SINTEF

CASE STUDY 2

INCENTIVES FOR EXTENDING ENERGY DISTRIBUTION INFRASTRUCTURE

TABLE OF CONTENTS

Page

INTRODUCTION

The planning study in this example concerns the extension of the existing energy distribution system in a town. The existing energy distribution system under consideration comprises both the electrical system and a district heating system. The heat is supplied by a district heating plant SARA (Sentrum Avløps Rense Anlegg) that has been in use since 1994. This heat plant is composed of two heat pump installations (SARA), two oil boilers and one electric boiler. The material presented here is a summary based on [1]

The energy balance for the area shows that the maximum forecasted demand is approximately two times larger than the existing capacity of the heat plant. This and several other operation problems are the reason to seek for upgrading solutions.

The possibility of building a new heat plant consisting of a bio-boiler and an oil-boiler, with the associated district heating network is estimated.

The decision-maker in this case is Enova. Enova is a governmental agency whose 'main mission is to contribute to environmentally sound and rational use and production of energy, relying on financial instruments and incentives to stimulate market actors and mechanisms to achieve national energy policy goals'. This agency has the capacity to stimulate energy efficiency by motivating and giving financial support for cost-effective and environmentally sound investment decisions. In relation with this particular case-study, Enova needs to make a decision on what expansion alternative to support, financially.

However, the existing infrastructure is owned and operated by the local commune (administration) who is also the main investor in the new infrastructure. In these decision settings, the commune is practically a *stakeholder*: Enova's final decision for supporting one of the expansion alternatives will have to be implemented by the commune.

Customers that will get access to the district heating network will be also *stakeholders* in this planning problem. There are no concession rights on the district heating infrastructure. This means that the commune has no obligation to deliver energy or to connect new customers to the district heating network. Therefore, most of the customers in the area have installed local heat back-ups, small oil-based boilers. This leads to unpredictable loads in the system and consequently to a suboptimal use of the district heating infrastructure.

1 PROBLEM STRUCTURING

1.1 System boundaries

The 'target' area is also defined strictly geographically, as a circle with the centre in the centre of the town and a radius of 2km. For example, the 22kV distribution network considered in this study has been cut from the larger local distribution network: only 165 stations (from 732) have been included and those lines that go out from the area (to connect to larger transformer stations) have been defined as electricity-sources at the system border. These supply points have been assigned hourly prices.

Electricity price at each customer has been calculated as a sum of an average common price at system border plus the cost of losses in conversion and distribution to each customer location [1].

1.2 Identification of alternatives

There are two alternatives in this planning problem: to build or not the new heat plant and the afferent district heating network.

Initial prospects identified that the best position for the new plant would be in the eastern part of town's centre and that this plant should have two components - a bio-fuelled boiler (with capacity of 3-4MW) and an oil-fuelled boiler (with a capacity of 4 MW).

It is important to mention that the electricity distribution system does not seem to need major reinforcements in order to cover the possible increase in demand, although the replacement of electricity with other carries in covering the heat demand would have only be positive for the electrical network.

With the addition of the new heat plant, the local heat supply capacity will increase to 14GWh/year. However, there is one more condition to include in the analysis. If more than 10GW heat will be sold annually, concession is obligatory. When concession rights will be applied in the region, all new buildings should connect to the district heating networks and therefore be constructed with heating systems based on hot water.

1.3 Identification of criteria

The main objective for the decision-maker in this case-study is to find a candidate for financial support, among the available planning alternatives. As mentioned previously, Enova's main task is to stimulate energy efficiency by motivating and giving financial support for cost-effective and environmentally sound investment decisions. In the original case-study no detailed information is given about the various criteria that can be considered by such decision-maker. However, from the written report describing this case, we could derive a set of criteria, as following:

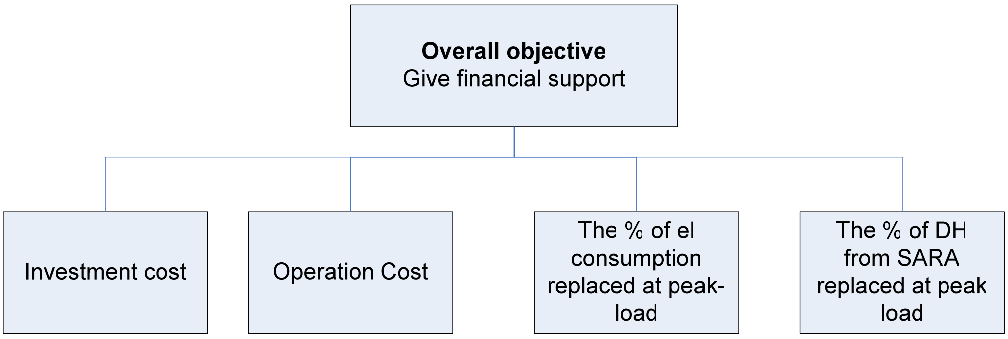

Figure 1 The hierarchy of objectives

Why two cost criteria? An investment in the new heat plant would lower the operation costs for the entire systems, just because using biomass for heating is less expensive that electricity or oil. Thus, the two cost objectives are not complementary: when the investment cost is low (alternative with no new heat plant) operation costs are high and vice-versa.

The other two criteria reflect the interplay between energy carriers in satisfying the end-use demand for heat. Analysing this interplay coincide with Enova's interest in supporting energy efficiency and environmental sound investment decisions. The work in this case study has not been taken to the level of detail that would allow a direct analysis of the efficiencies or environmental impacts.

2 MODELLING THE PROBLEM

2.1 Gathering data

The data used for this case study was extracted from a realistic case of an existing planning problem in Norway.

Data about the electrical distribution system (loads, load-flows) has been obtained from the local electricity distribution company that operated this network. The customers using electricity for heating and hot water (electric boilers) have been carefully considered.

Data about electricity prices and tariffs have been obtained from NVE's reports for 2005 (related to Nordpool's average prices). At system borders an average price, combining two types of tariffs (NHD/22kV and NL/230V), have been used.

Oil prices at the consumer have been calculated by adding to the oil prices at system border the conversion losses (the efficiency has been set to 0,9 for large boilers and 0,8 for smaller boilers). Oil prices at system border are highly variable, and therefore three price scenarios have been considered in this analysis: 20, 40 and 60 øre/kWh.

Several assumptions had to be made about the district heating system. First, the heat source for heat pumps have been considered as a free resource while the costs for electricity used has been calculated as explained above. The price of biomass has been considered 14øre/kWh (dry biomass with a burning efficiency of 0,85). Also, the losses in the district heating system have been considered to be 30% for the existing network and 10% for the new, reinforced network. Loads of potential end-users that are not currently connected to the existing district heating network are also defined, individually [1]. No CO_2 taxes have been taken into consideration.

It has been assumed that the new investments (alternative 2) will not take place before 2010. Consequently, to periods of analysis have been defined: Period 1 (2005-2010) and Period 2 (2010-2015). Moreover, for each period, it has been assumed a certain increase of demand for electricity and heat.

2.2 Considering the uncertainty

In this case-study the uncertainty in oil and biomass prices has been taken into consideration. First, alternatives have been analysed in three oil price scenarios: 20, 40 and 60 øre/kWh. Then possible evolutions of the price of biomass (12øre/kWh, 14øre/kWh, 15,8øre/kWh or 17øre/kWh) have been considered for the calculation of the level of financial support Enova should provide. It has been assumed that an investment in the bio-boiler would not be profitable without financial support, especially if the price of biomass will rise above a certain limit.

2.3 Energy system modelling

The tool used to model the local energy system was in this case the eTransport model. However, comparing with the example in case study 1, the level of modelling detail in this case study was much higher.

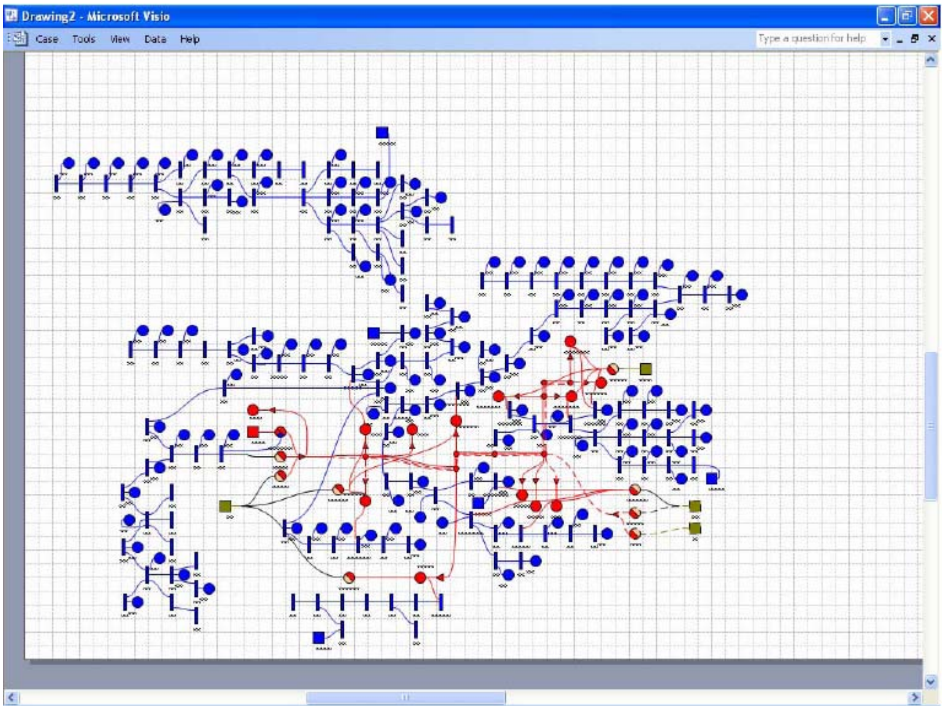

Figure 2 The model of the local energy system, represented with eTransport

The model has been used to simulate the operation of the system in each system alternative during different time periods (day, season, year) and to derive the total actualized costs (operation plus investment costs) under each oil price scenario.

2.4 Preference modelling

The scope of this case study was to inform Enova about the energy supply possibilities in the region. Unlike the previous example, the decision-maker has not been involved in the analysis process, and therefore no preference modelling took place.

3 USE THE MODELS TO INFORM THE DECISION MAKER

The results provided by the eTransport model and reported to Enova have been of two types. First the operation of the system in the two alternative configurations (without and with the new investment) has been explained in each scenario (oil price) - see Figures 3 and 4.

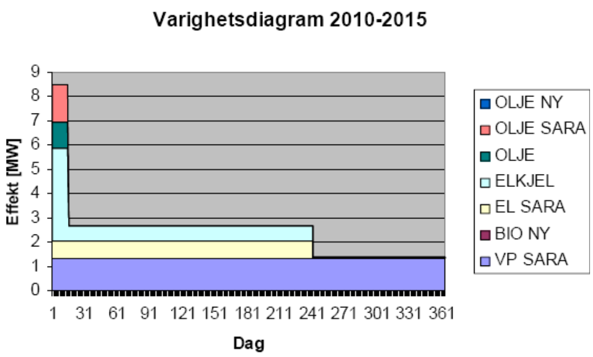

Figure 3 Duration curve in alternative 1
(oil price 40øre/kWh)

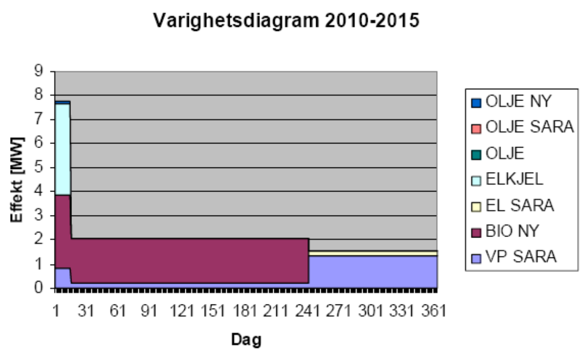

Figure 4 Duration curve in alternative 2
(oil price 40øre/kWh)

These figures show how the demand can be covered during the year and how heat is generated. One can observe that without the expansion of the district heating system (alternative 1) the consumers will use at peak load their local electrical boilers. Although most of energy demand can be covered using the existing district heating system, in peak load periods oil boilers will be used as well.

When the new investment is set in place (alternative 2), the bio-mass boiler will partly replace the electricity used for heating, and also part of the load currently covered by the existing district heating system. This will happen both during normal and peak demand periods.

It has been also showed how the different energy production capacities are used in the three oil price scenarios, in both alternatives; see Figures 5 and 6.

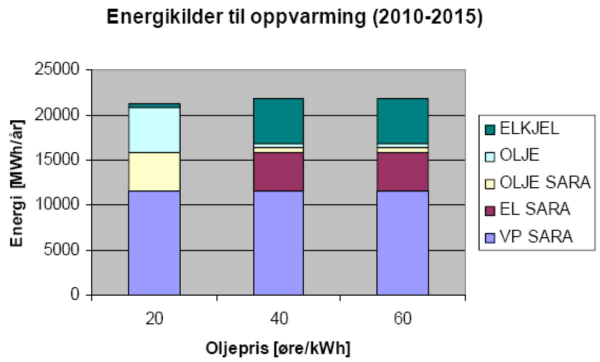

Figure 5 Sources for covering the heat demand in alternative 1

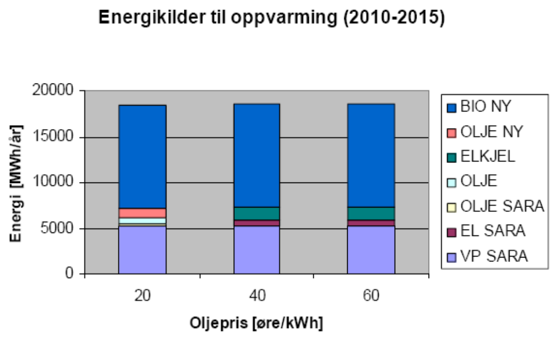

Figure 6 Sources for covering the heat demand in alternative 2

One can observe that in alternative 1, with an oil price of 20øre/kWh it becomes profitable to use the large-scale oil boilers. However when the oil price is higher, electricity becomes a cheaper energy supply solution. When the new heat plant is built (alternative 2), one can observe that again, the price of oil should be low in order to be profitable to use the oil burner. Consequently, given the uncertainty oil prices, it can be better to have several energy sources available in the system in order to assure a steady energy supply.

Another result obtained in this case study was a comparison of alternatives based on their costs over the planning period. Figure 7 shows the total costs (investment cost + operation cost) in alternative 1 and in two other scenarios for alternative 2 (constructed by varying the type of biomass used - dry or wet biomass). The costs below have been calculated based on an oil price of 40øre/kWh.

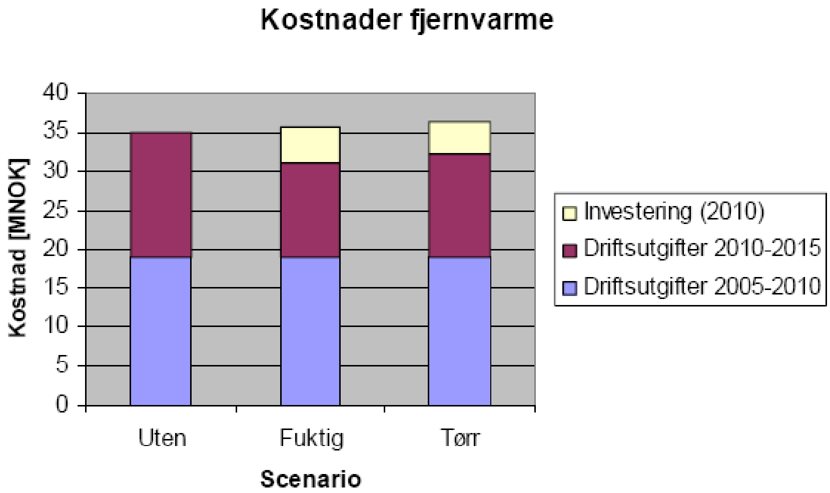

Figure 7 Total actualized costs for district heating
(oil price of 40øre/kWh)

It can be observed that the investment in the bio-boiler would reduce the operation costs of the district heating system, since it is cheaper to use bio-fuel than oil or electricity. However, increased biomass prices might change this situation. For example, the cost-based optimization with the eTransport model shows that it is optimal to use biomass only when the net present value of the total costs is low.

If Enova decides to support the new investment in renewable energy (biomass and heat pumps) the necessary sum can be calculated in a simple way. For example the total costs of using biomass is lower than using oil or electricity, only if the biomass price does not increase more than 12,2 øre/kWh. If the biomass price becomes higher, financial support from Enova is needed in order to carry on the project. The following figure shows, roughly, that Enova should finance 3MNOK if the price of biomass is 14 øre/kWh, and respectively 6MNOK is the price raises to 15,8 øre/kWh. For these calculations, again an oil price of 40 øre/kWh has been considered. With this oil price 60% of the necessary heat is produced in the bio-boiler.

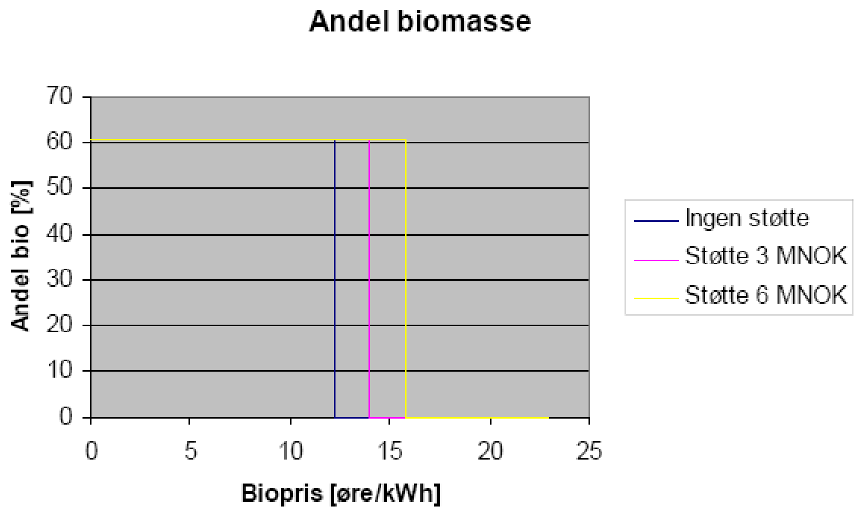

Figure 8 The share of demand covered by the biomass boiler,
as a function of biomass price and investment support form Enova
(oil price 40øre/kWh)

4 REFERENCES

[1] Skjelbred, H.I., Wolfgand, O.:
Energitransport i Stjørdal.
Trondheim: SINTEF Energiforskning AS 2005
(TR A6217)