

CREE WORKPLAN 2016

CREE's activities are divided into research, dissemination and dialog.

For the research activities, we have reorganized the work package structure for 2016. In the first period of CREE, one of the main additional activities financed by CREE was the focus on developing the new generation of numerical models for energy and environmental policy analyses. This has materialized in two new versions of partial energy market models, the extended version of the European energy market model LIBEMOD that is a joint project between Frisch and SSB, and a new version of the international oil market, PETRO2, an especially important analyzing tool for Norway as a petroleum producing economy. The other main model project has been the development of a new family of macroeconomic general equilibrium models, the SNoW-models (Statistics Norway World models) that include a global model version and a version for Norway (SNoW-NO). As the focus now is re-orientated from model development to usage for proper analyses, we have reorganized the work package structure as follows (work package leaders are mentioned in parenthesis):

WP1: Regional and national climate and energy policies (Brita Bye)

WP2: Global climate policies and negotiations (Michael Hoel/Mads Greaker)

WP3: Innovation and Diffusion Policy (Rolf Golombek)

WP4: Regulation and Market (Nils-Henrik von der Fehr)

WP5: Evaluation of Environmental and Energy Policy Measures (Bente Halvorsen)

With this new structure, we focus on regional and national energy and climate policies in WP1 and global climate policies and negotiations in WP2. Regional and national policies have been the basis for most of the European and Norwegian climate policies until now and will also be important parts of the follow up of Paris 2015. WP2, on the other hand, with its paramount global focus, presents strategies for globally focused policy solutions which include the Paris agreement and the future negotiations that will make place to concretize this agreement. The last three WPs are kept mainly as before, but the numbering is changed. Note, however, that if CREE gets funding for the period 2016-2019, we will make a new plan for this period which also means a long term plan for all work packages.

The research will take place at the four research partners - Frisch Centre (Frisch); Department of Economics, University of Oslo (ØI); Research Department, Statistics Norway (SSB); and Tilburg Sustainability Center (Tilburg) – and our subcontractors – Institute for Energy Technology (IFE); Centre for Development and the Environment, University of Oslo (SUM); and Natural Resources Law at the Faculty of Law, University of Oslo (UiO Law). In addition to this, several international researchers connected to the center will also contribute.

CREE has at present seven user partners (Statkraft, Statnett, Statoil, NVE, Gassnova, OED, MDir) that are involved in the research as sponsors and/or as giving inputs to research in different ways. New users will also be involved in our research for 2016 such as Energi Norge, Ringerikskraft and Vegdirektoratet that are all part of a new KPN-project. As we have had close contact with these new users in 2015, we will consider extending the number of user partners in CREE.

Our research is published in the CREE working paper series (see www.cree.uio.no), but also in other reports and series. The final product of our research is mainly peer reviewed journal articles, book chapters and books. All CREE working papers have a Norwegian summary to make them more accessible for users. Regularly, we inform everybody involved in CREE about our new working paper publications, by posting on the web-page and e-mailing.

When it comes to dissemination and dialog at workshops, seminars and meetings, we have so far made plans for the following arrangements:

12 January: Half day seminar at Energi Norge – program developed in cooperation with CREE and Energi Norge.

Spring 2016: Climate agreement colloquium – 3-4 half day meetings with subcontractors, user partners and researchers, see CREE project directory, project no. 11.

March: CREE model forum – a forum for discussion of energy modelling that includes our technology subcontractor (IFE) and user partners.

March/April: Seminar in the Model and Methods expert committee at the Ministry of Finance.

April: CREE/CICEP user conference.

April/May: A first workshop with participation from the international advisory board on the project “Security of supply in a green power market”, see CREE project directory, project no. 42.

May/June: Workshop at the WILL-project (see project no. 3), CREE/SSB/CICERO.

Late spring/summer: Half day seminar at NVE.

September: CREE research workshop at Lysebu, Oslo.

November: Half day dialog seminar for user partners and researchers.

Fall 2016/spring 2017: Hopefully we are able to host the European workshop on the “Implications of Paris” project in Oslo, see CREE project directory, project no. 10.

In addition to this, we continue with the regular CREE seminar series that is held at the Frisch Centre, Statistics Norway and Department of Economics (UiO). In 2015, we organized 20 seminars in this series.

We will also continue with our regular CREE lunches (usually 6 times a year), summer party and Julegløgg. The “Julegløgg” also includes a popular presentation either from a user partner representative or from one of our researchers.

We also plan to improve our web pages (www.cree.uio.no) to make them more accessible. This involves establishing web pages for all CREE projects. We will continue to publish our media activity on this homepage.

Finally, we will continue with information on CREE activities and news in our e-mail newsletters “News from CREE” that are sent out about 3 times a year.

We also refer to the “Tiltaksdokument for CREE” which describes several changes to meet the criticism of the evaluation committee reported in the mid-term evaluation. Many of these measures are implemented already, and the rest will be followed up in 2016.

Below we summarize the planned 2016 research activities for the different work packages. For more details, we refer to the “CREE Project directory 2016” which is an attachment to this Work Plan.

WP1: Regional and national energy and climate policies

WP1 concentrates on analyses of regional and national energy and climate policies. Analyses of regional and national energy and climate policies are in nature more close to reality and often analyzed empirically. Examples of topics analyzed in this work package are policies that deal with carbon leakage when the carbon policy is unilateral or multi-lateral but not global, as border carbon adjustments (tariffs etc.), supply vs. demand side regulations of fossil fuels, or free allocation of quotas in a tradeable emission quota system as, e.g., the EU-ETS. Interactions between policy instruments as energy efficiency measures, carbon pricing and other regulations are other topics.

The methods range from simple models used to illustrate some theoretical results, to detailed multi-sector and multi-region partial and economy-wide models that analyze specific policies such as the LIBEMOD, PETRO2 and SNoW models mentioned above.

All research partners in CREE participates in WP1 (Frisch, SSB, ØI, Tilburg) in addition to CREE’s subcontractor Institute for energy technologies (IFE), Cicero, NMBU, University of Stavanger and Norwegian environmental agency (NEA). Further, Professor Chris Böhringer (University of Oldenburg) is central in the numerical general equilibrium model analyses. In addition to direct funding from CREE and the research partners, the projects have own funding coming from RCN (other research projects), and users such as the Ministry of Finance and the Ministry of Climate and Environment. The projects include multidisciplinary studies with technology expertise at IFE and science expertise at Cicero.

Research activities in 2016

The projects in WP1 are summarized in Table 1 (detailed description is given in the Project directory).

Table 1: WP1 - Planned projects for 2016 (numbers refer to project directory)

<i>Projects</i>	<i>Institution</i>
a) Carbon leakage <ul style="list-style-type: none"> - 1. Reducing carbon leakage - 2. Output based allocation of carbon permits - 3. “WILL” - Governing EU-Norwegian willingness to extract, combust and consume less carbon 	SSB/Frisch/NMBU/UC Berkeley/ UoOldenburg/RFF SSB/NMBU/Cicero/UoOldenburg SSB/NMBU/Cicero/UoOldenburg
b) Climate policies, the oil market and Norway <ul style="list-style-type: none"> - 6. International oil market analyses - 7. Global and national transformation from a fossil-fuel-dependent economy 	SSB/NMBU/Frisch SSB/NMBU/Frisch/ UoOldenburg/UiS
c) Energy efficiency <ul style="list-style-type: none"> - 4. Residential energy efficiency and European carbon policies - 5. Energy efficiency, energy systems and the economy 	SSB SSB/IFE
d) Climate policy scenarios <ul style="list-style-type: none"> - 8. Abatement of greenhouse gas emissions in Norway and the EU towards 2030 	SSB/UoOldenburg/MDir
e) Other <ul style="list-style-type: none"> - 9. Regionalizing Norway in LIBEMOD 	SSB

Carbon leakage

A key challenge for unilateral policy initiatives in a global market place, is carbon leakage and competitiveness concerns. We analyze economic and emission effects of introducing carbon taxes combined with different kinds of border tax adjustments, rebating etc. We are especially concerned about the development of second-best optimal policies in a world where a considerable share of global carbon emissions is still not regulated.

A main strategy in Norwegian climate policy is embracing and encouraging the climate and energy policy initiatives of the EU by coordinating Norwegian policies with the EU. The purpose of this project is to explore and identify how to best mind the ambitions for coordinated policies in the EU and Norway, in terms of maximizing the overall effectiveness of their combined initiatives. We focus on how the EU and Norway should target policies towards different points of the fossil fuel and emissions supply chain, from the point of extraction, to the point of combustion, and finally consumption. We use both theoretical and detailed numerical models as the SNOW-models family to analyze the different approaches to carbon pricing targets, and measure their efficiency in terms of global emission effects and economic welfare. A problem with international climate agreements is also that few countries will sign an abatement agreement due to the free rider problem: all countries benefit whereas cost of abatement is born entirely by the country itself. We analyze how a border tax improves the attractiveness of international climate agreements and increases the number of signatories. The design of subsidy policies for abatement technology will also influence the competitiveness of firms and carbon leakage, and the effects may differ between large versus small regions/countries.

Climate policies, the oil market and Norway

The project addresses the transformation from a petroleum-dependent Norwegian economy. In its first stage, it analyses the prospects of the Norwegian petroleum sector by identifying factors that are expected to affect the extraction on the Norwegian continental shelf in the medium and long run. This involves looking at global market developments and current and alternative Norwegian policy regimes targeting the industry. This first stage will combine ex post econometric analyses and model projections by means of global numerical energy models. In the next stage we will look at the effects of a declining Norwegian petroleum extraction sector for the domestic economy as a whole. Based on econometric analysis and economic models we will examine the flow of workers, competence and knowledge spillovers from the petroleum sector and its surrounding innovation activities to other, greener parts of the economy.

In many large countries, fuel use is heavily subsidized. We will analyze the oil market effects on prices and quantities of removal of fuels subsidies in selected regions using the oil-market model PETRO2 that is a dynamic simulation model that analyses how market conditions and/or climate-/energy-policies affect the oil market.

Energy efficiency

Ambitious energy efficiency goals constitute an important part of the EU's road to a low carbon economy. While the introduction and reformation of climate policy instruments take place rapidly in Europe, the knowledge on how the instruments interact lags behind. The traditional approach in the literature analyzing residential energy efficiency policies has been to increase energy efficiency exogenously, implying that energy efficiency policies make energy more productive in providing comfort and other services to the households. In this project we will combine knowledge from both technological science and economics to analyze effects of energy efficiency policies. The aim is to add knowledge into the complex topic of energy efficiency from both kinds of sciences represented by economic model

analyses at Statistics Norway and detailed information of technological energy investment possibilities derived from the bottom-up model TIMES-Norway at IFE.

Climate policy scenarios

Norway's climate targets for 2030 correspond to those of the EU. The Norwegian government intends to fulfil the ambitions jointly with the EU, but it is still unsettled how flexible the mechanism for joint implementation will be and the conditions Norway will face. The EU has decided that some trading of emissions will be possible within the non-ETS sector and that some of the commitments within non-ETS can be fulfilled by cancelling quotas in the emission trading system (ETS). The aim of the project is twofold: First, we will analyze costs and emissions for Norway under alternative designs of these flexibility mechanisms, taking into account the EU actions and consequences for energy prices and carbon prices. We do this by means of simulations of the energy market model LIBEMOD and SSB's CGE models. The second aim is to develop the CGE model SNoW-No (for Norway) to account for potentials for changes in climate technologies towards 2030. The latter is based on close collaboration between SSB, University of Oldenburg and NEA, who provides engineering and emissions expertise.

The project analyzing Norway's climate targets interacts with the project initiated by JGCRI at the University of Maryland, USA, about the implications of a Paris agreement on climate change. This will further be described in WP2.

Other

We will analyze how European climate and energy policy may affect the renewable energy production in Norway and the corresponding necessary investments in the grids. LIBEMOD is an energy multi-market equilibrium model, developed by researcher at Statistics Norway and the Frisch Centre. Its main focus is on the electricity and natural gas markets of Europe, but it also covers markets for coal and oil. The model distinguishes between model countries – each of 30 European countries – and exogenous countries/regions, the latter group containing all countries in the world outside Europe. In order to focus on the production and transmission of renewable energy in Norway, we will regionalize LIBEMOD for Norway. The regionalization will follow (or can be aggregated to follow) the current spot price areas in Norway.

Research output in 2016

For WP1, we plan to write 14 working papers in 2016 or early 2017, about half of them will be submitted to international peer-review journals in 2016 and the rest in 2017, a number of popular scientific article for Norwegian journals, several presentations for users and for the research community at national and international conferences and workshops.

Some of the projects in WP1 will also be presented at CREE model forum that will take place in March 2016. In particular, analyses using the SNoW-NO model will be presented at a seminar in the Model and Methods expert committee at the Ministry of Finance in March/April 2016.

WP2: Global climate policies and negotiations

WP2 concentrates on analyses of global climate policies and negotiations. By the end of 2015 the ongoing UN climate negotiations ended with a treaty in Paris. The treaty is exceptional because nearly all countries in the world committed to reduce their GHG emissions. The main elements of the treaty can be described as follows:

- The 2⁰ C target was confirmed, and nations agreed to “*pursue efforts to limit the temperature increase to 1.5⁰ C*”
- A single system through which the GHG emission reductions of all countries are evaluated, both industrialized and developing, will be developed and implemented
- Parties aimed to reach global peaking of GHG emissions *as soon as possible*, and neutrality e.g. global zero net emissions in the second half of this century
- Each country commit to the emission reductions that were given prior to the Paris conference, and further commits to revise their emission reduction plans every 5 years

In addition to this, a subset of countries promised to double their R&D funding for research into clean technologies.

Although a success, the Paris treaty raises many challenges: First and foremost, the current emission reduction pledges are not large enough to reach the 2⁰ C target. Thus, a crucial question which CREE aims to study is how to get countries to step up their emission reduction pledges. Second, the emission reduction pledges are not legally binding, and there is no sanction mechanism built into the treaty aimed at countries not fulfilling their pledges. Third, everyone agrees that technological development is crucial for combatting climate change, but how the clean R&D step up is going to happen is not formalized in the treaty.

For 2016, CREE aims to do research inquiring further into these challenges. Parts of this research will take place in a new project we will call the “Climate agreement colloquium”.

While the research in this work package builds on economic theory and game theory, it is multidisciplinary as several of the projects are based on behavioral economics and theories of equity. Also researchers from several other fields such as psychology, law, political science and technology are involved. The two new projects related to the Paris agreement will also involve closer user interaction. As seen below this work package also includes major international cooperation with researchers from American and European universities.

Research activities in 2016

The projects in WP2 are summarized in Table 1 below.

Table 2: WP2 - Planned projects for 2016 (numbers refer to project directory)

<i>Projects</i>	<i>Institution</i>
<p>a) Design and impacts of climate agreements</p> <p>i) Game theoretic analysis of alternative/complimentary climate agreements</p> <ul style="list-style-type: none"> - 12. Pareto improving climate treaties - 13. Climate treaties with reciprocal preferences - 14. Decision making in environmental-related treaties - 15. Sectoral approaches and R&D clubs - 19. Investments in green technology in dynamic games - 20. Resource extraction in dynamic games <p>ii) The Paris agreement</p> <ul style="list-style-type: none"> - 10. Implications of Paris - 11. Climate agreement colloquium 	<p>Frisch/JGCRI ØI</p> <p>Frisch/ØI/Oslo Economics</p> <p>SSB/Columbia U</p> <p>ØI/UoVienna/Northwestern/ UoChicago/UoMadrid ØI</p> <p>Frisch/ØI/SSB/JGCRI/CenSES SSB/Frisch/ØI/ UiO Law/ SUM/CICEP/ MDir/ KLD</p>
<p>b) Ethical foundations of climate agreements</p> <ul style="list-style-type: none"> - 16. The implications of unfair background conditions for trade - 23. Intergenerational decision making 	<p>Frisch/UoHamburg</p> <p>ØI</p>
<p>c) The implications of uncertainty</p> <ul style="list-style-type: none"> - 17. Ambiguity aversion - 21. Modelling risk of irreversible catastrophes - 22. Learning about the climate system 	<p>ØI/UiO Psychology</p> <p>Frisch/Beijer Institute</p> <p>Frisch/UC Berkeley</p>

Design and impacts of climate agreements

A majority of the research in 2016 can be categorized under this label. In particular, the game theoretic models of climate treaties that we have used for earlier analyses will be further developed. These include treaties that focus on new technology implementation, treaties that focus on the supply of fossil fuels, instead of the emissions from fossil fuel use, the potential role of reciprocity in climate agreements and sector based treaties instead of country based treaties. We will also look at so called Pareto-improving treaties in which there is a transfer of wealth from future generations to current generations so that no generation will lose from a treaty.

Moreover, we will start a new project on the implications of the Paris UNFCCC treaty. The project will consist of modelling groups from North America, Europe and Asia, and will be organized as a research program and an international workshop series in 2016/2017. The idea is to inform key stakeholders on the environmental, economic and energy implications of the new agreement based on integrated scientific and technical analysis and to stimulate dialogue on next steps in the process. The key questions are: What do the INDCs mean in the context of a 2 degree C long-term limit? What does it mean for key countries and regions? What does it mean for the energy system? We will run different numerical models with point of departure in the emission reduction pledges made in Paris, and the 2⁰ C/1.5⁰ C targets. By comparing the outcome of different models the research community and stakeholders will be able to get a better understanding of the need for future greenhouse gas (GHG) abatement. This project is initialized by JGCRI at University of Maryland, and several stakeholders are in the steering group. On the European side, CREE will work closely with CenSES on this.

Parts of this research will take place in a new project called the “Climate agreement colloquium”

Ethical foundations of climate agreements and global climate policy measures

Ethics and the distribution of costs and benefits are important for climate treaties. It is widespread acceptance that a treaty that is considered unfair has low possibility to be accepted by many parties. The question of distribution and acceptability have also been discussed in projects mentioned above (Pareto optimal climate policies; Decision making in environmental-related dilemmas), but are also introduced in two new projects. One is about how unfair background conditions may possibly make unfair distribution acceptable even for the parties that are treated unfair. Thus, this challenges the result on the acceptability of unfair distributions mentioned above. The other project is a PhD project at Department of Economics, UiO, which discusses the problem of discounting the future, i.e., the distribution between the present and future generations.

The implications of uncertainty

Work on this area is directed towards finishing ongoing projects. One is a multidisciplinary project (psychology and economics) that studies the impact of ambiguity on decision making, which is relevant to understand climate policy. One uncertain impact of climate change may be irreversible catastrophes. To be able to make optimal policy choices under such risk, we need to improve the modelling of this, which we continue to work on. Finally, the last question studied is how the potential for learning about crucial parameter values in the climate system affects optimal climate policy.

Research output in 2016

The work on this work package will give several outputs for the users such as the international workshop series for “Implications of Paris” and a policy brief for the “Climate agreement colloquium”. In addition to this, it will lead to around 10 working papers to be

published in 2016 or early 2017, and we aim at publishing several on the ongoing projects in high ranked journals.

WP3: Innovation and Diffusion Policy

Transition to a low-carbon society will require radical environmentally-friendly technology innovations. Work package 3 contains theoretical and empirical studies on how to promote innovation in environmentally-friendly technologies on how to ensure that these technologies are widely used by firms and consumers. The methods used in this work package cover applied economic theory, large-scale simulation models and econometrics/statistics. In 2016 the research will be conducted by all four CREE research partners in close contacts with user partners, in particular Gassnova and the Ministry of Petroleum and Energy. We will also have cooperation with the Norwegian University of Life Sciences (NMBU) and Resources for the Future (RFF) in the US. This work package also includes parts of two PhD-theses and the work of one Post Doc.

Research activities in 2016

In 2016 the main research activities will draw on economic theory to study design of policies to promote energy-friendly innovations and diffusions. The planned activities, and the involved research institutions, are summarized in the Table below. All activities are ongoing. Most of the activities (measured in man-hours) are joint projects between at least two of the research partners. Whereas we had collaboration between the Norwegian research partners and the international research partner Tilburg Sustainability Centre in 2015, this may not be the case in 2016, but is planned for in 2017. Thus, the close collaboration between the research partners on this work package is an additionality of the center activity. Another additionality is the use of a numerical model that was developed in the old work package 5.

Table 3: WP3 - Planned projects for 2016 (numbers refer to project directory)

<i>Projects</i>	<i>Institution</i>
a) Innovation	
- 27. Environmental R&D instruments	Frisch/SSB/ØI
- 28. Innovation in clean energy as a commitment device	Tilburg
- 29. Effective climate policies with trade and international technology spillovers	Tilburg
- 30. Innovation policies, patenting and technological quality	SSB

<i>Projects</i>	<i>Institution</i>
b) Diffusion <ul style="list-style-type: none"> - 25. Strategic technology policy as supplement to renewable energy standards - 26. How should CCS technologies be supported? 	SSB/NMBU/RFF Frisch/SSB/NMBU
c) Other projects <ul style="list-style-type: none"> - 31. Policy instruments that can promote the development and use of environment-friendly technologies - 32. Investment policy for time-Inconsistent discounters - 33. Avoiding Arctic oil extraction 	SSB/Frisch ØI ØI

Innovation

This part of WP3 examines which policy measures are efficient in promoting innovation in energy-friendly technologies. Policy advices are derived both from theoretical studies and empirical work.

A key reason to support private R&D is that the innovator will in general not be able to appropriate the full social benefit of the innovation. We examine how three technology push policies - Patent systems, Innovation prizes and R&D subsidies - should be designed in order to overcome the appropriability problem both for environmental R&D and R&D directed at standard market goods. In 2015 we identified conditions under which an innovation prize for environmental R&D should be greater than an innovation prize aimed to lower cost of production for standard market goods, and how these conditions depend on i) heterogeneity among users of the technology, ii) the environmental policy instrument of the regulator, and iii) the sequence of moves. Early in 2016 a paper on innovation prizes will be submitted to a journal.

Present generation can make future generations reduce their GHG emissions by developing and installing environmentally friendly capital and technologies now. Through development of cheap solar power or insulation 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.

The idea of lowering future emissions through current green investments has been studied in a recursive Integrated Assessment Model. The numerical results suggest that policies stimulating cost-reducing innovations in clean energy technologies may not, however, induce deep emission reductions in the future. We plan to submit at least one paper to a journal in 2016 on this topic.

Innovations can be directed at achieving lower cost of producing standard market goods or lower cost of abatement. Because the share of resources allocated to R&D on abatement technologies may vary significantly between countries, a key question is whether a group of countries can implement global sustainable growth, or alternatively, whether global

sustainable growth can be reached only if all countries aim at this target. We have studied conditions under which unilateral policies can implement global sustainable growth. A calibration exercise suggests that the US or EU alone are too small to implement sustainable growth. A coalition of countries that ratified the Kyoto protocol can implement sustainable growth, yet required tax rates are very high. A paper has been submitted to a journal.

Also empirical work is undertaken in work package 3. Here we examine the effect of the Norwegian R&D tax credit program - SkatteFUNN - on firm innovation, measured by patenting. Skattefunn is generic in the sense that it offers the same R&D support for clean and dirty technologies. We also investigate the effects of R&D support targeted towards environmental technology development. The study provides knowledge on the effectiveness of the various Norwegian R&D support instruments, and it is part of a PhD thesis, joint with two senior researchers. A paper will be submitted to a journal in 2016.

Diffusion

This part of WP3 examines which policy measures are efficient in promoting diffusion of energy-friendly technologies. Policy advices are derived both from theoretical studies and empirical work.

One study compares renewable energy standards, which have been introduced in several countries as a supplement to climate policy, to subsidies either to users of renewable energy capital or to producers of renewable energy capital. We find that if 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. A paper has been submitted to a journal. In 2016 a book chapter will be published.

One example of an abatement technology is carbon capture and storage (CCS). For some years this technology has been seen by the IEA and the EU as having 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). We study optimal design of CCS subsidizes within a simple theory model of imperfect competition. We also 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 when factors that are not contained in the theory model are taken into account. Technical assumptions in the LIBEMOD CCS model block have been developed joint with Gassnova. In 2016 a paper will be submitted to a journal.

Other projects

In 2015 CREE researchers wrote a summary and assessment of the recent literature on policy measures to promote the development and use of environmental technology for the Green Tax

Commission. The survey was published as an Appendix to the White Paper. In 2016 we plan to make a popular article out of the survey, aimed at publication in *Samfunnsøkonomen*.

Transition to a low-carbon society requires investment in environmentally-friendly technologies. A key factor in determining the amount of investment is the discount rate. While standard analyses of economic policy assume exponential discounting, empirical and experimental evidence show that preferences are time-inconsistent and discounting is hyperbolic. We analyze the investment strategy as a function of the technology's type and position in the production chain. A key result is that investment in "green" technologies should be subsidized, whereas adaptation and "brown" technologies should be taxed. In 2016 a CREE working paper will be revised, and the updated version will be submitted to an international journal (in 2016 or 2017).

Oil activity in the arctic region entails many global risks. This project studies the strategies a country bordering the arctic can employ to avoid that other arctic countries explore and extract arctic resources. The project focuses on the role of technology spillovers by taking into account that arctic oil activity requires specific technology, which is largely undeveloped to date. In 2016 a working paper will be written. Later, this paper will be submitted to a journal.

Research output in 2016

As indicated above, three papers have been submitted to journals, and we expect around six more submissions in 2016 or early 2017. The latter papers will also be available in the CREE working paper series. Papers already submitted to journals will require revisions in 2016. We will continue to present papers at academic conferences as well as seminars designated for decision makers/CREE user groups.

WP4: Regulation and Market

In this work package, the main research 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 CO₂. The work is planned mainly as theoretical and empirical studies, but numerical models, either already existing or developed in other work packages, will be utilized also. As such, part of the work within this package will be conducted in cooperation with, or as part, of Working Packages 1 and 2.

Contributors to this work package come from all the three main (Norwegian) CREE partners, the Frisch Centre, Statistics Norway and, in particular, the Department of Economics, University of Oslo. In addition, there is close cooperation with CREE partners at the Scandinavian Institute of Maritime Law at the University of Oslo and Institute for Energy Technology (IFE), as well as colleagues at The Global Economic Dynamics and the

Biosphere programme (GEDB) at the Royal Swedish Academy of Sciences, IFO Munich, Norwegian University of Life Science, University of Gothenburg, University of Pennsylvania and the University of Reykjavik. Thus, we have contributions to the work package from several fields, even if economics is the main field. Also, user partners are involved in the project as sponsors and by designing research topics.

Research activities in 2016

Work in 2016 will to a large extent consist of continuation and finishing of on-going projects, but will also involve the starting up of new projects; in particular, in 2016 work on our new, large project on supply security will be in full swing. All of the projects are of direct policy relevance and are either based on ideas and earlier work with user partners or will be undertaken in cooperation with them. The table below summarizes current projects under three main headings: energy markets, natural resource governance and other projects.

Table 4: WP4 - Planned projects for 2016 (numbers refer to project directory)

<i>Projects</i>	<i>Institution</i>
a) Energy Markets	
- 34. Green Certificates and Competition in Electricity Markets	ØI/Agora Energiewende
- 35. Effects of reduced nuclear capacity in Europe	Frisch/SSB/NMBU
- 39. Integration of, and competition between, electricity market places	ØI
- 40. Flexibility in electricity markets	ØI
- 41. Nodal pricing	ØI/Frisch
- 42. Security of supply in a green power market	Frisch/IFE/SSB/ØI/UiOLaw
b) Natural Resource Governance	
- 36. Natural resources and sovereign expropriation	ØI/Reykjavik/IFO Munich/Penn
- 37. Should foresters forecast?	ØI/GEDB/R.Swedish Ac.Sc.
- 38. The Hveding Conjecture: optimal operation of hydro	ØI/Frisch
c) Other	
- 24. Systems for refunding emission payments (III.13)	SSB/UiO/Gothenburg
- 18. Effects of the EU ETS (I.18)	SSB/NMBU

Energy markets

The European electricity market is evolving rapidly, due both to regulatory reform and technological change. During 2015, we finalized a first draft of a paper (based on work previously undertaken for the Norwegian regulator, NVE), discussing the integration of the market in light of the relevant literature, which subsequently formed the basis for a more general analysis of on-going events in the European electricity market, resulting in another paper. In 2016, the second paper will be finalized for publication. We will also consider

whether, and if so, how, to take the original analysis further, depending on its relevance in light of recent development in the market.

Closely related to - and in fact resulting from the above project - is our work on the flexibility of electricity wholesale markets. During 2015, we worked on analyzing the so-called Market Time Unit, a work that has been challenging, due to the need to develop a suitable theoretical framework. The work so far is documented in an unpublished manuscript, and in 2016 we will continue working on the theoretical model with the aim of producing a first complete draft of a paper. We also plan to extend the work in various directions, by considering other significant design elements that affect market flexibility.

Another important regulatory issue is the design of network tariffs and in particular the potential refinement of the European model of price zones. In 2016, we continue work on nodal pricing with the aim of producing a working paper on a theoretical framework for studying this issue.

The future of nuclear capacity is crucial to the development of the European energy market. Our work on this issue - specifically, the simulation of the effects of a phase out of nuclear power - will proceed with a recalibration of the supply of bio energy and rerun of all scenarios. An earlier draft paper will be split into two papers, one concentrating on a nuclear phase out and the other analyzing the European energy markets in 2030.

One of the most important challenges of the electricity supply industry is ensuring security of supply in a green power market, so as to handle the challenges and opportunities of intermittent power. Towards the end of 2015, we started up a new, large project on this issue, sponsored by the Norwegian Research Council, and work on this project will be one of the major efforts of the work package in 2016. A first workshop with participation from the international advisory board for the project will be held in April/May 2016, while a first report on storage technologies will be produced during the year.

Natural Resource Governance

An important question for governments of countries endowed with large natural energy resources is how to govern these resources, including choice of ownership structure and rights to exploitation. We will continue our work on this issue along a number of different lines.

The project on sovereign expropriation is in its final phase, where we continue revisions of a working paper with the aim of journal publication; we hope to have the paper accepted during 2016. The project will also be extended in various directions, including studies of underlying issues concerning political economy.

The project "Finders Keepers?" has, during 2015, resulted in a working paper setting out a theoretical model and results. In order to help test the empirical predictions, Arthur van Benthem (University of Pennsylvania) has joined the project. We have worked hard on getting hold of relevant data and have now reached an agreement with Rystad Energy about the exploitation of their data. Hence, during 2016 we are looking to perform the empirical tests and finalize and submit the paper to a scientific journal. We also aim to present the paper

at several conferences and seminars in Europe and the US to get feedback and promote the work. A number of extensions can be made from this work and our hope and belief is that many outside the core project team will find it interesting to do so. Rystad Energy, which is generously sharing their data, have shown significant interest in the project as it is considered of high relevance both for policy makers and the industry; they have asked us to present it internally for their consultants and at an industry conference.

The project Nationalization of natural resources has not progressed significantly during 2015, as an analytical problem has been encountered, but we will continue the work with the aim of overcoming the problem.

The unpredictability of climate change makes it hard to calculate the profitability of forestry, a problem we study by applying Monte Carlo simulations to establish an upper bound on potential losses. In 2016, we will revise the working paper "Should foresters forecast?" with the aim of journal publication.

Our work on resource governance includes a study of how the ideas on optimal hydro management has evolved over time, including the extent to which earlier ideas still have relevance today. A working paper on the so-called Hveding Conjecture will be revised for publication during 2016.

Other projects

The project on refunding emissions payments considers two of the most relevant mechanisms, namely output-based and expenditure-based refunding. We investigate the theoretical properties of these mechanisms and compare them with respect to their efficiency and distributional characteristics. The aim is to have a paper published in an international journal by the end of 2016.

The project Effects of the EU ETS on plants' emissions, emissions intensities and economic performance also falls under Work Packages 2 and 5; we refer to this package for a description of plans.

Research output in 2016

We plan to finalize 5 articles for publication in international journals, and to prepare 6 drafts of papers aimed for international publication. We will also organize a workshop on supply security. In addition, we will develop some of the on-going projects in new directions, exploring new research ideas and their potential.

WP5: Evaluation of Environmental and Energy Policy Measures

Work Package 5 contains empirical studies evaluating the impact of environmental and energy policy measures. In 2016, the work on WP5 will be conducted by all research partners in CREE with the exception of the Department of Economics, UiO. In addition, we have a

close collaboration with social anthropologists from Centre for Development and the Environment (SUM), which is one of our sub-contractors. During 2015, we also established a close collaboration with three new outside institutions; the Institute of transport economics (TØI), KULeuven in Belgium and SINTEF Building and Infrastructure (SINTEF Byggforsk). In 2016, we will work closely with researchers at these institutions on common projects, some financed directly by CREE funds and some by the RCN on other programs. We also work very closely with user partners on several of the projects within this work package (see more details below).

The different research communities will apply a variety of methods to analyze the research questions and also co-produce multi-disciplinary work based on syntheses of results. In addition to economists at CREE-research partners and KULeuven, social anthropologists from SUM and architects from SINTEF apply social practice theory to describe how policy measures affect habits and the interrelation between household members, and through this affect household energy consumption.

This work package includes the works on three PhD-theses (Dalen, Klemetsen and Ciccone). Ciccone finished and defended her thesis in November 2015, Klemetsen will submit her thesis at the end of December 2015, whereas Dalen is in the final stages on hers, but will be on maternity leave most of 2016.

Research activities in 2016

In 2016, the main research activities in WP5 will focus around policies to change household stationary and mobile energy consumption, as well as firm behavior and a literature study of the effects of energy efficiency measures. Some of these activities are new, starting up in 2016, whereas others are ongoing and in the final stages of publication. The planned activities on WP5, and the involved research institutions, are summarized in Table 5.

Table 5: WP5 - Planned projects for 2016 (numbers refer to project directory)

<i>Projects</i>	<i>Institution</i>
a) Household stationary energy consumption	
- 43. Rebound and adverse effects of energy efficiency measures	SSB/SUM
- 44. The households' response to soft policy measures	SUM
- 48. Consumption of energy efficient household products	SSB
- 49. Household energy practices in low energy buildings	SUM/SINTEF Byggforsk

<i>Projects</i>	<i>Institution</i>
b) Mobile energy consumption <ul style="list-style-type: none"> - 45. Environmentally friendly transportation - 50. Electrification of transport: Challenges, mechanisms and solutions 	Tilburg SSB/Frisch/TØI/ KULeuven
c) Other projects <ul style="list-style-type: none"> - 46. Which policy instrument induces the best environmental performance in firms? - 47. Evaluation of energy efficiency measures 	SSB SSB

Household stationary energy consumption

In 2015, analyses of the effects of energy efficiency and soft policy measures on household energy consumption have continued, both at Statistics Norway and at SUM. Most of these studies were finished and submitted for publication during 2015. The activities in 2016 will thus mainly be focused on responding to referee comments and final preparation for international publication. At this stage, we have three articles that is submitted for publication on these two projects; one econometric analysis on the effects of heat pump ownership on household energy consumption, one multidisciplinary economic and anthropological analysis on the effects of heat pump ownership on household energy use and one anthropological study on the effects of in-home displays on household energy practices (see project directory for more information).

Although on maternity leave, the work on Dalen's PhD-thesis will commence during 2016. This will include work on a micro simulation model to explain how different aspects such as norms, attitudes, polices and socio-demographic variables, affect households in their choice of adopting environmentally friendly items related to energy saving. Work to finalize other parts on Dalen's thesis, discussing various aspects of policy tool use to regulate energy consumption, will also be conducted in 2016.

Finally, SUM has started a new collaboration with architects from SINTEF Byggforsk, to analyze household energy practices in low energy buildings. This work started in 2015, where researchers from SINTEF and SUM collaborated on several in-depth interviews of households living in a passive house communion building in Oslo. In 2016, work on analyzing these data and writing a common multidisciplinary paper is planned. This work is financed by CREE funds. The collaboration will function as a pilot project, to gain useful insight before starting a larger project on this subject, involving a multidisciplinary team of researchers from SINTEF, SUM and SSB.

Household mobile energy consumption

In 2016, the analyses of efforts making transportation more environmentally friendly are focused around two main projects. The first is situated at Tilburg, and focuses on analyzing the effect of fiscal policies on average CO₂ emissions of new cars, using an economic model on a large database of vehicle-specific taxes in 15 EU countries. A paper on this topic is submitted for international publication, and the work in 2016 will be responding to referee

comments and finalizing the paper for publication. In addition, a new paper on how car manufacturers respond to these regulations have started, and the plan in to finish a first version of this paper during 2016.

Our second project analyzing the road to a more environmentally friendly transport sector is a new Knowledge building Projects for Industry (KPN) project sponsored by RCN (ENERGIX). This project touches on topics relevant to both WP1 and WP4. With respect to WP5, the analyses assessing different policy packages and explore the effects on the electricity market and the transportation sector of the electrification of the transport sector is of particular relevance. This project involves several research partners, and will work in close collaboration with the user partners involved in the project. The project will start up in 2016, and no publications are expected this year.

Other projects

Finally, we have two projects which are almost finalized, where only minor work preparing for publication remains. The first is a paper discussing which policy instrument induces the best environmental performance in firms. This paper is a part of Klemmetsen's PhD-thesis, and is submitted for international publication. The other project is a report written for the Oil and energy department (OED), surveying the literature on evaluation of energy efficiency measures. The report will be published after the publication of the new White paper on Energy, planned to be released in the spring of 2016.

Research output in 2016

We plan to finalize five to six articles for publication in international journals, and to have two to three first draft on papers aimed for international publication. To increase the availability of the research at an early stage, all papers aimed for publication in international journals are published in CREE's working paper series. We will also publish a Report in Statistics Norway's Report series. Additionally, the second PhD-thesis associated to this WP will also be submitted at the end of 2015.