SOCIOECONOMIC EVALUATION OF THE BALLEN-BRUNDBY DISTRICT HEATING PLANT

MSC THESIS

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Table of Contents:

List of Tables:

1 Summary

The aim of this paper was to examine whether an ex ante cost benefit analysis (CBA) can accurately account for the impact of a specific project. An ex ante and ex post CBA of the same project were compared and it was found that an ex ante CBA incorporating normal measures for uncertainty, e.g. sensitivity analysis, was able to accurately account for the actual impact of the project with one exception. One type of uncertainty could not accurately be accounted for in either the CBA analyses or in a contingent valuation analysis that was conducted with the consumers of the project. If this project is representative of other renewable energy investments in Denmark, then the potential consumer base could be seriously underestimated in project proposals.

2 Introduction

The aim of this paper is to determine whether there exists structural differences between an ex post and an ex ante cost benefit analysis (CBA) of the same renewable energy project. If such differences exist, they are most likely due to uncertainties in the estimation process (evaluation uncertainty) or in the expected project outcome (project uncertainty). To what extent has the realised socioeconomic impact (thus far) diverged from the original expectations? If there are differences, do they lie within the scope of the uncertainty that could be estimated in the original analysis, or are there significant structural differences? If ex ante CBA studies do not accurately reflect the actual costs and benefits, there may be policy-related implications in using ex ante CBA to evaluate renewable energy initiatives.

The structure of the paper is as follows: first, an introduction to the key concepts applied in this paper and a brief summary of the Ballen-Brundy district heating plant. The second section provides a description of the data used. Section three provides an outline of the key assumptions used in the analyses. Section four estimates the ex post CBA and section five estimates the ex ante CBA. A comparison of the two follows immediately from the ex ante CBA. Section six estimates stated preference using contingent valuation methods. Section seven concludes.

2.1 Uncertainty principle

The 'Green Book' published by the UKs' Treasury (2003), outlines the following types of bias in project appraisals:

- Optimism Bias – the overstatement of benefits and/or understatement of costs and timing

- Expected Value – multiplying an anticipated benefit (in monetary values) by the expected likelihood of it occurring
- Sensitivity Analysis – using alternate values for key parameters to assess the potential impact on the net present value
- Scenarios – describing verbally 'what if' situations
- Monte Carlo Analysis – a risk modelling technique which can calculate both the range and expected value of the collected impact when there are several types of risk involved.

All of these can be applied to both project uncertainty and evaluation uncertainty; e.g. optimism bias can occur either on the basis of inaccurate data available at the time whether the data available accurately predicts the reality of the project and reference scenarios.

The most commonly used method in the cost benefit literature appears to be sensitivity analysis (Petersen et al., 1984; Bentzen et al., 1993; Meyer et al., 1996; Nielsen et al., 2002; Bornholms Forsyning, 2008), though others (Meyer et al., 1996; Gutman, 2002) also calculate expected value to value the likelihood of an event occurring.

2.2 The Ballen-Brundby District Heating Plant

This section briefly outlines the history and context of the Ballen-Brundby district heating plant.

Figure 2.1: Ballen-Brundby District Heating Plant

The Ballen-Brundby district heating plant (BBF) is one of four district heating plants located on the renewable energy island Samsø in Denmark. In 1997, Samsø won the Danish Energy Authority's (DEA) competition to create a 100% self sufficient renewable energy island in order to showcase Danish renewable energy technology to the rest of the world. At the time, there was only one district heating plant in operation, which was located in the island's largest village, Tranebjerg. The district heating plant in Ballen-Brundby was the last of the four to open, beginning to distribute heat in the winter of 2004 (Samsø – A Renewable Energy Island 2007).

A feasibility analysis of the proposed district heating plant was conducted in 1998 by the main heating supplier, NRGi (formerly ARKE). The project was eventually abandoned, as not enough local interest could be raised. However, in 2003 local initiative resulted in the establishment of the heating plant as a local cooperative. Those who agreed to participate from the start only had to pay a connection fee of 80 DKr, relative to the estimated full connection costs of 45,000 DKr.

The Ballen-Brundby district heating plant currently produces around 4900 MWh per year, operating at app. 90 percent of its total capacity (potential capacity is estimated as 5500 MWh a year). It uses a 1.6 MW LIN-KA furnace and an auxiliary oil-based generator of 2 MW, consuming app. 4,700 litres of oil a year (SEA-BBF website).

3 Description of data

The primary source of data used for the calculations in both the cost benefit analyses is the original spreadsheet from the work group that successfully completed the construction of a district heating plant in Ballen-Brundby. The spreadsheet contains detailed data obtained from 171 interested home owners, including address, home owner, house size in square meters, whether the home is a summerhouse, and annual oil and electrical heating consumption. An additional 119 homes are listed without detailed information. Based on these figures, average heating costs including operation and maintenance (O&M) of the individual installations and fixed and variable costs for the district heating plant have been calculated.

The table below summarizes the data available in the spreadsheet. A total of 152 parties had accepted the contract at the time of the spreadsheet, and a total of 171 had provided information on their consumption patterns, not including the seven larger consumers. All costs have been adjusted to the 2007 price level.

Table 3.1: Summary of spreadsheet data

Type of consumer	No. of obs.	Avg. size of building	Avg. heat demand	Avg. individual costs	Avg. district heating costs	Predicted savings	Oil demand	Electrical heating demand
		m^2	MWh	DKr	DKr	DKr	litres	MWh
Oil-based heating	145	125.2	16.53	16,965	13,475	3,491	2,150	-
Electrical heating	18	117.7	11.26	16,483	9,952	6,531	-	10.73
Combination oil/electrical	8	199.3	23.83	29,631	18,366	11,265	1,763	9.79
Unweighted household average	171	114.8	16.31	17,284	13,333	3,951	-	-
Large consumers	7	-	66.99	57,074	41,036	8,512	-	-

Oil consumption is calculated based on the assumption that the individual furnaces have an efficiency rate of 75 percent. The costs are based on an oil price of 6.15 DKr/litre and an electricity price of 1.54 DKr/KWh at the 2007 price level[1]. Individual costs include annual O&M costs of oil furnaces set equal to 3,749 DKr[2]. Average district heating costs include both the annual fixed costs of 2,410 DKr and variable costs of 670 DKr/MWh per household[3]. The annual fixed cost for the larger consumers is set equal to 4,821 DKr[4], but one of the larger consumers pays the smaller fixed rate, probably because it is on the same property as one of the larger consumers. Estimates for average electrical heat consumption have been multiplied by 1.05 and oil consumption by 1.025, possibly to account for expected growth in demand from 2003 to 2004. In addition to the consumers outlined in the table above, 19 owners of empty lots have expressed an interest in being connected to the district heating net.

30 of the households which provided data are registered as summerhouses; unexpectedly, there were no large differences between the heating demanded from summerhouses relative to permanent residences. This may reflect underlying issues with the data available as it seems quite unlikely that a summerhouse would require as much heating as a permanent residence.

In comparison the average values for the 152 households who had already accepted the contract is shown in Table 3.2 below:

Table 3.2: Summary of data for prospective customers from spreadsheet data

Type of consumer	No. of obs.	Avg. size of building	Avg. heat demand	Avg. individual costs	Avg. district heating costs	Predicted savings	Oil demand	Electrical heating demand
		m^2	MWh	DKr	DKr	DKr	Litres	MWh
Oil-based heating	130	126	16.52	16,933	13,454	3,480	2,161	-
Electrical	14	121	11.61	16,989	10,183	6,806	-	11.06

[1] 2004 price level: 5.74 DKr/litre and 1.43 DKr/KWh
[2] 2004 price level: 3,500 DKr
[3] 2004 price level: 2250 DKr and 625 DKr/MWh
[4] 2004 price level: 4500 DKr

heating								
Combination oil/electrical	8	199.3	23.83	29,631	18,366	11,265	1,763	9.79
Unweighted household average	152	129	16.45	17,607	13,411	4,196	-	-
Large consumers	7	-	66.99	57,074	41,036	8,512	-	-

Of the 19 households who provide data but do not wish to be part of the district heating plant, 4 are electrical heat users and 15 have oil-based furnaces. Average data for the two types of consumers changes very little after excluding these 19 observations, making it impossible to conclude whether those who do not wish to join share similar physical characteristics. The unweighted household averages shown in the table above are slightly larger than those shown in Table 3.1, mainly due to the increased influence of the combination oil/electrical heating households.

The actual project proposal is based on figures using an average heat consumption of 16.5 MWh/year, based on the unweighted household average from Table 3.2, and a total of 290 households in the area. A further assumption is that 160 households will join the district heating network, equivalent to 55 percent of the total. The total net heating demand is expected to be 2,633 MWh/year for the households and 501 MWh/year for the larger consumers.

The table below summarizes assumptions and figures used in the project proposal from the district heating cooperative (2003), actual figures obtained from the yearly accounts of the district heating plant (2004-2007) and the initial project proposal from the energy company formerly known as ARKE (1999). All prices have been adjusted to the 2007 price level.

Table 3.3: Central assumptions behind the district heating plant

Assumptions		BBF Project Proposal	BBF Yearly Accounts (2007)	ARKE Project Proposal
Project lifetime	Years	20	5-30	20
Investment	DKr	16,752,009	17,565,253	23,173,021
Net demand	MWh/year	4128	-	3986
Gross demand	MWh/year	4691	4916	7019

Total no. of consumers		167	258 (2008 figure)	194
Reduction in Co2 emissions over period	Tons	22,338	-	25,000
Net user savings	DKr/year	4,196	-	1,063
District heating net loss	%	App. 32	App. 30	-
Efficiency of individual oil furnaces	%	75	-	70
Efficiency of straw furnace	%	-	-	83-85
M&O costs	DKr/year	363,149	462,611	465,689
Reference M&O costs	DKr/year	3,749	-	1,760
Electricity consumption of plant	DKr/year	68,559	70,470 (incl. water)	64,516
Consumers originally using electrical heating	%	14.5	-	0
Consumers originally using oil heating	%	85.5	-	100
Fixed price for households	DKr/year	2,410	2,500[5]	1,833
Variable price	DKr/MWh	670	675	674
Price of hay	DKr/MWh	97	110[6]	105
Price of oil, individual	DKr/litre	6.15	-	3.99
Plant production		Straw 99%, oil 1%, electricity 3 %	Straw 96%, oil 4%[7]	Straw 90%, Oil 10%

The figures in the table above are discussed in greater detail prior to use in the two cost benefit analyses following this section. Most of the assumptions are comprised of similar elements, however there are key differences in what is included in O&M costs. An outline of this is shown below for each of the three categories, but only the BBF values are used in the following analyses. All costs are at the 2007 price level.

Table 3.4: M&O costs by category

M&O Cost Category (DKr/year)	BBF project proposal	BBF annual account (2007)	ARKE project proposal

[5] Fixed and variable prices for 2007 taken from Municipality Memo: 13.03.00G01
[6] Calculated by dividing total expenses on straw (incl. storage) 2007/received amount of straw 2007 (number from the district heat office)
[7] Calculated by dividing expense on straw and expense on oil by expense of oil and straw

<table>
<tr><td>Administration</td><td>67,488</td><td rowspan="3">111,066</td><td rowspan="2">91,496</td></tr>
<tr><td>Management</td><td>10,712</td></tr>
<tr><td>Insurance</td><td>21,425</td><td>0</td></tr>
<tr><td>Maintenance, distribution net</td><td>92,126</td><td>-</td><td>23,460</td></tr>
<tr><td>Maintenance, plant</td><td rowspan="2">160,686</td><td>8,897</td><td>145,455</td></tr>
<tr><td>Operation</td><td>179,194</td><td>117,302</td></tr>
<tr><td>Chemical & ash disposal</td><td rowspan="2">10,712</td><td rowspan="2">163,454</td><td>23,460</td></tr>
<tr><td>Other</td><td>-</td></tr>
<tr><td>Electricity consumption</td><td>n/a</td><td>n/a</td><td>64,516</td></tr>
<tr><td>Total</td><td>363,149</td><td>462,611</td><td>465,689</td></tr>
</table>

Note that only ARKE includes electricity consumption in M&O. This is not assumed elsewhere, either in the M&O of the plant, or in the private oil furnaces.

4 Central Assumptions

Lifetime

This paper uses an expected lifetime of 15 years rather than 20, as the DEA recommends using the expected lifetime of the key investment; in this case it would be the straw-based district heating furnace which is expected to have a useful lifetime of 15 years. In the ex post project scenario, any investment which has a lifetime longer (shorter) than this has its scrap value (additional investment) calculated and added to the total. In the ex ante scenario which is based on the BBF project proposal spreadsheet with an expected lifetime of 20 years, a scrap value corresponding to the remaining five year term is added to the total. This process is described in further detail in each respective CBA. 2004 is counted as the first year of operation despite the plant only operating from winter 2004.

Price level

All of the prices in the CBA analyses are shown at the 2007 price level. Prices are adjusted using the inflation index from table 1 in the DEA (2009). This index covers the time period from 2000-2030. For any values that were given in prices from before 2000, the 2000 deflator was used. The index is included in the appendix.

Discount rate

The DEA recommended social discount rate of 6 percent is applied to both CBAs in this paper. The sensitivity analysis following the ex ante CBA section also uses the 3.5 percent discount rate recommended by 'The Green Book' (HM Treasury).

Combustion value

Combustion values are also taken from the DEA website, and included in the appendix. Straw has an expected combustion value of 14.5 GJ/ton when it has a moisture content of 15 percent. Heating oil has a combustion value of 0.036 GJ/litre.

Initial investment

The ex post CBA uses the initial investment recorded in the yearly accounts, equal to 17.6 mil DKr at the 2007 price level. The ex ante CBA uses the initial investment as predicted in the project proposal from the BBF spreadsheet, equal to 16.8 mil DKr at the 2007 price level. Both of these investments are shown without the 2.6 mil DKr subsidy from the DEA. For the reference scenario in both cases, it is assumed that no new investment in the existing source of heating is required. That is, houses with electrical heating or private oil furnaces are not expected to require further investment throughout the entire 15 year period used in the calculations. This assumption may be slightly unrealistic, but private oil furnaces are generally expected to have a useful lifetime of 20 years, above the 15 year horizon used in this paper.

Maintenance and operation costs

The ex post CBA uses the M&O costs as derived from the yearly accounts for the period 2005-2007, and the average of the three years, equal to 462,611 DKr for the remaining years (2004 is set equal to 2005). The ex ante CBA uses the M&O costs from the BBF project proposal spreadsheet, equal to 363,149 DKr. Electrical heating is assumed to have M&O costs equal to zero. Private oil furnaces M&O costs are based on a DEA memo from 2007 and equal 1,755 DKr per household without electricity costs.

Efficiency rate

The privately owned oil furnaces are expected to have an efficiency rate of 75 percent, based on the value used in the BBF project proposal spreadsheet (2004). Electrical heating is assumed to be 100 percent efficient. The straw-based furnace is assumed to have an efficiency rate of 85 percent (Videncenter for Halm- og Flisfyring, 2002), and the auxiliary oil-based furnace is assumed to have an efficiency rate of 95 percent. Assuming that the auxiliary furnace provides 1 percent of total heat production (see

Table 3.3) and the straw furnace provides 99 percent results in an overall furnace efficiency rate of 85.1 percent. The electricity consumption required for production in both the individual furnaces and for the district heating plant is ignored in this paper. The BBF project proposal spreadsheet estimates electricity needs to be app. 27 KWh/MWh, but including this value in the calculations without the equivalent electricity demand of the residential oil furnaces will unnecessarily complicate the final results.

Distribution net heat loss

The BBF project proposal spreadsheet calculates distribution net loss for both the central net and the private extensions. The central distribution net is expected to have a loss equal to 760 MWh annually and each individual installation equal to 1.425 MWh. Compared to a net heating demand of 3,134 MWh/year, this results in a total distribution loss of app. 32 percent. According to the BBF office, the net loss in 2008 was 31.5 percent. Therefore the distribution net loss is assumed to be 31.5 percent in both the ex ante and ex post CBA calculations. No net loss is expected for private oil-based heating or electrical heating.

Electrical heating subsidy

A subsidy is available for the houses which have electrical heating. This subsidy is equivalent to 5,000 DKr per house, and an additional 75 DKr per square meter. Of the 24 households which use electrical heating or a combination of electrical and oil-based heating, 16 qualified for this subsidy. However the additional benefit to the consumer/cost to society that this subsidy represents is not included in either CBA in this paper.

Socioeconomically adjusted fuel prices

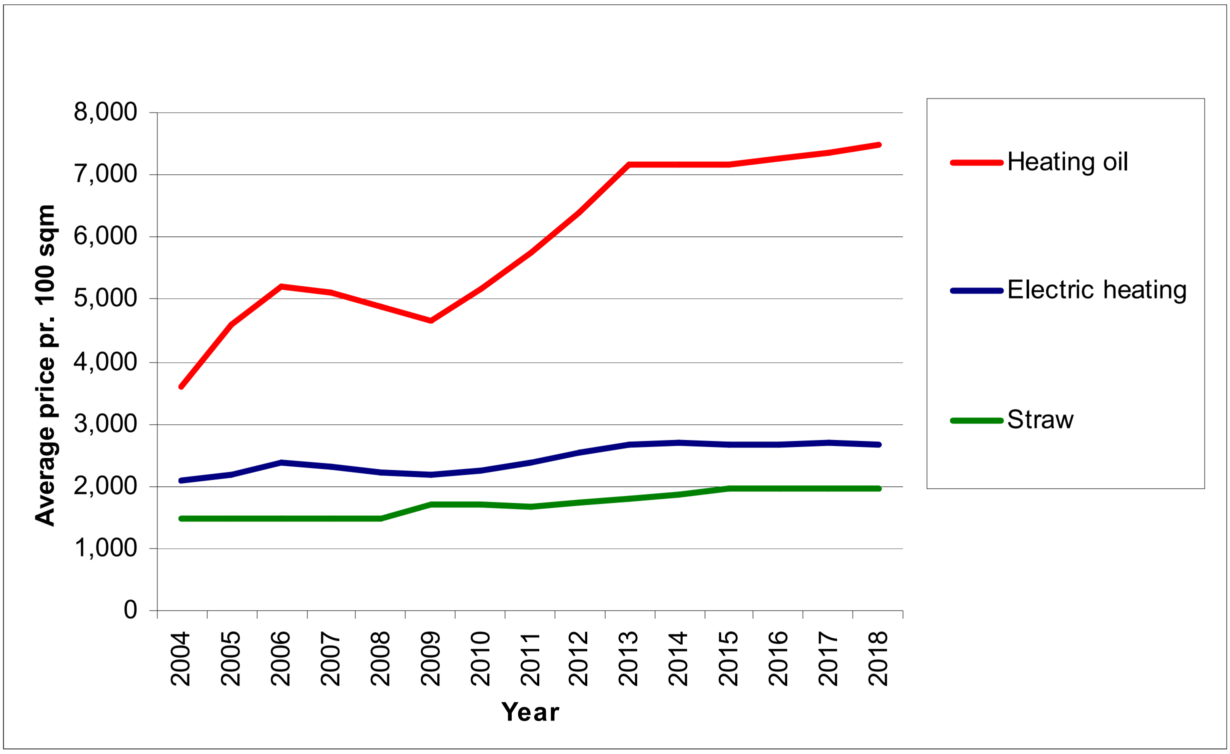
The factor prices used in both CBA analyses are taken from table 5 and table 6 in the DEA's Recommendations from May 2009. The factor prices for straw and oil include transportation costs and represent expected costs at the place of use, the district heating plant and household. Electrical heating costs are based on supply from a central district heating plant delivered directly to the consumer. Prices do not include taxes or VAT. Electrical heating prices are based on the national average of electrical district heating calculated by the DEA. When consumption of electrical heating is reduced by 1 GJ, net consumption should be multiplied by 1.25 to account for the distribution net loss of 20 percent. Thus, in both the CBA analyses, saved electrical heating consumption is multiplied by 1.25 (DEA 2009). The DEA (2009) notes that the factor prices for electrical heating are very rough approximations and not recommended for local analysis; however, as the proportion of electrical heat out of total heat is very low, it is unlikely to be a major problem for the results of this analysis.

Heating oil is an imported product and as such, its price depends partly on the exchange rate used. The rate is assumed to be equal to 5.81 DKr/USD in 2009 and from then on, but as exchange rates are known to volatile it is worth remembering that the fuel prices used here are subject to significant changes. The distribution costs of heating oil are given as 21.7 DKr/GJ at the 2007 price level, but given that Samsø is an island, this may be an understatement of the true distribution cost which also requires ferry transportation.

Straw is a domestically produced good, usually considered a by-product of wheat harvests. Distribution costs of straw are given as 8.3 DKr/GJ at the 2007 price level. Based on interviews conducted with local suppliers, distribution costs are estimated to be app. 2-2.6 DKr/GJ at the 2007 price level (30-40 DKr/ton). Generally, all straw is sourced locally, as the extra transport costs imposed by the ferry crossing are prohibitive. However, this estimate of transport cost may not include the socioeconomic cost of diesel, estimated as 0.13 DKr per ton/km. The calculations in this paper are based on the DEA assumptions unless otherwise specified.

The evolution of factor prices for fuel per 100 m^2 is illustrated in Figure 4.1 below. Fuel consumption is based on the DEA prices and combustion values and the average heat demand is based on the detailed data from the BBF project proposal spreadsheet (see Table 3.2).

Figure 4.1: Expected factor prices over the period



Source: DEA (2009) and own calculations

As can be seen from the figure, heating oil prices are expected to increase significantly over the period, with only modest increases in electrical and straw prices.

Private and public sector fuel costs

In order to calculate the impact on the public sector (economy as a whole) and the private sector (participating households), factor prices must be adjusted with taxes, VAT and the net social impact factor of 1.17. Danish VAT is constant at 25 percent of the factor costs + additional taxes. Values for additional taxes are taken directly from the DEA homepage, and adjusted according to the Danish tax authority's expectations that taxes will increase by 1.8 percent a year.

For heating oil, relevant additional taxes include the energy tax, carbon dioxide (CO_2) tax and sulphur dioxide (SO_2) tax. Emissions are calculated based on the conversion table 7 in the DEA recommendations (2009). Electrical heating only incurs energy and CO_2 taxes, while straw only incurs SO_2 taxes.

Emission coefficients

Expected emissions of CO_2, CH_4, N_2O, NO_X and SO_2 are calculated based on the data from the DEA Recommendations (2009). Emissions from oil and straw consumption are based on values recorded in 2007, while emissions from electrical heating are taken as the average of expected values over the period 2009-2030. The DEA (2009) also provides expected socioeconomic costs for each type of emission (the greenhouse gases CH_4 and N_2O are factored into the CO_2 equivalent value and the counted as CO_2). It is assumed that the DEA values accurately reflect the costs imposed by the emissions, e.g. that the impact of acid rain caused by SO_2 on local woodland and water quality is completely accounted for.

4.1 Non-quantifiable and non-valued impacts:

The following lists the major benefits and costs which have <u>not</u> been monetarized in this paper.

Benefits

- *The bequest/existence value in switching to renewable energy to promote a cleaner environment*
- *Reduction in fuel transportation from the switch to locally sourced straw rather than imported oil*
- *Impact on local labour force*
- *Impact on 'energy tourism' as a part of the 'Renewable Island' initiative*
- *The indirect or option use value of keeping fossil fuels intact (heating oil)*
- *Reduction in household maintenance from removal of residential oil furnaces*

Costs

- *Disruption in harmony of landscape from construction of plant (location of plant)*
- *Impact on local wildlife – although this appears to be minimal, as the local nature school does not think there has been any adverse impact (interview)*

In addition, the difference in the externalities of the respective fuel cycles is ignored. Given that straw is classified as a bi-product of grain harvest and is sourced locally, whereas drilling for oil represents a costly affair and takes place far away, the relative fuel cycle cost of oil is expected to be significantly larger than that for straw (Meyer et al., 1996). The above list indicates that the advantages of the district heating system are likely to be understated given amount of expected benefits relative to costs.

5 Ex Post Cost Benefit Analysis

This section outlines the cost-benefit calculations based on recommendations from the DEA and figures obtained from the current operation of the Ballen-Brundby district heating plant. The section following this will outline the cost benefit analysis that would have been obtained from the figures available before the plant was built, i.e. the ex-ante cost benefit analysis. The two analyses will then be compared to see how the plant has performed relative to expectations.

In accordance with the DEA's recommendations for cost-benefit analyses from 2005, the Ballen-Brundby district heating plant is not subject to regulations governing the CO_2 trading scheme, as it is below the minimum level of a 20 MW effect. This means that a potential substitution effect in the CO_2 emission trading scheme can be disregarded in this study.

5.1 Description of the project

The total net heating demand in the two villages was estimated to be 5.488 MWh/year or 19,757 GJ by the municipality of Samsø in 2004. However, based on a total of 297 consumers (BBF spreadsheet 2004) and the averages from Table 3.2, total heating demand is estimated as 18,454 GJ, and is used as the base value in all of the following calculations. A total of 167 consumers were expected to participate based on information from 2003, and an additional 20 signed up during the implementation phase in 2004 (Minutes 22.11.2004). A total of 258 users currently exist, of which 8 are registered as properties without buildings, 7 are larger consumers and 82 are registered as summerhouses. Assuming that the annual total net heating demand does not change from 2003 levels, Table 5.1 below illustrates the heating by provision type.

Table 5.1: Net heating demand by provision type

GJ	Reference	Project			
	2004-2018	2004	2005	2006	2007-2018
Annual heating needs met by private heating oil furnaces or electricity	18,452	6,101	5,924	2,014	1,896
Annual heating needs met by straw based district heating	0	12,351	12,528	16,438	16,556
Annual heating needs in total	18,452	18,452	18,452	18,452	18,452
Number of consumers	297	187	190	256	258

Note that expected evolution in the number of consumers is an approximation based on data from the BBF Annual Reports and current number of consumers (258).

The calculations in the table above are based on the average heating demand per type of consumer illustrated in Table 3.2. The consumers not expected to join the district heating network are all assumed to own oil-based furnaces, i.e. none of them are expected to have electrical heating or a combination of the two. The expected annual heating need to be met by the district heating plant is calculated using the average for each user type (oil-based, electrical, combination, large).

Table 5.2 shows the calculations for the amount of oil and straw necessary to meet the heating demand from Table 5.1 based on the net heat demand and efficiency rates. For example, the amount of fuel oil in the project scenario in 2004 divided by the efficiency rate is 6,101/0.75 = 8,135 GJ.

Table 5.2: Gross heating demand by provision type

GJ	Reference	Project			
	2004-2018	2004	2005	2006	2007-2018
Annual heating needs met by private oil furnaces or electricity	24,529	8,135	7,898	2,685	2,527
Annual heating needs met by straw based district heating	0	23,042	23,374	30,667	30,888
Annual heating needs in total	24,529	31,177	31,272	33,353	33,416

The applied efficiency rate for oil furnaces in the reference scenario is 75 percent. Electrical heating users are assumed to have a net distribution loss, and so their net consumption is multiplied by a factor of 1.25. The efficiency rate for the straw-based furnace is expected to be subject to the transmission loss in the BBF spreadsheet, which is calculated as 31.5 percent. In both of the CBA's in this paper a combined furnace efficiency rate of 85.1 percent is assumed, resulting in an overall efficiency rate for the district heating plant of 53.6 percent.

The above calculations would imply that annual production at the central district heating plant was equal to 8,588 MWh (30,888/3.6) in 2007. According to the plant manager, the measured production at the plant in 2007 was only 4,916 MWh, indicating a significant overstatement arising from the calculation method used in this paper. If the measured value is taken after the expected loss from the furnace i.e. only including distribution net loss, then annual production is estimated as 6,714 MWh (24,170/3.6), still significantly above actual measured production. It is possible, but improbable, that there has been a reduction in total heating demand relative to the 2004 level.

Alternatively, there may be an issue with the assumption that registered summerhouses consume as much heat as permanent residences (refer to *2. Description of data*). Out of the current 258 consumers, 82 are registered as summerhouses. If one assumed that they used the equivalent of 2 months worth of heating in a year, i.e. 1/6 of the average user, then an annual production (assuming only distribution net losses of 31.5 percent) of 4,715 MWh would suffice. This estimate is much closer to actual measured production. However, as this assumption of summerhouse heating demand is not supported by the available data, there is no choice but to ignore it in the following calculations.

Although a suitable explanation for the above discrepancy has not been found, the rest of the calculations in the CBA are based on the estimated values from Table 5.2. The reader should be aware this means the following figures likely represent an overstatement of the costs and benefits resulting from the project. An annual district heating plant production of 8,588 MWh corresponds to 2,109 tons of hay and 8,588 litres of heating oil.

5.2 Investment and M&O costs

Investments in the extension of the district heating system, construction of the district heating plant and modification of the user installations is estimated to be 17.6 mil. DKr[8] (Annual Report 2005). All costs in Table 5.3 are stated in 2007 factor prices. Out of the total investment of 17.6 mil. DKr, costs of establishing the distribution system total 11.7 mil. DKr. The expected useful lifespan of installations related to the district heating plant are as follows (from the Annual Report 2007):

- Furnace — 15 years
- Buildings — 30 years
- Operations — 10 years (however IT ~ 3 years)
- Distribution system — 30 years
- Extension of system (2006) — 29 years
- Individual user installations:
  - Annual expenditure < 50.000 — 5 years
  - Annual expenditure > 50.000 — 10 years

[8] 16.4 mil DKr at the 2005 price level, does not include the 2.6 (2.5) mil DKr subsidy from the ministry

The district heating plant furnace is expected to have a useful lifespan of 15 years, and for the sake of simplicity it is assumed that the existing oil-based furnaces also have a remaining lifespan of 15 years without further investment. The DEA uses a lifespan of 20 years in its examples, but adds that it would be more accurate to assume that the existing oil furnaces would need to be exchanged within 20 years, and that this would increase the costs in the reference scenario relative to the project proposal.

Original extensions to the district heating system have an expected lifetime of 30 years, but extensions from 2006 only have 29 years. In order to take into account the different lifetimes of the project and the reference scenario, a scrap value for the distribution system after 15 years is included. Using simple linear depreciation, the scrap value of the net can be estimated as 15/30 of the original investment of 11.7 mil DKr, i.e. 5.83 mil DKr, which can be seen as a negative investment (i.e. a benefit to the project) in 2018. Using a discounting rate of 6 percent, the net present value of 1 DKr in 15 years is equal to 0.42 DKr today, so the scrap value is reduced by more than a factor of 2 in net present value – for the distribution system this is roughly equivalent to 2.43 mil DKr. A similar approach can be employed for the district heating building, and the reverse is applied to individual user installations and operations, which require further investments in the 15 year time period.

Maintenance and operating costs for individual oil furnaces (including depreciation) are set to equal app. 1,755 DKr annually per oil-based furnace (DEA memo 2007), and average 421,752 DKr per year for the project (Annual Accounts 2005-2007). Assuming for simplicity that the costs per oil-based furnace are irrespective of size, total costs for 289 consumers equal 484,380 DKr per year for the reference scenario. Electrical heating consumers are assumed to have M&O costs equal to zero. Table 5.3 below uses the M&O costs of oil furnaces from the DEA against the costs from the Annual Reports[9].

Table 5.3: Investment, maintenance and operating costs

	Scenario	2004	2005	2006	2007-2017	2018
Investment (DKr.)	Reference	0	0	0	0	0
	Project	17,565,253	21,179	342,816	0	-6,923,208[10]

[9] Throughout this paper, the year 2004 is treated as a full year of operation, despite the plant only opening in the winter.
[10] Scrap value of buildings and distribution system minus the extra investment required for individual installations and operations in 2018 at the 2007 price level

M&O costs (DKr./year)	Reference	484,380	484,380	484,380	484,380	484,380
	Project	541,701	536,436	501,378	518,771	518,771

In the table above, the project M&O costs vary with the number of consumers. From 2007 onwards, it is assumed that the number of consumers remains constant at 258, so the M&O costs are not expected to rise further. Interestingly, the marginal costs of the project scenario are falling over the period 2004-2006, indicating the presence of an 'economies of scale' effect in the trade-off between M&O costs of residential furnaces and the district heating plant. After 2006, marginal M&O costs in the project are increasing again, suggesting that the benefits from pooling M&O costs are exhausted.

Given that the number of consumers is assumed to remain constant in the period 2007-2018, the level of investment for the period equals zero. A more realistic assumption would be to assume an increasing number wishing to join the district heating system, an investment above zero and increasing M&O costs, but for the sake of simplicity, this is not attempted here.

5.3 Environmental Impact

The Ballen-Brundby district heating plants' evaluated environmental impact includes the change in the emissions of the greenhouse gases CO_2, CH_4 and N_2O as well as the change in emissions of NO_X and SO_2, as can be seen in Table 5.4 below. The plant reduces CO_2 emissions, but increases all other emissions. Despite the significant decrease in CO_2-emissions, the plant cannot be said to have an unequivocally positive impact on the environment.

Table 5.4: Air Emissions

Kg per year	**Reference**	**Project**			
	2004-2018	**2004**	**2005**	**2006**	**2007-2018**
CO_2	1,782,868	619,038	601,750	221,408	209,883
CH_4	66	743	753	976	983
N_2O	50	108	109	127	128
Total CO_2 Equivalents	1,799,788	668,104	651,291	281,407	270,199
Kg per year					
NO_x	1,334	2,597	2,611	2,927	2,937
SO_2	625	3,158	3,195	4,016	4,041

The impacts in Table 5.4 are calculated using the emission coefficients in Table 7 from the DEA's Recommendations (2009), in which the greenhouse gases are listed in terms of tons of CO_2-equivalents per year. For example 1.5 g CH_4 is released per GJ from the heating oil used in residential furnaces, which results in yearly emissions of 35.1 Kg of CH_4 (=23,427 GJ*1.5 g/GJ) in the reference scenario (the remaining 30.9 Kg CH_4 comes from electrical heating). Given that the emission equivalent of 1 kg of CH_4 is equal to 21 kg CO_2 (DEA 2009), the emission is equivalent to 738 kg CO_2 (= 21*35.1 kg) per year.

5.4 Summary with respect to costs

Table 5.5 and Table 5.6 illustrate the pertinent information regarding the reference scenario and the project, respectively. Combustion costs in 2007 level factor prices are based on the used fuel amount (refer to Table 5.2) and the fuel prices of heating oil per consumer (e.g. 74.4 DKr per GJ in 2004) and for straw per district heating plant (31.4 DKr per GJ in 2004, 2007). Fuel prices are taken from the DEA's Recommendation for Cost Benefit Analyses 2005, 2007 and 2009 and calculated at 2007 price levels. For a complete list of prices used, please refer to the appendix. The heating costs in the reference scenario are 1,812,603 Dkr (=1,743,000+69,603) in 2004.

Table 5.5: Reference Scenario

	Reference Scenario: Heating oil + Electricity					
	Factor prices				Market prices	
	Fuel Cost			M & O Costs	CO_2 Costs	NO_x and SO_2 Costs
	Total Demand	Cost Oil	Cost Electricity			
Year	GJ	DKr	DKr	DKr	DKr	DKr
2004	24,529	1,743,000	69,603	484,380	319,208	142,379
2005	24,529	2,213,891	72,908	484,380	319,208	142,379
2006	24,529	2,516,105	79,109	484,380	319,208	142,379
2007	24,529	2,466,907	77,501	484,380	319,208	142,379
2008	24,529	2,356,798	74,263	484,380	365,247	142,379
2009	24,529	2,251,375	72,809	484,380	161,650	142,379
2010	24,529	2,499,706	75,452	484,380	210,759	142,379
2011	24,529	2,778,492	79,418	484,380	276,237	142,379
2012	24,529	3,097,105	84,154	484,380	360,132	142,379

2013	24,529	3,467,258	88,780	484,380	468,581	142,379
2014	24,529	3,462,573	89,882	484,380	468,581	142,379
2015	24,529	3,457,887	89,111	484,380	468,581	142,379
2016	24,529	3,509,428	88,560	484,380	468,581	142,379
2017	24,529	3,563,311	89,882	484,380	468,581	142,379
2018	24,529	3,617,194	88,890	484,380	468,581	142,379
NPV		**28,066,444**	**821,048**	**4,986,684**	**3,586,460**	**1,465,787**

The CO_2 costs in the reference scenario in the above table are based on the total CO_2 equivalent emissions of 1,800 tons from Table 5.4, and multiplied with the socioeconomically adjusted CO_2 prices from the specified year (DEA2009). Electrical heating emissions were excluded, since a CO_2 tax is already included in the list price. Although no prices exist for 2004, since the CO_2 quota system was not instigated before 2005, it is assumed that the value in 2004 is equivalent to the value in 2005. Similarly, the socioeconomic costs of NO_X and SO_2 based on total emissions from Table 5.4 have also been calculated. Only the constant values from 2009 of 50 DKr/kg for NO_X and 121 DKr/kg for SO_2 have been used in this paper, rather than the upper and lower boundaries suggested in previous editions of the DEA recommendations. The annual socioeconomic costs of the NO_X and SO_2 emissions from the reference scenario in Table 5.5 can be calculated as:

$$1{,}334 \text{ Kg } NO_X \cdot 50 \text{ DKr/Kg } NO_X + 625 \text{ Kg } SO_2 \cdot 121 \text{ DKr/Kg } SO_2 = 145{,}686 \text{ DKr}$$

It should be noted that there exist two values for the cost of a kg of SO_2; the upper bound is recommended for inhabited areas. The final row in Table 5.5 shows the net present value for the different costs in the period 2004-2018 when using the discounting rate of 6 percent.

The table below illustrates the district heating scenario with respect to costs.

Table 5.6: District Heating Scenario

	Project Scenario: Heating oil + Straw					
	Factor prices				Market prices	
	Fuel Cost			M & O Costs	CO_2 Costs	NO_x and SO_2 Costs
	Total Demand	Cost Oil	Cost Straw			
Year	GJ	DKr	DKr	DKr	DKr	DKr
2004	31,177	552,032	716,285	541,701	121,942	511,948
2005	31,272	700,795	726,591	536,436	118,874	517,178
2006	33,353	296,448	944,221	501,378	51,362	632,250
2007	33,416	275,116	951,026	518,771	49,317	635,737
2008	33,416	261,843	951,026	518,771	56,430	635,737
2009	33,416	249,023	1,110,040	518,771	24,974	635,737
2010	33,416	279,087	1,110,040	518,771	32,562	635,737
2011	33,416	312,839	1,079,460	518,771	42,678	635,737
2012	33,416	351,695	1,119,214	518,771	55,639	635,737
2013	33,416	396,224	1,162,025	518,771	72,394	635,737
2014	33,416	395,657	1,210,953	518,771	72,394	635,737
2015	33,416	395,090	1,269,054	518,771	72,394	635,737
2016	33,416	401,613	1,269,054	518,771	72,394	635,737
2017	33,416	408,137	1,269,054	518,771	72,394	635,737
2018	33,416	414,660	1,278,228	518,771	72,394	635,737
NPV		**3,964,866**	**10,649,571**	**5,364,854**	**694,164**	**6,306,158**

5.5 Socioeconomic costs and benefits

Table 5.7 below contains calculations on the socioeconomic costs and benefits found in the district heating plant relative to the reference scenario. Numbers from the reference scenario in Table 5.5 have been subtracted from the district heating values in Table 5.6. Thus a positive value is indicative of higher costs in the actual scenario relative to the reference, and a negative value means the actual scenario performs better than the reference. The final column shows that the actual scenario, based on the assumptions previously described, results in a loss of app. 6.1 mil. DKr in 2007 level prices at the net present value in 2004. The other columns illustrate where this loss comes from.

Table 5.7: Socioeconomic result

Project less Reference								
	Factor Prices			Calculated Costs				
	Inv., M&O	Fuel	Inv., M&O, Fuel	Inv., M&O, Fuel	Deadweight loss	CO_2 Cost	NO_x and SO_2 Costs	Total
Year	DKr	DKr	DKr	DKr	DKr	DKr	DKr	DKr
2004	17,622,574	-544,287	17,078,287	19,981,596	731,473	-197,265	369,569	20,885,372
2005	73,235	-859,413	-786,178	-919,828	198,433	-200,334	374,799	-546,930
2006	359,815	-1,354,546	-994,731	-1,163,835	255,162	-267,845	489,871	-686,648
2007	34,391	-1,318,266	-1,283,875	-1,502,134	256,881	-269,891	493,358	-1,021,786
2008	34,391	-1,218,192	-1,183,801	-1,385,048	256,881	-308,818	493,358	-943,626
2009	34,391	-965,121	-930,730	-1,088,954	256,881	-136,676	493,358	-475,391
2010	34,391	-1,186,031	-1,151,640	-1,347,419	256,881	-178,197	493,358	-775,377
2011	34,391	-1,465,611	-1,431,220	-1,674,527	256,881	-233,560	493,358	-1,157,848
2012	34,391	-1,710,350	-1,675,959	-1,960,872	256,881	-304,493	493,358	-1,515,126
2013	34,391	-1,997,789	-1,963,398	-2,297,175	256,881	-396,186	493,358	-1,943,123
2014	34,391	-1,945,845	-1,911,454	-2,236,401	256,881	-396,186	493,358	-1,882,348
2015	34,391	-1,882,854	-1,848,463	-2,162,702	256,881	-396,186	493,358	-1,808,649
2016	34,391	-1,927,320	-1,892,929	-2,214,727	256,881	-396,186	493,358	-1,860,675
2017	34,391	-1,976,002	-1,941,611	-2,271,685	256,881	-396,186	493,358	-1,917,632
2018	-6,888,817	-2,013,196	-8,902,013	-10,415,356	256,881	-396,186	493,358	-10,061,303
NPV	**15,206,367**	**-14,273,054**	**933,313**	**1,091,977**	**3,062,509**	**-2,892,297**	**4,840,371**	**6,102,560**

Columns 1-3 in Table 5.7 show the difference between the district heating scenario from Table 5.6 less the reference scenario from Table 5.5, in terms of investment, maintenance and operation costs and fuel costs in factor prices. Columns 4-8 have been calculated in socioeconomically weighted prices. The combined excess costs for investment, maintenance and operations as well as fuel costs in factor prices from column 3 have been multiplied by the net social impact factor of 1.17 to illustrate the socioeconomic impact. The values in column 4 thus give the value (in social prices) of the alternate use value lost from having to produce the same amount of heat as in the reference scenario.

Column 5 gives the deadweight loss, calculated as 20 percent of the government loss of revenue in terms of energy taxes due to the change in heat supply. This revenue loss is shown in more detail in
Table 5.8 below, and sums to a loss of 12.6 mil DKr in net present value. The deadweight loss of this when added to the government subsidy of 2,500,000 gives a social deadweight loss of 3.1 mil DKr in net present value. Columns 6 and 7 give the excess costs from the change in emissions of greenhouse gases as well as in NO_X and SO_2, calculated as the difference between Table 5.5 and Table 5.6. These costs were originally portrayed in terms of their socioeconomic impact and so have not been altered.

The final column shows the evolution over time of the district heating plant, which is as expected for this type of project. The first year carries very high excess costs relative to the reference scenario, followed by a series of negative costs and finally the scrap value of the investment. Especially the reduction in fuel prices weighs heavily in favour of the district heating plant scenario. Without applying the discount rate of 6 percent, the stream of benefits sums to app. 5.7 mil. Dkr in favour of the district heating plant, but the high discount rate results in a net cost at the project's start-up year in 2004.

5.6 Social costs and benefits

Calculating social deadweight loss requires an accounting of the projects impact on public finances. Additionally, it is necessary to value the financial (private) excess costs for the following:

- The district heating plant
- The directly affected households
- The public sector (i.e. indirect impact)

The socioeconomic values used for calculations may differ from the ones used to calculate the private impact.

5.7 District Heating Plant Costs

District heating plants are expected to set a price on heating which covers average costs. Given that the plant's profits are assumed to equal the plant's costs, there are no net excess costs resulting from the project. The price of the plant must just cover depreciation and rents of investment as well as maintenance and operation and fuel costs. These private costs are not directly observable from the socioeconomic values, as the producer's finances, taxation relation etc. must be known precisely. The following calculations are based on the socioeconomic costs, but a sensitivity analysis will be conducted using private prices.

The district heating plant is owned by the consumers. VAT is calculated as 25 percent of the sum of the district heating plants costs (including investment costs), resulting in a cost-based heating price payable by the households which includes VAT.

5.8 Private and Public Sector Costs

Table 5.8 below illustrates the excess costs for the participating households in terms of the prices payable by them including all taxes and 25 percent VAT. The final column in the table shows that the district heating plant results in a net benefit of app. 14.6 mil DKr. to consumers in net present value in 2004 in 2007-prices, even though net heating demand remains unchanged.

This is essentially due to the much lower price of straw delivered to the district heating plant relative to the price of heating fuel delivered directly to the household. The prices are taken from the DEA's Recommendations (2009), although data on CO_2 and SO_2 taxes are taken directly from the DEA homepage. All prices have been converted to the 2007 price level using the deflator from the DEA's Recommendations (2009).

Table 5.8: Direct private costs and benefits for users

Project less Reference								
	Investment, M&O			Fuel				
	Excl. VAT	VAT	Sum	Excl. taxes & VAT	Taxes	VAT	Sum	Sum Total
Year	DKr	DKr	DKr	DKr	DKr	DKr	DKr	DKr
2004	17,622,574	4,405,644	22,028,218	-544,287	-979,270	-380,889	-1,904,446	20,123,771
2005	73,235	18,309	91,544	-859,413	-992,163	-462,894	-2,314,470	-2,222,927
2006	359,815	89,954	449,768	-1,354,546	-1,275,811	-657,589	-3,287,945	-2,838,177
2007	34,391	8,598	42,989	-1,318,266	-1,284,406	-650,668	-3,253,340	-3,210,351
2008	34,391	8,598	42,989	-1,218,192	-1,284,406	-625,650	-3,128,248	-3,085,259
2009	34,391	8,598	42,989	-965,121	-1,284,406	-562,382	-2,811,909	-2,768,920
2010	34,391	8,598	42,989	-1,186,031	-1,284,406	-617,609	-3,088,046	-3,045,057

2011	34,391	8,598	42,989	-1,465,611	-1,284,406	-687,504	-3,437,521	-3,394,532
2012	34,391	8,598	42,989	-1,710,350	-1,284,406	-748,689	-3,743,445	-3,700,456
2013	34,391	8,598	42,989	-1,997,789	-1,284,406	-820,549	-4,102,743	-4,059,755
2014	34,391	8,598	42,989	-1,945,845	-1,284,406	-807,563	-4,037,813	-3,994,825
2015	34,391	8,598	42,989	-1,882,854	-1,284,406	-791,815	-3,959,075	-3,916,086
2016	34,391	8,598	42,989	-1,927,320	-1,284,406	-802,932	-4,014,658	-3,971,669
2017	34,391	8,598	42,989	-1,976,002	-1,284,406	-815,102	-4,075,510	-4,032,521
2018	-6,888,817	-1,722,204	-8,611,021	-2,013,196	-1,284,406	-824,401	-4,122,003	-12,733,024
NPV	**15,206,367**	**3,801,592**	**19,007,959**	**-14,273,054**	**-12,634,452**	**-6,726,877**	**-33,634,383**	**-14,626,424**

Connected households principally gain from the lower costs of fuel and lower environmental taxes due. However, the lower environmental taxes cannot be considered a social benefit, as it represents a loss of revenue from the government, which must be regained by increased taxation elsewhere. The private benefit/social loss posed by a reduction in taxes in columns 5-6 sums to 19.4 mil DKr in NPV in the above table. In this sense, the financing of the district heating plant is partly financed by all citizens at the national level. Given that the reduction fuel costs principally arises from a shift from imported fossil fuels to locally sourced biomass, the NPV of 14.3 mil DKr from column 4 can be interpreted as a social benefit.

5.9 Fuel supplier costs

The shift from residential oil based furnaces to the straw-based district heating plant results in a net national supply-side benefit, as there is a reduction in the demand for imported heating oil. The island is fully capable of producing sufficient straw for all the district heating plants on the island, which also means that there is a net environmental benefit, as the costs from fuel transportation are significantly reduced. A coalition of farmers supply straw to the Ballen-Brundby district heating plant, and supply is based on 5-year contracts where yearly prices are adjusted using a composite price index from Denmark's Statistical Database.

Some of the suppliers have borne additional costs in the building of storage facilities for straw. Interviews indicate that only 2 such facilities have been built, and that the storage space is used for other purposes when not filled with straw. It is assumed that the higher prices that are given for straw in the heating season and value from alternate use exactly offsets the additional cost imposed by the construction of such a storage facility; such that the net benefit/cost of the facility is zero.

The table below illustrates the alternate use value of the straw as a fertiliser and the value of straw when delivered to the district heating plant both in terms of the fuel price index recommended by the DEA. The prices calculated by the DEA are set to increase over the period to take into account expected increases in demand for renewable energy, as well as expected increases in the price of oil. This expected price increase may not hold true for Samsø; as there are no imminent plans for additional district heating plants on the island, the demand for hay on the island is not expected to increase significantly, the way it is on the national level. According to interviews conducted with local suppliers, the demand for straw from all of the district heating plants on the island are more than met by the islands' capacity; it was even stated that over the past decade, the production of straw has decreased in favour of other crops. Exporting excess straw off the island is infeasible due to high shipping costs (the same argument applies to importing straw) so national demand patterns will have very limited impacts on local prices. The most likely reason for an increase in the price of hay would be from the competition of other agricultural goods; blackcurrants are currently seen as the main competition for grain and straw.

Table 5.9: Impact on local suppliers

Project impact on supplier						
	Straw demand	**Price**	**Revenue**	**Additional cost**	**Alternate use value**	**Net benefit**
Year	GJ	DKr	DKr	DKr	DKr	DKr
2004	22,812	31.4	715,579	439,037	307,326	-30,784
2005	23,140	31.4	725,875	445,354	311,748	-31,227
2006	30,361	31.1	944,825	584,330	409,031	-48,536
2007	30,580	31.1	951,634	588,541	411,979	-48,885
2008	30,580	31.1	951,634	588,541	411,979	-48,885
2009	30,580	36.3	1,110,040	588,541	411,979	109,520
2010	30,580	36.3	1,110,040	588,541	411,979	109,520
2011	30,580	35.3	1,079,460	588,541	411,979	78,941
2012	30,580	36.6	1,118,371	588,541	411,979	117,852
2013	30,580	38.0	1,161,952	588,541	411,979	161,432

2014	30,580	39.6	1,212,156	588,541	411,979	211,636
2015	30,580	41.5	1,269,938	588,541	411,979	269,418
2016	30,580	41.5	1,269,268	588,541	411,979	268,748
2017	30,580	41.5	1,268,548	588,541	411,979	268,028
2018	30,580	41.8	1,276,827	588,541	411,979	276,307
NPV			**10,649,535**	**5,770,686**	**4,039,480**	**839,368**

The first column shows the expected demand for straw heating used in previous tables. The prices are factor prices from the DEA, adjusted to the 2007 level. The alternate use value is the value of using the straw as fertiliser, equal to between 0.28 DKr/kg.[11] In order to use the straw for district heating, additional costs for gathering, transportation etc are incurred, estimated to between 167 – 223 DKr/ton. For the estimations above, the median value was used, corresponding 0.195 DKr/kg for additional incurred costs.

Although using the standard local price indicates that the supplier suffers a net loss relative to his alternative use value, the prices used in the table above are very rough approximations. For example, once the base price is adjusted for moisture content, revenues increase significantly; in 2005, average moisture content was only slightly above 12 percent, meaning the price was adjusted by 1.11.

6 Ex Ante Cost Benefit Analysis

The cost benefit analysis in this section is based on numbers from the original spreadsheet behind the Ballen-Brundby district heating plant proposal and key figures from the DEA's recommendations. The previous section used numbers based on the current operation of the district heating plant, taken from the BBF Annual Accounts. Immediately following this section, key results from both analyses will be compared and contrasted.

6.1 Description of the project

The total net heating demand for the area was estimated to be 5,126 MWh/year or 18,454 GJ for a total of 297 consumers. The following calculations are based on participation from 160 households and 7 larger consumers, resulting in a net heating demand of 3,102 MWh/year or 60.5 percent of the

[11] Numbers based on interviews with local suppliers, equivalent to 30 øre/kg in 2009 prices. Additional transport costs are from the same source.

total demand. Total demand was expected to remain constant over the period; Table 6.1 below illustrates the heating by provision type.

Table 6.1: Net heating demand by provision type

GJ	Reference	Project			
	2004-2018	2004	2005	2006	2007-2018
Annual heating needs met by private oil furnaces or electricity	18,454	7,286	7,286	7,286	7,286
Annual heating needs to be met by straw based district heating	0	11,168	11,168	11,168	11,168
Annual heating needs in total	18,454	18,454	18,454	18,454	18,454

The calculations in the table above are based on the average heating demand per type of consumer illustrated in Table 3.2. The 123 consumers who are not expected to join the district heating network are all assumed to own oil-based furnaces, i.e. none of them are expected to have electrical heating or a combination of the two. The expected annual heating needs that will be met by the district heating plant are calculated using the average for each user type (oil-based, electrical, combination, large).

Table 6.2 estimates the gross amount of heating necessary to meet the heating demands from Table 6.1 based on the efficiency rates of the distribution network and the different furnaces. For example, the amount of heating oil demanded in 2004 divided by the efficiency rate is 7,286/0.75 = 9,715 GJ.

Table 6.2: Gross heating demand by provision type

GJ	Reference	Project			
	2004-2018	2004	2005	2006	2007-2018
Annual heating needs met by private oil furnaces or electricity	24,532	9,715	9,715	9,715	9,715
Annual heating needs met by straw based district heating	0	20,835	20,835	20,835	20,835
Annual heating needs in total	24,532	30,550	30,550	30,550	30,550

The efficiency rate for existing oil furnaces is assumed to be 75 percent. The efficiency rate for the straw-based furnace is estimated to be app. 85 percent and the transmission loss is estimated to be app. 31.5 percent, resulting in an overall efficiency rate equal to app. 53.6 percent. The above calculations correspond to an annual district heating production equal to 5,788 MWh or app. 1,420 tons of hay and 5,788 litres of heating oil.

6.2 Investment and M&O costs

Investments in the extension of the district heating system, construction of the district heating plant and modification of the user installations is estimated to cost 16.8 mil DKr[12]. All costs in are stated in 2007 factor prices. Out of the total investment of 16.8 mil DKr, costs of establishing the heating system total 11.4 mil DKr.

Based on the original data from the spreadsheet, 130 of the expected users had heating based on individual oil furnaces, 14 consumers had electrical heating and 8 had a combination of oil and electrical heating. An additional 8 users are presumed to have oil-based heating, as are all of the 7 larger consumers, summing to a total of 167 consumers.

Maintenance and operating costs for individual oil furnaces (including depreciation) are set to equal app. 1,755 DKr annually per oil-based furnace (DEA memo 2007), relative to expected O&M costs of 364,000 DKr for the plant. Assuming for simplicity that the costs per oil-based furnace are irrespective of size, total costs for 153 consumers equal 268,515 DKr per year and 215,865 DKr per year for 123 non-consumers. The total of 484,380 DKr is presented in the reference scenario below in Table 6.3.[13]

Table 6.3: Investment and M&O costs for both the reference and project scenario

		2004	2005	2006	2007-2017	2018
Investment (DKr.)	Reference	0	0	0	0	0
	Project	16,752,009	0	0	0	-4,187,970[14]
M&O costs (DKr./year)	Reference	484,380	484,380	484,380	484,380	484,380
	Project	364,000	364,000	364,000	364,000	364,000

In the table above, the M&O costs are constant over the period as it is assumed that the number of consumers remains constant at 167, which is the starting level. Given that the number of consumers is assumed to remain constant, the level of investment for the period 2005-2018 is set to zero.

[12] 15.6 mil DKr at the 2004 price level, does not include the expected 2.5 mil DKr subsidy from the ministry
[13] Throughout this paper, the year 2004 is treated as a full year of operation, despite the plant only opening in the winter.
[14] Scrap value of buildings and distribution system in 2018 at the 2007 price level

The expected useful lifespan used in the original spreadsheet estimations is 20 years. In order to facilitate comparison, the lifespan is shortened to the 15 years used in the ex post CBA, with the value of the remaining years included as scrap value using a simple linear depreciation method.

6.3 Environmental Impact

Total emissions of CO_2, NO_X and SO_2 for both the reference and project scenarios based on the gross heat demand of 297 consumers (GJ) are reported in Table 6.4 below. Estimates of CH_4 and N_2O are rescaled to their CO_2 equivalent value and added to total CO_2 emissions. The reference scenario includes emissions from users of both electrical and oil-based heating. The plant scenario includes the expected demand from the district heating plant in terms of both straw and oil, as well as the demand from the non-participating consumers (oil).

Table 6.4: Annual emissions of known gases over the period

Kg CO_2 Equiv. per year	Reference	Project			
	2004-2018	2004	2005	2006	2007-2018
CO_2	1,783,060	734,296	734,296	734,296	734,296
Total CO_2 Equivalents	1,799,983	780,200	780,200	780,200	780,200
Kg per year					
NO_x	1,334	2,501	2,501	2,501	2,501
SO_2	626	2,910	2,910	2,910	2,910

Expected emissions in Table 6.4 are calculated using the emission coefficients in Table 7 from the DEA's Recommendations (2009). CO_2 equivalent emissions in the reference scenario sum to 1,800 tons, same as for the ex post CBA. However, total expected emissions for 2004 are 668 tons in the ex post CBA and 780 for the ex ante CBA. Over time, this difference grows to app. 510 tons of CO_2 equivalent emissions annually in the period 2007-2018, principally due to the higher proportion of district heating consumers in the ex post scenario. NO_X and SO_2 emissions follow this evolution.

6.4 Summary with respect to costs

Table 6.5 and Table 6.6 illustrate pertinent information regarding the reference scenario and the project, respectively. Fuel costs in 2007 level factor prices are based on the used fuel amount (refer to Table 6.2) and the fuel prices of heating oil per consumer (e.g. 74.4 DKr per GJ in 2004) and for straw per district heating plant (31.4 DKr per GJ in 2004, 2007). Fuel prices are taken from the

DEA's Recommendations (2005, 2007 and 2009) and calculated at 2007 price levels. For a complete list of prices used, please refer to the appendix. For example, the heating costs in the reference scenario are 1,812,797 Dkr (=1,743,193 + 69,603) in 2004.

Table 6.5: Reference Scenario

	Reference Scenario: Heating oil + Electricity					
	Factor prices				Market prices	
	Fuel Cost			M & O Costs	CO_2 Costs	NO_x and SO_2 Costs
	Total Demand	Cost Oil	Cost Electricity			
Year	GJ	DKr	DKr	DKr	DKr	DKr
2004	24,532	1,743,193	69,603	484,380	319,243	142,393
2005	24,532	2,214,137	72,908	484,380	319,243	142,393
2006	24,532	2,516,384	79,109	484,380	319,243	142,393
2007	24,532	2,467,181	77,501	484,380	319,243	142,393
2008	24,532	2,357,060	74,263	484,380	365,288	142,393
2009	24,532	2,251,625	72,809	484,380	161,668	142,393
2010	24,532	2,499,983	75,452	484,380	210,782	142,393
2011	24,532	2,778,800	79,418	484,380	276,268	142,393
2012	24,532	3,097,449	84,154	484,380	360,172	142,393
2013	24,532	3,467,643	88,780	484,380	468,633	142,393
2014	24,532	3,462,957	89,882	484,380	468,633	142,393
2015	24,532	3,458,271	89,111	484,380	468,633	142,393
2016	24,532	3,509,817	88,560	484,380	468,633	142,393
2017	24,532	3,563,706	89,882	484,380	468,633	142,393
2018	24,532	3,617,595	88,890	484,380	468,633	142,393
NPV		**28,069,558**	**821,048**	**4,986,684**	3,586,858	**1,465,931**

The CO_2 costs in the reference scenario in the above table are based on the total CO_2 equivalent emissions of 1,800 tons from Table 6.4, and multiplied with the socioeconomically adjusted CO_2 prices from the specified year (DEA 2009). Again it is assumed that the value in 2004 is equivalent to the value in 2005. The final column shows the socioeconomic costs of NO_X and SO_2 based on total emissions from Table 6.4 have also been calculated. The final row in the table shows the net present value for 2004-2018 when using the discounting rate of 6 percent.

The table below follows the methodology of Table 6.5, adjusted for the differences in the project scenario.

Table 6.6: Project Scenario

	Project Scenario: Heating oil + Straw					
	Factor prices				Market prices	
	Fuel Cost			M & O Costs	CO_2 Costs	NO_x and SO_2 Costs
	Total Demand	Cost Oil	Cost Straw			
Year	GJ	DKr	DKr	DKr	DKr	DKr
2004	30,550	654,813	647,690	579,014	142,402	477,150
2005	30,550	855,157	647,690	579,014	142,402	477,150
2006	30,550	983,163	641,502	579,014	142,402	477,150
2007	30,550	962,523	641,502	579,014	142,402	477,150
2008	30,550	916,084	641,502	579,014	162,941	477,150
2009	30,550	871,232	748,762	579,014	72,114	477,150
2010	30,550	976,415	748,762	579,014	94,022	477,150
2011	30,550	1,094,498	728,135	579,014	123,233	477,150
2012	30,550	1,230,442	754,951	579,014	160,659	477,150
2013	30,550	1,386,232	783,828	579,014	209,039	477,150
2014	30,550	1,384,247	816,832	579,014	209,039	477,150
2015	30,550	1,382,263	856,023	579,014	209,039	477,150
2016	30,550	1,405,085	856,023	579,014	209,039	477,150
2017	30,550	1,427,908	856,023	579,014	209,039	477,150
2018	30,550	1,450,731	862,211	579,014	209,039	477,150
NPV		11,040,649	7,500,798	5,960,940	1,599,959	4,912,257

6.5 *Socioeconomic costs and benefits*

Table 6.7 below contains calculations on the socioeconomic costs and benefits found in the district heating plant relative to the reference scenario. Numbers from the reference scenario in Table 6.5 have been subtracted from the district heating values in Table 6.6. Thus a positive value is indicative of higher costs in the actual scenario relative to the reference, and a negative value means the actual scenario carries lower costs than the reference. The final column shows that the actual scenario, based on the assumptions previously described, results in a loss of app. 10.3 mil. DKr in 2007 level prices at the net present value in 2004. The other columns illustrate where this loss comes from.

Table 6.7: Socioeconomic result

Project less Reference								
	Factor Prices			Calculated Costs				
	Inv., M&O	Fuel	Inv., M&O, Fuel	Inv., M&O, Fuel	Deadweight loss	CO_2 Cost	NO_x and SO_2 Costs	Total
Year	DKr	DKr	DKr	DKr	DKr	DKr	DKr	DKr
2004	16,846,643	-510,293	16,336,350	19,113,529	714,310	-176,841	334,758	19,985,756
2005	94,634	-784,198	-689,564	-806,789	178,692	-176,841	334,758	-470,181
2006	94,634	-970,829	-876,195	-1,025,148	178,692	-176,841	334,758	-688,540
2007	94,634	-940,657	-846,023	-989,847	178,692	-176,841	334,758	-653,239
2008	94,634	-873,737	-779,103	-911,550	178,692	-202,347	334,758	-600,448
2009	94,634	-704,439	-609,805	-713,472	178,692	-89,554	334,758	-289,576
2010	94,634	-850,258	-755,624	-884,080	178,692	-116,760	334,758	-487,391
2011	94,634	-1,035,585	-940,951	-1,100,912	178,692	-153,036	334,758	-740,498
2012	94,634	-1,196,210	-1,101,576	-1,288,844	178,692	-199,513	334,758	-974,908
2013	94,634	-1,386,363	-1,291,729	-1,511,323	178,692	-259,594	334,758	-1,257,467
2014	94,634	-1,351,760	-1,257,126	-1,470,837	178,692	-259,594	334,758	-1,216,981
2015	94,634	-1,309,096	-1,214,462	-1,420,920	178,692	-259,594	334,758	-1,167,065
2016	94,634	-1,337,268	-1,242,634	-1,453,882	178,692	-259,594	334,758	-1,200,027
2017	94,634	-1,369,656	-1,275,022	-1,491,776	178,692	-259,594	334,758	-1,237,921
2018	-4,093,336	-1,393,543	-5,486,879	-6,419,649	178,692	-259,594	334,758	-6,165,793
NPV	**15,873,921**	**-10,349,160**	**5,524,761**	**6,463,971**	**2,375,246**	**-1,986,899**	**3,446,325**	**10,298,643**

Columns 1-3 in Table 6.7 show the difference between the district heating scenario from Table 6.6 less the reference scenario from Table 6.5, in terms of investment, M&O costs and fuel costs in factor prices. Columns 4-8 have been calculated in socioeconomically weighted prices. The combined excess costs for investment, maintenance and operations as well as fuel costs in factor prices from column 3 have been multiplied by the net social impact factor of 1.17 to account for the socioeconomic impact. The values in column 4 thus give the value (in consumer prices) of the alternate use value lost from having to produce the same amount of heat as in the reference scenario.

Column 5 gives the deadweight social loss, calculated as 20 percent of the government loss of revenue in terms of energy taxes due to the change in heat supply. This revenue loss is shown in more detail in
Table 5.8 below, and equals 9.2 mil DKr in net present value. The deadweight loss of this when added to the distortion caused by the government subsidy of 2,500,000, gives the social deadweight loss of app. 2.4 mil DKr in net present value. Columns 6 and 7 give the excess costs from the change in emission of greenhouse gases as well as of NO_X and SO_2, calculated as the difference between Table 6.5 and Table 6.6.

The final column shows the evolution over time of the impact of the district heating plant. The first year carries very high excess costs relative to the reference scenario, followed by a series of (mainly) negative costs and finally the scrap value of the investment.

6.6 District Heating Plant Costs

As before, district heating plants are expected to set a price on heating which covers average costs. The following calculations are based on the socioeconomic costs, and a subsequent section will analyse how these costs differ from the ones given by the district heating plant.

6.7 Private and Public Sector Costs

Table 6.8 below illustrates the excess costs for the participating households in terms of the prices payable by them including all taxes and 25 percent VAT. The final column in the table shows that the district heating plant results in net savings of app. 4.6 mil DKr. in net present value in 2004 in 2007-prices.

This is essentially due to the much lower price of straw delivered to the district heating plant relative to the price of heating fuel delivered directly to the household. The prices are taken from the DEA's Recommendations (2009), although data on CO_2 and SO_2 taxes are taken directly from the DEA homepage. All prices have been converted to the 2007 price level using the deflator from the DEA's Recommendations (2009).

Table 6.8: Net benefit to the consumer

Project less Reference								
	Investment, M&O			Fuel				
	Excl. VAT	VAT	Sum	Excl. taxes & VAT	Taxes	VAT	Sum	Sum Total
Year	DKr	DKr	DKr	DKr	DKr	DKr	DKr	DKr
2004	16,846,643	4,211,661	21,058,304	-510,293	-893,458	-350,938	-1,754,689	19,303,614
2005	94,634	23,659	118,293	-784,198	-893,458	-419,414	-2,097,070	-1,978,777
2006	94,634	23,659	118,293	-970,829	-893,458	-466,072	-2,330,359	-2,212,066
2007	94,634	23,659	118,293	-940,657	-893,458	-458,529	-2,292,644	-2,174,352
2008	94,634	23,659	118,293	-873,737	-893,458	-441,799	-2,208,994	-2,090,701
2009	94,634	23,659	118,293	-704,439	-893,458	-399,474	-1,997,371	-1,879,079
2010	94,634	23,659	118,293	-850,258	-893,458	-435,929	-2,179,645	-2,061,352
2011	94,634	23,659	118,293	-1,035,585	-893,458	-482,261	-2,411,303	-2,293,011
2012	94,634	23,659	118,293	-1,196,210	-893,458	-522,417	-2,612,085	-2,493,793
2013	94,634	23,659	118,293	-1,386,363	-893,458	-569,955	-2,849,776	-2,731,484
2014	94,634	23,659	118,293	-1,351,760	-893,458	-561,304	-2,806,522	-2,688,230
2015	94,634	23,659	118,293	-1,309,096	-893,458	-550,638	-2,753,192	-2,634,900
2016	94,634	23,659	118,293	-1,337,268	-893,458	-557,682	-2,788,408	-2,670,116
2017	94,634	23,659	118,293	-1,369,656	-893,458	-565,779	-2,828,893	-2,710,601
2018	-4,093,336	-1,023,334	-5,116,670	-1,393,543	-893,458	-571,750	-2,858,752	-7,975,422
NPV	**15,873,921**	**3,968,480**	**19,842,402**	**-10,349,160**	**-9,198,137**	**-4,886,824**	**-24,434,121**	**-4,591,719**

The reduction in taxes payable by the consumer on fuel represents a net cost to society, as these revenues would have to be secured elsewhere. Alternatively, the reduction in taxes could be considered an indirect subsidy to the area. Unfortunately, it is beyond the scope of this paper to assign distributional weights to the benefits for local consumers versus cost to the society in general.

6.8 Fuel supplier costs

The shift from private heating oil based furnaces to the straw-based district heating plant results in a net national supply-side benefit, as heating oil is imported from outside the country and transported to the island via trucks. Any potential loss resulting from wages to truck drivers or benefit resulting from shorter transportation are ignored.

Table 6.9 below illustrates the alternate use value of the straw as a fertiliser and the value of straw when delivered to the district heating plant in terms of the fuel price index recommended by the DEA.

Table 6.9: Impact on local suppliers

Project impact on supplier						
	Straw demand	**Price**	**Revenue**	**Additional cost**	**Alternate use value**	**Net benefit**
Year	GJ	DKr	DKr	DKr	DKr	DKr
2004	20,627	31.4	647,051	277,895	396,992	-27,836
2005	20,627	31.4	647,051	277,895	396,992	-27,836
2006	20,627	31.1	641,912	277,895	396,992	-32,975
2007	20,627	31.1	641,912	277,895	396,992	-32,975
2008	20,627	31.1	641,912	277,895	396,992	-32,975
2009	20,627	36.3	748,762	277,895	396,992	73,875
2010	20,627	36.3	748,762	277,895	396,992	73,875
2011	20,627	35.3	728,135	277,895	396,992	53,248
2012	20,627	36.6	754,382	277,895	396,992	79,495
2013	20,627	38.0	783,779	277,895	396,992	108,892
2014	20,627	39.6	817,643	277,895	396,992	142,756
2015	20,627	41.5	856,619	277,895	396,992	181,732
2016	20,627	41.5	856,168	277,895	396,992	181,280
2017	20,627	41.5	855,682	277,895	396,992	180,795
2018	20,627	41.8	861,267	277,895	396,992	186,379
NPV			**7,500,467**	**2,860,921**	**4,087,031**	**552,515**

The first column shows the expected demand for straw heating used in previous tables. The national prices are factor prices from the DEA, adjusted to the 2007 level. The alternate use value and the additional transportation costs are the same as in the ex post CBA; 0.28 DKr/kg and 0.195 DKr/kg, respectively.[15]

The final column shows the net outcome for the local farmers from supplying straw the district heating plant. According to the numbers used, the net annual outcome is negative until 2009; however, it should be noted that the alternate use and additional cost values used in the analysis are very uncertain. Given the alternative use value available to the farmers, it is unlikely that they would continue to supply straw if they were consistently making a net loss. The overall net present value in 2004 at the 2007 price level is over half a million DKr; money that is retained in circulation around the island rather than being sent outside.

6.9 Comparison of ex ante and ex post results

The following table illustrates key results from ex ante project scenario and the ex post project scenario. The first three columns are in NPV in 2004 based on 2007-level prices.

Table 6.10: Comparison of ex ante and ex post project scenarios

Impact	Unit	Ex Ante Project Scenario	Ex Post Project Scenario
Socioeconomic result	DKr.	10,298,643	6,102,560
Net benefit to consumer	DKr.	-4,591,719	-14,626,424
Net impact on supplier	DKr.	-552,515	-839,368
CO_2 emissions	tons	-15,731	-22,782

The first row in the table summarises the socioeconomic result from Table 5.7 and Table 6.7 in the preceding sections. The figure represents the net socioeconomic <u>loss</u> of the plant, as the costs correspond to the excess cost of the project relative to the reference scenario. Despite higher M&O and investment costs in the ex post scenario, the loss is 40.7 percent lower in reality than anticipated. This is principally due to the higher number of users; 56 percent were expected relative to the reality of 86 percent out of the original 297 potential users accounted for.

The net benefit to the users (based on socioeconomic prices) is 10 mil DKr higher in the ex post scenario than in the ex ante scenario. Adjusting for the number of users in each scenario gives

[15] Numbers based on interviews with local suppliers, equivalent to 30 øre/kg in 2009 prices

values for the ex ante and ex post scenario of app. 27,500 DKr and 56,700 DKr, respectively. This is principally due to the much lower taxes payable on biomass heating relative to oil-based or electrical heating; taxes equal 61.63 DKr/GJ for heating oil, 171.66 DKr/GJ for electrical heating, relative to 1.64 DKr/GJ for straw. However this benefit is indirectly paid for by all citizens at the national level, since the lost taxes must be recouped elsewhere. It can be viewed as an indirect subsidy to the rural economy.

The net impact on the supplier is the NPV of the benefit of supplying straw to the district heating plant relative to its alternate use as fertiliser. The increased value in the ex post scenario is a direct result of the higher demand used in the ex post scenario. The same reason applies to the reduction in tons of CO_2 emitted in the ex post scenario relative to the ex ante scenario, calculated as the total for the entire period.

6.10 Sensitivity analysis

In correspondence with the methods to counter uncertainty outlined in the introduction, the CBA results are subjected to sensitivity analysis.

Table 6.11: Sensitivity analysis of calculations

Variable	15 years	20 years	3.5 % discount rate
Original ex ante	10,263,024	9,967,026	7,798,404
Original ex post	6,102,560	5,817,209	2,208,155
Local straw prices	-2,561,587	-3,049,277	-2,985,559
Including oil investment	-3,774,580	-4,059,931	-7,668,985

The first column contains the estimates based on a 15 year lifetime as is used throughout the paper. The second column shows the same estimates extended to a 20 year lifetime. The scrap value for both CBAs is assumed to equal zero in the final period. The final NPV for both the CBAs remains in favour of the reference scenario, as all the values in the first two rows indicate additional socioeconomic costs of the investment relative to the reference. The third column illustrates the estimates for the 15 year lifetime using a discount rate of 3.5 percent as recommended by the Green Book (2003) rather than the 6 percent discount rate otherwise used.

The third row shows the impact on the local suppliers based on the prices given during interviews. A median value of 330 DKr/ton was used (353.3 Dkr/ton at the 2007 price level). Assuming no price increases over the period, due to the reasons mentioned earlier, the local suppliers would suffer a NPV loss equal to between 2.6 and 3.1 mil DKr, respective of the discount rate and period examined. The estimates indicated that they would already have experienced a loss relative to the alternate use value; this is unlikely, as in this case they would not continue to supply the district heating plant as they have so far. Although using the standard local price indicates that the supplier suffers a net loss relative to his alternative use value, the prices used in the table above are very rough approximations. For example, once the base price is adjusted for moisture content, revenues increase significantly; in 2005, average moisture content was only slightly above 12 percent, meaning the price was adjusted by 1.11.

The final row includes estimates of the investment cost of an oil furnace from Bornholms Forsyning (2008), equal to 31,500 DKr per furnace (2007 price level). Assuming this cost is irrespective of size, the total investment cost in 2004 would be 8.4 mil DKr for 268 heating-oil consumers. Including this in the CBA drastically changes the NPV of the project; it now carries a positive net value between 3.8 and 7.7 mil DKr, depending on specification.

7 Stated Preference Section

7.1 Literature Review

A significant element of CBA studies is the valuation of non-monetarized goods through stated preference methods such as willingness to pay/willingness to accept estimation or through revealed preferences, e.g. hedonic pricing. Comparisons of the validity of the two approaches has been examined elsewhere (Carson et al., 1996; McFadden 1994) and is therefore not discussed in this paper. Past research has investigated consumers' willingness to pay (WTP) for hypothetical renewable energy programs using choice experiments (Bergmann et al., 2006; Bergmann et al., 2007; Longo et al., 2007; Banfi et al., 2008) and contingent valuation methods (Hanley & Nevin, 1999; Nomura & Akai 2004; Whitehead & Cherry 2006). In this paper, a contingent valuation approach is employed to investigate the willingness to pay for a hypothetical improvement to an existing renewable energy plant on the 'Renewable Energy Island' Samsø. The paper follows the general guidelines as set forth by Hanemann (1994).

Contingent valuation (CV) is a stated preference approach and can be used to estimate either an individual's WTP for a given improvement in a households heating supply or an individual's willingness to accept (WTA) compensation for the costs imposed on them due to such an arrangement. It is beyond the scope of this paper to estimate both revealed preference and stated preference WTP.

7.2 Methodology

This study was performed by mail survey. A total of 258 households were identified as users of the local district heating plant in Ballen-Brundby, 7 of which were larger enterprises such as hotels and medium/large stores. 85 of the questionnaires were posted to addresses off the island, and 119 were hand-delivered to local households. An additional 2 were posted after the first, personal delivery attempt failed. Out of the letters that were delivered in person, approximately 55 percent were delivered directly to a representative in the household, and the remaining 45 percent placed in their mail box. Altogether 206 questionnaires were delivered, out of which 91 were returned by mail. 2 of the 119 hand-delivered questionnaires were interviewed directly by the author.[16] 4 returned questionnaires could not be used due to missing information, resulting in a usable response rate of 42 percent (34 percent out of total households).

7.3 Structure of the questionnaire

An introductory section in the questionnaire presented the topic of the survey; users' opinions of the local district heating plant. Additional information was supplied about the project and its purpose, namely that the survey was part of a socioeconomic analysis of the heating plant, an evaluation which was being conducted as part of an MSc degree. The questionnaire consisted of four parts. In the first part, respondents were asked for the general characteristics of their residence, including questions on length of stay in the house and age of the building. The second part focused specifically on the households' heating supply and questions regarding the users' satisfaction with the current supply, and included questions on annual heating bills, supplementary sources of heating and whether plans to modify the current heating arrangements were under consideration.

The third section was the central part of the questionnaire, containing questions concerning a hypothetical improvement of the district heating plant which would reduce harmful emissions and improve efficiency, but which would increase the heating bill with a fixed amount over a period of one year. The first question stated that the improvements would require a one-time increase in the annual heating bill of 2600 DKr, approximately 15-20% of the annual heating bill to be paid in quarterly instalments (650 DKr per quarter). Respondents could answer "yes", "maybe" and "no".

[16] A copy of the questionnaire is included in the appendix, but only in Danish

The second question, placed on the following sheet of paper, asked whether the respondents would be interested in the improvement given a government subsidy, which would reduce the costs to approximately 1400 DKr over a year (350 DKr per quarter). Respondents could again answer “yes”, “maybe” and “no”. The “maybe” option was included in order to avoid hypothetical bias from the respondents given the issue of inflated WTP values often found in stated preference survey designs (Whitehead & Cherry, 2007). The “maybe” option was intended to isolate those respondents who would be most susceptible to “cheap talk”, i.e. answer “yes” in a survey but not be interested in paying in the case of a real commitment. Thus respondents who answered “maybe” to both of the questions are considered as being very unlikely to have positive WTP values. Naturally, those respondents who answered either “no” or “maybe” to the first question and “yes” to the second question do not fall into this category, as they have indicated a positive, albeit lower, WTP value for improvements to the district heating plant.

Originally, the intention was simply to ignore the respondents who answered “maybe” to both investment decisions, but as this turned out to be the majority of the respondents, an ordered logistic approach (Jackman 2000; Gruszczynski, 2004) was applied instead. The ordered logistic approach assigns a value to each different response category, similar to the ordinary logistic approach but instead of the binomial 0-1 values, ordered responses values 1-3 are assigned to the dependent variable.

The final section contained the usual questions on the demographic characteristics commonly used in econometric analysis as well as questions regarding the users’ opinions on the importance of the environment in a general sense, as well as specifically in terms of the impact on the islands’ attraction as a tourist destination. Additionally, an internal validation question was included to test the consistency of the results (Bergmann et al., 2006; Bergmann et al., 2007).

7.4 Data Description

The survey questions relating to the independent variables can be roughly divided into three distinct categories; attitudinal, socioeconomic and demographic. The demographic variables include age of respondent, sex, age of residence, number of years in residence and a dummy indicator if the respondent had children. In a survey of WTP conducted by Menegaki (2008), WTP is positively correlated with younger age groups, women and those with children. WTP for renewable energy is thought to be positively correlated with being a parent as it reflects the so-called ‘bequest value’;

i.e. parents wish to leave a good environment to their children (Menegaki, 2008). Hanley & Nevin (1999) find that the number of years of residence in the community was inversely related to support for the construction of renewable energy plants, most likely due to the change in the landscape imposed by such construction.

7.5 Demographic variables

The demographic variables found in the questionnaire are summarized below:

Table 7.1: Summary of demographic variables

Variable	Average	Minimum	Maximum	No. of responses
Age	60.5	32	94	86
Age of house	67.9	1	228	86
Years in house	19.4	1	86	83
Sex (Male = 1)	58.6 %	-	-	87
Parent (Yes = 1)	81.9 %	-	-	83

The average age of the respondents was 60.5 years, and 58.6 percent of the respondents were male. According to Denmark's Statistic Database, the average age of adults living on Samsø is 57.3 and 47.8 percent are male[17]. The slight discrepancy in statistics is most likely due to those respondents who own a summerhouse on the island but do not live there permanently. Nationally, the average age of adults is 48.3 and 49.1 percent of all adults is male, indicating that the population on Samsø is slightly older than the average population.

7.6 Socioeconomic variables

Socioeconomic variables include household income, heating bill, house modifications exceeding 5,000 DKr[18], supplementary sources of heating, house size and moving plans. Household income is assumed to be positively correlated with WTP for renewable energy (Menegaki, 2008). As the proposed additional investment is in fixed prices, a person currently paying a high heating bill may be either *more* likely to accept the investment, as a small increase does not matter much, or the person will be very resistant towards further increases to an already high cost. Those who have high incomes in conjunction with high heating bills are most likely to be in the former group, and those with lower incomes and high heating bills are even more likely to be more resistant to price

[17] Numbers from 2008
[18] The minimum investment level of 5,000 DKr was arbitrarily imposed by the author

increases. This effect is captured by using an interaction term to control for house size, as those with high heating bills relative to house size are expected to be less sensitive to (relatively) small changes to price.

Owning a supplementary heating source such as a fireplace is quite common in both older buildings and in houses built for leisure use. Owning a supplementary source of heating means the respondent is likely to be more responsive to changes in variable costs, and therefore also more resistant to changes in fixed costs.

Those who had recently completed household modifications which impacted household heating or are planning to in the immediate future are expected to be more in favour of additional investment, as they can be seen as a 'home-improvement' type. Alternatively, if the reason for house modifications is due to dissatisfaction with current heating provision, then the 'house modification' group may be the most resistant to additional improvements in the heating plant, as they may view it as a waste of time. Those respondents on the verge of moving are less likely to be in favour of additional investment, as any benefit to the house accruing from the district heating connection has already been realised and is not likely to change the slight improvement proposed in the questionnaire. The socioeconomic variables and satisfaction with current heating supply are summarized in the table below (no. of observations in brackets):

Table 7.2: Summary of socioeconomic variables

Variable	Average	Minimum	Maximum	No. of responses
Income category	3.13	1 (19)	5 (22)	82
Heating bill category	2.75	1 (7)	5 (3)	85
House size category	2.56	1 (6)	5 (6)	87
House modifications (none = 0)	0.77	0 (30)	2 (11)	82
Satisfaction index (yes = 1)	89.4 %	-	-	85
Supplementary heat (yes = 1)	45.9 %	-	-	85
Intention to move (yes = 1)	3.6 %	-	-	83

The variables in the first three rows were divided into five categories and ordered according to magnitude in the questionnaire. For instance, 19 of the respondents were in income category 1, corresponding to a yearly income of less than 150,000 DKr (roughly corresponding with a single person on state pension or similar). 6 of the respondents had a house size category of 5, corresponding to a house of more than 200 square meters.[19] For an overview of the contents of each category, please refer to the questionnaire in the appendix.

The average income for respondents in the questionnaire was roughly in category 3, corresponding to a household income between 300,000 and 449,000 DKr. According to Denmark's Statistical database, the average household income for Samsø is 379,000 DKr and the average national household income is 445,000 DKr[20]. Thus it appears that the average income group in the questionnaire is representative of the average income group of the island, as well as nationally.

Two separate binary choice questions were asked to determine whether the house had recently undergone improvements or was likely to be modified in the near future, and were subsequently combined to created a trinomial outcome variable. 30 respondents had not carried out nor planned any improvements that might affect the heating supply, whereas 11 respondents had implemented improvements and were planning further modifications in the near future. 7 of the 9 unsatisfied respondents either had implemented household modifications with respect to heating or were planning to (data not shown above). 39 respondents had a supplementary heating source; 30 had their own fireplace, 7 had electrical heating, 2 had solar heating and 3 had other heating sources (some had a combination of two).

7.7 Attitudinal variables

Attitudinal variables include evaluation of own energy saving behaviour, opinion on Samsø's transition to a renewable energy island, opinion on the impact on tourism from Samsø's transition to a renewable energy island and the internal validation question outlined below.

Internal validation

Respondents were asked to weigh six attributes according to preference, with one being the most important and six being the least important. The first three attributes related to the environment and the following three to price, impact on the landscape and creation of local improvement, respectively. The list is reproduced below (translated to English):

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[19] There was a typo in the questionnaire, where category 5 corresponds with a house size of more than 150 square meters, but as category 4 was a house size between 150 and 200 square meters it is assumed that the respondents were able to overlook the error.

[20] Numbers from 2007

- Your heating supply should not negatively impact air quality
- Your heating supply should not generate pollution
- Your heating supply should not harm local wildlife
- Your heating supply is as cheap as possible
- Your heating supply should not be an eyesore in the local landscape
- Your heating supply should generate local employment

The second point, the generation of pollution, is a general form of the preceding and following points relating to the environment. It has been deliberately placed second in order to reduce or isolate order effect bias, assuming the question is correctly interpreted (Hanemann 1994). However, given that the question is placed near the end of the questionnaire, respondents may have been impatient to finish and might have found the mix of general and specific attributes irritating. Not all respondents were willing to weight one attribute over another; a few assigned an equal weight to all attributes, whereas others assigned the weight 1 to some attributes and left others blank. Bergmann et al. (2006 & 2007) found the following ranking of attributes: air pollution, wildlife, price, landscape and employment. The ordering uncovered by this questionnaire was: general pollution, air pollution, price, wildlife, local employment and landscape impact.

Given the discrepancies in the method of answering this question, the inverse was taken for the regression analysis. Hence, if a respondent had rated all attributes equally with a ranking of 1, the inverse value 1/1 was used in the analysis. A ranking of 6 would be weighted as 1/6 and a missing value was left blank. This approach to ordering the various attributes leads to viable, albeit different, estimates than was intended, as a preference ordering was still in effect.

It is expected that the respondents who rated themselves as consistently careful of their energy consumption would be the most open to the proposed investment, as it promises an efficiency increase. However, if the reason for their care in energy consumption is cost motivated, then they are more likely to be resistant to further increases in the heating costs. Following this argument, we would expect those who never save on heating to be indifferent to proposed price increases, as a 1,400-2,600 DKr increase in a +20,000 DKr annual heating bill will be felt as a low marginal increase (relative to a category 1 heating bill of less than 5,000 DKr annually).

WTP for the proposed improvement to the district heating plant is expected to increase alongside positive valuations of the importance of renewable energy to Samsø's attractiveness, both intrinsically and as a tourist destination. Both of these variables and the self-rated energy consumption are categorical variables with four possible answers, with the highest value corresponding to the least positive etc. Similar to the internal validation question, the inverse value was then taken, such that a category 1 answer has a value 1/1 and a category 4 answer has a value 1/4. No negative responses were recorded for the question regarding Samsø's attractiveness. The table below summarizes the results from the responses to the attitudinal variables (no. of observations in brackets).

Table 7.3: Summary of attitudinal variables

Variable	Average	Minimum	Maximum	No. of responses
Self rated energy consumption	0.77	0.25 (2)	1 (51)	86
Samsø's RE: transition value	0.87	0.33 (2)	1 (66)	87
Samsø's RE: attractiveness to tourists	0.75	0.33 (4)	1 (44)	85
Internal validation question	2.62	0 (3)	6 (7)	87

59 percent of respondents considered themselves consistently careful of their energy consumption and 76 percent felt that Samsø's transition to a renewable energy island was inarguably positive development, whereas only 44 percent felt that this was important in terms of the islands' attractiveness to tourists. As Samsø has been a major tourist destination for many decades prior to the renewable energy initiative this is not surprising. The average value for the internal validation question is 2.6. If the respondents had all complied with the answering method requested, we would expect an average of 2.45 (1/1+1/2+…+1/6), which would also have been the minimum and maximum value. However, as stated previously, this method of data transformation allows for enough variation in the variable for it to be used a predictor of the dependent variable, despite the non-conformity of the answers. Please note that in the internal validation question in the table above, ratings for the six options were added together in the interest of saving space. Each option was included separately in the regression, and tested jointly.

Finally, one question which was not included in the questionnaire but for which many respondents volunteered answers to was whether the house in question was used as a summerhouse/leisure residence. In 22 of the returned questionnaires, the respondents pointed out that the house was only used rarely and so a dummy variable indicating whether or not this was the case was included in the regression specification. In the list of consumers provided by the Ballen-Brundby district heating plant, 31.8 percent of the houses are registered as summerhouses. In the regression, 25.3 percent have been marked as summerhouses, but as this was not a question, it is possible that this figure is an understatement of the true number in the returned questionnaires.

7.8 Regression Results

Willingness to pay for a small improvement to plant efficiency and reduction in emissions, above the actual heating bill payments, was estimated using the contingent valuation method. As stated previously, two investment scenarios were proposed. The purpose was to determine whether the consumers' willingness to pay was exhausted under the current prices. The results from the questionnaire are summarized in the table below:

Table 7.4: Respondent Response to Investment Scenarios in Questionnaire

Answer	Investment Scenario 1	Investment Scenario 2	Difference
Very interested	8 (9%)	21 (24%)	13
Need more information	58 (67%)	51 (59%)	7
Not interested	21 (24%)	15 (17%)	6
Total	**87 (100%)**	**87 (100%)**	**-**

Out of the 87 respondents, 9 percent were 'very interested' in the investment proposal under scenario 1, and 24 percent were 'very interested' in the subsidized investment proposal in scenario 2. Assuming that the questionnaire respondents are representative of all the district heating users in Ballen and Brundby, simple linear aggregation results in a total WTP of between 60,372 – 86,688 DKr or an average WTP of 234 – 336 DKr per household. Given that this is the WTP for a slight improvement to an existing source of renewable energy, the value is surprisingly high; corresponding to an additional WTP per MWh between 12.4 – 17.8 DKr.

In scenario 1, 24 percent of the respondents were 'not interested' in the investment proposal but only 17 percent felt the same way about investment scenario 2. Those respondents who changed their answer in response to a decrease in the required payment for the investment did so strictly in adherence to the transitivity principle required for the rationality assumption, i.e. respondents who chose 'not interested' for the first scenario either answered the same or changed to 'need more information' for the second scenario. Respondents who chose 'need more information' under scenario 1 either answered the same under scenario 2 or changed their answer to ‘very interested’ in scenario 2. Respondents who chose ‘very interested’ in scenario 1 answered the same under scenario 2.

The original decision to include the ‘need more information’ answer was motivated by the intent to isolate potential ‘cheap talk’ respondents from those who were serious about payment. However, Table 7.4 above shows that the response category was treated as an ordered variable with a value in between the ‘very interested’ and ‘not interested’ categories. If this were not the case, respondents who selected ‘not interested’ in scenario 1 would have discounted the middle category and instead selected the ‘very interested’ category in scenario 2. No respondents did this; instead, all changes occurred in step-wise increments as detailed above. In order to take advantage of this response pattern an ordered logistic regression was considered more appropriate than a binomial logistic regression. Values of 1-3 were assigned to the response categories, with 1 indicating the ‘not interested’ category and 3 indicating the ‘very interested’ category.

Ordered logistic models were estimated using the investment response as the dependent variable for each of the two investment scenarios. Socioeconomic, demographic and attitudinal variables were included as independent explanatory variables in order to evaluate their impact on the probability of a positive response to the investment question. The regression equation estimated is shown below:

$$y_i = \beta 1\mathbf{X}'_{Socioeconomic} + \beta_2\mathbf{X}'_{Demographic} + \beta_3\mathbf{X}'_{Attitudinal} + \varepsilon_i \qquad i = 1,2,3$$

Where Y_i represents the ordered response variable with values from 1 to 3, where 1 indicates a ‘not interested’ response etc. Stata software automatically suppresses the intercept value when running ordered logistic regressions, so no constant value is reported.

The results for both logit and probit coefficient estimations are shown in

Table 7.5 (standard errors in brackets).

Table 7.5: Logistic Regression Results

Variable	Ordered Probit Regression		Ordered Logit Regression	
	Inv Scenario 1	Inv Scenario 2	Inv Scenario 1	Inv Scenario 2
Heating Bill	1.48*** (0.55)	1.50*** (0.47)	2.59** (1.02)	2.68*** (0.91)
Household Income	-0.70** (0.30)	-0.59** (0.25)	-1.34** (0.58)	-1.08** (0.45)
House Size_Bill Interaction	-2.53** (1.05)	-1.74** (0.85)	-4.88** (2.10)	-3.20** (1.58)
Summerhouse Dummy	-0.14 (0.87)	2.20*** (0.86)	-0.28 (1.57)	3.85** (1.59)
Satisfaction Index	-1.33 (1.18)	-0.94 (0.90)	-2.74 (2.32)	-1.77 (1.63)
House Modifications_Improvement	0.49 (0.48)	0.26 (0.39)	0.98 (0.89)	0.51 (0.70)
Energy Island Rating Index	1.68 (1.52)	-0.31 (1.29)	2.59 (2.67)	-0.30 (2.66)
Air Indicator	0.92 (1.29)	0.37 (0.97)	1.98 (2.41)	0.50 (1.74)
Fauna Indicator	0.98 (1.80)	0.42 (1.70)	1.55 (3.22)	1.44 (3.24)
Environment Indicator	4.69*** (1.50)	2.98*** (1.05)	8.33*** (2.81)	5.20*** (1.89)
Harmony Indicator	-3.01* (1.62)	-3.69** (1.50)	-5.36* (3.09)	-6.56** (2.75)
Cheap Indicator	0.43 (0.86)	2.08** (0.99)	0.94 (1.59)	3.40* (1.83)
Employment Indicator	-0.54 (1.74)	-0.74 (1.29)	-1.10 (3.17)	-1.44 (2.38)
Self-rated Energy Savings Index	-5.65*** (2.09)	-4.53*** (1.31)	-10.62*** (4.07)	-8.20*** (2.52)
Sex Dummy	0.04 (0.81)	-0.27 (0.67)	-0.02 (1.44)	-0.49 (1.19)
Age	-0.01 (0.03)	0.01 (0.03)	-0.01 (0.06)	0.01 (0.05)
Children Dummy	0.45 (0.66)	-0.46 (0.54)	1.14 (1.30)	-0.77 (0.98)
_cut 1	*-4.87 (4.10)*	*-4.00 (3.09)*	*-9.46 (7.76)*	*-8.17 (5.88)*
_cut 2	*0.44 (3.74)*	*-0.71 (3.06)*	*0.25 (6.89)*	*-2.43 (5.70)*
No. of Observations	51	51	51	51
Log Likelihood	-19.28	-24.56	-19.17	-24.75
Pseudo R-squared	0.529	0.450	0.532	0.446
Lacy R-squared$_O$	0.529	0.496	0.535	0.495
Count R-squared (Adjusted Count R-squared)	0.824 (0.400)	0.784 (0.421)	0.824 (0.400)	0.784 (0.421)

*,**,*** denote significance at the 10%, 5% and 1% level

The variables HEATING BILL, HOUSEHOLD INCOME, interaction variable HOUSESIZE_BILL, ENVIRONMENT valuation, and SELF-RATED ENERGY SAVINGS are significant at the 5 percent or 1 percent significance level for both scenarios and across logistic specifications.

The results presented in the table above lead to the following conclusions:

- *Model accuracy improves*: the inclusion of attitudinal variables, such as the importance of Samsø's status as a renewable energy island (ENERGY ISLAND RATING), improves the fit of the model substantially. Although only two attitudinal variables are consistently significant at the 5 percent significance level across all specifications, model specifications omitting the insignificant variables resulted in lower r-squared values across specifications (results not reported in this paper in the interest of saving space). This is consistent with other CVM studies which find that attitudinal variables may be better at predicting WTP than standard socioeconomic and demographic variables (Wiser 2005).
- *Structural differences*: there are additional significant variables affecting acceptance of investment scenario 2 relative to scenario 1. The SUMMERHOUSE dummy and the HARMONY indicator are significant at the 5 percent significance level for investment scenario 2 across specifications. Additionally, the CHEAP indicator is significant at the 5% level in the probit model of investment scenario 2 and at the 10 percent level in the logit model of the same scenario. At the lower cost outlined in scenario 2, those respondents with a summerhouse are more likely to accept the investment than in scenario 1. Given that summerhouse users would be less likely to be affected by the smoke nuisance than permanent residents, they would in general be expected to have a lower WTP. However, the effect of the summerhouse owners may be slightly understated, as explained before. Those respondents who valued 'cheapness of heating bills' highly on the questionnaire are more likely to accept the investment in scenario 2 than in scenario 1. Those who rated 'plant must be harmonious with landscape' in the questionnaire are unlikely to accept the investment in either scenario 1 (significant at the 10 percent level) or in scenario 2 (significant at the 5 percent level), which is what we would expect, as the investment proposal does nothing to improve the plants' appearance.

The magnitudes of the coefficients in the model specifications reported in the table are not directly suitable for inference. Instead, the table below presents the predicted probabilities to investment scenario 1 and 2, respectively. The income variable from

Table 7.5 above is negatively related to the investment scenarios in the model, which runs counter to intuition as it is generally assumed that WTP increases with income.

Calculating predicted probabilities for income while controlling for the size of the heating bill gives the following results[21]:

Table 7.6: Predicted Probabilities from INCOME/HEATING BILL

	'Very interested' response		'Not interested' response	
INCOME/BILL Category	**Inv. Scenario 1**	**Inv. Scenario 2**	**Inv. Scenario 1**	**Inv. Scenario 2**
5/1	0.000	0.000	0.847	0.844
3/3	0.025	0.449	0.000	0.001
1/5	0.992	1.000	0.000	0.000

Interestingly, the table shows that the low-income/high heating bill group has a predicted probability equal to 0.99 of accepting investment scenario 1, whereas the high-income/low heating bill group has a predicted probability equal to 0.85 of rejecting the same scenario. Slightly larger probabilities were obtained for investment scenario 2. This result does not help determine why the income effect seemingly runs counter to what would be expected. However, once heating bill magnitude is controlled for relative to house size, a different pattern emerges, as can be seen in the table below:

Table 7.7: Predicted Probabilities from INCOME/HEATING BILL_HOUSE SIZE

	'Very interested' response		'Not interested' response	
INCOME/BILL_HOUSESIZE Category	**Inv. Scenario 1**	**Inv. Scenario 2**	**Inv. Scenario 1**	**Inv. Scenario 2**
5/high	0.000	0.000	0.831	0.583
3/medium	0.010	0.283	0.001	0.003
1/low	0.779	0.961	0.000	0.000

Respondents with low incomes and low heating bills relative to house size have a predicted probability of 0.78 of accepting investment scenario 1, while respondents with high incomes and high heating bills relative to house size have a predicted probability of 0.83 of rejecting the same

[21] Note that only results from the ordered probit specification are reported in the table. The results from the ordered logit specification were quantitatively similar, and were therefore omitted to save space.

scenario, with similar patterns occurring for investment scenario 2. Comparatively, the low-income/high heating bill relative to house size only have a predicted probability of 0.002 of accepting investment scenario 1, with the high-income/ low heating bill relative to house size has a predicted probability of 0.003 of rejecting the same investment (results not reported here). Overall, rather than low (high) income on its own being a suitable predictor of acceptance (rejection) of investment, low (high) income in combination with low (high) heating bills given house size is a more logical predictor, as it takes into account individual preferences.

The results from Table 7.6 and Table 7.7 above indicate that income as an explanatory variable on its own is an unsatisfactory predictor of WTP. Problems with generating significant values for income in WTP estimations or finding positive relationships between WTP and income are common in the literature (Bergmann et al. 2006; Wiser 2006; Bergmann et al. 2008; Ek 2005). Papers which find significant positive income effects include Zarnikau (2003) (only between 8-11 cents per additional thousand dollar income), Roe et al. (2001) and Batley et al. (2001). However, Batley et al. (2001) note that using income by itself as an explanatory variable can be subject to bias, as income alone does not reflect spending patterns or preferences. Spending on renewable energy was more likely to increase with higher social groups than with income alone (for the UK). Roe et al find similar results for their survey of the US, where regional indicators, educational attainment and environmental affiliation are more stable indicators of WTP than income.

In addition to income, the SELF-RATED ENERGY SAVINGS index shows a perplexing relationship to the WTP function. It is consistently significant and negative across specifications, where we might expect a positive relationship between WTP and attitude towards energy conservation. However, if we consider the variable to be a function of individual preference in terms of spending, where high ratings indicate lower willingness to pay for heating then this may make sense. The table below illustrates the ‘always tries to save energy’ and ‘never tries to save energy’ responses crossed with heating bills relative to house size.

Table 7.8: Predicted Probabilities for SELF-RATED ENERGY SAVINGS/HEATING BILL_HOUSE SIZE

	‘Very interested’ response	‘Not interested’ response

SELF-RATED ENERGY SAVINGS/BILL_HOUSESIZE Category	Inv. Scenario 1	Inv. Scenario 2	Inv. Scenario 1	Inv. Scenario 2
never/low	0.975	0.996	0.000	0.000
never/high	0.012	0.401	0.001	0.001
always/low	0.011	0.229	0.001	0.006
always/high	0.000	0.001	0.884	0.641

The table above shows the same tendencies as the previous two; predicted probabilities for 'very interested' responses tend to increase as the cost decreases from scenario 1 to scenario 2, whereas the predicted probabilities for the 'not interested' response decrease. What is interesting is that those who consider themselves as less likely to save on heating are *more* likely accept the investment scenarios compared to those who always try to save energy, even after controlling for the size of heating bills. This may be a reflection of attitude; those who have high heating bills despite being very conscious of their heating consumption may be more sceptical of the proposed improvements from the questionnaire, where those who pay low bills but never consciously reduce heating may be more indifferent. Alternatively, those with low heating bills are most likely to be the owners of summerhouses, with different spending habits than the permanent residents.

7.9 Specification Tests

Several specification tests were conducted to assess the validity of the regression models in accordance with Long & Freese (2006), Lacy (2006) and UCLA Academic Technology Services. The first test is a general logistic model specification test to determine whether any additional statistically significant predictors are likely to have been omitted. The results are presented in the table below:

Table 7.9: Model Specification Test for omitted predictors

Model Specification	β_hat	Standard error	β_hatsquared	Standard error
Ordered Probit Inv. Scenario 1	0.81**	0.33	-0.05	0.06
Ordered Probit Inv. Scenario 2	0.70**	0.34	-0.12	0.14
Ordered Logit Inv. Scenario 1	0.76**	0.37	-0.03	0.03
Ordered Logit Inv. Scenario 2	0.57	0.5	-0.06	0.07

** indicates significance at the 5% level

The only regression which fails the specification test is the ordered logit specification for investment scenario 2, indicating some caution is advisable when using these results for inference. However, the test holds for the other specifications; the variable *β_hat* should be a statistically significant predictor, since it is the predicted value from the model, and is at the 5% significance level in the first three specifications. *β_hatsquared* should test as non-significant, otherwise either omitted variable bias or misspecification of the model is present, and it does this even at the 10% level.

The second test conducted was to ascertain whether the parallel regression (proportional odds) assumption holds. This is a critical assumption in ordered logistic regression and requires that slope coefficients are identical across specifications, i.e. irrespective of the y_i value. The test is conducted by comparing the β's from the ordered logistic models with β's from ordinary logistic models. If the assumption holds, the values of the coefficients should be close to equal. A significant test statistic provides evidence that the parallel regression assumption has been violated. Neither logistic specification for the investment 2 scenario provided significant test statistics, but both logistic specifications for the investment 1 scenario did. As this might be due to the large number of explanatory variables used, two of the insignificant explanatory variables for scenario 1[22] were dropped, which resulted in insignificant test statistics indicating that the parallel regression assumption was restored. The omission of two explanatory variables in scenario 1 only had minor impacts on the goodness of fit, significance and predictive power of the explanatory variables and so the new results are not reported here.

The data in the regression did not appear to exhibit signs of multicollinearity, which was confirmed after applying the simple multicollinearity test to the variables. No variables had a variance inflation factor above 5, which is substantially below the rule of thumb cutoff point of 10. The reported pseudo R-squared value and the recommended ordinal Lacy R-squared value (Lacy 2006) indicate the model's overall goodness of fit is superior or comparable to similar analyses with a reported pseudo R-squared (Banfi et al., 2006; Bergmann et al., 2006; Bergmann et al., 2007).

7.10 Summation of results

The results from the questionnaire indicate that the willingness to pay for environmentally friendly heat has not been exhausted even after the creation of the district heating plant. The table below shows the results from other WTP studies relative to the estimates uncovered here.

Table 7.10: Comparison of WTP from literature

Author(s)	Summary	Year	WTP per respondent	WTP equivalent

[22] Where one was the CHILDREN variable

				(DKr 2009 price level)
Banfi et al.	WTP for improvements to insulation in existing/new houses or flats in Switzerland using CV	2006	1-13 % of flat prices 2,030/1,330 CHF per month, depending on improvement type *(one-time payment)*	862–17,094
Kooten et al.	WTP for continued access to forest amenities in Sweden using fuzzy logic CV	1992 (survey performed by Li & Mattsson)[23]	3,116 – 3,561 SEK *(one-time payment)*	2,913- 3,329
Nomura & Akai	CV WTP for wind power/photovoltaic energy in Japan	2004	Average of 24,864 yen annually (2,027 yen per month)	1,520
Alvarez-Farizo & Hanley	WTP to preserve local wildlife and landscape from a windmill installation using CV and choice experiments in Spain	2002	3,062-6,162 pesatas annually	165-332
Hanley & Nevin	WTP for different local renewable energy plants in Assynt, Scotland using CV	1998[1]	UK £ 26 - 55 annually	276-594
Bergmann et al.	WTP to reduce externalities such as landscape and air quality impacts in Scotland using CV	2004	UK £ 3.21-14.40 annually	32-142
Whitehead & Cherry	WTP ex ante and ex post CV of amenities associated with a Green Energy program in North Carolina	2005	US $ 51 annually per household	297
Longo et al	WTP for a 1 percent decrease in GHG emissions in England using choice experiments	2005	UK £ 39 – 182 annually (UK £ 10 - 46 quarterly)	334-1,560
This study	WTP for a small reduction in GHG emissions and slight increase in efficiency of local district heating plant	2009	234-346 DKr average one-year increase in heating bill	234-346

All values in the last column have been transformed to the 2009 price level and exchanged into DKr using the exchange rates from 22-08-2009, and so are rough approximations of the true value.

Table 7.10 shows that while the one-time willingness to pay uncovered in this study fall far short of the other one-time payments found elsewhere, it is very similar to annual WTP values in the literature.

[23] Note that these values were inflated using the 2000 level base, so the true value is slightly understated

7.11 Additional comments

Literature focusing on rural rather than urban WTP preferences includes Hanley & Nevin (1999) and Bergmann et al. (2007). Bergmann et al. compare urban and rural groups from Scotland in terms of their preferences for renewable energy and find significant differences between the two. The choice experiment method used by Bergmann et al. indicated that rural respondents were very influenced by the creation of permanent local employment resulting from new renewable energy plants in contrast to the urban respondents. The survey conducted by Hanley and Nevin used the minimum acceptable level of generated local employment interchangeably with willingness to accept (WTA) monetary compensation in a comparison of three potential renewable energy projects in a remote community in North West Scotland. The district heating plant in Ballen-Brundby employs one part-time employee in conjunction with another local district heating plant located in Onsbjerg. Additional local employment is generated from the demand for hay, mainly sourced from local farmers, and as a part of the tourist attraction that is Renewable Energy Island Samsø – the Energy Agency on Samsø frequently guides tourists around the district heating plant. Respondents to the questionnaire were asked to rate the importance of generating local employment relative to price and environmental concerns to determine whether local employment is a key to the satisfaction of the existing plant. As local employment was ranked the lowest in the questionnaire, and was consistently insignificant in the regression analysis, this 'local employment effect' does not appear to be valid on Samsø.

According to Whitehead & Cherry, two other methods of mitigating the upward bias in WTP estimates caused by hypothetical bias are the ex-ante approach and the ex-post approach. The ex-ante approach variously informs the respondents that (a) there are substitutes available for the given policy/program, (b) they are subject to income constraints, (c) they are to treat the question as though it were ecumenically binding, and (d) hypothetical bias is a problem in survey design and asked to take it into account when considering their answer. The ex-post approach requires respondents to rate the certainty they have of their WTP in a follow-up question, and this rating is subsequently used to recode the WTP response with respect to the certainty of payment. Neither of these approaches was used in this survey design. The two face-to-face interviews conducted when the questionnaire was handed out indicated that the valuation question was treated as a serious suggestion, despite having stressed the non-commercial academic aspect of the paper in the introduction. Thus it is expected that most of the hypothetical bias is contained within the "maybe" answer framework.

Implications for municipal policies

Based on the results from the WTP analysis conducted on Samsø, the recent efforts by different municipalities to establish renewable energy policies within their municipality may illustrate more of a 'bottom-up' effect rather than a 'top-down' effect. From the regression results it can be seen that Samsø being a renewable energy island was insignificant, i.e. being part of the initiative had no effect on WTP for additional renewable energy investments. Rather, strongly prioritizing the importance of a pollution-free environment was highly significant and positively correlated with WTP, suggesting that causality moves from a strong environmental conscience towards becoming a successful renewable energy municipality. Although it is impossible to completely rule out reverse causality, as the flow of information from the municipality to the environmental conscience may be a vital factor.

7.12 Uncertain supply or quality of an environmental asset

This section is based on an abbreviated version of Chapter 8 from *Cost-Benefit Analysis of Environmental Change* by Per-Olov Johansson (1996). For a more detailed exposition, please refer to the original work. The purpose is to illustrate the significance of the connection fee charged to users by BBF prior to the construction of the plant relative to after operation was initiated. The original fee payable was 80 DKr, which increased to 45,000 DKr immediately after construction was finished.

Using an intertemporal model following from option-value literature, a Neumann-Morgenstern household is assumed to consume an unpriced environmental asset z and a composite private priced good which serves as the numeraire. The smooth indirect utility function of the household is written as $V(y,z^i)$. z represents the (unknown) supply/quality of the environmental asset, in this example the district heating plant, and it is assumed that z takes on values in a finite set. There is a probability distribution assigning probabilities $\pi^1,\dots,\pi^n$ to the points $z^1,\dots,z^n$, with $\pi^i \geq 0$ for $i= 1,\dots, n$ and $\Sigma_i\pi^i=1$. The analysis is restricted to uncertainty with regard to z in this paper, but could be extended to cover income uncertainty and/or state-dependent preferences, i.e. demand-side uncertainty. In what follows we only consider the case where the supply or quality of an environmental asset is uncertain; the probability that supply/quality for z^i is π^i for $i=1,\dots,n$.

Expected utility of the household over both periods is defined as:

$$V^E = U(x_1,z^i{}_1) + \beta V_2(s_t) \qquad \text{s.t. } y_1 - p_1x_1 - s_t = 0$$

Where subscript *1* refers to first-period levels and β is the household's discount factor, s_t refers to the connection fee respective of time period ($s_1 < s_2$) and *E* is the expectation operator. A willingness-to-pay function associated with a stochastic change in environmental quality can be defined by the relationship:

$$E[V^h(y^h - S^{ih},z^i)] = E[V^h(y^h,\hat{z}^{ih})] \qquad \textit{for all h}$$

Where *h* refers to household *h*, S^{ih} is the payment collected from household *h* in state *i*, and the expectation is taken with respect to the distribution of the environmental quality. The household's maximization problem in period 2 is defined as:

$$U(x_2, z_2{}^i) \qquad \text{s.t. } \tilde{y} + s_t(1+r) - \acute{p}_2x_2 = 0$$

where *s* is the amount of money saved in period 1 and carried over to period 2, *r* is the risk-free rate of interest, x_2 is a vector of private goods consumed in period 2, $p_2 = \acute{p}_2/(1+r)$ is the corresponding transposed vector of present-value prices, and $y_2 = \tilde{y}/(1+r)$ is the present value of the income received in period 2. Since period 2 is the final period, it makes no sense to save for future periods, implying that current plus saved income is consumed in period 2. The household's maximisation problem in period 2 assumes decisions are taken after uncertainty about the supply/quality of the environmental asset is resolved. Thus, when maximizing second-period utility, the household knows that the stochastic variable z_2 happened to take on value $z^i{}_2$. This technique of backwards induction follows from Bellman (1975).

It follows naturally from the above that the value of the uncertainty of quality/supply of the district heating plant corresponds to the difference between the connection fee in period 1 and the fee in period 2, at least under the assumption that households are identical. The district heating plant is no more valuable in period 2 than proposed in period 1, *except* for the fact that it has been built according to specifications. Given the quality level $z^i{}_2$, a household would have been better off paying s_1 in period 1 rather than paying s_2 in period 2. Assuming that there were no external shocks or changes in the composition of non-participating consumers between periods 1 and 2 suggests that the level of uncertainty of quality/supply associated with this specific plant is in the excess of 44,000 DKr, which can be seen as the accepted risk premium for those who participated from the start, but below the value of risk of those who joined since. Whether this value is transferable to other projects is not known; however, it is a subject that warrants further study.

8 Conclusion

The aim of this paper was to determine whether there were significant differences between an ex ante and ex post CBA of the same project, and, if this were the case, whether these differences could be reliably accounted for within the uncertainty estimation framework that exists in the literature. Most of the methods recommended to minimise the uncertainty of a project can (somewhat) reliably account for the effects of inadequate data, potential shocks to the economy or the expected impact of a given project. WTP (or WTA) analyses are used to estimate the value assigned to a given state, where some potential is achieved, but carry their own brand of uncertainty. However, even the WTP surveys generally only estimate scenarios where a given event has occurred, and not the value that is attached to the likelihood of it occurring (they are more concerned with the uncertainty of the payment occurring given the event has occurred).

Neither of the CBA conducted in this paper nor the contingent valuation were able to account for the project uncertainty described above. In a case such as this, where the risk free-riding on the district heating network is minimal, the import of the uncertainty of a given state occurring is easily observed. Based on the comparison of the ex-ante and ex post CBA's, substantially more people joined the central district heating than was first assumed. Even the 'optimistic' proposal circulated in an internal BBF paper only included a total of 182 consumers (8 larger consumers) and 50 empty lots expected to eventually becoming consumers. Given the reality of 258 consumers and 8 empty lots suggests that while people may be hesitant at joining a project before its construction given fears of optimism bias or similar types of uncertainty, a significant proportion are more than willing to join after the project has proven that it will live up to expectations. This effect is apparent despite the first mover advantages (connection fees of 80 DKr relative to 45,000 DKr). It would be interesting in further studies to see whether this effect holds true for other projects.

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Also: Assorted information obtained from Samsø Energy Agency, the BBF office and interviews with locals.

Appendix 1 Fuel factor prices incl. transport costs delivered to place of use

Source: Table 5 & 6 DEA Recommendations 2009, 2007 and 2005 DKr/GJ – 2007 Price Level				
	Heating oil	Straw	Heating oil	Electrical heating
	At heating plant		At household	
2004	65.99	31.4	74.4	63.19
2005	86.18	31.4	94.5	66.19
2006	99.08	31.1	107.4	71.82
2007	97.00	31.1	105.3	70.36
2008	92.32	31.1	100.6	67.42
2009	87.8	36.3	96.1	66.1
2010	98.4	36.3	106.7	68.5
2011	110.3	35.3	118.6	72.1
2012	124.0	36.6	132.2	76.4
2013	139.7	38.0	148.0	80.6
2014	139.5	39.6	147.8	81.6
2015	139.3	41.5	147.6	80.9
2016	141.6	41.5	149.8	80.4
2017	143.9	41.5	152.1	81.6
2018	146.2	41.8	154.4	80.7
2019	148.5	42.0	156.7	81.6
2020	150.9	42.3	159.2	79.9
2021	152.3	42.6	160.6	79.8
2022	153.9	42.9	162.1	80.1
2023	155.4	43.0	163.7	80.5
2024	157.0	43.2	165.3	80.0
2025	158.6	43.4	166.9	80.4

Appendix 2 CO2, Energy and Sulphur Taxes in 2009

Source: DEA Website						
Purpose	Energy Type	Combustion Value	Unit	CO_2	Energy	Sulphur
				DKr/GJ	DKr/GJ	DKr/GJ
Transportation	Diesel oil	0.036	GJ/l	7.03	80.52	Taxes equal 20 DKr/Kg for these energy types
	Light diesel oil	0.036	GJ/l	7.03	77.62	
	Ultra light dieseloil	0.036	GJ/l	7.03	0.00	
	Low-sulphur diesel oil	0.036	GJ/l	7.03	72.43	
	Petroleum	0.035	GJ/l	7.24	82.99	
	Natural gas	0.040	GJ/m^3	5.15	74.05	
	Liquified petroleum gas (LPG)	0.025	GJ/l	6.00	72.78	
	Other liquified gas	0.046	GJ/kg	6.09	72.32	
	Leadbased gas	0.033	GJ/l	6.94	141.00	
	Unleaded gas	0.033	GJ/l	6.94	120.52	
Other Purposes	Heating oil 0.2%	0.036	GJ/l	7.03	53.64	0.96
	Fuel oil 1%	0.041	GJ/kg	7.33	53.34	5.12
	Fyringstjære 1% S	0.036	GJ/kg	7.17	53.75	5.71
	Petroleum	0.035	GJ/l	7.24	55.29	
	Gas (LPG)	0.046	GJ/kg	6.09	53.60	
	Refinery gas	0.052	GJ/kg	5.19	47.42	
	Orimulsion	27.650	GJ/ton	7.56	52.00	1.99
	Stone coal, coal	26.5	GJ/ton	8.52	56.67	Taxes are 20.4 DKr per Kg
	Petro coal	29.3	GJ/ton	10.28	60.39	
	Lignite	18.3	GJ/ton	9.07	59.34	
	Natural gas	0.040	GJ/m^3	5.15	53.22	0.00
	Coal gas	0.018	GJ/m^3	11.66	120.39	0.00
	Electric heating	0.004	GJ/kWh	24.72	146.94	
	Other electricity	0.004	GJ/kWh	24.72	165.56	
	Waste to power plants	10.50	GJ/ton	0.00	26.67	0.89
	Waste to district heating	10.50	GJ/ton	0.00	31.43	0.89
	Waste to combustion					
	Heat from waste				12.90	
	Straw	14.5	GJ/ton			1.64
	Wood pellets (sulphurous)	17.5	GJ/ton			2.37
	Other wood pellets	17.5	GJ/ton			
	Other wood	14.7	GJ/ton			

Appendix 3 Combustion values, dollar exchange rates and inflation assumptions

Source: DEA Recommendations 2009 Table 1			
Combustion values			
Heating oil		42.7	GJ/ton
Straw		14.5	GJ/ton
Dollar exhange rate			
2007		5.45	DKr/USD
2008		5.11	DKr/USD
2009 and forward		5.81	DKr/USD
General inflation(Deflator)		Price index 2007=1	Increase in %
	2000	0.8525	
	2001	0.8730	2.40
	2002	0.8926	2.25
	2003	0.9088	1.81
	2004	0.9335	2.72
	2005	0.9608	2.92
	2006	0.9804	2.04
	2007	1.0000	2.00
	2008	1.0418	4.18
	2009	1.0750	3.19
	2010	1.1006	2.38
	2011	1.1287	2.56
	2012	1.1569	2.49
	2013	1.1841	2.36
	2014	1.2131	2.45
	2015	1.2430	2.46
	2016	1.2737	2.47
	2017	1.3043	2.41
	2018	1.3367	2.48

Appendix 4: Questionnaire

Kære Ballen/Brundby beboer!

Jeg har sendt denne spørgeskemaundersøgelse til dig i håb om at du vil bruge 10-15 minutter på at besvare den, og sende den tilbage til mig i den medfølgende frankerede kuvert. Jeg er en studerende fra Handelshøjskolen i Aarhus, og jeg har valgt at skrive om Samsø i mit kandidatspeciale. Jeg er i gang med en samfundsøkonomisk evaluering af Ballen - Brundby varmeværket, og vil være ***meget*** *taknemmelig for at høre din mening. Opgaven vil blive lagt op på Samsø energiakademiets hjemmeside www.seagency.dk engang i september, og kan frit downloades. Alle besvarelser der er modtaget senest d. 23 juli vil kunne deltage i lodtrækningen om 3x2 billetter til Samsø Bio*[24].

De besvarende personer garanteres fuld anonymitet, og oplysninger om enkeltpersoner vil aldrig blive offentliggjort. Spørgeskemaerne destrueres efter endt anvendelse. Resultaterne fra spørgeskemaerne vil ikke blive brugt kommercielt. Besvarelsen vil blive brugt som del af et forsøg på en værdisætning af Ballen/Brundby værket. Hvis du ønsker at forblive anonym, men stadig gerne vil give din mening til kende, så undlad bare at skrive navn og kontaktdetaljer. Det medfører desværre, at du ikke kan deltage i lodtrækningen om biografbilletterne. Har du nogle videre spørgsmål er du velkommen til at kontakte mig via min email, tanja.groth@gmail.com, eller mobil, 26 25 83 16.

Denne spørgeskemaundersøgelse støttes økonomisk af Vestas gennem Handelshøjskolens legatfond 2009, og skrives i samarbejde med Samsø Energiakademi (kontakt: Jan Jantzen jj@seagency.dk).

Projektansvarlig:

Tanja Groth

FØRSTE AFSNIT OMHANDLER SPØRGSMÅL OM DIN BOLIG

Hvor gammel er boligen?

(angiv boligens alder i antal år)

[24] Vinderne vil få direkte besked samt blive annoceret i Samsø Posten

Hvor længe har du boet i huset?

(angiv antal år)

Sæt venligst et kryds på den stiplede linje ud fra dit ønskede svar.

Ud over tilslutningen til Ballen - Brundby fjernvarmeværket, har der været foretaget andre større moderniseringer eller reparationer vedrørende husets energimæssige stand (isolering, solvarme/celler, andel i lokal vindmølle osv.) inden for de sidste 10 år (*for beløb på mindst 5.000,- kr.*)?

Ja

Nej

I DET FØLGENDE KOMMER DER EN RÆKKE SPØRGSMÅL, SOM VEDRØRER HUSETS INSTALLATIONER, OG HER MENES PRIMÆRT VARMEFORSYNINGEN

Anvendes nogen former for supplerende opvarmning ved siden af husets brug af fjernvarme fra Ballen – Brundby varmeværk?

Ja

Nej

Hvis "ja", angiv én eller maksimalt to af husets supplerende varmekilder.

Eget oliefyr

Eget solvarmeanlæg

Elvarme

Brændeovn

Eget halmfyr

Eget træ/træpillefyr

Eget komb. træ/oliefyr

Egen varmepumpe

Andet

Hvor stor en del af huset, målt på kvadratmeter, er jævnligt opvarmet?

Under 50 m^2

Mellem 50 og 99.9 m^2

Mellem 100 og 149.9 m^2

Mellem 150 og 199.9 m^2

Over 150 m^2

Hvor meget koster det at varme huset op om året?

Under 5.000,-

Mellem 5.000 og 9.999,-

Mellem 10.000 og 14.999,-

Mellem 15.000 og 19.999,-

Over 20.000,-

Forsøger du bevidst at spare på energien til daglig? (*Her menes kun vedrørende huset og ikke energiforbrug i forbindelse med transport o.lign.)*

Ja, hele tiden

Ja, periodevis

Sjældent

Aldrig

Er du tilfreds med din nuværende varmeforsyning?

Ja

Nej

Hvis "nej", er dette på grund af (*Der må kun vælges én grund*):

Prisen på varme – det blev dyrere end forventet

Kvaliteten af selve forsyningen (driftsforstyrrelser m.m.)

Problemer med selve anlægget (luftforurening, anlæggets placering, osv.)

Anden grund (*specificer venligst)*

Har du aktuelle planer om at forbedre husets energimæssige tilstand, bortset fra selve centralvarmeanlægget?

Ja

Nej

Hvis "ja", regner du med at

Udskifte eller forbedre vinduer/døre

Efterisolere mure/loft/gulve

Installere solvarme/celler til eget forbrug

Andet:

DETTE AFSNIT OMHANDLER SPØRGSMÅL OM MULIGE FORBEDRINGER AF FORSYNINGEN FRA BALLEN – BRUNDBY VARMEVÆRKET

Det er muligt at forbedre røgrensningsudstyret på anlægget ved at udskifte det eksisterende system med et kondensationsanlæg, som vil kunne rense røgen effektivt for partikler, saltsyre og svovlsyre samt øge energivirkningsgraden med omkring 10 %. Anlægget vil koste ca. 580.000 kr., og med reduktionen i brændsel og svovlafgift (ca. 87.000 kr. årligt) vil den oprindelige investering være tilbagebetalt i løbet af 7-8 år.

Investeringen vil medføre en forhøjelse af dine varmeudgifter på ca. 650 kr. pr. kvartal over det næste år.

Ville du være interesseret i en sådan investering?

Ja, meget interesseret

Muligvis, men vil ikke forpligtige mig før jeg ved mere

Nej, absolut ikke

Det vil måske være muligt at få tilskud til installation af anlægget fra Energistyrelsen. Tilskuddet ville kunne dække mellem 1/3 til 1/2 af omkostningerne, hvilket betyder at dine varmeudgifter kun ville stige med ca. 350 kr. pr. kvartal over det næste år.

Ville du være interesseret i investeringen under disse forudsætninger?

Ja, meget interesseret

Muligvis, men vil ikke forpligtige mig før jeg ved mere

Nej, absolut ikke

DET SIDSTE AFSNIT OMHANDLER SPØRGSMÅL OM DIN HUSHOLDNING OG GENERELLE HOLDNINGER

Mener du at Samsøs udvikling til en Vedvarende Energi Ø er:

Overvældende positivt

Nogenlunde positivt

En dårlig ide

Ligegyldigt

Hvilke punkter er vigtigst for dig i den følgende liste (*sæt venligst et tal 1-6, hvor 1 er mest vigtig og 6 er mindst vigtig***):**

At din varmeforsyning ikke bidrager til luftforurening

At din varmeforsyning ikke belaster miljøet

At din varmeforsyning tager hensyn til dyrelivet

At din varmeforsyning er billigst mulig

At din varmeforsyningsbygning er i harmoni med landskabet

At din varmeforsyning genererer arbejde i lokalsamfundet

Hvad er dit køn?

Mand

Kvinde

Hvordan mener du at Samsøs skift til Vedvarende Energi Ø påvirker Samsø som turist attraktion?

Vigtig del af Samsøs tiltrækning

Lille del af Samsøs tiltrækning

Ingen effekt

Påvirker tiltrækning negativt

Hvor gammel er du?

(Angiv venligst antal år)

Har du børn?

Ja

Nej

Hvad er husholdningens årlige indtægter? (*brutto før skat og fradrag)*

Under 150.000,- kr.

Mellem 150.000 og 299.000,- kr.

Mellem 300.000 og 449.000,- kr.

Mellem 450.000 og 599.000,- kr.

Over 600.000,- kr.

Har du aktuelle planer om at flytte fra din nuværende bolig?

Ja

Nej

Tusind tak for din deltagelse. Hvis du ønsker at være med i lodtrækningen om 2 x biografbilletter til SamsøBio, så venligst skriv dit navn og telefonnummer nedenfor. Lodtrækningen finder sted d. 24-07-2009 og alle besvarelser modtaget inden denne dato har mulighed for at deltage.

Med venlig hilsen,

Tanja Groth

Navn____

Tlf____

Evt. kommentarer: