The Research Council of Norway
Division for Energy, Resources and the Environment

Midterm Evaluation of the Centres for Social Science-related Energy Research

(FME Samfunn)

E – Project description for the final three-year period and further plans

CREE - Oslo Centre for Research on Environmentally friendly Energy
.....
(Name of centre)

209698
.....
(Project number)

*To be prepared by the centre and signed by the Centre director and Chair of the Board. Maximum length (Excluding front page) **8** A4 pages. Word format, Times New Roman, 12 pitch font, single line spacing*

Background

Each centre has a current project description for the whole period of the centre and a work plan for each year. During the four to five years since the original project description was written, many things may have changed. Even if some centres have made revisions through the first years, it is expected that the centre now should perform a more in depth review of the different sections of the project description. ***This report should focus topics that, as a result of this review, is going to be changed in the project plans for the final years. Those items where the centre will continue to follow present plans need not be commented upon.***

The centres may not have budget plans for the complete eight year period. In any case the budget for the next four years should be presented.

Objectives for the centre and background for changes in the project description

The primary and secondary objectives of CREE are reported in form A (Template for Self-evaluation), and we do not repeat them here. These objectives have not changed.

Since the center started its activities in 2011, the climate change challenge has grown bigger. The IPCC fifth assessment report made it even more certain that manmade climate change is happening. At the same time IPCC underscored how difficult it will be to reach the 2 degree target. Not only must global greenhouse gas (GHG) emissions start to decline already by 2020, but GHG emissions must possibly also become negative towards the end of the century. Thus, the main objective for social science energy and climate research in the coming years will, in our opinion, be to study how the transition process towards a carbon free society can happen.

We will still continue to organize our research in the five work packages:

WP1: The International Politics of Climate and Energy
WP2: Innovation and Diffusion Policy
WP3: Regulation and Market
WP4: Evaluation of Environmental and Energy Policy Measures
WP5: The Next Generation of Numerical Models

However, new ideas based on how to achieve a transmission to a carbon free society will be included in these work packages.

1. Status

National and international state-of-the-art of the research topics for the centre.

Much of the state-of-the-art of the research topics for the center is described in the latest IPCC assessment report working group III: Mitigation of Climate Change, which was published in 2014, and where several CREE researchers were involved. In brief, this report states that we have a carbon budget if we want to limit the concentration of GHGs at a level that fulfills the 2 degree target; we need to reach a carbon free society at the end of this century. One important challenge is that emissions are increasing fast in upper middle income countries, countries that so far have limited regulations on GHG emissions and are not included in the Kyoto Protocol. Global poverty reduction has led to higher GHG emissions. However, 40-70 % reductions in GHG emissions are necessary by 2050 if we want to be on track for the 2-degree target, meaning that most fossil fuel reserves should stay in the ground. Model simulations with CGE models and other macroeconomic models show that this does not have

to be expensive, but there are still barriers such as transition costs and distributional effects. Anyway, to reach this goal we need to have an increased electrification of the economy, a decarbonization of the power sector, possible land use changes, use CCS, be more energy efficient, and plan infrastructure investments. Furthermore, when it comes to climate agreements, game theoretical models are still pessimistic about the outcome of negotiations. Thus, there seem to be need for institutional changes to reach a significant agreement. Finally, ethical questions have received much more attention, especially in studies of climate agreements, the last few years.

Nationally, the research challenges we face are the same as for the international community. CREE researchers are on the research frontier in energy- and climate economics, and we want to follow up the challenges pointed out by IPCC. Our future research agenda will, however, be dependent on external funding. As the competition for funding is much harder than when the center started, we expect to have fewer degrees of freedom in future research.

2. Research methodology

Describe the methodology and theories planned used, and explain why they are suitable for generating relevant knowledge in the field. Describe plans for publication in scientific peer-reviewed journals as well as plans for conferences.

As CREE is relatively broad in topics analyzed and we want to be successful in contributing new knowledge as well as in disseminating relevant results to users, our research will be based on a broad set of methodologies. These includes theoretical studies anchored in microeconomics and game theory, numerical simulation models including computable general equilibrium models and integrated assessment models, econometrics which we make use of our large datasets, and laboratory experiments.

Further, we are involved in interdisciplinary work with our research partners. They also use different methodologies from other social sciences, law and technology. Field studies are for instance used under WP4.

When it comes to publications in scientific peer-reviewed journals, we aim for Level II, journals on the Norwegian Scientific Index, i.e., the internationally most prestigious journals. We also hope for top 5 or top 10 publications (i.e., the economic journals ranked among the best 5 or 10) and general economics journals. However, we note that there is a potential conflict between this aim and the aim to involve user partners in our research.

We will continue with our established conferences for user partners and researchers, but have also sent an application to organize the EAERE 2017 conference (European Association of Environmental and Resource Economists), together with CICEP and UiO Energy. We further aim for media conferences, i.e., conferences meant for a non-expert audience.

3. Research tasks

Identify and describe the research questions that will be examined. Define key research tasks and research-related targets and explain their significance for policy-making and the society.

Based on the transmission to a carbon free society, we plan the following new research tasks in the final four years of CREE. Note, however, that this will be dependent on our success in getting external funding. We also refer to the "CREE work plan 2015" for ongoing research and plans.

WP1: The International Politics of Climate and Energy

Negotiating and agreeing on a new global climate treaty has proven much more difficult than expected only a few years ago. Instead of a legally binding global climate treaty, we may rather see an extension of the Copenhagen accord in which countries state their own targets that are not legally binding. Such a scheme opens up for a large variety of more fragmented approaches to climate cooperation, on technology, on sector wise targets, and on non-binding pledges. The CREE centre will investigate such approaches with the overarching belief that such measures, if successfully implemented, can lead to a global treaty longer down the road. The long process from pledges to a significant global treaty can be studied by modelling the current negotiation process as an evolutionary game in which individual countries learn about other countries and change strategies according to this.

The approaches described above may fall under the headline of institutional changes. These are important as game theoretical studies still give us quite pessimistic predictions for the outcomes of international climate negotiations. Thus, the rules of the games must change. We have had some suggestions in our earlier research (for instance a deposit account), but this is of significant importance and we therefore hope to contribute more on this.

Barriers to international treaties must also be removed to be able to reach a significant international treaty. For instance, disagreement over burden sharing between rich countries, emerging economies, and poor countries seems to be among the factors blocking the negotiations for a new climate treaty. This is especially important as upper middle income countries such as China and Brazil have had the highest growth in emissions. Thus, we should no longer only talk about developed and less developed countries as we have mainly done in our previous studies on burden sharing. While distribution and ethical questions have been part of the work package, how to deal with a third group of countries that contributes to a large share of GHG emissions is an important question to study as we recognize that there is a conflict between increasing GHG emissions and the fight to reduce poverty.

Barriers in Norway and the EU to becoming a carbon-free society are also important. Such barriers can be political and driven by burden sharing consideration within the developed economies. Barriers can also be technological and/or norm based, and will often require that politicians divert from "optimal" policies, and instead find second- or third-best solutions. We will investigate both potential barriers, and the possible political responses.

Technology transfer might be a potent way to encourage future participation of poor countries in climate treaties. We are interested in identifying the most promising types of technology to support, and by what measures transfer should take place. We will differ between energy efficiency technologies, end-of pipe abatement such as carbon capture and storage, and technological substitutes to fossil fuels such as renewable energy. Moreover, we will analyse the performance of different funding mechanisms.

WP2: Innovation and Diffusion Policy

In the original project description, we described behavioral economics and laboratory experiments as part of this WP. The activity on this has been low, even if we have put a lot of effort in getting data that can be used as described in the "CREE work plan 2014". Most of the behavioral economics and lab experiments are moved to WP1, and will not be an important part of WP2.

Three new topics will be added to this work package:

As mentioned above, increased electrification of the economy combined with decarbonization of the power sector is important for the transmission process to a carbon free society. The transport sector is one of the sectors where electrification can happen in the next decades. We will focus on electric vehicles (EV), hopefully in several research projects. One example is to study how the demand for EVs in Norway depends on privileges (e.g., driving in bus lanes, no road toll, free charging stations). These privileges vary geographically and between different groups of the population. We can control for this by taking into account where people live. By looking at the demand in different regions with different privileges, we can study the effect of the privileges on the demand for EVs. This may be important for the design of policies to increase the diffusion of EV. Another interesting aspect includes the learning curves for battery technologies, e.g., to study the cost reduction potential of future zero carbon transport technologies. Finally, these topics may be included is a large proposal initiative at the University of Oslo and CIENS (see section 14 below) on smart cities in an energy perspective.

The second topic is technology policies in an open economy. While activities in WP2 partly focus on the innovation process from a partial equilibrium perspective, we now plan to examine the whole process from an economy-wide and even a global perspective. Economists normally favor technology-neutral technology push and pull schemes; for instance, a tax credit for expenditures on R&D can be applied equally to all technologies. Similarly, a carbon tax incentivizes a range of cleaner options without mandating particular technologies. We will challenge this conventional wisdom and investigate reasons for giving priority to zero-emission technologies. Under what conditions should an open economy give priority to clean technology development? What is the potential of different technology push policies to redirect R&D from carbon-intensive to carbon-free technologies in a multi-region world with insufficient and differing carbon pricing?

Finally, we will do empirical work on environmentally friendly R&D. In the original description of WP2, there were no activities within the field of econometric studies. We have, however, conducted econometric studies using rich Norwegian panel data on firms' characteristics, emissions and patents. In 2015 we will conduct an econometric study that compares knowledge spillovers - measured by patent citations - from clean and dirty technologies, and also to compare these across industries. Similar studies are planned for 2016. In particular, we would like to estimate learning/experience curves, for instance for battery technologies (see above), and for renewable electricity technologies, as wind mills, to explore to what extent costs have been decreasing over time.

WP3: Regulation and Market

Most of the projects described in the original project description were studies on the power sector. An area that is receiving increased interest, especially in light of the introduction of new capacity of intermittent electricity, is demand flexibility. Traditionally, discussions about security of electricity demand with intermittent power have focused on the supply side of the market, but 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. We aim to explore if and how demand side flexibility should be promoted.

However, we will also extend the agenda as other markets are of large importance for the process towards a carbon free society. One such market is the market for biofuels. The importance of biofuels is mentioned by IPCC, for instance bio power plants with CCS. Biofuels used to transport

was previously included in WP4, but the subject will now be moved to WP3. As seen from our publication lists, we have already published several studies on biofuels. Some new projects are planned. For instance, we would like to focus on carbon storage and energy provision. On the one hand, increased use of biofuels will temporarily reduce the amount of carbon stored by biological resources. On the other hand, biofuels can substitute for fossil fuels, the main source of GHG emissions. How increased supply of bioenergy influences current and future consumption of fossil fuels, and how harvesting influences the dynamics of the carbon stock of bio resources are complex issues. Carbon leakage, that is how a biofuels policy in one country could increase emissions in other countries, is a third important challenge in this context.

We will also focus on global fossil fuel markets, as the development of these markets are important for global CO_2 emissions. This can be done with our new petroleum market model – PETRO2 – such as analysis of global and regional policy measures. One such problem is the effect of new technological development on the extraction of oil from both conventional and unconventional sources; another is how the effects on the oil market depend on the policy measures used for increasing the diffusion of these technologies. We will also pursue other empirical and theoretical studies in this area, including how exploration for oil, coal and gas is affected by national resource taxes, how the potential for exploration affects the taxation, and how the oil price is affected by oil discoveries. The latter issue is important to understand as the oil price in itself may determine whether using new (clean) energy is profitable.

WP4: Evaluation of Environmental and Energy Policy Measures

Our research on environmentally friendly transportation under WP4 is now finished. A new subject related to energy efficiency, an important subject according to IPCC, is introduced, namely household adaptation to smart technologies.

The distribution of smart technologies in the residential sector may be a result of household decisions and/or governmental regulations. The building regulations give minimum standards, and guarantee a broad distribution of the technology. We will focus on the actual energy savings of the efficiency measures, distinguishing whether the measure is initiated by i) governmental regulations or ii) by the household itself.

i) Governmental building regulations: We are interested in how households have adapted their energy use to the introduction of a heat recovery systems (HRS) in their residences as a result of the 2010 change in the building regulations. How does this affect the households' airing and other habits, and how do habits affect the energy efficiency of the HRS? How does this affect the efficiency gains of the HRS on household energy consumption, and does the result depend on whether the HRS was installed before or after the 2010-regulation? Another aspect will be to examine the effects on household energy consumption of historical changes in the building standards with respect to insulation of roofs and walls. We aim to quantify how the effect on energy consumption of additional insulation changes with the level of insulation, when the behavioral changes associated with these passive measures are included, and whether these regulations affect household energy habits and other energy saving behavior.

ii) Household induced efficiency measures: There will always be a group of households that do more than is required by governmental regulations. These early movers are the pioneers in testing out new technology such as low-energy houses and passive houses. To study early movers, we start with an anthropological analysis of families living in houses which comply with the passive house standard, recording people's account of how habits and routines changed when they moved from their earlier residence into the passive house, distinguishing between changes that may be attributed to the housing construction and what were caused by other factors. We will also do

econometric analyses of households living in low-energy buildings. Second, we follow up earlier studies on heat pumps, both economic and anthropological, to conduct an interdisciplinary analysis based on practice theory, synthesizing the findings to obtain a deeper understanding of the processes behind the behavioral changes resulting from investing in a heat pump.

WP5: The Next Generation of Numerical Models

We will continue to use the unique competence available in our research team (including our technology subcontractor IFE) to further develop our energy market models (LIBEMOD and PETRO2), and our integrated macroeconomic computable general equilibrium models – the SNoW (Statistics Norway World) models – to make them well suited for our analyses of energy- and environmental policies. We will develop the SNoW_No(rway) model by incorporating investment dynamics, modeling energy and climate technology, diffusion processes and relevant policy parameters, to make it more suitable for scenario analyses and relevant policy analyses. We will use our experience with energy technology modeling to develop a European version of the global SNoW model for analyses of joint Norwegian-EU policies. The LIBEMOD model with uncertainty will be extended to introduce learning and hence option values, as this is especially relevant for energy investments. Higher time resolution might also be implemented, for example to study the effect of climate and energy policy on cross border electricity exchange.

Finally, new petroleum resources will be incorporated in PETRO2 to improve the modeling of the world's petroleum resources and petroleum technologies.

4. Researcher training and recruitment

Describe plans for researcher recruitment. Specify the number of doctoral degrees planned within which research areas. Provide a target figure for the percentage of women fellowship-holders (cf. Point 8).

The aim has been to recruit three PhD students and one post-doc researcher over the center lifetime. Originally the plan was to recruit two post-doc researchers, but due to lack of external funding as well as satisfactory funding of post docs at the Department of Economics, University of Oslo, we decided to only fund one post doc directly. Two PhD students were recruited in 2011 and one in 2014, while we recruited one postdoc researcher in 2012. The research recruits are studying at the PhD program at the Department of Economics, University of Oslo. The post doc is employed at the same department. In addition, we contribute to the funding of one PhD student at Statistics Norway and one post doc at Tilburg University.

Two out of three PhD students funded by CREE have been women. Also, the majority of students receiving a master scholarship has been women.

In the original project description, we described our cooperation with MILEN, the University of Oslo's interfaculty research network on environmental change and sustainable energy, in organizing interdisciplinary seminars and workshops. MILEN does no longer exists, as UiO Energy has taken over as the University's coordinator of energy and climate research. The demand for interdisciplinary PhD has subsequently been reduced.

Due to the difficult funding situation, we have not been able to employ permanent researchers within our field over the last few years. Even if we hope for a better funding situation, we do not expect this to change dramatically over the next few years.

5. Relevance and benefit to users and society

Describe further plans to ensure that research activity is relevant to user partners
Describe plans for communication activities

As described in "The Centre Self-evaluation", we are visible in the public debate via several channels. Our experience with user involvement is that we have been successful in establishing fruitful connections and mutual gains with ministries and other public agencies. Thus, our research is policy relevant and applicable for policymakers. However, we have not yet achieved the same level of mutual gains/synergies in relations with private companies.

The policy of the Research Council of Norway is to include user partners from industry and governmental agencies in Knowledge-building Projects for Industry (KPN) by letting industry fund parts of the project, with 20% funding from users and a minimum of 10% funding from a private company. So far we have not succeeded in establishing a full KPN. However, we are working hard to involve industry in KPN projects in the future, and this is one of the top priorities for CREE in the coming years.

6. Organisation

Describe how the cooperation at the centre will be organised and why this structure has been chosen.
Describe how knowledge acquired through research activities at the centre will be transferred to the partners.

The organization of the center will continue as described in "The Centre Self-evaluation", with the board, the management group and the administration at the Frisch Centre.

We will continue with the four research partners, and we also plan to continue with the seven user partners. Cooperation between the research partners will mainly be as before; however, we hope to get closer cooperation with our industry user partners through KPN projects.

We have had several subcontractors that have been funded by CREE: IFE (Institute for Energy Technology), SINTEF Energy, SUM (Centre for Development and the Environment) and the Faculty of Law, University of Oslo. From 2015, we decided to continue with only IFE as the technology subcontractor, so SINTEF Energy is no longer part of the team. On the other hand, we have established cooperation with the Department of Psychology, University of Oslo, and hope to extend this.

7. International cooperation

Describe plans for international cooperation at the centre.

Each of the Norwegian research partners in CREE have a large international network, which we will continue to build on in the coming years. For instance, we participate in the EU funded ENTRACTE project. However, we will also try to expand this network as we are currently involved in new international consortiums that are planning proposals for HORIZON2020 and Nordic Flagship Projects (Nordic Energy Research).

As mentioned, CREE (together with CICEP and UiO Energy) has applied for organizing the 2017 annual conference of the EAERE, This will hopefully be a door opener for new contacts and collaboration. The decisions will be taken in June 2015.

8. Gender balance

Describe how gender-related considerations will be incorporated into the centre's activities as well as plans for increasing recruitment of women.

Environmental and resource economics is probably one of the fields in economics with the best gender balance. This is reflected in the gender balance of CREE researchers. When it comes to the board and management team, two of five work packages are headed by a woman, and three out of six in the CREE board are women. Unfortunately, the funding of environmental and resource economics has been quite difficult the last few years, and we have therefore not been able to hire new researchers in permanent positions at the center, and we do not have any plans to hire new researchers, PhD students or Post Docs, beyond the regular hires at University of Oslo and Tilburg University. However, three out of four PhD students partly or fully funded by CREE at the Norwegian research partners are women.

9. Progress plan with milestones

The plan should provide a timeline for and describe the main activities and milestones, including project deliveries associated with the given milestones.

The progress plan and milestones will mainly follow the plan outlined in the original project description. All working packages will run until the summer of 2019. The activities will also follow the plan with several user partner activities (meetings and workshops at the user partners, user conference and a user seminar), research activities (seminars and the research workshops) and the Model Forum. In addition we plan to organize a media seminar where we will invite journalists, stakeholders and other non-experts. The first seminar is planned in 2015, and based on the experience with this, this may be an annual event.

10. Budget

General comments on budget situation. Action plans for the final three year period.

As described in "The Centre Self-evaluation", the budget situation is our main challenge. The direct annual funding of the center (NOK 9.1 millions) has been constant since 2011, thus the actual number of man months dedicated to research has been decreasing due to inflation and wage increases. In addition, our external funding, which mainly comes from the Research Council of Norway, has decreased, and we have less success with our research proposals than we had when the center started. This is particularly true for climate research, while the success rate has been higher for energy research. Thus, to be able to keep up activity, we need to get involved in new types of projects, such as the KPN projects described above, and look for new sources of funding (e.g., EU funding and Nordic Energy Research).

11. Costs distributed among the individual partners

An overview of how the project costs will be distributed among each of the R&D-performing partners is to be presented in table form.

Cost	**2014**	**2015**	**2016**	**2017**	**2018**
Frisch - Host institution	8 981	12 664	11 050	10 350	9 350
ØI UiO – Partner	2 378	1 800	1 500	1 200	1 200
SSB - Partner	6 609	8 000	7 000	7 000	7 000
Tilburg - Partner	500	500	500	500	500
Subcontractor	1 804	950	950	950	950
Total	**20 272**	**23 914**	**21 000**	**20 000**	**19 000**

12. Financial contributions from the individual partners

An overview of the partners which will contribute financially to the centre and their individual contributions are to be presented in table form.

Funding	**2014**	**2015**	**2016**	**2017**	**2018**
RCN FME-grant	8 252	8 600	8 608	8 307	7 518
Frisch - Host institution	4 631	7 464	5 542	5 343	5 132
ØI UiO – Partner	1 000	1 000	1 000	1 000	1 000
SSB - Partner	5 039	5 500	4 500	4 000	4 000
Tilburg - Partner	250	250	250	250	250
User partner	600	600	600	600	600
Other funding – UiO	500	500	500	500	500
Total	**20 272**	**23 914**	**21 000**	**20 000**	**19 000**

13. Environmental impacts

Describe whether and how the research conducted by the centre or the use of the results will have environmental impacts of significance (positive or negative).

Hopefully research from the center will have impacts on energy and climate policy both nationally and internationally. We also hope that our research will help the industry in making choices that lead to a transition towards a carbon-free society.

14. Plans for further activities after the eight year period of financing from RCN

Due to the difficult funding situation, it is hard to predict what will happen after 2019. However, CREE has made the research group stronger and has given us several new arenas to play on, such as EU projects, Nordic projects and KPN projects. We are also much more engaged in interdisciplinary activities, and we hope these will lead to new projects. One example is an initiative at the University of Oslo and CIENS, a research umbrella of environmental research institutions in Oslo, on smart cities in an energy perspective. There are plans for a common research proposal on this.

Signatures

Place and date OSLO / BERGEN 14 JANUARY 2015

Centre director
(Signature and name in print)

SNORRE KVERNDOKK

Chair of the board
(Signature and name in print)

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