

CICERO Report 2007:08

A note on social versus private value of the Halten CO₂ project

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Sammendrag: Rapporten samanliknar den samfunnsøkonomiske og bedriftsøkonomiske verdien av Halten CO₂ prosjektet. Dette er eit karbonhandteringsprosjekt i Midt-Noreg som inneheld eit gasskraftverk, fangstanlegg for CO₂, injisering av CO₂ for meiroljeutvinning, og lagring av CO₂ i ein akvifer under Kontinentalsokkelen. Eg finn argument for offentleg støtte til prosjektet p.g.a. læringseffekten og overføringsverdien av denne.

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Abstract: This report compares the social and private value of the Halten CO₂ project. This is a carbon capture and storage project in Mid-Norway comprising a gas-fired power plant, CO₂ capture facilities, enhanced oil recovery, and CO₂ storage in a sub-sea aquifer. I argue that there is a case for public support to the project due to spillovers in learning, i.e. knowledge with public good features.

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Preface

This report on the social and private value of the Halten CO₂ project is part of a broader study. The aim of the study is to assess institutional, political and legislative issues associated with the planned industrial project “CO₂ value chain from Tjeldbergodden to Draugen and Heidrun”, for short “the Halten CO₂ project”. The report is supplemented by a report on implementation issues under climate policy, written by CICERO (Torvanger et al. 2007) and a report on legislative issues, written by the Scandinavian Institute of Marine Law at University of Oslo (Berger, 2007). The three reports are part of a main study of the Halten CO₂ project, with the objective of evaluating the likely future conditions for CO₂ capture and storage projects in general and the Halten CO₂ project in particular.

1 Introduction

In this short report we compare the social and private value of the Halten CO₂ project. If the social value is the larger, one can make a case for public subsidies to the project or another form of public intervention. The analysis is mainly based on economic theory. The discussion in this report is qualitative and no numerical examples are included. Therefore we are not in a position to draw a specific conclusion regarding the social and private value of the Halten CO₂ project.

The social value is defined as the net value of the project for Norway, which is all benefits of the project, subtracted all costs. The private value is defined as the benefits of the project for private investors, subtracted their costs. This approach assumes that taxes or an emission quota system that correct for the global warming effect of CO₂ emissions are not fully in place since in that case the social and private value would coincide. A full account of the warming effect of CO₂ would put a price on emissions equal to the marginal damage (i.e. a 'Pigovian' tax), and would also provide an equal subsidy for capturing and storing CO₂.

The Halten CO₂ project is an early CO₂ value chain in Mid-Norway initiated by Shell and Statoil. It consists of four main components, where the first is a 860 MW gas-fired power plant linked to the methanol production facility at Tjeldbergodden. The power plant can also supply electricity offshore and contribute to regional electricity supply. The second component is facilities at Tjeldbergodden for capture of up to 2.25 Mt CO₂ annually. These emissions are associated with the power plant, transportation of the CO₂ to the Draugen and Heidrun oil reservoirs and injection of CO₂ at these sites. The third is enhanced oil recovery (EOR) at the Draugen and Heidrun oil reservoirs, and possibly other sites, which after the end of the project can serve as final storage for the CO₂. The fourth and last component is an aquifer, likely close to the Heidrun reservoir, which can be used for final storage of captured CO₂ that is not permanently trapped in one of the oil reservoirs. The elements of the Halten CO₂ project are described in some greater detail in Torvanger et al. (2007).

Recently, the feasibility of the EOR component of the Halten CO₂ project has been thrown into doubt. A study by Shell and Statoil concluded that CO₂-assisted EOR is not feasible at the Draugen field. The EOR potential at the Heidrun field is still being assessed. In case use of CO₂ from Tjeldbergodden for EOR purposes is not deemed feasible at all, there is still a possibility that the companies and the Norwegian government will agree on plans for a Carbon dioxide Capture and Storage (CCS) concept based on storage of CO₂ in a nearby aquifer.

Public subsidies to CCS projects in Norway raise other issues, such as government subsidies being legitimate under European Economic Area (EEA) rules. However, such issues are outside of the scope of this report.

Another issue outside the scope of this brief report is the role of the Norwegian tax system on petroleum activity for the comparison of private and social value of CCS, and more specifically the Enhanced Oil Recovery (EOR) component, see Jakobsen et al. (2005). A large share of the profits from enhanced oil recovery accrue to the state, and the high tax rate could potentially mean that companies do not carry out some projects that have a positive social value. (This debate includes a counterargument, namely that costs are covered by the state through the same tax system at a similar rate).

Government intervention could also be called for due to coordination problems generated by different ownership of different links in the CO₂ value chain. Such coordination problems are more important to the extent that the Halten CO₂ project is seen as the first step towards a larger linked infrastructure covering more sources, oilfields and aquifers. Government

intervention, possibly through ownership, is furthermore a solution if a large-scale pipeline infrastructure is being planned. This is due to 'economies of scale' (decreasing cost) in such infrastructure, which makes optimal pricing of transport services in pipelines difficult.

The present analysis focuses on the social value of the CCS and EOR elements of the Halten CO₂ project. It does not address potential costs and benefits of building the power plant itself. We then discuss the social value of carrying out the CCS and related EOR components, compared with a situation where a similar gas-fired power plant is built without CCS. Current concerns for electricity supply in the region offer some reasons to expect that new gas-fired electricity generating capacity will be introduced. Government involvement in such a project may also be motivated by electricity supply concerns (in the region and to offshore facilities) in combination with political targets. These concerns will not be addressed here. We thus start our analysis by assuming that a deficit in electricity supply in the Mid-Norway region leads to construction of a gas-fired power station at Tjeldbergodden. In the reference scenario the power station is built without CCS facilities. This implies that emissions from the power station must likely be covered through purchase of emission quotas. Two CCS scenarios are compared to the reference scenario. In the first CCS scenario a gas-fired power station with CCS and EOR is constructed, see section 2. This scenario is in line with the original Halten CO₂ plans. In the second CCS scenario a gas-fired power station with CCS but no EOR is constructed, see section 3.

2 Social versus private value of the Halten CO₂ project

To illustrate the principle issues involved we look at a schematic case of a CCS project that is to be realized or not. The project involves a gas-fired power station, capture facilities, and pipeline to storage sites. CO₂ is stored in oil reservoirs suitable for EOR. In addition an aquifer is included, suitable for storing CO₂ that is not permanently stored in the oil reservoirs.

Now there are two questions that must be answered for the government to consider public support in terms of contributing to funding of the project:

- a) Is the project sufficiently profitable to be realized based on the private investors' interest in the project (i.e. is the private value positive and large enough)?
- b) In case the answer to a) is no, is the social value larger than the private value, and is it positive and sufficiently large such that the government wants the project realized? (An additional question not addressed here is if it has a positive social value, but with a larger positive value when buying quotas in stead of using CCS.)

A CCS project is only candidate for government subsidies given that the answer to question a) is no and the answer to question b) is yes. With a) being answered affirmatively, we shall understand that the investor finds that the CCS project has a positive value under a quota market, the assumption being that quotas will have to be purchased in full either for the small emissions after CCS or for the large emissions without CCS. If the answer to a) is yes the project should in any case be realized without public subsidies, no matter if social value is larger than private value.

CO₂ value chains with EOR have been seen as the most promising route to the realization of CCS projects. However, so far most studies conclude that such CO₂ value chains do not have a positive private value and it is not certain that the social value is positive, see e.g. Gassco et al. (2006). The value of EOR is i.a. sensitive with regard to oil price, the climate value of storing CO₂ (i.e. the quota price), and large investments in the value chain in terms of pipelines and CO₂ capture facilities. In the case of CCS projects we therefore assume that the

answer to question a) is no. Thus the more interesting question is b). In this brief report we will limit the focus to discuss reasons why the social value may be higher than the private value, which is a prerequisite for public subsidies to CCS projects. We will not discuss what share public subsidies should have of the total project cost. The government could either supply enough additional funding that the project will be sufficiently profitable for the project developers and thus be realized, even if this is less than the additional social value. Alternatively the government could give a public subsidy equal to the whole difference between social and private value. (In the interest of building a CCS plant at minimal cost authorities could use a specially designed contract – referred to as an “incentive contract” in economics.)

In the following we discuss some reasons why the social value of a CCS project could be larger than the private value, and to what extent these apply to the Halten CO₂ project.

2.1 Technological innovation and spillover effects

For CO₂ capture and storage to mature as a greenhouse gas mitigation option, technological improvements are still required to reduce costs and further improve confidence in the reliability of storage. Today projected CCS costs by far exceed estimated quota prices for the next couple of decades. This requires research, development and demonstration (RD&D) of new technologies. But equally important, it requires practical experience with designing and operating integrated CCS systems on a commercial scale. Such experience should lead to learning-by-doing benefits and potential cost savings. While CO₂-assisted EOR is an established industry practice onshore, it has not been tried in offshore oil fields. Adapting methods for CO₂-assisted EOR to an offshore context would also involve learning benefits.

From economic theory it is well established that there is likely to be underinvestment in technologies by private companies since the social value is higher than the private value. Other firms will learn from the investing firms' efforts, so benefits of the efforts are not fully captured by the investors. In economic terms this is an example of a positive externality. This is likely the case for CCS technologies. Both with regard to RD&D and learning by doing there is likely to be substantial *spillover benefits*, meaning benefits from the project that accrue to others than the project owners. The experience gained making CCS less costly and more feasible has a value to other prospective investors, firms and nations involved or interested in CCS. For Norway and the global community there could be a very high value to improved CCS technologies and industrial application if CCS turns out to be one of a few major options to mitigate man-made climate change through reducing CO₂ emissions. Such benefits could accrue to owners of fossil reserves, owners of storage sites, users of fossil fuels, and engineering firms, etc. The external benefits of knowledge generation are generally acknowledged to be the rationale for government funding of education and research, and more so for basic research than for applied research. In the applied end, protection of intellectual property is instituted by government to facilitate private rewards, and often is supplemented with subsidies for early application (one example is subsidies for renewable energy sources).

If the social value of a project is higher than the private value, government intervention could take the form of subsidies, direct regulation, or (partly) public ownership to make certain that the project is carried out. In the more general case where the scale of the project can be varied, government subsidies could make certain that the scale of the project becomes as large as prescribed by the social value. Asymmetric information on the private value of the project could be a challenge in such a setting, since private investors have incentives to understate the private value of the project in a situation where public subsidies are possible.

What sets the Halten CO₂ project apart from similar projects under way in Norway (Mongstad, Kårstø) and also most planned projects abroad is that it involves an offshore EOR component, and final storage of some of the CO₂ in abandoned offshore oil fields. The offshore EOR features of the project are most likely to lead to large learning benefits. Thus inclusion of EOR in the project could be an argument for a relatively larger public funding. The post-combustion capture and aquifer storage elements will be less unique to the Halten CO₂ project, and the spillover effects from technological learning would probably offer less compelling arguments for government contributions in case the EOR component is scrapped. Still, this would be an early full-scale CCS project, which would contribute to the learning curve for capture, transportation and storage along with other projects. A scenario where a Halten CCS project is completed without EOR is discussed in section 3.

A related angle on improved CCS technologies is to consider this as a type of “global public good”. The two requirements for a *pure* public good is non-rivalry in consumption, which means that one consumer’s use of the good does not reduce the value of the good to others, and non-excludability, which means that the producer is unable to prevent others from using the good. The general result from economic theory that these features leads to too low investments in public goods by private interests, basically because they are not able reap (enough) profits for the investments. Thus there is a place for government intervention.

One can argue that efficient (low-cost) CCS technologies has public good characteristics in the sense that knowledge of improved CCS technologies can be utilized across the World without diminishing the value for e.g. Norway or an oil company applying the technology to reduce its emissions. Of course the argumentation changes if this is seen from the perspective of the technology developer, who wants to reap profits from the investments made, for instance with the help of patents. One can also argue that the second criterion for a public good is satisfied since it is difficult to stop the diffusion of new, efficient CCS technologies. And even more strongly phrased, for the joint benefit of controlling man-made global warming this technology should have the widest diffusion possible.

From this public good perspective there are thus further arguments for public subsidies for developing more efficient CCS technologies, both for securing large enough investments in such projects, and with a view to secure the widest possible diffusion of these technologies. In the case of a CCS project, possible solutions are funding support from the government (where there should be a clause related to less restrictions on diffusion of the technology, e.g. in terms of reduce patent period), or partly public ownership. Other alternatives for the government is to guarantee a fixed (and high enough) price on the captured and stored CO₂ from applying the technology, or organizing a bidding process whereby firms are invited to plan and construct CCS facilities that yields most mitigation of CO₂ for a specified amount of money spent.

2.2 Planning horizon and discount rate

The value and profitability of a CCS project depends on assumptions made with regard to project horizon, discount rate, expectations on the climate value of capturing and storing a ton of CO₂ at some point in future, expectations on cost of CCS per ton of CO₂ in future, expectations on gas, oil and coal price, other energy sources, the potential of renewable energy sources and more energy-efficient equipment, etc. (see Barrio and Tangen 2006 for an assessment of CO₂ price scenarios). Furthermore one must assess the level of risk investments are exposed to, and decide willingness to take on risk (that is compensation required to take on risk, measured as the degree of risk aversion, first and foremost for the government).

In all these respects the government may make different assumptions or expectations compared to private firms. One example is that the government has a lower discount rate (or accepts a lower internal rate of return) since society’s climate strategy is based on a longer

time horizon. The focus of private firms is on optimal return on invested capital. Another example is risk attitude, where one could argue that society should be risk neutral, whereas private investors have some degree of risk aversion.

Such differences in assumptions can lead to a CCS project being less attractive for private investors but the government wants it realized. Again this is an example of a situation where public support, e.g. in terms of investment subsidies, could be warranted.

3 The Halten CO₂ project without EOR

Offshore EOR and permanent CO₂ storage in oil reservoirs are the components that most clearly set the Halten CO₂ project apart from other CCS projects underway in Norway (Mongstad, Kårstø) and also most planned projects abroad. These are therefore the elements likely involving the most important learning-by-doing and spillover benefits.

However, it appears that the use of CO₂ for EOR in the Draugen and Heidrun fields may not be economically attractive from a private viewpoint. Given this, an alternative scenario that the developers and the government of Norway may consider is a pure CCS project with post-combustion capture at Tjeldbergodden and storage in an aquifer on the continental shelf.

The post-combustion capture and aquifer storage elements will not be unique to the Halten CO₂ project. Without EOR, the characteristics of the project would be less distinct from other planned and ongoing efforts. Consequently, the spillover effects from technological learning would probably offer less compelling arguments for government contributions to this particular project under this alternative scenario.

That is not to say that there would be no learning benefits from the project. It would still be an early full-scale CCS project, which would contribute to the learning curve for capture, transportation and storage along with other projects. Arguably there is a need for a large number of full-scale CCS demonstration projects worldwide.

In order to maximize the social value of a Halten CO₂ project without an EOR component, one can take a close look at how the project can be designed so as to incorporate new technological solutions and design elements where there seems to be a promising learning-by-doing potential. Such elements may strengthen the case for government subsidies.

4 Is there a case for public subsidies?

In this report we have discussed reasons why the social value of the Halten CO₂ project may be larger than the private value, and thus be a candidate for public subsidies. The discussion has been performed under the assumption of a general incentive for CO₂ reductions, as with a quota price paid for all sectors. Thus, the ‘subsidy’ discussed here is for an incentive over and beyond this. The “public good” reasons for providing such a benefit must be grounded primarily in spillovers from learning.

The main reasons are due to technology learning-by-doing and spillover effects and the possibility that the government’s calculation of benefits and costs of the Halten CO₂ project is based on other assumptions than private investors.

We find that off-shore EOR is the project component that likely has the largest learning-by-doing potential, and that the social value of the total Halten CO₂ project is likely reduced without EOR. This learning-by-doing aspect and associated technology spillover potential therefore could be an argument for a relatively larger public subsidy of the project. In the absence of an EOR component in the Halten CO₂ project, the likelihood for public subsidies

to be justified would increase if new technological solutions and design elements are included. To identify and maximize learning-by-doing effects Norway should, in coordination with efforts by EU and other interested countries, develop and test different CCS technologies and designs, allocate public subsidies towards a variety of technologies, solutions and designs so that these can be tested and compared.

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