University of Stavanger

IRIS

Research Centre on Sustainable Energy: Draft research programme

January 28, 2008

1. Introduction

"**The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable – environmentally, economically and socially. But that can – and must – be altered; there's still time to change the road we're on.** It is not an exaggeration to claim that the future of human prosperity depends on how successfully we tackle the two central energy challenges facing us today: securing supply of reliable and affordable energy; and effecting a rapid transformation to a low-carbon, efficient and environmentally benign system of energy supply. What we need is nothing short of an energy revolution…**Preventing catastrophic and irreversible damage to the global climate ultimately requires a major decarbonization of the world energy sources.** "
(IEA World Energy Outlook 2008)

Energy presents one of the most critical problems for modern societies. Energy underpins economic development and public welfare. In coming years world energy consumption is expected to rise, especially due to demand from large and rapidly industrializing economies. Today more than 80% of world energy is derived from fossil fuels, but there are rising concerns about oil and gas prices and security of supply, as well as a growing appreciation that greenhouse gas emissions from fossil fuel combustion constitute a serous risk to the stability of the global climate system.

Therefore, there is urgent need for technological, social and political change. Sustainable energy solutions are energy solutions that promote sustainable development. And sustainable development is development that meets the needs of the future without undermining the ability of future generations to meet their needs. Thus sustainable energy solutions deal with meeting society's energy needs, now and in the future. It is concerned with the production, distribution and consumption of energy, and it wrestles with the technological, economic, social, environmental and security dimensions of energy use. It concerns the activities of energy producers, business, local and regional administrations, national governments, and international organizations, as well consumers.

Sustainable energy is not just about renewable energy (energy that is derived from natural flows such as wind, biomass, and solar), because fossil fuels and nuclear energy are likely to remain part of the world energy supply for the foreseeable future. Rather it is about the appropriate mix of energy sources and consumption practices to meet our needs now and in the future without imposing undue burdens on the biosphere. The key challenge is the transformation to an energy system with much lower carbon emissions per capita than today. This **decarbonization** will be a long term process, but it can no longer be postponed. The transformation will require 1) quantum leaps in the development and use of renewable energy, 2) major improvements in energy efficiency from production to end use to be backed by technological innovation as well as new consumer preferences and 3) major progress in decarbonization of the carbon fuels themselves, most notably carbon capture and storage and more efficient use of natural gas.
These three, critical areas will constitute the core of research within the new centre.

3. Centre mission: providing sustainable energy solutions

The centre shall:

1) Conduct world class research and be a major provider of knowledge and technology, in particular in the development of methods and tools for analysis, monitoring, control and optimization of energy systems.

2) Contribute to a transfer of experience and expertise in the petroleum cluster in the Stavanger region to long-term, sustainable energy solutions and the training of a new generation of experts

3) Contribute to the commercialization of sustainable energy solutions and the long-term economic and social development of the region

4) Provide and disseminate analysis of technological, economic, societal and political conditions for sustainable energy solutions and communicate with the public and decision makers about energy policy choices

5) Demonstrate practical solutions to industry, policy makers and the public at large

In order to achieve these objectives, the centre shall be characterized by

- Cross-disciplinary research including natural science, engineering and social sciences (drawing in contributions from economics, sociology, political science, and policy studies) both ‘in house’, and externally. The split between technology/natural science and the social sciences will be approximately 80/20.

- A preoccupation with technological development and processes of technological and social innovation, and with the drivers and obstacles to such change.

    - A holistic approach to understanding the evolution of energy systems, their social embededness, and the assessment of their social and environmental impacts.

4. Key research areas:

Four research areas have been selected as the most urgent and important fields of work within the centre.

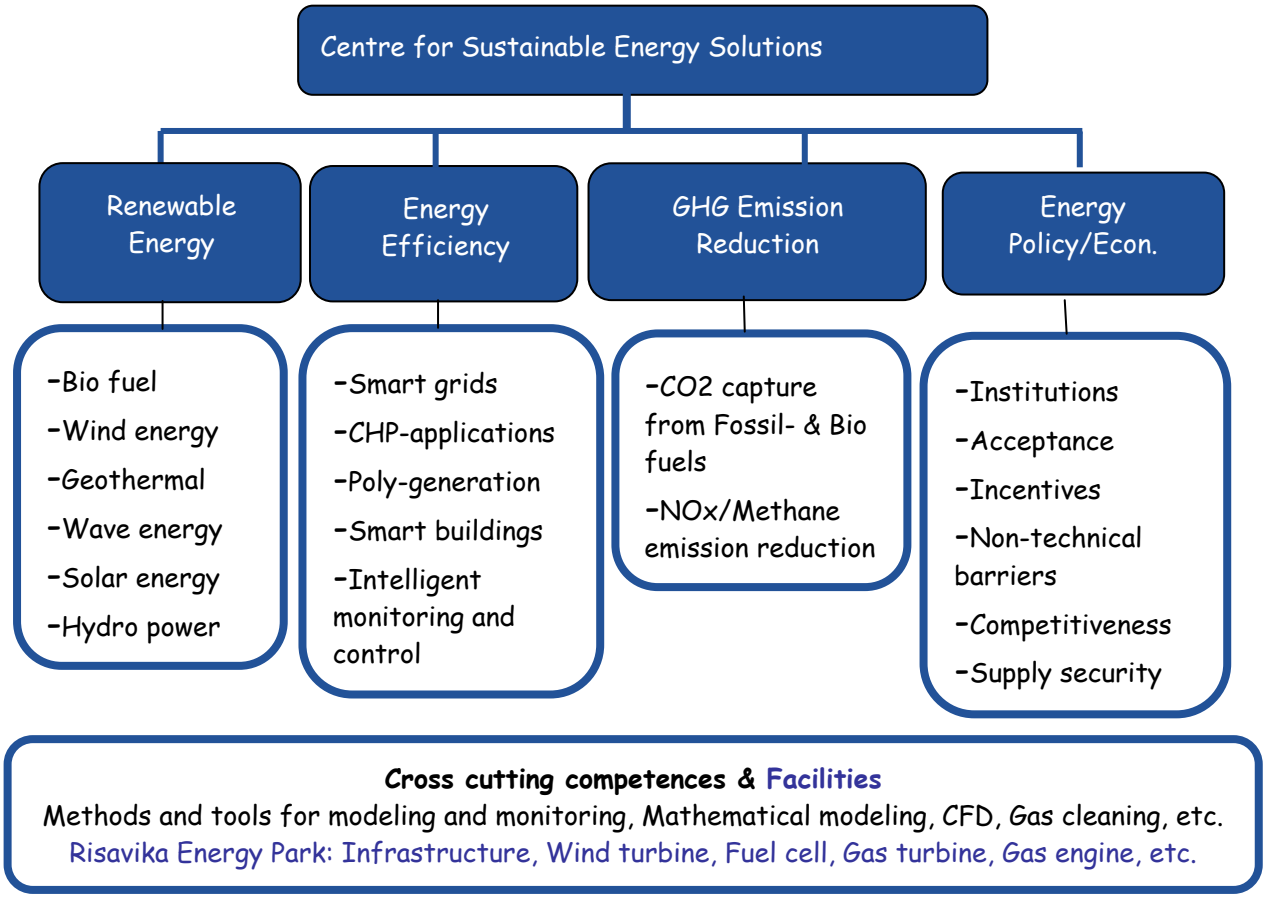

Figure 1: Overview of research areas

4.1. Renewable energy

Renewable energy sources such as bio fuel, wind energy, wave energy, solar energy, geothermal energy and hydro power are among energy sources to be investigated within the frame of the research centre's activities. Special attention and focus will be dedicated to bio fuels, especially biogas production and use, wind energy applications in both on- and offshore installations and geothermal energy.

Biogas production: IRIS "Bio-miljø", "Mat-Nat" and "Biotechnology" at UiS are the groups identified within the UiS/IRIS group with competences relevant for this research area. Research tasks such as optimized mix of the feed stocks (waste), development of bacterial cultures for effective anaerobe processes, chemicals and enzymes for pre-treatment of feedstock, identification of optimum operating temperature and second generation of bio material for biogas production are among the activities of interest in this area.

Offshore wind power: Representing a potential of becoming a major new offshore industry in direct continuation of offshore petroleum, this is a key area for the coming decades of energy research and development. The nature given conditions offshore Rogaland and the marine offshore industry cluster in the area represent a unique combination for facilitating sound research and development programs in offshore wind technology. This is confirmed through the ongoing wind/hydrogen project at Utsira and the upcoming installation of the full scale Hywind floating windmill west of Karmøy later this year. UiS has nearly 150 offshore master students, specializing in design, installation, operation and maintenance of offshore structures and systems, including environment and safety disciplines. The competence from offshore petroleum can be directly applied in a new offshore wind industry. The maritime industry including ship owners, marine service providers, sub sea construction companies and consulting entities are now all preparing for meeting the requirements of a new industry. The planned MET centre at Karmøy will be a key element in this development and shall be strongly supported by UiS and IRIS.

Geothermal energy: Geothermal energy, as a renewable source of energy, will play an important roll for security of supply and environmental friendly energy generation in the near future. Combination of competences from petroleum technology, i.e. drilling and geology, with system integration, modelling and analysis will provide a strong basis for knowledge development within this important research field.

Hydro power: It is estimated that the hydro power based electricity production in the world could be increased considerably by modernization of the existing power plants and utilization of small scale hydro power units. Neither of these measures would have any negative impact on the environment. Therefore, investigation of existing hydro power plants for identification of possible improvements and development and installation of small scale hydro power units would be one of the research focuses of the centre.

4.2. Energy efficiency

Improved energy efficiency is identified by the international research community as the most important area with highest potential to contribute to reduction of harmful emissions to the atmosphere.

Substantial reduction in energy consumption in buildings is possible, using a combination of intelligent energy management and energy savings. Availability of data transfer network, based on optical fibre net, opens a new dimension for intelligent energy management and control at the end user sites. Development of data driven modelling and online monitoring tools will be a major focus for research activities at the centre.

Increased efficiency of energy conversion technologies, using highest possible temperatures, combined with effective utilization of low temperature heat sources, such as industrial waste heat, provides new opportunities for improved energy efficiency.

Combining production of electricity, heat, cooling and other useful products, such as hydrogen and liquid fuels, in poly-generation units contributes to increased total plant efficiency and highest possible utilization of the energy content in the fuel. Investigation of various system layouts for poly generation will be one the research focuses of the centre.

Efficient distribution of energy carriers, aiming at minimization of the distribution losses in e.g. electrical net, district heating and cooling net, and hydrogen and natural gas grid is yet another area with high potential to contribute to energy efficiency. Thermo-economical optimization of distribution net and optimized integration of production units with end user applications will be a major research area for the centre.

4.3. GHG emission reduction

Combating global warming, caused by increased concentration of green house gases (GHG) in the atmosphere, has become a major task for humanity to save the earth for the future generations. Development of various technologies for reduction of green house gas emissions, including CH4, NOx, and CO2 will be one of the research focuses of the centre.

All available technologies for CO2 capture, i.e. post-, pre-, and oxy-fuel processes, will be studied, developed and evaluated within the frame of the research centre. Combination of the unique experimental resources at Risavika Gas Centre (RGC) and modelling and monitoring competences at UiS and IRIS will be fully utilized to further develop GHG emission reduction technologies.

Gas cleaning and gas separation technologies using various combinations of membrane based separation technologies as well as chemical and physical absorption will be developed and evaluated in the research centre. Based on interdisciplinary research activities, combining various competences at UiS and IRIS, new and innovative solutions will be developed and evaluated in the centre. This research field requires a combination of competences and expertise covering detail modelling, CFD-analysis, chemical reactions, physical separation technique, data driven modelling, system integration, optimization and monitoring. Therefore, collaboration between several groups will be needed to tackle problems in this research filed and develop needed knowledge and competences.

Since offshore oil and gas installations are major contributors to Norway's CO2 emissions, development of compact CO2 capture technology for offshore applications will be a selected research topic within CO2 capture. Combination of competences from offshore technology and CO2 capture plant modelling and analysis is the key for knowledge and technology development within this important field. Dynamic modelling, mixing and reacting flows are

other areas of importance for development of compact CO2 capture units for offshore applications. Combination of competences from CFD-modelling, thermodynamic and modelling, system analysis and offshore technology is needed for development of this research field.

Increased fuel flexibility of various energy conversion technologies is another research topic of the centre, aiming at GHG emission reduction by replacement of carbon intensive fuels by low-carbon content fuels.

4.4. Energy politics and policies

While technological development is the core activity of the Energy & Environment Centre, the politics and policies of sustainable energy will have a prominent place in the Centre's activities, for several reasons. There is no agreement as to what constitutes sustainable development or "sustainable energy solutions". Thus, energy is highly political and politicised, not only in Norway but in the World as such. Moreover, sustainable energy policy engages with a variety of economic actors and sectors, including energy production and transformation, the transportation system, industry, agriculture and households. For we are all energy users. And our patterns of energy use are deeply embedded both in physical infrastructure and in social institutions.

In light of the urgent need for an energy transformation to renewable energy, Norway's position as both a major international oil and gas producer and an important international advocate of more vigorous international action to address climate change, a number of particular themes will feature in the energy politics and policy work of the centre, including:

- Renewable energy challenges: Policy support for the development of new renewables (especially biomass and bio-fuels, wind, wave, and solar), including issues about political and policy obstacles to its development and deployment, consumer behaviour, public perceptions, attitudes and acceptability, competitiveness and regulation issues.

- Energy efficiency challenges: The identification of energy efficiency barriers and opportunities (including political, policy, economics, public perceptions and attitudes). Business responses to energy and climate change and business efforts to capture new energy opportunities, including corporate sustainability strategies and multi stakeholder initiatives, aiming at energy efficiency and energy innovations.

- GHG emission reduction challenges: The politics of carbon capture and storage CCS; including economic and environmental risks and benefits, appropriate regulatory regimes, strategic place in international climate abatement efforts; export potential, and integration into international climate regime, CDM, etc. The future of hydrocarbon production in the North Sea, Russia and the Artic. European energy policy and climate change policy, and Norway's place within the European energy supply and climate change response framework (including the integration of energy security and climate change policies).
- **Security of supply:** Policies to reduce CO2 emissions will have profound impacts on security of supply, in particular in Europe. In some cases the two concerns are

compatible and mutually reinforcing, in others they are contradictory. Within the centre attention should be devoted to this complex relationship by analyzing how and to what extent the two ends, security of supply and climate protection, can be reconciled, depending on technological progress in the areas described above.

The figure below illustrates connection between some of the integrated research topics of the centre, starting from biogas production and gas cleaning to end user monitoring and control, via energy conversion technologies, exhaust gas cleaning and distribution grid optimization and control.

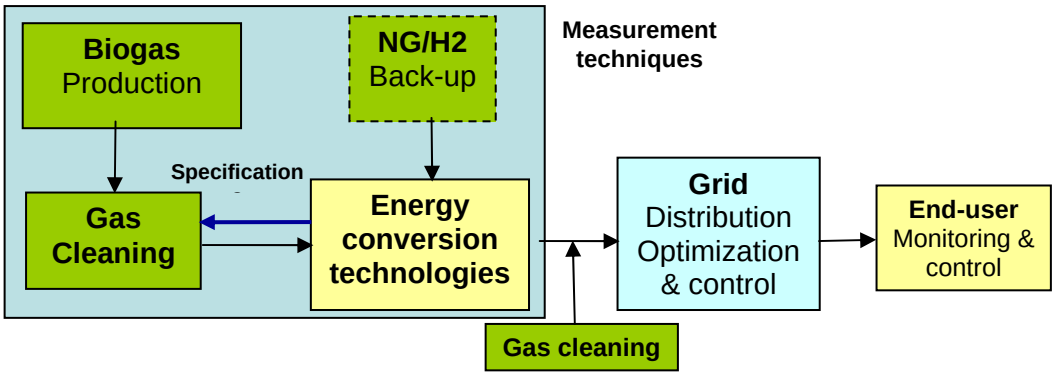

Figure 2: Schematic presentation of the research activities 1

5. Education

High level education at under graduate, graduate and PhD level will be one of the priorities of the centre. Using available facilities and engaging internationally recognized lecturers will substantially contribute to improved quality of higher education within the field of energy at UiS.

Direct integration of research results and experiences in the education program of UiS will provide unique opportunity for the students to become familiar with real world problems and gain scientific insights of great value.

6. Commercialization

Text to be added!

7. Resources

A description of the facilities at RGC, IRIS and UiS will be added!