Short-term objectives and direct impacts versus long-term energy efficiency: A case study of Norway's energy agency model

Håvard Solem
Enova SF
Abels gate 5
NO-7030 TRONDHEIM, NORWAY
havard.solem@enova.no

Andreas Krüger Enge
Enova SF
andreas.k.enge@enova.no

Anita Eide
Enova SF
anita.eide@enova.no

Keywords

Energy agency model, short-term impacts, long-term efficiency, institutional setting, cost efficiency

Disclaimer

Any opinions expressed are those of the authors and not those of the Norwegian Ministry of Petroleum and Energy, or Enova SF.

Abstract

Energy agencies make prioritizations among which measures and programs to implement, and which projects to support or to take part in. Further, the energy agencies' results vary with respect to whether the results are direct or indirect, and whether they are realized in the short-term or long-term. In addition, the agencies' resources must be used cost efficiently. The main point in this paper is to demonstrate that one must be aware that the organization and design of the energy agencies have important implications for how they conduct their everyday business. Hence, the accomplishments of the agency coincide with the owners' overall goals for the agency only if the design of the agency allows it to make the right decisions. To discuss this issue, we construct a general energy agency model and discuss the Norwegian model in light of the general model, pointing to the shortcomings and the potential for improvement.

Introduction

Increasing production of renewable energy and energy efficiency measures are often profitable from society's point of view but not necessarily for the decision maker being public or private enterprises, or the individual household or consumer. This happens mostly because third party effects are not accounted for when decisions are based on individual costs and benefits. However, it is more puzzling that we often observe that efficiency measures are not implemented in cases where the individual decision maker's benefits outbalance the costs. In general we find that a number of obstacles are precluding sound investments and rational behavior, ranging from economic and organizational factors to lack of information and policy measures aimed at other focus areas. To remedy what seems to be an inherent problem, a number of countries have established energy agencies aimed at increasing the production of renewable energy and/or energy efficiency measures.

This paper addresses a general issue related to the operation of energy agency activities and the fact that agencies operate within an objective structure and are influenced by political, social and economic factors, which all have important impacts on the agency's prioritizing of instruments and targets. More specifically, the discussion demonstrates that the way the agency is organized, its relation to its owners, customers, the market and other government bodies, strongly influences the practice of the energy agency. However, we do not analyze the economic efficiency of the various ways one can organize an agency *per se*, but instead focus on the implications that follow from how the energy efficiency agency is designed.

The paper elaborates on a general agency model and later discusses the Norwegian agency model in light of the general discussion. The different issues are discussed along two dimensions, namely the direct and indirect, and short-term

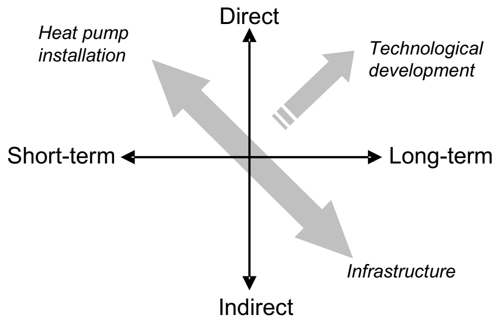

Figure 1. *Impacts are generally found along two dimensions, short-term and long-term, and direct and indirect. The arrows are indicating where we typical expect impacts to occur, and examples are in italics.*

and long-term (see Figure 1). The typical constellation is a menu of measures leading to direct impacts in the short-term as a contrast to measures producing indirect effects that can be seen only in a long-term perspective.

The relationship between an energy agency and its owners is often characterized by asymmetry in available information and a difference in the goals for the agency as the agency can have an agenda of its own in addition to the official goals. Hence, the situation often resembles a classical principal-agent problem, but we choose not to go very deep into principal-agent theory issues, but are more concerned with the narrower question of how choices made by the agency is affected by the institutional setting. The reason for this is that our main concern is not as much related to informational advantages and disadvantages as it is to the institutional setting. By institutional setting we understand the agencies relation to its owners, as well as how it interacts with its customers. For the same type of reasons we do not dig into contract theory, game theory or negotiation theory.

The next section gives a brief overview of the different ways of organizing energy agencies around the world, before we sketch the situation prior to the new Norwegian energy agency Enova. The main characteristics of Enova are presented before we develop a general energy agency model. Following a discussion of the general case, the Norwegian energy agency model is presented. Today's situation is compared to the previous regime, and benefits and limitations of both models are analyzed. The next section takes a critical view of more general issues related to the design of energy agency models. The last section concludes.

Energy agency models

Many industrialized countries have state-owned or private agencies with the objective to increase energy efficiency and in some cases combined with an aim to increase production of renewable energy. The organization and design of the agencies differs in many respects and consequently does their prioritization among the choice of measures, goals and time perspectives.

The financing of the agencies' activities ranges from funding through participation in projects receiving financing from the EU, national governments to public grants, levies on electricity distribution tariffs, etc. The goals also differs with respect to aspects such as cost efficiency, direct and indirect energy results and activities such as general information, awareness campaigns etc. In addition there is a possibility to dedicate the agencies' efforts to all aspects of energy use or to focus only on demand side issues or on the supply side providing financial support to producers of renewable energy. One must also consider where in the product chain the effort is to be targeted. Should the agency develop programs aimed at research activities, technological development and educational measures?

The core issue is that agencies typically must choose from a range of programs and projects with different characteristics with respect to when and how the effects occur. With reference to Figure 1, the typical situation is one where a project has a short-term direct impact and indirect impacts in a long-term perspective. We may also see that the direct impact is achieved in the longer run, especially if the program is aimed at building different kinds of infrastructure, which takes time to implement. Obviously, if the agency's goal is set to increase research aimed at increasing energy efficiency and the deployment of this new technology, the agency cannot focus on short-term energy results. What is more important is the relationship between the design of the agency and how this affects the day to day operations of the agency. What is important to be aware of is the danger of creating situations where the design of the agency and its consequences for the resulting strategies conflicts with the goals set by the agency's owners. The owners should therefore state a strategy and a goal for the agency and then use this as a basis for the organization and design of the agency. For example, there should be consistency between performance measurement and the overall target for the agency.

Norway's energy efficiency efforts prior to Enova

Prior to the establishment of Enova the responsibility for energy efficiency efforts was shared between the Norwegian Water Resources and Energy Directorate (NVE) and the utilities. NVE regulates the electricity sector on behalf of the Norwegian Ministry of Petroleum and Energy. It was charged with implementing energy efficiency and renewable energy policy prior to the birth of Enova and it did so through mainly through its four operatators (buildings; industry; information and training; and campaigns). Investment aid was provided to promote wind power, renewable heat production, waste heat and heat pumps. The energy efficiency efforts consisted mainly of information, training and education measures targeting the building sector and industry. Information campaigns and a telephone helpline were the main measures aimed at the household sector.

NVE's various roles meant that the pursuit of energy efficiency objectives in some cases came in conflict with other tasks of the regulatory body such as licensing of new generation and the regulation of the tariff and revenue structure of the grid operators. That is, the directorate had to balance the societal interests and environmental issues associated with licensing new generation against the active pursuit of promoting more development of wind power and heat power plants.

After the deregulation of the electricity market in 1991 the local grid operators were mandated to provide neutral information and advice about how to achieve energy efficiency and energy savings to end users. The government encouraged the grid operators to establish regional energy efficiency centres as a mechanism to deliver these services. The costs of operating the centres and implementing the energy efficiency activities were funded through a levy on the distribution tariff of 0.2 øre per kWh (0.025 Eurocent per kWh). In 1998, the number of agencies was 20 - one covering each region of the country.

Weaknesses characterizing this way of organizing energy efficiency activities was a lack of coordination between NVE and its operators on the one hand and the grid operators and their regional energy efficiency centres on the other. The efforts were fragmented, without set quantitative goals as to how much energy efficiency or how much new generation from renewable energy was supposed to be achieved, activities were not systematically logged or monitored and not subjected to periodic evaluations. The different centres chose different strategies to increase energy efficiency and a detailed and comprehensive overview of the activities that were carried out did not exist. Moreover, energy efficiency was never the core business of grid operators, which meant that there were contradicting incentives – the revenue structure meant that the grid operators were rewarded for maximizing the sale of electricity, thus they had no real incentive to encourage energy savings and energy efficiency. The organization of activities was fragmented and coordination was sketchy. There was a lack of flexibility with respect to policy measures and few incentives existed to encourage the centres to focus on cost effectiveness. All of these factors were part of the backdrop that led the Norwegian government to consider new models for organizing government sponsored energy efficiency efforts.

Norway's new energy efficiency agency: Enova

By gathering strategic policy responsibilities in a small, flexible and market oriented organization, Norway wanted to create a pro-active national agency that should be able to stimulate energy efficiency by motivating cost-effective and environmentally sound investment decisions. Enova, the new energy efficiency agency, was operational by January 1, 2002.

Enova is a public enterprise owned by the Norwegian Ministry of Petroleum and Energy, which set the following specific targets for the new agency (White Paper nr. 29 of 1998-99):

- to increase annual use of water-based central heating based on new renewable energy sources, heat pumps and waste heat of 4 TWh by the year 2010;
- to install wind power capacity of 3 TWh by the year 2010;
- and increase environmentally friendly land-based use of natural gas.

When it comes to energy efficiency, the following goal is stated in the White Paper: *Enova shall facilitate a substantial reduction in the growth in energy use compared to what would happen if Enova had not existed*. In Enova's contract with the Royal Norwegian Ministry of Petroleum and Energy, this goal has materialized itself as a residual term of 3 TWh. This gives Enova a total goal of 10 TWh to be provided by the end of 2010, which is approximately 10 percent of Norway's electricity use in 2000. The contract was renewed in 2004, where the main changes are an increase in the total goal to 12 TWh, leaving the technology specific targets unchanged, and discretion to focus more on contributing to technology development.

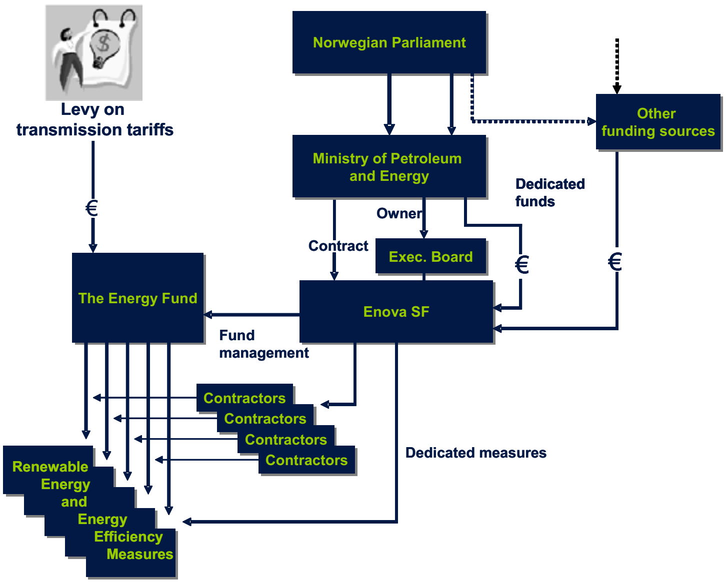

Figure A.

To achieve its objectives, the Norwegian Parliament set up an Energy Fund and indicated grants within a framework of up to NOK 5 billion (app. 650 million Euro) over a ten-year period. The funding was based on a levy on the electricity distribution tariffs and from ordinary grants over the national budget, but as of 2005 the funding is based only on a levy on the electricity distribution tariffs. Enova is the manager of the Energy Fund, which finances programs and initiatives that support and underpin national objectives. Enova is given some discretion with respect to choosing its policy measures and establishing incentives and financial funding schemes that will result in cost effective and environmentally sound investments. Enova works through subcontractors, on a competitive basis, and the contracts reflect commercial terms. Enova also cooperates with other public institutions, hereby the ministries of Environment and Petroleum and Energy, and with several directorates, on a strategic level.

A general energy agency model

In this section a formal presentation of the objective function for a general energy agency is offered. Assume that we have an agency with a contract with its owners defining a budget constraint and a specified energy target that should be reached by year *T*. The target can include direct and indirect impacts related to a baseline. The agency's general goal can therefore be formulated as maximizing an energy result given a budget, in addition to a minimum energy result to be accomplished:

$$\max_{x_{i,t}, z_{i,t}} \sum_{t=0}^{T} \Omega_t = \sum_{i=1}^{n} \sum_{t=0}^{T} \omega_{i,t}$$

subject to a budget constraint, $\overline{Y}$,

and an energy target, $\overline{\Omega}$

where the annual energy result (Ω_t) consists of individual projects ($\varpi_{i,t}$)which is a function of the direct ($\mathbf{x}_{i,t}$)and indirect effect ($\beta_{i,t}$) : $\varpi_{i,t} = \varpi_{i,t}(x_{i,t}, \beta_{i,t})$. Further, $x_{i,t}$ denotes the direct number of GWh's in project i, project area i or program i, at time t, whereas $\beta_{i,t}$ indicates the indirect number of GWh's that is expected from project i at time t, given as $\beta_{i,t}(x_{i,t}, x_{j,t}, z_{i,t}, E_{i,t})$ e.g. a function of other projects ($x_{j,t}$), indirect measures without a direct energy result (information campaigns etc.) ($z_{i,t}$), and exogenous factors such as government policy, business cycles etc ($E_{i,t}$). Notice that $\beta_{i,t} > 0$ indicates positive indirect impacts (market transformation), whereas $\beta_{i,t} < 0$ reflects a net rebound effect reducing the overall energy result from the project. Rebound effects can be caused by premature technological lock-ins, increased energy consumption caused by lower prices due to increased production etc., which can be traced back to earlier measures supported by the agency.

The energy target Ω_t, denotes the total number of GWh in year t, and $\overline{\Omega}$ is the target number for total energy savings and/or increased production of renewable energy. The energy savings and production target can be specified on an annual basis or related to an accumulated target at some specific point in time:

$$\Omega_t \geq \overline{\Omega_t} \text{ or } \sum_{t=0}^{T} \Omega_t \geq \overline{\Omega}$$

The indirect measures, denoted $z_{i,t}$ include activities such as the number of informational and awareness campaigns, educational lectures, publications, etc.

The expenditure in year t is found as

$$Y_t = \sum_{i=1}^{n} p_{i,t}\omega_{i,t}$$

where p_i denotes the unit price of total GWh produced ($x_{i,t} + \beta_{i,t}$)

$$p_{i,t} = \frac{c_{i,t}}{\omega_{i,t}}$$

Here $c_{i,t}$ is the cost faced by the agency, i.e. investment aid and administration of the program, related to investments in project i at time t, which is assumed to increase with x_i (the marginal cost of energy efficiency is increasing). To capture the total cost for society the cost should in principle also include negative third party impacts, so called external costs.

The budget is restricted by $\overline{Y}$. This constraint can be formulated either as:

$$Y_t \leq \overline{Y_t} \text{ or } \sum_{t=0}^{T} Y_t \leq \overline{Y}$$

The main difference is that the first constraint restricts the agency's activities to the size of the annual funding, whereas the second alternative allows the agency discretion with respect to allocating its budget over its time horizon.

The Norwegian case

As pointed to above, the regional utilities were instructed to establish and to offer funding for energy efficiency agencies in its own region. The regional agencies conducted several activity based operations subject to a yearly budget. Their objectives can be summarized as:

$$\max_{z_l} \sum_{l=1}^{m} z_{l,t} \quad \text{s.t.} \quad Y_t \leq \overline{Y_t}$$

As the focus was mostly on initiating and administrating activity based projects, it was paid little attention to the quantitative energy savings results and cost efficiency as criteria for prioritizing measures or focus areas. Moreover, there is nothing in the model that ensures that cost efficiency is attained, there is no coordination between agencies and the individual agency has little flexibility with respect to allocating resources over time and choosing the most efficient measures.

By establishing Enova the Norwegian government wanted the resources allocated to energy efficiency efforts to be more focused on the actual energy production and energy savings. Given the explicit energy production targets the prioritizing of projects should be based on cost-efficiency. The energy target and the budgetary conditions Enova works under can be expressed as:

$$\max_{x_{i,t}} \sum_{t=0}^{T} \Omega_t = \sum_{i=1}^{n} \sum_{t=0}^{T} \omega_{i,t}$$

$$\text{subject to} \quad Y_t \leq \left(\sum_t \overline{Y_t} - \sum_{t-1} Y_t \right),$$

$$\sum_{t=0}^{T} \Omega_t \geq \overline{\Omega}, \text{ where } \omega_{i,t} = \omega_{i,t}\left(x_{i,t}, \beta_{i,t}\right)$$

As is evident from the objective function Enova's target is to save as many GWh's and increase the production of renewable energy as much as possible. However, a number of complicating issues follows. Each of the below listed issues will be discussed:

- The energy result can be made up of projects with indirect as well as direct effects. The measurement and verification of the results is an issue by itself, but also the way these effects are measured influences the prioritizing of the agency's funds.

- When are the results set to be reached? Related to the fact that it takes time before the results come in to effect this have some important implications for the prioritizations made by the agency.
- Since the agency is restricted by a budgetary constraint cost efficiency follows from the objective function. On what grounds should cost efficiency be evaluated?
- Note also that Enova's budget constraint is designed so that the agency can save funds one year and use it later, but not borrow funds from future funding. This means that the agency has some degree of flexibility with respect to allocating funds over time.

DIRECT VERSUS INDIRECT IMPACTS

The main goal set for Enova is a specified increase in the production level of energy from specific technologies (wind, heat) and increased energy efficiency. Enova can allocate its funding schemes to projects that produce direct as well as indirect production or reductions in energy use. The distinction of direct effects as compared to indirect effects is not trivial, but turns out to be rather important.

A criterion set by Enova's owner is that the reported energy results must be justified. To ensure that this criterion is fulfilled, Enova has focused on activities with direct impacts, where the direct energy result is specified in a contract between the agency and the project owner. While Enova offers investment aid to the project, the project owner signs a contract which obligates the project to produce the specified amount of kWhs. The rationale behind choosing this approach is that it is the alternative with the lowest costs related to measurement and verification of the energy results which is believed to more than fulfill the criterion set by Enova's owner for justifying energy results. To ensure that the energy savings or production is carried out, Enova requires that the results from the projects are reported in the subsequent 5-10 years.

Two implications follow from this. First, the project faces no incentives to measure indirect effect, thus leaving out possible market transformation and rebound effects:

$$\sum_{t=0}^{T} \Omega_t^* = \sum_{i=1}^{n} \sum_{t=0}^{T} \omega_{i,t}^* >$$

$$\max_{x} \sum_{t=0}^{T} \Omega_t^{Enova} = \sum_{h=1}^{n} \sum_{t=0}^{T} x_{h,t}$$

subject to the budget and the energy target

where the asterisk indicates the theoretical optimum. The main point is that without all relevant information available Enova are not able to choose the theoretical optimal portfolio of projects and measures. This holds regardless of whether is positive or negative. If we have positive indirect effects these are neglected and less than the optimal amount of resources are allocated to this program. If rebound effects are present, too many resources are allocated to the project. The second implication is that projects with most of the effect being indirectly related to the projects will not be preferred. Because indirect effects are more difficult to measure, this means that the project owner faces a higher risk compared to a project obligated only to produce direct impacts. The higher risk is also faced by Enova, which has an obligation towards its owner. Thus, projects with relatively small direct impacts and large indirect impacts (e.g. market transformation etc.) are not able to compete with other projects.

COST EFFICIENCY

The agency model implies that Enova must make efforts to attain as many kWhs per euro as possible. From the model we have that the expenditure in year t is given as:

$$Y_t = \sum_{i=1}^{n} p_{i,t}\omega_{i,t}$$

where p_i denotes the unit price of the total production of GWh in project i according to:

$$p_{i,t} = \frac{c_{i,t}}{\omega_{i,t}}$$

However, measurement and verification of indirect effects are not straightforward. In order to increase the amount of relevant information it is necessary to allocate resources to develop a methodology and the necessary tools. In addition, there will always be present a degree of uncertainty as to whether the estimate on indirect effects is as accurate as one ideally would like. The complexity of today's societies has reached a level where the costs associated with gathering and analyzing all of the information needed to make the *optimal* decisions is far greater than the benefits of doing so. As a consequence the agency recognizes that it is easier, i.e. lower costs, related to make allocations based on the direct effects only. A cost reducing approach is to use the following identity to identify what can be seen as the price for each kWh faced by Enova:

$$p_{i,t}^* = \frac{c_{i,t}}{x_{i,t}}$$

Notice that the calculated unit price can be both higher and lower than the theoretically correct depending on the indirect impacts are positive (desired market transformation) or negative external effects. Thus, when decisions are based on cost-efficiency as defined above, there is always the chance of misallocating funds since the price does not include all of the relevant information. Energy agencies should gather an amount of information which enables it to perform a reasonable analysis of how to best allocate its resources. By this one must look at the costs associated with measuring and verifying indirect effects to the benefit of establishing a system for doing this.

Another factor that should be taken into consideration is the duration of the effects from a project. As the agency is interested in the total energy savings or production, it is of relevance how "durable" the effects are. When the reported result is aggregation of yearly production of energy, the lifetime of the project will generally be the same as the total time for depreciation of the capital or the economic lifetime. For energy efficiency measures the lifetime of the energy results are less clear-cut to determine, which means that the agency must deal with uncertain estimates for the energy result. With respect to reporting to its owner, this means that Enova must clarify its procedure and underlying methodology that is used to determine the reported results.

As the total amount of funding available is less than the total amount of funding in the projects applying for financial support, there is need for criterion that can be used by Enova to rank the individual projects. Transparent methodologies are important in themselves, but with respect to durability of the energy result in projects, it is important also because projects are ranked according to the unit price on kWhs. All else equal, this implies that the longer it is likely that the energy results from the project prevails, the better are the chances of receiving funding from Enova.

TIME HORIZON AND INDIRECT IMPACTS

The size of any indirect impacts following a project or the implementation of a measure will generally be dependent on the type of project, related projects, the implementation of other measures, e.g. information campaigns, and external factors such as national policy on different policy areas. And as mentioned above, it is possible to have both negative and positive indirect impacts. Increased investment aid can lead to larger production of energy with a possible downward pressure on energy prices which can increase total energy consumption.

When considering different projects one should make assessments of the total indirect impacts over time in order to make rational decisions, as indirect impacts typically will come into effect over time. Moreover, the type of impact can change from being positive on a short and medium term perspective to become negative in a longer time perspective.

Above, the indirect impacts are denoted as:

$$\beta_{i,t} = \beta_{i,t}\left(x_{i,t}, x_{j,t}, z_{i,t}, E_{i,t}\right)$$

Figure 2 illustrates three different programs characterized by three different time paths for the aggregated indirect impacts (see). The figure shows that which of the three programs a, b or c that will be chosen depends on the time horizon of the agency (assuming that the direct effect is equal and that programs are chosen based on the total impacts). In other words, the choice of programs is depending critically on whether the energy result of the agency is set for time t_1 or t_2. If each category of measures is correlated differently to the time from implementation to the effect is realized, a shorter time horizon will imply that measures with relatively large impacts in the short run will be prioritized. Further, if the effect of energy savings measures take longer time to show up compared to measures directed towards increased production of renewable energy, we may see a systematic discrimination against savings measures. Apparently, it is of crucial importance for the owners of the agency to make sure that the design of the agency, its objective function and time horizon all are coherent with the overall target set for the agency. If not, we may see a mismatch between the perception of what the agency should accomplish and how it actually prioritizes in its day to day business.

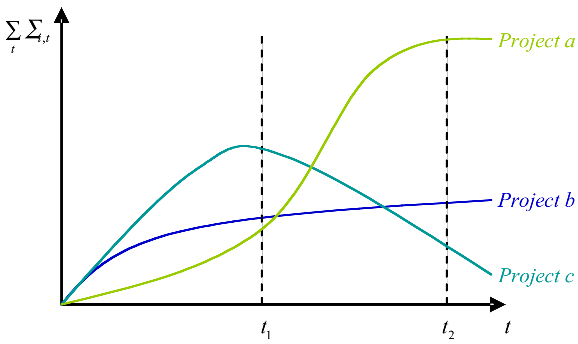

Figure 2. *The choice of projects is dependent on the time horizon of the agency and the characteristics of the indirect impacts over time.*

Table 1. Aggregated contracted energy results, GWh (2001-2004).

Program	2001	2002	2003	2004	Total
Energy use	372	394	412	646	1 824
Wind power	120	80	450	1 023	1 673
Heat	328	289	862	518	1 997
Other renewable	0	1	0	35	36
Total	820	764	1 724	2 223	5 530

BUDGETARY DISCRETION

In general we have two models for budgetary discretion with regards to transferring of funds between years:

The budget is given on a year to year basis:

$$Y_t \leq \overline{Y_t}$$

The agency has a given amount of money that can be used each year but is also allowed to transfer unused funds to the next year:

$$\sum_{t=0}^{T} Y_t \leq \overline{Y_t}$$

In general, the agency will be able to run its operations more efficiently the more discretion it is given. The ability to save funding and to be able to use it later increases the opportunity to take advantage of situations in the markets, to focus on specific technologies or market segments, and to have the discretion to not spend the entire yearly budget when this means spending it on less cost efficient measures or projects.

For example, if an agency wants to wait for important information about a certain technological development one may avoid implementing measures today which can postpone the implementation of an alternative, and better, technology. This kind of technological lock-in is an example of costs associated with a situation where one is not able to allocate funds over time more than one year ahead.

Table 2. Energy results and use of funds, 2004.

		Number of projects [1]	GWh	Mill. Euro [2]
Energy use		188 (159)	646	17.2
	Housing, buildings, lighting	*133 (110)*	*290*	*10.1*
	Industry	*55 (49)*	*357*	*7.1*
Wind power		8 (7)	1 023	47.2
Heat		37 (31)	518	13.3
Other renewable		4 (2)	35	4.1
Total		237 (199)	2 223	81.8

[1] Number of projects with contracted energy results in parentheses

[2] Total amount of investment support, including administration costs.

Table 3. Projects' life time and cost efficiency (2003, 2004).

		2003		2004	
	Average lifetime	Euro/kWh	Euro/kWh over project's lifetime	Euro/kWh	Euro/kWh over project's lifetime
Energy use	10 years	0.029	0.003	0.027	0.003
Wind power	20 years	0.025	0.001	0.047	0.002
Heat	20 years	0.012	0.001	0.026	0.001
Weighted average	15 years	0.020	0.001	0.037	0.002

Enova results 2001-2004

Enova is making efforts to improve the basis for the decisions made in throughout the organization. Areas of special attention are identification of baselines for the different sectors, developing methodologies for estimating indirect effects and tools for handling uncertainty and risk. A baseline for energy consumption in households are identified, and projects with the aim of identifying baselines for energy consumption in industry and the public sector have been started. In addition, Enova has developed an application for determining the level of investment support on a project level.

Up until now the results reported by Enova is, as mentioned above, an aggregate of the energy results found in the contracts between Enova and the project owners. The numbers reported in Table 1 consists therefore of direct effects from the projects.

The trend is that Enova has increased its energy result over the years and that the increase is seen in all program areas. Relative to the goal of 3 TWh wind power and 4 TWh water based heat in 2010, Enova seems to be ahead of schedule. In addition there has been identified large potentials for the programs aimed at energy use, especially in the housing sector.

The most distinguishing differences between programs are the number of projects within each. In 2004 there was a range from 2 projects in other renewable energy production (wave and geothermal) and 7 wind power projects, to 110 projects related to housing, commercial buildings and lighting (see Table 2). Another characteristic feature is that the size of the projects in monetary terms also differs greatly. The average size of an energy use project was 0.1 million Euro, whereas the average size of wind power projects was almost 7 million Euro. The average for all programs was 0.4 million Euro. The same variation is seen in the energy result per Euro given in investment support. The lowest average is 0.02 million Euro/GWh in the program for energy use in industry, whereas the average for energy production from what is denoted other renewable (wave, geothermal, solar, etc.) is 0.1 million Euro/GWh.

Table 3 reports the Euro/kWh for each of the largest programs on an annual basis as well as for the expected duration of the projects. The most cost efficient is projects with production of water based heat, with a cost for Enova of 0.001 Euro/kWh. The life time of projects under the Energy use program is more uncertain but with an estimate of an average 10 year duration of energy results, we find that Enova has paid 0.003 Euro per kWh in 2004.

Concluding remarks

Norway has moved from a situation with shared responsibility for energy efficiency and renewable energy production between the Norwegian Water Resource and Energy Directorate and the utilities, to a model where a national energy agency, Enova, acts as the manager of an Energy Fund. Focusing on market orientation and cost efficiency, Enova establishes incentives and offers funding schemes so that subcontractors and market actors are able to implement efficiency measures and increase the production of renewable energy. The goals for Enova are set out in a contract with its owner the Norwegian Ministry of Petroleum and Energy.

The presented discussion shows that the Norwegian approach to energy policy has great potentials. The model is an efficient way of organizing the Norwegian effort. However, there are some important conditions that have to be fulfilled. Of the most important is the need for a methodology to measure and verify indirect effects. As we have demonstrated, the combination of a relatively low energy target combined with no relatively strong incentive to focus on indirect effects such as market transformation, behavioral changes, etc., the outcome is likely to be too much emphasis on direct effects.

Despite some shortcomings of the Norwegian model, it has some very positive characteristics which opens up for an even better coordination of measures and to reap the great potentials that are identified in the Norwegian economy. However, picking the low-hanging fruits is the easy part of the job. Facing increasing marginal costs of energy production and energy efficiency benefits, Enova must develop its methodology and make the best of the degrees of freedom that the model offers. Even so, one must always be aware of important trade-offs. For instance, the costs related to improving the amount and quality of required information must be traded off against the potential benefits.

Acknowledgements

The authors would like to thank colleagues at Enova for valuable comments on an earlier draft.