SkatteFUNN scheme also helps to draw companies' attention to the Research Council's ordinary research programmes, and gives the Research Council the opportunity to support network-building and collaboration with R&D institutions, in addition to purely company-related activities.
- *Public funding instruments from R&D to market.* The authorities employ a wide array of direct and indirect funding instruments covering the entire chain from research to market introduction and application. It is vital that these numerous instruments are seen as part of a unified whole, or at the very least, not in conflict with one another. *Enova SF, Innovation Norway and the Norwegian Water Resources and Energy Directorate (NVE)* administer public funding

instruments to support the application and market introduction of new technologies and products. Through close cooperation on funding instruments, these three public stakeholders and the RENERGI programme can enhance each other's activities.

- The *Transnova* project was established in accordance with the white paper on Norwegian climate policy and the broad-based political agreement on climate policy achieved in the Storting and presented on 17 January 2008. The mandate for Transnova states that greenhouse gas emissions from the transport sector are increasing more rapidly than other emissions. The objective is to stop this development and achieve zero-growth in emissions, maintaining them at current levels. The role of Transnova is to provide support for demonstration projects and the like in the transport sector, while the RENERGI programme is responsible for funding research activities in this area.

9. Organisation

The programme board of the RENERGI programme is appointed by and reports to the Research Board of the Division for Strategic Priorities. The programme board will strive to achieve programme objectives by implementing the instruments available to the programme, in accordance with the intentions and objectives of the overall strategy for the Research Council, guidelines from the Executive Board of the Research Council and the Research Board of the Division for Strategic Priorities, the work programme and the Energi21 strategy. It is especially important to assess and adjust the programme objectives and the prioritisation of research tasks according to financial framework conditions in the event of unforeseen changes in the national budget and the ministerial allocation letters. The programme board acts on behalf of the Research Council and reports to the Research Board via the Executive Director.

The programme administration of the RENERGI programme is responsible for carrying out the day-to-day tasks of the programme and consists of a programme coordinator assisted by personnel with scientific and administrative expertise. The programme administration carries out the scientific and administrative functions of the programme and facilitates the implementation of the programme board's decisions. The programme coordinator reports to the programme board and takes a proactive role in ensuring that the programme is carried out in accordance with the approved work programme.

The RENERGI programme is a key instrument for the implementation of the Energi21 national R&D strategy. The programme administration has therefore established close cooperation with the Energi21 secretariat, board and groups under the various priority R&D areas.

Processing of grant applications

Grant proposals for Researcher Projects and Knowledge-building Projects with User Involvement will primarily be assessed by international referees. When feasible, the referees will convene together for consensus discussions. The consensus process will provide the formal basis for application assessment.

User-driven Innovation Projects will be assessed by national referee panels convened for discussion. The programme administration will incorporate the referee assessments into its recommendation to the programme board. Applicants who wish to have their applications for innovation projects treated confidentially must explicitly request this. In such cases applicants will have the opportunity to comment on the proposed referees.

10. Thematic priority areas

Raising energy efficiency

Improving energy efficiency will be crucial if Norway is to become carbon-neutral by 2030, as set out in the broad-based political agreement on climate policy achieved in the Storting in 2008. One measure under consideration is to require the Passive House standard for all new buildings by 2020. To succeed, such a strategy is contingent on the development of more energy-efficient construction components as well as knowledge about the use of such components and the interactions between them. Additionally, raising the level of expertise will be required, as will access to reliable computational tools for all players in the construction industry: professional contractors, private individuals, consultants, planners and builders.

Most of the buildings of the future, however, have already been constructed, so achieving Norway's climate targets will also require a dramatic reduction in energy consumption in existing buildings. There is great potential here, but it is imperative to develop new materials, products and renovation methods that can satisfy tomorrow's energy-efficiency requirements.

There is significant potential for raising energy efficiency in industry. In previous studies of selected industrial sectors, Enova and the Federation of Norwegian Process Industries estimate that it is technically possible to achieve a reduction of 5.3 TWh, about half of which would lead to cost savings. The studies also found that the waste heat contained in air and water represents an untapped energy resource of 9 TWh. New calculations are being carried out that are expected to reveal even higher potential than previously estimated.

A key task under the RENERGI programme will be to obtain the knowledge needed to realise the potential for energy efficiency. This will involve generating knowledge about mechanisms and framework conditions that either promote or pose obstacles to the realisation of this potential. Furthermore, raising energy efficiency in buildings and in industry will be viewed in the context of related fields such as energy supply.

Within this thematic priority area the programme will seek to:

- Facilitate a significant reduction in energy consumption within the building sector and industry in general.
- Enhance insight within the research community, the business sector, and among the public at large in relation to energy use, energy-efficient solutions and consumption patterns.
- Cultivate competitive Norwegian suppliers of energy-efficient equipment for industry and the building sector.

Potential areas of focus for achieving the above may include:

**Adopted by the Research Board of the Division for Strategic Priorities on 7 April 2010
(preliminary version in English – without tables in chapter 7**

- Knowledge about mechanisms that further the realisation of energy efficiency potential, including public funding instruments and their effects.
- Better control and management of energy through knowledge-building, outsourcing, follow-up systems, etc.
- Increased focus on raising the company-wide level of energy-related expertise as well as methods for disseminating knowledge among the various industry players.

Buildings

- Low-energy and Passive House solutions for new buildings.
- Low-energy and Passive House solutions for renovation of existing buildings.
- Development of better tools for assessing energy-efficient and climate-neutral solutions for buildings.
- Innovative solutions for alternative heating of existing buildings.

Industry

- Raising energy efficiency within the production process.
- Greater utilisation of process heat.
- Energy-efficient methods of heating and cooling.

Renewable energy production

Norway is rich in renewable energy resources such as hydropower, wind power, solar energy, and energy from the ocean such as wave, osmotic and tidal power.

Hydropower will play a central role in the output of power in the power market of the future, in which climate considerations will necessitate more non-regulatable power production and in which Norway will increasingly interact with the European power market. Norwegian energy companies, suppliers and research groups are at the forefront of the hydropower field. Existing expertise should be further enhanced to facilitate future operations and the further development and upgrading of hydropower plants, as well as the development of small-scale plants. Furthermore, research activities should help to realise the export opportunities available to the Norwegian business sector.

Land-based wind power is a well-established, mature market. For Norwegian players, experience from operations on land is vital for developing wind power production at sea. There is enormous technical potential associated with offshore wind power in Norway. An established competence platform already exists in many relevant scientific disciplines, along with high basic expertise in industries related to oil, gas, maritime activities and power production. Offshore wind power production, both in deep and shallow waters, has already been identified as an important area of focus for several of Norway's major industrial companies. As is the case with Norwegian offshore technology, there should be significant potential for Norwegian-developed technology and supplier services on the international market.

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The Norwegian solar cell industry has already generated substantial value creation, and possesses considerable growth potential both in terms of activity in Norway and on the larger international market. Norway has top expertise in this industry, and Norwegian researchers have high aspirations in this area. Norwegian value creation is at a premium here, and the overall challenge is to continue boosting the learning curve in terms of reducing production costs and raising operational efficiency.

Within this thematic priority area the programme will seek to:

- Foster the development of renewable energy production in Norway.
- Increase value creation in Norway through environmentally adapted technology development within renewable energy production.

Potential areas of focus for achieving the above may include:

Hydropower

- Operational and environmental impacts of alternative regulation of hydropower production.
- Market-related, technologically optimised solutions for coordination of regulatable and non-regulatable power production.
- Optimal use of water resources and increase in operational efficiency gained by renovating power facilities.
- Products and services in connection with small-scale power plants.

Wind power

- Lowering operating costs of wind power, both on land and offshore.
- Environmental impact of wind power production.
- Developing competitive solutions for offshore wind power.

Solar energy

- Competence-building for next-generation solar-cell technologies.
- New materials for solar-cell production, e.g. nanomaterials.
- Development of solar-cell products for integration into buildings.

Marine energy

- Reducing investment and operating costs.
- Environmental impact.
- Developing competitive solutions for marine energy.

Energy systems

The vision of Norway as a genuinely low-emissions society and a major supplier of renewable power to Europe is contingent on significant restructuring of both the local and the international energy systems. A large proportion of unregulated renewable power will challenge the level of supply security that Europe enjoys and which is a fundamental condition for value creation and welfare development. Facing these

challenges will require intensified cooperation internationally and better utilisation of local resources.

It is important to create a framework for realising the enormous potential of wind power on land and offshore in conjunction with easily regulatable hydropower in such a way that Norway emerges as a strategic partner for Europe in the role of supplier of reliable and renewable energy. The situation today subjects certain parts of Norway to irregularities in the availability of power, while at the same time demands are rising for the development of solutions that have less environmental impact.

Within this thematic priority area the programme will seek to:

- Ensure the acquisition of wide-ranging knowledge of national and international legislation, rules and support schemes for developing and operating the energy system.
- Cultivate the capability to analyse commercial rules that promote sustainable solutions and a sound economy for market players.
- Facilitate the development of a regional energy system, including offshore as well, which will enable Norway to deliver climate-friendly power to Europe on a large scale.
- Develop environment-friendly technology as well as planning tools to ensure optimal coordination between end use, infrastructure for a greater number of energy carriers, and local energy production/storage.

Potential areas of focus for achieving the above may include:

Infrastructure

- Offshore wind power infrastructure for electricity transmission and grid connections to land, including intercontinental connections and grid reinforcements on land.
- Solutions for coordinating regulatable and non-regulatable production. technology for stabilising large fluctuations in feed-ins.
- Solutions for environment-friendly infrastructure.
- Knowledge and new technology for subsea transmission grids.
- Design of a user-driven, interactive energy system with standardised, open infrastructure and seamless integration of new production.

Analysis

- Planning/prognosis tools and control systems that take adequate account of security of supply in a more complex energy system.
- Development of scenarios for various types of international frameworks.
- Local energy planning.

Alternative energy carriers: hydrogen, natural gas and biogas

Norway has substantial natural gas resources, and occupies a unique position internationally in relation to production solutions and exports. Various other Research Council programmes provide funding for research on production solutions and chemical conversion to industrial products. The RENERGI programme focuses on new opportunities for energy production and related industrial development.

Comprehensive international efforts on hydrogen as an energy carrier are underway, driven primarily by the need for security of energy supply, concern for the environment, and opportunities for industrial development. These international efforts are a prerequisite for Norwegian activities in this field. Norway is particularly well-equipped to develop hydrogen use, with opportunities for large-scale hydrogen production from both water electrolysis and natural gas. Norway also has major industry players in this field as well as research groups that are at the forefront in key technological areas.

Biogas can be produced from organic waste such as food waste and livestock manure. The prohibition of landfilling of wet organic waste makes this technology all the more relevant for use in Norway, as does the national effort to reduce greenhouse gas emissions from agriculture.

Within this thematic priority area the programme will seek to:

- Promote Norway's participation in international efforts on hydrogen. To achieve this Norway's community of experts, industry players and public authorities must assume a leading role in selected areas relating to knowledge about the production, storage, transport and use of hydrogen.
- Develop innovative technical solutions for energy production from natural gas.
- Facilitate efficient utilisation of energy from organic waste.

Potential areas of focus for achieving the above may include:

Natural gas

- New technology for the direct use of natural gas, including fuel cells.
- Decentralised heat production.

Hydrogen

- Production of hydrogen from natural gas or water electrolysis.
- Hydrogen storage.
- Development of fuel-cell components and systems for the use of hydrogen.
- Hydrogen-related materials research.
- Use of hydrogen in upgrading biogas.

Biogas

- Optimisation of the production process for biogas.
- Developing cost-effective solutions for upgrading biogas to fuel quality as well as its conversion to liquid fuel products.

Low-carbon heating and cooling

There is great untapped potential for the introduction of renewable energy to fulfil society's needs for heating and cooling. There is enormous opportunity for value creation in the form of new markets for fuel and the sale of electricity, heat and refrigeration. There is also substantial potential to develop Norwegian technology in selected niche areas.

Environment-friendly heating solutions can be expected to be constructed in Norway within a relatively short timeframe. One challenge lies in finding the most cost-effective solutions. In addition, the use of cooling in the Norwegian building sector is growing. One of the Government's stated policy objectives is to ensure targeted and coordinated use of policy instruments to expand the production of bioenergy by up to 14 TWh by 2020. In the area of bioenergy, there will be a need for long-term activities, related for instance to cleaner emissions, higher efficiency, and increased flexibility of both output and fuels. The heating and cooling market is an interesting one in which there are already energy resources, technologies and system solutions that can be applied today. At the same time, there is a need for innovative solutions that yield an even better economy of resources and environmental profile.

As a result of trends within the building sector, new challenges are arising related to the development of heating systems. With the emergence of low-energy and Passive Houses comes the need for CO₂-neutral heating systems that can cost-effectively satisfy low emissions requirements in accordance with the Passive House standard.

Within this thematic priority area the programme will seek to:

- Increase utilisation of bioresources and heat from surroundings.
- Promote industrial development related to efficient power/heat production.

Potential areas of focus for achieving the above may include:

Utilising thermal energy

- Innovative solutions for alternative heating of existing buildings.
- The use of solar heating in buildings and in industries with considerable hot-water demands.
- Energy-efficient heat-based cooling.
- Developing better combustion processes aimed at efficient energy utilisation and environment-friendly combustion.
- Developing cost-effective, CO₂-neutral heating systems for low-energy and Passive Houses.

Power/heat production

- CHP solutions (combined heat and power).
- Developing various technologies that deliver combinations of electricity, fuel, heat and refrigeration – from biomass and waste or a combination of these sources.
- Efficient energy utilisation from seawater, geothermal energy and other heat from the surrounding environment.
- Technology development for geothermal energy with an emphasis on drilling technology, resource mapping and other areas where cutting-edge expertise within the Norwegian petroleum industry can be exploited.

Low-carbon transport

Fully 25 per cent of Norway's greenhouse gas emissions in 2007 were generated by the transport sector, and in the last 10 years emissions in this sector have been rising sharply. In the white paper on Norway's climate policy (Report No. 34 (2006–2007) to the Storting), the Government's target is that existing and new policy instruments in

the transport sector should result in a reduction in greenhouse gas emissions from this sector of 2.5-4 million tonnes CO₂ equivalents relative to expected emissions in 2020. In light of the challenges facing the transport sector and the fact that environment-friendly transport is so closely associated with the stationary energy system, low-carbon transport has emerged as an important research area as the programme period has progressed.

Activities under the programme focus on those technology areas where real contributions are possible in terms of converting Norway's transport system – and where Norwegian players can advance international development while positioning themselves for value creation within an international market for a sector in rapid growth. On this basis, activities within low-carbon transport technology are focused on three main areas: hydrogen, biofuels, and electrification of the transport sector. Norway has the resources needed for the future implementation of solutions in all three areas, and Norwegian players can play a role both in terms of the energy supply and delivery of technology. Given the many opportunities and uncertainties associated with how the technological situation for these technologies will develop, generating reliable, relevant knowledge in all three areas makes strategic sense. This will make it possible to develop the knowledge needed to implement them, along with the mechanisms this requires, while providing the chance to advance and refine those areas of technology where Norwegian players already have an advantage and can contribute and compete in the international arena.

In addition to technological research, a growing need is arising for social science perspectives in order to create regimes and innovation instruments which promote a rapid transition to environment-friendly technology where available, and to ensure that research findings, both Norwegian and international, are incorporated into Norway's transport system.

Within this thematic priority area the programme will seek to:

- Reduce the use of petroleum-based fuel and hence greenhouse gas emissions in the Norwegian transport sector.
- Further the development of Norwegian industrial clusters in one or more priority areas.

Potential areas of focus for achieving the above may include:

Electrification

- Technology and systems related to power lines for electric vehicles.
- Energy storage and batteries in vehicles.

Hydrogen as a fuel

- Supply and use of hydrogen.
- System-related challenges associated with hydrogen.
- Advanced materials technology for use in the transport sector.

Biofuels

- Production of synthetic biofuel with gasification, gas purification and processes of synthesis.
- Efficient processes for upgrading biogas.

Energy markets and energy policy: framework conditions, instruments, markets and analyses

In recent years there has been a growing recognition of the value of social science-related knowledge in achieving the objectives of energy and environmental policy. This is especially apparent in the Energi21 strategy, where research on frameworks and instruments is one of the five priority R&D areas. If the objectives of Energi21 are to be reached, it will be necessary to enhance the knowledge base in relation to several key areas.

Within this thematic priority area the programme will seek to:

- Generate knowledge about trends in European energy policy and the impact of this on the targeting of Norway's energy policy and R&D initiatives.
- Provide knowledge about the framework conditions of various countries and the significance of these conditions in relation to the industry's investment in R&D and for the implementation of new technology and energy-efficient solutions.
- Obtain knowledge about and promote the development of models, instruments and tools that can effectively help to realise the stated energy policy objectives. This includes, among other things, better understanding of the future's supply and demand sides.

Potential areas of focus for achieving the above may include:

Sub-area 1: Energy policy and policy instruments to achieve energy policy objectives

- International energy policy, including an understanding of the international context, which influences the latitude of political action at the national level.
- Framework conditions and instruments for R&D and innovation.
- Development of models, instruments and tools that can facilitate the realisation of energy policy objectives.
- The options and limitations of the political governance system within the area of energy and environmental policy, including studies of interactions between the various levels of government (national, county, municipal) and interactions with other national policy areas.

Sub-area 2: Energy markets

- Market design that ensures sustainable development within e.g. environmental markets: for example, green certificates markets, emissions trading markets, quota markets, etc.
- International harmonisation of legislation and regulations in integrated energy markets to ensure efficiency and sustainability, as well as take adequate account of Norway's unique characteristics.
- Incentives for investments (and security of supply). Projects addressing regulations on income parameters, distributed generation and the expansion of the Norwegian energy supply (through coordination/placement of hydro, wind and gas power plants, bio-heating, etc.)
- Public procurement and organisation of innovation processes, such as public-private partnership models. Processes related to effective commercialisation of new energy technologies and industrial development.
- Economic cost analyses for new energy technologies.

Sub-area 3: Analyses at the community and international levels

- Consumer behaviour.
- Acceptance of public instruments and acceptance issues concerning the introduction of new technologies (and existing ones such as hydropower and nuclear power).
- The relationship between instruments and energy demand.
- Comparative energy studies that address both political and cultural perspectives.
- The impact on and influence of the development of new energy facilities on the natural surroundings, the environment and the local population which is intended to be used as a basis for, e.g., impact studies.