Oslo Centre for Research on Environmentally friendly Energy

Annual Report 2013

Executive 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 centre started its activities in August 2011.

The main focus is on economic research as the research partners include the Frisch Centre, Department of Economics (ØI) at the University of Oslo (UoO), the Research department at Statistics Norway (SSB), and Tilburg Sustainability Center, the Netherlands. Cooperation with Centre for Development and Environment (UoO), Faculty of Law (UoO), 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 centre is to collect and develop knowledge on the effects of regulatory conditions in the energy market and how these affect technological improvements such as innovation in and diffusion of technology for renewable energy, energy efficiency and carbon capture and storage. The centre provides a basis for better regulatory strategies and for policy instruments designed to reach energy and climate goals established nationally and internationally. CREE will also strive to develop methodological frameworks appropriate for achieving these goals.

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

2013 has been the second full year of CREE activities. The activities have been concentrated on the research in the different working packages, the annual research workshop, CREE seminars, model forums and several user activities including the annual user conference. In 2013 we published 21 papers in international peer reviewed journals, 7 articles in books, 30 working papers and 12 popular science articles. The CREE scientists have held 100 conference and seminar presentations in 2013, and they have been mentioned numerous times in the media. CREE is involved in the EU funded project ENTRACTE on climate policies.

1 CREE

There is increasing evidence that the global climate is changing, and that this change is mainly due to human activities. Climate change can have a substantial impact on the economy, ecosystems and human welfare, and may have catastrophic impacts for parts of the world. Thus, there is a need to reduce greenhouse gas emissions as well as to adapt to inevitable changes. Technology improvements are widely held to be essential if we are to achieve the required emission cuts.

However, there are several challenges beyond the purely technological. The research and development effort, as well as diffusion and utilization of new, environmentally friendly energy sources, require appropriate incentives. 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. The aim of CREE, Oslo Centre for Research on Environmentally friendly Energy, is to provide a solid base for policy making on these questions. CREE will also contribute to the collection and establishment of

knowledge on how different regulations affect both the energy market and technological development. The centre studies policy instruments designed to reach the goals established in national and international energy and climate policy, while also examining how international treaties could be designed differently to better achieve broad participation and deep abatement.

The research of the centre is primarily grounded in economics, as reflected by the main research partners: Department of Economics at the University of Oslo, the Research Department at Statistics Norway, the Frisch Centre and the Tilburg Sustainability Centre. In addition, the centre draws on other disciplinary perspectives through cooperation with researchers from other disciplines within the social sciences, law and technology (IFE, SINTEF Energy and the MILEN network at the University of Oslo).

The centre has the following vision:

- We want to be a leading international research centre within energy, environmental and resource economics.
- We will generate knowledge that can contribute to a cost-effective and sustainable exploitation of Norwegian and international energy resources by industry and governments, as well as an effective and fair climate and energy policy, both nationally and internationally.
- We will contribute to recruitment and training at the master, doctoral and post doctoral levels in energy and environmental economics at the University of Oslo. Recruiting women to research will have a particular focus.

This report summarizes the activities and the achievements of the centre in 2013.

2 Research plan and strategy

CREE organizes its research into five different working packages:

Working Package I: The International Politics of Climate and Energy

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

The research questions in this working package focus on the following issues:

- 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 – preventing carbon leakage
- Equity issues – intergenerational vs. intragenerational
- Implications of the above for energy market policies

Working Package II: 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 III: 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:

- 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 IV: 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_2 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 V: 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. We use and develop

- The energy market model LIBEMOD
- Computable general equilibrium (CGE) models at Statistics Norway; the MSG-TECH model, the ITC (Induced Technological Change) model, and the SNoW-models (Statistics Norway World models).

Our strategy is to follow the plans put down in the annual research plans, see http://www.cree.uio.no/ projects.html. The research will benefit from close contact with subcontractors and user partners. For the vision and strategy of the total CREE activity, see the CREE strategy plan http://www.cree.uio.no/adm/Strategi_Komunikasjon/CREE%20strategic%20plan%20March%202013.pdf , which was finalized in 2013.

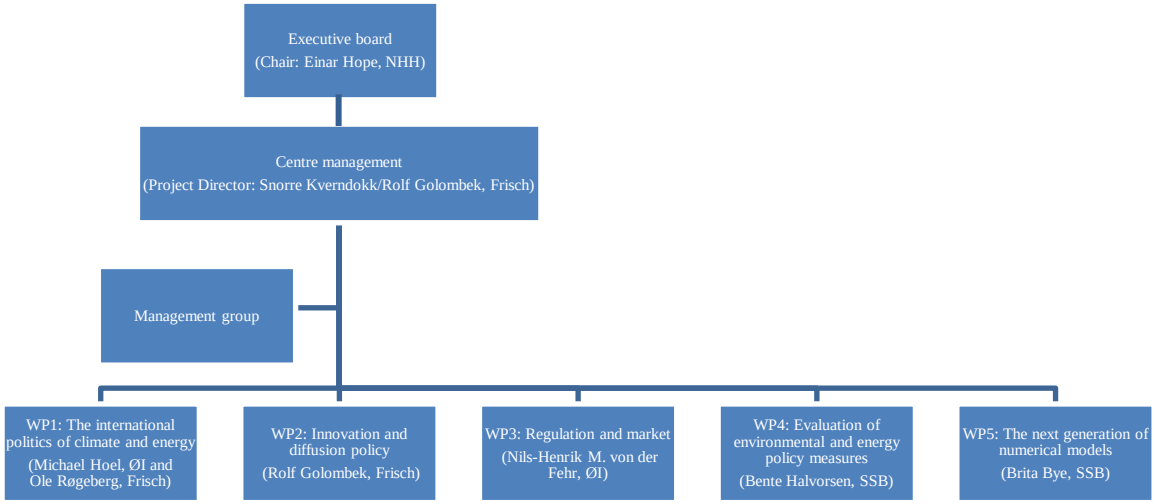
3 Centre organization

The organization of the centre in 2013 was as shown in the figure below.

The chair of the executive board (Einar Hope, The Norwegian School of Economics - 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 (Oddbjørn Raaum, 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 (Guro Børnes Ringlund, The Norwegian Environment Agency). The board had three meetings in 2013, see http://www.cree.uio.no/board_meetings.html.

The administration of CREE is located at the Frisch Centre. Dr. Snorre Kverndokk was the Project Director from 1 January to 31 March. In the remaining part of 2013, Dr. Rolf Golombek served as the temporarily Centre Director. Jørg Gjestvang was the Centre Manager.

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



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, Oslo
Department of economics, University of Oslo
Tilburg Sustainability Center, Netherlands

CREE has seven user partners:

Gassnova SF
Norwegian Environment Agency
Norwegian Ministry for Petroleum and Energy
Norwegian Water Resources and Energy Directorate
Statkraft Energy AS
Statnett SF
Statoil ASA

The user partners of the centre contribute with funding and with members on the board, but also to the research with detailed knowledge about markets, technologies and politics.

Like in 2012, we have a CREE luncheon every second month that brings together the CREE network and contributes to unify the Norwegian CREE research institutions.

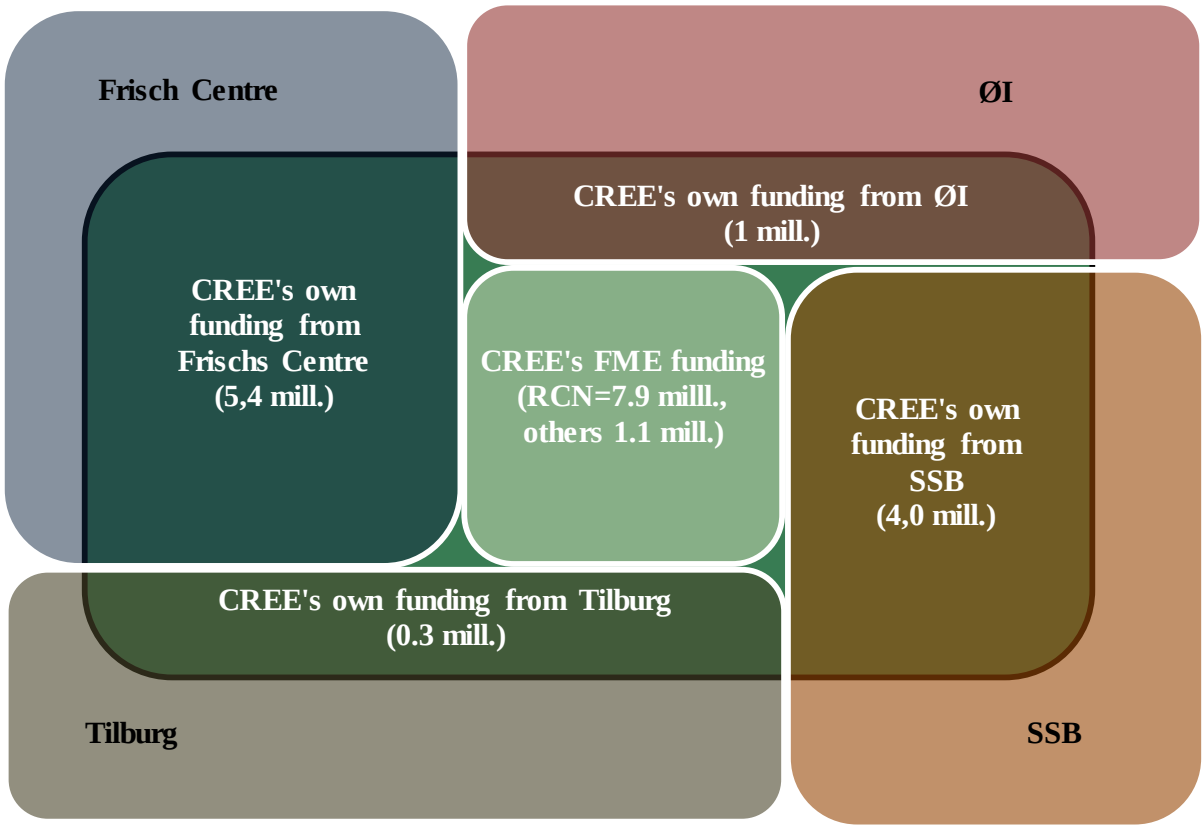
4 Funding

The funding of CREE in 2013 comes from various sources. The centre has an annual contribution from the Research Council of Norway (RCN) of NOK 8 millions, user partner funding of NOK 600.000, and funding from the University of Oslo (UoO) of NOK 500.000. In addition, the centre has secured its own funding through other programs under RCN and international research programs. The figure below gives an overview of the total funding in 2013. Note that in the figure, the funding from RCN is NOK 7.9 million, which is less than the annual grant. The reason is that some of the money is transferred to 2014. For more detailed information, see Appendix A2, which also shows the distribution of costs by CREE

research partners and other units affiliated to the centre. Note that costs cover activities directly funded by RCN as well as activities financed by own funding, for example, funding through other research council programs.

CREE funding in 2013

Total CREE centre funding incl. own funding. (19,6 mill.)



Own funding = professional work that is beneficial to the CREE centre, but is not part of CREE's direct funding from The Research Council of Norway. Own funding should be at least 25% of the total budget of CREE.

FUNDINGS

The Research Council of Norway		7,9
Others		1,1
Public funding (UoO)	*0,5*	
Privat funding (User partners)	*0,6*	
Own funding		10,7
Frisch	*5,4*	
SSB	*4,0*	
ØI	*1,0*	
Tilburg	*0,3*	
Sum total funding		19,6

5 Professional activities and results

The professional activities in 2013 have been concentrated on the research in the different working packages described above, the research workshop, CREE seminars, two model forums and several user activities including the user conference.

The CREE workshop took place in Oslo (Lysebu hotel) on 17-18 September. About 35 people attended the workshop, mainly researchers from the research partners and sub-contractors in CREE, but also from our international network. Presentations covered research from all our work packages, and on subjects related to the work packages. The program is available at http://www.cree.uio.no/Workshop_Sem_Conf/3rd_research_workshop.html.

The CREE seminar series included 13 seminars in 2013, among them 4 international visitors. The seminars were given at Statistics Norway, Frisch Centre and University of Oslo. For a list of all seminars, see http://www.cree.uio.no/seminars_earlier_years.html.

The first model forum was held in April where CREE presented the new versions of our numerical models LIBEMOD and SNOW. In addition to researchers from CREE, the participants included our subcontractors IFE and SINTEF as well as user partners, see http://www.cree.uio.no/Workshop_Sem_Conf/modelforum_160413.html. The second model forum took place in October. This was a one-day joint venture with CenSES; both centres presented their models and model analyses. See http://www.cree.uio.no/Workshop_Sem_Conf/modelforum_241013.html

The user conference was held in April and was co-organized with CICEP, another social since FME centre. The conference was in Norwegian and the topics were energy transition in Europe and financing of climate actions in developing countries. About 60 people attended the conference. The program is available at: http://www.cree.uio.no/docs/Brukerkonferanse_apr_2013/Invitasjon%20brukerkonferanse%20for%20CICEP%20og%20CREE.pdf. CREE also organized a joint half-day meeting with all its user partners as well as three other users (ENOVA, the Ministry of the Environment and the Ministry of Finance). At the meeting, the scientific status and plans of the centre were presented and discussed.

When it comes to publications, we had 21 papers published in international peer reviewed journals, see the Publications table below and Appendix A3. We have also published 7 articles in books. We produced 27 CREE working papers and published 3 working papers in other working papers series. Further, we have published 12 popular science articles and 3 other publications. The CREE scientists have also held 100 conference and seminar presentations. They have also been mention at least 31 times in the media.

Publications 2011-2013

	2011	**2012**	**2013**
Journal Papers:	8	16	21
Books and article in books:		2	7
Working Papers:	9	21	30
Popular scientific articles:	4	10	12
Other publications:		5	3
Conference and seminar presentations:		100	100
CREE in the Media:	9	41	31

It also worth mentioning that in 2013 the CREE researcher Bård Harstad was awarded the Erik Kempe prize for his paper entitled "Buy coal! A case for supply-side environmental policy". Since the establishment of this biannual award in 1996, this is the third time a CREE researcher is the winner of the award, see
http://www.eaere.org/content/b%C3%A5rd-harstad-erik-kempe-award-2013

Below we give an overview of the research in the five different research packages in 2013.

5.1 The International Politics of Climate and Energy (WP I)

The main question in this work package is how international climate treaties best can achieve GHG abatement. This raises questions regarding how treaties should be structured to raise participation rates, abatement targets and policy implementation, and also how abatement efforts will influence other important goals – such as global equity issues.

Abatement treaties are the type of international climate treaties mostly studied in the literature. However, other designs like sectorial treaties, regional treaties or "topical" treaties focusing, for example, on R&D efforts are also possible. The increasing pessimism regarding prospects for a single, UN-led, ambitious "top-down" abatement treaty with global coverage has raised the question of whether such smaller, partial treaties could be coordinated and gradually integrated with each other, thereby addressing the climate problem "bottom-up".

The research activities in this work package spans from theoretical studies to numerical models and experimental studies using laboratory participants.

I.1 Equity in climate policy

Equity is an important issue in designing climate treaties as greenhouse gas abatement affects the welfare distribution between present and future generations, but also the distribution within a generation, such as between rich and poor countries. In the project we study how these two equity dimensions affect the design of climate policies and the implications for emissions and energy investments. We also study the implications for transfers from rich to

poor countries (climate finance and development aid). This work resulted in two working papers in 2013.

The starting point of the final part of the project is that future generations will be richer than us, but may have a more inferior environment. While mitigation today will increase the quality of the future environment, it implies costs to the current generation. However, by transferring resources from the future to the present generation there may be possibilities for improving the welfare of all generations. This can be done by compensating mitigation today by less investment so that the present generation does not have to reduce consumption. This is a numerical project where we do simulations with the RICE model.
Contact person: *Snorre Kverndokk*

I.2 Border Tax Adjustment

A standard result in the literature on international climate agreements is that few countries will sign an abatement agreement due to the free rider problem: all countries benefit from abatement activities of other countries whereas cost of abatement is born entirely by the country itself. In several studies, the equilibrium number of coalition members is two or three, and even if it is possible to construct bigger coalitions the effect on aggregate abatement is typically modest.

This subproject examines whether the introduction of a border tax on the carbon content of goods may make participation in an international climate agreement more attractive and thereby increase the equilibrium number of signatories. The basic idea is that a border tax imposed on imports of carbon-intensive goods to the group of signatories may increase the revenues to this group and/or change the relative prices of goods in favor of the signatories.
Contact person: *Rolf Golombek*

I.3 Climate treaties with reciprocal preferences

Research in behavioural and experimental economics indicate that reciprocity, that is, a preference to repay mean intentions by mean actions and similarly to repay kind intentions by kind actions, is widespread. If voters or individuals in power have reciprocal preferences, states may conceivably act as if they have such preferences too. This would make climate

negotiators less (more) willing to contribute to a binding global emission reduction agreement if other parties are perceived as irresponsible and unfriendly (responsible and friendly).

The importance of reciprocity is studied within a standard model for international environmental agreements with identical countries and a definition of "kindness" from behavioural economics. It is shown that with reciprocity, no cooperation and full cooperation may both be equilibria in the global climate game. A draft paper has been written, which combines the literatures of international environmental agreements and the theory of reciprocity as indicated above.
Contact person: *Karine Nyborg*

I.4 Participation and duration of climate agreements

Theoretical contributions to the formation of international environmental agreements often analyze either participation in abatement agreements or participation in an R&D partnership that aims to develop environmentally friendly technologies that will lower costs of abatement. However, abatement and R&D efforts are interrelated. If a country manages to lower its costs of abatement through successful R&D in environmentally friendly technologies, its future bargaining position may be weaken as other countries may claim that this country should abate more because its costs have been reduced (the hold-up problem). In the present project we therefore analyze participation in international environmental agreements in a dynamic game where countries pollute and also invest in green technologies.

We show that if complete contracts are feasible, participants eliminate the hold-up problem associated with their investments; however, most countries prefer to free-ride rather than participate. If investments are non-contractible, countries face a hold-up problem every time they negotiate; but the free-rider problem can be mitigated and significant participation is feasible. Participation becomes attractive because only large coalitions commit to long-term agreements that circumvent the hold-up problem. Under well-specified conditions even the first-best outcome is possible when the contract is incomplete. Since real-world IEAs fit in the incomplete contracting environment, our theory may help explaining the rising importance of IEAs and how they should be designed. A draft paper has been written.
Contact person: *Snorre Kverndokk*

I.5 Reducing carbon leakage

A key challenge for unilateral policy initiatives, even for a big coalition like the EU, is carbon leakage and competitiveness concerns. In 2013 we have analyzed economic and emission effects of introducing carbon taxes combined with output-based rebating and also how second-best optimal rebate rates interact with carbon policies in other regions. We are especially concerned about the development of second-best optimal rebating rates for large versus small regions/countries in a world where a considerable share of global carbon emissions is still not regulated. We use both theoretical and numerical methods, the last one exemplified by the global CGE model SNoW.

Contact person: *Brita Bye*

I.6 Inequality aversion and trade

Widespread skepticism towards tradable emission quotas is apparent in surveys and political debates. One potential explanation is that opponents see markets as rigged and favoring "rich countries." In a laboratory experiment we allow resource owners and buyers to trade at *given* prices, and examine the effect on trading volumes of high prices (that distribute most of the gains from trade to sellers), low prices (that distribute most of the gains to buyers) and "fair" prices that give both parties the same payoffs. Preliminary results are promising, and the experiment will be developed further and run on a larger sample of respondents during PhD-student Alice Ciccone's visit to Columbia University, spring 2014.

Contact person: *Kjell Arne Brekke*

I.7 Is it wrong to buy a right to do a wrong?

An alternative hypothesis to the one explored in I.6 is that opposition to tradable emission quotas stems from a view that sees emissions as moral bads. Philosopher Michael Sandel from Harvard has made several arguments in this vein over the years. The project has run a laboratory experiment to see if a market in "bads" (taking from a common resource pool to benefit oneself despite hurting others even more) would trigger negative attitudes towards market trade. Results showed no effects on neither attitudes towards markets, trading volumes in markets, nor prices in markets relative to a control treatment with trade in a non-harmful good.

Contact person: *Kjell Arne Brekke*

I.8 Earned pies and outside options in structured bargaining.

Theoretical analyses of bargaining typically employ game theory, but the predictions of such models need to be tested empirically in order to identify the most descriptively accurate theory. In a seminal paper from 1989, it is shown that non-binding outside options have no impact on the bargaining outcome, which is consistent with Rubinstein classic bargaining model. However, the axiomatic Nash bargaining solution predicts that players will take their outside option and then share the remaining surplus, that is, "split the difference".

Recent experimental studies on Nash demand game and unstructured bargaining games have found that the outside option has an effect on the bargaining outcome and this effect is stronger if the outside option is earned. We provide experimental evidences by testing change in behavior when the outside option is exogenously allocated by the researcher or earned through an effort task. In addition, we extend this study by including loss aversion in the model. In a second treatment, subjects can earn their individual contribution to the pie or they can get a random allocation of it. This allows us to test predictions of standard theory against the alternative theory of loss aversion.

We have completed the first treatment. Our experimental results for the control treatment successfully replicate that non-binding outside options have no impact on the bargaining outcome.

Contact person: *Kjell Arne Brekke*

5.2 Innovation and diffusion (WP II)

Atmospheric greenhouse gas stabilization targets as low as 450 ppm CO_2 equivalents could be needed in order to avoid dangerous anthropogenic interferences with the earth's climate system. Such targets may require more than twice as much carbon-free power by the middle of this century than we now derive from fossil fuels - this is the technological challenge of the century.

Environmentally friendly R&D is a tale of several market failures. First, there are environmental externalities which need to be internalized through appropriate environmental policy measures. This is essential since it is the internalizing of the environmental externalities that create the demand for the new environmental technology. Second, there may be market failures in the innovation and diffusion processes. Research creates new knowledge which benefits other firms, and thus entails a positive externality. On the other hand, competing research firms may duplicate each other and/or exhaust the pool of good ideas, thereby negatively affecting other research firms.

Economists have realized that there are market failures also in the adoption and diffusion of new technologies. For a number of reasons, the value to a user of a new technology may depend on how many other users have adopted the technology. This type of "increasing returns" may be created by learning-by-using, learning-by-doing or network externalities. When the qualities of a product are hard to assess, consumers may assess it by observing the number of other people who are purchasing the product, inducing informational cascades which creates a scope for advertising. Similarly, the responsibility to act in an

environmentally friendly manner is shaped by observing others, although this may cause market failures with multiple equilibria. The adoption of new technologies may also be hindered by principal-agent problems and cognitive costs. In this work package we address a broad set of topics which are of interest from both a research and political perspective.

II.1 Strategic technology policy as supplement to renewable energy standards

Renewable energy standards have been introduced in several countries as a supplement to climate policy. Some countries have also subsidized the use of renewable energy or the producers of renewable energy capital. In this subproject we examine the rationale for such policies.

Our point of departure is that a renewable energy standard creates new profit opportunities for firms that supply renewable energy capital. With imperfect competition among technology suppliers, technology policy could be used strategically. We consider both downstream subsidies to renewable energy suppliers and upstream subsidies to renewable energy capital producers. To the extent that there is imperfect competition upstream, subsidies may improve welfare both globally and nationally. Moreover, upstream subsidies are preferred over downstream subsidies from a national perspective. Finally, we show that strategically chosen subsidies by individual countries could in fact be optimal from a global perspective, given that the shadow price of emissions is correct from a global perspective. A draft paper has been written.

Contact person: *Mads Greaker*

II.2 Carbon leakage: Pay or not pay the polluter?

Asymmetric regulation of a global pollutant between countries can alter the competitiveness of industries and cause emissions leakage. For most types of pollution, abatement technologies are available, but the markets for these technologies are not competitive, particularly when emissions regulations and advanced technologies are new. In this context of twin market failures, we consider the relative effects and desirability of subsidies for abatement technology.

We find that downstream subsidies tend to increase global abatement technology prices, reduce pollution abatement abroad and increase emissions leakage. In contrast, upstream subsidies reduce abatement technology prices, and hence also emissions leakage. Whereas downstream subsidies may weaken the position of domestic abatement technology firms, upstream subsidies may provide domestic abatement technology firms with a competitive advantage. A draft paper has been written.
Contact person: *Mads Greaker*

II.3 How should CCS technologies be supported?

Carbon capture and storage (CCS) technologies have the potential to bridge the gap between the current carbon-based society and a future low-carbon society. Using CCS electricity technologies, either with coal or natural gas as the fuel, may reduce emissions by as much as 90 percent relative to standard fossil-fuel based technologies.

One main disadvantage of CCS is high cost. These may, however, be lower through continued R&D. An important question is then whether CCS should be prompted through subsidizing the producers of CCS technology (upstream subsidy) or through subsidizing the use of CCS technology (downstream subsidy). In a combined theoretical-empirical subproject we first study optimal design of CCS subsidizes within a simple model of imperfect competition where CCS technology producers are divided into two groups according to whether they are owned by EU citizens/member countries. We show that upstream subsidizes to EU producers outperform downstream subsidizes.

We then use the numerical equilibrium model of the European energy market LIBEMOD, combined with a new model block with non-competitive supply of CCS technologies, to study how the CCS subsidy should be designed. Although LIBEMOD encompasses many effects not captured in the simple theoretical model used in the first part of the subproject, for example, terms-of-trade effects, we obtain the same type of result as in the theoretical part of the subproject; upstream subsidizes to EU producers are preferable, though in some cases these should be combined with downstream subsidies. A draft paper has been written.
Contact person: *Rolf Golombek*

II.4 Environmental R&D instruments

There are several reasons to support environmental R&D: knowledge spillovers that make future R&D more efficient, commitment problems with respect to future environmental policy and globally insufficient environmental policies due to lack of international environmental agreements on global pollutants. We will study the optimal use of three technology push policies 1) Patent systems, 2) Innovation prizes and 3) Subsidies to R&D projects under various circumstances: i) Global environmental policies are too weak in the near and intermediate future, and ii) Governments cannot commit to future environmental policy goals. In particular, we are interested in to what degree there are systematic differences between market goods R&D and environmental R&D that suggest that different support programs should be offered.

This topic has also funding from EU's seventh framework program (ENTRACTE), which will last until 2015. The project was started in 2013, but on a very low activity level.
Contact person: *Rolf Golombek*

II.5 Optimal timing of clean energy policies

Should technology subsidies be used a as climate policy instrument in addition to imposing a price on GHG emissions, or is pricing of GHG emissions sufficient in order to obtain a social desirable outcome? If technology subsidies should be offered as well, how should the path of subsidies be designed? This subproject examines these questions within a theoretical model where abatement requires use of environmentally friendly technologies and R&D makes these technologies more productive. We find that whereas the price of GHG emissions should always reflect the marginal environmental damage, the optimal level of the R&D subsidy, as well as the duration of a patent, should be time dependent. Often, the technology subsidy should be high but decrease over time. If, alternatively, the technology subsidy is kept constant over time, the optimal duration of a patent should be long, but decrease over time. Hence, the main result is that an optimal climate policy requires innovation subsidies to complement carbon pricing. The paper has been accepted for publication in The Journal of Environmental Economics and Management.
Contact person: *Snorre Kverndokk*

II.6 Innovation in clean energy as a commitment device

The starting point of this project is how the present generation can make future generations reduce their GHG emissions. The basic idea is that by developing and installing environmentally friendly capital and technologies, for example, cheap solar power or insolation of buildings, costs of obtaining low GHG emissions will be reduced for future generations, thereby fulfilling the aim of the present generation to lower future GHG emissions.

In the first part of the project, Thomas Michielsen and Reyer Gerlagh at the Tilburg Sustainability Centre, set up and studied a model where concerns for future climate change introduce a time-inconsistency in policy-making. The study shows a regular pattern where a regulator prefers a tight climate target, but also prefers to delay costly tasks. Over time, targets are weakened as a natural outcome of the preferred delay.

In the model by Michielsen and Gerlagh, the government is naïve as is mistakenly assumes that it can control future governments. In a refinement, Reyer Gerlagh and Samuel Okullo sets up a recursive Integrated Assessment Model that can be used to study innovations as commitment device for climate policy by deriving the Markov equilibrium, that is, the current government correctly anticipates the response of the future governments. In 2013, the main task has been to write and test the model code for a simplified model version, as this is a new type of model.

Contact person: *Reyer Gerlagh*

II.7 Can non-market regulations spur innovations in environmental technologies?

Economists tend to prefer market-based regulations such as taxes or tradable quotas over non-market-based instruments such as technology standards and non-tradable emission quotas. One important argument in this regard is that market-based regulations will better encourage innovation in environmental technologies. However, the latter types of regulation are common when a regulator faces complexities, such as multiple emission types and targets, heterogeneous recipients, and uncertainty with regard to marginal damages. Firms emit a number of different pollutants that cause damages, such as cancer, acidification, and global warming. Capturing all these aspects in relevant prices is difficult. Non-market-based regulations are therefore still necessary.

We have analysed empirically whether non-market-based regulations spur innovation in environmental technologies. Using a unique Norwegian panel data set that includes information about the type and number of patent applications, technology standards, non-tradable emission quotas, and a large number of control variables for almost all large and medium-sized Norwegian incorporated firms in the years 1993-2010, we are able to conduct a comprehensive study of the effect of non-market-based regulations on environmental patenting. Unlike previous studies that are typically conducted at the industry level, we are able to take firm heterogeneity into account, and thereby reduce the common problem of omitted variable bias.

We empirically identify strong and significant effects on innovations from implicit regulatory costs associated with the threat that a firm will be sanctioned for violating an emission permit. This suggests that non-market regulations have an effect through warnings of sanctions (fines, permit withdrawal, prosecution, and bad publicity). The results contrast most existing empirical studies on the effects of non-market regulations. The policy implication of our results is that technology standards and non-tradable emission permits can be a useful complement to market-based instruments in spurring innovation in environmentally friendly technologies. A paper has been submitted to an international journal.
Contact person: *Brita Bye*

II.8 Technology agreements

Most of the literature on international climate agreements focuses on treaties that directly regulate emissions. In contrast to these papers, the present project analyzes an agreement between a group of countries that implement a joint R&D effort to reduce abatement costs. Even without an explicit agreement on emission reductions, a technology agreement leading to lower abatement costs as a consequence of the agreed upon R&D expenses might result in a broad reduction of emissions. There may exist an equilibrium with a group of countries participating in a coalition that undertakes R&D in order to reduce abatement costs, and another group of countries (generally differing but overlapping with the first group) that uses the new technology to reduce their emissions. The paper gives an extensive analysis of the special case in which there are only two types of countries; some with “high” willingness to

pay to avoid emissions, others with "low" willingness to pay. It is demonstrated how total emissions depend on the number of countries with high willingness to pay: It may be the case that as the number of such countries increases, emissions may first decline, then rise, and then again increase. The paper has been accepted for publication in a book.
Contact person: *Michael Hoel*

II.9 Obstacles to dissipation of environmentally friendly technology

In 2013 a literature survey, within the fields of behavioral and experimental economics, on energy efficiency investment was finalized and submitted to a Norwegian journal. Below is summary of the literature review.

Several studies claim that it is possible to save between 10 and 25 % of our total energy consumption through profitable investment. For an economist it is a paradox that apparently profitable investments are disregarded; this is the so-called energy paradox. While standard economic theory assumes that agents are rational, the field of behavioral economics can be classified into three main branches where each branch relaxes one of the following assumptions: bounded rationality, bounded will-power and bounded self-interest. The survey goes through the empirical literature on energy efficient behavior and policies relevant for such behavior, and interprets the findings in light of these three theoretical branches of behavioral economics.

If people have bounded self-interested preferences, investing in energy efficient technology could be motivated by the desire to contribute to the wellbeing of others, or the wellbeing of nature. Providing information on the positive effects for the environment or climate of energy efficiency and energy saving thus should increase investments in energy efficiency. However, studies do not find any significant effect on investment in energy efficiency from informational campaigns. If behavior is motivated by following social norms, then providing information about the behavior of others should matter. Several large US studies have documented that providing comparative information about how a household's energy consumption compares to other's consumption has positive effects when this information is combined with faces that indicates whether the behavior is good (smile) or bad (sour).

If people are characterized by bounded rationality, providing different types of information should improve investment in energy efficiency. If the lack of investments is caused by ignorance about the investment opportunities, general information about energy saving or energy efficiency should help. Research shows that general information through information campaigns does not work, but tailored information through home audits, where an advisor comes home to people and informs them about exactly which investments would be profitable for their home, does help. Also, providing customers with information on product lifetime energy costs together with the sales price, as well as labeling energy efficient products, shifts sales towards more energy efficient products. Finally, providing households with feedback on their energy consumption has proven to give significant reductions in energy consumption.

If people have bounded will-power, for instance by having time-inconsistent preferences, they might fail to invest in energy efficiency because they give higher weight to the investment cost paid in present, compared to the future reductions in energy costs due to lower energy consumption. There has been limited research within this field. In general, goal-setting, either personal goals, goals combined with feedback, or publishing goals in public, could be relevant strategies for people with bounded will-power. However, research has not found any effects of personal goal-setting, and only very small effects of goals combined with feedback and publishing goals in public.

Contact person: *Karen Hauge*

5.3 Regulation and Market (WP III)

In this work package, the main question is how regulation of energy markets affects the development of green energy, and how measures to promote green energy impact the functioning of energy markets. It is of particular interest to study the implication of regulation across national borders, especially with respect to infrastructure, since an international regulatory framework is crucial for the exploitation of Norwegian energy and environmental resources, both in traditional areas and in new areas like capture and storage of CO_2. The work is planned mainly as theoretical and empirical studies, but will also utilize numerical models, either already existing or developed in other work packages. As such, part of the work within this package will be conducted in cooperation with or as part of Working Packages 4 and 5.

III.1 Information and transparency in electricity markets

The performance of electricity markets depends crucially on information collected from and made available to market participants. The EU Commission is currently working on new legislation to regulate the amount, type and format of such information. This raises fundamental question about the relationship between transparency, market power and competition, as well as the cost of collecting and publishing information. A fundamental insight from economic theory is that more information is not always better and the challenge is therefore to balance the positive and negative effects by collecting and publishing the right information, see von der Fehr, N. H. (2013): "Transparency in Electricity Markets, *Economics of Energy & Environmental Policy*, 2(2), p. 71-89.

Contact person: *Nils-Henrik M. von der Fehr*

III.2 Interaction between Electricity and Quota Markets

Prices in the European market for CO_2 permits have varied considerably. These price variations have not only created uncertainty for market participants with respect to the profitability of investments to reduce CO_2 emissions, but have an impact on the cost of producing electricity, and hence electricity prices, which again have affected incentives to invest in generation. In this project, we study how price variations on the permit market affect the electricity market, and how the interaction between these markets impact incentives to invest in generation and measures to reduce emissions. In 2013, this project was concluded with a forthcoming publication in Environmental and Resource Economics.

Contact person: *Nils-Henrik M. von der Fehr*

III.3 Integration of Intermittent Power in Northern-European Power Markets

Wind power, on-shore as well as off-shore, and solar power has been identified as a key technologies for renewable energy, where the EU has an ambition that Europe should become a global leader and where countries like Denmark, the United Kingdom, Sweden and Germany already invest heavily, or have concrete plans to do so. Short-term variation in the availability of wind and solar power makes it difficult to integrate these technologies on a large scale in conventional energy systems, but with access to sufficient amounts of storable hydropower, the potential for wind is substantially larger. The idea that Scandinavia may become an electric battery for Europe has therefore attracted considerable interest, both academically and politically. In this project, we ask to what extent the existing hydro capacity can accommodate a large-scale expansion of intermittent power in and around the North Sea, taking account of the possibility of building pumped storage and the cost of constructing large international interconnectors that will provide back up and balancing capacity for the countries both inside and outside of the Nord Pool area. A draft paper has been written.

Contact person: *Finn R Førsund*

III.4 Green Certificates and Competition in Electricity Markets

A number of studies have analysed how green certificates affect the functioning of electricity markets, both with respect to short-term price formation and long-term investment. One result is that green certificates may undermine the efficiency of energy markets by increasing price volatility. In addition, green certificates may provide market participants with the possibility

of exploiting market power by imposing so-called "margin squeezes". In this project we study the importance of green certificates for electricity markets, and analyse how potentially negative effects may be counteracted by suitable regulation. A paper has been submitted to a scientific journal.

Contact person: *Nils-Henrik M. von der Fehr*

III.5 Effects of Reduced Nuclear Capacity in Europe

The aim of this project is to study numerically possible impacts of reduced nuclear capacity in Europe. The nuclear crisis at Fukushima, Japan, in 2010 has affected nuclear policy in several countries. For Europe the most important policy change is the announcement of the German government to phase out all nuclear power plants by 2022. Nuclear power in Germany accounted for 23 % of national electric consumption before the shutdown of 8 nuclear power plants in March 2011. The shutdown of the remaining plants will have a significant impact on the energy markets in Europe. Will the shortage of supply be met be increased fossil fuels or other renewable energy? How will this affect CO_2 emissions in Europe and from different European countries? How will the trade in energy goods between countries be affected from the shutdown? To study these questions, we will use a large-scale partial equilibrium model for the European energy market, LIBEMOD, see work package V.

Contact person: *Rolf Golombek*

III.6 Natural Resources and Sovereign Expropriation

An important question for governments of countries endowed with large natural resources is how to govern these resources, including choice of ownership structure and rights to exploitation. An example is the Norwegian hydro resources, which, since the introduction of the "panic laws" in the early 20th century, have been governed by a regime in which "national" ownership is combined with leasing of exploitation rights to third parties. Questions of ownership and governance are inherently political and policies may change abruptly, following changes in government, changes in the value of the resources or other events. At the same time, the type and quality of governance is crucial for the efficient exploitation of natural resources. In this project we study such issues, including how the regime governing natural resources depend on political and economic factors, as well as how

such factors, through their influence on the regime, affect the efficiency of resource exploitation.

During 2013, we have continued work on building a suitable theoretical model to study some of the relevant questions. This is a challenging process, given the inherent dynamic feature of the problem, which requires use of sophisticated mathematical techniques, and has taken more work and a longer time than originally envisioned. Nevertheless, we are now approaching a suitable model and aim to finalise a first draft of a paper documenting this work early in 2014. Preliminary versions have been presented at a number of seminars and workshops.

Another part of this subproject is undertaken by Daniel Spiro. He studies how resource owners will behave with a risk of losing their resource due to nationalisation, how this in turn affects the incentives for governments to nationalise such resources and how world prices for resources may be affected by such interaction. The central result in this work is that nationalisation in one country will be closely linked to nationalisation in other countries. The analysis shows that if one country nationalises its resource then resource prices will rise making it worthwhile for others to nationalise too, thus raising the price further. This way the model predicts waves of nationalisation in correlation with price surges. The novelty of this paper is that it would be one of the first to analyse the interaction between political processes and world prices. While the main mechanism is in place, the remaining work relate to analysing alternative equilibria and some extensions of the model.
Contact person: *Daniel Spiro*

III.7 Should Foresters Forecast?

Growth dynamics of forests will likely be altered by climate change. As these shifts are hard to predict, this paper asks whether forecasting them is necessary for profitable management. While unpredictability of climate change makes it hard to calculate expected profit losses of not forecasting, by using Monte Carlo simulations we can obtain an upper bound of these losses. We show that an owner following a rule of thumb, which completely ignores future changes and only observes changes as they come, will closely approximate optimal management. If changes are observed without too much delay, profit losses and errors in harvesting are negligible. This has implications for the effort foresters should devote to long-

run forecasting. It also implies the argument that bounded rational agents may behave as if being fully rational has traction in forestry. A draft paper has been written.

Contact person: *Daniel Spiro*

5.4 Evaluation of Environmental and Energy Policy Measures (WP IV)

In the first three years, the activities in WP4 have focused on four research topics:

a) Rebound and adverse effects of energy efficiency measures.
b) The households' response to soft policy measures.
c) Environmentally friendly transportation.
d) Indoor temperature and energy consumption in families with children.

The work on WP4 is undertaken in four research communities: economists from Statistics Norway (SSB), social anthropologists from Centre for Development and the Environment (SUM), and economists from the Frisch Centre/University of Torino and the Department of

Economics at the University of Oslo (ØI). The different research communities will apply a variety of methods to analyse the research questions listed above. The economists at SSB apply micro econometric analysis to estimate how policy tools affect household energy demand based on micro data from the Norwegian Survey of Consumer Expenditure. The social anthropologists from SUM apply social practice theory to describe how energy is a part of daily tasks, and how policy measures affect habits and the interrelation between household members, and through this its effects on household energy consumption. The economists at Frisch/Torino/ØI will build a micro simulation model for car purchases based on estimations on vehicle purchase data. Simulations will be done to analyse how the goals for a reduction in CO_2 emissions in 2020 may be achieved. In addition, economists from the Frisch Centre will use experimental economics method to perform a field experiment, aiming to explain more in depth some specific aspects of the households' decisions.

During the first couple of years, each research community will apply its own methods to the research questions. The aim is to learn from the traditional research approaches within each field, discuss differences in results and assess the strengths and weaknesses of each approach. We want to learn from each other's disciplines, with the final goal of combining the analytic approaches. The first collaboration is planned between SSB and SUM, and a joint study is planned when the first economics and anthropological analyses are finished.

IV.1 Rebound and adverse effects of energy efficiency measures

Lately, there has been an increased focus on energy efficiency in Norwegian households, and several policy measures have been implemented to increase efficiency. Whether or not these policy measures achieve the anticipated reduction in energy consumption depend on how the households respond to these measures. Several studies on energy efficiency show that energy consumption is not reduced as much as the energy savings potential embedded in the efficiency measure suggest because efficiency increases spur households to change their behaviour (rebound effects). The rebound effects reflect that increased efficiency reduces the cost of using the energy source, which changes the relative prices of using different energy goods and reduces the cost of producing a given household service (heating, cooking, etc.). The article by Bøeng, A.-C., B. Halvorsen and B.M. Larsen (2013): "Fører effektiviseringstiltak til uønskede adferdsendringer?", RØST nr 1, discusses the effects these rebound effects may have on household energy consumption, illustrated by the effect on

household electricity consumption of increased use of heat pumps to heat Norwegian homes. The data indicates that there are considerable rebound effects in the introduction of heat pumps in Norwegian homes, and these rebound effects are as large as the energy savings potential embedded in the heat pumps.

To understand why these large rebound effects occur, in a published paper we examine different changes in energy consumption that has resulted from the increased use of heat pumps in Norwegian homes. The article looks at how heat pump ownership affects consumption of electricity, firewood and fuel oils, as well as how it affects indoor temperature. We find that households owning a heat pump use less firewood and fuel oils compared to households without a heat pump, as well as keeping a higher indoor temperature in the living room when it is not in use (on cold winter mornings). Only households with several alternatives to electricity used for space heating have a lower average electricity consumption than households without a heat pump, presumably because they have alternatives to electricity for heating in periods during the winter when it is so cold that the heat pump does not work properly. On average, the entire energy savings potential of electricity embedded in the heat pump is taken out in increased welfare by the households. However, total energy consumption is reduces and energy efficiency has risen.
Contact person: *Bente Halvorsen*

IV.2 The households' response to soft policy measures

The effectiveness of soft policy measures is often analysed based on stated preference surveys. Most humans have strong preferences with respect to how they like to present themselves and how others perceive them. This wish to present an image may bias results from stated preference surveys, depending on the underlying social norm in the questionnaire and the norms of the interview object. In an article published in Environmental Economics, we model how moral and social norms affect how we answer questions from stated preference surveys. The model is illustrated by using data from a survey on environmentally friendly household behaviour, which was simultaneously conducted in ten different OECD countries. We find clear indications that norms and how we like to be perceived by others affect how much we over- and understate our actual behaviour. These misrepresentations of behaviour occur both by respondents that want to appear environmentally friendly and those who oppose to this norm. The over- and under reporting of environmentally friendly behaviour appears to be

evenly distributed, so that the mean seems to be relatively unbiased, see Halvorsen, B. (2012): "Good Girl – Bad Boy: Do identity statements bias results from stated preference questionnaires", *Environmental Economics*, 3(2), 65 - 79.

In a draft paper the households' response to a combination of policy tools, both soft (energy labelling, energy economising advice and other information tools) and hard (energy taxes), are modelled. The model is illustrated by a data set from the Norwegian consumer expenditure survey for the years 1986 to 2009 to see if changes in energy policies during this period have changed household electricity consumption. We find that energy taxes are very effective, and that several soft policy tools reinforce this effect. We also find that the direct effect of most soft policy tools are modest, with the exception of energy labelling of household appliances, which seem to have a significant but decreasing effect on household energy consumption over time.
Contact person: *Bente Halvorsen*

IV.3 Environmentally friendly transportation

In 2013 a PhD student at the economics department at the University of Oslo analysed the impact of the purchase tax on new cars; this reform was announced in connection with the Government Budget in October 2006 (effective from 1 January, 2007). Sales data revealed there was a strong increase in the sales of cars with high CO_2 emissions during the fall of 2006. Thus the announcement of the new policy had an impact on CO_2 emissions in the fleet of cars after October 2006. But it also seems that the total sales of cars were not changed very much. Thus cars that otherwise would have been bought with somewhat lower CO_2 emissions in the fall of 2006 were replaced by bigger cars with higher potential CO_2 emissions. Sales in 2007 did not drop. For that reason the policy implemented since January 1st 2007 had a lasting impact on CO_2 emissions in the fleet of new cars after this date. A draft paper has been written.
Contact person: *Steinar Strøm*

IV.4 Indoor temperature and energy consumption in families with children

Each year, the Norwegian Research Council and Network for environmental studies at University of Bergen, organize a research project called "Forskningskampanjen for skolene"

in which children from all over Norway are involved in research. In the 2012 Research campaign, the pupils measured the temperature in four rooms (the living room, the bathroom, their own bedroom and their parent's bedroom) in the morning and evening, and registered the electricity consumption. In addition, the pupils interviewed family members about how pleased they are with the indoor temperature in different rooms, what they do to save energy, as well as attitudes and nagging about energy savings in the household. We find that almost half of the family members state that they hold a lower temperature in the living room and their own bed room than they find comfortable, and the mothers are the ones that freeze the most. The data also indicate that this is intentional, and that the reason many of these household choose to keep the room a little cooler than they find comfortable is to save money, energy and/or resources.

We also find that the indoor temperature varies with the heating equipment. The group with the highest indoor temperature is households with a common central heating system, followed by households with a heat pump, whereas households that use a lot of firewood for heating have a lower average temperature in the living room than other households. These results have been documented in two published papers and in one Master thesis.
Contact person: *Bente Halvorsen*

IV.5 Residential end-use electricity demand

A large share of policies aiming to reduce household energy consumption is related to specific end-uses, such as heating. It is very expensive and difficult to measure how much electricity that is used in different household activities, such as space and water heating, lighting, washing, etc. We have developed a model for estimating electricity consumption in different end-uses that uses cross sectional household data. The model is applied on three different data sets for the years 1990, 2001 and 2006 to compare the distribution of electricity on different end-uses over time. We find that electricity for basic use, such as washing, cooling of food and heating of water, does not vary much over the period. However, electricity for heating may vary considerably across years, depending on relative energy prices, temperature, etc. This paper has been revised and resubmitted to The *Energy Journal*.
Contact person: *Bente Halvorsen*

IV.6 Energy consumption and stocks of firewood

Policy measures applied during the last few decades aims to (i) reduce the households' consumption of fuel oils and electricity and (ii) increase the use of solid biomass to heat residences. One major problem in evaluating these policies is that many households may have large stocks of fuel oils and firewood. This means that there will be a difference between the purchased amount of these energy sources and consumption. Since we only have information on purchases, not consumption, it may be difficult to evaluate the effects of these policies. Thus, a method for estimating the price- and income effects on consumption and changes in stocks based on information about purchases, and whether this equipment has been used, is developed. This method is illustrated on data from the Norwegian Consumer Expenditure Survey, see Halvorsen, B. (2013): "Estimating consumption and changes in stock of storable goods applying micro expenditure data", *Environmental Economics* 2, pp. 42 - 53.
Contact person: *Bente Halvorsen*

IV.7 Bioenergy

In cooperation with a project at the Norwegian University of Life Science called "Bioenergy markets" we have written two papers published in a special issue of *Biomass and Energy*. The first examines motives for purchasing air-to-air heat pumps and also four different types of heating equipment; either based on firewood, wood pellets, electric floor heating or panel ovens. We analyse how this choice depends on how the households value the aesthetics of the equipment, its effectiveness, its utilisation and investment costs, its effects on the environment, in addition to time spent on applying the equipment. The article analyses how these factors affect the choice of heating equipment. Different factors tend to favour the purchase of different equipment. For instance, households concerned about costs tend to invest in heat pumps more than others, whereas environmental concerns are paramount in explaining purchase of wood pellets stoves. However, the most important explanatory factors are characteristics of the household and the residence, see Lillemo, S.C., F. Alfnes, B. Halvorsen and M. Wik: (2013): "Households' Heating Investments: The effect of motives and attitudes on choice of equipment ", *Biomass and Energy*, February.

The second article analyses what influences demand for fuel wood. This analysis focuses on how different factors, such as live style and environmental consciousness, in addition to

characteristics of the household and the residence, affect demand. The analysis applies data from the Norwegian Survey of Consumer Expenditures for the years 1997 and 1998, where the latter contains additional information on attitudes, lifestyles and energy consumption. We find that an urban lifestyle and a focus on comfort reduce demand for firewood. We also find that the price of firewood, as well as characteristics of the household and the residence, have a large and significant effect on firewood demand, see Lillemo, S.C. and B. Halvorsen (2013): "The impact of lifestyle and attitudes on residential firewood demand in Norway", *Biomass and Energy*, February.

Contact person: *Bente Halvorsen*

IV.8 Aggregation

When evaluating the effect of a policy measure on energy demand for the entire household sector, we face the problem of aggregation; that is, whether results from analyses on micro data are valid also for the effect on aggregate demand. Likewise, econometric analyses on aggregate demand will include more than the behavioural effect of the policy tool. The reason is that preferences and behaviour differ across households, which has to effects: First, the properties of the micro functions are not representative of aggregate behavioural effects, and second, it is not possible to identify behavioural effects based on analyses of aggregate functions only. This seems like a Catch 22 situation, but it is not, as it is always possible to calculate both micro and aggregate properties based on analyses on micro data. In a paper published in an international journal a method for a theoretically consistent aggregation of micro properties to macro is presented. The method is illustrated on household electricity consumption data from the Norwegian Survey of consumer expenditures. We find relative large aggregation biases, especially when estimating on aggregate data, see Halvorsen, B. and B.M. Larsen (2013): "How serious is the aggregation problem? An empirical illustration". *Applied Economics* 45, pp. 3786–3794.

Contact person: *Bente Halvorsen*

5.5 The Next Generation of Numerical Models (WP V)

To analyze policies that stimulate innovation and diffusion of new environmentally friendly technologies, integrated economy-energy-environment models are necessary tools. In 2013 we have developed and updated our energy market model LIBEMOD, and this work will be completed in 2014.

In 2013 we have also continued our work with establishing and building a new family of integrated macroeconomic Computable General Equilibrium (CGE) models; the SNoW-models (Statistics Norway World models).

Development and updating of numerical models are very resource-intensive activities. Outputs from these activities will materialize as papers under the other work packages.

LIBEMOD

In 2013 we have continued to update and extend the LIBEMOD model; the model base year is changed from 2000 to 2009, and more countries, energy goods and energy technologies have been included. Research assistant Hilde Hallre (Frisch Centre) together with Finn Roar Aune (Statistics Norway) have completed the data work and the programming of the model is almost finished (but has been delayed). The new model version will be documented in a report. Once the new model version is operative, we will continue the project with SINTEF Energy to identify the extent to which output from LIBEMOD and SINTEF's Samkjøringsmodell (Europe version) differ when input data are harmonized as much as

possible. We will also use the two models to examine an environmental policy issue. This project will be completed in 2014. Finally, in 2013 we obtained funding to develop the stochastic version of LIBEMOD under ENERGIX – extensions and applications of this model will take place over the next three years.
Contact person: *Rolf Golombek*

SNoW models

In 2013 we have continued to develop our new family of integrated macroeconomic Computable CGE models for energy and environmental policy analyses; the SNoW-models (Statistics Norway World models). SNoW_No is our new CGE model for Norway. A static version of this model (42 industries) based on the GTAP database structure (a global database on trade, environmental and energy) was established in 2013 and the model was programmed in GAMS. The database for SNoW_No builds on the National accounts, and also the Energy and the Environmental statistics, all from Statistics Norway. We have extended the GTAP database by including Norwegian process emissions of CO2. The model has been tested by simulating a carbon cost curve for Norway for different unilateral carbon emissions reductions.
Contact person: *Brita Bye*

Policy analyses

In 2013 we finalized a study on the impact of policies, like direct investment support, that aim to spur diffusion of climate technologies. This study uses the MSG-TECH model, which is a detailed CGE model for Norway that contains different abatement technologies across industries. In another study we have used the ITC-model (Induced technological change) to analyze the effects of Norwegian policies towards diffusion of climate technologies abroad. Both these analyses are part of the research project "Diffusion of Climate Technologies" funded by the RENERGI-program that ended in 2013.

We have also used the global version of the SNoW-model in a project that analyses carbon leakage reducing policy, see work package I, project 1.5.
Contact person: *Taran Fæhn*

6 International cooperation

Each of the Norwegian research partners in CREE has a large international network and it will be difficult to give a comprehensive and detailed report of all the collaboration with foreign researchers. Below we give some examples of this activity.

There is an international research partner in CREE, Tilburg Sustainability Center, and we also have contracts with several foreign researchers who have a part-time position paid by CREE:

Fridrik Baldursson, Reykjavik University
Matti Liski, Aalto University
Christoph Böhringer, Oldenburg University
Jared Carbone, University of Calgary.

CREE organizes an annual research workshop where we invite our international research partners, those having a part-time position in CREE as well as other relevant researchers from our network. At this year's workshop (16-17 September) the following international researchers attended:

Fridrik Baldursson, Reykjavik University
Aart de Zeuw, Tilburg Sustainability Center
Inge van den Bijgaart, Tilburg Sustainability Center
Reyer Gerlagh, Tilburg Sustainability Center
Samuel Jovan Okullo, Tilburg Sustainability Center
Matti Liski, Aalto University School of Economics
Elena Verdolini, FEEM – Fondazione Eni Enrico Mattei.

Our seminar series also had presentations by foreign scholars, see the chart on our website http://www.cree.uio.no/seminars.html.

We also have ongoing collaborative projects with foreign researchers in CREE. Some of these projects are reported in the CREE working paper series, while others have been reported in other series (see the appendix on publications). We also have cooperation that has not yet resulted in publications, for example through the CESifo network, both under projects that are

directly funded by CREE, and also under projects that count as our own funding (RENERGI, MILJØ2015 and NORKLIMA).

CREE is part of the ENTRACTE project (Economic iNsTRuments to Achieve Climate Targets in Europe) funded by the seventh EU Framework Programme. The project group consists of a consortium of nine European applied research centres, and is headed by Zentrum für Europäische Wirtschaftsforschung (ZEW). CREE heads one of the work packages and three research tasks, which involves collaboration with researchers from the other research centres. CREE has achieved funding from the Research Council of Norway to further deepen collaboration with the ENTRACTE network.

Snorre Kverndokk has been involved in the IPCC - Intergovernmental Panel on Climate Change. IPCC presents its fifth Assessment Report (AR5) in the fall of 2013 (Working Group I) and in the spring of 2014 (Working Groups II and III). Snorre Kverndokk has been engaged in WGIII - Climate Change 2014: Mitigation of Climate Change – which discusses measures to reduce greenhouse gas emissions, as a Review Editor.

Finally, a CREE researcher - Karine Nyborg - at the University of Oslo was the president of the European Association of Environmental and Resource Economists in 2013.

7 Recruitment

The overall plan for CREE is to recruit three PhD students and two post-doc researchers over the lifetime of CREE. While two PhD students were recruited in 2011, we recruited one post-doc researcher in 2012.

CREE gives a master scholarship of NOK 20.000 to up to three master students annually. In 2013, three master students received the grants and started on their master thesis. One of these students – Runa Haave Andersson – was later awarded a prize for the best Master Thesis within microeconomics among the economics students at the University of Oslo.

In connection with the recruitment of candidates, we are also engaged in research training

through teaching and supervising at the Tilburg University and the University of Oslo. Further, we are involved in MILEN's research school. This is an interdisciplinary research school for PhD candidates in energy and environment at the University of Oslo. In 2013 CREE organized, jointly with the MILEN research school, a one-week PhD course on integrated assessment models. Except for two lectures by geo scientists, the lectures and lab seminars were given by researchers in the CREE network. Three CREE researchers also participated with talks in three MILEN mini conferences.

8 Cooperation with other FME centres

When it comes to cooperation with other FME, our main contact is CICEP. This is mainly due to common research subjects as well as geographical proximity. We coordinate with CICEP our annual user conference that is held in April every year. Some research cooperation has been undertaken, for example, in 2013 we had two seminars on nuclear phase out and one half-day work shop on international climate cooperation. Finally, we submitted three applications to the KLIMEFORSK research program jointly with CICEP.

Like in 2012, we contributed to the research school of all the FME centres; NORREN. We also organized a one-day work shop with CenSES on numerical energy market models.

9 Communication and dissemination

CREE has invested heavily in communication, for instance through an internal reward system for communicating through the media. We have dedicated a website for news on CREE research, see http://www.cree.uio.no/CREE_in_the_news.html,
and had over 30 reports in the media in 2013. Researchers from CREE has been involved in key debates in the media over the past year on subjects such as heat pumps, global warming, electric vehicles and the effect of reduced extraction of oil a climate action.

When it comes to user-oriented communication measures, we had a lot of activity in 2013 with about 100 events. This includes meetings with all user partners, seminars, workshops and

conferences. Moreover, CREE participated in a "communication" meeting, organized by the Ministry of Petroleum and Energy, between the three social science centres on environmentally friendly energy (FME S) and the ministry. In addition, CREE has had three meetings with the Ministry of Petroleum and Energy, one meeting with the Ministry of the Environment, and one meeting with ENOVA. At these meetings we have either presented CREE in detail or results from some of our projects.

In 2013 CREE finalized its communication plan, see http://www.cree.uio.no/adm/Strategi_Komunikasjon/Communication%20plan%20CREE%20October%202012.pdf

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Annual report: CREE

Appendix: A1 Personnel

Key Researchers

Name	Institution	Main research area
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	Behaviroal Economics, Experimental Economics, Resource and Enviornmental Economics, Real options and stochastic analysis
Framstad, Nils Christian	Department of Economics, University of Oslo	Resources Energy and Environment
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	Energy and environmental economics
Fæhn, Taran	Research Department, Statistics Norway	Energy and environmental economics
Greaker, Mads	Research Department, Statistics Norway	Energy and environmental economics
Grimsrud, Kristine	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
Holtsmark, Bjart	Research Department, Statistics Norway	Energy and environmental economics
Isaksen, Elisabeth Thuestad	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
Rosnes, Orvika	Research Department, Statistics Norway	Energy and environmental economics
Storrøsten, Halvor	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

Adjunct professor

Name	**Institution**
Baldursson, Fridrik	Reykjavik University
Böhringer, Christoph	University of Oldenburg
Carbone, Jared	University of Calgary
Eyckmans, Johan	Hogeschool-Universiteit Brussel
Green, Richard	Inperial College London

Post Doc students with financial support from the Centre budget

Name	Funding	Nationality	Period	Sex M/F	Topic
Spiro, Daniel	CREE/ Department of Economics, University of Oslo	Swedish	2012-2016	M	Energy and environmental economics
Okullo, Samuel	CREE/ Research Department, Statistics Norway / Tilburg Sustainability Center	Ugandan	2013-2015	M	Innovation and climate change policy

PhD students with financial support from the Centre budget

Name	Funding	Nationality	Period	Sex M/F	Topic
Ciccone, Alice	CREE/ Department of Economics, University of Oslo	Italian	2011-2015	F	Economic of the climate change with econometric applications and climate technologies diffusion
Klemetsen, Marit	CREE/ Research Department, Statistics Norway /	Norwegian	2011-2015	F	Innovation in energy- and environmental technology industries: Identifying knowledge externalities and effects of policies
Michielsen, Thomas	CREE	Dutch	2010-2013	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
Dalen, Hanne Marit	Research Department, Statistics Norway	Norwegian	2009-2014	F	The use of multiple instruments in energy and environmental policy.
Holtsmark, Katinka Kristine	Department of Economics, University of Oslo	Norwegian	2012-2016	F	Development Economics, Natural Resource Economics, Microeconomics
Mideksa, Torben	Department of Economics, University of Oslo	Swedish	2012-2016	M	Primary Concentration: Contract Theory Seconday Concentrations: Environmental Economics and Political Economics
Midttømme, Kristoffer	Department of Economics, University of Oslo	Norwegian	2011-2014	M	Technology diffusion
van den Bijgaart, Inge	Tilburg Sustainability Center	Dutch	2012-2016	F	Environmental economics, technological change

Master degrees

Name	Sex M/F	Topic
Andersson, Runa Haave	F	"STABILITY OF INTERNATIONAL CLIMATE TREATIES THE IMPORTANCE OF HETEROGENEITY"
Beisland, Christina Stene	F	"From targets and timetable to technology investments"
Birkelund, Henriette	F	"Oppvarming og innetemperaturer i norske barnefamilier. En analyse av husholdningenes valg av innetemperatur."
Nesje, Frikk	M	"Distrust, but verify? Theoretical insights into auditing carbon sequestration in tropical forests"

A2 Statement of Accounts

(All figures in 1000 NOK)

Funding

	Amount
The Research Council	7 937
Research Partners (own funding)	
Frisch Centre (Host Institution)	5 396
Statistics Norway	3 950
Department of Economics,UoO	1 000
Tilburgs Sustainability Center	250
User partners	
Statkraft Energy AS	100
Statnett	250
Statoil ASA	250
Public partners	
University of Oslo	500
Total	19 633

Costs

Research Partners	
Frisch Centre (Host Institution)	9 706
Statistics Norway	5 488
Department of Economics, UoO	2 788
Tilburgs Sustainability Center	500
Centre for Development and the Environment, UoO	750
The Faculty of Law - Natural Resources Law, UoO	155
Institute for Energy Technology (IFE)	200
SINTEF	46
Total	19 633

A3 Publications

Journal Papers:

Bjertnæs, G. H., Tsygankova, M. and Martinsen, T (2013): Norwegian Climate Policy Reforms in the Presence of an International Quota Market, *Energy Economics*, 39, 147-158.

Carbone J. C.(2013): Linking Numerical and Analytical Models of Carbon Leakage, *American Economic Review, Papers and Proceedings*, May 2013, 103, 3, 326-331.

Carbone J. C. and K. Smith (2013): Valuing Nature in General Equilibrium *Journal of Environmental Economics and Management*, Volume 66, Issue 1, July 2013, Pages 72–89

Chakravorty U. and M. Liski (2013): Economics of Market Power in the Extraction of Nonrenewable Resources *Encyclopedia of Energy, Natural Resource, and Environmental Economics*, Volume 2, 2013, Pages 22-30

Fæhn, T., A. G. Gómez-Plana and S. Kverndokk (2013): How can carbon policies impact unemployment? *OPINION, Carbon Management* 4(1), 27–29.

Golombek, R., S. A. C. Kittelsen, and K. E. Rosendahl (2013): Price and welfare effects of emission quota allocation, *Energy Economics*, Volume 36, March, Pages 568–580

Golombek, R., K. A. Brekke and S.A.C. Kittelsen (2013): Is electricity more important than natural gas? Partial liberalizations of the Western European energy markets. *Economic Modelling*. Volume 35, September 2013, Pages 99-111

Greaker M. and C. Hagem (2013): Strategic Investment in climate friendly technologies: The impact of permit trade, *Environmental and Resource Economics* August 2013

Greaker M., P. E. Stoknes, K. H. Alfsen and T. Ericson (2013): A Kantian approach to sustainable development indicators for climate change, *Ecological Economics* 91, p.10-18

Haberl, H, ED Schulze, C. Körner, BE Law, B. Holtsmark, S. Luyssaert (2013): Response: complexities of sustainable forest use. *GCB Bioenergy* 5: 1-2.

Hagem, C. (2013).: Incentives for Strategic Behavior in the Permit Market.Strategic *Behavior and the Environment*, Volume 3, issue 3.

Halvorsen, B.(2013): Estimating consumption and changes in stock of storable goods applying micro expenditure data, *Environmental Economics* 2, pp. 42 - 53.

Halvorsen, B. and B. M. Larsen (2013): How serious is the aggregation problem? An empirical illustration, *Applied Economics*, 45:26, 3786-3794

Holtsmark, B. (2013): Boreal forest management and its effect on atmospheric CO2. *Ecological Modelling* Volume 248, 10 January 2013, Pages 130–134.

Holtsmark B. (2013): Quantifying the global warming potential of CO2 emissions from wood fuels. *Global Change Biology – Bioenergy* (in press, doi: 10.1111/gcbb.12110)

Kverndokk, S., K. R. Rosendahl (2013): Effects of Transport Regulation on the Oil Market: Does Market Power Matter? *The Scandinavian Journal of Economics.* Volume 115, Issue 3, pages 662–694, July

Lillemo, S.C. and B. Halvorsen: (2013): The impact of lifestyle and attitudes on residential firewood demand in Norway, forthcoming in *Biomass and Energy.*

Lillemo, S.C., F. Alfnes, B. Halvorsen and M. Wik: (2013): Households' Heating Investments: The effect of motives and attitudes on choice of equipment, *Biomass and Energy*.

Moe T., K. Alfsen and M. Greaker (2013): Sustaining Welfare for Future Generations: A Review Note on the Capital Approach to the Measurement of Sustainable Development, *Challenges in Sustainability*, 1:1, p. 16–26

Nyborg, K. and T. Zhang (2013): Is Corporate Social Responsibility Associated with Lower Wages? *Environmental and Resource Economics*, vol 55, 107-117]

von der Fehrr, N.-H. (2013): Transparency in Electricity Markets, *Economics of Energy & Environmental Policy*, 2 (2), p. 71-89

Books and article in books:

Gabriel, S.A., A. Moe, K.E. Rosendahl and M. Tsygankova (2013): The Likelihood and Potential Implications of a Natural Gas Cartel, in R. Fouquet (ed.): Handbook on energy and climate change, Cheltenham, *UK: Edward Elgar Publishing*.

Greaker M. (2013): Strategic Environmental Policy. In: Shogren, J.F., (ed.) *Encyclopedia of Energy, Natural Resource, and Environmental Economics*, volume 3, pp. 313-320 Amsterdam: Elsevier

Harstad B. and M. Liski (2013): Games and Resources, *Encyclopedia of Energy, Natural Resource, and Environmental Economics*, Volume 2, 2013, Pages 299-308

Holtsmark, B. (2013): International cooperation on climate change: why is there so little progress? Chapter 13 in R. Fouqet (ed) Handbook on Energy and Climate Change. *Edward Elgar*.

Kverndokk, S (2013): Moral positions on tradable permit markets - Handbook on Energy and Climate Change edited by Roger Fouquet - *Edward Elgar Publishing Ltd*.

Nævdal, E., (2013): Safe Minimum Standard (SMS), *Encyclopedia of Sustainability*, vol 5, 352-353

Spiro, D (2013): Ändliga resurser, Chapter in Nationalekonomi för miljöintresserade, ed. *Stavlöt U. Ivrig förlag*, ISBN 91-87379-09-0

Working Papers:

Beisland, C. S.: From Targets and Timetables to Technology Investments. Thesis for the Masterdegree, *CREE Working Paper* No. 12/2013, ISSN/ISBN 1892-9680/978-82-7988-149-0

Birkelund, H.: Oppvarming og innetemperaturer i norske barnefamilier: En analyse av husholdningenes valg av innetemperatur. Thesis for the Masterdegree, *CREE Working Paper* No. 13/2013, ISSN/ISBN 1892-9680/978-82-7988-150-6

Bjertnæs, G. H.: Are tax exemptions for electric cars an efficient climate policy measure? *CREE Working Paper* No. 21/2013, ISSN/ISBN 1892-9680/978-82-7988-158-1

Bjertnæs, G. H.: Biofuel mandate versus favourable taxation of electric cars: The case of Norway. *CREE Working Paper* No. 20/2013, ISSN/ISBN 1892-9680/978-82-7988-157-5

Brekke, K. A., R. Golombek, M. Kaut, S. A. C. Kittelsen and S. Wallace: The Impact of Uncertainty on the European Energy Market: The scenario aggregation method. *CREE Working Paper* No. 4/2013, ISSN/ISBN 1892-9680/978-82-7988-139-1

Brekke, K. A., R. Golombek, M. Kaut, S. A. C. Kittelsen and S. Wallace: The Impact of Uncertainty on the European Energy Market: The scenario aggregation method. *CESifo Working Paper* No. 4500, November 2013.

Bøeng, Ann Christin og Orvika Rosnes (2013): Konsekvenser av Energieffektiviseringsdirektivet i Norge. Energieffektiviseringsforpliktelser og kraftbalanse. *SSB Rapporter* 26/2013

Böhringer, C., J. C. Carbone and T. R. Rutherford: Embodied carbon Tariffs. *CREE Working Paper* No. 25/2013, ISSN/ISBN 1892-9680/978-82-7988-164-3

Böhringer, C., J. C. Carbone and T. R. Rutherford: The Strategic Value of Carbon Tariffs. *CREE Working Paper* No. 24/2013, ISSN/ISBN 1892-9680/978-82-7988-163-6

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Dalen, H. M. and B. L. Larsen: Residential end-use electricity demand. Development over time. *CREE Working Paper* No. 17/2013, ISSN/ISBN 1892-9680/978-82-7988-154-4

Eyckmans, J., S. Fankhauser and S. Kverndokk: Equity, Development Aid and Climate Finance. *CREE Working Paper* No. 15/2013, ISSN/ISBN 1892-9680/978-82-7988-152-0

Framstad, N. C. and J. Strand: Energy Intensive Infrastructure Investments with Retrofits in Continuous Time: Effects of Uncertainty on Energy Use and Carbon Emissions. *CREE Working Paper* No. 9/2013, ISSN/ISBN 1892-9680/978-82-7988-144-5

Framstad, N. C.: When can environmental profile and emissions reductions be optimized independently of the pollutant level?. *CREE Working Paper* No. 10/2013, ISSN/ISBN 1892-9680/978-82-7988-146-9

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Fæhn, T., E. I. Isaksen og O. Rosnes: Kostnadseffektive tilpasninger til togradersmålet i Norge og EU fram mot 2050. *CREE Working Paper* No. 22/2013, ISSN/ISBN 1892-9680/978-82-7988-160-5

Fæhn, T., E. I. Isaksen, K. Jacobsen and B. Strøm: MSG-TECH: Analysis and documentation of a general equilibrium model with endogenous climate technology adaptations. *CREE Working Paper* No. 23/2013, ISSN/ISBN 1892-9680/978-82-7988-161-2

Greaker, M. and K. Midttømme: Optimal environmental policy with network eects: Is lock-in in dirty technologies possible?. *CREE Working Paper* No. 27/2013, ISSN/ISBN 1892-9680/978-82-7988-168-1

Grimsrud, K., K. Einar, R. Halvor, B. Storrøsten, and M. Tsygankova: Short run effects of bleaker prospects foroligopolistic producers of a nonrenewable resource. *CREE Working Paper* No. 26/2013, ISSN/ISBN 1892-9680/978-82-7988-165-0

Hagem, C.: Incentives for Strategic Behavior in the Permit Market. *CREE Working Paper* No. 7/2013, ISSN/ISBN 1892-9680/978-82-7988-142-1

Halvorsen, B. and B. L. Larsen: How do investments in heat pumps affect household energy consumption?. *CREE Working Paper* No. 6/2013, ISSN/ISBN 1892-9680/978-82-7988-141-4

Hoel, M. and A. de Zeeuw: Technology Agreements with Heterogeneous Countries. *CREE Working Paper* No. 1/2013, ISSN/ISBN 1892-9680/978-82-7988-136-0

Hoel, M.: Supply side climate policy and the green Paradox. *CREE Working Paper* No. 2/2013, ISSN/ISBN 1892-9680/978-82-7988-137-9

Klemetsen, M. E., B. Bye and A. Raknerud: Can non-market regulations spur innovations in environmental technologies? A study on firm level patenting. *CREE Working Paper* No. 16/2013, ISSN/ISBN 1892-9680/978-82-7988-153-7

Kverndokk, S., E. Nævdal and L. Nøstbakken (2013): The Trade-off between Intra- and Intergenerational Equity in Climate Policy, CESifo Working Paper No. 4285, June 2013

Nesje, F.: Distrust, but verify? Theoretical insights into auditing carbon sequestration in tropical forests. Thesis for the Master degree, *CREE Working Paper* No. 18/2013, ISSN/ISBN 1892-9680/978-82-7988-155-1

Parchomovsky, G. and E. Stavang: Contracting around tort defaults: The knock-for-knock principle and accident costs. *CREE Working Paper* No. 14/2013, ISSN/ISBN 1892-9680/978-82-7988-151-3

Parchomovsky, G. and E. Stavang: The Environmental Option. *CREE Working Paper* No. 3/2013, ISSN/ISBN 1892-9680/978-82-7988-138-4

Storrøsten, H. B.: Prices vs. quantities with endogenous cost structure. *CREE Working Paper* No. 19/2013, ISSN/ISBN 1892-9680/978-82-7988-156-8

von der Fehrr, N.-H. M.: Transparency in electricity markets. *CREE Working Paper* No. 8/2013, ISSN/ISBN 1892-9680/978-82-7988-143-8

Popular scientific articles:

Brekke, K. A., R. Golombek, M. Kaut, S. A. C. Kittelsen, S. W. Wallace (2013): Modellering av usikkerhet i numeriske likevektsmodeller med stokastisk scenariometode. *Samfunnsøkonomen*, Nr 2 2013

Bye, B., K. P. Hagen (2013): Gjennomgang og revisjon av rammeverket for samfunnsøkonomiske analyser. *Samfunnsøkonomen*,Nr 1 2013

Bøeng, A.-C., B. Halvorsen og B.M. Larsen (2013): Fører effektiviseringstiltak til uønskede adferdsendringer? *RØST* nr 1 2013

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Fæhn, T., C. Hagem, L. Linholt, S. Mæland og K. E. Rosendahl (2013): Oljekutt og klimapolitikk, *Samfunnsøkonomen*, Nr 9 2013

Greaker M., C. Hagem, J. Hovi (2013): Hvordan kan en internasjonal klimaavtale håndheves? *Samfunnsøkonomen*, Nr 2 2013

Grimsrud, K.M. og M. Greaker (2013): Hvordan sikre bærekraftig forvaltning av økosystemer? *Samfunnsøkonomen*, Nr 4 2013 (127):25-33

Grimsrud, K.M., K. E. Rosendahl og H. B. Storrøsten (2013): Skifergassrevolusjonen og det europeiske gassmarkedet. *Økonomisk analyser*, 4/2013

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Halvorsen B. og B. M. Larsen (2013): Hvem eier varmepumpe og hva gjør det med strømforbruket? *Økonomiske analyser*, 2/2013

Hoel M. (2013): Bør vi subsidiere fornybar energi? *Samfunnsøkonomen*, Nr 2 2013

Lindholt L. (2013): Dragkampen mellom knapphet og teknologisk fremgang i oljemarkedet *Økonomisk analyser*, 4/2013)

Other publications:

Halvorsen, B. og H. M. Dalen, (2013): "Ta hjemmetempen". : rapport fra Forskningskampanjen 2012

Roine J. og D. Spiro, (2013): Utvinning för allmän vinning – en ESO-rapport om svenska mineralinkomster, Expertgruppen för studier i offentlig ekonomi 2013:9

Rosenberg E., (2013): Energieffektivisering i bygninger – norske potensialstudier, Institutt for energiteknikk, *rapport IF/KR/F-2012/079*

Conference and seminar presentations:

Bjærtnes G.: Biofuel mandate versus favourable taxation of electric cars: The case of Norway IIPF, Italia

Brekke K.: The Impact of Uncertainty on the European Energy Market: The scenario aggregation method European Association of Environmental and Resource Economists, 20th Annual Conference, Toulouse, France, 26 -29 June

Brekke K.: The stochastic scenario method for modeling uncertainty in computable equilibrium models Application to European energy markets CREE -CenSES modellforum, 24. oktober

Bye B.: Economic Models for Energy and Environmental analysis CREE -CenSES modellforum, 24. oktober

Carbone J.: Carbon Taxes and Deficit Reduction December 10

Carbone J.: Linking Numerical and Analytical Models of Carbon Leakage AEA, Annual Meeting, San Diego, January 6

Carbone J.: The Strategic Value of Carbon Tariffs, Carbon Leakage Session University of Colorado, Boulder February 11

Carbone J.: The Strategic Value of Carbon Tariffs Conference on Consumption Based Approaches in Climate Policy, ZEW, Mannheim, Germany, March 6,

Carbone J.: Climate policy and competitiveness: A review of the evidence from applied general equilibrium models Environment Canada, September 27

Egging R.: MultiMOD -An equilibrium model for energy market & infrastructure analysis CREE -CenSES modellforum, 24. oktober

Egging R.: AN SCGE model integrating the energy system and the regional economy CREE -CenSES modellforum, 24. oktober

Fæhn T.: The climate policy of an oil producing country demand-side versus supply-side policies CREE Workshop, Lysebu Sept. 16.-17

Fæhn T.: Induced technological change through innovation and absorption -CGE studies of policy options SEEK Workshop, Dublin, September 11

Fæhn T.: General equilibrium models for Norway and technological change -some lessons learned CREE -CenSES modellforum, 24. oktober

Førsund F.: Pumped Storage Hydroelectricity. Bergen economics of energy and environment research conference NHH, 13 – 14 May 2013

Golombek R.: Presentasjon av CREE ENOVA, Trondheim, 7. mai

Golombek R.: CREE brukermøte Oslo 9. Oktober

Golombek R.: Presentasjon av CREE Dialogmøte mellom OED og FME S, Oslo 10. Oktober

Golombek R.: Presentasjon av LIBEMOD CREE -CenSES modellforum, Oslo 24. oktober

Golombek R.: Is technology agreement the solution? MILEN mini konferanse Climate negotiations and coalitions, 22 oktober

Golombek R.: Norsk olje-og gassproduksjon fra et globalt klimaperspektiv. OED, Oslo 27.11.2013

Green R.: The impact of wind power on electricity markets BEEER, conference, Bergen, May 13-14

Hagem C.: The climate policy of an oil producing country demand-side versus supply-side Policies Beeer conference, Bergen, Norway, 13-14 May,

Hagem C.: Refunding emissions payments. European Association of Environmental

Hallre H.: LIBEMOD data sources CREE -CenSES modellforum, 24. oktober

Halvorsen B.: Households response to multiple energy policy instruments 37th International IAEE Conference, Daegu, South Korea, June 16-20

Hauge K.: Pro-social representatives? Decision-making on behalf of others in a public good game experiment Forskermøtet 2013, Stavanger, Januar 10

Hauge K.: Randomiserte forsøk Nye problemstillinger og miljøer inn i klimaforskningen, Workshop, Norges Forskningsråd, Oslo, 27.februar 2013

Hauge K.: Når Viljar, Rasmus og Egil skal investere i energi-effektivitet Møte med Enova/CenSes, Trondheim, 7.mai 2013

Hauge K.: Gender differences in leadership response 8th Nordic Conference in Behavioral and Experimental Economics, Stockholm, Sweden, September 26

Helgesen P.: RegPol. Model links and integration CREE -CenSES modellforum, 24. oktober

Hoel M.: Good and Bad Climate Policy Instruments CIENS-uka, Oslo, June 5

Hoel M.: Does a biofuels mandate reduce climate change costs? EAERE 20th Annual Conference, Toulouse, June 26-29

Hoel M.: Technology Agreements with Heterogeneous Countries EAERE 20th Annual Conference, Toulouse, June 26-29

Hoel M.: Incentives for environmental R&D HSE-EUSP International Workshop, St.Petersburg, 2 -4 October

Holtsmark B.: Carbon storage in boreal forests -economic and environmental policy approaches. Paper presented at ESSE European Society for Ecological Economics Conference, Lille, France 18-21 June

Holtsmark B.: Quantifying the global warming potential of CO2 emissions from wood fuels. Invitert foredrag på workshop arrangert av EU-kommisjonen/ Joint Research Centre i Arona, Italia, 1. -2. juli andResource Economists? 20th Annual Conference, Toulouse, France, June 26-29 Bergen economics of energy and environment research conference NHH, 13 14 May CESifo Area Conference on Energy and Climate Economics 2013, Munchen, October 11

Kittelsen S.: Two calibration submodels in LIBEMOD CREE -CenSES modellforum, 24. oktober

Klemetsen M.: Can non-market regulations spur innovation in environmental technologies? A study on firm level patenting Thursday Seminar, Statistics Norway Research Seminar, March 7

Klemetsen M.: Can non-market regulations spur innovation in environmental technologies? A study on firm level patenting Friday Seminar, University of Oslo-Economic Institute, April 26

Klemetsen M.: Can non-market regulations spur innovation in environmental technologies? A study on firm level patenting ZEW/MaCCI Conference on Economics of Innovation and Patenting, Mannheim, June 2-4

Klemetsen M.: Can non-market regulations spur innovation in environmental technologies? A study on firm level patenting EAERE, Toulouse, June 26-29

Klemetsen M.: Can non-market regulations spur innovation in environmental technologies? A study on firm level patenting CREE Workshop, Lysebu (Oslo), September 16-17

Kverndokk S.: The Trade-off between Intra-and Intergenerational Equity in Climate Policy: Can Carbon Leakage be Justified? Forskermøtet for økonomer, Stavanger, January 7-8.

Kverndokk S.: Inter-and Intragenerational Ethical Aspects of Climate Policy MILENS etikkseminar, January

Kverndokk S.: Intra-and Intergenerational Equity in Climate Policy: A project at the Frisch Centre MILJØ2015konferansen, Oslo, February 6-7

Kverndokk S.: Equity in Climate Finance: Development assistance may be the best instrument Onsdagslunsj Frischsenteret, March 6

Kverndokk S.: Klimafinansiering - hvordan bør den utformes hvis den er motivert av fordelingshensyn? CREE brukerkonferanse, Oslo, April 16

Kverndokk S.: Equity, Development aid and Climate Finance BEEER conference, Bergen, May 13-14.

Kverndokk S.: Thematic session 5: Equity and climate policy EAERE, Toulouse, June 27-28.

Kverndokk S.: Equity, Development aid and Climate Finance EAERE, Toulouse, June 27-28.

Kverndokk S.: An introduction to integrated assessment models on economics and climate systems Lecture MILEN 9012, September 9

Kverndokk S.: The economic side of IAMs -some critical aspects Lecture MILEN 9012, September 11.

Kverndokk S.: Presentasjon av bokkapittel om klimaendringer Forfattermøte, bok om naturressursøkonomi, Trondheim, October 10-11.

Kverndokk S.: Intra- and Intergenerational Equity in Climate Policy CREE-CICEP workshop, December 5.

Lind A.: Renewable energy production and the impact of various energy demand scenario CREE -3rd research workshop, Lysebu, Oslo, September 16-17

Lind A.: TIMES CREE -CenSES modellforum, 24. oktober

Lindholt L.: Climate policies in a fossil fuel producing country – Demand versus supply side policies Presentation for the Division for Energy and Environmental Statistics, Holmsbu, October 8, 2013

Liski M.: Consumer in the Lab: Technology choices in housing and electricity markets EPRG & CEEPR European Energy Policy Conference Helsinki, June 11-12

Liski M.: No News is Good News in Climate Change: thematic session organizer and paper Presented at the EAERE conference, EAERE 20th Annual Conference, Toulouse, June 26-29

Nyborg K.: Managing Oil and Gas Finds -Insights from the Norwegian Experience. Publicpolicy.ie, Dublin, 23.05.13.

Nyborg K.: What does cost-benefit analysis really measure? Manchester Economics Seminars, University of Manchester, UK, April 17.

Nyborg K.: What does cost-benefit analysis really measure? Forskningsseminar, UNI Rokkan senter, Bergen, April 26.

Nyborg K.: What does cost-benefit analysis really measure? Research seminar, University College Dublin, Mai 05.

Nyborg K.: Do we pay sufficient attention to institutional aspects in environmental policy? Presidents Forum, 20th Annual Conference of EAERE, Toulouse, Juni 27

Nyborg K.: What does cost-benefit analysis really measure? Research seminar, University of Rostock, September 15

Nyborg K.: Framing Cooperation with Mixed Motives (with Kjell Arne Brekke and James Konow) Research seminar, WZB, Berlin Oktober

Nyborg K.: Hva kan nyttekostnadsanalyser egentlig fortelle? Faglig-pedagogisk dag, Blindern, 31.10.13.

Nyborg K.: Klimaproblemet fra et økonomisk perspektiv. Gimle Rotary, 13.11.13.

Nøstbakken L.: The Trade-off between Intra-and Intergenerational Equity in Climate Policy AERE summer conference 2013, Association of Environmental and Resource Economists, Banff, Canada; June 6-9

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Rosnes O.: SNOW. Ny CGE-modell for energi-og klimaanalyser CREE -CenSES modellforum, 24. oktober

Seljom P.: Short-term uncertainty in investment models CREE -3rd research workshop, Lysebu, Oslo, September 16-17

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Storrøsten, H. B., M. Tsygankova, K. E. Rosendahl, K. M. Grimsrud: Short run effects of bleaker prospects for oligopolistic producers of a non-renewable resource Lunsjseminar. Oldenburg.

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von der Fehr N. -H. : Who Should Pay for Transmission? CICEP-CREE Brukerkonferanse. "Mulighetenes marked: Energiomstilling og klimafinansering", Oslo, April 16

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von der Fehr N. -H. : Regulation as Coordination: Comment, Reflexive Regulation: Regulation in a Multilevel and Multimode Perspective Florence, September 13-14

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Wolfgang O.: Introduksjon til Samkjøringsmodellen CREE -CenSES modellforum, 24. oktober

CREE in the Media (in Norwegian):

- Debatt om klima, næringsliv og politikk i *Dagens Næringsliv*. Innlegg av Annegrete Bruvoll, forsker på SSB og Vista Analyse, og Taran Fæhn forsker på SSB og CREE og motinnlegg av Kristin Skogen Lund, adm. dir. i NHO og Stein Lier-Hansen, adm.dir. i Norsk Industri. DN jan. 2013

- Elbil og miljø. Bjart Holtsmark uttaler seg i saken "SSB-fosker mener elbilpolitikken gir mer biltrafikk og større miljøproblemer", *NRK P1 - Her og Nå* 7 feb 2013.

- CREE nevnes blant de tre FMEene tilknyttet UiO. I et intervju med Apollon snakker Professor Arild Underdal om UiOs og FMEenes rolle med energi- og klimautfordringene. *APOLLON* 7 feb 2013

- Når skog bør forbli et karbonlager. Katinka Holtsmark, stipendiat ved Økonomisk Institutt UiO og forsker CREE har skrevet en artikel om dette i APOLLON. *APOLLON* 7 feb 2013

- Å regne med fremtiden. Bård Harstad, professor ved Økonomisk Institutt UiO og forsker CREE har skrevet en artikel om diskontering i Aftenposten. *Aftenposten* 28. feb. 2013

- Norway shows the way with electric cars, but at what cost? REUTERS hadde et oppslag der Bjart Holtsmak, forsker SSB og CREE, og andre snakker om norske forhold i tilknytting til Elbiler. Denne har gitt opphav til flere internasjonale oppslag.

- Ansvarlige bedrifter, ansvarlige ansatte. Karine Nyborg, professor på Universitetet i Oslo og forsker CREE, skriver om den enkelte ansattes verdi av å jobbe i en bedrift som tar miljøhensyn utover det pålagte. *Aftenposten* 21 mar. 2013

- Debatt om små oljefelt gir høye utslip. Lars Lindholt, forsker SSB og Knut Einar Rosendahl, Professor UMB og forsker CREE skriver om CO2 utslip og små oljefelt. Freddy Frydenbø, sivilingeniør, kommer med motinnlegg. *DN* apr. 2013

- Omtaler av Karine Nyborgs bok Ethics and Politics of Environmental Cost-Benefit Analysis. - Div omtaler.

- Ta hjemmetempen og Varmepumpe-DP. Forskningsresultatene til Bente Halvorsen, Hanne Marit Dalen og Bodil Merethe Larsen, forskere SSB og CREE, blir nevnt i flere media. Flere oppslag i Media.

- Gir global oppvarming en matkrise? Bjart Holtsmark, forsker SSB og CREE, argumenterer for at noen av konsekvensene av den globale oppvarmingen er overdramatisert. *E24* 15 mai 2013

- Naturens mange verdier. Karine Nyborg, professor Universitetet i Oslo og forsker CREE, har en kommentar om at markedspriser er en villedende analogi for verdsetting av natur. *Aftenposten* 23 mai 2013

- Regnskogsavtaler. Skal vi bruke penger på miljø, er det lite som kaster så mye av seg som å bevare skog. Men vi vet enda ikke hvordan vi gjør det. Kommentar av Bård Harstad, professor Universitetet i Oslo og forsker CREE. *Aftenposten* 6 juni 2013

- Norge bør sette foten på bremsen når det gjelder oljeutvinning, mener Knut Einar Rosendahl, professor Universitetet i Ås og forsker CREE. Ikke alle er enig. *DN* 19 juni 2013

- Debatt etter forskningrapporten Climate policies in a fossil fuel producing country: Demand versus supply side policies - by Taran Fæhn, Cathrine Hagem, Lars Lindholt, Ståle Mæland and Knut Einar Rosendahl. Forskerne selv og andre debaterer temaet. Diverse innslag.

- Taran Fæhn i innslaget «Norsk oljekutt er billig klimatiltak» i NRK radio, Her og nå. *NRK Her og nå* 19 juni 2013

- Stortinget åpnet Barentshavet sørøst for oljeleting, SSB: Billigst å redusereutvinningen. Forskere tilknyttet SSB og CREE anbefaler reduksjon i oljeproduksjonen. Siste del falt ut i vår pdf. *Vårt Land* 20 juni 2013

- Bård Harstad tildelt Erik Kempe pris for 2013. Bård Harstad, professor Universitetet i Oslo og forsker CREE har fått Erik Kempe pris for 2013 for sin artikkel Buy Coal! A Case for Supply-Side Environmental Policy i Journal of Political Economy Vol. 120 No 1 Feb 2012 Diverse innslag om dette.

- Diverse innslag om Elbiler. Mye knyttet til Bjart Holtsmark. Diverse innslag om elbiler

- Smarte målere gir liten spareeffekt. Tanja Winther, forsker ved Senter for utvikling og miljø, UiO og CREE gir utrykk for skepsis til stor spareeffekt av nye strømmålere. *Aftenposten* 09 juli 2013

- Knut Einar Rosendahl deltar i Dagsnytt 18 og kommenterer rapport om miljø og oljekutt i «Har fattige land ingen nytte av norsk olje- og gassproduksjon?». Knut Einar Rosendahl er forsker tilknyttet SSB, UMB og CREE *Dagsnytt atten* 21 august 2013

- CO2 og hogst. Debatt hvor Bjart Holtsmark, forsker SSB og CREE, kommenterer et innlegg av Gunnar S. Eskeland, professor på NHH. *Dagens Næringsliv* september 2013

- Diverse innlegg rundt SSB rapporten: Norsk olje- og gassproduksjon: Effekter på globale CO2-utslipp og energisituasjonen i lavinntektsland skrevet av Taran Fæhn, Cathrine Hagem og Knut Einar Rosendahl Diverse innlegg

- Global dugnadsånd. Karine Nyborg, professor UiO ØI og forsker CREE, har et debattinnleg om temaet. *Aftenposten* 18. okt. 2013

- Biobrensel mindre klimavennleg enn antatt. Bjart Holtsmark, forsker SSB og CREE, intervjuet på forskning.no. *forskning.no* 29 okt. 2013

- Diverse debatter angående miljøøkonomers rolle i klimapolitikken. Dette på bagrunn av boken Drivhuseffekter av Erik Martiniussen. Diverse innlegg

- En uke på dagsordenen. I forbindelse med lanseringen av den femte hovedrapporten fra FNs klimapanel ble blant andre også Snorre Kverndokk intervjuet. Kverndokk er forsker på Frisch og CREE. *Forskerforum* 6. nov 2013

- Global oppvarming er lønnsomt – for oss. Snorre Kverndokk forsker på Frischsenteret og CREE og Mads Greaker, forsker SSB og CREE, kommer med kommentarer i artikkelen. *Forskning.no* 20. nov. 2013

-Varmepumper. Bente Halvorsen og Bodil Larsen, forskere SSB og CREE, har laget rapport om varmepumper og bruken av disse. Flere intervjuer og henvisninger til denne rapporten. Diverse innlegg.