

# CREE annual report

2011

## Summary

CREE – Oslo Centre for Research on Environmentally friendly Energy was established in 2011 as a social science based energy research centre funded by the Research Council of Norway (FME Samfunn) with an annual grant of NOK 8 million for 5 years, with a possible 3 years extension. The center started its activities in August 2011.

The main focus is on economic research as the research partners include the Frisch Centre, Department of Economics, University of Oslo (ØI), the Research department at Statistics Norway (SSB), and Tilburg Sustainability Center, the Netherlands. Cooperation with Centre for Development and Environment (University of Oslo), Faculty of Law (University of Oslo), SINTEF Energy Research and Institute for Energy Technology broadens the research perspective. The user perspective is ensured by several partners from industry and government.

The main aim of the center is to collect and develop knowledge on the effects of framework conditions in the energy market and on technological development, including innovation and the diffusion of technology for renewable energy, energy efficiency and carbon capture and storage. The centre provides a basis for better framework conditions and policy instruments designed to reach the energy and climate goals established nationally and internationally. CREE will also strive to develop the methodological framework required to reach these goals.

Our portfolio is divided into five working packages studying international climate and energy policy, innovation and diffusion, markets and regulation, evaluation of policy measures, and development of numerical models.

## **CREE – Oslo Centre for Research on Environmentally friendly Energy**

There is an increasing evidence for a changing climate and that this change is due to human activities. The impacts of climate change on the economy, ecosystems and welfare can be significant and may be catastrophic for parts of the world. Thus, there is a need to reduce emissions that affect the climate as well as to adapt to inevitable changes, and it is recognized that technology improvements are an important element for achieving the deep emission cuts.

However, there are several challenges that are not only technological such as how to make it profitable to develop and utilize new technology and more environmentally friendly energy sources. This does not occur by itself, but instead is dependent on institutional and economic frameworks. Another important challenge is to design climate and energy treaties that will help achieving a better social outcome. In this respect effective policy instruments and fair outcomes are important. To make a solid base for policy making on these and other important questions, social science research, including economics, is important.

In this regard, CREE will contribute to the collection and establishment of knowledge on how framework conditions affect both the energy market and technological development, including innovation and the diffusion of technology for renewable energy, energy efficiency and carbon capture and storage. The centre will work on developing better framework conditions and policy instruments designed to reach the goals established in national and international energy and climate policy, but also study the possibilities to improve international treaties to be able to reduce the negative impacts of global warming.

The research of the center will primarily be grounded in economics as the research partners are the Department of Economics (University of Oslo), the Research Department (Statistics Norway), the Frisch Centre and the Tilburg Sustainability Centre, but will also draw on other disciplinary perspectives. Using economics to study the problems mentioned is one approach. Economics is useful and important, although coupling knowledge from economics with knowledge from other fields is essential for establishing a solid basis for energy and climate policies. This is the reason why we will have a close cooperation with other disciplines within the social sciences, law and technology (IFE, SINTEF Energy and the MILEN network at the University of Oslo).

The center has the following vision:

- We want to be a leading research center internationally in the fields of environmental, energy and resource economics.
- We will generate knowledge that can contribute to a rational, cost-effective and sustainable exploitation of the Norwegian and international energy resources as well as an effective and fair climate and energy policy both nationally and internationally. This will be achieved through a broad dissemination of our research results.
- We will contribute to the recruitment and education at the graduate and post doctoral levels in energy and environmental economics at the University of Oslo.

This report will briefly summarize the activities and the achievements of the center in 2011.

## **Research plan and strategy**

CREE organizes its research into five different working packages:

### ***Working Package 1: The International Politics of Climate and Energy***

***(Research Directors: Michael Hoel, Department of Economics, University of Oslo, and Ole Jørgen Røgeberg, Frisch Centre)***

The research questions in this working package are basically on:

- Improving the current climate regime – increase incentives to join and comply
- Alternative treaty forms – sector based treaties; research and development (R&D) treaties?
- Dealing with non-signatories – prevent carbon leakages
- Equity issues – intergenerational vs. intragenerational
- Implications for energy market policies

### ***Working Package 2: Innovation and Diffusion policy***

***(Research Director: Rolf Golombek, Frisch Centre)***

Important research questions in this working package are:

- What is the optimal mix of policy instruments to achieve innovation of environmentally friendly technologies?

- What is the optimal R&D policy for a small country with limited demand for carbon capture and storage (CCS), but with good technological competence?
- What types of market failures may arise in the application and diffusion of environmentally friendly technologies and how can we overcome them?

***Working Package 3: Regulation and Market***

***(Research Director: Nils-Henrik M. von der Fehr, Department of Economics, University of Oslo)***

This research package focuses mainly on the electricity markets and study questions like:

- Is there a contradiction between the policy to develop more green energy and regulations that will provide more efficiency in the energy market?
- Which policies can provide a sustainable use of energy?
- What is a reasonable level of energy security and how can we ensure that it is achieved?

***Working Package 4: Evaluation of Environmental and Energy Policy Measures***

***(Research Director: Bente Halvorsen, Statistics Norway)***

This is an empirical part of the project and studies the success of environmental and energy policy measures so far. Important questions are:

- What amount of energy savings is eaten up by increased consumption (rebound-effect)?
- Can regulation of a good have unintended effects on close substitutes?
- What are the effects of soft policy measures?
- Focus on transportation: Does CO<sub>2</sub> taxation lead to higher demand for energy efficient vehicles? How does the increase in cars that run on biofuels and electricity affect emissions from road traffic?

***Working Package 5: The Next Generation of Numerical Models***

***(Research Director: Brita Bye, Statistics Norway)***

This working package focuses on developing our numerical models by updating the data, improving the modeling of new technologies, and making innovation processes endogenous. The models will be used to study research questions in the other working packages.

Our strategy is to follow the plans put down in the annual research plans. The research will benefit from close contact with subcontractors and user partners. For a the vision and strategy of the total CREE activity, see the CREE strategy plan (written in Norwegian).

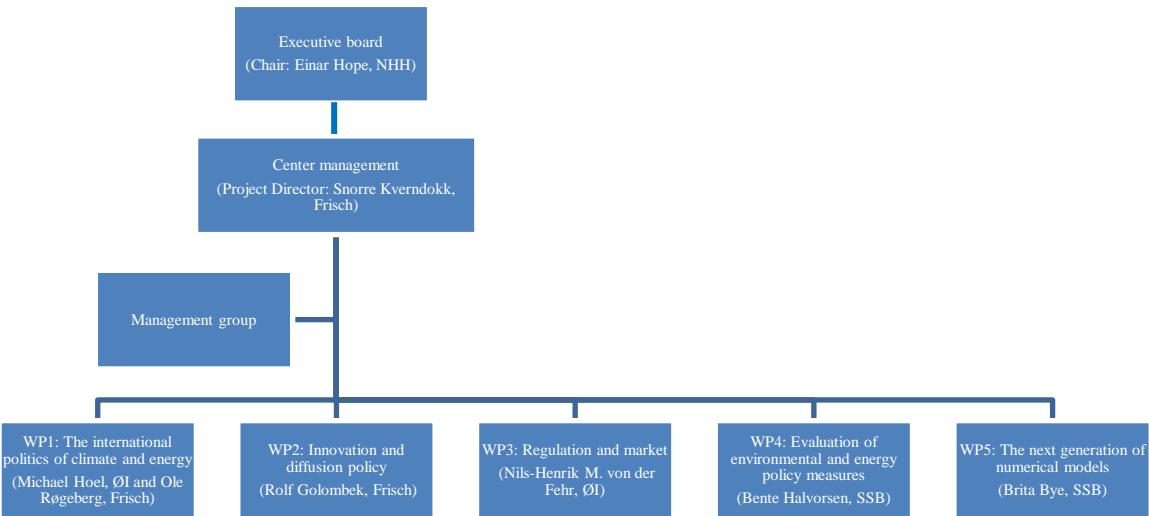
### Center organization

The organization of the center in 2011 was as shown in the figure below. It is also described in a separate document in Norwegian (Styringsstruktur – CREE).

The chair of the executive board (Einar Hope, NHH) does not represent any of the research partners, user partners or sub-contractors, and is therefore independent of the partners in CREE. The board also consists of one member from each of the three Norwegian research partners (Erik Hernæs, Frisch; Taran Fæhn, SSB; Karine Nyborg, ØI), while the user partners are represented by two members, one from industry (Tor Kartevold, Statoil) and one from Government (Tor Arnt Johnsen, NVE). The first board meeting was held on 11 October, 2011.

The administration of CREE is located at the Frisch Centre with Snorre Kverndokk as the Project Director and Jørg Gjestvang as the Project Manager.

The administration has regular meetings with the management group consisting of all the working package leaders to discuss matters of importance for the center.



The partners of CREE are divided into research partners and user partners. The research partners are:

Ragnar Frisch Centre for Economic Research (Frisch Centre), Oslo (host institution)  
Research department, Statistics Norway (SSB), Oslo  
Department of economics, University of Oslo  
Tilburg Sustainability Center, Netherlands

CREE had seven user partners in 2011:

Gassnova SF  
Norwegian Climate and Pollution Agency (KLIF)  
Norwegian Ministry for Petroleum and Energy  
Norwegian Water Resources and Energy Directorate (NVE)  
Statkraft Energy AS  
Statnett SF  
Statoil ASA

While there has been cooperation among the research partners before CREE was established, the center facilitates a deepening of this by providing resources and an organizational structure for collaboration both within the community of economists and with the wider research community.

The resources and the organization of CREE make it easier to maintain better contact with the users of energy and environmental research, and to establish a formal meeting point with them. The user partners of the center contribute with funding and with members in the board, but also to the research with detailed knowledge about markets, technologies and politics.

### **Professional activities, results**

The professional activities in 2011 have been concentrated on the research in the different working packages described above, a kick-off workshop, a new seminar series and a user party conference.

The CREE kick-off workshop took place in Oslo (Lysebu hotel) on 26-27 September. About 50 people attended the workshop, mainly researchers from the research partners and sub contractors in CREE, but also from our international network and from user partners. It was organized according to our work packages, and was therefore quite broad when it comes to topics discussed.

Our new seminar series started in November and we had 4 seminars in 2011. We also organized a user partner seminar in December where we focused on CCS and had presentations both from economics, technology and law.

As the activities started in August, we do not have a long list of results yet, but the new CREE working paper series had 5 titles in 2011, and we also had publications in other working paper series. We also had 5 papers published in international peer reviewed journals (however, these were written before the CREE project started) and several papers have been accepted for publication.

Below we will give a short overview of the research that started in the five different research packages in 2011, and go into more detail about one work for each package.

### **WP1: The International Politics of Climate and Energy**

Many of our researchers were involved in this work package in 2011, and we started working on the following question:

- 1) How can international climate treaties be structured to improve participation, ambitions and implementation?
- 2) How is participation in climate treaties influenced by R&D cooperation aimed at reducing abatement costs?
- 3) How does international emission quota trading influence efficiency and equity when the treaty is characterized by weak international cooperation?
- 4) How can carbon leakage be reduced?
- 5) Equity issues. For instance is there a trade-off between intra- and intergenerational equity in climate policies, and how can economic mechanisms such as quota trading be used to handle ethical issues?
- 6) How will the energy market and energy policies vary under different climate-treaty scenarios?



Below is the result from one project related to question 2 above.

### **International cooperation on climate-friendly technologies**

*Forthcoming in Environmental and Resource Economics*

*Rolf Golombek and Michael Hoel*

Because of the shortcomings of the ‘Kyoto track’, several observers have asked whether other types of agreements might be designed to support large reductions of GHG emissions. One idea would be to focus on technology improvements in order to reduce abatement costs, as this might increase a country’s willingness to undertake significant emission reductions. Even with no explicit agreement on emissions, a technology agreement leading to increased R&D, and thus to lower abatement costs, might result in a reduction in emissions.

We examine international cooperation on technological development as an alternative to international cooperation on emission reductions. The basic idea of cooperating on technological development is to spur innovation and/or diffusion of climate-friendly technologies. Cooperation on technological development may be designed in several ways. For example, it may commit governments to finance, or organize, basic research on a limited number of technologies, or to develop technology standards that all countries commit to impose domestically. Alternatively, countries may cooperate on policies directed toward private agents, for example, by providing instruments (e.g., technology subsidies or tax breaks) that foster more R&D or increased application of new technologies. Our focus is on technology subsidies, and we assume that R&D leads to improved technology that decreases the marginal cost of emission reductions.

We show that an agreement on technological development should increase R&D in each country beyond the non-cooperative level (i.e., without an agreement) if at least one of the following conditions hold: (i) there are technology spillovers between countries so that the technology level in one country is positively affected by R&D in other countries, or (ii) the domestic carbon tax is lower than the Pigouvian level, that is, the optimal price of carbon when the R&D externality is disregarded, or (iii) the domestic carbon tax is set directly through an international tax agreement. We also show that an optimally designed technology agreement has higher R&D, higher emissions, or both compared with the socially best outcome. If the price of carbon is the same under a technology agreement and the case without any R&D cooperation, welfare is highest, R&D is highest and emissions are lowest under the R&D agreement.

### **WP2: Innovation and Diffusion Policy**

The work in this working package in 2011 mainly followed two lines of research, theoretical analyses and numerical analyzes on the numerical model LIBEMOD (see under WP5 below), and theoretical analyzes on more general principles. On the numerical side, the focus was on the CCS market. Should the Government support the innovation of CCS technologies, and if so, how should that support be designed? We organized a user partner seminar on this topic and have also initiated close cooperation with our user partner Gassnova on this.

Below we give more details on one of the projects under this working package, a theoretical project on support for environmental R&D.

### **Incentives for environmental R&D**

*CREE working paper 1/2011*

*Mads Greaker and Michael Hoel*

Some argue that environmental R&D should take precedence over markets goods R&D in subsidy programs. Hence, in this paper we compare the incentives for environmental R&D with the incentives for market goods R&D in a more general economic model of innovations.

There are many reasons why the incentives for R&D are socially inefficient. First, there are both positive and negative externalities in the production of new knowledge; examples of the former are the "standing-on-shoulders" effect and on the latter is the "stepping-on-toes" effect. Second, due to imperfect patent protection, the innovator may not be able to recover the initial R&D investment. As far as we can see these market failures are equally relevant for environmental R&D and market goods R&D. Unless there is reason to believe there is a systematic difference in the magnitude of these market failures between the two cases, these market failures should not lead to any systematic difference in the incentives for environmental R&D and for market goods R&D.

Our point of departure is another potential difference between the market goods case and the environmental technology case, namely the way in which demand for the new innovation is determined. In the market good case demand for an innovation is given from the underlying preferences of consumers or technology of firms, and governments seldom interfere with demand even if they in theory could benefit from doing so. One reason why the government may not want to interfere is that it would entail additional administrative costs which may exceed the expected benefits of its use. These costs may include the political costs of terminating the use of the subsidy when the innovation is overtaken by a new and better innovation. In the environmental technology case, we have the opposite situation: Through its environmental policy the government must interfere with the demand for the new technology, and hence interfering does not imply any extra administrative costs. This makes it easier for the government partly or fully to expropriate the innovation, and clearly, this may distort the private incentives for environmental R&D.

Although governments may be able to expropriate innovations in new abatement technology after they have been developed, we show that the presentiment that incentives for environmental R&D are lower than incentives for market goods R&D is not generally true. When the innovator is able to commit to a license fee before environmental policy (tax or quota) is resolved, incentives are always higher for environmental R&D than for market goods R&D. This result holds independent of the type of environmental policy instrument being used. Further, when the government is able to commit, but the innovator is not, or when neither the innovator nor the government is able to commit, the relative size of the incentives could go both ways. This result also holds independent of the type of environmental policy instrument being used.

There may exist good reasons for giving priority to environmental R&D in R&D subsidy budgets, however, the argument based on there being a systematic difference in the incentives for R&D favoring market goods R&D should be used with greater care.

### **WP3: Regulation and Market**

Several projects on the electricity market were initiated or finished in 2011. While, the main question of the working package is on how regulation of energy markets affects the development of green energy, and how measures to promote green energy impact on the functioning of energy markets, we also studied the impacts on the electricity market of climatic changes. The ongoing work is theoretical as well as based on numerical models.

Below we give more details from a project that was finalized in 2011-

#### **Wetter and Wilder: Impacts on the electricity industry in Western Europe of climate change**

*Forthcoming in Climatic Change*

*Rolf Golombek, Sverre A.C. Kittelsen and Ingjerd Haddeland*

In a joint project with CICERO, Met.no, NVE and Econ, the Frisch Centre has sought to assess the impact of climatic change on the electricity markets of Western Europe. In separate sub-projects, the expected impacts of climate change on electricity demand, thermal plant efficiency and the inflow of water to hydro power plants have been studied. The Frisch Centre has worked in particular with integrating the different effects in an equilibrium model (LIBEMOD). This has resulted in this paper which is also a joint work with one of our user partners (NVE- Ingjerd Haddeland).

The paper studies some impacts of climate change on electricity markets. In order to illustrate the impact of climate change on electricity markets, below we use a pedagogical tool, namely to postulate that the average climate in a future time period (2070-2099) materializes in a much earlier year (2030). The year 2030 is long enough into the future to enable optimal investments to change production and transport capacities, but short enough that the economic and political structure can reasonably be expected to continue on the historical trends presently observed.

We focus on three climate effects. First, demand for electricity is affected because of changes in the temperature. Second, changes in precipitation and temperature have impact on supply of hydro electric production through a shift in the inflow of water. Third, plant efficiency for thermal generation will decrease because the temperature of water used to cool equipment increases. To find the magnitude of these partial effects, as well as the overall effects, on Western European energy markets, we use the multi-market equilibrium model LIBEMOD. We find that each of the three partial effects changes the average electricity producer price by less than 2%, while the net effect is an increase of only 1%. The partial effects on total electricity supply are small, and the net effect is a decrease of 4%. The greatest effects are found for Nordic countries with a large market share for reservoir hydro. In these countries, annual production of electricity increases by 8%, reflecting more inflow of water, while net exports doubles. In addition, because of lower inflow in summer and higher in winter, the reservoir filling needed to transfer water from summer to winter is drastically reduced in the Nordic countries.

#### **WP4: Evaluation of Environmental and Energy Policy Measures**

This research package is based on empirical studies of the effects of different policy measures.

During the first couple years, the activity will mainly be on three different research topics:

- i) *Rebound and adverse effects of energy policy.*
- ii) *The households' response to soft policy measures.*
- iii) *Environmentally friendly transportation*

This working package is collaboration between economists from Statistics Norway (SSB), social anthropologists from Centre for Development and the Environment (SUM), and economists from the Frisch Centre/University of Torino. Below we give more details on the work done in Statistics Norway in 2011 on the first research topic above.

##### **Household response to policy issues**

*Published in Økonomiske Analyser 5/2011, Statistics Norway  
Bøeng, Ann-Christin., Bente Halvorsen and Bodil M. Larsen*

We started the work on this work package by making a summary of all energy and environmental policy instruments aimed at reducing household energy consumption, and writing a popular science article discussing the reasons we observe rebound effects of increased energy efficiency. These rebound effects occur because the energy efficiency measures changes the relative costs of different energy goods in household production of services (e.g. space heating), in addition to the increase in purchasing power that follows from the reduction in energy expenditures. This will change the energy mix in household consumption, as well as increase the demand for all goods, including energy good. Several empirical studies have illustrated that the energy savings from increased energy efficiency to be less than the energy saving potential of the measure (the rebound effect).

In our paper, the problem with rebound effects are illustrated using the case of investments in air-to-air heat pumps in Norwegian homes, and how this has affected household energy consumption. The data in our analysis indicate the existence of considerable rebound effects, and, on average, the savings in electricity consumption are small and far less than what we would expect from the energy savings potential in the heat pump. This is because Norwegian households like to use some of the reduced expenditures this energy-efficiency measure gives them to increase their comfort level; increase indoor temperature, heat rooms that previously were not heated during the winter, reduce firewood consumption, and reduce the use of night set-backs and other savings efforts. Thus, the purchase of the heat pump has given the households an increase in welfare for approximately the same amount of energy (and cost), and is thus a good for the households. However, these behavioural responses make it harder to reach the goal of reduced energy consumption using efficiency measures.

## **WP5: The Next Generation of Numerical Models**

This working package develops numerical models that will be used under the other working packages. At the moment the numerical model portfolio consists of two models LIBEMOD and MSG. While the first is an equilibrium model for the European energy market, the second is a general equilibrium model for Norway. In 2011, the main activity has been to update and develop the LIBEMOD model, and a description of this model follows below.

### **LIBEMOD**

LIBEMOD is a numerical multi-market equilibrium model for the energy sector. Its main focus is on the electricity and natural gas industry in Europe, but it also covers markets for other fuels like coal and oil. The model is a synthesis of the bottom up and top-down modeling traditions. On the one hand it offers a detailed description of the electricity and natural gas industry in Europe, in particular production of electricity, and on the other hand it has a clear foundation in economic theory by deriving structural behavioral relations from well-specified optimization problems, and imposing that all markets should clear.

LIBEMOD distinguishes between model countries and other countries. In a model country, there is production, investment, trade and consumption of all energy goods, that is, electricity, natural gas, three types of coal (coking coal, steam coal and lignite), oil, and biomass. In the present version of LIBEMOD, each of sixteen countries in Western Europe is a model country, whereas all other countries in the world are represented mainly through supply of, and demand for, coal and oil.

Electricity and natural gas are traded in competitive well-integrated Western European markets, using existing capacity in international transmission of these energy goods. These capacities will be expanded (in the model) if there are profitable investment opportunities. Coking coal, steam coal and oil are traded in competitive global markets, whereas lignite (used for emission-intensive coal-power production) and biomass (used to produce electricity) is traded in national markets only.

There are four groups of users of energy in each model country. First, there is intermediate demand from electricity producers: for example, gas power producers demand natural gas. Furthermore, there is demand from end users: the household, industry and transport sectors, though the latter demands only oil products. For end users, demand is derived from a (nested CES) utility function with five levels. Electricity is traded in four time periods throughout the year (summer vs. winter, day vs. night), whereas fossil fuels are traded in annual markets.

In each model country, there is production of electricity by various technologies: steam coal power, lignite power, gas power, oil power, reservoir hydro power, pumped storage power, nuclear power, biomass power, waste power and wind power. Some of these are not available in all countries. There are costs related to electricity production: fuel costs, non-fuel operating costs, maintenance costs (related to the maintained power capacity), start-up costs and investment costs. The power producer obtains revenues either from using the maintained power capacity to produce and sell electricity, or by selling part of the maintained power capacity to a national system operator who buys reserve power capacity in order to ensure (if necessary) that the national electricity system does not break down.

LIBEMOD is run for a distinct year, and determines all energy quantities (investment, production, trade and consumption), all energy prices (both producer prices and end-user prices), and also emission of CO<sub>2</sub> by sector and country.

## **International cooperation**

All the research partners in CREE have large international networks that we build on in the center. The international cooperation in 2011 can be divided into the following activities: Participation in the kick-off workshop and other workshops we have organized, presentations at the CREE seminars, guest visits and ongoing collaborative projects. Details are given below.

At the kick-off workshop in September, the following researchers from other countries attended:

Fridrik Baldursson, Reykjavik University  
Chris Böhringer, Oldenburg University  
Jared Carbone, University of Calgary  
Johan Eyckmans, European University College Brussels  
Samuel Fankhauser, London School of Economics  
Reyer Gerlagh, Tilburg Sustainability Center  
Richard Green, Imperial College, London  
Kristine Grimsrud, University of New Mexico  
Anita Halvorsen, University of Denver  
Thomas Michielsen, Tilburg Sustainability Center

We also organized other conferences where foreign scholars have been invited. Frisch Centre held a kick-off meeting on 28 September for the project "Intergenerational and intragenerational equity in climate policy" (funded by MILJØ2015, but is included as own funding in the center) with several foreign researchers (Johan Eyckmans, Samuel Fankhauser, Reyer Gerlagh). SSB organized two workshops in the fall. One was in connection with the RENERGI project "Diffusion of Climate Technologies" which is also a part of own funding. It took place at Kleivstua 19-20 October where participation included Reyer Gerlagh and Thomas Michielsen from Tilburg, Thomas Sterner from Gothenburg, Valentina Bosetti of FEEM /University of Milan, and collaborators from the Development Research Center in Beijing, China. The second workshop was held on 17-18 November and was organized in conjunction with the Energy Modeling Forum where SSB is participating in an international project on "Border carbon policies", and where 15 foreign partners participated, including

Chris Böhringer (University of Oldenburg), Thomas Rutherford (ETH - Zurich), Ed Balistreri (Colorado) and Carolyn Fischer (RFF).

During our seminar series in the fall, only researchers from other countries gave presentations. There have also been seminars with foreign researchers on CREE-related issues before the CREE seminar series started in November.

CREE had a number of foreign visiting scholars in the fall. Jared Carbone (University of Calgary), Andreas Lange (University of Hamburg) and Linda Nøstbakken (University of Alberta) visited the Frisch Centre for a few days in connection with project collaboration. Kristine Grimsrud (University of New Mexico) had a sabbatical at SSB during the summer and the fall.

We also have several ongoing collaborative projects with foreign researchers in CREE. Some outcome of these projects are reported in the CREE working paper series, while others have been reported in other series (see the appendix on publications). In addition to this, we have extensive cooperation that has not yet resulted in publications, both under projects that are directly funded by CREE, and also under projects that count as our own funding (RENERGI, MILJØ2015 and NORKLIMA).

## **Recruitment**

The overall plan for CREE is to recruit two PhD students and one post-doc researcher at the beginning of the project period and to recruit a new PhD student and a post-doc in 2015. Hence, if we get funding for eight years, we will have funded at least three PhD students and two post-docs over the lifetime of CREE.

So far we have recruited four people who are funded by CREE. Jørg Gjestvang was appointed Project Manager of CREE in 50% position from 1 October. He is trained as an economist and employed by the Frisch Centre, and he is also working 50% for the Frisch Centre administration. Hilde Hallre is also an economist and is employed at the Frisch Centre as a research assistant in a one-year position from September 2011. She is updating and developing the LIBEMOD model, a numerical model for the European energy market. In addition, we employed the two PhD students as planned. Alice Ciccone started her work at the Department of Economics on 15 August last year as a fellow fully funded by CREE, while

Marit Klemetsen started at Statistics Norway at the same time in a position that also will lead to a PhD. She is partially funded by CREE funds, and partly funded by other research council means (own funding). In addition to this, Kristoffer Midttømme also started as a PhD student at the Department of Economics in August last year and is also working on CREE relevant topics. He is funded by the University of Oslo (own funding).

The post doc position funded by CREE will be filled in August 2012.

In connection with the recruitment of candidates, we are also engaged in research training through teaching and supervising at Tilburg University and the University of Oslo. But we are also involved in MILEN's research school. This is an interdisciplinary research school for PhD candidates in energy and environment at the University of Oslo. Several of the CREE researchers are engaged in organizing the lectures and seminars for this research school for 2012.

### **Communication and dissemination**

In addition to meetings and seminars, findings from our research are disseminated through our web page, a new working paper series, papers in scientific journals, articles in popular science journals, newspaper articles and other media coverage. The connection to University of Oslo and Tilburg University means that our research will be spread to students at different levels. Another important channel of communication is user partners activities and conferences meant for users of research. The CREE website ([www.cree.uio.no](http://www.cree.uio.no)) gives a good overview of papers in the CREE working paper series, published work, media coverage, the CREE seminar series, work-shops and conferences, and user partner activities.

A communication plan for CREE will be made in 2012.



**Annual report: CREE**  
**Appendix:**

**A1 Personnel**

**Key Researchers**

<b>Name</b>	<b>Institution</b>	<b>Main research area</b>
Golombek, Rolf	Frisch Centre	Environmental Economics, Energy Economics, Applied Game Theory
Hallre, Hilde	Frisch Centre	Environmental Economics
Hauge, Karen	Frisch Centre	Environmental Economics
Kittelsen, Sverre	Frisch Centre	Production theory, Efficiency measurement, Regulation, Health Economics, Energy Economics
Kverndokk, Snorre	Frisch Centre	Environmental and Resource Economics, Health Economics
Nævdal, Eric	Frisch Centre	Resource Economics, Economic management of ecological systems, dynamic optimization, modeling of the risk of disasters, animal behavior
Røgeberg, Ole	Frisch Centre	Welfare analysis, endogenous preferences, rational addiction theory, consumer theory
Strøm, Steinar	Frisch Centre	Microeconomics
Asheim, Geir	Department of Economics, University of Oslo	Game theory, intergenerational justice, green national accounting
Brekke, Kjell Arne	Department of Economics, University of Oslo	Behavioral Economics, Experimental Economics, Resource and Environmental Economics, Real options and stochastic analysis
Førsund, Finn	Department of Economics, University of Oslo	Resources, energy, environment, production theory, productivity
Harstad, Bård	Department of Economics, University of Oslo	Political Economics, Public Economics, Contract Theory, Environmental Economics
Hoel, Michael	Department of Economics, University of Oslo	Energy and climate economics, environmental economics, resource economics
Lund, Diderik	Department of Economics, University of Oslo	Resources, energy and environment, economics
Nyborg, Karine	Department of Economics, University of Oslo	Environmental economics, economic analysis of social and moral norms, behavioral economics.
Vislie, Jon	Department of Economics, University of Oslo	Microeconomics, environmental economics, incentives, public economics
Von der Fehr, Nils	Department of Economics, University of Oslo	Microeconomics, Industrial Economics, Regulation, Competition Policy.
Aune, Finn Roar	Research Department, Statistics Norway	Energy and environmental economics
Bye, Brita	Research Department, Statistics Norway	Macroeconomic
Fæhn, Taran	Research Department, Statistics Norway	Macroeconomic
Greaker, Mads	Research Department, Statistics Norway	Energy and environmental economics
Hagem, Cathrine	Research Department, Statistics Norway	Energy and environmental economics
Halvorsen, Bente	Research Department, Statistics Norway	Energy and environmental economics
Holtmark, Bjart	Research Department, Statistics Norway	Energy and environmental economics
Larsen, Bodil Merethe	Research Department, Statistics Norway	Energy and environmental economics
Rosendahl, Knut Einar	Research Department, Statistics Norway	Energy and environmental economics
Gerlagh, Reyer	Tilburg Sustainability Center	Climate Change, Economics, Energy economics, Environmental economics
de Zeeuw, Aart	Tilburg Sustainability Center	Sustainability, Dynamic game theory, Environmental economics, Environmental policy, Mathematical economics

**Visiting Researchers**

Name	Affiliation	Nationality	Sex M/F	Duration	Topic
Grimsrud, Kristine	University of New Mexico	Norwegian	F	2 month	Resource economics.
Tangerås, Thomas	Research Institute of Industrial Economics, Stockholm	Norwegian	M	1 day	Energy markets
Nøstebakken, Linda	University of Alberta	Norwegian	F	1 week	Equity in climate policy
Hassler, John	University of Stockholm	Swedish	M	1 day	Integrated assesment modeling
Eyckmans, Johan	Hogeschool-Universiteit Brussel	Belgian	M	3 days	Equity in climate policy
Fankhauser, Samuel	LSE	Swiss	M	3 days	Equity in climate policy
Halvorsen, Anita	University of Denver	Norwegian	F	3 days	Equity in climate policy
Green, Richard	Imperial College, London	English	M	3 days	Equity in climate policy
Baldursson, Friedrik	Reykjavik University	Icelandic	M	3 days	Equity in climate policy
Michielsen, Thomas	Tilburg Sustainability Center	Dutch	M	3 days	Equity in climate policy
Gerlagh, Reyer	Tilburg Sustainability Center	Dutch	M	3 days	Equity in climate policy
Carbone, Jared	University of Calgary	Canadian	M	3 days	Equity in climate policy
Böhringer, Chris	Oldenburger University	German	M	3 days	Equity in climate policy

**PhD students with financial support from the Centre budget**

Name	Nationality	Period	Sex M/F	Topic
Ciccone, Alice	Italian	2011-2015	F	Economic of the climate change with econometric applications and climate technologies
Klemetsen, Marit	Norwegian	2011-2015	F	Innovation in energy- and environmental technology industries: Identifying knowledge externalities and effects of policies
Michielsen, Thomas	Dutch	2010-2014	M	Innovation in energy marked

**PhD students working on projects in the centre with financial support from other sources**

Name	Funding	Nationality	Period	Sex M/F	Topic
Midttømme, Kristoffer	Department of Economics, University of Oslo	Norwegian	2011-2014	M	Technology diffusion
Dalen, Hanne Marit	Research Department, Statistics Norway	Norwegian	2009-2014	F	The use of multiple instruments in energy and environmental policy.
Bråten, Ragnhild Haugli	Frisch Centre	Norwegian	2008-2012	F	Measuring environmental behavior with lab experiments
Jensen, Sverre	Frisch Centre	Norwegian	2008-2012	M	Global challenges in oil and gas markets: Market developments and reactions to climate and energy security policies

## A2 Statement of Accounts

(All figures in 1000 NOK)

### Funding

	Amount
The Research Council	3 346
<b>Research Partners</b>	
Frisch Centre (Host Institution)	3 885
Statistics Norway	5 000
Department of Economics, UoO	350
Tilburgs Sustainability Center	125
<b>Enterprise partners</b>	
Statkraft Energy AS	50
Statnett	125
Statoil Petroleum AS	250
<b>Public partners</b>	
Climate and Pollution Agency (KLIF)	200
<b>Total</b>	<b>13 331</b>

### Costs

<b>Research Partners</b>	
Frisch Centre (Host Institution)	6 041
Statistics Norway	6 152
Department of Economics, UoO	670
Tilburgs Sustainability Center	250
Centre for Development and the Environment	125
The Faculty of Law - Natural Resources Law, UoO	50
Institute for Energy Technology (IFE)	50
SINTEF	58
<b>Total</b>	<b>13 396</b>

## A3 Publications

### Journal Papers

Michael Hoel The Green Paradox and Greenhouse Gas Reducing Investments, *International Review of Environmental and Resource Economics* Vol 5, No 4, pp 353-379

Böhringer, Chris. and Knut Einar Rosendahl Greening Electricity More Than Necessary: On the Cost Implications of Overlapping Regulation in EU Climate Policy, *Journal of Applied Social Science Studies (Schmollers Jahrbuch)* 131, 469-492.

Baldursson, Fridrik M. and Nils-Henrik M. von der Fehr. Price Volatility and Risk Exposure: On the Interaction of Quota and Product Markets. *Environmental and Resource Economics* DOI 10.1007/s10640-011-9525-3

Godal, Odd, Bjart Holtmark. Emissions trading: Merely an efficiency neutral redistribution away from climate change victims? *Scandinavian Journal of Economics*. Published online: 16 SEP 2011. DOI: 10.1111/j.1467-9442.2011.01674.x

Golombek, Rolf., and Michael. Hoel (2011): International cooperation on climate-friendly technologies, *Environmental and Resource Economics*, Vol 49. (4), 473-490.

Golombek, Rolf, Mads Greaker, Sverre.A.C. Kittelsen, Ole. Røgeberg and Finn.R. Aune (2011): Carbon capture and storage in the European power market. *The Energy Journal*, Vol. 32 (3), 209-237

Holtmark, Bjart, Harvesting in boreal forests and the biofuel carbon debt. *Climatic Change* (DOI 10.1007/s10584-011-0222-6)

Rosendahl, Knut Einar. and Jon Strand Carbon Leakage from the Clean Development Mechanism *The Energy Journal* 32(4), 27-50.

### Working Papers

Carbone Jared C and Roberts S. Gazzale A Shared Sense of Responsibility: Money Versus Effort Contributions in the Voluntary Provision of Public Goods Williams College Economics Department Working Paper No. 2011-14 (also CREE Working Paper 5/2011). September 2011.

Carbone Jared C. Embodied Carbon Tariffs, with Christoph Boehringer and Thomas F. Rutherford. NBER Working Paper No. 17376. August 2011.

Gerlagh Reyer, Snorre Kverndokk, and Knut Einar Rosendahl Timing of environmental R&D policy Working Paper 2/2011 CREE

Greaker Mads and Michael Hoel Incentives for environmental R&D Working Paper 1/2011

Golombek, Rolf, Sverre A.C. Kittelsen and Ingjerd Haddeland Wetter and Wilder: Impacts on the electricity industry in Western Europe of climate change CREE Working Paper 3/2011

Golombek, Rolf, Sverre A.C. Kittelsen and Knut Einar Rosendahl Price and welfare effects of emission quota allocation CREE Working Paper 4/2011

Böhringer, Chris., Carolyn. Fischer and Knut Einar Rosendahl (2011): Cost-Effective Unilateral Climate Policy Design: Size Matters, RFF DP 11-34, Resources for the future (RFF)

Godal Odd, Bjart Holtmark. On the efficiency gains of emissions trading when climate deals are non-cooperative. Working Paper 17/11. Institute for Research in Economics and Business Administration. ISSN 1503-2140

Liski Matti and Juan-Pablo Montero Paper On the exhaustible-resource monopsony, completed and submitted in July

Liski Matti and Reyer Gerlagh Paper Public Investment as commitment, completed and submitted in August 20110, joint with Reyer Gerlagh.

### **Popular scientific articles**

Greaker, Mads: Innretning av støtte til biodrivstoff. Økonomiske Analyser 5/2011, Statistisk sentralbyrå.

Bøeng, Ann Christin, Bente Halvorsen og Bodil M. Larsen (2011); Vil subsidiering av energieffektivt utstyr løse miljøproblemene?, Økonomiske Analyser 5/2011, Statistisk sentralbyrå.

Førsund, Finn R. (2011). Innfasing av vindkraft, Samfunnsøkonomen nr 3 2011, 46-54

Kverndokk, Snorre.: Nytt senter for samfunnsøkonomisk energiforskning, Klima, 3-11, s. 32-33.

### **CREE in the Media**

Lønnsomt å la oljen ligge. Vårt Land 30 des. 2011 - Knut Einar Rosendahl

Oljekutt effektive klimatiltak. Dagens Næringsliv des. 2011 - Debatt med innlegg av Knut Einar Rosendahl

Flere former for klimaavtaler - forskning.no 14 des.2011 - Intervju med Snorre Kverndok, Mads Greaker og andre.

Redusert oljeproduksjon bør med på listen over norske klimatiltak, Dagens Næringsliv 7. des. 2011 - Knut Einar Rosendahl

Lenge til neste oljekrise, Teknisk Ukeblad 0711 - Rolf Golombek

Må knekke energikoden, Teknisk Ukeblad 0711 - Rolf golombek

Laboratoriets makt, artikkel i Forskerforum 4, 2011.

Fremtidens klima - likevel ingen kaastrofe? E24 1 des. 2012 - Bjart Holtsmark

Artikkel i Dagen Næringsliv: 14. juli 2011 (side 34): EUs klimapolitikk på ville veier - Hoel, Michael