CREE WORKPLAN 2015

CREE's activities are divided into five work packages as described in the project plan. The leaders of the work packages are listed in parentheses:

WP1: The International Politics of Climate and Energy (Michael Hoel/Mads Greaker)

WP2: Innovation and Diffusion Policy (Rolf Golombek)

WP3: Regulation and Market (Nils-Henrik von der Fehr)

WP4: Evaluation of Environmental and Energy Policy Measures (Bente Halvorsen)

WP5: The Next Generation of Numerical Models (Brita Bye)

The research will take place by the four research partners - Frisch Centre (Frisch), Department of Economics, University of Oslo (ØI), Research department, Statistics Norway (SSB) and Tilburg Sustainability Center (Tilburg) - 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 (Law). In addition to this, several international researchers connected to the center will also contribute.

Below the planned 2015 activities are described in detail. These activities are funded by CREE or have funding from one the four research partners. Activities related to applications to be determined in 2015 are not included.

In the workplan for 2014, we started to number the projects. We continue this numbering in the present workplan.

Below, we do not report projects that finished before 2014 and published in 2014, or still undergo revisions for resubmissions to journals, unless they were reported in the workplan for 2014.

WP 1: The International Politics of Climate and Energy

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".

We are also concerned about how climate policies both directly and indirectly through for instance technical change affect global energy markets.

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

The plans for new projects are unclear as a result of funding uncertainty.

Ongoing projects

I.1 Pareto-improving climate policies

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 fewer investments so that the present generation does not have to reduce consumption.

This is a numerical project where we do simulations with the RICE model. The project started in 2013, but most of the work has been done in 2014. A first draft is written and is presented at several workshops and seminars. This will be finalized, published as a CREE Working Paper and submitted to a journal in 2015.

We have applied KLIMAFORSK, for a continuation of this project. To be more precise we want to study questions such as:

- The welfare gains of a better climate can be distributed in several ways. How would the different alternatives affect the distribution between the present and the future generations as well as between poor and rich regions of the word?
- What kind of transfers would be best between regions to ensure acceptable welfare distributions; technology transfers or transfers of goods?
- How would uncertainty about future outcomes affect the conclusions above?
- We will mainly do this by using global integrated assessment models.

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 that are traded internationally 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. In 2014, the model was refined and a draft of a working paper was produced. In 2015, the working paper will be finalized. This is a joint project between the Frisch Centre and the University of California at Berkeley.

I.3 Climate treaties with reciprocal preferences

This project explores possible impacts of reciprocal preferences on participation in international environmental agreements. Reciprocal countries condition their willingness to abate on others' abatement. No participation is always stable. A full or majority coalition can be stable, provided that reciprocity is sufficiently strong and widespread. In addition, a stable minority coalition can exist, even with weak reciprocity preferences. This latter coalition is weakly larger than the maximum stable coalition with standard preferences, but is characterized by mutually negative sentiments.

In 2014, a discussion paper has been published:

Nyborg, K.: Reciprocal Climate Negotiators: Balancing Anger against Even More Anger, Memorandum, 17/2014, Department of Economics, University of Oslo.

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.

In 2014, a paper has been accepted for publication:

Harstad, B. and M. Battaglini: Participation and duration of environmental agreements, forthcoming in Journal of Political Economy.

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.

In 2014 the project finalized a discussion paper:

Böhringer, C., B. Bye, T. Fæhn and K. E. Rosendahl: Output-based rebating of carbon taxes in the neighbor's backyard - Competitiveness, leakage and welfare, CREE WP 06/2014.

In 2014 the carbon leakage project will analyze other kinds of policies like endogenous carbon tariff rates. Financing will mainly come from the WILL project financed by the RCN through its Klimaforsk program.

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.

A lesson often drawn in the experimental economics literature is that social preferences like inequity aversion are not triggered in market settings. Our experiment tests whether people willingly "leave money on the table" rather than trade at inequality increasing terms. The results indicate that, in a simple two-person trade game with fixed prices, a significant amount of trade is withheld when it creates strong inequality, in spite of trade being Pareto-improving in monetary outcomes. This behavior is consistent over 10 rounds of experience for the favoured and disfavoured player compared with the neutral treatment when no inequality is created by trading resources. We conclude that fairness concerns may affect outcomes in a

fixed price trade set- ting, even when there are no strategic or retaliation motives present for restricting trade.

This project is part of Alice Ciccones PhD project and will be finalized in 2015.

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.

A paper by Kjell Arne Brekke, Ragnhild Bråten and Ole Røgeberg is now to consideration in a journal.

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

Bargaining is central to many economic applications and certainly a key to an international climate agreement. To better understand bargaining, Alice Ciccone and Kjell Arne Brekke at UiO/CREE together with Leif Helland and Tom-Reiel Heggedal at BI have conducted a series of experiment. The experiments are designed to test the effect of earning either an outside option or earning a share of the pie, prior to alternating offer bargaining. We have solved for the subgame perfect equilibrium with loss-aversion preferences and the model prediction is that earning an outside option should not matter, unless the option is binding, while subjects who earned a larger share of the pie should also end up with a larger share. This latter prediction is contrary to most other models of bargaining, but supported by the experimental results. We are in the process of collecting more data and testing our model rigorously

This is part of Alice Ciccones PhD project and will be finalized in 2015.

I.9 Natural resources and the climate

We will write a chapter on climatic change in a Norwegian book on natural resource economics; the book is aimed for undergraduate students. In our contribution, we first go through the history of research and policy on climatic change, and then explain institutional factors. Then we go through the facts we have about climate change today and what we expect will happen in the future. In the analysis we first introduce a dynamic model that shows how we can determine the optimal emission reductions. We then turn to a simpler model and show how to implement the optimal emission reductions by means of direct regulation and economic instruments such as tradable permits and taxes. Game theory is then used to explain why it is difficult to reach a binding and comprehensive climate agreement.

The chapter concludes with what a small country like Norway can do, as well as some thoughts about the future.

This project finished in 2014 and is now published as:

Kverndokk, S. and C. Hagem (2014):«Klimaendringer» (Climate change), chapter 8 in O. Flåten and A. Skonhoft (eds.): Naturressursenes økonomi (Natural resource economics), Gyldendal.

I.10 Climate negotiations and investments in green technology

This is the final paper in Alice Cicconnes PhD project. She will study the effects of country's investments in green technology for the outcome of the subsequent international negotiation over emission reduction, through an experimental approach. Then she will test the implications of ex-ante cooperation rate in a public good game on an ex-post bargaining stage. Ciccone will submit her PhD project in 2015.

I.11 Supply side versus demand side policies

This project studies in an integrated framework supply-side versus demand-side policies taking into account both spatial and inter-temporal carbon leakages (the green paradox).

The starting point of this analysis is unilateral long-term climate policy in the presence of free- riders. Both demand side and supply-side unilateral policies may lead to both spatial and inter-temporal leakages. We derive the optimal combination of the two types of policies, and illustrate the outcome by a numerical model for the global energy markets.

We are currently working on this and a paper suitable for submission to a journal should be available in 2015. This project is funded under the Klimaforsk program by the RCN.

I.12 The future oil market and the impacts from innovation

In this project we will investigate the main global trends determining future oil prices, and likely market outcomes for several decades into the future. We will use Statistics Norway´s new PETRO 2 model which focuses on predicting long run, future oil prices in a consistent way by modelling oil supply in a state-of-the art manner. While most existing studies consider a static, competitive oil market, PETRO 2 reflects market power in OPEC. Moreover, it is dynamic and models oil as a non-renewable resource and oil producers as inter-temporally optimizing.

One paper that we started working on in 2014, was the impact of Fuel efficiency and the oil market. We study how fuel efficiency (i.e., vehicles becoming more fuel efficient) affects distributional effects among oil producers, and feedback mechanisms such as carbon leakage and the rebound effect. A first draft is expected to be finished in winter 2015. This paper is

partly financed by Petrosam, and is a joint project between Frisch Centre and Statistics Norway.

The shale gas revolution in the US has led to lower gas prices and increased demand for compressed gas in the transport sector. Such a transition may take place in other regions with large shale gas reserves and put a downward pressure on oil prices. The model is also suitable for analyzing the effect of technical change. One possible future scenario is widespread conversion to electric cars in the transport sector. Another, maybe more probable, scenario is one of large increases in energy efficiency and a switch towards gas-fuelled utility vehicles in the transport sector. Finally, we will look at the effects of more widespread use of climate policies, e.g. CO_2-taxes, implying both new technologies and down-scaling of emission-intensive demand. The project has funding from the RCN under the Petrosam program.

I.13 Sectoral approaches

Assuming that enthusiastic countries accept a general ceiling on their emissions, reluctant countries might be persuaded to participate in a climate treaty covering only a particular emission-intensive sector, such as steel or cement production. Sectoral treaties have also been proposed within the UNFCCC to broaden the scope and accuracy of emissions reductions via the clean development mechanism (CDM), and sectorial treaties constitute a possible outcome of the current negotiations on the so-called New Market Mechanism. Sectorial treaties could include fixed sector-wide targets for developing countries, where emissions below the targets generate credits accepted by emissions trading schemes in developed countries. This proposal is akin to a global permit trading regime between developed and developing countries, where the system's total cap is the sum of developing countries' sectorial targets and developed countries' overall targets. We have already started on a paper on sectorial treaties, and this could be finished by the second half of 2015. We have further applied for funding to continue this from the Klimaforsk program.

I.14 The role of decency in emission permits trade

Permit trading is a preferred environmental policy instrument among economists, and is a popular tool in environmental treaties, e.g. the Kyoto Protocol. In theory and practice such market-based policy instruments have been shown to foster cost effectiveness. Still, NGOs, political parties and individuals have expressed concerns. Some even view permit trading as morally wrong in principle: a way of avoiding one's obligations or paying indulgence. By means of a laboratory experiment, this project will test one possible reason behind such skepticism, namely the following hypothesis: Permit trade is less acceptable when the distribution of initial permits is perceived as unfair. In 2015 an economic lab experiment testing this will be designed and conducted. This project is part of the larger project "The Climate Economics of Decency" led by Karine Nyborg at the Departement of Economics, University of Oslo. This project has applied for funding through Klimaforsk. However, we have also got some internal funding from the Frisch Centre to start on this project in 2015.

New projects (not numbered yet – will be deleted if we do not get funding)

Technological development and financial transfers

Enthusiastic countries may engage reluctant countries by providing subsidized clean technology and direct financial transfers (climate finance). Under the 2009 Copenhagen Accord, developed countries promised to provide additional climate finance of up to $100 billion a year from 2020 to help developing countries reduce their emissions and adapt to the consequences of climate change. Both strategic and moral reasons exist for providing climate finance to poor countries. The literature has so far not examined the technology-transfer mechanism in any detail. Thus, more thorough analysis of this mechanism is needed. The design issues concern both (1) the type of technology funded and (2) the kind of economic instruments used to support diffusion of the chosen technologies. We will in particular look at to what extent sector treaties can function as a vehicle for technology transfer. This project will not be started unless we receive external funding from Klimaforsk.

Climate cooperation based on non-cooperative GHG reduction strategies

There exists a large game-theoretic literature on participation in climate coalitions. In this literature a coalition is interpreted as a binding climate treaty, and it is assumed that coalition members maximize their combined utility. On the other hand, the current UNFCCC process does not look like a coalition formation game as countries are to individually set their GHG emission reduction targets. We therefore propose to build further on the literature on non-cooperative GHG reduction strategies. There is already a rich literature studying the choice of environmental policies as a dynamic game between countries when countries share a common pool resource. We suggest that a possible way to look at the current UNFCCC negotiations is as a learning process in which big countries and/or regional units such as the EU over time coordinates on a non-cooperative equilibrium in emission reduction strategies. Such strategies need of course not be legally binding. However, the question is whether a non-cooperative equilibrium in abatement strategies can achieve significant global emission reductions. The dynamic game literature mostly uses the concept of Markov perfect equilibrium (feed-back Nash equilibrium). Although, this equilibrium concept is empirically relevant, the learning interpretation of the negotiation process suggests that one should look more into other equilibrium concepts, for instance, evolutionary game theory. This project will not be started unless we receive external funding from Klimaforsk.

Optimal global climate policies when faced with risk of irreversible catastrophes

This project addresses some weaknesses in how risk of irreversible catastrophes is modelled in economics. The two most common approaches imply either that one may at any point in time eliminate all risk or that risk is persistent so that for a given level of atmospheric carbon, the probability of a disaster will be constant forever. We suggest to model climate induced risk as a process with inertia. This implies that risk is a slow variable that responds over time. This represents an intermediate case to the two approaches used in the literature. This project is dependent on external funding from Klimaforsk.

Table 1: Planned work months, WP1 (MÅ OPPDATERS)

Activity	Primary institution	Planned work Months	Cree funded work months
I.1 Pareto-improving climate policies	Frisch Centre		
I.2 Border tax adjustment	Frisch Centre		
I.3 Climate treaties with reciprocal preferences	Dep. of economics		
I.4 Participation and duration of climate treaties	Frisch Centre		
I.5 Reducing climate leakage	Statistics Norway		
I.6 Inequality aversion and trade	Dep. of economics		
I.7 Is it wrong to buy a right to do a wrong?	Dep. of economics		
I.8 Earned pies and outside options	Dep. of economics		
I.9 Natural resources and the climate	Frisch Centre		

WP2: INNOVATION AND DIFFUSION POLICY

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.

Ongoing activities in 2014

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 rational 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.

This paper will be published in 2015 in a book on climate and technology policy, funded by the World Bank. A working paper will be published parallel with the book chapter.

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 working paper has been published:

Fischer, C., M. Greaker and K. E. Rosendahl: Robust Policies against Emission Leakage: The Case for Upstream Subsidies, CESifo Working Paper No. 4742.

This paper has also been submitted to an international journal in 2014.

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.

In 2014 a robustness analysis of the numerical part of the paper was undertaken. Here we focus on the importance of i) number of suppliers within the EU and outside the EU, ii) the importance of whether CCS suppliers offer two technologies – CCS coal and CCS gas – or only one type of CCS technology, and iii) the range of variation in upstream and downstream subsidies. A draft paper has been written, and it will be submitted to an international journal in 2015.

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. In addition, we have applied ENERGIX for means to extend the study. The project was started in 2013 but on a very low activity level. In 2015 a draft paper will be written that covers topics described above.

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 also technology subsidies should be offered, how should the path of subsidies be designed? A paper that examines these questions within a theoretical model where abatement requires use of environmentally friendly technologies and R&D makes these technologies more productive were published in JEEM in 2014.

Gerlagh, R., S. Kverndokk and K. E. Rosendahl (2014): «The Optimal Time Path of Clean Energy R&D Policy When Patents Have Finite Lifetime», Journal of Environmental Economics and Management, 67(1): 2-19.

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, researchers at the Tilburg Sustainability Centre (TSC) 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 the government is naïve as is mistakenly assumes that it can control future governments. In a refinement, a recursive Integrated Assessment Model is specified. This model 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 2014, the main task has been to calibrate and test the model.

In 2015 the model will be extended in collaboration with Mads Greaker from Statistics Norway to include innovations. The expected result is an assessment of the usefulness of policies that stimulate cost-reducing innovations in clean energy technologies as a mechanism that induces deep emission reductions in the future. This model will also be used in an EU project (Entracte) where both TSC and CREE participate.

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

Market-based regulations such as taxes or tradable quotas are recommended to encourage innovation in environmental technologies rather than non-market-based instruments, such as technology standards and non-tradable emission quotas. 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 whether these 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 revise-and-resubmit of an earlier version of this paper has been submitted to an international journal.

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 was published as a chapter in a book in 2014.

As indicated in the 2013 CREE work plan, the level of activity will depend on whether this subproject obtains external funding. So far no funding has been available. Potential future activity will be related to research questions like: i) How do the equilibrium amount of emissions depend on the distribution of willingness to pay across countries? ii) What is the effect of introducing a subsidy to users of the new technology?, and iii) Under what circumstances will an agreement of this type outperform an agreement focusing only on emission reductions?

II.9 Obstacles to dissipation of environmentally friendly technology

In 2014 the literature survey, within the fields of behavioral and experimental economics, on energy efficiency investment was published in Samfunnsøkonomen.

The starting point of the review is the so-called energy paradox: several studies claim that it is possible to save between 10 and 25% of our total energy consumption through profitable investment. This claim is discussed within the framework of behavioral economics.

Hauge, K. E. (2014): Når Viljar, Egil og Rasmus skal investere i energibesparende teknologi. Samfunnsøkonomen, Nr 1 2014.

II.10 Knowledge spillovers from clean and dirty technologies

We investigate whether different R&D support instruments, such as R&D tax credit and R&D loans, lead to patented technologies of a higher quality. This knowledge is an important evaluation criterion of the success of different types of R&D support. We will also investigate whether the effect of R&D instruments differs for environmental technologies as polluting firms are often subjected to more regulation than non-polluting firms. Moreover, environmental technologies are often less mature than generic technologies.

The quality of the technology is measured as the number of patent citations in the first three years after the patent is granted. Despite some drawbacks, forward patent citations are a common proxy for patent impact or quality. We use a Norwegian firm level panel data set

with patents and patent citations where the firm is identified through organizational numbers. This allows us to merge with other firm level data, and thereby add several important control variables. This strategy should reduce omitted variables bias, which is typically present in studies using patent data. The data on Norwegian patent citations is new, and we include patent citations data from PATSTAT in order to include foreign citations of Norwegian patents.

A draft paper will be written in 2015.

II.11 Should environmental R&D be prioritized?

There are at least two reasons to support private R&D: First, the R&D process generates knowledge spillovers from which all future innovators will benefit. Second, even if the innovator succeeds to patent her new idea, she will not be able to appropriate the full social benefit of her innovation. This project focuses on the appropriability problem for supporting R&D.

The point of departure is two innovations of equal social value; one lowers the cost of producing an ordinary market good that has no particular impact on the environment, whereas the other reduces the cost of pollution abatement. In the market good case, demand for a patented technology is given from the underlying preferences of consumers or the technology of firms. Governments seldom interfere with demand for a standard market good even if society could benefit from such an intervention. In contrast, in the environmental technology case the government is bounded to interfere with demand for the new technology through its environmental policy. No research has so far investigated whether this asymmetry implies that environmental R&D should be prioritized in public R&D budgets.

In order to analyze this question we apply a game theoretic model. In the first stage of the game an innovator invests in R&D under uncertainty. If the innovator succeeds, she obtains a patent and can market her idea as a technology improvement. If the new idea is a new production process for some market good, the government does not intervene and the innovator simply maximizes profit. To the extent that the realized increase in social surplus exceeds the value of the patent, there will be too little R&D and hence R&D should ideally be subsidized.

On the other hand, if the innovation is a new pollution abatement technology the government will want to change its environmental policy since the cost of reducing emissions has become smaller. Thus, the government affects demand for the innovation, and our research question is whether this intervention makes the discrepancy between the social value of the innovation and the private value of the patent larger than in the market goods case. A larger discrepancy implies that environmental R&D should receive a higher subsidy.

II.12 Transitions to clean technologies

Jointly funded by the EU Entracte project and CREE, researchers at the TSC have set up a series of lab experiments to study the effect of various instruments on the transition from a benchmark to a clean technology. The lab experiments have been carried out in 2014. An early assessment of outcomes suggest that both communication and the availability of commitment mechanisms support the transition, while a first-mover leadership is less effective as support. Framing the transition as 'green' increases overall support but makes subjects also less responsive to feedback from other group members.

In 2015, TSC will analyze the experiment outcomes and produce a working paper to be submitted to a journal. The research question is whether communication, commitment devices, leadership, and framing can support a transition to a clean energy system. The underlying structure of the problem is that the transition is costly, and the payoff for support by individual members is risky.

II.13 Effective climate policies with trade and international technology spillovers

TSC has studied the consequences of international innovation spillovers between open economies when countries have heterogeneous environmental preferences. A key result is that the size of a coalition (both in terms of its number of researchers as well in terms of its market for demand) determines whether it is optimal to stimulate foreign clean production and innovation, or to follow a protective policy for domestic clean production and innovation. In 2014 a paper was submitted to a journal.

CREE WP 15/2014?

Table 2: Planned work months, WP2 2014 tall

Activity	Primary institution	Planned work months	Cree funded work months
II.1 Strategic technology policy	Statistics Norway	0.5	0
	Statistics Norway	0.5	0
II.2 Carbon leakage: Pay or not pay the polluter?	Frisch Centre	1.5	0.5
II.3 How should CCS technologies be supported?	Frisch Centre	3.0	1.0
II.4 Environmental R&D instruments	Tilburg	5.0	2.5
II.6 Innovation in clean energy as a commitment device	Statistics Norway	1.0	0.5

II.7 Can non-market regulations spur innovations?	Frisch Centre	2.0	0.6
II.8 Technology agreements	Frisch Centre	2.5	2.5
II.9 Obstacles to dissipation of env. friendly technology	Statistics Norway	6.5	1.5
II.10 Knowledge spillovers from clean and dirty technologies	Department of Economics	X	X
II.11 Should environmental R&D be prioritized?	Tilburg	X X	X X
II.12 Transitions to clean technologies	Tilburg		
II.13 Effective climate policy	Tilburg		

WP3: Regulation and Market

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 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 4 and 5.

Work in 2015 will consist partly of continuation and finishing of on-going projects and partly of starting up of new projects. Some of these projects are of direct policy relevance and are either based on ideas and earlier work with user partners or will be undertaken in relation with these. Below we describe plans for core projects.

Note that the projects III.1 (Information and transparency in electricity markets) and III.2 (Interaction between Electricity and Quota Markets) have been finalized.

On-going projects

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 - a "blue 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.

Work on this project is documented in CREE Working Papers no 6/2012 and 14/2012. These papers will be prepared for journal publication. In addition, the book Hydropower Economics is being revised, where, in addition to extensions and improvements of existing chapters, two new chapters will be included, based on the above-mentioned working papers.

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.

Work on this project was documented in 2013 in Nils-Henrik M. von der Fehr and Stephanie Ropenus, Green Certificates, Vertical Relations and Market Power. The paper is currently being revised for publication in a scientific journal.

III.5 Effects of Reduced Nuclear Capacity in Europe

Following the Fukushima accident in 2011, some EU member states decided to phase out nuclear power. We explore the impact of an EU-wide nuclear phase out provided the proposal of the EU Commission to reduce GHG emissions by 40 percent in 2030 relative to 1990 is implemented. Using a numerical simulation model of the European energy industry (LIBEMOD), we find that a complete nuclear phase out in Europe by 2030 has a moderate impact on total production of electricity and only a tiny impact on total consumption of energy. Lower nuclear production is to a large extent replaced by more renewable electricity production, in particular wind power and bio power. More generally, the equilibrium composition of electricity technologies reflects the stringency of the climate target, which climate instruments that are imposed and whether some technologies are being promoted, either directly through subsidies or indirectly through a tailor-made policy goal.

A draft paper suitable for submission to a journal has been written.

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 2014, 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. As planned, we have during 2014 developed a suitable model and finalized a first draft of a paper (Fridrik Baldursson and Nils-Henrik von der Fehr, Natural Resources and Sovereign Expropriation). In 2015, the paper will be further developed, with the aim of publication in a scientific journal. The project will also be extended in various directions, including studies of underlying issues concerning political economy.

Another part of this subproject is undertaken by Daniel Spiro who is a Post Doc at UiO funded by CREE. He studies how resource owners will behave with a risk of losing their resource due to nationalization, how this in turn affects the incentives for governments to nationalize such resources and how world prices for resources may be affected by such

interaction. The central result in this work is that nationalization in one country will be closely linked to nationalization in other countries. The analysis shows that if one country nationalizes its resource then resource prices will rise making it worthwhile for others to nationalize too, thus raising the price further. This way the model predicts waves of nationalization in correlation with price surges. The novelty of this paper is that it would be one of the first to analyze the interaction between political processes and world prices. While the main mechanism is in place, the remaining work relate to analyzing alternative equilibria and some extensions of the model.

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 boundedly rational agents may behave as if being fully rational has traction in forestry.

This has been published as a CREE WP:

Gars, J. and D. Spiro: Should Foresters Forecast?, CREE WP 11/2014.

III.8 The Hveding Conjecture: Optimal Operation of Hydro Power

The thinking about how to operate hydro generation facilities in an integrated system has developed considerably over time, with ideas from economics gradually becoming more influential. In this project this history will be revisited, with particular emphasis on the relevance and success of the so-called Hveding Conjecture.

This has resulted in a CREE WP in 2014:

Førsund, F. R.: Hveding's Conjecture: On the Aggregation of a Hydroelectric Multiplant – Multireservoir System, CREE WP 17/2014.

III.9 Integration of, and Competition between, Electricity Market Places

A new phase in the integration of the European electricity industry has been initiated with the coupling of physical trade on different regional market places. Some developments have already taken place, mostly based on bilateral agreements between regional players, but a

more comprehensive approach is currently being taken by regulators in North-Western Europe, with the aim of subsequently extending the process to the rest of Europe. The coupling of trade not only raises question about how to harmonize market places and efficiently utilize physical interconnectors, but also how to handle competition between different market places. Such competition is already present in the UK, as well as in certain regions of Germany, but further integration may increase the extent of rivalry between market places. In this project, we study challenges raised by market coupling.

III.10 Flexibility in Electricity Markets

Consumption and demand of electricity must be balanced at all times. Achieving this balance requires a high degree of flexibility, either on the supply side, on the demand side or both. Achieving the warranted flexibility has become more challenging with the increased share of intermittent and distributed generation. A fundamental question is whether this requires new ways of organizing and governing the electricity market, including the availability of contracts and market places to allow market participants, as well as system operators and other decision makers, to operate efficiently. In this project we aim to study such questions.

A preliminary analysis (Nils-Henrik von der Fehr: Market Time Unit) was developed in 2014 and presented at various conferences. In 2015, the work will be developed.

III.11 Conflicts and price contagion on resource and energy markets

Whether the world market will make the transition to renewable energy sources and clean technologies by itself, largely depends on long-run prices of fossil energy and mineral inputs such as silicon and lithium which are needed in the new technologies. Likewise, to be able to analyze the efficiency of various policy measures curbing climate change or directed at renewable technology it is central to understand the long-run workings of fossil energy markets. Now, exhaustible resource markets are notoriously politicized. Yet there is virtually no literature on how world markets for these resources interact with national and international political incentives. The current project on contagious resource conflict aims to take a step in bridging this gap.

A well-known feature of many of these markets is that property rights are either not defined or not practically upheld. This is in particular the case for many minerals which are abundant in non-stable countries and which are necessary for production of renewable energy technologies. This would also be true for renewable energy resources such as wood in some countries. How does this feature of the world market affect global supply and prices? This is essential to understand when thinking about a future market for renewable energy relying on technologies whose supply is unpredictable. This project intends to study theoretically how world prices of such resources affect the prevalence of violence and conflict in unstable countries, how this feeds back to affect world prices and how this in turn may lead to conflict in other countries or regions. Apart from the theoretical part, the project intends to test the

predictions using a new dataset of reserves and production of all resources in all countries over the last 20 years.

III.12 Finders keepers

Related to the ongoing projects on Natural Resources and Sovereign Expropriation is the question of public policy and taxation. Governments do not only have the possibility to expropriate the resource but can also change the tax schedule. Few governments can make promises on behalf of future governments several decades into the future, hence this is a real concern for private investment.

But what is the optimal tax scheme incentivizing exploration and investments that will provide the government with a large share as possible of the profits? Investments in hydropower, solar power installations and new resource deposits of oil and gas typically create incentives for a government to increase taxation after a major investment has been made. This in turn may lead to underinvestment. Another complication is that, normally, investments are made in the most profitable projects first. Then, if the tax scheme remains the same over time, projects with lower expected profits, but which are still profitable enough to warrant investment, may remain undeveloped due to the distortionary tax.

This project analyses theoretically what the optimal taxation will be in such a case of limited commitment to future taxes, how the tax will change after findings have been made and how it will change over time as investments become less and less profitable. It also aims to study how this depends on the type tax used (royalty, profit tax, etc).

III.13 Systems for refunding emission payments

We analyze two mechanism designs for refunding emission payments to polluting firms: Output Based (OB) and Expenditure Based (EB) refunding. In both instruments, emissions fees are returned to the polluting industry, typically making the policy more politically acceptable than a standard tax. The crucial difference between OB and EB is that the fees are refunded in proportion to output in the former, but in proportion to the firms' expenditure on abatement equipment in the latter. We show theoretically that to achieve a given abatement target, the fee level in the OB design exceeds the standard tax rate, whereas the fee level in the EB design is lower. Furthermore, the use of OB and EB refunding may lead to large differences in the distribution of costs across firms. Both designs imply a cost-ineffective provision of abatement as firms put relatively too much effort into reducing emissions through abatement technology compared with reducing output or improving management. However, maintaining output may be seen as a political advantage by policymakers if they seek to avoid activity reduction in the regulated sector. A first version of this paper is about to be finalized (Hagem, C. Hoel, M. Holtsmark, B. and Sterner, T., Refunding emission payments), and we will soon submit it to an international journal.

New Projects in 2015

III.14 Resource taxes and exploration

In this project, Daniel Spiro, in collaboration with, Niko Jaakkola (Ifo) plan to analyse how exploration for oil, coal and gas (which are primary sources of CO_2-emissions) is affected by national resource taxes and how the potential for exploration affects the taxation. They will also analyze how these forces determine global exploration.

III.15 Resource discovery and CO2-emissions

In this project, Daniel Spiro, in collaboration with Sjak Smulders (Tilburg University), will analyze how the oil price is affected by oil discoveries. This is important to understand as the oil price in itself may determine whether using new (clean) energy is profitable. The oil price also affects how much oil (and coal and gas) that is explored and burnt which in turn affects CO_2-emissions.

III.16 Nodal pricing

This project, which will be headed by Finn Førsund, starts from the observation that, in Norway and Sweden, the pricing of electricity may vary between geographical areas of the countries reflecting the capacity of transmission capacities, i.e. areas with pressure on transmission capacities will have a higher price than areas with a lower or no pressure on capacities. Economists have advocated much smaller geographical areas, namely production and consumption nodes. Theoretical models of production- and consumption nodes have indicated a welfare gain of having node-specific prices (Green, R. J., 2007, Nodal pricing of electricity: how much does it cost to get it wrong?, Journal of Regulatory Economics 31, 125-149; Torstein Bye, Mette Bjørndal, Gerard Doorman, Gerd Kjølle og Christian Riis, Flere og riktigere priser - Et mer effektivt kraftsystem, Ekspertutvalget om driften av kraftsystemet, Rapport, 30.11.2010, OED). The purpose of the study is to establish the theoretical framework for analyzing optimal electricity pricing and to explore ideas how to implement such a system.

The following projects will be included if they get funding

Designing flexible energy demand

Traditionally, discussions about security of electricity demand with intermittent power have focused on the supply side of the market. Demand-side management emphasizes the need to control the demand for power rather than meeting the user's requirements regardless of cost, and has proven successful in several countries. Moreover, development of new technologies has made possibilities for demand-side management more promising. This project will explore if and how demand side flexibility should be promoted.

This project is part of the larger project “Security of supply in a green power market – The challenges and opportunities of intermittent power" led by Sverre Kittelsen, Frisch Centre. This project has applied for funding through EnergiX, and will be carried through given that the project is given funding. Response from the Norwegian Research Council regarding funding is waited in the middle of December 2014.

Location of renewable generation

In this project, which will be organized by Cathrine Hagem, Statistics Norway, the aim is to study market design of location signals for renewable power generation and use, and the development of the grids. Realization of the project depends on funding.

Table 3: Planned work months, WP3

Activity	Primary institution	Planned work months	Cree funded work months
III.3 Integration of intermittent power	Frisch Centre	X	X
III.4 Green certificates	Dep. of Economics	0.5	0.5
III.5 Reduced nuclear power	Frisch Centre	X	X
III.6 Natural resources and sovereign expropriation	Dep. of Economics	4.0	4.5
III.7 Should foresters forecast?	Dep. of Economics	X	X
III.8 The Hveding conjecture	Dep. of Economics	0.5	0.5
III.9 Competition between electricity market places	Dep. of Economics	1.0	0.5
III.10 Flexibility in electricity markets	Dep. of Economics	1.0	0.5
III.11 Conflicts and price contagion on resource and energy markets	Dep. of economics	3.0	3.0
III.12 Finders keepers	Dep. of Economics	5.0	3.0
III.13 Systems for refunding emission payments	DoE, SSB	X	X
III.14 Resource taxes and exploration	Dep. of Economics	X	X
III.15 Resource discovery and CO2-emissions	Dep. of Economics	6.0	3.0
III.16 Nodal pricing	Dep. of Economics	6.0	3.0
III. Designing flexible energy demand	Frisch Centre	1.0	1.0
III. Location of renewable generation	SSB	X	X

WP4: Evaluation of Environmental and Energy Policy Measures

The activities within WP4 in 2014 and the plans for 2015 are focused on nine research topics:

IV.1 Rebound and adverse effects of energy efficiency measures.

IV.2 Households' response to soft policy measures

IV.3 Environmentally friendly transportation

IV.5 Residential end-use electricity demand

IV.11 Which policy instrument induces the best environmental performance in firms?

IV.13 Agent based modelling

IV.14 Development in the households' stock of heating equipment

IV.15 Household adaption to smart technologies (HAST)

IV.16 Evaluation of energy efficiency measures

Some of these topics are terminated in 2014, some will continue into 2015 and some are new in 2015.

Research communities and methods

In this period, the work on WP4 is located at two research communities: economists from Statistics Norway (SSB) and social anthropologists from Centre for Development and the Environment (SUM). In addition, Alice Ciccone, PhD student at Department of Economics, University of Oslo has contributed to the work package. The different research communities will apply a variety of methods to analyze the research questions listed above and also co-produce multi-disciplinary work based on syntheses of results. 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. 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 goal of combining the analytic approaches.

Analyses planned for 2015

The projects IV.4 (Indoor temperature and energy consumption in families with children), IV.6 (Energy consumption and stocks of firewood), IV.7 (Bioenergy) and IV.8 (Aggregation) were all finalized last year.

The plans for 2015 is connected both to ongoing and new activities. Table 4 provides information on planned analyses on different research questions in 2015, by research topic and institution. We plan to write articles for publication in international journals for each research question reported in the table, and also to write one report in Norwegian on research

question IV.6. SSB plan to submit the drafts written in 2014 on research topic IV.1 for publication in international journals, and write two papers on research topic IV.7 in 2015. Researchers from SUM plan to publish an article on the research question IV.4. To increase the availability of the research at an early stage, all papers aimed for publication in international journals will also be published in working paper series.

Table 4: Planned analyses in WP4 for 2015

Research question	***Institution***
IV.1 Rebound effects of energy efficiency measures	
- Interdisciplinary study of effects of heat pump ownership on household energy consumption	SUM and SSB
- Econometric study of rebound effects of heat pump ownership on household energy consumption	SSB
- Anthropologic study of rebound effects of heat pump ownership	SUM
- Econometric study of determinants of heat pump ownership	SSB
IV.2 Households' response to soft policy measures	
- The effects of displays among Norwegian households. Collaboration between SUM/CREE, CICERO (project ESPARR) and SINTEF	SUM
- The agentive role of in-home displays in Norway and the UK. Collaboration between SUM/CREE/ESPARR and Durham University.	SUM
IV.3 Environmentally friendly transportation	
- Price setting by car manufacturers	Tilburg
IV.5 Residential end-use electricity demand	
- Compare results over time	SSB
IV.11 Which policy instrument induces the best environmental performance in firms?	
- Compare the effects from direct and indirect regulations	SSB
- Are the effects persistent or only temporary?	
IV.13 Agent based modelling	
- Build a simulation model	SSB

Research question	*Institution*
- The effect of energy labeling and standards for cooling appliances on household electricity consumption	
IV.14 Development in the households' stock of heating equipment - Documentation of data from the Consumer Expenditure Surveys of 1993, 1994, 1995, 2001, 2004, 2006, 2009 and 2012.	SSB
IV.15 Household adaption to smart technologies (HAST) - Energy consumption, building regulations and habits	SSB
IV.16 Evaluation of energy efficiency measures – Literature study	SSB

Ongoing activities

In 2014, analysis of the effects of energy efficiency and soft policy measures on household energy consumption has continued (research topics IV.1 and IV.4), both at Statistics Norway and at SUM. Some of these studies were finished in 2014, and some will continue into 2015. The work package also includes the works on three PhD-theses (Dalen, Klemetsen and Ciccone). In 2015, only the work of Dalen will fall under this work package (see IV.5). However, Klemetsen will submit the work described in topic IV.2 for publication in international journals. Ciccone finished a working paper under this work package in 2014 (CREE WP 9/2014), and will try to get it published in 2015. Below, we give a brief summary of the planned ongoing activities on this work package.

IV.1 Rebound and adverse effects of energy efficiency measures

In quantitative studies by SSB Norway, a rebound effect has been detected after households have installed a heat pump. In this paper we use an interview sample with 28 households to attempt to identify and interpret changes in practices that may have contributed to rebound in electricity consumption after a heat pump is taken into use. The results show that a comfort rebound effect (direct rebound) is at work in two specific senses. First, people expand the time period in which they heat the home (both daily and seasonally). Second, users expand the total space of the house heated after heat pumps are taken into use. We point to a general attitude among many of the respondents that these changing practices were justified because of their investments in and anticipated savings from the heat pump. Finally, the study found that people did not keep a close accounting of money saved by the heat pump nor could they associate any particular investment or purchase with the savings. This lack of accounting by the users makes it difficult to pin down indirect rebound effects. See:

Winther, T. and H. Wilhite (2014): An analysis of the household energy rebound effect from a practice perspective: spatial and temporal dimensions, Energy Efficiency, 7(5). DOI 10.1007/s12053-014-9311-5.

Several ongoing studies on this topic will be competed in 2015. First, researchers at Statistics Norway have analyzed the effects of heat pump ownership on household energy consumption (reported last year). This paper will be processed further for publication in an international in 2015.

In addition, economists at Statistics Norway have conducted an analysis of the main drivers for the sharp increase in the proportion of households that have acquired heat pumps in Norway. This development has occurred very rapidly and almost without public subsidies. We have not seen similar structural changes in heating technology in Norwegian homes since the transition from wood and oil to electricity in 1970 - and 80's. We study the characteristics of households that have acquired a heat pump. Preliminary results indicate that this increase is largely driven by economic conditions to reduce fuel costs, and a change in heating technology appears to have occurred in all walks of life. This paper will be finished and submitted for international publication in 2015. The paper will also be published in CREE's working paper series.

In an interdisciplinary paper, economists and anthropologists study the perplexing case of the Norwegian heat pump ownership, a technology that theoretically should reduce household heat consumption by up to 25%, but when taken into use results in little or no change in electricity consumption. Our two coordinated studies find a major change in how households heat their residences after acquiring a heat pump. The anthropological study shows that many households increase the heated living area and no longer turn down the heat at night and when away. The economic study quantifies large effects of heat pump ownership on the consumption of all energy sources. On average, households with and without a heat pump use approximately the same amount of electricity, implying that the changes in behavior discussed in the anthropological study completely offsets the savings potential of the heat pump. However, total energy consumption is lowered and energy efficiency is increased since the consumption of firewood and fuel oils are reduced. A first draft of this paper is finished, and invited to be submitted to a special issue of *Journal of Indoor and Built Environment*. The paper will also be published in CREE's working paper series.

IV.2 The households' response to soft policy measures.

Anthropologists at SUM, in collaboration with economists at CICERO, have tested how households adapt to visual in-home displays of their electricity consumption. The displays were tested out in 26 homes at a housing cooperative at Røverkollen in Oslo. The study analyzed how the different members of the household reacted and interacted with the new technology, and recorded how the used it to monitor and control their consumption of electricity. The study found that many households were surprised by how much (or little) electricity different appliances used. Several of the households changed their habits based on

the new information, by changing electric ovens or light bulbs. The collection of empirical material has been completed, and the work will result in two international scientific papers in 2015. A summary in Norwegian has been published on our webpage under http://www.cree.uio.no/publications.html#Other_publications.

IV.3 Environmentally friendly transportation.

As part of Alice Ciccones PhD project funded by CREE, she analyzed 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.

This has resulted in the following publication:

Ciccone, A.: Is it all about CO_2 emissions? The environmental effects of a tax reform for new vehicles in Norway, CREE WP 9/2014.

Reyer Gerlagh and Inge van den Bijgaart (jointly with Hans Nijland and Thomas Michielsen,) at Tilburg Sustainability Center have studied the effects of fiscal personal vehicle policies on the CO_2 emissions-intensity of new bought cars in the EU. They find clear empirical evidence that CO_2 sensitive registration taxes and fuel taxes shift the car fleet additions to more fuel-efficiency. A manuscript will be submitted for a WP before December 2014. The plan is to extend the research on the effects of fiscal policies on new car sales in 2015, looking more closely to the response by car manufactures, in terms of their price setting. One result so far is that there is evidence that car prices excluding taxes are structurally different between countries in response to fiscal measures.

IV.5 Residential end-use electricity demand

It is costly and difficult to meter electricity consumption for different end uses, e.g. space heating, lighting and household appliances. We deduce a model for using cross-sectional data for total annual electricity consumption for a sample of households, together with information from energy surveys, to estimate the end uses within an econometric demand model conditional on appliance ownership. By applying a consistent method to Norwegian data for 1990, 2001 and 2006 (repeated cross-sections), we compare results over time and detect possible trends. We find that electricity consumption for many end use necessities such as washing, water heating and refrigeration varies somewhat from year to year, but they show no trend. We find a steady increase in electricity used for more untraditional end uses and newer

types of appliances. Total energy consumption for heating purposes is quite stable over the time period. See:

Dalen, H.M. and B.M. Larsen (2013): "Residential end-use electricity demand: Development over time". Discussion papers 736, Statistics Norway, forthcoming in Energy Journal.

IV.9 Effects on energy use of changes in building regulations

This research problem was postponed due to lack of financing. Parts of this project will be covered by the new HAST-project, which we have applied for through the Energix-program.

IV.10 Effects on energy use of new technologies

This project was postponed due to lack of financing. Parts of this project will be covered by the new HAST-project, which we have applied for through the Energix-program.

IV.11 Which policy instrument induces the best environmental performance in firms?

The aim of this paper is to compare the effects from various environmental regulations on environmental efficiency. In particular, we seek to compare the effects from so-called "incentive-based" (market-based) and "command-and-control" (non-market-based) regulations. The paper study the effects of various environmental regulations on environmental performance measured as emission intensity. Moreover, we aim to test whether any such effects are persistent or only temporary. Conventional theory predicts that indirect regulations as opposed to direct regulations provide continuous dynamic incentives for emission reductions. Our unique Norwegian firm level panel data set allow us to identify effects from different types of regulations such as environmental taxes, non-tradable emission quotas and technology standards. The data includes information of different environmental regulations, all kinds of polluting emissions, and a large number of control variables for all polluting incorporated firms. Empirically we identify positive and significant effects from both direct and indirect policy instruments. We also investigate whether the regulations provide continuous dynamic incentives that lead to persistent effects. In contrast to what the literature suggests, we find evidence that direct regulations promote persistent effects. Indirect regulations will, on the other hand, only have potential persistent effects if environmental taxes are increasing over time. See:

B. Bye and M.E. Klemetsen (2014): The impacts of alternative policy instruments on environmental performance: A firm level study of temporary and persistent effects, Discussion Papers No. 788.

IV.12 Are there secondary benefits of CO_2 regulations of firms?

This research question was planned for 2014, but was postponed due to changes in the plans for Klemetsen's PhD thesis. No work is planed on this research topic for 2015.

IV.13 Agent based modelling

In Dalen's PhD-thesis, the construction of a simulation model based on the agent based modeling framework is planned for 2015. The model will be used to analyze the diffusion and consumption of energy efficient household cooling appliances. The model is further complemented with econometric analyses of the effect of energy labeling and standards for cooling appliances on household electricity consumption. The results from these analyses will be presented in Dalen's PhD-project that is planned finished in 2015. The results are further planned to be presented in two articles intended for international publication.

IV.14 Development in the households' stock of heating equipment

As many policy instruments are attached to household energy consumption for heating purposes, information about what heating equipment the households own and how they use it, is of greater importance. On request from the Norwegian Water Resources and Energy Directorate, Statistics Norway have documented data describing the development of the stock of heating equipment and the use of this equipment, based on the Consumer Expenditure Surveys of 1993, 1994, 1995, 2001, 2004, 2006, 2009 and 2012. It also includes a literature study, describing the main results from various Norwegian studies on related topics. The tables will be documented in Statistics Norway's Notater series. See:

A.C. Bøeng, B. Halvorsen and B.M. Larsen (2014): «Kartlegging av oppvarmingsutstyr i husholdningene - En dokumentasjon av data fra Forbruksundersøkelsen», forthcoming as Notater, Statistics Norway.

New activities

IV.15 Household adaption to smart technologies (HAST)

A major element in the transition towards smarter cities is to increase the energy efficiency of existing and new buildings. Some technologies are passive in the sense that they reduce the need for energy without active intervention (insulation of walls, roofs, doors and energy efficient windows). Others are more active and need to be operated (heat pumps, heat recovery systems). Even if passive measures do not require any operation, the consequences of their installation may result in a change of behavior. Also, some energy intensive habits are hard to change. For instance, many Norwegian households like to frequently air out their homes or leave the valve for the air supply on their firewood ovens open when not in use. If not changed, these practices may seriously compromise the efficiency of the building.

To study how habits and routines affect household energy consumption and the energy efficiency of a building we plan two studies: i) How does household energy consumption depend on various habits related to energy use; such as airing habits, closing the valve for the air supply on their firewood ovens, closing the door to non-heated areas of the house, turning off lights when you leave the room. ii) An interdisciplinary study of how Norwegian households adapt to investments in a heat pump, synthesizing the findings in an econometric and an anthropological study (Halvorsen and Larsen 2013, Winther and Wilhite 2014). The analyses in ii) has already started up in 2014 whereas the analyses in i) will start in 2015.

SUM plans to conduct two new empirical studies in 2015 and 2016 which will complement the econometric analysis performed by SSB. In the first we focus on the use of heat recovery systems, where approximately 20 families will be recruited through suppliers of such equipment for in-depth interviews. We will examine people's airing habits and to what extent people consider their energy use, perceptions of comfort etc. to have changed as a result of the heat recovery system. The material will inform a multi-disciplinary analysis with researchers at SSB on the effects of heat recovery systems on energy use, including the impact of regulations. Secondly, SUM will study 20 families living in so-called passive houses and examine their energy use in everyday life as compared with the situation before they reached this building standard. The material will inform a multi-disciplinary analysis with researchers at SSB on the effects of passive house standard on electricity consumption.

Researchers from SSB and SUM have applied for financing for this project from the NRC program Energix.

IV.16 Evaluation of energy efficiency measures

This project is a study of existing literature on partial microeconomic analyses of energy efficiency measures. We plan to write a section on this in a report in 2015 (a wider report also containing a literature study on macroeconomic analyses).

2015 budget

This research is planned financed through a combination of CREE funding and own funding through RCN and other projects. The resource use and share financed by CREE are indicated in Table 5 (by institution and subject). Own funding is still very uncertain, as the activities under research question IV.7 are subject for a grant application to the ENERGIX program. Thus, the shares in the tables are given under the assumption that this project is funded. If not, the plan needs to be revised.

Table 5: Planned work months, WP4

Activity	Primary institution	Planned work months	Cree funded work months
Administration	Statistics Norway	1	1
IV.1 Rebound effects of energy	Statistics Norway	2	1
efficiency measures	SUM	X	X
IV.2 The households' response to soft policy			
Measures	SUM	X	X
IV.3 Environmentally friendly transportation	Tilburg	X	X
IV.13 Agent based modelling	Statistics Norway	7	3
IV.15 Household adaption to smart technologies	Statistics Norway	9	4
	SUM	X	X
IV.16 Evaluation of energy efficiency measures	Statistics Norway	1.5	0

WP5: The Next Generation of Numerical Models

To analyze policies that stimulate innovation and diffusion of new environmentally friendly technologies, integrated economy-energy-environment models are necessary tools. At CREE we have the energy market model LIBEMOD, the petroleum market model PETRO2, and the new family of integrated macroeconomic Computable General Equilibrium (CGE) models; the SNoW-models (Statistics Norway World models). We will continue our work on all the main topics in WP5 as described in the project application from 2011, see Table 9 for detailed plans. Most of the policy analyses based on numerical model simulations are mentioned under WP1, WP2 and WP3; these activities are listed in Table 9. Below we concentrate on projects that are not part of other WPs.

LIBEMOD

Ongoing activities

In 2014 the activities to update and upgrade the numerical model LIBEMOD were finalized. Building on economic theory, this model provides a detailed modeling of the energy markets in 30 European countries. It encompasses all activities in the energy markets: investment, extraction of fossil fuels, production of bioenergy and electricity, trade in energy and consumption of energy. LIBEMOD produces a consistent set of quantities and equilibrium prices.

In the new version of the model more countries have been added (13 East-European countries); the end-user sectors have been refined (the service and public sector has been separated from the household segment); the modeling of wind power has been changed and more renewable technologies have been included (run-of-river hydro and solar power); the modeling of natural gas has been refined; bioenergy has been split into biomass and biofuel; all data have been updated (the data year has been changed from 2000 to 2009) and the complete model has been recalibrated. A detailed documentation of the new version of LIBEMOD is now available at http://www.frisch.uio.no/ressurser/LIBEMOD/

The new version of LIBEMOD has been converted into a stochastic model. Here we build on stochastic programming where a crucial distinction is made between decisions made before the uncertainty is revealed, and decisions made afterwards. To this end the stochastic LIBEMOD has two periods. In period 1, some actors make decisions under uncertainty, that is, to determine their future capacities through investments. In the beginning of period 2, the uncertainty is revealed and all actors learn the true state of the economy, that is, which scenario that has materialized. Then all actors make decisions; producers determine how much to produce (given the predetermined capacities), arbitrators determine how much to trade, and consumers determine how much to consume.

For each realization of the uncertainty, the model determines supply of, and demand for, all goods from all agents and the corresponding vector of prices that clears all markets. In fact, the stochastic equilibrium model determines simultaneously all quantities (investment, production, trade and consumption) and all market clearing prices for *all* possible future states. The determination of quantities and prices are based on the assumption that all actors have rational expectations, that is, when investment decisions are taken in the first period actors take into account the probability distribution over the scenarios and the equilibrium prices of all scenarios. So far, the source of uncertainty is future climate policy – political uncertainty – but more applications are planned, see below.

Comparative model project with harmonized data

We have produced a full set of input data and output variables from the new (deterministic) LIBEMOD for a run that describes the European energy market under the assumption that the climate policy of the EU, that is, an emission reduction of 40 percent in 2030 relative to 1990, is implemented. These data are used by SINTEF in their own stochastic model for the European electricity market. By harmonizing the data used in the two models, we can identify sources that produce differences in output variables. The project is expected to be finalized in 2015.

New activities/Plans for 2015

The social value of green technologies

In the future, electricity supply may be dominated by carbon-friendly technologies like floating windmills, solar power and Carbon Capture and Storage (CCS) electricity technologies. Governments are currently involved in the development of these technologies, and support basic research, demonstration facilities and market diffusion. It is hard for governments to know what role these technologies might play in the future, and hence to allocate their support optimally. Using the stochastic version of LIBEMOD with climate policy uncertainty, we will run the model with different sets of capital investment costs for climate-friendly technologies. Thereby we can estimate demand functions for these technologies, and thus identify the social value of each technology. Hvor er denne finansiert?

Dynamics and learning about future climate policy

In the current stochastic version of LIBEMOD there is no explicit dynamic structure, but implicitly there are two periods and all the uncertainty is resolved at one point in time. All agents know all possible future states that may materialize, but not which particular state that will materialize, and there is no learning until the uncertainty is totally resolved. By extending the model to more periods, we will introduce learning, and hence option values, that is, the value of being in a position to make use of new information later. An obvious example is energy investments: These are irreversible, and hence capacities cannot be built down rapidly. By delaying an investment, the agent keeps an option to either invest or not invest later, depending on whether new information is favorable for the investment. We want to study implications of learning, both about future climate policy and economic development, on investments in green technologies. This will be done by developing a multi-period version of LIBEMOD with Bayesian updating of expectations (in each period) and irreversible investments. In an extension, the role of risk aversion will be studied; the current stochastic version of LIBEMOD assumes risk neutrality. Hvor er denne finansiert?

Regionalizing Scandinavian countries

In 2015 we want to regionalize each of the three Scandinavian countries so that each country will be divided into several regions. Each region will then be treated as an "original country" with its own economic activity and trade with other regions and countries. This regionalization can be beneficial to illuminate Norwegian and Scandinavian issues, such as effects of a joint Norwegian-Swedish certificate market. Henning Wahlquist, who is a new PhD student funded by CREE, will start to work on this. His PhD project will be on numerical energy models and uncertainty.

Petroleum market models – PETRO2

(Tekst fra Kristine om modellen, utvikling og analyser - kommer)

SNoW models

Ongoing activities – model developments

In 2014 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 with 41 industries, based on the GTAP database structure (a global database on trade, environmental and energy) and programmed in GAMS. The model is continuously being developed to make the model more like SSB's earlier version of a computable general equilibrium model for Norway, the MSG-model, which has been used by the Ministry of Finance for decades. Many of these new properties have not been implemented in GTAP-based models before, and examples are modelling of process emissions and a more detailed consumer system.

Ongoing activities – analyses

In 2014 Snow-No has been used to analyze emission scenarios for Norway dependent on different assumptions on important exogenous variables as international oil-price, international business cycles, and population forecasts. The scenarios are documented in an article submitted to Samfunnsøkonomen. In another project we use the dynamic version of the SNoW_No model to analyze environmental and economic efficiency effects of climate- and energy efficiency policies. This is part of the EU project ENTRACTE. We model energy efficiency measures and technology costs based on a report by IFE on long-term scenarios for energy efficiency investment costs in buildings. This continues our cooperation with IFE on energy efficiency investments. The project is going to be presented at a workshop in Milan in February 2015, and synthesized in a report with FEEM (Milano) in May 2015.

The global model has been used in two different projects analyzing policies to curb carbon leakage. The first paper investigates how carbon taxes combined with output-based rebating (OBR) in an open economy perform in interaction with the carbon policies of a large neighboring trading partner. This paper is submitted to an international journal. The other paper concerns possibilities, limitations, and implications of various border carbon adjustment (BCA) systems designed particularly for targeting the emission intensities of foreign producers. Succeeding to design and implement such systems would improve the efficiency and effectiveness of BCAs. The final working paper will be submitted to an international journal by March 2015. This project is part of the ENTRACTE-project, and the results will also be included in a synthesis report from the ENTRACTE project, together with ZEW (Mannheim) by May 2015.

Skrive opp publikasjonene det refereres til ovenfor.

New activities – model developments

In 2015 we will continue to develop and refining the model for Norway – SnoW-No. The developments depend on the research projects the model is a part of. In addition there is a

long term goal of making the model more alike the above mentioned MSG-model. This is necessary to establish SNoW_No as a real alternative model to the MSG-model for long term analyses. We have the following plans for model development; generating a dynamic version of the model, refining the consumption system, modelling of all greenhouse gas emissions (at present only CO_2 emissions are included), modelling technological change (other than energy efficiency), and establishing an income account model. Parallel to the model developments we also work on improving the data input to the model. Beyond 2015 our goal is to link SNoW_No to the global SNoW-model structure, with especially emphasize on developing the European part of the model to be able to analyze Norwegian and EU climate policies.

New activities – analyses

In a project for OED we will analyze the main macro-economic drivers for the development of energy consumption in Norway towards 2030 based on the long-run scenarios from the Ministry of Finance long term projections.

We will also, dependent on financing from FRIKLIM Klimaforsk), finalize a study on diffusion of climate technologies in a small open economy. This study applies the ITC-model, which is an empirical growth model with endogenous technological change. A preliminary version of this paper was presented at the RERC conference in Oslo in June 2014.

Petroprospects

This project is related to effects on the Norwegian economy and Norwegian emissions of a diminishing petroleum industry in Norway. We will use a model with endogenous technological change to analyze how human capital, research and development an innovation activities that have taken place in the petroleum industry may be reallocated to gain the activities in other industries. This will depend on how resources reallocate between industries and how the innovation activities and productivity effects interact with other industries and also countries through trade and possible network effects. In 2015 the project design and model development will start. (RCN)

We will also use the global model to analyze optimal combinations of consumption and extraction policies for an EU-Norwegian coalition to reduce global emissions. This project will start in 2015, and final report will be delivered in 2016. This is part of the WILL-project funded by Klimaforsk.

Model Forum

We plan to have the next CREE model forum in April 2015.

Table 9 describes our plans for the coming years, while Table 10 describes the amount of resources that will be spent on each project in 2015 and how they are financed.

Table 6: Time schedule for subprojects under WP5, 2015 – 2016 (Må oppdateres)

Topic	*2014*	*2015*	*Institution*
LIBEMOD – development			
Finalizing the upgrading of LIBEMOD	X		Frisch and SSB
Stochastic version of LIBEMOD	X	X	Frisch
LIBEMOD – applications			
Promotion of CCS in power generation (WP2)	X		Frisch and SSB
Phasing out nuclear power in Europe (WP3)	X		Frisch
Comparative model project with harmonized data	X		Frisch, SSB and SINTEF
Applications of stochastic version of LIBEMOD	X	X	Frisch and SSB
CGE-development			
Improving data/modeling of SNoW_No	X	X	SSB
Dynamic investment and consumer behavior	X		SSB
Modeling energy efficiency measures	X		SSB
Testing the model	X	X	SSB
Incorporating new parameters from quant. studies (WP4)	X	X	SSB
Linking the SNoW_No to the global SNoW family	X	X	SSB
CGE- applications			
National and international climate policies; welfare and carbon leakage effects, SNoW-model (WP1)	X	X	SSB
Energy efficiency policies in SNoW_No	X	X	SSB
Innovation and diffusion processes and policies for new energy- and climate technologies (MSG-TECH/ITC) (WP2)	X	X	SSB
Model Forum			
Meeting point for development of integrated environmental- and economy models with a rich presentation of energy- and environmental technologies	X	X	Frisch, SSB, Frisch, SSB
Presentation of empirical model analyses of energy- and environmental policies	X	X	Frisch, SSB

Table 7: Planned work months, WP5 (Må oppdateres)

Activity	Primary institution	Planned work months	Cree funded work months
Administration		1.0	1.0
LIBEMOD – development and applications			
	Frisch Centre	1.2	1.2
	Statistics Norway	2.5	1.0
	SINTEF	4.4	4.4
SNoW – development and applications	Statistics Norway	13.5	3.8
	IFE	0.9	0.9

Total funding (Denne teksten er fra i fjor og må oppdateres)

Table 8 summarizes the total funding for all 5 working packages in 2014. We also include the numbers from the Work Plan for 2012 and 2013. Note that these are budget numbers and do not reflect the exact accounts for these years. One main difference between 2012/13 and 2014 is related to our post. doc; from 2014 all his activities are allocated to work package 3. Table 9 shows costs of the working packages by institution in 2012, 2013 and 2014.

Table 8: Cost plan funding in 2012- 2014 by working package (1000 NOK)

Budget	2012	2013	2014
Frisch hosting			
Administration	1 321	1 257	1 133
Conferences	300	300	215
Scholarship for students	60		40
MILEN's research school	100	100	0
WP1	2601	2821	1 894
WP2	1270	1025	1 044
WP3	881	1047	1 449
WP4	1221	1489	1 697
WP5	1911	1982	2 108
	9 665	**10 021**	**9 580**

Table 9: Cost plan for 2012 – 2014 distributed to institutions (1000 NOK)

Budsjett	2012	2013	2014
Frisch hosting			
Administration	1 314	1 257	1 133
Conferences	300	300	215
Scholarship for students	60	40	40
MILEN's research school	100	100	
Frisch research partner	3 403	3 042	2 797
SSB	1 641	1 538	1 570
ØI	1 398	1 723	1 795
TSC	250	250	250
Subcontractors	1 200	1 770	1 780
	9 665	**10 021**	**9 580**

The external funding of CREE is shown in Table 9 by institution and year (2012-2014). The table provides information about type of funding, which is typically either a project funded by the Norwegian Research Council or own funding. Applications to be determined in 2014, for example, to the Klimaforsk program, are *not* included; CREE is part of 10 applications submitted to this program. CREE has also applied to three Joint Program Initiative (JPI).

Table 10: Own funding (1000 NOK)

Program	Source	Institution	2012	2013	2014
Uncertainties in the European Energy Market: Modelling Approaches and policy issues	NFR	Frisch		520	2 535
PETROSAM: Petroleum industry research in economics and economic management	NFR	Frisch	1 509		
Export of Natural Gas from Russia	NFR	Frisch	317	152	
SAMFUNN: Norms, green agents and environmental policy	NFR	Frisch	500	250	
Managing Thresholds and Uncertainty in Resource Economics	NFR	Frisch	1 664	1 435	10
Intergenerational and intragenerational equity in climate policy	NFR	Frisch	1 348	1 308	335
Improving international cooperation on emission abatement	NFR	Frisch	1 826		
Managing Risk in Climate Change - A Dynamic Perspective	NFR	Frisch	1 864		
Stimuleringsmidler til EU-prosjektet ENTRACTE	NFR	Frisch	38	382	304
Forskningskampanjen 2012 – CREE	NFR	Frisch		90	
Intergovernmental Panel on Climate Change	KLIF	Frisch	150	27	
ENTRACTE: EU-midler	EU/Inter.	Frisch/SSB	147	1 118	1 414
PETROSAM: Petroleum markets	NFR	SSB	800		
RENERGI: Diffusion of climate technologies	NFR	SSB	2 500	1 100	
RENERGI: Household response to multiple environmental policy instruments	NFR	SSB	1 200	1 000	
Frie midler: Sustainable biofuels	NFR	SSB	1 300		
MSG-Contract	Ministry of	SSB	400	400	400

	Finance				
Own funding		SSB	400	700	700
Nordic funding	Inter.	SSB		750	750
Own funding		ØI	1 000	1 000	1 000
Own funding	Inter.	Tilburg	250	250	250
Total			**17 212**	**10 481**	**7 689**

As indicated by the line "total" in Table 10, the external funding of CREE by far exceeds the requirement of 25 percent. For 2014, the total budget of CREE is NOK 17.269.000.

Other activities

Like previous years, in 2015 CREE will organize a user conference (joint with CICEP), a user seminar, a model forum and a research work shop, as well as meetings/events with the CREE users.