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The social cost of district heating in a sparsely populated country

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Abstract

Many Governments support district heating projects because they are regarded as environmentally beneficial. However, often their social costs and benefits are not adequately assessed before support is granted. The purpose of this paper is to develop methods that can be useful to public authorities to prioritise among energy projects.

We develop criteria for cost–benefit analyses—using district heating projects as a case study—emphasising both economic and environmental costs of the various energy alternatives. We discuss how the existence of an internationally integrated electricity market—in this case the market in the Nordic countries—affects the results. In an integrated market emissions may take place in countries other than where energy is used, a property that may have important consequences for social cost assessments.

We conclude that one should assess environmental costs directly as far as possible, and that one should not include existing energy taxes or other taxes in calculation prices for energy projects. The same CO_2 cost estimate should be used for all energy alternatives. Results from case studies indicate that the social cost (economic and environmental) of district heating may be lower than those associated with electrical heating, for meeting energy demand in new buildings. © 2001 Elsevier Science Ltd.. All rights reserved.

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1. Introduction

In many European countries governments support combined heat and power (CHP) and district heating (DH) as environmentally friendly alternatives to existing energy technologies. Comparatively high-energy efficiency in district heating projects, often combined with use of renewable fuels, makes the technologies attractive especially in order to reduce emissions of greenhouse gases.

This view has also been the motivation for recent tax exemptions and the introduction of a programme that entails support to individual district heating projects in Norway. Thus, at the administrative level there is an increased need for ranking energy projects since support to projects is given on an individual basis. However, until now, various government bodies participating in decision-making use different criteria for evaluating such projects. There may also be doubts whether current practice in environmental evaluation is appropriate within the context of a liberalised Nordic electricity market. Thus, today's practice in project evaluation raises the question whether support is given in appropriate amounts and to the best projects.

The aim of this paper is to develop a method that ranks energy projects by social costs—economic as well as environmental, and to improve upon social cost assessments of district heating projects. This method—or more elaborate versions of it—can be a useful tool to prioritise between projects. In particular we look at direct valuation of environmental impacts and impacts that are indirectly a result of trade in the integrated Nordic electricity market. How should these be included in the analysis? How should current taxes on electricity and fuels be accounted for? We propose to utilise principles from cost benefit analysis and economic valuation of environmental damage, and recommend disregarding existing energy taxes, relying instead on independent estimates of environmental costs, which should be the same for all emission sources.

This paper develops the principles for evaluation of district heating projects compared with the traditionally

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preferred alternative of electric heating in a Norwegian context. The Norwegian context is a liberalised electricity market where production and trade of electricity is separated from transmission. Furthermore, the market for electric energy comprises all Nordic countries. That implies that changes in demand in one country may induce changes in production and emissions in neighbouring countries.

We apply the principles to two different district heating projects, one that has been completed and is in operation and one that is in the planning stage. The first project is based mostly on biomass (forest residues) as energy source while the other is based on an electricity-driven heat pump. For economic reasons both projects use oil boilers in order to meet peak load demand. We compare these projects with the alternative that in most cases have been most common until now, electric heating.

The paper is structured as follows. Section 2 gives a brief description of the project alternatives while the theoretical principles for evaluation of the projects are analysed in Section 3. Section 4 explains our assessments of environmental costs while economic costs are discussed in Section 5. The results are summarised in Section 6, which also contains some sensitivity analyses. Conclusions are contained in the final section.

2. Project alternatives

We compare two different district heating projects in Norway with an electric heating alternative for supplying energy for space heating to large residential and commercial customers. Electric heating seems to be the cheapest alternative to district heating at current energy prices.

When analysing the social costs of energy projects, it is important to account for the fact that bioenergy and heat pumps in district heating often are used together with fossil fired peak load capacity (e.g. oil boilers or electricity). This was not always accounted for in earlier analyses (cf. an analysis of environmental costs of bioenergy by Miranda and Hale, 1998). A district heating plant using bioenergy or a heat pump as the primary source of energy usually incorporates an oil-fired boiler to meet demand at peak load. This design of the project is made to keep down costs, since capital costs are lower for oil boilers. District heating projects are usually designed such that oil boilers will supply 10–30 per cent of annual energy.

2.1. District heating 1: Heat pump/oil boilers

At the site of the previous Oslo Airport (Fornebu) there are plans to develop an industrial area as well as private homes (Bærum District Heating, 1999). The local electricity grid owner has prepared a detailed plan for meeting expected heat demand through district heating plant and a transport grid for hot water. The heating system is planned to include an electrically driven heat pump as the main energy source, using the energy from the sea. The conversion factor for heat is 3 and the project is planned to produce 141 GWh energy.

In our empirical application we have made some simplifications. First, we disregard the fact that the developer has planned to invest in the heat pump a number of years after the start of energy production, and using oil-fired boilers the first years when demand is assumed to be lower. Second, in the application for concession, parts of the energy sales are based on cooling instead of heat while we assume all energy sales are in the form of heat, which has a lower energy conversion factor than cooling. Third, instead of assuming that some existing electricity-driven peak load boilers may be used in the project, we assume that oil-fired boilers produce 30 per cent of the energy. These changes compared to the detailed plans are made to facilitate comparison with the biomass-fired district heating project.

2.2. District heating 2: Bio energy/oil boilers

At the new Oslo Airport a district heating plant is already in operation, delivering heat to the airport facilities. Peak load demand for heat is supplied by oil-fired boilers. The technical and economic data used in this paper are taken from the first step of the project (NVE, 1996).

Biomass (forest residues) is the dominating fuel, and fossil-fired energy constitutes 30 per cent of planned energy production (oil boilers). The project is assumed to produce 49 GWh annually.

2.3. Electric heating—the reference case

We have constructed an electric heating alternative, based on average transportation tariffs and assessments of the price of electric energy. The price of electric energy can be decomposed into the wholesale (spot) price in the integrated Nordic electricity market and a trade margin. In addition, costs of transporting energy to the customer must be added (network charges).

There are (at least) two reasons why social costs of electricity using the above principles may deviate from the private costs. First, environmental impacts (emissions) may not be properly internalised in the electricity price. Increased demand for electricity will be met with increased electricity production from plants with higher short run marginal costs. In most loads these high cost plants are coal plants in Denmark and Finland, at least in the shortterm. Thus, increased electricity