Heat Saving Strategies in Sustainable Smart Energy Systems

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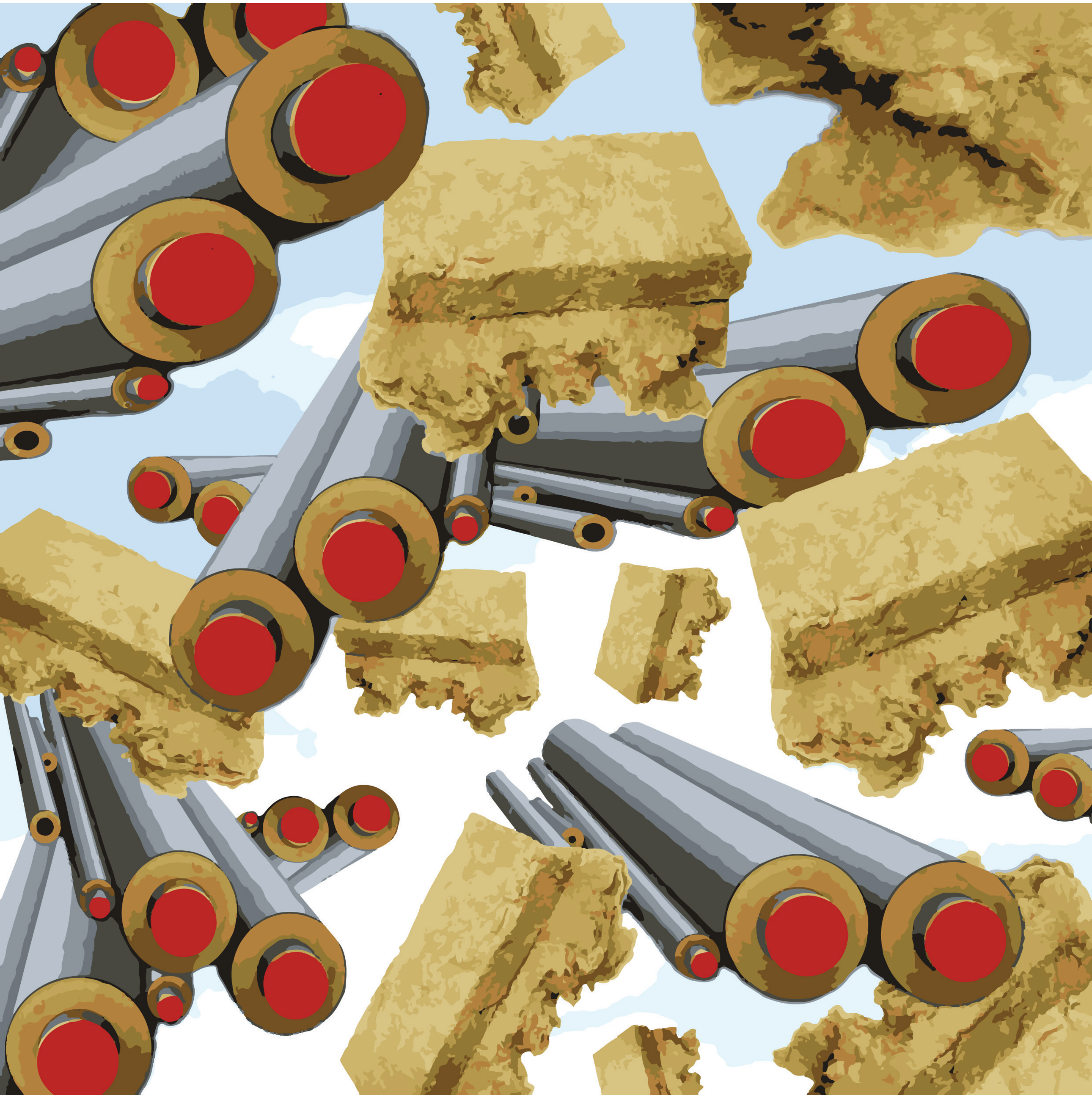

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Content

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Abstract

One of the important issues related to the implementation of future sustainable smart energy systems based on renewable energy sources is the heating of buildings. Especially, when it comes to long-term investment in savings and heating infrastructures it is essential to identify long-term least-cost strategies. With Denmark as a case, this paper investigates to which extent heat should be saved rather than produced and to which extent district heating infrastructures, rather than individual heating solutions, should be used. Based on a concrete proposal to implement the Danish governmental long-term target of becoming completely fossil-free by 2050, this paper identifies marginal heat production costs and compares these to marginal heat savings costs for two different levels of district heating. A suitable least-cost heating strategy seems to be to implement savings in new buildings and buildings which are being renovated anyway. This will decrease the net heat demand of space heating and hot water by approximately 50% compared to the present level, while the implementation of heat savings in buildings which are not being renovated hardly pays. Moreover, the analysis points in the direction that a least-cost strategy will be to provide approximately 2/3 of the heat demand from district heating and the rest from individual heat pumps.

Keywords: Energy Efficiency, Renewable energy, Heating strategy, Heat savings, District heating, Smart energy

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1. Introduction and overall methodology

The design of future sustainable energy solutions including 100 per cent renewable systems is described in a number of recent reports and studies including [1-6]. Such systems are typically based on a combination of renewable energy sources (RES) such as wind, geothermal and solar, together with residual resources such as waste and biomass. In order to ease the pressure on biomass resources and investments in renewable energy in future sustainable energy systems, feasible solutions typically involve a substantial focus on energy conservation and energy efficiency measures. One of the important issues to address is, in some countries, the heating and, in others, the cooling of buildings. Thus, the issue of reducing heat demands through the implementation of low-energy buildings and how to heat these buildings becomes essential.

The design and perspective of low-energy buildings have been analysed and described in many recent papers [7,8], including concepts like energy efficient buildings [9], zero emission buildings, and plus energy houses [10,11]. However, these papers mostly deal with future buildings and not as often the existing building stock which, due to the long lifetime of buildings, is expected to constitute the major part of the heat demand for many decades to come. Some papers address the reduction of heat demands in existing buildings and conclude that such an effort involves a significant investment cost [12]. Consequently, an important question is to which extent least-cost heating strategies should involve such an investment.

Another essential question for heating strategies is how to provide the remaining heat. For example, how much should one invest in infrastructures such as district heating? District heating comprises a network of pipes connecting the buildings in a neighbourhood, town centre or whole city, so that they can be served from centralised plants or a number of distributed heat producing units. This approach allows the use of any available source of heat. The inclusion of district heating in future sustainable cities allows the wide use of combined heat and power (CHP) together with the utilisation of heat from waste-to-energy and various industrial surplus heat sources as well as the use of geothermal and solar thermal heat [13-19]. In the future, such industrial processes may involve various processes of converting solid biomass fractions into bio(syn)gas and/or different sorts of liquid biofuels for transport purposes, among others [20,21].

To complicate matters even more, heating strategies should, however, not be designed for the present energy system but for the future system. Further, one of the future challenges will be to integrate heating and cooling with the electricity sector as well as the transport sector [22-24]. In [25-27], such a future system is referred to as a *smart energy system*, i.e., an energy system in which smart electricity, thermal and gas grids are combined and coordinated to identify synergies between them and to achieve an optimal solution for each individual sector as well as for the overall energy system. A transition from the current fossil fuel- and nuclear-based energy systems into future sustainable energy systems requires the large-scale integration of an increasing level of intermittent renewable energy. This also entails the rethinking and redesign of the energy system. In smart energy systems, focus is on the integration of the electricity, heating, cooling, and transport sectors, and on using the flexibility in demands and various short-term and longer term storage options across the different sectors. To enable this, the smart energy system must coordinate a number of smart grid infrastructures for the different sectors in the energy system, which includes electricity grids, district heating and cooling grids, gas grids, and different fuel infrastructures.

A number of recent studies [28-40], including Heat Roadmap Europe [28,35], come to the conclusion that district heating plays an important role in the implementation of future sustainable energy systems. However, the same reports also emphasise that the present district heating system must undergo a radical change into low-temperature district heating networks to interact with low-energy buildings and become an integrated part of smart energy systems.

The aim of this paper is to present a methodology to identify least-cost strategies of reductions in the heat demand of buildings as a part of implementing sustainable smart energy systems. The basic assumption is that these reductions have an important impact but are also very investment intensive. The important point which is emphasised in this paper is that the size of the investment costs strongly depends on whether energy conservation is done in existing buildings or as additional investments in new buildings. And it depends on whether investments are made solely for the purpose of reducing heat demand or as an integrated part of renovation which will take place anyway. Moreover, the identification of proper strategies depends on the marginal alternative production of the energy system, and the cost of this marginal production again depends on which system one addresses. In the following, the context used is the case of Denmark, in which the Government has formulated a strategy for transforming the whole energy system into a system based on 100% renewable energy by year 2050.

The purpose of this paper is to analyse and answer the following three questions:

1. To which extent should heat for space heating and hot water be reduced by saving measures and investments and to which extent should it be produced/supplied?
2. Which is the best combination of investments in heat savings, divided into new houses and existing houses?
3. Which share of the supply should come from district heating and which share from individual solutions?

2. Marginal Production Cost in a Future Sustainable Smart Energy System

2.1 Definition of Future Sustainable Smart Energy System

The identification of a least-cost heating strategy highly depends on the context; i.e., on the one hand, which kind of sustainable energy system one expects to have, and on the other hand, how one expects the building sector to develop.

Here, the analyses have been carried out in the context of the decision of the Danish Government to transform the Danish energy supply to be fossil-free by 2050. A specific proposal on how to implement this goal has been defined in a research project financed by the Danish Council for Strategic Research in 2011 (CEESA) [41], which again is based on a proposal put forward by the Danish Society of Engineers (IDA) in 2006 [42] and 2009 [31] . The IDA study is based on the technical inputs of the members and is the result of the organization's "Energy Year 2006," during which 1600 participants at more than 40 seminars discussed and designed a model for the future energy system of Denmark. The CEESA scenario is the result of the collaboration of researchers from five Danish universities, performing a coherent energy and environmental systems analysis (CEESA) of the transformation into 100 per cent renewable energy systems. The study might be seen as a follow-up on the first IDA Plan, in which an important further step was taken with regard to the *smart energy systems* analysis and the integration of the transport fuel pathways. Among others, hour-by-hour analyses of electricity and district heating are supplemented with similar hour-by-hour calculations for gas. Both the IDA and CEESA scenarios involve the design of coherent and complex renewable energy systems, including the suitable integration of energy conversion and storage technologies. Furthermore, both studies are based on detailed hour-by-hour simulations carried out in the EnergyPLAN software.

In CEESA, a focal point is the fact that the transition to 100 per cent renewable energy solutions highly relies on the technologies which are assumed to be available within the specified time horizon and which may have different effects on the biomass consumption. To highlight this, the CEESA project has identified scenarios based on three different assumptions regarding the available technologies. This methodology allows a better optimization and understanding of the energy systems. To enable a thorough analysis of the different key elements in 100 per cent renewable energy systems, two very different 100 per cent renewable energy scenarios as well as one recommendable scenario have been designed.

In all scenarios, energy savings and direct electricity consumption are given high priority, and all scenarios rely on a holistic *smart energy system* approach as explained in [25]. This includes the use of heat storages, district heating with CHP plants, and large heat pumps as well as the integration of transport fuel pathways with the use of gas storage. These *smart energy systems* enable a flexible and efficient integration of large amounts of fluctuating electricity production from wind turbines and photovoltaics. The gas grids and liquid fuels allow long-term storage, while the electric vehicles and heat pumps provide shorter-term storage and flexibility.

The CEESA project includes a careful examination of the pathways to provide biomass resources. The starting point is an overview of the available amount of residual resources in terms of straw, wood, and biogas from manure, etc., summing up to approximately 180 PJ/year. A shift in forest management practices and cereal cultivars could increase the potential further to approximately 240 PJ/year by 2050. The 180 PJ/year could also be increased to 200 PJ by enacting dietary changes. This potential represents the use of residual resources only. This means that the CEESA 2050 *recommendable* scenario is kept within the boundaries of residual resources, and the CEESA 2050 *conservative* scenario illustrates that an active energy and transport policy is required to stay within these limits. It should be noted that a target of 240 PJ/year by 2050 implies a number of potential conflicts due to many different demands and expectations from ecosystem services; it requires the conversion of agricultural land otherwise allocated to food crop production to energy crop production, potentially reducing food and feed production. All crop residues must be harvested, potentially reducing the carbon pool in soils. A way to reduce these potential conflicts is to reduce the demand for biomass for energy or to further develop agriculture and forestry to increase the biomass production per unit of land.

One important learning outcome from the hourly analysis of the complete system including both electricity and gas balances is that relatively cheap gas storage capacities (which in the Danish case are already there) can be used to balance the integration of wind power into the electricity grid. Consequently, in the CEESA 2050 scenario, it is possible to decrease excess electricity production to nearly zero at the same time as high fuel efficiencies are achieved by using heat and gas storages rather than electricity storages.

Both the IDA and the CEESA scenarios are comprehensive in the way that they provide a 100% renewable solution to the complete system, i.e., including all transport also ships and aeroplanes. Moreover, as already explained, they have a focus on identifying the best solution for the whole system while taking into consideration all kinds of synergies between the individual sectors, i.e., taking a smart energy systems approach.

2.2 Methodology, software and assumptions

To identify the marginal cost of heat production, this study has applied the same software and model as in the IDA and CEESA scenarios. The EnergyPLAN software makes hourly calculations of the complete smart energy system as described above for countries like Denmark. For other countries, the model can also include the integration with district cooling and desalination [43]. The model is publicly available and further described on www.EnergyPLAN.eu.

CEESA has been evaluated on the basis of the fuel prices shown in Table 1.

CEESA DKK/GJ (2010 costs)	Crude oil	Coal	Natural gas	Fuel oil	Diesel fuel / Gas oil	Petrol / JP	Straw / Wood chips	Wood pellets (general)	Energy crops
Low fuel costs	69.7	15.4	43.2	48.8	87.1	92.7	32.2	72.2	40.2
Medium fuel costs	112.7	24.6	78.3	102.3	127.5	132.1	42.2	83.1	56.1
High fuel costs (Real	158.7	42.2	110.2	144.0	177.5	158.8	*62.1*	*102.1*	*87.9*

Table 1: Fuel price assumptions in the CEESA scenario which have also been applied to this study. In this study, the important assumption is the natural gas price of 78.3 DKK/GJ, since it illustrates the cost of changes between the scenarios in the use of less or more synthetic gas similar to natural gas. In CEESA, the low price scenario is based on assumptions from the Danish Energy Agency in 2008; medium fuel prices from 2011, and high fuel costs for fossil fuels are based on actual prices in the summer of 2008. To form a high biomass fuel cost level, twice the biomass price difference assumed by the Danish Energy Agency from 2008 and 2010 is added to the medium biomass prices. The high fuel cost level is constructed for biomass and stated in *italics*.

The same fuel prices have been used in the following. However, given the nature of the analysis, the only important assumption is the natural gas price of 78.3 DKK/GJ equal to 3.10 DKK/m^3.

With regard to buildings, the CEESA scenario includes an expansion of heated areas of approximately 40% by 2050 and a cut in the space heating demand per unit of 50%. Moreover, the scenario includes an expansion of the district heating share from the current level of approx. 50% to 66% in 2050. In this study, the CEESA scenario has been used to determine the marginal cost of changing the heat demand as well as the share of district heating in the following way. A matrix has been designed for the investigation consisting of two different levels of district heating share and four different levels of annual heat demand reductions in the buildings, as illustrated below:

Matrix	A Current (year 2010) share of district heating versus individual supply, i.e., approx. 52.5%	B CEESA (Heat Plan Denmark) share of district heating, i.e., approx. 66 per cent.
100% of current space heating demand per unit		
75%		
50%		
25%		

Table 2: Matrix definition of Sustainable Smart Energy Systems scenarios.

In CEESA, the reference start heat demand was from 2008, while in this study, it has been adjusted to the statistics of 2010. According to these statistics, the net heat demand (space heating and hot water) in 2010 (after climate corrections) was a total of 50 TWh/year divided into 94.6 TJ/year (equal to 26.28 TWh/year) of district heating and 85.4 TJ/year (equal to 23.72 TWh/year) of individual heating. Thus, the share of district heating was 52.5%. With a 40% increase and no savings, the heat demand increases to 70 TWh in 2050.

Table 3 shows the development in the heated area in Denmark for the past 40 years and four 10-year growth rates have been identified. As can be seen, growth rates have a tendency to fall and have for the past 30 years been in the order of magnitude of 10%. In this study, an increase of the heated area is assumed equal to a 40 per cent increase by 2050 compared with 2010. Table 3 also shows the development in specific heat demands illustrating a decrease from 147 kWh/m^2 in 1970 to 122 kWh/m^2 in 2010 equal to a 17% decrease over a 40-year period. This historical development emphasizes the fact that the implementation of, e.g., a 50% decrease during the next 40 years will require an active policy [44].

Year (primo)	1970	1980	1990	2000	2010
Total heated area (Million m^2)	185.1	246.7	278.0	298.3	331.7
Total heat demand (TWh/year)	27163	34155	36793	38466	40327
Specific demand (kWh/m^2)	147	138	132	129	122
10-year growth factor		1.33	1.13	1.07	1.11

Table 3: Historical development in the main parts of the Danish building stock. Based on the heat atlas described in [45].

Moreover, in the present situation, 15% of the heat demand is assumed to be hot water and 85% is for space heating. Based on these assumptions, the heat demands of the matrix have been calculated and divided into district and individual heating as shown in Table 4.

Heat demand year 2050 (Space heating plus hot water)	A Current (year 2010) share of district heating versus individual supply, i.e., approx. 52.5 per cent	B CEESA (Heat Plan Denmark) share of district heating, i.e., approx. 66 per cent.
100% of current space heating demand per unit	DH = 36.8 (TWh/y) Indv. = 33.2 (TWh/y)	DH = 46.2 (TWh/y) Indv. = 23.8 (TWh/y)
75%	DH = 29.0 (TWh/y) Indv. = 26.2 (TWh/y)	DH = 36.4 (TWh/y) Indv. = 18.7 (TWh/y)
50%	DH = 21.2 (TWh/y) Indv. = 19.1 (TWh/y)	DH = 26.6 (TWh/y) Indv. = 13.7 (TWh/y)
25%	DH = 13.3 (TWh/y) Indv. = 12.0 (TWh/y)	DH = 16.7 (TWh/y) Indv. = 8.6 (TWh/y)

Table 4: Net heat demand including hot water divided into district heating (DH) and individual heating (Indv).

In the hourly modelling of the CEESA scenarios, the current hourly duration of heat demand and grid losses as well as the cost of expanding the district heating grid have been adjusted on the basis of the detailed study "Varmeplan Danmark (2008) [33,46,47]. The same data have been used here as illustrated in Table 5.

District heating technology	A Current (year 2010) share of district heating versus individual supply, i.e., approx. 52.5 per cent	B CEESA (Heat Plan Denmark) share of district heating, i.e., approx. 66 per cent
100% of current space heating demand per unit	Grid loss =21 Distribution curve = VpDkFjv00.txt	Grid loss =20 Distribution curve = VpDkFjv00.txt
75%	Grid loss =19 Distribution curve = VpDkFjv75.txt	Grid loss =18 Distribution curve = VpDkFjv75.txt
50%	Grid loss =23 Distribution curve = VpDkFjv50.txt	Grid loss =21 Distribution curve = VpDkFjv50.txt
25%	Grid loss =30 Distribution curve = VpDkFjv25.txt	Grid loss =27 Distribution curve = VpDkFjv25.txt

Table 5: Grid losses and name of hourly distribution curves of district heating demands in the EnergyPLAN software. Grid loss is given in per cent of total district heating demand from plant. Source: Varmeplan Danmark (2008), appendix 13.3 [46].

The same source has been used to determine the cost of individual heat pumps for the areas outside district heating, as shown in Table 6.

Individual heat pump technology	A Current (year 2010) share of district heating versus individual supply, i.e., approx. 52.5 per cent	B CEESA (Heat Plan Denmark) share of district heating, i.e., approx. 66 per cent
100% of current space heating demand per unit	COP = 3.2 and 2.6 = ave 2.9 Distribution curve = hour-indv-heat-100percent.txt	Ditto
75%	COP = 3.1 and 2.5 = ave 2.8 Distribution curve = hour-indv-heat-75percent.txt	Ditto
50%	COP = 3.0 and 2.4 = ave 2.7 Distribution curve = hour-indv-heat-50percent.txt	Ditto
25%	COP = 2.8 and 2.3 = ave 2.55 Distribution curve = hour-indv-heat-25percent.txt	Ditto

Table 6: COP of individual heat pumps and name of hourly distribution curves of individual heating demands in the EnergyPLAN software. Source: Varmeplan Danmark (2008), appendix, p. 102 [46].

The investment cost of expanding the district heating grid from 46% in 2006 to 63% has in [46] been identified as 33 billion DKK. Here, it is considered to expand from 52% to 66%, which is a little less. On the other hand, the expansion concerns a higher level which increases the marginal costs. Consequently, it seems fair to use the same investment cost as an appropriate approximation. In the calculations, a lifetime of 40 years and annual operation and maintenance costs of 1% of the investment are used.

Then, based on the CEESA scenario as explained above and using the EnergyPLAN model, the total annual costs of the different scenarios in the matrix have been calculated. The following changes in input between the scenarios have been made in the modelling:

- Heat demands, COPs and share of district heating are as specified above
- In Scenario B, a cost of 33 billion DKK is added for the extra district heating grid
- The capacity of district heating boilers is calculated as the maximum district heating demand plus 10 per cent
- The use of biomass is fixed so that any change in fuel demands becomes import/export of synthetic gas (except from scenario 25% in which some biomass is also saved).
- Power plant capacities are adjusted compared to the CEESA scenario to compensate any changes in individual heat pump electricity peak demands plus 20% reserve.
- The costs for energy savings are removed.

As described above, the CEESA scenario has been designed as a 100% renewable energy scenario using only available residual biomass resources. When changing the heat demand, the need for biomass and other renewable sources will consequently either increase or decrease. Here, the changes have been calculated in terms of changes in the need for net import/export of fuel equivalent to natural gas or similar gasses made on biogas/biomass. Since this is an economic assessment, the important aspect here is the price which has been set to 78 DKK/GJ as previously mentioned. More details can be found in Appendix 1.

2.3 Results

The resulting annual costs of the different scenarios are shown in Table 7 and Fig's. 1 and 2. Basically, reductions in heat demands decrease the total costs of the complete energy supply. However, the marginal benefits of one unit of saved energy are reduced as more savings are implemented. This has to do with the low-temperature waste heat available in the system from industrial surplus, CHP (thermal or fuel cell power production), and biomass conversion processes. These resources are relatively low-cost resources and once they have been used, any additional heat demand gradually requires increased heat pump and/or boiler productions as well as additional investments in production capacity. Moreover, solar thermal and geothermal can better be exploited with an hourly distribution of a low energy demand than a high energy demand due to the seasonal differences being more severe with a high heat demand.

In summary, the results in terms of costs are as illustrated in Table 7 and Fig. 1.

Results: Total annual cost in million DKK	A Current (year 2010) share of district heating versus individual supply, i.e., approx. 52.5 per cent	B CEESA (Heat Plan Denmark) share of district heating, i.e., approx. 66 per cent.
100% of current space heating demand per unit	173.9	171.8
75%	164.0	162.3
50%	155.4	154.6
25%	147.2	147.4

Table 7: Total annual cost of different energy solutions in Denmark 2050.

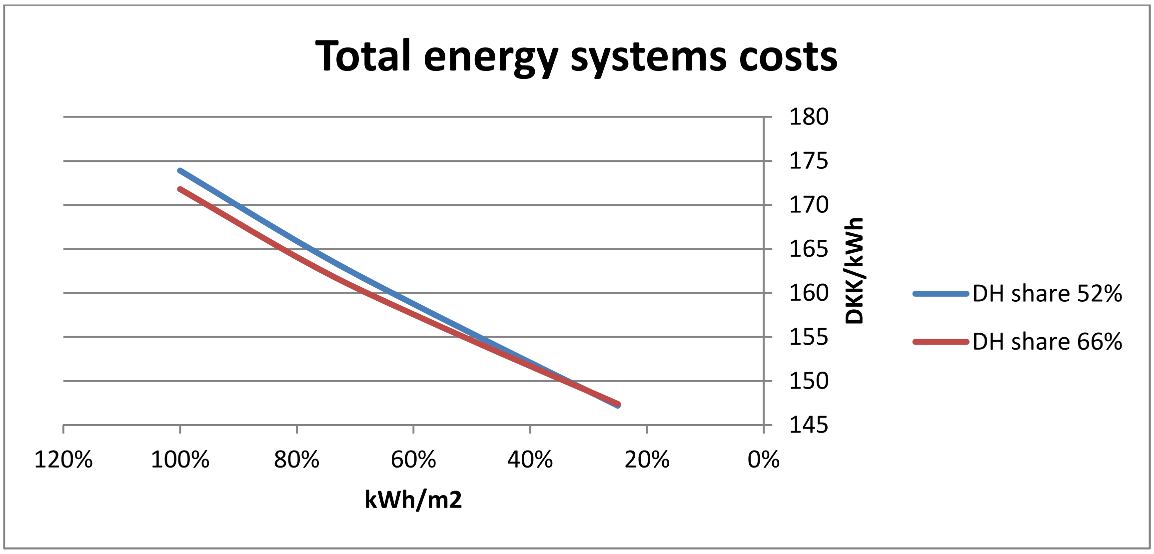

Fig. 1: Total annual cost of different energy solutions in Denmark 2050 as a function of the percentage of heat savings per unit. 100% is equal to the current level of 122 kWh/m^2.

The total cost has been converted to marginal cost per unit as illustrated in Fig. 2 under the assumption that the 2010 level corresponds to 122 kWh/m^2 as listed in Table 3. In the conversion, it has been considered that hot water in the current level accounts for 15% equal to approx. 18 kWh/m^2. This level has been kept constant.

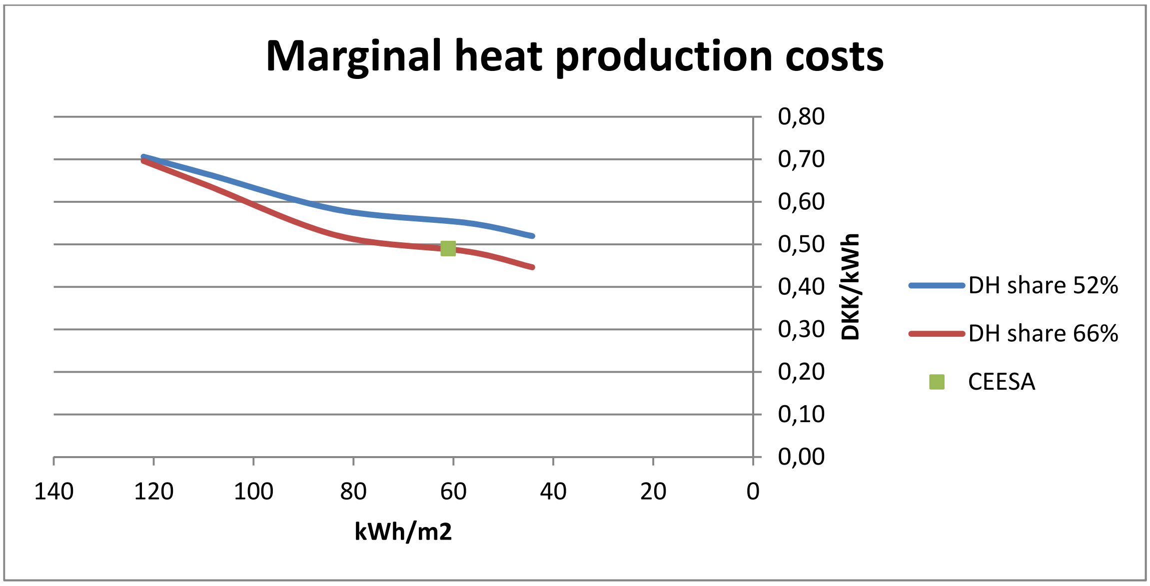

Fig. 2: Marginal heat production cost as a function of heat savings per unit.

Fig. 2 illustrates the fact that the marginal heat production cost per unit of the overall energy system decreases from approx. 0.7 DKK/kWh to approx. 0.5 DKK/kWh with decreasing heat demands. Moreover, Fig. 1 illustrates how an expansion of district heating will decrease the total (and per unit) costs until an average level of 30% for the total building mass is reached.

The CEESA scenario of 66% district heating and a 50% cut in heat demands is marked in Fig. 2.

3. Marginal Saving Cost

The next step has been to identify the marginal cost curve when increasing the energy saving activities for new and existing buildings, respectively. For new buildings, the marginal cost represents an increased investment in all new buildings, since the least-cost solution is to be found when all new buildings are insulated to the same level. However, for existing buildings, this is not the case, because the investment in conservation is mainly relevant in the cases in which renovation is being carried out anyway. Therefore, the least-cost solution (within a certain number of years, i.e. till 2050) is identified as a scenario in which the buildings being renovated include all energy conservation measures, while the buildings not being renovated are left more or less as they are. Consequently, for existing buildings, the marginal cost has been identified in such a way that it represents investments in an increasing number of buildings.

3.1 New Buildings

When increasing the energy saving activities in new buildings, a marginal cost curve has been made based on the report “Cost-optimal levels of minimum energy performance requirements in the Danish building regulations” [48,49] and data related to the study described in the report; see Appendix 2. The report identifies the costs of different levels of energy savings in new single-family houses of 150 m^2. By creating a marginal cost curve from this data and combining it with the supply costs of energy from the previous section, an optimal level of savings can be identified.

When calculating such a marginal cost curve, one issue turned out to be very important: how to treat the marginal cost of mechanical ventilation? The above-mentioned report indicates that, at a certain point of increasing saving measures, mechanical ventilation must be installed in buildings to reach lower heat reductions than what is possible with natural ventilation. This creates two problems.

The first problem is that a change from natural to mechanical ventilation leads to an increase in the electricity demand due to the operation of the ventilation system. In principle, this electricity demand should be treated as a change to the smart energy system. However, for practical reasons and since this paper defines least-cost solutions, the electricity demand has been treated as a cost of 1.00 DKK/kWh. In principle, this cost reflects the marginal cost of producing one more unit of electricity in the smart energy system. However, due to the size of the electricity demand the exact value of this price is not essential.

The second problem is connected to the identification of the investment and operation costs of adding mechanical ventilation. In the report above, the following is assumed:

- Electricity consumption for ventilation: 4.25 kWh/m^2
- Electricity price: 1 DKK/kWh
- Investment cost: 88,826 DKK
- Maintenance: 1000 DKK/year
- Lifetime: 25 years

However, these cost assumptions create a result in which it will never pay to include mechanical ventilation or any measure that requires mechanical ventilation. This is illustrated in Fig. 3 (left), which is based on the numbers in table 9, see Appendix 2. The marginal cost of the step in which mechanical ventilation is included creates a bulge that it will never pay to pass.

This result has led to two considerations. One is if the whole investment cost should be regarded only a heat saving cost since mechanical ventilation also provides other benefits in terms of a better indoor climate. The other consideration is if the investment costs are right. Therefore, the same calculations have been carried out with another set of investment costs reflecting the author's own experience with 23 years of operation of 16 mechanical ventilation investments in 16 attached low-energy houses, namely:

- Electricity consumption for ventilation: 4.25 kWh/m^2
- Electricity price: 1 DKK/kWh
- Investment cost: 40,000 DKK
- Maintenance: 200 DKK/year
- Lifetime: 40 years

The results are shown in Fig. 3 (right). As shown, such a change in costs reduces the bulge significantly.

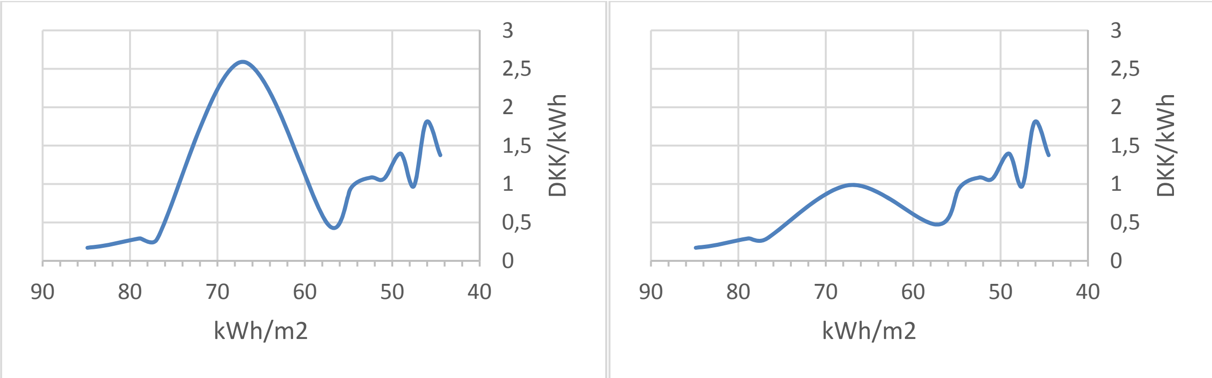

Fig. 3: Marginal cost of investments in heat savings for two different price assumptions regarding mechanical ventilation.

Table 9 shows the two sets of data used for describing improvements in energy performances of new houses. One based on a house with natural ventilation and one based on a house with mechanical ventilation. Both include a curve based on current price levels and a curve based on an estimate of future price levels. The future price level estimates insulation to be 20% cheaper and components to be 50% cheaper. Appendix 2 describes these analyses.

The development is as follows:

Measure	Natural ventilation house			Mechanical ventilation house		
	Energy use [kWh/m^2]	MC Current prices [DKK/kWh]	MC New prices [DKK/kWh]	Energy use [kWh/m^2]	MC Current prices [DKK/kWh]	MC New prices [DKK/kWh]
No	84.87	0.17	0.04	67.13	0.18	0.04
Windows B	79.73	0.21	0.11	62.20	0.22	0.11
Loft 220 mm insulation	78.00	0.29	0.23	60.53	0.30	0.24
Wall 150 mm insulation	75.87	0.28	0.22	58.53	0.30	0.24
Wall 190 mm insulation	73.40	0.46	0.37	56.13	0.47	0.38
Windows A	70.40	0.94	0.47	53.20	0.96	0.48
Loft 245 mm insulation	68.93	1.03	0.83	51.80	1.08	0.87
Slap 200 mm insulation	67.27	1.11	0.89	50.07	1.07	0.86
Loft 290 mm insulation	65.13	1.35	1.08	48.00	1.40	1.12
Loft 315 mm insulation	64.20	0.97	0.78	47.07	0.97	0.78
Wall 250 mm insulation	62.13	1.69	1.36	45.13	1.81	1.45
Loft 365 mm insulation	60.80	1.30	1.04	43.87	1.38	1.10

Table 9: Development in marginal costs based on current and future prices when increasing the energy performance of new buildings.

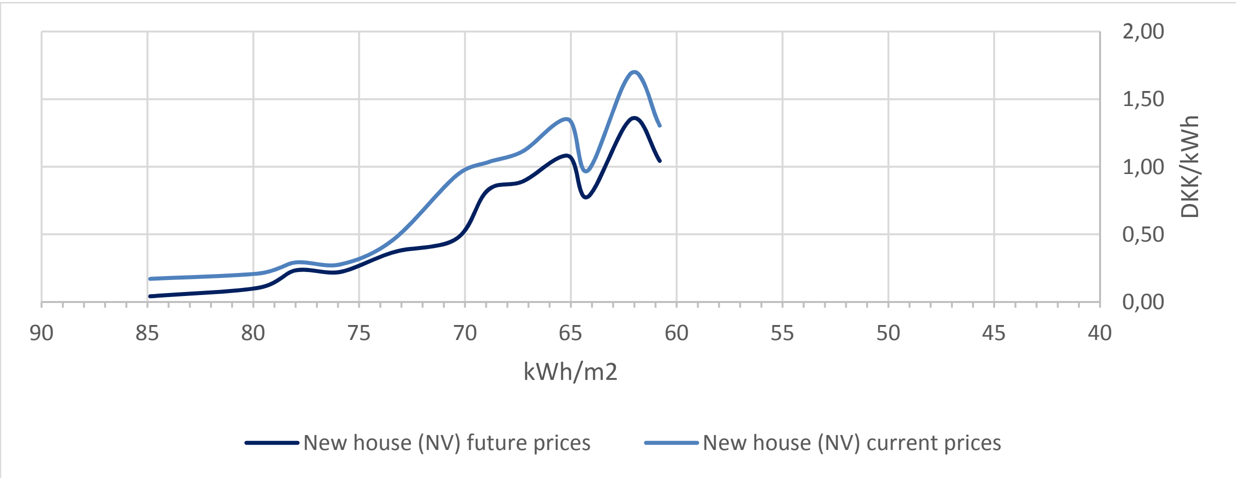

Fig. 4: Marginal costs when increasing the energy performance of new buildings with and without mechanical ventilation.

These curves show that if investments in mechanical ventilation are made independently from the implementation of energy measures, the house performs 37 kWh/m^2 better than if only using natural ventilation. The costs of electricity, however, lead to a minor increase in the price per kWh. An argument for assuming that all houses have mechanical ventilation is that this is required to maintain a certain level of indoor climate. Thus, the future calculations are based on a house with mechanical ventilation under the assumption of current price levels. In Fig. 5, this is shown alongside the production curve.

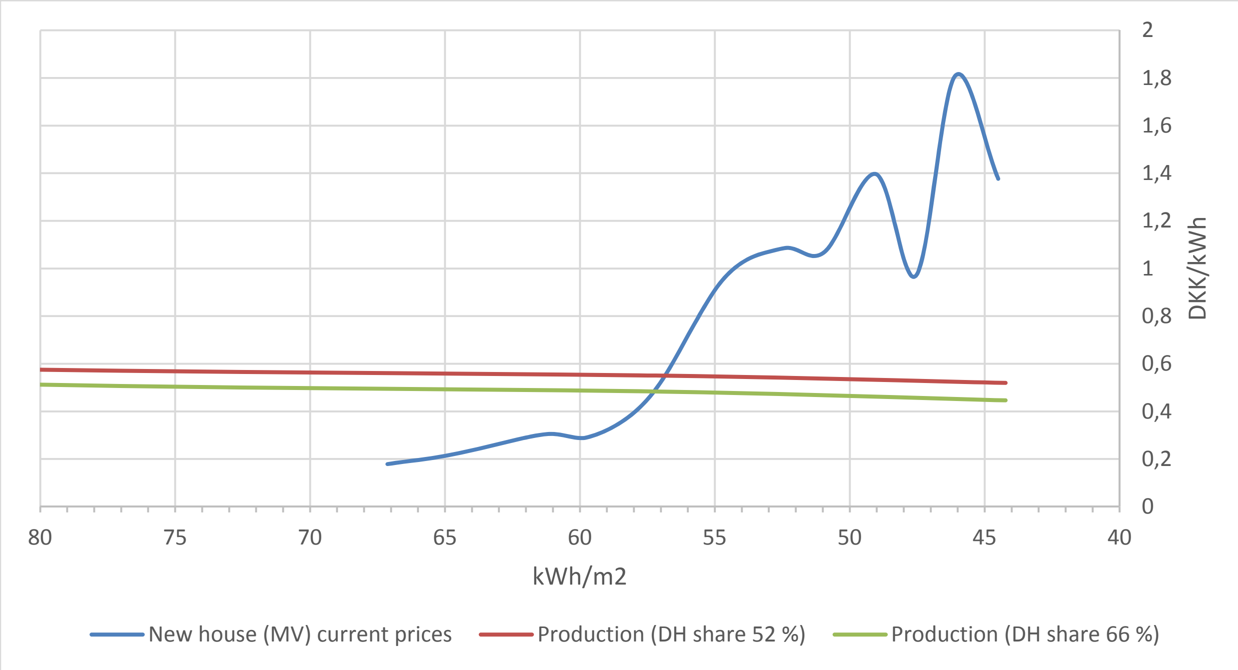

Fig. 5: Marginal cost of improving the energy efficiency in a new house compared with energy production.

3.2 Existing Buildings

The second part of increasing the energy performance of buildings involves the refurbishment of the existing building stock. When determining the marginal cost curve for current buildings, the renovation of each building is assumed to take the building from the current energy use level to the most cost-efficient low energy use level. This means no "step-by-step" improvement, as was the case of the new buildings. The analysis includes two scenarios. One that shows the costs of improving the buildings under the assumption that they were to be refurbished anyway (marginal costs), and one that shows the total costs including the expenses related to initializing the refurbishment. The numbers come from studies relating to the report "Heat Demand in Danish Buildings in 2050" [50].

The previous section analysed only one type of building, but here multiple types of buildings with different construction years are included. These are:

- Single-family house
- Terrace house
- Farmhouse

For the following construction years:

- Before 1850
- 1850-1930
- 1931-1950
- 1951-1960
- 1961-1972
- 1973-1978
- 1979-1998
- 1999-2006
- After 2007

Combining the building types and the construction period gives 27 different categories, which to a certain extent show the variation in the Danish building stock. It is important to include this variation within the building stock because each category is different in terms of specific heat demand as well as the savings potential. However, the data does not include apartment blocks and office buildings since the numbers for these indicate too large efficiency increases. This means that the analysis only looks at the building types that would be the most expensive to refurbish; thus, for the total building mass, more buildings are most likely feasible to renovate.

The potential energy savings in newer buildings are not as high as in the older buildings and the costs of implementing the savings also differ. This means that for some building categories, higher heat savings can be achieved by implementing less expensive measures than in other building types. For each building category, five heat saving measures are implemented; these are roof, floor, outer wall, window, and ventilation. Based on data shown in Appendix 2, it is possible to identify the costs of renovating each house. These have to be corrected to include information about the lifetimes of insulation and components. The following lifetimes are used:

- Roof: 40 years
- Floor: 60 years
- Outer wall: 60 years
- Window: 60 years
- Ventilation: 40 years

By combining the costs of investments for each element that increases the energy efficiency with the lifetimes and a discount rate of 3%, it is possible to define the yearly cost based on annualized figures. By dividing the costs with the savings, the marginal and total costs per energy unit are found. Hereafter, the buildings are organized according to an increase in costs. Therefore, the main part of the analysis is a prioritization of existing building types in terms of which should be renovated first.

The marginal cost and total cost are plotted on the y-axis, with the corresponding x coordinate being the average between the former building type and the latter building type. The points therefore illustrate an increase in the buildings renovated. The plot looks as shown in Fig. 6.

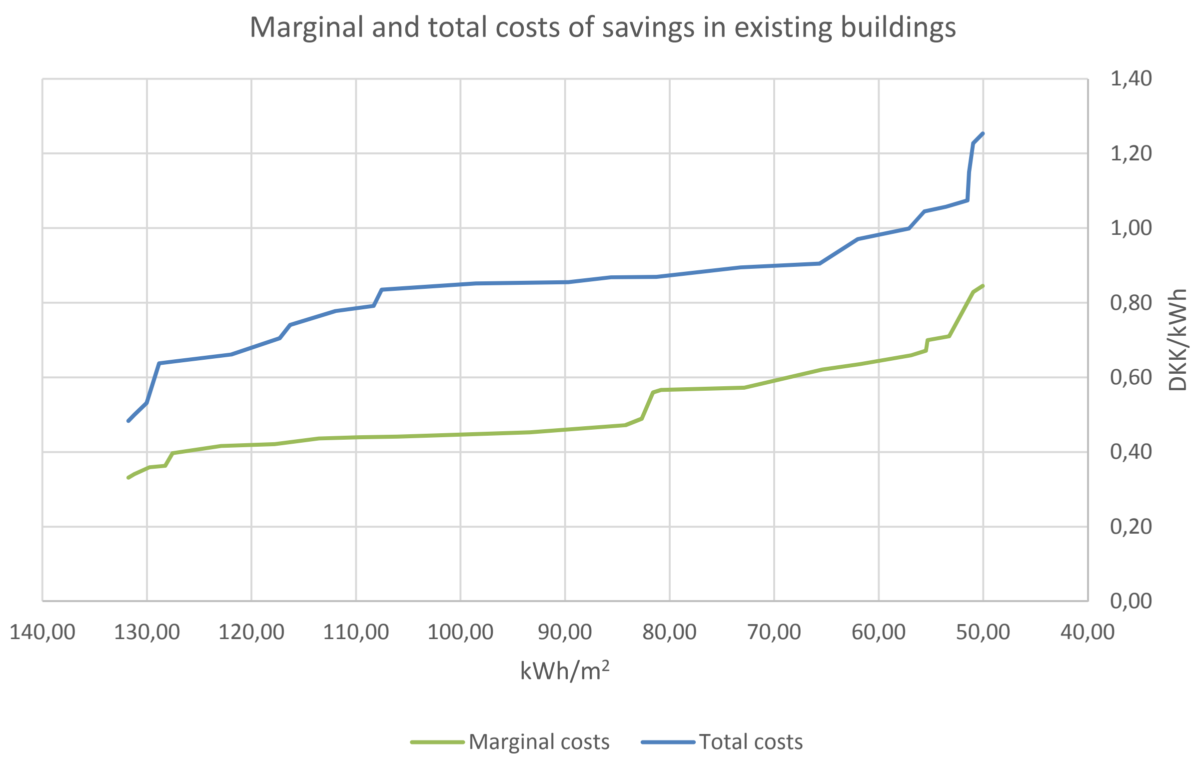

Fig. 6: The marginal and total costs of energy renovating existing buildings represented here as single-family houses, farmhouses and terrace houses.

4. Results and discussion

Fig. 7 shows the combination of the previous analyses and calculations.

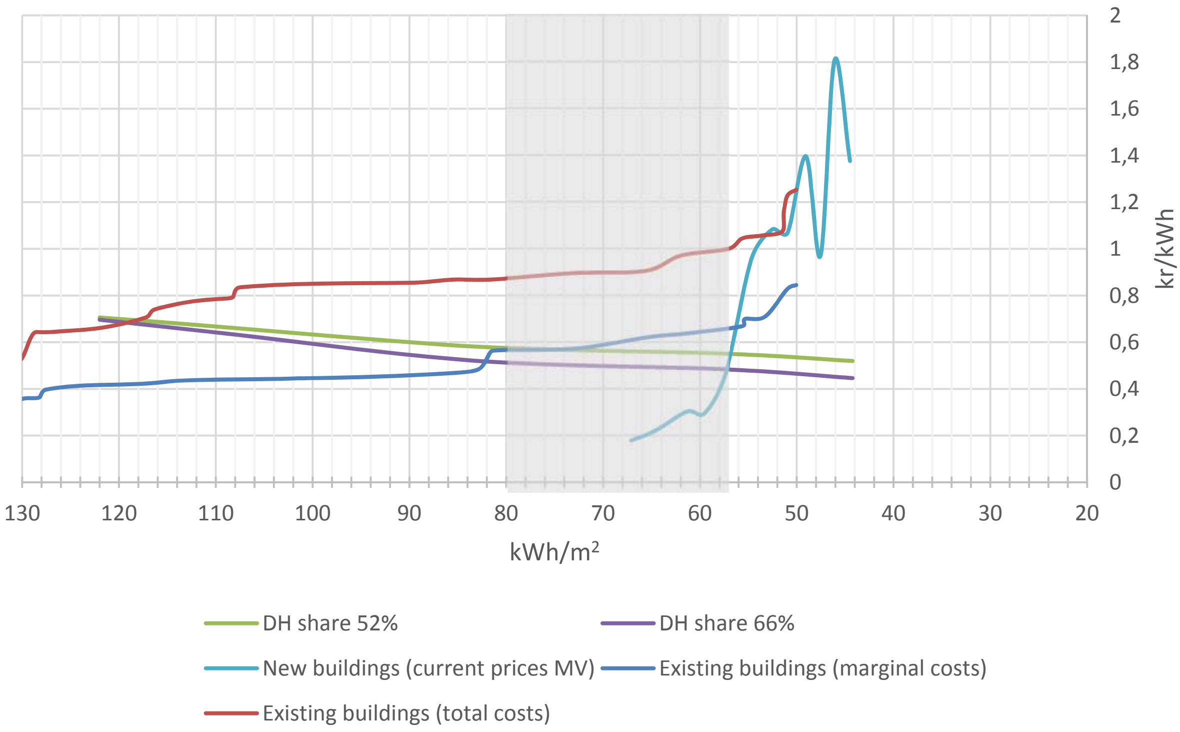

Fig. 7: Marginal cost of heat production in the overall energy system in year 2050 compared to the marginal cost of improving the energy efficiency in a new building, an existing building (total costs) and an existing building being renovated anyway (marginal costs). New buildings are here represented by a 150 m^2 single-family house and existing buildings as the total m^2 of single-family houses, farmhouses and terrace houses. Both are shown as a function of the average heat demand per unit in the buildings.

The following can be learned from the diagram:

- The least-cost heating strategy seems to be found with 35% to 53% savings; i.e., when the average heat demand per unit is decreased to 35-53% of the current level, equal to a decrease in the net heat demand per unit from the current 122 kWh/m^2 to approx. 58-80 kWh/m^2. However, because the graph only takes into account the single-family houses, farmhouses and terrace houses, and more cost-efficient savings are expected in apartment blocks and offices, the least-cost strategy is expected to be closer to 50% than 35%.
- Savings should primarily be implemented in new buildings and only in existing buildings in combination with renovation being carried out anyway. Otherwise the marginal costs are substantially higher than the heat production costs.
- There is only a minor difference between the marginal cost in new buildings compared to existing buildings IF investments in savings are identified as marginal when renovation is being carried out anyway. This is due to the assumption that, in both situations, marginal costs become more or less equal to material costs.

Moreover, based on the total cost shown in Table 7, a least-cost heating strategy points in the direction of increasing the district heating share to approx. 2/3, while the remaining share should be individual heat pumps.

The results of the analysis highlight the importance of identifying long-term heating strategies since the identified least-cost solution can best be implemented with a long time horizon. Thus, savings should mostly be implemented when renovations are being carried out anyway and a suitable district heating infrastructure should be developed over a long period.

As previously explained, the marginal cost of energy conservation has been identified in two different ways for new and existing buildings, respectively. For new buildings, the marginal cost represents an increased investment in all new buildings, since the least-cost solution is to be found when all new buildings are insulated to the same level. However, for existing buildings this is not the case, because investments in conservation are only relevant when renovation is being carried out anyway. Therefore, the least-cost solution (within a certain number of years, i.e. till 2050) is identified as a scenario in which the buildings being renovated include all energy conservation measures, while buildings not being renovated are left more or less as they are. Consequently, for existing buildings, the marginal cost represents investments in an increasing number of buildings. The increased marginal cost illustrates the fact that in old and not renovated buildings, one can achieve more savings for the same money than in new and/or renovated buildings. This also corresponds well with the fact that the old buildings are likely to be the ones that will be renovated first.

For the same reason, the diagram includes the phenomenon that the marginal cost of new buildings ends up being slightly higher than that of existing buildings when measured in DKK/kWh. Thus, for the existing buildings, this part of the curve still includes energy conservation of the full spectrum of buildings, from the existing level to the level of low energy buildings. In principle, some of the “expensive” measures in existing buildings are already part of the mix in the beginning of the curve, leaving a small portion of the “cheap” measures to the end of the curve and therefore the ability to become cheaper than new buildings.

In principle, this is a contradiction since, theoretically, one would then be able to identify a cheaper solution in which only the “cheaper” measures were implemented. However, the curve shows that in practice this is not possible, since the “cheap” measures can only be implemented when the building is being renovated, and not all buildings are being renovated during the period of time in question. Therefore, some “cheap” measures can still be introduced in the existing buildings (and not the new) after implementing the optimal least-cost strategy.

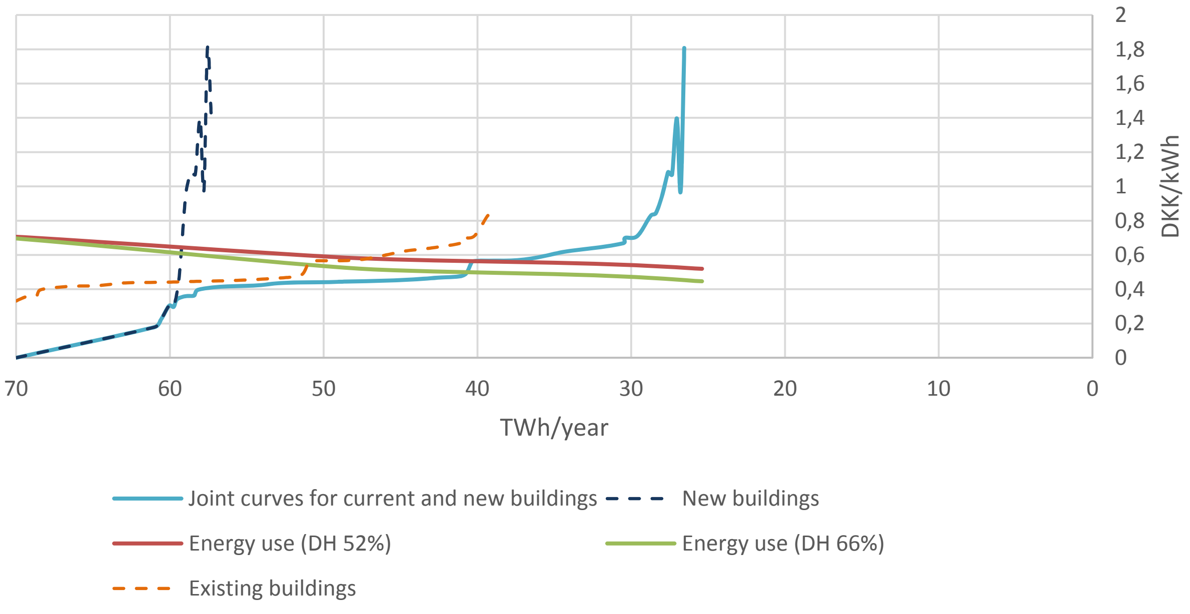

Fig. 8: Marginal cost of heat production in the overall energy system in year 2050 compared to the marginal cost of improving the energy efficiency in buildings in a scenario in which the building stock is increased by 40% from 2010 till 2050. New buildings are here represented by a 150 m^2 single-family house and existing buildings as the total m^2 of single-family houses, farmhouses and terrace houses. Both are shown as a function of the total net space heating and hot water heat demand in the buildings.

Fig. 7 shows demands per unit (kWh/m^2). However, the identification of least-cost strategies also has to do with the share of existing versus new buildings in the 2050 scenario. Consequently, to supplement Fig. 7, a calculation has been made on the basic assumption of a 40% expansion of new buildings from 2010 to 2050. The results are shown in Fig. 8 as a function of absolute heat demand (TWh/year). Again production costs are shown for two district heating shares. Savings in existing buildings concern 50 TWh/year and can decrease by approx. 32 TWh/year, while new buildings concern 20 TWh/year and can decrease by approx. 14 TWh/year. Merging the curves of existing and new buildings into one, the curve concerns 70 TWh/year and can decrease to 25 TWh/year. However, as can be seen, the least-cost solution is to be found with a 42% cut from 70 TWh/year to approx. 40 TWh/year. Again, since the data only takes into account buildings accommodating only one family, the cut should be expected to be closer to 50% than the shown 42%.

The shade in Figure 7 highlights the difference between feasible savings in existing buildings and new buildings. This could indicate that the result might be a little sensitive to the future mix of new and existing buildings, because of the difference between 58 kWh/m^2 and 80 kWh/m^2. However, since the analysis does not include apartments and offices, the cut off for existing buildings should be lower; thus minimizing the sensitivity of the future mix between existing and new buildings.

The above-mentioned calculation has been carried out with a real interest rate of 3%. Sensitivity analyses of 1% and 5%, respectively, show that both total costs and marginal cost are sensitive to the interest rate, since a significant part of the costs are investments. This matters because the energy renovations are almost only investment costs, whereas the energy system also contains fuel costs. Figure 9 shows this. From Figure 9, it is seen that using an interest rate of 5% results in a reduction from 70 TWh to 52 TWh, whereas the optimal heat consumption is 40 TWh when the interest rate is 3%. An interest rate of 1% results in a heating consumption of 32 TWh. When looking at the energy renovation of houses they are, however, meant to be long-term investments; thus it makes sense to use interest rates of 3% and below. Thus, the cost optimal point of around 42-50% savings remains the recommendation, even though the point is sensitive to the interest rate.

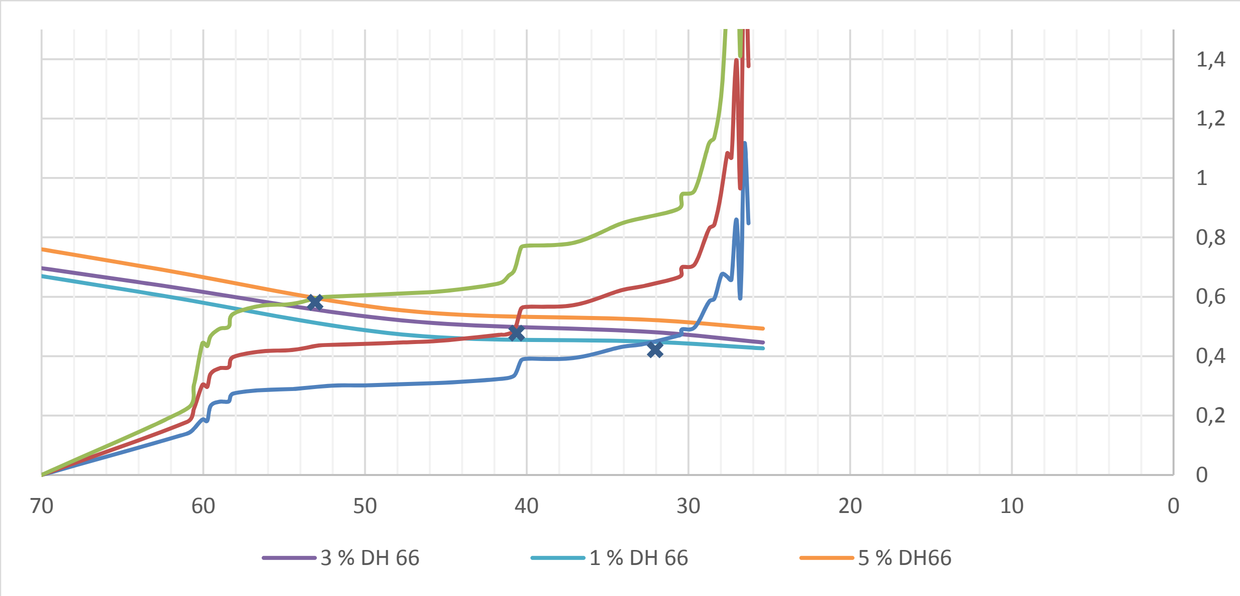

Fig. 9 Sensitivity to the discount rate in both savings cost and energy production costs, and how it affects the cost optimal point. The crosses mark the three different cost optimal points.

The result is not particularly sensitive to the costs of investing in saving measures in the buildings. A sensitivity analysis has been carried out with potential future cost reductions. However, due to the steep rise in marginal costs related to savings, the potential lower costs will have only a minor influence of around 3% on the least-cost optimal point.

However, one issue was found to be of outmost importance, namely the issue of mechanical ventilation. The size of the investment costs and the degree to which mechanical ventilation is considered only an energy saving cost will completely change the picture in terms of the amount of savings defined as least-cost.

5. Conclusion

This paper has presented a methodology to identify least-cost strategies for reducing the heat demand of buildings as a part of implementing sustainable smart energy systems. The methodology has then been applied to the case of Denmark.

Based on the detailed hourly modelling of a proposal to implement the Danish governmental strategy of an energy system based on 100% renewable energy by year 2050, the future marginal costs of producing heat have been identified. The marginal heat production costs have then been compared to similar marginal heat savings costs.

The important point which is emphasised in this paper is that the size of the investment costs strongly depends on whether energy conservation is done in existing buildings or as additional investments in new buildings. Furthermore, it depends on whether investments are made solely for the purpose of reducing the heat demand or as an integrated part of a renovation which will take place anyway.

Moreover, the identification of proper strategies depends on the marginal alternative production of the energy system, and the cost of this marginal production again depends on which system one addresses.

Further, the analysis highlights the importance of identifying long-term heating strategies since least-cost solutions require a long period of implementation. First, savings should mostly be implemented when buildings are being constructed or when renovations are being carried out anyway, which requires several decades to cover the building stock. Second, a suitable district heating infrastructure should be developed and adjusted to low-energy buildings, which also calls for a long time horizon.

For Denmark, a suitable least-cost heating strategy seems to be to implement savings in new buildings and buildings which are being renovated anyway. Savings should be implemented to an extent that will decrease the net heat demand of space heating and hot water by approximately 50% compared to the present level, while heat savings in buildings which are not being renovated hardly pay. Moreover, the analysis points in the direction that a least-cost strategy will be to provide approx. 2/3 of the heat demand from district heating and the rest from individual heat pumps.

It should be emphasized that such a future heat saving strategy is very ambitious compared to previous years. Thus, a similar development in specific heat demands for the previous 40 years shows only a 17% per cent decrease from 147 kWh/m^2 in 1970 to 122 kWh/m^2 in 2010. This historical development emphasizes the fact that the implementation of a 50% cut during the next 40 years is very ambitious and will require an active policy.

Acknowledgement

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Appendix 1: EnergyPLAN Calculation

The starting point is the CEESA 2050 scenario:

Attached as CEESA_2050_REC_MI_201312_Complete

The CEESA scenario has been adjusted to fit this study. The following changes have been made:

First, to adjust to the forecasting of new buildings in the ZEB project as explained in the main text, the district heating and individual heat demands were adjusted together with some small changes in solar thermal and the inclusion of cooling demands:

- District heating demand has been changed from 37.28 TWh to 33.6 TWh and distributed among the different groups as shown in the table below
- Individual heat demand is increased from 9.30 TWh to 13.7 TWh
- 0.33 TWh of solar thermal is moved from collective gr.1 to individual
- Cooling demand of 1.11 TWh (diff between 38.39 TWh og 37.28 TWh) is added as cooling in gr.3

Moreover, to fit with the assumptions of Heat Plan Denmark, the COP of individual heat pumps was adjusted:

- COP for individual heat pumps is defined as 2.7

Finally, to achieve a zero net import of fossil fuels as well as to adjust to the biomass consumption in CEESA, a minor adjustment has been made in biomass and in the production of synthetic gas:

- The direct use of biomass in boilers has been set to a fixed amount (as specified in Table 1.1)
- Forced input demand for the production of synthetic fuel was lowered from 14.16 to 11.65

Moreover, the cost of district heating expansion was added since this is a 66% DH scenario.

- Adding 33 billion DKK with a lifetime of 40 years and annual o&m costs of 1% of the investment.

In accordance with "Varmeplan Danmark (2008)", the cost of increasing district heating from 46% in 2006 to 63% is 33 billion DKK. In this study, district heating is increased from the current level (2010) to 66%. On the one hand, the increase is smaller which makes it cheaper; on the other hand, the starting point is higher which makes it more costly. On this background, the cost of increasing the district heating has been estimated at an investment of 33 billion DKK with a lifetime of 40 years and annual o&m costs of 1% of the investment.

For individual heat pumps, the same costs per unit are used as in CEESA, which again is based on the Heat Plan Denmark report. Under these assumptions, a house with an annual heat demand of 10 MWh/year (equal to a 50% cut in heat for space heating compared to today) has the investment cost of an individual heat pump of 65,000 DKK, a lifetime of 15 years and annual o&m costs of approx. 450 DKK.

The exact changes in inputs are specified in Table 1.1.

Table 1.1. Adjustments from the original CEESA scenario (scenario file 1) to the one used in this report (scenario file 2).

Compare

File Help

Compare Inputs Compare EnergyPLAN input Scenario files

Select scenario file 1 \\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\CEESA_2050_Rec_MI_201312_Complete.txt

Select scenario file 2 \\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B50_AdjustedFromCEESA.txt

Show comparison There are 25 differences between the files

Show only differences Show full file contents highlighting differences

	Scenario File 1	Scenario File 2
input_dh_ann_gr1	2,96	2,4
input_dh_ann_gr2	11,09	13,1
input_dh_ann_gr3	24,34	18,2
input_solar_ann_gr1	1,33	1
input_cap_boiler2_th	3484	4500
input_cap_boiler3_th	7574	6300
input_fuel_dhp[3]	0	1
input_fuel_dhp[4]	1	1,46
input_fuel_Boiler2[3]	0	1
input_fuel_Boiler2[4]	1	0,86
input_fuel_Boiler3[3]	0	1
input_fuel_Boiler3[4]	1	0
input_fuel_Households[4]	1,134	2,44
input_HH_HP_solar	1,987	2,33
input_HH_HP_heat	8,37	11,7
input_HH_HP_COP	4,72	2,7
input_HH_HP_CapLimit	0,5	1
Input_Button_Biomass	Variable	Fixed
Input_Cooling_DHgr3_Heatdemand	0	1,11
Input_Cooling_DHgr3_eff	2	1
input_Period_Various5	0	40
input_FOM_Various5	0	1
input_Inv_Various5	0	33000
Various5Text		District heating grid expansion
Input_CO2HydroSynGridGas	14,16	10,52

The results are attached as:

ZEB_B50AdjustedFromCEESA

With these changes in the CEESA scenario, the biomass consumption remains the same, while the excess electricity production increases a bit from 1.75 to 1.87 TWh. The annual cost increases from 146.7 to 154.6 billion DKK due to an increase in individual production units as well as a higher capacity in boilers (It should be noted that one of the reasons is the inclusion of additional costs for district heating grids which are already included in CEESA. However, in order to be able to make the change between scenarios A and B exactly as specified, this cost has been added to scenario B and not A. This procedure increases the total cost of all scenarios but not the marginal costs).

Thereafter, all the other variants of the matrix have been calculated on the basis of the following changes:

- Scenario B has an additional cost of DH compared to scenario A as described above.
- District heating and individual demands are adjusted as specified in Table 1.2.
- District heating boilers are adjusted to peak load plus 10%. This means that the higher the district heating demand, the more must be invested in boilers.
- The COP of individual heat pumps is adjusted to Heat Plan Denmark assumptions as specified in the main text.
- Power plant capacities are adjusted compared to the CEESA scenario to compensate for any changes in individual heat pump electricity peak demands plus 20% reserve.

Hourly heat demands of district heating as well as individual houses have been adjusted so that hot water demands are the same, see Figures 1.1 and 1.2. Reductions in space heating reduce the peak load capacities as illustrated below for a 50% cut in the heat for space heating demands of individual buildings.

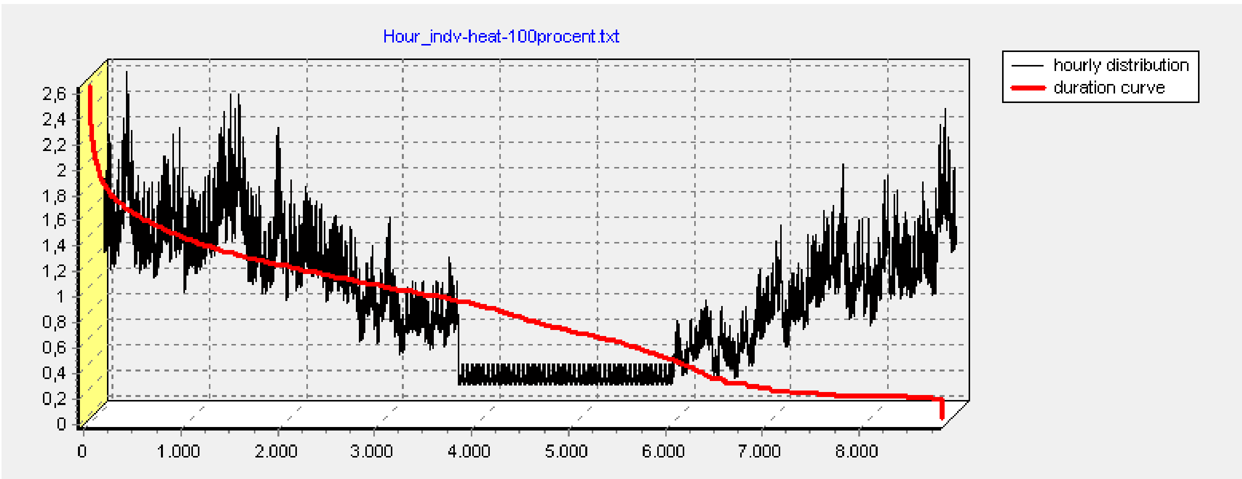


Figure 1.1. Distribution of heat demands with no demand reduction.

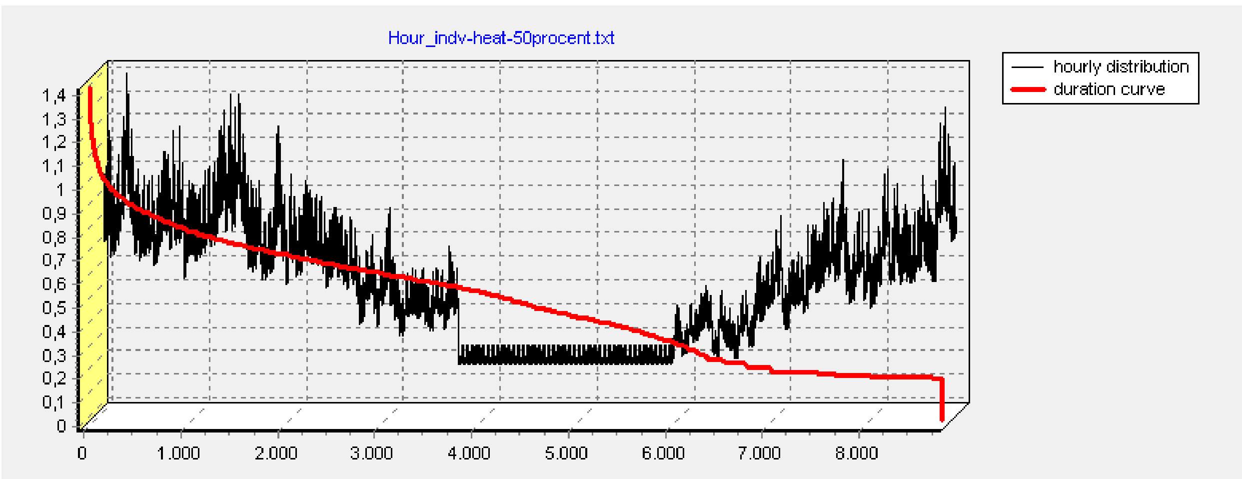


Figure 1.2. Distribution of heat demands with 50% demand reduction.

Table 1.2. Adjustments to the individual and district heating demand applied to the two scenarios (A and B) in this report.

Net heat demand (space heating + hot water) in 2010							
	TJ/year	TWh/year					
District heating	94,6	26,28					
Individual	85,4	23,72					
Total	180	50					
Increase in demand from 2010 to 2050:			40	percent			
Share of district heating in scenario B:			66	percent			
Share of hot water in 2010 numbers:			15	percent			
Net heat demand (hot water and space heating) year 2050							
TWh/year		A (52,5% DH share)				B (66% DH share)	
	DH=	36,8	TWh/year		DH=	46,2	TWh/year
100%	Indv=	33,2	TWh/year		Indv=	23,8	TWh/year
	Sum=	70,0	TWh/year		Sum=	70,0	TWh/year
	DH=	29,0	TWh/year		DH=	36,4	TWh/year
75%	Indv=	26,2	TWh/year		Indv=	18,7	TWh/year
	Sum=	55,1	TWh/year		Sum=	55,1	TWh/year
	DH=	21,2	TWh/year		DH=	26,6	TWh/year
50%	Indv=	19,1	TWh/year		Indv=	13,7	TWh/year
	Sum=	40,3	TWh/year		Sum=	40,3	TWh/year
	DH=	13,3	TWh/year		DH=	16,7	TWh/year
25%	Indv=	12,0	TWh/year		Indv=	8,6	TWh/year
	Sum=	25,4	TWh/year		Sum=	25,4	TWh/year
Distribution between DH groups in EnergyPLAN:							
Gr.I : (Boiler alone systems):		6	percent			7	percent
Gr. II: (Dec. CHP systems):		36	percent			39	percent
Gr. III: (Cen. CHP systems):		58	percent			54	percent
District heating grid loss in percent of total DH production ab plant							
100%		21	percent			20	percent
75%		19	percent			18	percent
50%		23	percent			21	percent
25%		30	percent			27	percent
Input to the EnergyPLAN model							
	Gr.I	2,8	TWh/year		Gr.I	4,0	TWh/year
100%	Gr. II	16,8	TWh/year		Gr. II	22,5	TWh/year
	Gr. III	27,0	TWh/year		Gr. III	31,2	TWh/year
	Total	46,6	TWh/year		Total	57,8	TWh/year
	Gr.I	2,1	TWh/year		Gr.I	3,1	TWh/year
75%	Gr. II	12,9	TWh/year		Gr. II	17,3	TWh/year
	Gr. III	20,7	TWh/year		Gr. III	24,0	TWh/year
	Total	35,8	TWh/year		Total	44,4	TWh/year
	Gr.I	1,6	TWh/year		Gr.I	2,4	TWh/year
50%	Gr. II	9,9	TWh/year		Gr. II	13,1	TWh/year
	Gr. III	15,9	TWh/year		Gr. III	18,2	TWh/year
	Total	27,5	TWh/year		Total	33,6	TWh/year
	Gr.I	1,1	TWh/year		Gr.I	1,6	TWh/year
25%	Gr. II	6,9	TWh/year		Gr. II	8,9	TWh/year
	Gr. III	11,0	TWh/year		Gr. III	12,4	TWh/year
	Total	19,1	TWh/year		Total	22,9	TWh/year

The changes in input between the different scenarios and the corresponding results are shown in the attachment as: ZEB_A25, ZEB_A50, ZEB_A75, ZEB_A100, ZEB_B25, ZEB_B75 and ZEB_B100.

In summary, the results are as illustrated in Table 1.3 and Figure 1.3.

Table 1.3. Total system costs for scenarios A and B.

Results: Annual cost in million DKK	A Current (year 2010) share of district heating versus individual supply, i.e., approx. 52.5 per cent	B CEESA (Heat Plan Denmark) share of district heating, i.e., approx. 66 per cent.
100% of current space heating demand per unit	173.9	171.8
75%	164.0	162.3
50%	155.4	154.6
25%	147.2	147.4

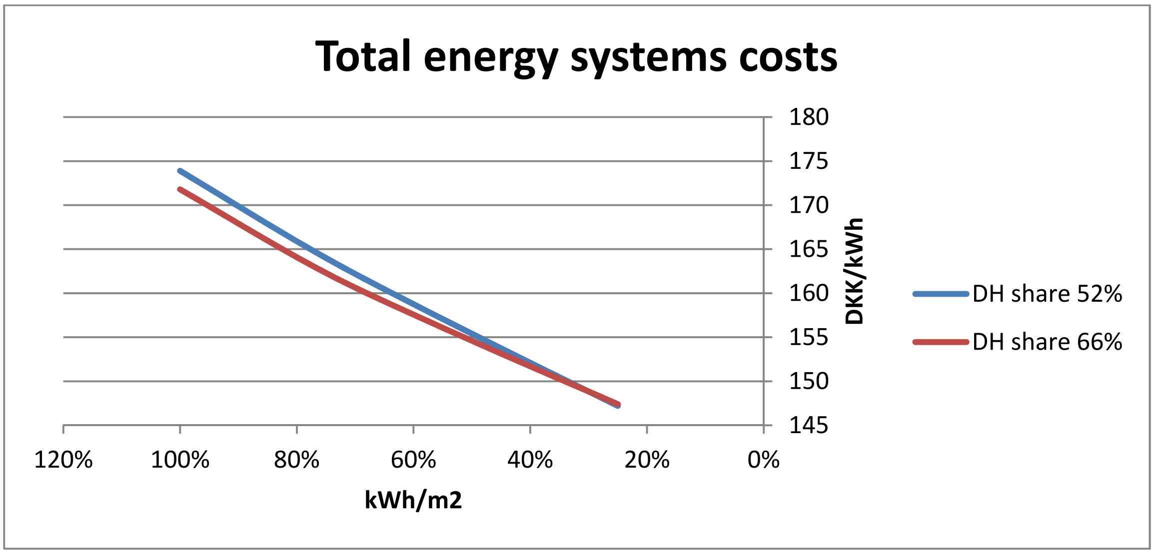


Figure 1.3. Total system costs for scenario A and B.

The total cost has been converted to marginal cost per unit as illustrated in Table 1.5 and Figure 1.4 on the basis that the current 2010 level corresponds to 122 kWh/m^2 (see Table 1.4). In the conversion, it has been considered that hot water in the current level accounts for 15% equal to approx. 18 kWh/m^2. This level has been kept constant.

Table 1.4. Heat demands at different reduction levels.

kWh/m^2	Hot water	Space heat	Total
100%	18	104	122
75%	18	78	96
50%	18	52	70
25%	18	26	44

Table 1.5. Heat demands and the marginal reduction price.

kWh/m^2	DKK/kWh	DKK/kWh
122	0.71	0.70
109	0.66	0.64
83	0.58	0.52
57	0.55	0.48
44	0.52	0.45

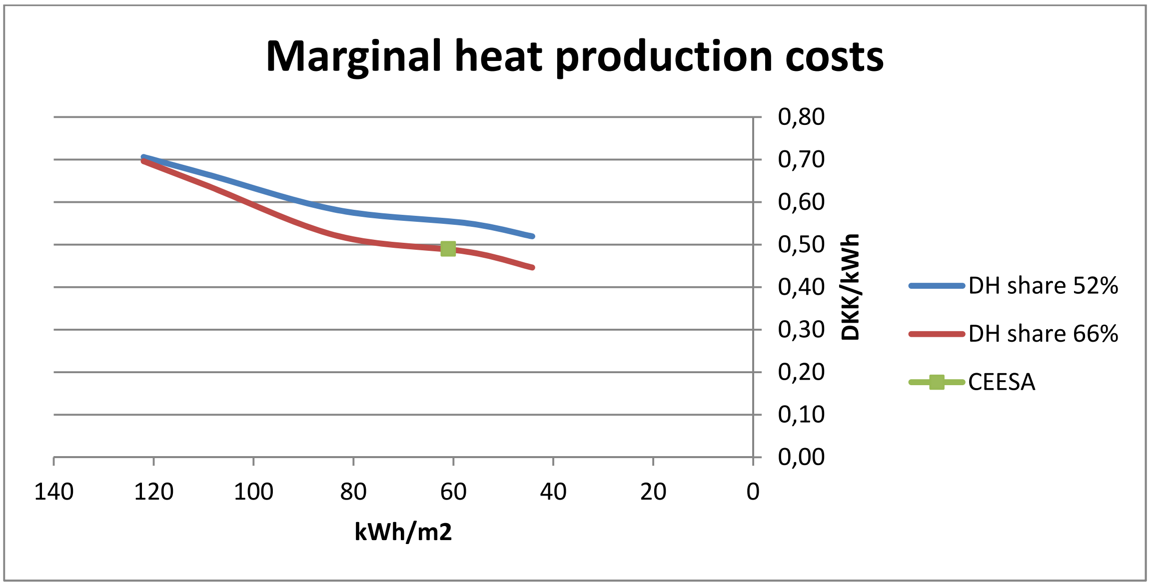


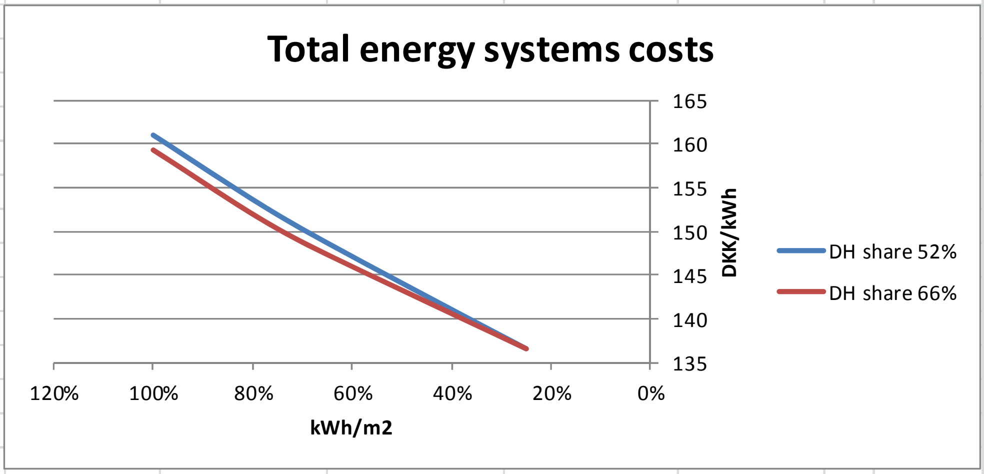
Figure 1.4. Marginal heat production costs for scenarios A (blue line) and B (red line).

All the calculations above have used a real interest rate of 3%.

A sensitivity analysis has been carried out with 1% and 5% interest rates, respectively, and the results are shown in Figures 1.5 and 1.6.

Savings in Spaceheating	Heat Demand TWh/year	DH share 52% Billion DKK	DH share 66% Billion DKK
100%	70	161	159,3
75%	55,1	151,9	150,3
50%	40,3	144,1	143,3
25%	25,4	136,6	136,6

Interest
1%



kWh/m2	Hotwater	Space heat	Total
100%	18	104	122
75%	18	78	96
50%	18	52	70
25%	18	26	44

kWh/m2	DKK/kWh	DKK/kWh
122	0,65	0,67
109	0,61	0,60
83	0,53	0,47
57	0,50	0,45
44	0,48	0,43

CEESA point in Diagram

61	0,5
61	0,5

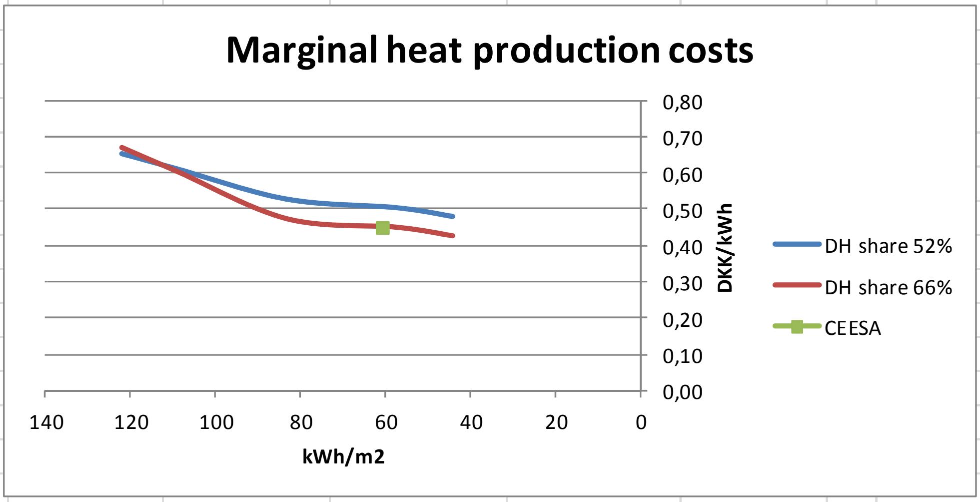
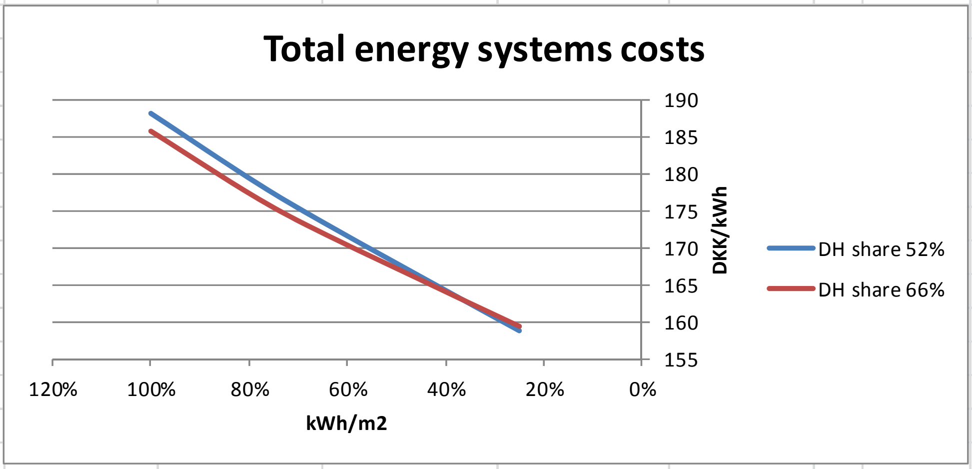


Figure 1.5. Results with an interest rate of 1%.

Savings in Spaceheating	Heat Demand TWh/year	DH share 52% Billion DKK	DH share 66% Billion DKK
100%	70	188,1	185,7
75%	55,1	177,3	175,4
50%	40,3	167,9	167,2
25%	25,4	158,8	159,4

Interest
5%



kWh/m2	Hotwater	Space heat	Total
100%	18	104	122
75%	18	78	96
50%	18	52	70
25%	18	26	44

kWh/m2	DKK/kWh	DKK/kWh
122	0,77	0,76
109	0,72	0,69
83	0,64	0,55
57	0,61	0,52
44	0,59	0,49

CEESA point in Diagram

61	0,5
61	0,5

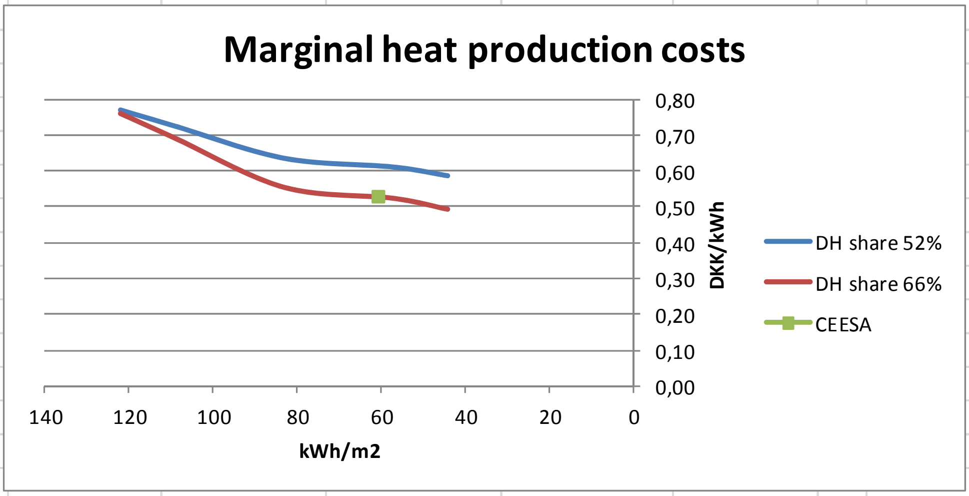


Figure 1.6. Results with an interest rate of 5%.

Input CEESA_2050_Rec_MI_201312_Complete.txt

The EnergyPLAN model 11.2

Electricity demand (TWh/year):		Flexible demand	4,07
Fixed demand	21,80	Fixed imp/exp.	0,00
Electric heating + HP	1,65	Transportation	8,22
Electric cooling	0,00	Total	35,74

District heating (TWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	2,96	11,09	24,34	38,39
Solar Thermal	1,25	2,05	0,91	4,20
Industrial CHP (CSHP)	0,00	0,00	2,65	2,65
Demand after solar and CSHP	1,71	9,04	20,78	31,54

Wind	4454 MW	12,63 TWh/year	0,00	Grid
Offshore Wind	10173 MW	41,75 TWh/year	0,00	stabili-
Photo Voltaic	5000 MW	6,46 TWh/year	0,00	sation
Wave Power	300 MW	0,79 TWh/year	0,00	share
Hydro Power	0 MW	0 TWh/year		
Geothermal/Nuclear	0 MW	0 TWh/year		

	Capacities		Efficiencies		
Group 2:	MW-e	MJ/s	elec.	Ther	COP
CHP	1945	1241	0,58	0,37	
Heat Pump	300	1050			3,50
Boiler		3484		0,95	
Group 3:					
CHP	2500	1292	0,60	0,31	
Heat Pump	600	2100			3,50
Boiler		7574		0,95	
Condensing	10333		0,60		

Heatstorage: gr.2: 40 GWh gr.3: 10 GWh
Fixed Boiler: gr.2: 0,5 Per cent gr.3: 0,5 Per cent

Electricity prod. from	CSHP	Waste (TWh/year)
Gr.1:	0,00	0,00
Gr.2:	0,00	0,39
Gr.3:	0,89	0,72

Regulation Strategy:	Technical regulation no. 3	
KEOL regulation	23458000	
Minimum Stabilisation share	0,00	
Stabilisation share of CHP	0,00	
Minimum CHP gr 3 load	0	MW
Minimum PP	0	MW
Heat Pump maximum share	0,50	
Maximum import/export	0	MW

Distr. Name :	Price_DKV_2008.txt	
Addition factor	100,00	DKK/MWh
Multiplication factor	1,05	
Dependency factor	0,02	DKK/MWh pr. MW
Average Market Price	541	DKK/MWh
Gas Storage	6000	GWh
Syngas capacity	3522	MW
Biogas max to grid	895	MW

Fuel Price level:

	Capacities	Storage	Efficiencies	
	MW-e	GWh	elec.	Ther.
Hydro Pump:	0	0	0,85	
Hydro Turbine:	0		0,85	
Electrol. Gr.2:	0	0	0,00	0,00
Electrol. Gr.3:	0	0	0,00	0,00
Electrol. trans.:	1909	477	0,73	
Ely. MicroCHP:	0	0	0,00	
CAES fuel ratio:		0,000		

(TWh/year)	Coal	Oil	Ngas	Biomass
Transport	0,00	0,00	0,00	0,00
Household	0,00	0,00	0,00	1,13
Industry	0,00	0,00	0,00	19,03
Various	0,00	0,00	0,00	0,00

Output WARNING!!: (1) Critical Excess;

	District Heating										Electricity																		Exchange	
	Demand	Production									Consumption						Production							Balance					Payment	
	Distr. heating MW	Solar MW	Waste+ CSHP MW	DHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Ba- lance MW	Elec. demand MW	Flex.& Transp. MW	HP MW	Elec- trolyser MW	EH MW	Hydro Pump MW	Tur- bine MW	RES MW	Hy- dro MW	Geo- thermal MW	Waste+ CSHP MW	CHP MW	PP MW	Stab- Load %	Imp MW	Exp MW	CEEP MW	EEP MW	Imp Million DKK	Exp
January	6657	190	1307	446	1332	2693	0	620	73	-2	2787	1398	1042	3364	73	0	0	5908	0	0	200	2340	385	100	0	15	15	0	0	0
February	6790	401	1307	391	873	2856	0	782	175	4	2759	1399	1079	4405	175	0	0	8139	0	0	200	1539	207	100	0	96	96	0	0	0
March	5921	454	1307	308	990	2459	0	311	80	11	2661	1422	944	4179	80	0	0	7306	0	0	200	1745	216	100	0	148	148	0	0	0
April	4928	692	1307	170	842	1853	0	74	24	-34	2361	1382	698	4162	24	0	0	6853	0	0	200	1492	224	100	0	141	141	0	0	0
May	4066	758	1306	63	718	1188	0	3	2	28	2307	1394	459	4434	2	0	0	7327	0	0	200	1276	192	100	0	399	399	0	0	0
June	2347	624	1270	17	241	237	0	0	1	-43	2246	1408	109	4113	1	0	0	7446	0	0	204	406	121	100	0	302	302	0	0	0
July	2347	685	1264	17	270	144	0	0	1	-33	2060	1411	70	2935	1	0	0	5747	0	0	205	463	381	100	0	320	320	0	0	0
August	2347	644	1266	17	249	204	0	0	0	-35	2349	1389	96	3245	0	0	0	6275	0	0	205	425	411	100	0	236	236	0	0	0
September	3109	581	1300	23	587	628	0	1	1	-13	2407	1412	256	3730	1	0	0	6412	0	0	201	1028	317	100	0	151	151	0	0	0
October	4179	398	1307	150	501	1779	0	12	19	14	2492	1408	659	5067	19	0	0	8794	0	0	200	876	154	100	0	380	380	0	0	0
November	5196	216	1307	325	752	2334	0	157	104	1	2682	1400	881	4637	104	0	0	8178	0	0	200	1325	148	100	0	140	140	0	0	0
December	6024	128	1307	416	1399	2284	0	407	74	10	2683	1378	905	3747	74	0	0	5913	0	0	200	2460	361	100	0	53	53	0	0	0
Average	4487	481	1296	195	730	1551	0	196	46	-8	2482	1400	598	3997	46	0	0	7017	0	0	202	1282	261	100	0	199	199	0	Average price	
Maximum	10955	3841	1307	836	2532	3150	0	3719	600	1613	3754	6906	1184	7659	600	0	0	18479	0	0	228	4445	3287	100	0	6418	6418	0	(DKK/MWh)	
Minimum	2170	0	1056	16	0	21	0	0	0	-2308	1312	-246	6	0	0	0	0	29	0	0	200	0	0	100	0	0	0	0	122	0
TWh/year	39,41	4,22	11,38	1,71	6,41	13,62	0,00	1,72	0,40	-0,07	21,80	12,30	5,26	35,11	0,40	0,00	0,00	61,63	0,00	0,00	1,77	11,26	2,29		0,00	1,75	1,75	0,00	0	0

FUEL BALANCE (TWh/year):	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon- version	Synthetic Fuel	Wind	Offsh.	PV	Wave	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Netto	CO2 emission (Mt): Total	Netto
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
N.Gas	-	8,44	10,61	-	-	3,82	-	-	-	-	-22,85	-0,01	-	-	-	-	-	-	-	-	0,00	-2,92	-2,91	0,00	-0,60
Biomass	1,81	-	-	0,77	1,05	-	-	-	4,16	-	38,87	-	-	-	-	-	-	-	0,92	19,03	66,60	0,00	66,60	0,00	0,00
Renewable	-	-	-	-	-	-	-	-	3,45	-	-	-	12,63	41,75	6,46	0,79	6,39	-	-	-	71,47	0,00	71,47	0,00	0,00
H2 etc.	-	0,00	0,00	0,00	0,00	0,00	-	-	-	-24,77	-10,85	35,62	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-32,15	-	-	-	-	-	32,15	-	-	0,00	0,00	0,00	0,00	0,00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Total	1,81	8,44	10,61	0,77	1,05	3,82	-	-	7,61	-24,77	5,17	3,45	12,63	41,75	6,46	0,79	6,39	32,15	0,92	19,03	138,07	-2,92	135,16	0,00	-0,60

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Output specifications CEESA_2050_Rec_MI_201312_Complete.txt The EnergyPLAN model 11.2

District Heating Production

	Gr.1 District heating MW	Gr.1 Solar MW	Gr.1 CSHP MW	Gr.1 DHP MW	Gr.2 District heating MW	Gr.2 Solar MW	Gr.2 CSHP MW	Gr.2 CHP MW	Gr.2 HP MW	Gr.2 ELT MW	Gr.2 Boiler MW	Gr.2 EH MW	Gr.2 Stor-age MW	Gr.2 Ba-lance MW
January	504	59	0	446	2006	92	146	645	829	0	246	49	15417	0
February	515	124	0	391	2044	193	146	412	909	0	267	114	16167	2
March	448	140	0	308	1793	219	146	462	762	0	141	51	12219	12
April	371	201	0	170	1506	341	146	374	599	0	49	18	11337	-21
May	305	241	0	63	1257	359	146	310	422	0	1	1	16531	18
June	172	155	0	17	761	325	146	163	137	0	0	1	15022	-12
July	172	155	0	17	761	363	146	163	85	0	0	1	14327	2
August	172	155	0	17	761	341	146	156	124	0	0	0	16037	-8
September	231	208	0	23	981	259	146	291	293	0	1	1	15200	-11
October	313	163	0	150	1290	164	146	254	698	0	9	14	14923	5
November	392	66	0	325	1584	104	146	357	777	0	105	90	15689	5
December	455	39	0	416	1823	62	146	676	704	0	179	51	17492	6
Average	337	142	0	195	1379	235	146	356	527	0	83	32	15032	0
Maximum	836	707	0	836	3247	2175	146	1241	1050	0	1332	400	30491	658
Minimum	158	0	0	16	709	0	146	0	7	0	0	0	0	-926
Total for the whole year TWh/year	2,96	1,25	0,00	1,71	12,11	2,07	1,28	3,12	4,63	0,00	0,73	0,28		0,00

	Gr.3 District heating MW	Gr.3 Solar MW	Gr.3 CSHP MW	Gr.3 CHP MW	Gr.3 HP MW	Gr.3 ELT MW	Gr.3 Boiler MW	Gr.3 EH MW	Gr.3 Stor-age MW	Gr.3 Ba-lance MW
January	4147	40	1161	687	1863	0	374	24	3117	-2
February	4231	85	1161	461	1946	0	515	61	5730	2
March	3680	96	1161	527	1697	0	170	30	4569	-1
April	3051	149	1161	468	1254	0	25	6	5081	-13
May	2505	157	1160	408	766	0	2	1	8299	9
June	1414	144	1124	77	100	0	0	0	6123	-31
July	1414	167	1118	107	59	0	0	0	6242	-36
August	1414	148	1120	93	80	0	0	0	6242	-27
September	1898	114	1155	296	335	0	0	0	6287	-2
October	2576	71	1161	247	1081	0	3	5	6298	9
November	3221	45	1161	395	1557	0	52	15	4931	-4
December	3746	27	1161	724	1580	0	228	22	2894	4
Average	2771	104	1150	374	1024	0	113	13	5482	-8
Maximum	6872	1275	1161	1292	2100	0	2597	200	10000	1117
Minimum	1302	0	910	0	14	0	0	0	0	-1392
Total for the whole year TWh/year	24,34	0,91	10,10	3,29	8,99	0,00	0,99	0,12		-0,07

	RES specification RES1 Wind MW	RES2 Offshoı MW	RES3 Photo ' MW	RES4 Wave I MW	Total er MW
January	1303	4348	168	88	5908
February	1841	5637	495	166	8139
March	1509	4962	716	119	7306
April	1271	4432	1093	58	6853
May	1270	4372	1631	53	7327
June	1356	4782	1260	48	7446
July	918	3345	1436	48	5747
August	1267	4289	654	65	6275
September	1265	4382	678	87	6412
October	2013	6214	439	128	8794
November	1930	5944	177	128	8178
December	1332	4408	73	99	5913
Average	1437	4753	736	90	7017
Maximum	4454	10173	5000	300	18479
Minimum	0	0	0	1	29
Total for the whole year TWh/year	12,63	41,75	6,46	0,79	61,63

ANNUAL COSTS (Million DKK)		
Total Fuel -		14787
Uranium -	0	
Coal -	0	
FuelOil -	0	
Gasoil/Diesel-	0	
Petrol/JP -	3380	
Ngas -	646	
Biomass -	10761	
Food income -	0	
Waste -	0	
Marginal operation costs -		275
Total Electricity exchange -		0
Import -	0	
Export -	0	
Bottleneck -	0	
Fixed imp/ex-	0	
Total CO2 emission costs -		0
Total Ngas Exchange costs -		1
Total variable costs -		15063
Fixed operation costs -		36426
Annual investment costs -		95161
TOTAL ANNUAL COSTS -		146650

	DHP & Boilers MW	CHP2 CHP3 MW	PP CAES MW	Indi-vidual MW	Trans port MW	Indu. Var. MW	Demand Sum MW	Bio-gas MW	Syn-gas MW	CO2Hy gas MW	SynHy gas MW	SynHy gas MW	Stor-age MW	Sum MW	Im-port MW	Ex-port MW
January	0	3959	642	0	0	0	4601	895	2254	1545	1814	-3660	1753	0	0	0
February	0	2602	345	0	0	0	2947	895	1616	2015	1814	-3660	267	0	0	0
March	0	2951	361	0	0	0	3311	895	1891	1896	1814	-3660	476	0	0	0
April	0	2521	373	0	0	0	2894	895	1868	1881	1814	-3660	96	0	0	0
May	0	2155	320	0	0	0	2475	895	1790	2045	1814	-3660	-409	0	0	0
June	0	691	202	0	0	0	894	895	991	1935	1814	-3660	-1081	0	0	0
July	0	786	636	0	0	0	1421	895	1497	1427	1814	-3660	-551	0	0	0
August	0	723	685	0	0	0	1407	895	1441	1531	1814	-3660	-613	0	0	0
September	0	1740	528	0	0	0	2268	895	1855	1738	1814	-3660	-375	0	0	0
October	0	1483	257	0	0	0	1740	895	1266	2325	1814	-3660	-900	0	0	0
November	0	2240	247	0	0	0	2487	895	1542	2110	1814	-3660	-214	0	0	0
December	0	4160	602	0	0	0	4762	895	2447	1749	1814	-3660	1517	0	0	0
Average	0	2169	435	0	0	0	2604	895	1707	1848	1814	-3660	0	0	0	0
Maximum	0	7520	5479	0	0	0	11042	895	3522	3703	1814	-3660	8471	0	0	0
Minimum	0	0	0	0	0	0	0	895	120	0	1814	-3660	-2872	0	0	0
Total for the whole year TWh/year	0,00	19,05	3,82	0,00	0,00	0,00	22,87	7,86	14,99	16,23	15,93	-32,15	0,00	0,00	0,00	0,00

RES Share: 100,0 Percent of Primary Energy 243,3 Percent of Electricity 62,5 TWh electricity from RES 21-januar-2014 [10:21]

Input ZEB_B50_AdjustedFromCEESA.txt

The EnergyPLAN model 11.2

Electricity demand (TWh/year):			
Fixed demand	21,80	Flexible demand	4,07
Electric heating + HP	3,47	Fixed imp/exp.	0,00
Electric cooling	0,00	Transportation	8,22
		Total	37,56

District heating (TWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	2,40	13,10	18,20	33,70
Solar Thermal	0,98	2,08	0,90	3,95
Industrial CHP (CSHP)	0,00	0,00	2,65	2,65
Demand after solar and CSHP	1,42	11,02	14,65	27,10

Wind	4454	MW	12,63	TWh/year	0,00	Grid
Offshore Wind	10173	MW	41,75	TWh/year	0,00	stabili-
Photo Voltaic	5000	MW	6,46	TWh/year	0,00	sation
Wave Power	300	MW	0,79	TWh/year	0,00	share
Hydro Power	0	MW	0	TWh/year		
Geothermal/Nuclear	0	MW	0	TWh/year		

	Capacities MW-e	Capacities MJ/s	Efficiencies elec.	Efficiencies Ther	COP
Group 2:					
CHP	1945	1241	0,58	0,37	
Heat Pump	300	1050			3,50
Boiler		4500		0,95	
Group 3:					
CHP	2500	1292	0,60	0,31	
Heat Pump	600	2100			3,50
Boiler		6300		0,95	
Condensing	10333		0,60		

Heatstorage: gr.2: 40 GWh gr.3: 10 GWh
Fixed Boiler: gr.2: 0,5 Per cent gr.3: 0,5 Per cent

Electricity prod. from	CSHP	Waste (TWh/year)
Gr.1:	0,00	0,00
Gr.2:	0,00	0,39
Gr.3:	0,89	0,72

Regulation Strategy:	Technical regulation no. 3	
KEOL regulation	23458000	
Minimum Stabilisation share	0,00	
Stabilisation share of CHP	0,00	
Minimum CHP gr 3 load	0	MW
Minimum PP	0	MW
Heat Pump maximum share	0,50	
Maximum import/export	0	MW

Distr. Name :	Price_DKV_2008.txt	
Addition factor	100,00	DKK/MWh
Multiplication factor	1,05	
Dependency factor	0,02	DKK/MWh pr. MW
Average Market Price	541	DKK/MWh
Gas Storage	6000	GWh
Syngas capacity	3522	MW
Biogas max to grid	895	MW

Fuel Price level: Basic

	Capacities MW-e	Storage GWh	Efficiencies elec.	Efficiencies Ther.
Hydro Pump:	0	0	0,85	
Hydro Turbine:	0		0,85	
Electrol. Gr.2:	0	0	0,00	0,00
Electrol. Gr.3:	0	0	0,00	0,00
Electrol. trans.:	1909	477	0,73	
Ely. MicroCHP:	0	0	0,00	
CAES fuel ratio:		0,000		

(TWh/year)	Coal	Oil	Ngas	Biomass
Transport	0,00	0,00	0,00	0,00
Household	0,00	0,00	0,00	2,44
Industry	0,00	0,00	0,00	19,03
Various	0,00	0,00	0,00	0,00

Output WARNING!!: (1) Critical Excess;

District Heating

	Demand Distr. heating MW	Production Solar MW	Waste+ CSHP MW	DHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Balance MW
January	6072	176	1307	365	1269	2406	0	459	94	-4
February	6177	371	1307	324	819	2598	0	589	162	6
March	5386	420	1307	258	919	2116	0	278	78	11
April	4470	644	1305	148	734	1519	0	111	47	-37
May	3669	697	1295	67	588	993	0	4	2	23
June	2137	592	1182	14	194	240	0	1	1	-87
July	2125	657	1169	14	227	141	0	0	1	-84
August	2127	614	1176	14	205	204	0	1	1	-88
September	2817	543	1279	19	461	542	0	1	2	-29
October	3798	369	1305	119	418	1473	0	28	73	13
November	4738	199	1307	268	675	1928	0	210	146	6
December	5498	118	1307	340	1314	2001	0	339	67	14
Average	4079	450	1270	162	652	1343	0	167	56	-21
Maximum	9855	3909	1307	678	2532	3150	0	3540	600	1151
Minimum	1965	0	1056	13	0	19	0	0	0	-1627
TWh/year	35,83	3,95	11,16	1,42	5,73	11,80	0,00	1,47	0,49	-0,19

Electricity / Exchange

	Consumption Elec. demand MW	Flex.& Transp. MW	HP MW	Elec- trolyser MW	EH MW	Hydro Pump MW	Production Tur- bine MW	RES MW	Hy- dro MW	Geo- thermal MW	Waste+ CSHP MW	CHP MW	PP MW	Balance Stab- Load %	Imp MW	Exp MW	CEEP MW	EEP MW	Exchange Payment Imp Million DKK	Exp Million DKK
January	2787	1398	1434	2966	94	0	0	5908	0	0	200	2213	375	100	0	17	17	0	0	0
February	2759	1399	1487	4059	162	0	0	8139	0	0	200	1429	194	100	0	96	96	0	0	0
March	2661	1422	1233	3730	78	0	0	7306	0	0	200	1602	183	100	0	168	168	0	0	0
April	2361	1388	863	3658	47	0	0	6853	0	0	201	1266	161	100	0	164	164	0	0	0
May	2307	1388	596	3947	2	0	0	7327	0	0	202	1001	143	100	0	432	432	0	0	0
June	2246	1416	180	3888	1	0	0	7446	0	0	214	304	91	100	0	324	324	0	0	0
July	2060	1407	134	2752	1	0	0	5747	0	0	215	357	383	100	0	347	347	0	0	0
August	2349	1388	162	3064	1	0	0	6275	0	0	215	322	410	100	0	256	256	0	0	0
September	2407	1414	360	3316	2	0	0	6412	0	0	203	762	299	100	0	178	178	0	0	0
October	2492	1407	803	4675	73	0	0	8794	0	0	201	710	116	100	0	371	371	0	0	0
November	2682	1400	1096	4219	146	0	0	8178	0	0	200	1167	137	100	0	139	139	0	0	0
December	2683	1378	1240	3320	67	0	0	5913	0	0	200	2286	346	100	0	57	57	0	0	0
Average	2482	1401	797	3629	56	0	0	7017	0	0	204	1119	237	100	0	213	213	0	Average price	
Maximum	3754	7561	2286	7533	600	0	0	18479	0	0	228	4445	3938	100	0	6468	6468	0	(DKK/MWh)	
Minimum	1312	-203	5	0	0	0	0	29	0	0	200	0	0	100	0	0	0	0	79	0
TWh/year	21,80	12,30	7,00	31,88	0,49	0,00	0,00	61,63	0,00	0,00	1,79	9,83	2,08		0,00	1,87	1,87	0,00	0	0

FUEL BALANCE (TWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon- version	Synthetic Fuel	Wind	Offsh.	PV	Wave	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Imp/Exp Corrected Netto	CO2 emission (Mt): Total	CO2 emission (Mt): Netto
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
N.Gas	0,04	9,26	7,43	0,55	0,14	3,47	-	-	-	-	-22,85	1,95	-	-	-	-	-	-	-	-	0,00	-3,12	-3,12	0,00	-0,64
Biomass	1,46	-	-	0,86	-	-	-	-	4,16	-	38,87	-	-	-	-	-	-	-	2,22	19,03	66,60	0,00	66,60	0,00	0,00
Renewable	-	-	-	-	-	-	-	-	3,08	-	-	-	12,63	41,75	6,46	0,79	6,46	-	-	-	71,17	0,00	71,17	0,00	0,00
H2 etc.	-	0,00	0,00	0,00	0,00	0,00	-	-	-	-22,51	-10,85	33,36	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-32,15	-	-	-	-	-	32,15	-	-	0,00	0,00	0,00	0,00	0,00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Total	1,50	9,26	7,43	1,41	0,14	3,47	-	-	7,24	-22,51	5,17	3,16	12,63	41,75	6,46	0,79	6,46	32,15	2,22	19,03	137,78	-3,12	134,65	0,00	-0,64

21-januar-2014 [11:43]

Output specifications ZEB_B50_AdjustedFromCEESA.txt The EnergyPLAN model 11.2

District Heating Production

Gr.1

	District heating MW	Solar MW	CSHP MW	DHP MW
January	409	44	0	365
February	417	93	0	324
March	363	105	0	258
April	301	153	0	148
May	247	180	0	67
June	139	126	0	14
July	139	126	0	14
August	139	126	0	14
September	187	168	0	19
October	254	135	0	119
November	318	50	0	268
December	369	30	0	340
Average	273	111	0	162
Maximum	678	573	0	678
Minimum	128	0	0	13
Total for the whole year TWh/year	2,40	0,98	0,00	1,42

Gr.2

	District heating MW	Solar MW	CSHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Stor-age MW	Ba-lance MW
January	2348	92	146	663	963	0	409	76	17438	0
February	2393	193	146	426	990	0	504	132	17569	2
March	2097	219	146	478	896	0	271	75	15160	11
April	1758	341	146	421	722	0	106	45	12634	-24
May	1464	359	146	372	553	0	4	2	18235	27
June	877	327	146	193	226	0	1	1	16829	-17
July	877	372	146	227	129	0	0	1	15765	3
August	877	345	146	203	191	0	1	1	18322	-10
September	1137	261	146	350	391	0	1	2	17279	-14
October	1503	163	146	266	817	0	28	72	17228	11
November	1850	104	146	378	870	0	205	142	17637	4
December	2132	62	146	698	855	0	302	64	18626	5
Average	1607	237	146	390	633	0	152	51	16899	0
Maximum	3815	2361	146	1241	1050	0	2072	400	32742	851
Minimum	817	0	146	0	8	0	0	0	0	-897
Total for the whole year TWh/year	14,12	2,08	1,28	3,43	5,56	0,00	1,33	0,45		0,00

Gr.3

	District heating MW	Solar MW	CSHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Stor-age MW	Ba-lance MW
January	3315	40	1161	607	1444	0	50	18	3097	-4
February	3366	85	1161	393	1608	0	85	30	5104	5
March	2926	96	1161	441	1220	0	7	2	4571	0
April	2411	149	1160	314	796	0	5	1	7731	-14
May	1958	157	1150	216	439	0	0	0	9797	-4
June	1120	139	1037	1	14	0	0	0	9644	-70
July	1108	159	1024	1	12	0	0	0	9649	-87
August	1110	143	1030	1	13	0	0	0	9649	-78
September	1493	114	1134	110	150	0	0	0	9649	-15
October	2041	71	1160	151	656	0	0	1	9667	2
November	2571	45	1161	297	1057	0	5	3	6416	1
December	2997	27	1161	615	1145	0	37	3	2500	9
Average	2198	102	1125	262	710	0	16	5	7290	-21
Maximum	5363	1275	1161	1292	2100	0	1468	200	10000	1074
Minimum	1019	0	910	0	11	0	0	0	0	-973
Total for the whole year TWh/year	19,31	0,90	9,88	2,30	6,24	0,00	0,14	0,04		-0,19

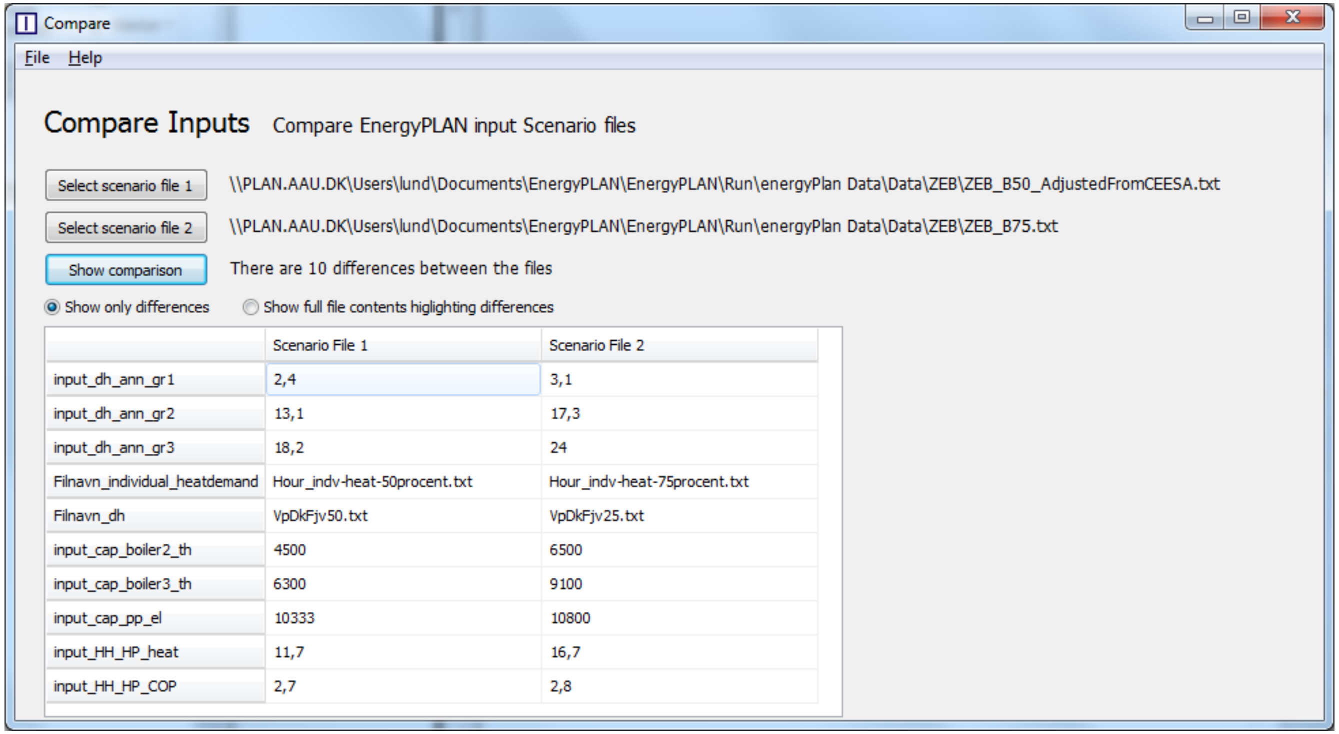
RES specification

	RES1 Wind MW	RES2 Offshoi MW	RES3 Photo ' MW	RES4 Wave I MW	Total er MW
January	1303	4348	168	88	5908
February	1841	5637	495	166	8139
March	1509	4962	716	119	7306
April	1271	4432	1093	58	6853
May	1270	4372	1631	53	7327
June	1356	4782	1260	48	7446
July	918	3345	1436	48	5747
August	1267	4289	654	65	6275
September	1265	4382	678	87	6412
October	2013	6214	439	128	8794
November	1930	5944	177	128	8178
December	1332	4408	73	99	5913
Average	1437	4753	736	90	7017
Maximum	4454	10173	5000	300	18479
Minimum	0	0	0	1	29
Total for the whole year TWh/year	12,63	41,75	6,46	0,79	61,63

ANNUAL COSTS (Million DKK)		
Total Fuel -		15080
Uranium -	0	
Coal -	0	
FuelOil -	0	
Gasoil/Diesel-	0	
Petrol/JP -	3380	
Ngas -	688	
Biomass -	11012	
Food income -	0	
Waste -	0	
Marginal operation costs -		242
Total Electricity exchange -		0
Import -	0	
Export -	0	
Bottleneck -	0	
Fixed imp/ex-	0	
Total CO2 emission costs -		0
Total Ngas Exchange costs -		0
Total variable costs -		15323
Fixed operation costs -		37269
Annual investment costs -		102051
TOTAL ANNUAL COSTS -		154643

	DHP & Boilers MW	CHP2 CHP3 MW	PP CAES MW	Indi-vidual MW	Trans port MW	Indu. Var. MW	Demand Sum MW	Bio-gas MW	Syn-gas MW	CO2Hy gas MW	SynHy gas MW	SynHy gas MW	Stor-age MW	Sum MW	Im-port MW	Ex-port MW
January	233	3748	625	0	0	0	4605	895	2406	1308	1814	-3660	1843	0	0	0
February	307	2420	324	0	0	0	3051	895	1865	1808	1814	-3660	329	0	0	0
March	127	2714	305	0	0	0	3146	895	1978	1618	1814	-3660	502	0	0	0
April	53	2148	268	0	0	0	2470	895	1809	1572	1814	-3660	40	0	0	0
May	4	1702	238	0	0	0	1944	895	1607	1763	1814	-3660	-474	0	0	0
June	1	524	152	0	0	0	676	895	893	1794	1814	-3660	-1059	0	0	0
July	1	615	638	0	0	0	1253	895	1448	1298	1814	-3660	-540	0	0	0
August	1	554	683	0	0	0	1238	895	1385	1408	1814	-3660	-604	0	0	0
September	1	1302	499	0	0	0	1802	895	1693	1496	1814	-3660	-435	0	0	0
October	15	1208	194	0	0	0	1417	895	1207	2119	1814	-3660	-957	0	0	0
November	98	1979	228	0	0	0	2305	895	1611	1872	1814	-3660	-227	0	0	0
December	174	3873	577	0	0	0	4623	895	2565	1460	1814	-3660	1550	0	0	0
Average	84	1901	396	0	0	0	2380	895	1707	1625	1814	-3660	0	0	0	0
Maximum	2422	7520	6563	0	0	0	11514	895	3522	3703	1814	-3660	8944	0	0	0
Minimum	0	0	0	0	0	0	0	895	229	0	1814	-3660	-2980	0	0	0
Total for the whole year TWh/year	0,74	16,69	3,47	0,00	0,00	0,00	20,91	7,86	14,99	14,27	15,93	-32,15	0,00	0,00	0,00	0,00

RES Share: 100,0 Percent of Primary Energy 89,5 Percent of Electricity 62,5 TWh electricity from RES 21-januar-2014 [11:43]


Compare
File Help
Compare Inputs Compare EnergyPLAN input Scenario files
Select scenario file 1
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B50_AdjustedFromCEESA.txt
Select scenario file 2
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B75.txt
Show comparison
There are 10 differences between the files
Show only differences
Show full file contents higlighting differences
Scenario File 1
Scenario File 2
input_dh_ann_gr1 2,4 3,1
input_dh_ann_gr2 13,1 17,3
input_dh_ann_gr3 18,2 24
Filnavn_individual_heatdemand Hour_indv-heat-50procent.txt Hour_indv-heat-75procent.txt
Filnavn_dh VpDkFjv50.txt VpDkFjv25.txt
input_cap_boiler2_th 4500 6500
input_cap_boiler3_th 6300 9100
input_cap_pp_el 10333 10800
input_HH_HP_heat 11,7 16,7
input_HH_HP_COP 2,7 2,8

Input ZEB_B75.txt

The EnergyPLAN model 11.2

Electricity demand (TWh/year):			
Fixed demand	21,80	Flexible demand	4,07
Electric heating + HP	5,13	Fixed imp/exp.	0,00
Electric cooling	0,00	Transportation	8,22
		Total	39,22

District heating (TWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	3,10	17,30	24,00	44,40
Solar Thermal	0,99	2,08	0,91	3,97
Industrial CHP (CSHP)	0,00	0,00	2,65	2,65
Demand after solar and CSHP	2,11	15,22	20,44	37,78

Wind	4454	MW	12,63	TWh/year	0,00	Grid
Offshore Wind	10173	MW	41,75	TWh/year	0,00	stabili-
Photo Voltaic	5000	MW	6,46	TWh/year	0,00	sation
Wave Power	300	MW	0,79	TWh/year	0,00	share
Hydro Power	0	MW	0	TWh/year		
Geothermal/Nuclear	0	MW	0	TWh/year		

	Capacities MW-e	Capacities MJ/s	Efficiencies elec.	Efficiencies Ther	COP
Group 2:					
CHP	1945	1241	0,58	0,37	
Heat Pump	300	1050			3,50
Boiler		6500		0,95	
Group 3:					
CHP	2500	1292	0,60	0,31	
Heat Pump	600	2100			3,50
Boiler		9100		0,95	
Condensing	10800		0,60		

Heatstorage: gr.2: 40 GWh gr.3: 10 GWh
Fixed Boiler: gr.2: 0,5 Per cent gr.3: 0,5 Per cent

Electricity prod. from	CSHP	Waste (TWh/year)
Gr.1:	0,00	0,00
Gr.2:	0,00	0,39
Gr.3:	0,89	0,72

Regulation Strategy:	Technical regulation no. 3	
KEOL regulation	23458000	
Minimum Stabilisation share	0,00	
Stabilisation share of CHP	0,00	
Minimum CHP gr 3 load	0	MW
Minimum PP	0	MW
Heat Pump maximum share	0,50	
Maximum import/export	0	MW
Distr. Name :	Price_DKV_2008.txt	
Addition factor	100,00	DKK/MWh
Multiplication factor	1,05	
Dependency factor	0,02	DKK/MWh pr. MW
Average Market Price	541	DKK/MWh
Gas Storage	6000	GWh
Syngas capacity	3522	MW
Biogas max to grid	895	MW

Fuel Price level:

	Capacities MW-e	Storage GWh	Efficiencies elec.	Efficiencies Ther.
Hydro Pump:	0	0	0,85	
Hydro Turbine:	0		0,85	
Electrol. Gr.2:	0	0	0,00	0,00
Electrol. Gr.3:	0	0	0,00	0,00
Electrol. trans.:	1909	477	0,73	
Ely. MicroCHP:	0	0	0,00	
CAES fuel ratio:		0,000		

(TWh/year)	Coal	Oil	Ngas	Biomass
Transport	0,00	0,00	0,00	0,00
Household	0,00	0,00	0,00	2,44
Industry	0,00	0,00	0,00	19,03
Various	0,00	0,00	0,00	0,00

Output WARNING!!: (1) Critical Excess;

	District Heating										Electricity														Balance					Exchange	
	Demand	Production									Consumption						Production													Payment	
	Distr. heating MW	Solar MW	Waste+ CSHP MW	DHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Ba-lance MW	Elec. demand MW	Flex.& Transp. MW	HP MW	Elec-trolyser MW	EH MW	Hydro Pump MW	Tur-bine MW	RES MW	Hy-dro MW	Geo-thermal MW	Waste+ CSHP MW	CHP MW	PP MW	Stab-Load %	Imp MW	Exp MW	CEEP MW	EEP MW	Imp Million DKK	Exp Million DKK
January	8319	176	1307	514	1354	3026	0	1847	97	-1	2787	1398	1969	2646	97	0	0	5908	0	0	200	2372	424	100	0	6	6	0	0	0
February	8487	371	1307	477	897	3071	0	2168	199	-2	2759	1399	1988	3763	199	0	0	8139	0	0	200	1572	245	100	0	48	48	0	0	0
March	7284	420	1307	383	1038	2855	0	1169	107	6	2661	1422	1748	3496	107	0	0	7306	0	0	200	1810	227	100	0	110	110	0	0	0
April	5897	650	1307	235	892	2298	0	476	62	-23	2361	1388	1307	3571	62	0	0	6853	0	0	200	1550	195	100	0	110	110	0	0	0
May	4688	693	1305	137	753	1663	0	66	31	39	2307	1388	933	3982	31	0	0	7327	0	0	201	1302	169	100	0	357	357	0	0	0
June	2343	606	1240	15	232	330	0	2	2	-84	2246	1416	221	3910	2	0	0	7446	0	0	208	366	90	100	0	315	315	0	0	0
July	2331	674	1230	15	287	184	0	0	1	-60	2060	1407	149	2824	1	0	0	5747	0	0	209	454	368	100	0	337	337	0	0	0
August	2333	627	1233	15	260	262	0	1	1	-67	2349	1388	191	3095	1	0	0	6275	0	0	208	412	375	100	0	247	247	0	0	0
September	3380	575	1297	22	653	843	0	2	2	-14	2407	1413	524	3463	2	0	0	6412	0	0	201	1101	247	100	0	152	152	0	0	0
October	4868	322	1306	235	504	2112	0	228	120	39	2492	1407	1144	4553	120	0	0	8794	0	0	200	864	135	100	0	277	277	0	0	0
November	6290	199	1307	370	785	2651	0	792	184	3	2682	1400	1543	4016	184	0	0	8178	0	0	200	1365	151	100	0	70	70	0	0	0
December	7445	118	1307	468	1436	2749	0	1282	82	4	2683	1378	1750	3071	82	0	0	5913	0	0	200	2508	371	100	0	28	28	0	0	0
Average	5297	452	1288	240	758	1833	0	665	73	-13	2482	1400	1120	3529	73	0	0	7017	0	0	202	1307	251	100	0	172	172	0	Average price	
Maximum	14136	4513	1307	963	2532	3150	0	6691	600	1901	3754	7963	2971	7539	600	0	0	18479	0	0	228	4445	3101	100	0	6347	6347	0	(DKK/MWh)	
Minimum	2082	0	1056	13	0	25	0	0	0	-2372	1312	-246	7	0	0	0	0	29	0	0	200	0	0	100	0	0	0	0	94	0
TWh/year	46,53	3,97	11,31	2,11	6,66	16,10	0,00	5,84	0,65	-0,12	21,80	12,30	9,84	31,00	0,65	0,00	0,00	61,63	0,00	0,00	1,78	11,48	2,20		0,00	1,51	1,51	0,00	0	0

FUEL BALANCE (TWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon-version	Synthetic Fuel	Wind	Offsh.	PV	Wave	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Imp/Exp Corrected Netto	CO2 emission (Mt): Total	CO2 emission (Mt): Netto
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
N.Gas	0,77	10,33	9,15	3,46	1,86	3,67	-	-	-	-	-22,85	2,48	-	-	-	-	-	-	-	-	8,86	-2,52	6,34	1,82	1,30
Biomass	1,46	-	-	0,86	-	-	-	-	4,16	-	38,87	-	-	-	-	-	-	-	2,22	19,03	66,60	0,00	66,60	0,00	0,00
Renewable	-	-	-	-	-	-	-	-	3,33	-	-	-	12,63	41,75	6,46	0,79	6,48	-	-	-	71,44	0,00	71,44	0,00	0,00
H2 etc.	-	0,00	0,00	0,00	0,00	0,00	-	-	-	-21,90	-10,85	32,74	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-32,15	-	-	-	-	-	32,15	-	-	0,00	0,00	0,00	0,00	0,00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Total	2,23	10,33	9,15	4,32	1,86	3,67	-	-	7,49	-21,90	5,17	3,08	12,63	41,75	6,46	0,79	6,48	32,15	2,22	19,03	146,91	-2,52	144,39	1,82	1,30

22-januar-2014 [16:20]

Output specifications ZEB_B75.txt The EnergyPLAN model 11.2

District Heating Production

	Gr.1 District heating MW	Gr.1 Solar MW	Gr.1 CSHP MW	Gr.1 DHP MW	Gr.2 District heating MW	Gr.2 Solar MW	Gr.2 CSHP MW	Gr.2 CHP MW	Gr.2 HP MW	Gr.2 ELT MW	Gr.2 Boiler MW	Gr.2 EH MW	Gr.2 Storage MW	Gr.2 Balance MW
January	558	44	0	514	3229	92	146	678	1047	0	1201	67	19424	0
February	570	93	0	477	3299	193	146	447	1042	0	1337	133	19445	0
March	488	105	0	383	2841	219	146	540	1023	0	838	73	18611	4
April	395	159	0	235	2318	341	146	481	903	0	411	46	17032	-10
May	313	176	0	137	1864	359	146	424	813	0	64	29	19852	29
June	151	136	0	15	959	328	146	222	291	0	2	2	23995	-31
July	151	136	0	15	959	374	146	275	160	0	0	1	23232	3
August	151	136	0	15	959	345	146	246	234	0	1	1	26150	-14
September	223	200	0	22	1359	261	146	442	517	0	2	2	24672	-10
October	324	89	0	235	1923	163	146	306	943	0	223	112	13049	31
November	420	50	0	370	2459	104	146	422	990	0	660	131	11853	6
December	498	30	0	468	2895	62	146	736	1022	0	873	56	12004	0
Average	353	113	0	240	2086	237	146	435	748	0	465	54	19105	1
Maximum	963	765	0	963	5491	2731	146	1241	1050	0	3434	400	40000	1237
Minimum	134	0	0	13	864	0	146	0	10	0	0	0	0	-973
Total for the whole year TWh/year	3,10	0,99	0,00	2,11	18,32	2,08	1,28	3,82	6,57	0,00	4,08	0,48		0,01

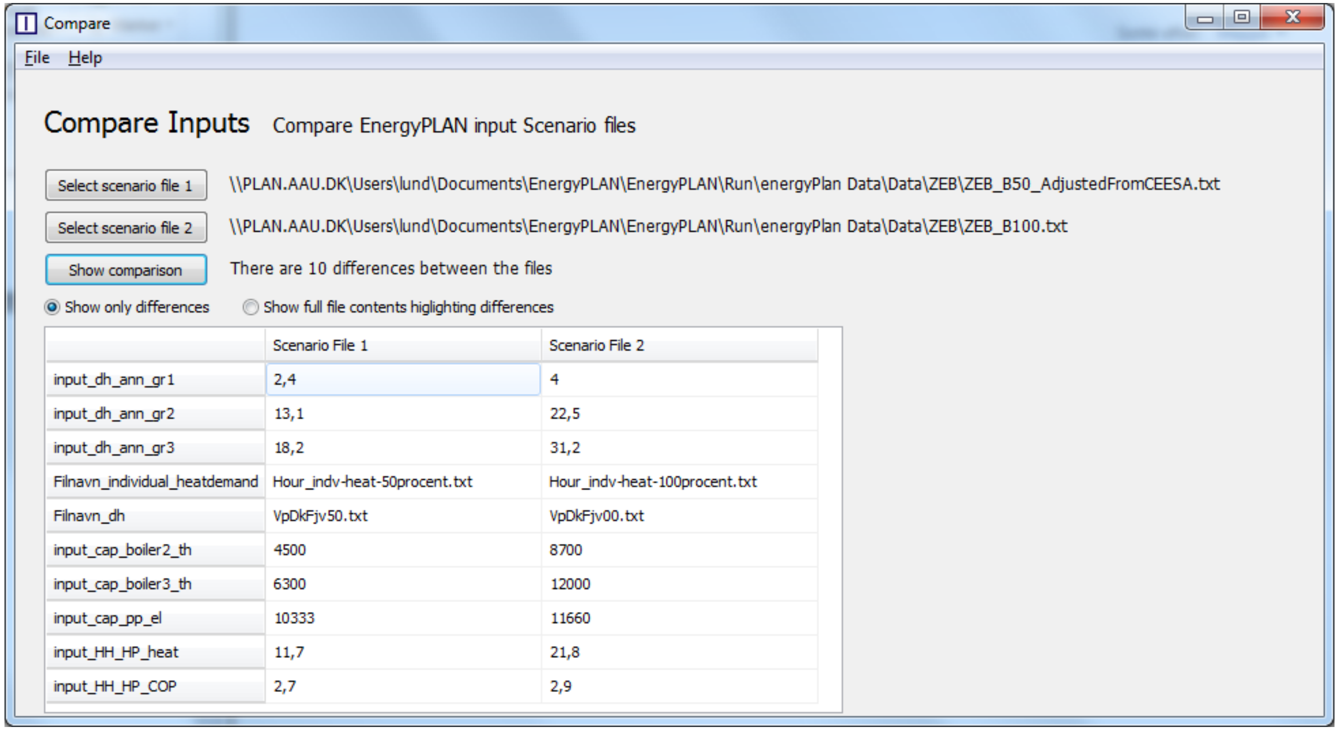
	Gr.3 District heating MW	Gr.3 Solar MW	Gr.3 CSHP MW	Gr.3 CHP MW	Gr.3 HP MW	Gr.3 ELT MW	Gr.3 Boiler MW	Gr.3 EH MW	Gr.3 Storage MW	Gr.3 Balance MW	RES specification RES1 Wind MW	RES2 Offshoi MW	RES3 Photo ' MW	RES4 Wave I MW	Total er MW
January	4532	40	1161	676	1979	0	646	31	2058	-1	1303	4348	168	88	5908
February	4618	85	1161	450	2029	0	831	65	7222	-2	1841	5637	495	166	8139
March	3955	96	1161	498	1832	0	331	35	3971	2	1509	4962	716	119	7306
April	3184	149	1161	412	1395	0	65	15	4499	-13	1271	4432	1093	58	6853
May	2510	157	1160	330	850	0	2	1	7900	10	1270	4372	1631	53	7327
June	1232	142	1094	9	40	0	0	0	5674	-53	1356	4782	1260	48	7446
July	1221	164	1085	12	24	0	0	0	5800	-63	918	3345	1436	48	5747
August	1222	146	1087	14	28	0	0	0	5800	-53	1267	4289	654	65	6275
September	1798	114	1151	211	326	0	0	0	5881	-4	1265	4382	678	87	6412
October	2621	71	1161	199	1170	0	5	7	6001	8	2013	6214	439	128	8794
November	3412	45	1161	364	1661	0	132	53	4828	-4	1930	5944	177	128	8178
December	4052	27	1161	699	1726	0	408	26	3558	4	1332	4408	73	99	5913
Average	2859	103	1142	323	1086	0	200	19	5256	-14	1437	4753	736	90	7017
Maximum	7682	1275	1161	1292	2100	0	3423	200	10000	1147	4454	10173	5000	300	18479
Minimum	1083	0	910	0	14	0	0	0	0	-1585	0	0	0	1	29
Total for the whole year TWh/year	25,11	0,90	10,03	2,84	9,54	0,00	1,76	0,17		-0,12	12,63	41,75	6,46	0,79	61,63

ANNUAL COSTS (Million DKK)

Total Fuel -		15389
Uranium -	0	
Coal -	0	
FuelOil -	0	
Gasoil/Diesel-	0	
Petrol/JP -	3380	
Ngas -	997	
Biomass -	11012	
Food income -	0	
Waste -	0	
Marginal operation costs -		286
Total Electricity exchange -		0
Import -	0	
Export -	0	
Bottleneck -	0	
Fixed imp/ex-	0	
Total CO2 emission costs -		469
Total Ngas Exchange costs -		2499
Total variable costs -		18643
Fixed operation costs -		37831
Annual Investment costs -		105807
TOTAL ANNUAL COSTS -		162281

	DHP & Boilers MW	CHP2 CHP3 MW	PP CAES MW	Individual MW	Trans port MW	Indu. Var. MW	Demand Sum MW	Bio-gas MW	Syn-gas MW	CO2Hy gas MW	SynHy gas MW	SynHy gas MW	Stor-age MW	Sum MW	Im-port MW	Ex-port MW
January	1886	4014	706	0	0	0	6607	895	2908	1132	1814	-3660	2510	1009	1009	0
February	2184	2660	409	0	0	0	5252	895	2556	1653	1814	-3660	986	1009	1009	0
March	1199	3066	379	0	0	0	4643	895	2356	1508	1814	-3660	721	1009	1009	0
April	502	2627	326	0	0	0	3455	895	1814	1513	1814	-3660	71	1009	1009	0
May	107	2208	281	0	0	0	2596	895	1472	1748	1814	-3660	-682	1009	1009	0
June	7	631	150	0	0	0	787	895	480	1797	1814	-3660	-1548	1009	1009	0
July	6	781	614	0	0	0	1401	895	906	1333	1814	-3660	-895	1009	1009	0
August	6	709	626	0	0	0	1341	895	893	1419	1814	-3660	-1027	1009	1009	0
September	10	1874	411	0	0	0	2295	895	1483	1545	1814	-3660	-790	1009	1009	0
October	280	1467	225	0	0	0	1972	895	1034	2039	1814	-3660	-1159	1009	1009	0
November	833	2313	252	0	0	0	3397	895	1684	1751	1814	-3660	-95	1009	1009	0
December	1341	4246	619	0	0	0	6206	895	2907	1345	1814	-3660	1896	1009	1009	0
Average	693	2218	418	0	0	0	3328	895	1707	1564	1814	-3660	0	1009	1009	0
Maximum	6658	7520	5168	0	0	0	17977	895	3522	3703	1814	-3660	14398	1009	1009	0
Minimum	5	0	0	0	0	0	5	895	0	0	1814	-3660	-3756	1009	1009	0
Total for the whole year TWh/year	6,08	19,48	3,67	0,00	0,00	0,00	29,24	7,86	14,99	13,74	15,93	-32,15	0,00	8,86	8,86	0,00

RES Share: 94,0 Percent of Primary Energy 236,8 Percent of Electricity 62,5 TWh electricity from RES 22-januar-2014 [16:20]


Compare
File Help
Compare Inputs
Compare EnergyPLAN input Scenario files
Select scenario file 1
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B50_AdjustedFromCEESA.txt
Select scenario file 2
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B100.txt
Show comparison
There are 10 differences between the files
Show only differences
Show full file contents higlighting differences
Scenario File 1
Scenario File 2
input_dh_ann_gr1 2,4 4
input_dh_ann_gr2 13,1 22,5
input_dh_ann_gr3 18,2 31,2
Filnavn_individual_heatdemand Hour_indv-heat-50procent.txt Hour_indv-heat-100procent.txt
Filnavn_dh VpDkFjv50.txt VpDkFjv00.txt
input_cap_boiler2_th 4500 8700
input_cap_boiler3_th 6300 12000
input_cap_pp_el 10333 11660
input_HH_HP_heat 11,7 21,8
input_HH_HP_COP 2,7 2,9

Input ZEB_B100.txt

The EnergyPLAN model 11.2

Electricity demand (TWh/year):		Flexible demand	4,07
Fixed demand	21,80	Fixed imp/exp.	0,00
Electric heating + HP	6,71	Transportation	8,22
Electric cooling	0,00	Total	40,80

District heating (TWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	4,00	22,50	31,20	57,70
Solar Thermal	1,00	2,08	0,91	3,99
Industrial CHP (CSHP)	0,00	0,00	2,65	2,65
Demand after solar and CSHP	3,00	20,42	27,64	51,06

Wind	4454	MW	12,63	TWh/year	0,00	Grid
Offshore Wind	10173	MW	41,75	TWh/year	0,00	stabili-
Photo Voltaic	5000	MW	6,46	TWh/year	0,00	sation
Wave Power	300	MW	0,79	TWh/year	0,00	share
Hydro Power	0	MW	0	TWh/year		
Geothermal/Nuclear	0	MW	0	TWh/year		

	Capacities		Efficiencies		
Group 2:	MW-e	MJ/s	elec.	Ther	COP
CHP	1945	1241	0,58	0,37	
Heat Pump	300	1050			3,50
Boiler		8700		0,95	
Group 3:					
CHP	2500	1292	0,60	0,31	
Heat Pump	600	2100			3,50
Boiler		12000		0,95	
Condensing	11660		0,60		

Heatstorage: gr.2: 40 GWh gr.3: 10 GWh
Fixed Boiler: gr.2: 0,5 Per cent gr.3: 0,5 Per cent

Electricity prod. from	CSHP	Waste (TWh/year)
Gr.1:	0,00	0,00
Gr.2:	0,00	0,39
Gr.3:	0,89	0,72

Regulation Strategy:	Technical regulation no. 3	
KEOL regulation	23458000	
Minimum Stabilisation share	0,00	
Stabilisation share of CHP	0,00	
Minimum CHP gr 3 load	0	MW
Minimum PP	0	MW
Heat Pump maximum share	0,50	
Maximum import/export	0	MW

Distr. Name :	Price_DKV_2008.txt	
Addition factor	100,00	DKK/MWh
Multiplication factor	1,05	
Dependency factor	0,02	DKK/MWh pr. MW
Average Market Price	541	DKK/MWh
Gas Storage	6000	GWh
Syngas capacity	3522	MW
Biogas max to grid	895	MW

Fuel Price level:

	Capacities	Storage	Efficiencies	
	MW-e	GWh	elec.	Ther.
Hydro Pump:	0	0	0,85	
Hydro Turbine:	0		0,85	
Electrol. Gr.2:	0	0	0,00	0,00
Electrol. Gr.3:	0	0	0,00	0,00
Electrol. trans.:	1909	477	0,73	
Ely. MicroCHP:	0	0	0,00	
CAES fuel ratio:		0,000		

(TWh/year)	Coal	Oil	Ngas	Biomass
Transport	0,00	0,00	0,00	0,00
Household	0,00	0,00	0,00	2,44
Industry	0,00	0,00	0,00	19,03
Various	0,00	0,00	0,00	0,00

Output WARNING!!: (1) Critical Excess;

District Heating

	Demand	Production								Ba- lance
	Distr. heating MW	Solar MW	Waste+ CSHP MW	DHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	MW
January	10900	176	1307	689	1417	3150	0	4081	81	0
February	11133	371	1307	657	950	3150	0	4509	190	0
March	9504	420	1307	534	1108	3125	0	2909	103	0
April	7629	654	1307	349	999	2805	0	1453	77	-13
May	5994	691	1307	228	863	2376	0	411	80	39
June	2804	629	1277	25	352	570	0	5	6	-60
July	2792	702	1270	24	494	324	0	1	2	-25
August	2794	654	1273	18	427	460	0	2	2	-43
September	4220	519	1306	135	833	1327	0	59	49	-8
October	6233	315	1307	335	579	2687	0	772	198	40
November	8153	199	1307	496	849	3018	0	2114	179	-9
December	9715	118	1307	622	1508	3094	0	2989	73	3
Average	6811	454	1298	342	866	2171	0	1600	86	-6
Maximum	18801	4700	1307	1280	2532	3150	0	10532	600	1245
Minimum	2461	0	1056	16	0	32	0	0	0	-2243
TWh/year	59,83	3,99	11,40	3,00	7,60	19,07	0,00	14,06	0,76	-0,05

Electricity

	Consumption						Production						
	Elec. demand MW	Flex.& Transp. MW	HP MW	Elec- trolyser MW	EH MW	Hydro Pump MW	Tur- bine MW	RES MW	Hy- dro MW	Geo- thermal MW	Waste+ CSHP MW	CHP MW	PP MW
January	2787	1398	2356	2462	81	0	0	5908	0	0	200	2487	493
February	2759	1399	2385	3533	190	0	0	8139	0	0	200	1667	287
March	2661	1422	2132	3314	103	0	0	7306	0	0	200	1944	262
April	2361	1385	1666	3459	77	0	0	6853	0	0	200	1742	228
May	2307	1391	1272	3882	80	0	0	7327	0	0	200	1496	198
June	2246	1415	293	4056	6	0	0	7446	0	0	204	578	88
July	2060	1406	185	3101	2	0	0	5747	0	0	204	816	314
August	2349	1385	244	3249	2	0	0	6275	0	0	204	704	281
September	2407	1413	721	3550	49	0	0	6412	0	0	201	1430	214
October	2492	1407	1460	4390	198	0	0	8794	0	0	200	996	154
November	2682	1400	1886	3833	179	0	0	8178	0	0	200	1485	166
December	2683	1378	2161	2849	73	0	0	5913	0	0	200	2644	405
Average	2482	1400	1394	3470	86	0	0	7017	0	0	201	1500	258
Maximum	3754	7820	3692	7520	600	0	0	18479	0	0	228	4445	3283
Minimum	1312	-246	9	0	0	0	0	29	0	0	200	0	0
TWh/year	21,80	12,30	12,25	30,48	0,76	0,00	0,00	61,63	0,00	0,00	1,77	13,18	2,27

	Balance					Exchange	
	Stab- Load %	Imp MW	Exp MW	CEEP MW	EEP MW	Payment Imp Million DKK	Exp
January	100	0	3	3	0	0	0
February	100	0	28	28	0	0	0
March	100	0	82	82	0	0	0
April	100	0	76	76	0	0	0
May	100	0	290	290	0	0	0
June	100	0	299	299	0	0	0
July	100	0	328	328	0	0	0
August	100	0	235	235	0	0	0
September	100	0	117	117	0	0	0
October	100	0	196	196	0	0	0
November	100	0	50	50	0	0	0
December	100	0	18	18	0	0	0
Average	100	0	144	144	0	Average price	
Maximum	100	0	6202	6202	0	(DKK/MWh)	
Minimum	100	0	0	0	0	64	0
TWh/year		0,00	1,27	1,27	0,00	0	0

FUEL BALANCE (TWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon- version	Synthetic Fuel	Wind	Offsh.	PV	Wave	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Netto	CO2 emission (Mt): Total	Netto
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
N.Gas	1,71	11,29	11,06	7,82	6,17	3,78	-	-	-	-	-22,85	2,80	-	-	-	-	-	-	-	-	21,78	-2,11	19,66	4,47	4,04
Biomass	1,46	-	-	0,86	-	-	-	-	4,16	-	38,87	-	-	-	-	-	-	-	2,22	19,03	66,60	0,00	66,60	0,00	0,00
Renewable	-	-	-	-	-	-	-	-	3,48	-	-	-	12,63	41,75	6,46	0,79	6,49	-	-	-	71,60	0,00	71,60	0,00	0,00
H2 etc.	-	0,00	0,00	0,00	0,00	0,00	-	-	-	-21,54	-10,85	32,38	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-32,15	-	-	-	-	-	32,15	-	-	0,00	0,00	0,00	0,00	0,00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Total	3,17	11,29	11,06	8,68	6,17	3,78	-	-	7,64	-21,54	5,17	3,03	12,63	41,75	6,46	0,79	6,49	32,15	2,22	19,03	159,98	-2,11	157,87	4,47	4,04

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Output specifications ZEB_B100.txt — The EnergyPLAN model 11.2

District Heating Production

	Gr.1 District heating MW	Gr.1 Solar MW	Gr.1 CSHP MW	Gr.1 DHP MW	Gr.2 District heating MW	Gr.2 Solar MW	Gr.2 CSHP MW	Gr.2 CHP MW	Gr.2 HP MW	Gr.2 ELT MW	Gr.2 Boiler MW	Gr.2 EH MW	Gr.2 Stor-age MW	Gr.2 Ba-lance MW
January	733	44	0	689	4238	92	146	694	1050	0	2201	55	19927	0
February	750	93	0	657	4333	193	146	465	1050	0	2351	129	19927	0
March	639	105	0	534	3709	219	146	545	1040	0	1689	70	19863	0
April	512	163	0	349	2995	341	146	520	1008	0	934	50	19168	-4
May	402	174	0	228	2375	359	146	472	965	0	337	65	18249	30
June	182	157	0	25	1140	329	146	281	401	0	5	6	19604	-28
July	182	158	0	24	1140	377	146	382	230	0	1	2	18542	3
August	182	164	0	18	1140	343	146	332	338	0	2	2	22174	-23
September	279	145	0	135	1688	261	146	494	689	0	57	48	20932	-8
October	416	81	0	335	2457	163	146	338	1014	0	616	154	19802	27
November	546	50	0	496	3187	104	146	432	1040	0	1342	122	19428	1
December	652	30	0	622	3783	62	146	745	1045	0	1736	49	19391	0
Average	455	114	0	342	2678	237	146	475	822	0	935	62	19749	0
Maximum	1280	1016	0	1280	7315	2805	146	1241	1050	0	4878	400	40000	883
Minimum	159	0	0	16	1013	0	146	0	13	0	0	0	0	-933
Total for the whole year TWh/year	4,00	1,00	0,00	3,00	23,52	2,08	1,28	4,18	7,22	0,00	8,22	0,55		0,00

	Gr.3 District heating MW	Gr.3 Solar MW	Gr.3 CSHP MW	Gr.3 CHP MW	Gr.3 HP MW	Gr.3 ELT MW	Gr.3 Boiler MW	Gr.3 EH MW	Gr.3 Stor-age MW	Gr.3 Ba-lance MW	RES specification RES1 Wind MW	RES2 Offshoi MW	RES3 Photo ' MW	RES4 Wave I MW	Total er MW
January	5930	40	1161	723	2100	0	1880	25	0	0	1303	4348	168	88	5908
February	6050	85	1161	485	2100	0	2158	62	144	0	1841	5637	495	166	8139
March	5156	96	1161	563	2084	0	1220	33	270	0	1509	4962	716	119	7306
April	4122	149	1161	479	1797	0	518	27	1240	-9	1271	4432	1093	58	6853
May	3218	157	1161	391	1411	0	74	15	4504	8	1270	4372	1631	53	7327
June	1482	144	1131	71	168	0	0	0	9825	-32	1356	4782	1260	48	7446
July	1470	167	1124	113	94	0	0	0	10000	-28	918	3345	1436	48	5747
August	1472	148	1127	95	122	0	0	0	10000	-20	1267	4289	654	65	6275
September	2253	114	1160	339	638	0	2	1	8956	0	1265	4382	678	87	6412
October	3360	71	1161	241	1674	0	156	45	5546	13	2013	6214	439	128	8794
November	4420	45	1161	417	1978	0	771	57	4507	-10	1930	5944	177	128	8178
December	5280	27	1161	763	2049	0	1253	24	4776	3	1332	4408	73	99	5913
Average	3678	104	1152	390	1349	0	665	24	4995	-6	1437	4753	736	90	7017
Maximum	10206	1275	1161	1292	2100	0	5654	200	10000	952	4454	10173	5000	300	18479
Minimum	1289	0	910	0	18	0	0	0	0	-1553	0	0	0	1	29
Total for the whole year TWh/year	32,31	0,91	10,12	3,43	11,85	0,00	5,84	0,21		-0,05	12,63	41,75	6,46	0,79	61,63

ANNUAL COSTS (Million DKK)

Total Fuel -		15819
Uranium -	0	
Coal -	0	
FuelOil -	0	
Gasoil/Diesel-	0	
Petrol/JP -	3380	
Ngas -	1426	
Biomass -	11012	
Food income -	0	
Waste -	0	
Marginal operation costs -		333
Total Electricity exchange -		0
Import -	0	
Export -	0	
Bottleneck -	0	
Fixed imp/ex-	0	
Total CO2 emission costs -		1151
Total Ngas Exchange costs -		6138
Total variable costs -		23441
Fixed operation costs -		38507
Annual Investment costs -		109892
TOTAL ANNUAL COSTS -		171840

	DHP & Boilers MW	CHP2 CHP3 MW	PP CAES MW	Indi-vidual MW	Trans port MW	Indu. Var. MW	Demand Sum MW	Bio-gas MW	Syn-gas MW	CO2Hy gas MW	SynHy gas MW	SynHy gas MW	Stor-age MW	Sum MW	Im-port MW	Ex-port MW
January	4476	4207	821	0	0	0	9505	895	3192	1036	1814	-3660	3749	2479	2479	0
February	4894	2820	479	0	0	0	8193	895	2946	1538	1814	-3660	1407	3254	3254	0
March	3202	3289	437	0	0	0	6928	895	2662	1410	1814	-3660	-51	3859	3859	0
April	1636	2951	380	0	0	0	4967	895	1959	1468	1814	-3660	-46	2537	2537	0
May	529	2537	331	0	0	0	3396	895	1324	1695	1814	-3660	-1150	2479	2479	0
June	19	988	147	0	0	0	1154	895	269	1844	1814	-3660	-2487	2479	2479	0
July	14	1395	523	0	0	0	1932	895	514	1453	1814	-3660	-1563	2479	2479	0
August	12	1203	469	0	0	0	1683	895	485	1489	1814	-3660	-1818	2479	2479	0
September	133	2429	356	0	0	0	2918	895	1232	1561	1814	-3660	-1066	2142	2231	89
October	943	1690	257	0	0	0	2889	895	952	1950	1814	-3660	0	938	1404	466
November	2377	2513	276	0	0	0	5166	895	1894	1662	1814	-3660	388	2175	2202	27
December	3332	4474	676	0	0	0	8482	895	3086	1246	1814	-3660	2624	2479	2479	0
Average	1789	2543	430	0	0	0	4762	895	1707	1528	1814	-3660	0	2479	2528	49
Maximum	11350	7520	5471	0	0	0	24341	895	3522	3703	1814	-3660	19292	15602	15602	2740
Minimum	9	0	0	0	0	0	9	895	0	0	1814	-3660	-5221	-2740	0	0
Total for the whole year TWh/year	15,71	22,34	3,78	0,00	0,00	0,00	41,83	7,86	14,99	13,42	15,93	-32,15	0,00	21,78	22,21	0,43

RES Share: 86,4 Percent of Primary Energy 87,8 Percent of Electricity 62,5 TWh electricity from RES

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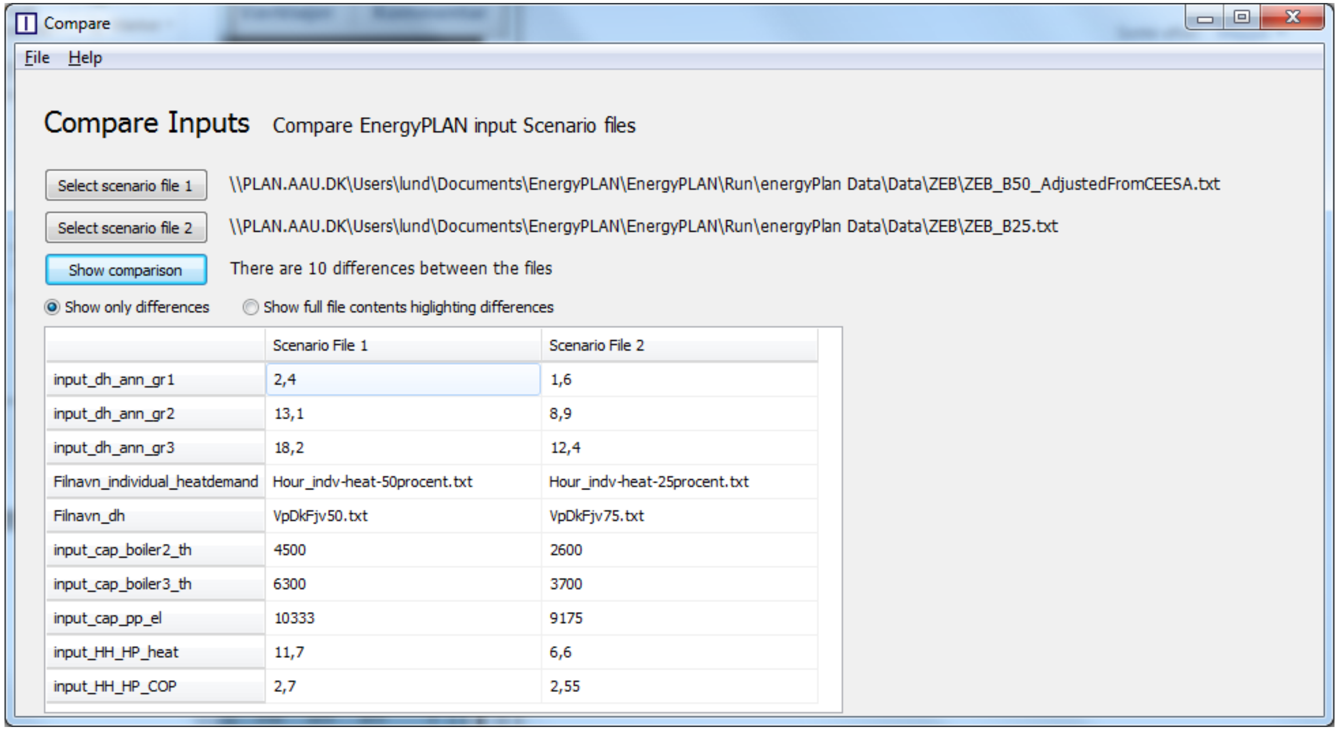
Compare
File Help
Compare Inputs Compare EnergyPLAN input Scenario files
Select scenario file 1
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B50_AdjustedFromCEESA.txt
Select scenario file 2
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B25.txt
Show comparison
There are 10 differences between the files
Show only differences
Show full file contents higlighting differences
Scenario File 1
Scenario File 2
input_dh_ann_gr1 2,4 1,6
input_dh_ann_gr2 13,1 8,9
input_dh_ann_gr3 18,2 12,4
Filnavn_individual_heatdemand Hour_indv-heat-50procent.txt Hour_indv-heat-25procent.txt
Filnavn_dh VpDkFjv50.txt VpDkFjv75.txt
input_cap_boiler2_th 4500 2600
input_cap_boiler3_th 6300 3700
input_cap_pp_el 10333 9175
input_HH_HP_heat 11,7 6,6
input_HH_HP_COP 2,7 2,55

Input ZEB_B25.txt

The EnergyPLAN model 11.2

Electricity demand (TWh/year):		Flexible demand	4,07
Fixed demand	21,80	Fixed imp/exp.	0,00
Electric heating + HP	1,70	Transportation	8,22
Electric cooling	0,00	Total	35,79

District heating (TWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	1,60	8,90	12,40	22,90
Solar Thermal	0,91	2,07	0,88	3,85
Industrial CHP (CSHP)	0,00	0,00	2,65	2,65
Demand after solar and CSHP	0,69	6,83	8,87	16,40

Wind	4454	MW	12,63	TWh/year	0,00	Grid
Offshore Wind	10173	MW	41,75	TWh/year	0,00	stabili-
Photo Voltaic	5000	MW	6,46	TWh/year	0,00	sation
Wave Power	300	MW	0,79	TWh/year	0,00	share
Hydro Power	0	MW	0	TWh/year		
Geothermal/Nuclear	0	MW	0	TWh/year		

	Capacities		Efficiencies		
Group 2:	MW-e	MJ/s	elec.	Ther	COP
CHP	1945	1241	0,58	0,37	
Heat Pump	300	1050			3,50
Boiler		2600		0,95	
Group 3:					
CHP	2500	1292	0,60	0,31	
Heat Pump	600	2100			3,50
Boiler		3700		0,95	
Condensing	9175		0,60		

Heatstorage: gr.2: 40 GWh gr.3: 10 GWh
Fixed Boiler: gr.2: 0,5 Per cent gr.3: 0,5 Per cent

Electricity prod. from	CSHP	Waste (TWh/year)
Gr.1:	0,00	0,00
Gr.2:	0,00	0,39
Gr.3:	0,89	0,72

Regulation Strategy:	Technical regulation no. 3	
KEOL regulation	23458000	
Minimum Stabilisation share	0,00	
Stabilisation share of CHP	0,00	
Minimum CHP gr 3 load	0	MW
Minimum PP	0	MW
Heat Pump maximum share	0,50	
Maximum import/export	0	MW

Distr. Name :	Price_DKV_2008.txt	
Addition factor	100,00	DKK/MWh
Multiplication factor	1,05	
Dependency factor	0,02	DKK/MWh pr. MW
Average Market Price	541	DKK/MWh
Gas Storage	6000	GWh
Syngas capacity	3522	MW
Biogas max to grid	895	MW

Fuel Price level:

	Capacities	Storage	Efficiencies	
	MW-e	GWh	elec.	Ther.
Hydro Pump:	0	0	0,85	
Hydro Turbine:	0		0,85	
Electrol. Gr.2:	0	0	0,00	0,00
Electrol. Gr.3:	0	0	0,00	0,00
Electrol. trans.:	1909	477	0,73	
Ely. MicroCHP:	0	0	0,00	
CAES fuel ratio:		0,000		

(TWh/year)	Coal	Oil	Ngas	Biomass
Transport	0,00	0,00	0,00	0,00
Household	0,00	0,00	0,00	2,44
Industry	0,00	0,00	0,00	19,03
Various	0,00	0,00	0,00	0,00

Output WARNING!!: (1) Critical Excess;

	District Heating: Demand	Production								Balance	Electricity: Consumption					
	Distr. heating MW	Solar MW	Waste+ CSHP MW	DHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Ba-lance MW	Elec. demand MW	Flex.& Transp. MW	HP MW	Elec-trolyser MW	EH MW	Hydro Pump MW
January	3865	176	1307	203	1016	1094	0	31	39	0	2787	1398	706	3219	39	0
February	3910	370	1306	158	634	1385	0	23	38	-4	2759	1399	780	4396	38	0
March	3511	420	1301	120	642	1008	0	3	2	15	2661	1422	610	3809	2	0
April	3041	633	1282	50	419	688	0	1	1	-33	2361	1389	408	3539	1	0
May	2627	670	1263	17	295	409	0	1	1	-28	2307	1391	275	3721	1	0
June	1873	566	1090	12	157	160	0	0	1	-113	2246	1416	131	3903	1	0
July	1861	621	1081	12	166	103	0	0	1	-122	2060	1408	105	2729	1	0
August	1863	586	1085	12	152	150	0	0	1	-122	2349	1389	117	3076	1	0
September	2207	496	1221	14	254	281	0	1	1	-60	2407	1415	193	3177	1	0
October	2705	392	1290	17	264	740	0	1	3	-2	2492	1407	425	4733	3	0
November	3188	216	1303	137	448	1074	0	4	8	-2	2682	1400	607	4306	8	0
December	3576	118	1306	198	945	949	0	26	28	6	2683	1378	633	3231	28	0
Average	2849	439	1236	79	450	667	0	8	10	-39	2482	1401	415	3648	10	0
Maximum	5710	2806	1307	375	2532	2529	0	383	344	846	3754	7797	1434	7639	344	0
Minimum	1778	0	1056	11	0	13	0	0	0	-1065	1312	-268	4	0	0	0
TWh/year	25,03	3,85	10,86	0,69	3,95	5,86	0,00	0,07	0,09	-0,34	21,80	12,31	3,64	32,05	0,09	0,00

	Electricity: Production							Balance					Exchange: Payment	
	Tur-bine MW	RES MW	Hy-dro MW	Geo-thermal MW	Waste+ CSHP MW	CHP MW	PP MW	Stab-Load %	Imp MW	Exp MW	CEEP MW	EEP MW	Imp Million DKK	Exp
January	0	5908	0	0	200	1748	346	100	0	53	53	0	0	0
February	0	8139	0	0	200	1091	168	100	0	226	226	0	0	0
March	0	7306	0	0	201	1096	159	100	0	259	259	0	0	0
April	0	6853	0	0	203	703	160	100	0	220	220	0	0	0
May	0	7327	0	0	205	485	152	100	0	475	475	0	0	0
June	0	7446	0	0	224	246	98	100	0	318	318	0	0	0
July	0	5747	0	0	225	259	410	100	0	339	339	0	0	0
August	0	6275	0	0	225	238	443	100	0	249	249	0	0	0
September	0	6412	0	0	210	402	360	100	0	190	190	0	0	0
October	0	8794	0	0	202	435	108	100	0	480	480	0	0	0
November	0	8178	0	0	201	754	135	100	0	266	266	0	0	0
December	0	5913	0	0	200	1608	354	100	0	121	121	0	0	0
Average	0	7017	0	0	208	756	242	100	0	267	267	0	Average price	
Maximum	0	18479	0	0	228	4445	4101	100	0	6497	6497	0	(DKK/MWh)	
Minimum	0	29	0	0	200	0	0	100	0	0	0	0	91	0
TWh/year	0,00	61,63	0,00	0,00	1,83	6,64	2,13		0,00	2,34	2,34	0,00	0	0

FUEL BALANCE (TWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon-version	Synthetic Fuel	Wind	Offsh.	PV	Wave	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Netto	CO2 emission (Mt): Total	Netto
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
N.Gas	-	7,37	3,95	-	0,00	3,54	-	-	-	-	-22,85	1,85	-	-	-	-	-	-	-	-	-6,15	-3,90	-10,05	-1,26	-2,06
Biomass	0,73	-	-	0,07	-	-	-	-	4,16	-	38,87	-	-	-	-	-	-	-	2,22	19,03	65,09	0,00	65,09	0,00	0,00
Renewable	-	-	-	-	-	-	-	-	2,58	-	-	-	12,63	41,75	6,46	0,79	6,29	-	-	-	70,51	0,00	70,51	0,00	0,00
H2 etc.	-	0,00	0,00	0,00	0,00	0,00	-	-	-	-22,63	-10,85	33,48	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-32,15	-	-	-	-	-	32,15	-	-	0,00	0,00	0,00	0,00	0,00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Total	0,73	7,37	3,95	0,07	0,00	3,54	-	-	6,74	-22,63	5,17	3,17	12,63	41,75	6,46	0,79	6,29	32,15	2,22	19,03	129,45	-3,90	125,55	-1,26	-2,06

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Output specifications ZEB_B25.txt The EnergyPLAN model 11.2

District Heating Production

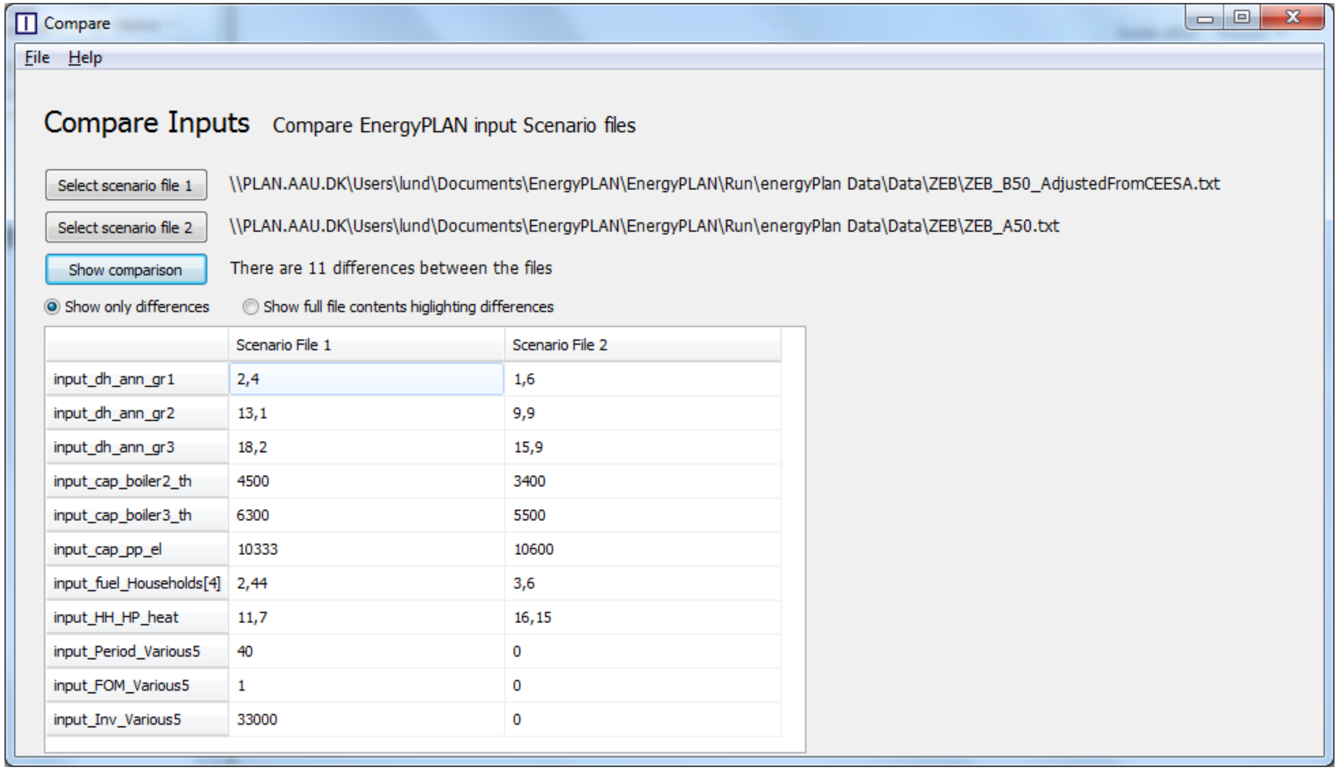
	Gr.1				Gr.2									
	District heating MW	Solar MW	CSHP MW	DHP MW	District heating MW	Solar MW	CSHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Stor-age MW	Ba-lance MW
January	247	44	0	203	1490	92	146	595	588	0	30	39	13957	0
February	251	93	0	158	1512	193	146	369	748	0	22	37	15780	-4
March	225	105	0	120	1368	219	146	399	583	0	3	2	13400	17
April	195	145	0	50	1202	338	146	293	442	0	1	1	11338	-19
May	169	153	0	17	1059	362	146	232	306	0	1	1	16460	12
June	118	107	0	12	775	325	146	157	153	0	0	1	15060	-7
July	118	107	0	12	775	364	146	166	95	0	0	1	14008	3
August	118	107	0	12	775	342	146	152	142	0	0	1	15938	-8
September	141	127	0	14	900	257	146	243	261	0	1	1	15256	-8
October	173	156	0	17	1078	166	146	205	551	0	1	3	14802	7
November	203	66	0	137	1247	104	146	305	680	0	4	8	16206	-1
December	228	30	0	198	1385	62	146	605	513	0	25	28	17371	6
Average	182	103	0	79	1129	235	146	310	420	0	8	10	14966	0
Maximum	375	320	0	375	2203	1504	146	1241	1050	0	378	336	26176	652
Minimum	113	0	0	11	744	0	146	0	6	0	0	0	0	-1065
Total for the whole year TWh/year	1,60	0,91	0,00	0,69	9,92	2,07	1,28	2,73	3,69	0,00	0,07	0,09		0,00

	Gr.3										RES specification				
	District heating MW	Solar MW	CSHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Stor-age MW	Ba-lance MW	RES1 Wind MW	RES2 Offshoı MW	RES3 Photo ' MW	RES4 Wave I MW	Total er MW
January	2128	40	1161	421	505	0	0	0	164	0	1303	4348	168	88	5908
February	2147	85	1161	265	636	0	1	0	705	0	1841	5637	495	166	8139
March	1918	96	1155	243	426	0	0	0	321	-2	1509	4962	716	119	7306
April	1644	149	1137	126	246	0	0	0	351	-14	1271	4432	1093	58	6853
May	1399	155	1117	62	104	0	0	0	351	-39	1270	4372	1631	53	7327
June	980	134	944	0	8	0	0	0	351	-106	1356	4782	1260	48	7446
July	968	150	935	0	8	0	0	0	351	-125	918	3345	1436	48	5747
August	970	138	939	0	8	0	0	0	351	-114	1267	4289	654	65	6275
September	1166	111	1075	11	20	0	0	0	351	-51	1265	4382	678	87	6412
October	1455	71	1144	59	189	0	0	0	351	-9	2013	6214	439	128	8794
November	1738	45	1157	142	393	0	0	0	355	-1	1930	5944	177	128	8178
December	1964	27	1160	341	436	0	0	0	508	0	1332	4408	73	99	5913
Average	1538	100	1090	139	247	0	0	0	374	-39	1437	4753	736	90	7017
Maximum	3132	1275	1161	1292	1483	0	150	79	1878	265	4454	10173	5000	300	18479
Minimum	921	0	910	0	8	0	0	0	0	-674	0	0	0	1	29
Total for the whole year TWh/year	13,51	0,88	9,58	1,22	2,17	0,00	0,00	0,00		-0,34	12,63	41,75	6,46	0,79	61,63

ANNUAL COSTS (Million DKK)		
Total Fuel -		14610
Uranium -	0	
Coal -	0	
FuelOil -	0	
Gasoil/Diesel-	0	
Petrol/JP -	3380	
Ngas -	505	
Biomass -	10725	
Food income -	0	
Waste -	0	
Marginal operation costs -		170
Total Electricity exchange -		0
Import -	0	
Export -	0	
Bottleneck -	0	
Fixed imp/ex-	0	
Total CO2 emission costs -		-325
Total Ngas Exchange costs -		-1734
Total variable costs -		12721
Fixed operation costs -		36565
Annual Investment costs -		98154
TOTAL ANNUAL COSTS -		147440

	DHP & Boilers MW	CHP2 CHP3 MW	PP CAES MW	Indi-vidual MW	Trans port MW	Indu. Var. MW	Demand Sum MW	Bio-gas MW	Syn-gas MW	CO2Hy gas MW	SynHy gas MW	SynHy gas MW	Stor-age MW	Sum MW	Im-port MW	Ex-port MW
January	0	2966	577	0	0	0	3544	895	2252	1422	1814	-3660	1521	-700	0	700
February	1	1851	279	0	0	0	2131	895	1688	1971	1814	-3660	124	-700	0	700
March	0	1863	264	0	0	0	2127	895	1874	1674	1814	-3660	231	-700	0	700
April	0	1198	266	0	0	0	1464	895	1724	1551	1814	-3660	-160	-700	0	700
May	0	829	254	0	0	0	1083	895	1543	1672	1814	-3660	-481	-700	0	700
June	0	424	163	0	0	0	588	895	1130	1775	1814	-3660	-666	-700	0	700
July	0	447	683	0	0	0	1131	895	1639	1268	1814	-3660	-124	-700	0	700
August	0	410	739	0	0	0	1149	895	1605	1395	1814	-3660	-200	-700	0	700
September	0	692	600	0	0	0	1291	895	1655	1432	1814	-3660	-143	-700	0	700
October	0	744	180	0	0	0	924	895	1302	2144	1814	-3660	-870	-700	0	700
November	0	1284	226	0	0	0	1510	895	1587	1931	1814	-3660	-356	-700	0	700
December	0	2734	590	0	0	0	3323	895	2459	1427	1814	-3660	1089	-700	0	700
Average	0	1288	403	0	0	0	1691	895	1707	1636	1814	-3660	0	-700	0	700
Maximum	158	7520	6834	0	0	0	9291	895	3522	3703	1814	-3660	7056	-700	0	700
Minimum	0	0	0	0	0	0	0	895	559	0	1814	-3660	-2610	-700	0	700
Total for the whole year TWh/year	0,00	11,31	3,54	0,00	0,00	0,00	14,86	7,86	14,99	14,37	15,93	-32,15	0,00	-6,15	0,00	6,15

RES Share: 104,8 Percent of Primary Energy 93,4 Percent of Electricity 62,6 TWh electricity from RES 22-januar-2014 [16:26]


Compare
File Help
Compare Inputs Compare EnergyPLAN input Scenario files
Select scenario file 1
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B50_AdjustedFromCEESA.txt
Select scenario file 2
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_A50.txt
Show comparison
There are 11 differences between the files
Show only differences
Show full file contents higlighting differences
Scenario File 1
Scenario File 2
input_dh_ann_gr1 2,4 1,6
input_dh_ann_gr2 13,1 9,9
input_dh_ann_gr3 18,2 15,9
input_cap_boiler2_th 4500 3400
input_cap_boiler3_th 6300 5500
input_cap_pp_el 10333 10600
input_fuel_Households[4] 2,44 3,6
input_HH_HP_heat 11,7 16,15
input_Period_Various5 40 0
input_FOM_Various5 1 0
input_Inv_Various5 33000 0

Input ZEB_A50.txt

The EnergyPLAN model 11.2

Electricity demand (TWh/year):		Flexible demand	4,07
Fixed demand	21,80	Fixed imp/exp.	0,00
Electric heating + HP	5,12	Transportation	8,22
Electric cooling	0,00	Total	39,21

District heating (TWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	1,60	9,90	15,90	27,40
Solar Thermal	0,85	2,06	0,89	3,79
Industrial CHP (CSHP)	0,00	0,00	2,65	2,65
Demand after solar and CSHP	0,75	7,84	12,36	20,96

Wind	4454 MW	12,63 TWh/year	0,00	Grid
Offshore Wind	10173 MW	41,75 TWh/year	0,00	stabili-
Photo Voltaic	5000 MW	6,46 TWh/year	0,00	sation
Wave Power	300 MW	0,79 TWh/year	0,00	share
Hydro Power	0 MW	0 TWh/year		
Geothermal/Nuclear	0 MW	0 TWh/year		

	Capacities MW-e	Capacities MJ/s	Efficiencies elec.	Efficiencies Ther	COP
Group 2:					
CHP	1945	1241	0,58	0,37	
Heat Pump	300	1050			3,50
Boiler		3400		0,95	
Group 3:					
CHP	2500	1292	0,60	0,31	
Heat Pump	600	2100			3,50
Boiler		5500		0,95	
Condensing	10600		0,60		

Heatstorage: gr.2: 40 GWh gr.3: 10 GWh
Fixed Boiler: gr.2: 0,5 Per cent gr.3: 0,5 Per cent

Electricity prod. from	CSHP	Waste (TWh/year)
Gr.1:	0,00	0,00
Gr.2:	0,00	0,39
Gr.3:	0,89	0,72

Regulation Strategy:	Technical regulation no. 3	
KEOL regulation	23458000	
Minimum Stabilisation share	0,00	
Stabilisation share of CHP	0,00	
Minimum CHP gr 3 load	0	MW
Minimum PP	0	MW
Heat Pump maximum share	0,50	
Maximum import/export	0	MW

Distr. Name :	Price_DKV_2008.txt	
Addition factor	100,00	DKK/MWh
Multiplication factor	1,05	
Dependency factor	0,02	DKK/MWh pr. MW
Average Market Price	541	DKK/MWh
Gas Storage	6000	GWh
Syngas capacity	3522	MW
Biogas max to grid	895	MW

Fuel Price level:

	Capacities MW-e	Storage GWh	Efficiencies elec.	Efficiencies Ther.
Hydro Pump:	0	0	0,85	
Hydro Turbine:	0		0,85	
Electrol. Gr.2:	0	0	0,00	0,00
Electrol. Gr.3:	0	0	0,00	0,00
Electrol. trans.:	1909	477	0,73	
Ely. MicroCHP:	0	0	0,00	
CAES fuel ratio:		0,000		

(TWh/year)	Coal	Oil	Ngas	Biomass
Transport	0,00	0,00	0,00	0,00
Household	0,00	0,00	0,00	3,60
Industry	0,00	0,00	0,00	19,03
Various	0,00	0,00	0,00	0,00

Output WARNING!!: (1) Critical Excess;

	District Heating: Demand Distr. heating MW	DH Production: Solar MW	Waste+ CSHP MW	DHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Ba- lance MW	Electricity Consumption: Elec. demand MW	Flex.& Transp. MW	HP MW	Elec- trolyser MW	EH MW	Hydro Pump MW	Electricity Production: Tur- bine MW	RES MW	Hy- dro MW	Geo- thermal MW	Waste+ CSHP MW	CHP MW	PP MW	Balance: Stab- Load %	Imp MW	Exp MW	CEEP MW	EEP MW	Exchange Payment Imp Million DKK	Exp
January	4999	176	1307	229	1279	1812	0	139	60	-2	2787	1398	1561	2912	60	0	0	5908	0	0	200	2238	385	100	0	13	13	0	0	0
February	5081	371	1307	185	829	2112	0	160	116	2	2759	1399	1657	4005	116	0	0	8139	0	0	200	1451	222	100	0	77	77	0	0	0
March	4433	419	1307	137	904	1561	0	67	24	15	2661	1422	1342	3693	24	0	0	7306	0	0	200	1582	215	100	0	161	161	0	0	0
April	3680	635	1301	55	627	1079	0	8	3	-28	2361	1387	938	3498	3	0	0	6853	0	0	201	1085	201	100	0	153	153	0	0	0
May	3021	666	1286	16	447	604	0	1	1	1	2307	1391	639	3732	1	0	0	7327	0	0	203	763	189	100	0	411	411	0	0	0
June	1771	541	1088	9	122	120	0	0	0	-111	2246	1417	211	3791	0	0	0	7446	0	0	224	191	115	100	0	311	311	0	0	0
July	1759	592	1078	9	117	79	0	0	1	-117	2060	1408	163	2648	1	0	0	5747	0	0	225	183	454	100	0	330	330	0	0	0
August	1761	560	1083	9	114	111	0	0	0	-118	2349	1390	196	3001	0	0	0	6275	0	0	225	179	500	100	0	241	241	0	0	0
September	2326	483	1252	12	300	317	0	1	1	-40	2407	1414	398	3127	1	0	0	6412	0	0	206	491	402	100	0	164	164	0	0	0
October	3131	389	1301	17	371	1046	0	1	3	2	2492	1408	850	4647	3	0	0	8794	0	0	201	632	140	100	0	367	367	0	0	0
November	3904	227	1307	134	631	1504	0	40	62	-1	2682	1400	1199	4137	62	0	0	8178	0	0	200	1091	147	100	0	137	137	0	0	0
December	4529	118	1307	217	1284	1432	0	101	52	18	2683	1378	1345	3209	52	0	0	5913	0	0	200	2236	359	100	0	41	41	0	0	0
Average	3362	431	1243	86	586	978	0	43	27	-32	2482	1401	873	3530	27	0	0	7017	0	0	207	1011	278	100	0	201	201	0	Average price	
Maximum	8077	3309	1307	452	2532	3150	0	1629	600	1364	3754	7786	2814	7638	600	0	0	18479	0	0	228	4445	4245	100	0	6440	6440	0	(DKK/MWh)	
Minimum	1628	0	1056	9	0	16	0	0	0	-1287	1312	-271	5	0	0	0	0	29	0	0	200	0	0	100	0	0	0	0	119	0
TWh/year	29,53	3,79	10,92	0,75	5,15	8,59	0,00	0,38	0,23	-0,28	21,80	12,31	7,67	31,00	0,23	0,00	0,00	61,63	0,00	0,00	1,82	8,88	2,44		0,00	1,77	1,77	0,00	0	0

FUEL BALANCE (TWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon- version	Synthetic Fuel	Wind	Offsh.	PV	Wave	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Netto	CO2 emission (Mt): Total	Netto
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
N.Gas	-	7,94	7,13	-	0,04	4,07	-	-	-	-	-22,85	2,48	-	-	-	-	-	-	-	-	-1,20	-2,95	-4,14	-0,25	-0,85
Biomass	0,80	-	-	0,36	-	-	-	-	4,16	-	38,87	-	-	-	-	-	-	-	3,38	19,03	66,60	0,00	66,60	0,00	0,00
Renewable	-	-	-	-	-	-	-	-	2,69	-	-	-	12,63	41,75	6,46	0,79	6,30	-	-	-	70,62	0,00	70,62	0,00	0,00
H2 etc.	-	0,00	0,00	0,00	0,00	0,00	-	-	-	-21,90	-10,85	32,75	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-32,15	-	-	-	-	-	32,15	-	-	0,00	0,00	0,00	0,00	0,00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Total	0,80	7,94	7,13	0,36	0,04	4,07	-	-	6,85	-21,90	5,17	3,08	12,63	41,75	6,46	0,79	6,30	32,15	3,38	19,03	136,02	-2,95	133,08	-0,25	-0,85

22-januar-2014 [16:28]

Output specifications ZEB_A50.txt The EnergyPLAN model 11.2

District Heating Production

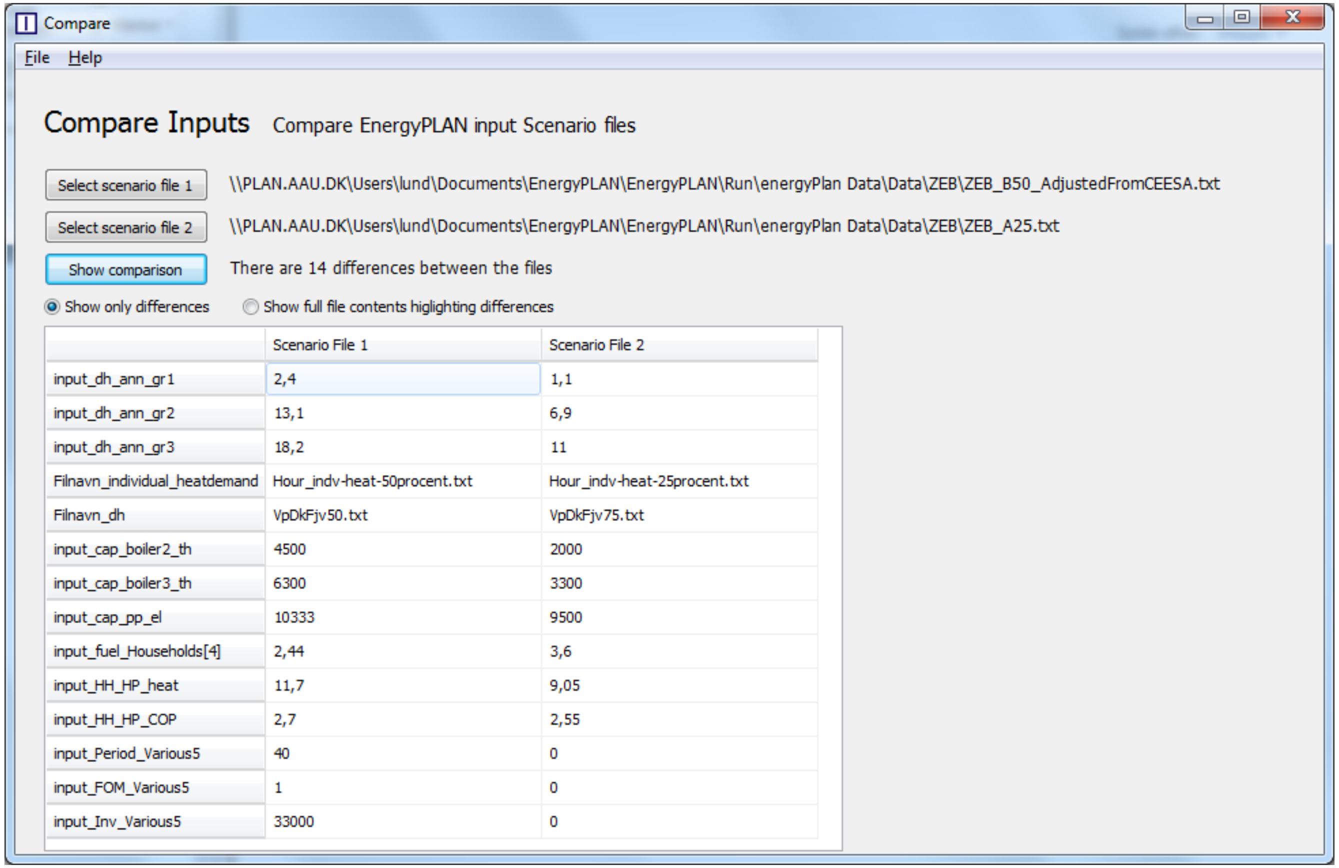
	Gr.1				Gr.2									
	District heating MW	Solar MW	CSHP MW	DHP MW	District heating MW	Solar MW	CSHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Stor-age MW	Ba-lance MW
January	273	44	0	229	1803	92	146	647	729	0	132	58	18760	0
February	278	93	0	185	1837	193	146	417	841	0	131	109	20283	0
March	242	105	0	137	1613	219	146	455	691	0	63	22	15950	17
April	201	145	0	55	1357	340	146	350	533	0	7	3	14688	-22
May	165	148	0	16	1135	360	146	275	337	0	1	1	19838	14
June	93	84	0	9	691	323	146	122	110	0	0	0	18622	-10
July	93	84	0	9	691	357	146	117	69	0	0	1	18032	2
August	93	84	0	9	691	337	146	114	102	0	0	0	19743	-8
September	125	112	0	12	888	258	146	244	247	0	1	1	19055	-8
October	169	152	0	17	1164	165	146	237	608	0	1	3	19426	4
November	212	78	0	134	1426	104	146	355	719	0	39	61	19841	3
December	246	30	0	217	1640	62	146	676	608	0	91	51	21511	7
Average	182	96	0	86	1243	234	146	334	465	0	39	25	18813	0
Maximum	452	382	0	452	2911	1950	146	1241	1050	0	907	400	33308	745
Minimum	86	0	0	9	646	0	146	0	6	0	0	0	0	-881
Total for the whole year														
TWh/year	1,60	0,85	0,00	0,75	10,92	2,06	1,28	2,94	4,08	0,00	0,34	0,22		0,00

	Gr.3										RES specification				
	District heating MW	Solar MW	CSHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Stor-age MW	Ba-lance MW	RES1 Wind MW	RES2 Offshoı MW	RES3 Photo ' MW	RES4 Wave I MW	Total er MW
January	2923	40	1161	632	1084	0	7	2	2624	-2	1303	4348	168	88	5908
February	2966	85	1161	412	1271	0	29	6	4908	2	1841	5637	495	166	8139
March	2578	96	1161	448	870	0	5	1	3205	-3	1509	4962	716	119	7306
April	2123	149	1156	277	546	0	1	0	4910	-6	1271	4432	1093	58	6853
May	1721	157	1140	171	266	0	0	0	5536	-14	1270	4372	1631	53	7327
June	986	135	942	0	10	0	0	0	5534	-100	1356	4782	1260	48	7446
July	975	152	932	0	10	0	0	0	5535	-119	918	3345	1436	48	5747
August	976	139	938	0	10	0	0	0	5535	-110	1267	4289	654	65	6275
September	1314	113	1106	56	70	0	0	0	5535	-31	1265	4382	678	87	6412
October	1798	71	1156	135	438	0	0	0	5677	-2	2013	6214	439	128	8794
November	2266	45	1161	276	785	0	1	1	6445	-4	1930	5944	177	128	8178
December	2643	27	1161	608	824	0	10	1	4656	11	1332	4408	73	99	5913
Average	1936	101	1098	252	513	0	4	1	5002	-32	1437	4753	736	90	7017
Maximum	4714	1275	1161	1292	2100	0	782	200	10000	761	4454	10173	5000	300	18479
Minimum	896	0	910	0	10	0	0	0	0	-679	0	0	0	1	29
Total for the whole year															
TWh/year	17,01	0,88	9,64	2,21	4,51	0,00	0,04	0,01		-0,28	12,63	41,75	6,46	0,79	61,63

ANNUAL COSTS (Million DKK)		
Total Fuel -		15202
Uranium -	0	
Coal -	0	
FuelOil -	0	
Gasoil/Diesel-	0	
Petrol/JP -	3380	
Ngas -	581	
Biomass -	11242	
Food income -	0	
Waste -	0	
Marginal operation costs -		223
Total Electricity exchange -		0
Import -	0	
Export -	0	
Bottleneck -	0	
Fixed imp/ex-	0	
Total CO2 emission costs -		-63
Total Ngas Exchange costs -		-337
Total variable costs -		15025
Fixed operation costs -		37182
Annual Investment costs -		103161
TOTAL ANNUAL COSTS -		155367

	DHP & Boilers MW	CHP2 CHP3 MW	PP CAES MW	Indi-vidual MW	Trans port MW	Indu. Var. MW	Demand Sum MW	Bio-gas MW	Syn-gas MW	CO2Hy gas MW	SynHy gas MW	SynHy gas MW	Stor-age MW	Sum MW	Im-port MW	Ex-port MW
January	7	3788	641	0	0	0	4437	895	2333	1260	1814	-3660	1932	-136	0	136
February	30	2457	369	0	0	0	2856	895	1781	1754	1814	-3660	410	-136	0	136
March	5	2677	358	0	0	0	3040	895	1980	1586	1814	-3660	562	-136	0	136
April	1	1840	335	0	0	0	2176	895	1855	1502	1814	-3660	-94	-136	0	136
May	0	1296	315	0	0	0	1612	895	1682	1664	1814	-3660	-646	-136	0	136
June	0	329	191	0	0	0	521	895	883	1729	1814	-3660	-1003	-136	0	136
July	0	315	757	0	0	0	1072	895	1413	1235	1814	-3660	-487	-136	0	136
August	0	308	833	0	0	0	1141	895	1422	1364	1814	-3660	-557	-136	0	136
September	0	841	670	0	0	0	1510	895	1647	1402	1814	-3660	-451	-136	0	136
October	0	1074	233	0	0	0	1307	895	1308	2082	1814	-3660	-996	-136	0	136
November	1	1851	245	0	0	0	2097	895	1632	1817	1814	-3660	-265	-136	0	136
December	10	3788	599	0	0	0	4397	895	2526	1395	1814	-3660	1564	-136	0	136
Average	4	1715	464	0	0	0	2183	895	1707	1564	1814	-3660	0	-136	0	136
Maximum	827	7520	7075	0	0	0	11537	895	3522	3703	1814	-3660	9103	-136	0	136
Minimum	0	0	0	0	0	0	0	895	371	0	1814	-3660	-2986	-136	0	136
Total for the whole year																
TWh/year	0,04	15,07	4,07	0,00	0,00	0,00	19,18	7,86	14,99	13,74	15,93	-32,15	0,00	-1,20	0,00	1,20

RES Share: 100,9 Percent of Primary Energy 91,1 Percent of Electricity 62,6 TWh electricity from RES 22-januar-2014 [16:28]


Compare
File Help
Compare Inputs
Compare EnergyPLAN input Scenario files
Select scenario file 1
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B50_AdjustedFromCEESA.txt
Select scenario file 2
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_A25.txt
Show comparison
There are 14 differences between the files
Show only differences
Show full file contents higlighting differences
Scenario File 1
Scenario File 2
input_dh_ann_gr1 2,4 1,1
input_dh_ann_gr2 13,1 6,9
input_dh_ann_gr3 18,2 11
Filnavn_individual_heatdemand Hour_indv-heat-50procent.txt Hour_indv-heat-25procent.txt
Filnavn_dh VpDkFjv50.txt VpDkFjv75.txt
input_cap_boiler2_th 4500 2000
input_cap_boiler3_th 6300 3300
input_cap_pp_el 10333 9500
input_fuel_Households[4] 2,44 3,6
input_HH_HP_heat 11,7 9,05
input_HH_HP_COP 2,7 2,55
input_Period_Various5 40 0
input_FOM_Various5 1 0
input_Inv_Various5 33000 0

Input ZEB_A25.txt

The EnergyPLAN model 11.2

Electricity demand (TWh/year):		Flexible demand	4,07
Fixed demand	21,80	Fixed imp/exp.	0,00
Electric heating + HP	2,64	Transportation	8,22
Electric cooling	0,00	Total	36,73

District heating (TWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	1,10	6,90	11,00	19,00
Solar Thermal	0,75	2,03	0,86	3,64
Industrial CHP (CSHP)	0,00	0,00	2,65	2,65
Demand after solar and CSHP	0,35	4,87	7,49	12,71

Wind	4454	MW	12,63	TWh/year	0,00	Grid
Offshore Wind	10173	MW	41,75	TWh/year	0,00	stabili-
Photo Voltaic	5000	MW	6,46	TWh/year	0,00	sation
Wave Power	300	MW	0,79	TWh/year	0,00	share
Hydro Power	0	MW	0	TWh/year		
Geothermal/Nuclear	0	MW	0	TWh/year		

	Capacities		Efficiencies		
Group 2:	MW-e	MJ/s	elec.	Ther	COP
CHP	1945	1241	0,58	0,37	
Heat Pump	300	1050			3,50
Boiler		2000		0,95	
Group 3:					
CHP	2500	1292	0,60	0,31	
Heat Pump	600	2100			3,50
Boiler		3300		0,95	
Condensing	9500		0,60		

Heatstorage: gr.2: 40 GWh gr.3: 10 GWh
Fixed Boiler: gr.2: 0,5 Per cent gr.3: 0,5 Per cent

Electricity prod. from	CSHP	Waste (TWh/year)
Gr.1:	0,00	0,00
Gr.2:	0,00	0,39
Gr.3:	0,89	0,72

Regulation Strategy:	Technical regulation no. 3	
KEOL regulation	23458000	
Minimum Stabilisation share	0,00	
Stabilisation share of CHP	0,00	
Minimum CHP gr 3 load	0	MW
Minimum PP	0	MW
Heat Pump maximum share	0,50	
Maximum import/export	0	MW

Distr. Name :	Price_DKV_2008.txt	
Addition factor	100,00	DKK/MWh
Multiplication factor	1,05	
Dependency factor	0,02	DKK/MWh pr. MW
Average Market Price	541	DKK/MWh
Gas Storage	6000	GWh
Syngas capacity	3522	MW
Biogas max to grid	895	MW

Fuel Price level:

	Capacities MW-e	Storage GWh	Efficiencies elec.	Ther.
Hydro Pump:	0	0	0,85	
Hydro Turbine:	0		0,85	
Electrol. Gr.2:	0	0	0,00	0,00
Electrol. Gr.3:	0	0	0,00	0,00
Electrol. trans.:	1909	477	0,73	
Ely. MicroCHP:	0	0	0,00	
CAES fuel ratio:		0,000		

(TWh/year)	Coal	Oil	Ngas	Biomass
Transport	0,00	0,00	0,00	0,00
Household	0,00	0,00	0,00	3,60
Industry	0,00	0,00	0,00	19,03
Various	0,00	0,00	0,00	0,00

Output WARNING!!: (1) Critical Excess;

District Heating

	Demand: Distr. heating MW	Production: Solar MW	Waste+ CSHP MW	DHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Balance MW
January	3263	176	1306	126	865	788	0	1	1	0
February	3298	366	1304	84	534	1005	0	1	2	2
March	2963	423	1296	47	516	679	0	1	1	1
April	2565	597	1269	18	293	426	0	1	0	-40
May	2214	612	1241	12	174	228	0	1	0	-54
June	1584	523	1056	8	88	84	0	0	0	-175
July	1572	558	1056	8	87	58	0	0	0	-194
August	1574	537	1056	8	83	79	0	0	0	-189
September	1864	450	1144	10	163	173	0	1	1	-78
October	2284	346	1267	12	198	469	0	1	2	-11
November	2692	271	1300	18	353	751	0	1	2	-3
December	3021	118	1305	127	784	681	0	1	1	3
Average	2406	414	1216	40	345	450	0	1	1	-62
Maximum	4796	2392	1307	258	2532	2233	0	39	9	717
Minimum	1502	0	1056	8	0	11	0	0	0	-878
TWh/year	21,13	3,64	10,69	0,35	3,03	3,95	0,00	0,01	0,01	-0,54

Electricity / Exchange

	Consumption: Elec. demand MW	Flex.& Transp. MW	HP MW	Elec-trolyser MW	EH MW	Hydro Pump MW	Production: Tur-bine MW	RES MW	Hy-dro MW	Geo-thermal MW	Waste+ CSHP MW	CHP MW	PP MW	Balance: Stab-Load %	Imp MW	Exp MW	CEEP MW	EEP MW	Exchange Payment Imp Million DKK	Exp
January	2787	1398	778	3004	1	0	0	5908	0	0	200	1487	421	100	0	48	48	0	0	0
February	2759	1399	836	4290	2	0	0	8139	0	0	201	920	235	100	0	209	209	0	0	0
March	2661	1422	653	3619	1	0	0	7306	0	0	202	881	198	100	0	230	230	0	0	0
April	2361	1388	444	3368	0	0	0	6853	0	0	204	489	220	100	0	205	205	0	0	0
May	2307	1395	305	3586	0	0	0	7327	0	0	208	281	232	100	0	454	454	0	0	0
June	2246	1416	144	3828	0	0	0	7446	0	0	228	137	125	100	0	300	300	0	0	0
July	2060	1408	107	2677	0	0	0	5747	0	0	228	136	462	100	0	321	321	0	0	0
August	2349	1390	125	3040	0	0	0	6275	0	0	228	130	504	100	0	232	232	0	0	0
September	2407	1414	226	3103	1	0	0	6412	0	0	218	257	439	100	0	174	174	0	0	0
October	2492	1407	441	4671	2	0	0	8794	0	0	205	324	143	100	0	452	452	0	0	0
November	2682	1401	636	4195	2	0	0	8178	0	0	201	594	177	100	0	234	234	0	0	0
December	2683	1379	702	3029	1	0	0	5913	0	0	201	1334	455	100	0	110	110	0	0	0
Average	2482	1402	449	3529	1	0	0	7017	0	0	210	581	302	100	0	248	248	0	Average price	
Maximum	3754	7404	1617	7738	9	0	0	18479	0	0	228	4445	4221	100	0	6465	6465	0	(DKK/MWh)	
Minimum	1312	-268	3	0	0	0	0	29	0	0	200	0	0	100	0	0	0	0	135	0
TWh/year	21,80	12,31	3,94	31,00	0,01	0,00	0,00	61,63	0,00	0,00	1,85	5,11	2,65		0,00	2,18	2,18	0,00	0	0

FUEL BALANCE (TWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon-version	Synthetic Fuel	Wind	Offsh.	PV	Wave	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Netto	CO2 emission (Mt): Total	Netto
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
N.Gas	-	5,58	3,11	-	0,00	4,42	-	-	-	-	-22,85	2,48	-	-	-	-	-	-	-	-	-7,25	-3,63	-10,88	-1,49	-2,23
Biomass	0,37	-	-	0,01	-	-	-	-	4,16	-	38,87	-	-	-	-	-	-	-	3,38	19,03	65,82	0,00	65,82	0,00	0,00
Renewable	-	-	-	-	-	-	-	-	2,31	-	-	-	12,63	41,75	6,46	0,79	6,15	-	-	-	70,09	0,00	70,09	0,00	0,00
H2 etc.	-	0,00	0,00	0,00	0,00	0,00	-	-	-	-21,90	-10,85	32,75	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-32,15	-	-	-	-	-	32,15	-	-	0,00	0,00	0,00	0,00	0,00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Total	0,37	5,58	3,11	0,01	0,00	4,42	-	-	6,47	-21,90	5,17	3,08	12,63	41,75	6,46	0,79	6,15	32,15	3,38	19,03	128,65	-3,63	125,02	-1,49	-2,23

22-januar-2014 [16:31]

Output specifications ZEB_A25.txt — The EnergyPLAN model 11.2

District Heating Production

	Gr.1 District heating MW	Gr.1 Solar MW	Gr.1 CSHP MW	Gr.1 DHP MW	Gr.2 District heating MW	Gr.2 Solar MW	Gr.2 CSHP MW	Gr.2 CHP MW	Gr.2 HP MW	Gr.2 ELT MW	Gr.2 Boiler MW	Gr.2 EH MW	Gr.2 Storage MW	Gr.2 Balance MW
January	170	44	0	126	1181	92	146	510	432	0	1	1	9287	0
February	173	88	0	84	1198	193	146	307	547	0	1	2	10420	2
March	155	108	0	47	1087	219	146	317	396	0	1	1	8231	7
April	134	116	0	18	958	332	146	211	279	0	1	0	7398	-11
May	117	105	0	12	847	355	146	151	189	0	1	0	10799	6
June	81	73	0	8	627	321	146	88	77	0	0	0	9877	-5
July	81	73	0	8	627	341	146	87	51	0	0	0	9472	1
August	81	73	0	8	627	331	146	83	72	0	0	0	10697	-5
September	97	87	0	10	724	254	146	163	165	0	1	1	10252	-5
October	119	107	0	12	862	169	146	162	378	0	1	2	9688	5
November	140	122	0	18	993	104	146	242	498	0	1	2	10652	0
December	157	30	0	127	1100	62	146	499	388	0	1	1	12131	4
Average	125	85	0	40	902	231	146	235	288	0	1	1	9910	0
Maximum	258	220	0	258	1734	1232	146	1241	1050	0	39	5	18015	607
Minimum	78	0	0	8	603	0	146	0	5	0	0	0	0	-786
Total for the whole year TWh/year	1,10	0,75	0,00	0,35	7,92	2,03	1,28	2,07	2,53	0,00	0,01	0,01		0,00

	Gr.3 District heating MW	Gr.3 Solar MW	Gr.3 CSHP MW	Gr.3 CHP MW	Gr.3 HP MW	Gr.3 ELT MW	Gr.3 Boiler MW	Gr.3 EH MW	Gr.3 Storage MW	Gr.3 Balance MW
January	1912	40	1160	355	356	0	0	0	36	0
February	1927	85	1158	227	458	0	0	0	62	0
March	1721	96	1150	198	283	0	0	0	8	-6
April	1473	149	1124	82	147	0	0	0	8	-28
May	1251	153	1095	23	40	0	0	0	8	-60
June	876	129	910	0	7	0	0	0	8	-170
July	864	143	910	0	7	0	0	0	8	-196
August	866	133	910	0	7	0	0	0	8	-183
September	1043	108	998	1	8	0	0	0	8	-72
October	1303	71	1121	36	91	0	0	0	8	-15
November	1560	45	1154	110	253	0	0	0	8	-3
December	1764	27	1159	285	294	0	0	0	26	-1
Average	1379	98	1071	110	162	0	0	0	16	-61
Maximum	2804	1275	1161	1292	1327	0	20	4	230	113
Minimum	822	0	910	0	7	0	0	0	0	-703
Total for the whole year TWh/year	12,11	0,86	9,40	0,96	1,42	0,00	0,00	0,00		-0,54

RES specification

	RES1 Wind MW	RES2 Offshoı MW	RES3 Photo ' MW	RES4 Wave I MW	Total er MW
January	1303	4348	168	88	5908
February	1841	5637	495	166	8139
March	1509	4962	716	119	7306
April	1271	4432	1093	58	6853
May	1270	4372	1631	53	7327
June	1356	4782	1260	48	7446
July	918	3345	1436	48	5747
August	1267	4289	654	65	6275
September	1265	4382	678	87	6412
October	2013	6214	439	128	8794
November	1930	5944	177	128	8178
December	1332	4408	73	99	5913
Average	1437	4753	736	90	7017
Maximum	4454	10173	5000	300	18479
Minimum	0	0	0	1	29
Total for the whole year TWh/year	12,63	41,75	6,46	0,79	61,63

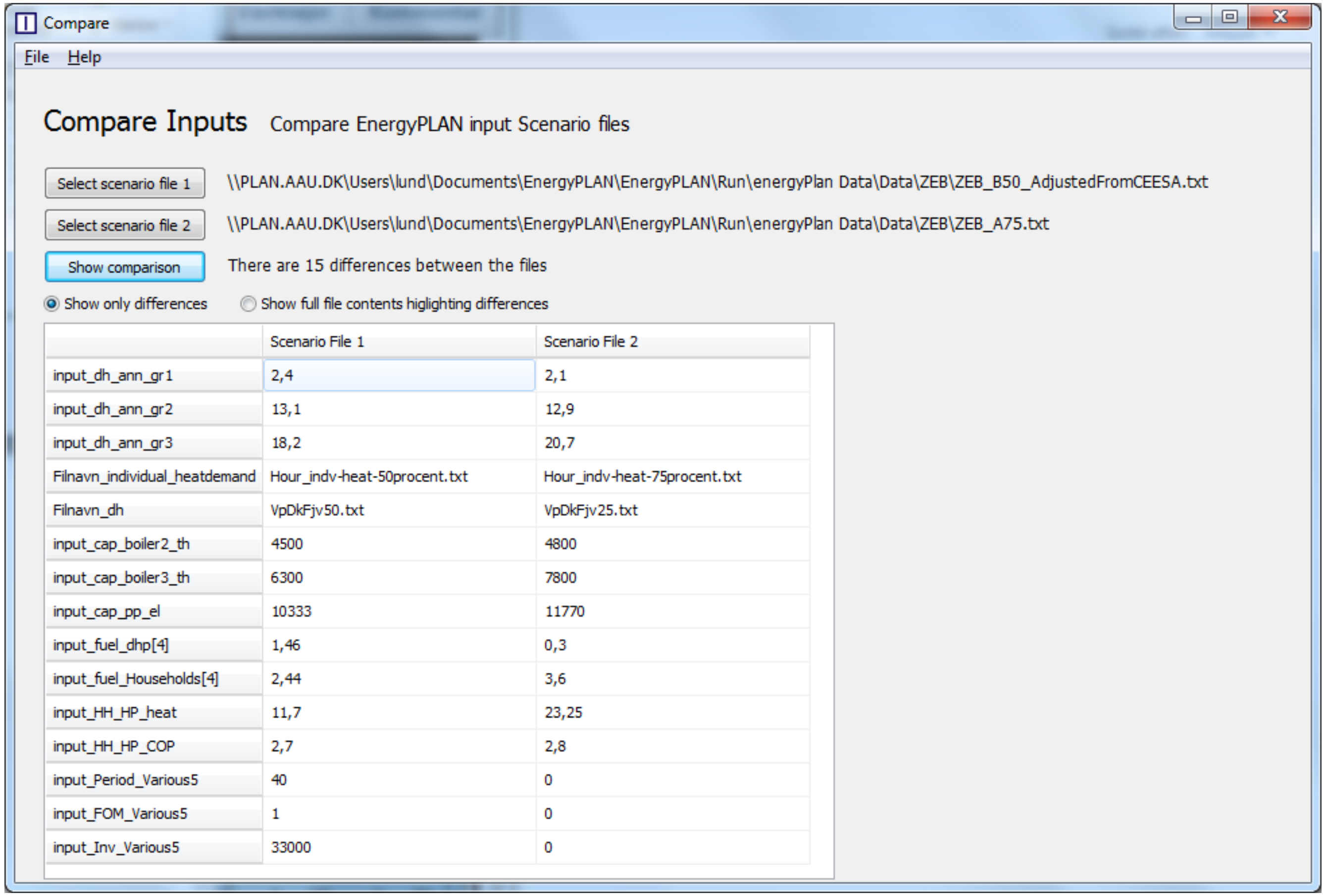
ANNUAL COSTS (Million DKK)

Total Fuel -		14879
Uranium -	0	
Coal -	0	
FuelOil -	0	
Gasoil/Diesel-	0	
Petrol/JP -	3380	
Ngas -	404	
Biomass -	11095	
Food income -	0	
Waste -	0	
Marginal operation costs -		145
Total Electricity exchange -		0
Import -	0	
Export -	0	
Bottleneck -	0	
Fixed imp/ex-	0	
Total CO2 emission costs -		-383
Total Ngas Exchange costs -		-2045
Total variable costs -		12595
Fixed operation costs -		36420
Annual Investment costs -		98146
TOTAL ANNUAL COSTS -		147160

	DHP & Boilers MW	CHP2 CHP3 MW	PP CAES MW	Indi-vidual MW	Trans port MW	Indu. Var. MW	Demand Sum MW	Bio-gas MW	Syn-gas MW	CO2Hy gas MW	SynHy gas MW	SynHy gas MW	Stor-age MW	Sum MW	Im-port MW	Ex-port MW
January	0	2524	702	0	0	0	3226	895	2311	1299	1814	-3660	1394	-826	0	826
February	0	1562	391	0	0	0	1952	895	1747	1906	1814	-3660	78	-826	0	826
March	0	1497	331	0	0	0	1827	895	1915	1575	1814	-3660	115	-826	0	826
April	0	834	367	0	0	0	1200	895	1676	1458	1814	-3660	-156	-826	0	826
May	0	483	386	0	0	0	869	895	1468	1594	1814	-3660	-415	-826	0	826
June	0	237	208	0	0	0	444	895	1073	1720	1814	-3660	-572	-826	0	826
July	0	235	770	0	0	0	1005	895	1603	1228	1814	-3660	-48	-826	0	826
August	0	224	840	0	0	0	1064	895	1606	1361	1814	-3660	-125	-826	0	826
September	0	442	732	0	0	0	1175	895	1616	1375	1814	-3660	-39	-826	0	826
October	0	555	239	0	0	0	794	895	1325	2097	1814	-3660	-850	-826	0	826
November	0	1011	295	0	0	0	1306	895	1618	1856	1814	-3660	-391	-826	0	826
December	0	2268	759	0	0	0	3027	895	2501	1327	1814	-3660	977	-826	0	826
Average	0	990	503	0	0	0	1493	895	1707	1564	1814	-3660	0	-826	0	826
Maximum	21	7520	7035	0	0	0	9036	895	3522	3703	1814	-3660	7273	-826	0	826
Minimum	0	0	0	0	0	0	0	895	642	0	1814	-3660	-2567	-826	0	826
Total for the whole year TWh/year	0,00	8,70	4,42	0,00	0,00	0,00	13,12	7,86	14,99	13,74	15,93	-32,15	0,00	-7,25	0,00	7,25

RES Share: 105,6 Percent of Primary Energy 94,2 Percent of Electricity 62,6 TWh electricity from RES

22-januar-2014 [16:31]


Compare
File Help
Compare Inputs
Compare EnergyPLAN input Scenario files
Select scenario file 1
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_B50_AdjustedFromCEESA.txt
Select scenario file 2
\\PLAN.AAU.DK\Users\lund\Documents\EnergyPLAN\EnergyPLAN\Run\energyPlan Data\Data\ZEB\ZEB_A75.txt
Show comparison
There are 15 differences between the files
Show only differences
Show full file contents higlighting differences
Scenario File 1
Scenario File 2
input_dh_ann_gr1 2,4 2,1
input_dh_ann_gr2 13,1 12,9
input_dh_ann_gr3 18,2 20,7
Filnavn_individual_heatdemand Hour_indv-heat-50procent.txt Hour_indv-heat-75procent.txt
Filnavn_dh VpDkFjv50.txt VpDkFjv25.txt
input_cap_boiler2_th 4500 4800
input_cap_boiler3_th 6300 7800
input_cap_pp_el 10333 11770
input_fuel_dhp[4] 1,46 0,3
input_fuel_Households[4] 2,44 3,6
input_HH_HP_heat 11,7 23,25
input_HH_HP_COP 2,7 2,8
input_Period_Various5 40 0
input_FOM_Various5 1 0
input_Inv_Various5 33000 0

Input ZEB_A75.txt

The EnergyPLAN model 11.2

Electricity demand (TWh/year):		Flexible demand	4,07
Fixed demand	21,80	Fixed imp/exp.	0,00
Electric heating + HP	7,47	Transportation	8,22
Electric cooling	0,00	Total	41,56

District heating (TWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	2,10	12,90	20,70	35,70
Solar Thermal	0,90	2,07	0,90	3,86
Industrial CHP (CSHP)	0,00	0,00	2,65	2,65
Demand after solar and CSHP	1,20	10,83	17,15	29,19

Wind	4454 MW	12,63 TWh/year	0,00	Grid
Offshore Wind	10173 MW	41,75 TWh/year	0,00	stabili-
Photo Voltaic	5000 MW	6,46 TWh/year	0,00	sation
Wave Power	300 MW	0,79 TWh/year	0,00	share
Hydro Power	0 MW	0 TWh/year		
Geothermal/Nuclear	0 MW	0 TWh/year		

	Capacities		Efficiencies		
Group 2:	MW-e	MJ/s	elec.	Ther	COP
CHP	1945	1241	0,58	0,37	
Heat Pump	300	1050			3,50
Boiler		4800		0,95	
Group 3:					
CHP	2500	1292	0,60	0,31	
Heat Pump	600	2100			3,50
Boiler		7800		0,95	
Condensing	11770		0,60		

Heatstorage: gr.2: 40 GWh gr.3: 10 GWh
Fixed Boiler: gr.2: 0,5 Per cent gr.3: 0,5 Per cent

Electricity prod. from	CSHP	Waste (TWh/year)
Gr.1:	0,00	0,00
Gr.2:	0,00	0,39
Gr.3:	0,89	0,72

Regulation Strategy:	Technical regulation no. 3	
KEOL regulation	23458000	
Minimum Stabilisation share	0,00	
Stabilisation share of CHP	0,00	
Minimum CHP gr 3 load	0	MW
Minimum PP	0	MW
Heat Pump maximum share	0,50	
Maximum import/export	0	MW

Distr. Name :	Price_DKV_2008.txt	
Addition factor	100,00	DKK/MWh
Multiplication factor	1,05	
Dependency factor	0,02	DKK/MWh pr. MW
Average Market Price	541	DKK/MWh
Gas Storage	6000	GWh
Syngas capacity	3522	MW
Biogas max to grid	895	MW

Fuel Price level:

	Capacities	Storage	Efficiencies	
	MW-e	GWh	elec.	Ther.
Hydro Pump:	0	0	0,85	
Hydro Turbine:	0		0,85	
Electrol. Gr.2:	0	0	0,00	0,00
Electrol. Gr.3:	0	0	0,00	0,00
Electrol. trans.:	1909	477	0,73	
Ely. MicroCHP:	0	0	0,00	
CAES fuel ratio:		0,000		

(TWh/year)	Coal	Oil	Ngas	Biomass
Transport	0,00	0,00	0,00	0,00
Household	0,00	0,00	0,00	3,60
Industry	0,00	0,00	0,00	19,03
Various	0,00	0,00	0,00	0,00

Output WARNING!!: (1) Critical Excess;

District Heating

	Demand: Distr. heating MW	Production: Solar MW	Production: Waste+ CSHP MW	Production: DHP MW	Production: CHP MW	Production: HP MW	Production: ELT MW	Production: Boiler MW	Production: EH MW	Balance MW
January	6754	176	1307	334	1418	2715	0	748	58	-1
February	6887	371	1307	293	951	2854	0	952	157	2
March	5914	420	1307	226	1065	2408	0	420	58	11
April	4789	641	1307	117	870	1719	0	134	32	-31
May	3809	693	1301	36	680	1068	0	3	2	26
June	1919	555	1142	10	145	162	0	1	1	-98
July	1907	612	1129	10	148	100	0	0	1	-92
August	1909	575	1136	10	139	144	0	1	1	-97
September	2755	510	1282	15	459	507	0	1	2	-22
October	3959	399	1306	54	490	1604	0	31	58	16
November	5112	199	1307	234	798	2191	0	268	111	4
December	6048	118	1307	308	1484	2273	0	489	60	9
Average	4307	439	1261	137	721	1475	0	252	45	-23
Maximum	11433	3949	1307	652	2532	3150	0	4328	600	1406
Minimum	1706	0	1056	9	0	20	0	0	0	-1780
TWh/year	37,83	3,86	11,08	1,20	6,33	12,96	0,00	2,21	0,39	-0,20

Electricity

	Consumption: Elec. demand MW	Consumption: Flex.& Transp. MW	Consumption: HP MW	Consumption: Elec-trolyser MW	Consumption: EH MW	Consumption: Hydro Pump MW	Production: Tur-bine MW	Production: RES MW	Production: Hy-dro MW	Production: Geo-thermal MW	Production: Waste+ CSHP MW	Production: CHP MW	Production: PP MW	Balance: Stab-Load %	Balance: Imp MW	Balance: Exp MW	Balance: CEEP MW	Balance: EEP MW	Exchange Payment Imp Million DKK	Exchange Payment Exp Million DKK
January	2787	1398	2327	2495	58	0	0	5908	0	0	200	2482	478	100	0	2	2	0	0	0
February	2759	1399	2387	3560	157	0	0	8139	0	0	200	1665	287	100	0	28	28	0	0	0
March	2661	1422	2017	3412	58	0	0	7306	0	0	200	1866	287	100	0	88	88	0	0	0
April	2361	1383	1441	3496	32	0	0	6853	0	0	200	1519	232	100	0	92	92	0	0	0
May	2307	1394	987	3886	2	0	0	7327	0	0	201	1178	216	100	0	345	345	0	0	0
June	2246	1416	243	3802	1	0	0	7446	0	0	218	228	117	100	0	302	302	0	0	0
July	2060	1408	197	2657	1	0	0	5747	0	0	220	232	448	100	0	324	324	0	0	0
August	2349	1390	228	2993	1	0	0	6275	0	0	219	219	482	100	0	234	234	0	0	0
September	2407	1413	566	3246	2	0	0	6412	0	0	203	772	384	100	0	137	137	0	0	0
October	2492	1408	1239	4544	58	0	0	8794	0	0	200	844	158	100	0	256	256	0	0	0
November	2682	1400	1738	3950	111	0	0	8178	0	0	200	1392	166	100	0	56	56	0	0	0
December	2683	1378	2005	2977	60	0	0	5913	0	0	200	2596	411	100	0	17	17	0	0	0
Average	2482	1401	1278	3415	45	0	0	7017	0	0	205	1250	306	100	0	158	158	0	Average price	
Maximum	3754	7595	3783	7638	600	0	0	18479	0	0	228	4445	3908	100	0	6340	6340	0	(DKK/MWh)	
Minimum	1312	-203	6	0	0	0	0	29	0	0	200	0	0	100	0	0	0	0	142	0
TWh/year	21,80	12,30	11,23	30,00	0,39	0,00	0,00	61,63	0,00	0,00	1,80	10,98	2,69		0,00	1,38	1,38	0,00	0	0

FUEL BALANCE (TWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon- version	Synthetic Fuel	Wind	Offsh.	PV	Wave	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Imp/Exp Corrected Netto	CO2 emission (Mt): Total	CO2 emission (Mt): Netto
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
N.Gas	0,97	9,39	9,23	0,75	0,73	4,49	-	-	-	-	-22,85	3,09	-	-	-	-	-	-	-	-	5,78	-2,31	3,48	1,19	0,71
Biomass	0,30	-	-	0,86	-	-	-	-	4,16	-	38,87	-	-	-	-	-	-	-	3,38	19,03	66,60	0,00	66,60	0,00	0,00
Renewable	-	-	-	-	-	-	-	-	2,95	-	-	-	12,63	41,75	6,46	0,79	6,36	-	-	-	70,94	0,00	70,94	0,00	0,00
H2 etc.	-	0,00	0,00	0,00	0,00	0,00	-	-	-	-21,20	-10,85	32,05	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-32,15	-	-	-	-	-	32,15	-	-	0,00	0,00	0,00	0,00	0,00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Total	1,27	9,39	9,23	1,61	0,73	4,49	-	-	7,11	-21,20	5,17	2,99	12,63	41,75	6,46	0,79	6,36	32,15	3,38	19,03	143,33	-2,31	141,02	1,19	0,71

22-januar-2014 [16:33]

Output specifications ZEB_A75.txt The EnergyPLAN model 11.2

District Heating Production

	Gr.1				Gr.2									
	District heating MW	Solar MW	CSHP MW	DHP MW	District heating MW	Solar MW	CSHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Storage MW	Balance MW
January	378	44	0	334	2437	92	146	715	969	0	476	39	17239	1
February	386	93	0	293	2490	193	146	476	991	0	576	106	17332	0
March	331	105	0	226	2148	219	146	529	880	0	311	52	14780	12
April	267	150	0	117	1758	341	146	450	686	0	123	31	12849	-19
May	212	176	0	36	1420	359	146	378	507	0	3	1	17173	25
June	102	92	0	10	745	325	146	145	146	0	1	1	16215	-19
July	102	92	0	10	745	362	146	147	87	0	0	1	15607	3
August	102	92	0	10	745	340	146	138	130	0	1	1	17606	-11
September	151	136	0	15	1043	261	146	316	328	0	1	2	16794	-10
October	219	165	0	54	1463	163	146	285	776	0	30	57	17260	7
November	284	50	0	234	1863	104	146	413	853	0	236	105	17035	6
December	337	30	0	308	2189	62	146	750	850	0	334	43	17686	5
Average	239	102	0	137	1585	235	146	395	599	0	173	36	16468	0
Maximum	652	551	0	652	4124	2418	146	1241	1050	0	2173	400	33384	875
Minimum	91	0	0	9	674	0	146	0	8	0	0	0	0	-916
Total for the whole year TWh/year	2,10	0,90	0,00	1,20	13,92	2,06	1,28	3,47	5,26	0,00	1,52	0,32		0,00

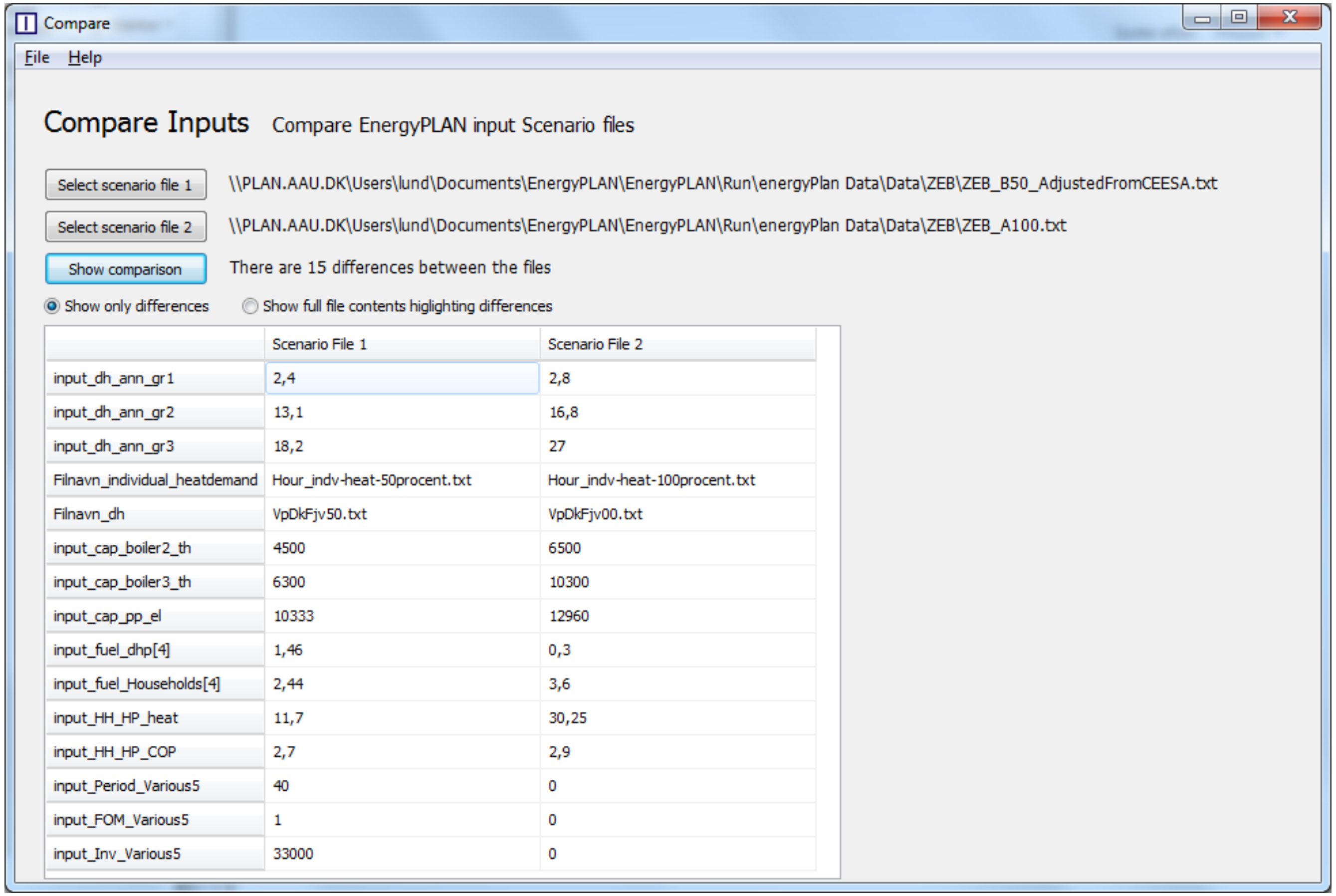
	Gr.3										RES specification				
	District heating MW	Solar MW	CSHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Storage MW	Balance MW	RES1 Wind MW	RES2 Offshoı MW	RES3 Photo ' MW	RES4 Wave I MW	Total er MW
January	3939	40	1161	703	1746	0	272	18	3099	-2	1303	4348	168	88	5908
February	4011	85	1161	474	1863	0	375	51	5425	2	1841	5637	495	166	8139
March	3435	96	1161	536	1528	0	109	7	4331	-1	1509	4962	716	119	7306
April	2764	149	1161	421	1033	0	11	1	5954	-11	1271	4432	1093	58	6853
May	2177	157	1155	302	561	0	1	0	8681	0	1270	4372	1631	53	7327
June	1072	138	997	0	16	0	0	0	8395	-79	1356	4782	1260	48	7446
July	1060	157	984	1	13	0	0	0	8428	-95	918	3345	1436	48	5747
August	1062	142	990	1	14	0	0	0	8428	-86	1267	4289	654	65	6275
September	1561	114	1136	143	179	0	0	0	8429	-11	1265	4382	678	87	6412
October	2277	71	1160	205	829	0	1	2	8450	9	2013	6214	439	128	8794
November	2965	45	1161	385	1339	0	32	6	4905	-3	1930	5944	177	128	8178
December	3522	27	1161	734	1423	0	155	17	2795	5	1332	4408	73	99	5913
Average	2483	102	1115	326	876	0	79	8	6444	-23	1437	4753	736	90	7017
Maximum	6656	1275	1161	1292	2100	0	2195	200	10000	1224	4454	10173	5000	300	18479
Minimum	941	0	910	0	12	0	0	0	0	-1070	0	0	0	1	29
Total for the whole year TWh/year	21,81	0,89	9,80	2,86	7,69	0,00	0,69	0,07		-0,20	12,63	41,75	6,46	0,79	61,63

ANNUAL COSTS (Million DKK)

Total Fuel -		15421
Uranium -	0	
Coal -	0	
FuelOil -	0	
Gasoil/Diesel-	0	
Petrol/JP -	3380	
Ngas -	798	
Biomass -	11243	
Food income -	0	
Waste -	0	
Marginal operation costs -		275
Total Electricity exchange -		0
Import -	0	
Export -	0	
Bottleneck -	0	
Fixed imp/ex-	0	
Total CO2 emission costs -		306
Total Ngas Exchange costs -		1630
Total variable costs -		17631
Fixed operation costs -		37973
Annual Investment costs -		108387
TOTAL ANNUAL COSTS -		163991

	DHP & Boilers MW	CHP2 CHP3 MW	PP CAES MW	Individual MW	Transport MW	Indu. Var. MW	Demand Sum MW	Biogas MW	Syngas MW	CO2Hy gas MW	SynHy gas MW	SynHy gas MW	Storage MW	Sum MW	Import MW	Export MW
January	791	4201	796	0	0	0	5788	895	2722	1045	1814	-3660	2314	658	658	0
February	917	2817	478	0	0	0	4212	895	2231	1522	1814	-3660	752	658	658	0
March	450	3157	478	0	0	0	4085	895	2209	1454	1814	-3660	715	658	658	0
April	166	2572	387	0	0	0	3126	895	1890	1470	1814	-3660	60	658	658	0
May	31	1997	359	0	0	0	2387	895	1646	1700	1814	-3660	-665	658	658	0
June	9	393	195	0	0	0	597	895	524	1734	1814	-3660	-1368	658	658	0
July	8	399	746	0	0	0	1154	895	1032	1238	1814	-3660	-823	658	658	0
August	9	378	804	0	0	0	1190	895	1051	1359	1814	-3660	-927	658	658	0
September	13	1316	640	0	0	0	1968	895	1561	1440	1814	-3660	-739	658	658	0
October	60	1433	264	0	0	0	1757	895	1139	2013	1814	-3660	-1103	658	658	0
November	339	2358	276	0	0	0	2973	895	1698	1694	1814	-3660	-126	658	658	0
December	576	4394	685	0	0	0	5655	895	2778	1283	1814	-3660	1888	658	658	0
Average	279	2119	511	0	0	0	2909	895	1707	1495	1814	-3660	0	658	658	0
Maximum	3798	7520	6513	0	0	0	16404	895	3522	3703	1814	-3660	13175	658	658	0
Minimum	7	0	0	0	0	0	7	895	0	0	1814	-3660	-3402	658	658	0
Total for the whole year TWh/year	2,45	18,61	4,49	0,00	0,00	0,00	25,55	7,86	14,99	13,13	15,93	-32,15	0,00	5,78	5,78	0,00

RES Share: 96,0 Percent of Primary Energy 90,9 Percent of Electricity 62,5 TWh electricity from RES 22-januar-2014 [16:33]



	Scenario File 1	Scenario File 2
input_dh_ann_gr1	2,4	2,8
input_dh_ann_gr2	13,1	16,8
input_dh_ann_gr3	18,2	27
Filnavn_individual_heatdemand	Hour_indv-heat-50procent.txt	Hour_indv-heat-100procent.txt
Filnavn_dh	VpDkFjv50.txt	VpDkFjv00.txt
input_cap_boiler2_th	4500	6500
input_cap_boiler3_th	6300	10300
input_cap_pp_el	10333	12960
input_fuel_dhp[4]	1,46	0,3
input_fuel_Households[4]	2,44	3,6
input_HH_HP_heat	11,7	30,25
input_HH_HP_COP	2,7	2,9
input_Period_Various5	40	0
input_FOM_Various5	1	0
input_Inv_Various5	33000	0

Input ZEB_A100.txt

The EnergyPLAN model 11.2

Electricity demand (TWh/year):		Flexible demand	4,07
Fixed demand	21,80	Fixed imp/exp.	0,00
Electric heating + HP	9,63	Transportation	8,22
Electric cooling	0,00	Total	43,72

District heating (TWh/year)	Gr.1	Gr.2	Gr.3	Sum
District heating demand	2,80	16,80	27,00	46,60
Solar Thermal	0,95	2,08	0,91	3,94
Industrial CHP (CSHP)	0,00	0,00	2,65	2,65
Demand after solar and CSHP	1,85	14,72	23,44	40,01

Wind	4454	MW	12,63	TWh/year	0,00	Grid
Offshore Wind	10173	MW	41,75	TWh/year	0,00	stabili-
Photo Voltaic	5000	MW	6,46	TWh/year	0,00	sation
Wave Power	300	MW	0,79	TWh/year	0,00	share
Hydro Power	0	MW	0	TWh/year		
Geothermal/Nuclear	0	MW	0	TWh/year		

	Capacities		Efficiencies		
Group 2:	MW-e	MJ/s	elec.	Ther	COP
CHP	1945	1241	0,58	0,37	
Heat Pump	300	1050			3,50
Boiler		6500		0,95	
Group 3:					
CHP	2500	1292	0,60	0,31	
Heat Pump	600	2100			3,50
Boiler		10300		0,95	
Condensing	12960		0,60		

Heatstorage: gr.2: 40 GWh gr.3: 10 GWh
Fixed Boiler: gr.2: 0,5 Per cent gr.3: 0,5 Per cent

Electricity prod. from	CSHP	Waste (TWh/year)
Gr.1:	0,00	0,00
Gr.2:	0,00	0,39
Gr.3:	0,89	0,72

Regulation Strategy:	Technical regulation no. 3	
KEOL regulation	23458000	
Minimum Stabilisation share	0,00	
Stabilisation share of CHP	0,00	
Minimum CHP gr 3 load	0	MW
Minimum PP	0	MW
Heat Pump maximum share	0,50	
Maximum import/export	0	MW

Distr. Name :	Price_DKV_2008.txt	
Addition factor	100,00	DKK/MWh
Multiplication factor	1,05	
Dependency factor	0,02	DKK/MWh pr. MW
Average Market Price	541	DKK/MWh
Gas Storage	6000	GWh
Syngas capacity	3522	MW
Biogas max to grid	895	MW

Fuel Price level:

	Capacities MW-e	Storage GWh	Efficiencies elec.	Ther.
Hydro Pump:	0	0	0,85	
Hydro Turbine:	0		0,85	
Electrol. Gr.2:	0	0	0,00	0,00
Electrol. Gr.3:	0	0	0,00	0,00
Electrol. trans.:	1909	477	0,73	
Ely. MicroCHP:	0	0	0,00	
CAES fuel ratio:		0,000		

(TWh/year)	Coal	Oil	Ngas	Biomass
Transport	0,00	0,00	0,00	0,00
Household	0,00	0,00	0,00	3,60
Industry	0,00	0,00	0,00	19,03
Various	0,00	0,00	0,00	0,00

Output WARNING!!: (1) Critical Excess;

District Heating

	Demand: Distr. heating MW	Production: Solar MW	Waste+ CSHP MW	DHP MW	CHP MW	HP MW	ELT MW	Boiler MW	EH MW	Ba-lance MW
January	8867	176	1307	469	1510	3120	0	2246	40	0
February	9052	371	1307	432	1037	3123	0	2655	131	-3
March	7732	420	1307	342	1181	2983	0	1439	53	7
April	6209	647	1307	202	1043	2397	0	592	44	-23
May	4880	694	1307	103	862	1787	0	60	22	44
June	2299	585	1256	13	217	308	0	1	2	-83
July	2287	652	1248	13	257	165	0	0	1	-50
August	2289	607	1250	13	236	236	0	1	1	-56
September	3445	551	1301	20	703	879	0	2	2	-12
October	5078	363	1307	162	590	2289	0	234	99	35
November	6638	199	1307	332	904	2768	0	1002	125	1
December	7906	118	1307	427	1594	2909	0	1493	54	4
Average	5548	448	1292	210	845	1911	0	805	48	-11
Maximum	15249	4467	1307	896	2532	3150	0	7364	600	2281
Minimum	2019	0	1056	11	0	26	0	0	0	-2378
TWh/year	48,73	3,94	11,35	1,85	7,42	16,78	0,00	7,07	0,42	-0,10

Electricity

	Consumption: Elec. demand MW	Flex.& Transp. MW	HP MW	Elec-trolyser MW	EH MW	Hydro Pump MW	Production: Tur-bine MW	RES MW	Hy-dro MW	Geo-thermal MW	Waste+ CSHP MW	CHP MW	PP MW	Balance: Stab-Load %	Imp MW	Exp MW	CEEP MW	EEP MW	Exchange Payment Imp Million DKK	Exp
January	2787	1398	2919	2273	40	0	0	5908	0	0	200	2650	659	100	0	0	0	0	0	0
February	2759	1399	2976	3250	131	0	0	8139	0	0	200	1820	365	100	0	9	9	0	0	0
March	2661	1418	2600	3152	53	0	0	7306	0	0	200	2070	356	100	0	47	47	0	0	0
April	2361	1382	1933	3388	44	0	0	6853	0	0	200	1826	280	100	0	53	53	0	0	0
May	2307	1398	1377	3889	22	0	0	7327	0	0	200	1505	233	100	0	274	274	0	0	0
June	2246	1414	290	3880	2	0	0	7446	0	0	206	348	112	100	0	281	281	0	0	0
July	2060	1408	211	2775	1	0	0	5747	0	0	207	413	402	100	0	314	314	0	0	0
August	2349	1389	245	3072	1	0	0	6275	0	0	207	382	415	100	0	221	221	0	0	0
September	2407	1412	760	3437	2	0	0	6412	0	0	201	1205	310	100	0	109	109	0	0	0
October	2492	1408	1641	4381	99	0	0	8794	0	0	200	1020	180	100	0	173	173	0	0	0
November	2682	1400	2229	3706	125	0	0	8178	0	0	200	1580	205	100	0	21	21	0	0	0
December	2683	1379	2621	2646	54	0	0	5913	0	0	200	2794	482	100	0	6	6	0	0	0
Average	2482	1400	1647	3318	48	0	0	7017	0	0	202	1468	334	100	0	127	127	0	Average price	
Maximum	3754	7344	4775	7658	600	0	0	18479	0	0	228	4445	4365	100	0	6071	6071	0	(DKK/MWh)	
Minimum	1312	-235	7	0	0	0	0	29	0	0	200	0	0	100	0	0	0	0	153	0
TWh/year	21,80	12,30	14,46	29,15	0,42	0,00	0,00	61,63	0,00	0,00	1,77	12,90	2,94		0,00	1,11	1,11	0,00	0	0

FUEL BALANCE (TWh/year):

	DHP	CHP2	CHP3	Boiler2	Boiler3	PP	Geo/Nu.	Hydro	Waste	CAES Elc.ly.	BioCon-version	Synthetic Fuel	Wind	Offsh.	PV	Wave	Solar.Th	Transp.	househ.	Industry Various	Total	Imp/Exp Corrected Imp/Exp	Netto	CO2 emission (Mt): Total	Netto
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
N.Gas	1,65	10,76	11,10	3,22	3,39	4,89	-	-	-	-	-22,85	3,61	-	-	-	-	-	-	-	-	15,76	-1,85	13,91	3,23	2,85
Biomass	0,30	-	-	0,86	-	-	-	-	4,16	-	38,87	-	-	-	-	-	-	-	3,38	19,03	66,60	0,00	66,60	0,00	0,00
Renewable	-	-	-	-	-	-	-	-	3,39	-	-	-	12,63	41,75	6,46	0,79	6,45	-	-	-	71,47	0,00	71,47	0,00	0,00
H2 etc.	-	0,00	0,00	0,00	0,00	0,00	-	-	-	-20,61	-10,85	31,45	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Biofuel	-	-	-	-	-	-	-	-	-	-	-	-32,15	-	-	-	-	-	32,15	-	-	0,00	0,00	0,00	0,00	0,00
Nuclear/CCS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0,00	0,00	0,00	0,00	0,00
Total	1,95	10,76	11,10	4,08	3,39	4,89	-	-	7,55	-20,61	5,17	2,91	12,63	41,75	6,46	0,79	6,45	32,15	3,38	19,03	153,84	-1,85	151,99	3,23	2,85

22-januar-2014 [16:36]

Output specifications ZEB_A100.txt The EnergyPLAN model 11.2

District Heating Production

	Gr.1 District heating MW	Gr.1 Solar MW	Gr.1 CSHP MW	Gr.1 DHP MW	Gr.2 District heating MW	Gr.2 Solar MW	Gr.2 CSHP MW	Gr.2 CHP MW	Gr.2 HP MW	Gr.2 ELT MW	Gr.2 Boiler MW	Gr.2 EH MW	Gr.2 Storage MW	Gr.2 Balance MW
January	513	44	0	469	3194	92	146	739	1046	0	1142	29	22428	0
February	525	93	0	432	3265	193	146	509	1039	0	1288	89	22446	0
March	447	105	0	342	2799	219	146	586	1015	0	793	35	21556	5
April	358	156	0	202	2266	341	146	525	859	0	375	29	20353	-9
May	281	178	0	103	1803	359	146	444	756	0	50	17	21487	31
June	127	115	0	13	880	328	146	194	242	0	1	2	24875	-32
July	127	115	0	13	880	373	146	227	131	0	0	1	24249	2
August	127	115	0	13	880	346	146	206	194	0	1	1	26849	-13
September	196	176	0	20	1289	261	146	420	469	0	2	2	25738	-9
October	291	129	0	162	1864	163	146	330	907	0	212	85	20347	21
November	382	50	0	332	2409	104	146	460	973	0	635	85	18937	7
December	456	30	0	427	2854	62	146	794	1012	0	804	37	19067	1
Average	319	109	0	210	2029	237	146	453	719	0	439	34	22359	0
Maximum	896	715	0	896	5491	2731	146	1241	1050	0	3300	400	40000	1346
Minimum	112	0	0	11	786	0	146	0	10	0	0	0	0	-992
Total for the whole year TWh/year	2,80	0,95	0,00	1,85	17,82	2,08	1,28	3,98	6,32	0,00	3,86	0,30		0,00

	Gr.3 District heating MW	Gr.3 Solar MW	Gr.3 CSHP MW	Gr.3 CHP MW	Gr.3 HP MW	Gr.3 ELT MW	Gr.3 Boiler MW	Gr.3 EH MW	Gr.3 Storage MW	Gr.3 Balance MW	RES specification RES1 Wind MW	RES2 Offshoi MW	RES3 Photo ' MW	RES4 Wave I MW	Total er MW
January	5160	40	1161	770	2074	0	1103	12	176	0	1303	4348	168	88	5908
February	5263	85	1161	528	2083	0	1367	42	2618	-3	1841	5637	495	166	8139
March	4486	96	1161	595	1968	0	646	18	2563	2	1509	4962	716	119	7306
April	3585	149	1161	518	1538	0	217	15	3398	-13	1271	4432	1093	58	6853
May	2796	157	1161	418	1032	0	10	6	5288	13	1270	4372	1631	53	7327
June	1291	143	1111	22	66	0	0	0	8622	-51	1356	4782	1260	48	7446
July	1279	165	1103	29	34	0	0	0	8939	-53	918	3345	1436	48	5747
August	1281	147	1104	30	43	0	0	0	8942	-43	1267	4289	654	65	6275
September	1960	114	1155	283	410	0	0	0	9014	-3	1265	4382	678	87	6412
October	2924	71	1161	260	1383	0	21	14	6573	13	2013	6214	439	128	8794
November	3847	45	1161	444	1795	0	367	41	4786	-6	1930	5944	177	128	8178
December	4596	27	1161	801	1897	0	689	17	2368	4	1332	4408	73	99	5913
Average	3200	103	1147	392	1191	0	365	14	5276	-12	1437	4753	736	90	7017
Maximum	8863	1275	1161	1292	2100	0	4310	200	10000	1325	4454	10173	5000	300	18479
Minimum	1121	0	910	0	16	0	0	0	0	-1567	0	0	0	1	29
Total for the whole year TWh/year	28,11	0,91	10,07	3,44	10,46	0,00	3,21	0,12		-0,10	12,63	41,75	6,46	0,79	61,63

ANNUAL COSTS (Million DKK)

Total Fuel -		15735
Uranium -	0	
Coal -	0	
FuelOil -	0	
Gasoil/Diesel-	0	
Petrol/JP -	3380	
Ngas -	1112	
Biomass -	11243	
Food income -	0	
Waste -	0	
Marginal operation costs -		325
Total Electricity exchange -		0
Import -	0	
Export -	0	
Bottleneck -	0	
Fixed imp/ex-	0	
Total CO2 emission costs -		833
Total Ngas Exchange costs -		4444
Total variable costs -		21337
Fixed operation costs -		38795
Annual Investment costs -		113765
TOTAL ANNUAL COSTS -		173897

	DHP & Boilers MW	CHP2 CHP3 MW	PP CAES MW	Individual MW	Transport MW	Indu. Var. MW	Demand Sum MW	Biogas MW	Syngas MW	CO2Hy gas MW	SynHy gas MW	SynHy gas MW	Storage MW	Sum MW	Import MW	Export MW
January	2538	4483	1099	0	0	0	8120	895	3062	930	1814	-3660	3285	1795	1795	0
February	2905	3079	609	0	0	0	6594	895	2708	1361	1814	-3660	1682	1795	1795	0
March	1650	3504	593	0	0	0	5747	895	2541	1329	1814	-3660	383	2444	2444	0
April	722	3091	467	0	0	0	4280	895	1983	1414	1814	-3660	37	1799	1799	0
May	144	2549	389	0	0	0	3083	895	1529	1676	1814	-3660	-966	1795	1795	0
June	12	597	187	0	0	0	796	895	271	1750	1814	-3660	-2068	1795	1795	0
July	12	709	669	0	0	0	1390	895	531	1292	1814	-3660	-1275	1795	1795	0
August	12	654	691	0	0	0	1358	895	608	1384	1814	-3660	-1476	1795	1795	0
September	19	2047	517	0	0	0	2583	895	1405	1500	1814	-3660	-1165	1795	1795	0
October	345	1730	300	0	0	0	2375	895	1066	1909	1814	-3660	-1149	1500	1625	125
November	1215	2675	341	0	0	0	4231	895	1810	1563	1814	-3660	385	1424	1527	103
December	1780	4728	804	0	0	0	7312	895	2993	1134	1814	-3660	2343	1795	1795	0
Average	941	2488	557	0	0	0	3986	895	1707	1436	1814	-3660	0	1795	1814	19
Maximum	7903	7520	7275	0	0	0	22698	895	3522	3703	1814	-3660	18334	9668	9668	2715
Minimum	10	0	0	0	0	0	10	895	0	0	1814	-3660	-4536	-2715	0	0
Total for the whole year TWh/year	8,26	21,86	4,89	0,00	0,00	0,00	35,01	7,86	14,99	12,61	15,93	-32,15	0,00	15,76	15,93	0,17

RES Share: 89,8 Percent of Primary Energy 90,2 Percent of Electricity 62,5 TWh electricity from RES 22-januar-2014 [16:36]

Appendix 2: Building Calculations

To identify the marginal cost curves relating to increased energy efficiency in buildings, the analysis considers both existing buildings and new buildings from the point of view of lowering the heat demand. To analyse the lowering of the heat demand in buildings, the data does not include energy production in the form of solar heating and photovoltaic. The data focuses on presenting the marginal costs of lowering heat demands through better windows and an increasing level of insulation. The analyses use two sets of data, one for the existing buildings and one for new buildings. The domestic use of hot water is constant.

The data for energy renovation in existing buildings is represented in a spreadsheet in relation to the study *"Heat demand in Danish buildings in 2050"* [1]:

- Tables 2.3-2.5

The data for savings in new buildings is based on data in relation to the study "*Cost-optimal levels of minimum energy performance requirements in the Danish Building Regulations"* [2]:

- Tables 2.6-2.7

Both sets of data apply the following assumptions concerning lifetimes, use of ventilation, inclusion of electricity, and actual performance of the buildings:

- To reach a higher energy efficiency, both existing and new buildings must include mechanical ventilation. Another argument for mechanical ventilation is that it increases the comfort in buildings. The primary assumption is therefore that mechanical ventilation is always included in new buildings and the refurbishment of existing buildings.
- By including mechanical ventilation, the electricity consumption of the building increases. This is modelled by adding an electricity price of 1 DKK/kWh. The basis for this cost is the marginal cost of producing one more unit of electricity in the smart energy system.
- Aggerholm [2] argues that in a building with a possible technical performance of 40 kWh/m^2, an average household can use up to 30% more energy than actually needed for heating based on user behaviour. This increase due to behaviour is not included in the study for the sake of comparison between the two data sets for new and existing buildings, and production calculations.

Table 2.1. Lifetimes of different types of insulations and windows [2,3].

Activity	Lifetime [years]
Windows	40
Wall insulation	60
Loft insulation	60
Slap insulation	60
Mechanical ventilation	40

Based on ”*Levetider for bygningsdele ved vurdering af bæredygtighed og totaløkonomi”* [3], which estimates the lifetime of mechanical elements at 25 years and of channels at 50 years, the total lifetime of mechanical ventilation is estimated at 40 years.

Existing buildings

The renovation of existing buildings takes place by increasing the energy efficiency in a single step. Thus, there is no gradual improvement of each building type. Tables 2.3-2.5 highlight the initial information for each building type. For practical reasons, the analysis only includes single-family houses, terrace houses and farmhouses, and existing buildings built after 2007 are not included. It should be noted that the hot water consumption here is 13.7 kWh/m^2, which is different from Appendix 1. However, this does not influence the results since the hot water consumption is fixed. Thus, the difference between before and after the implementation of savings is independent on the level of hot water consumption.

Based on the numbers shown in Tables 2.3-2.5, it is possible to calculate the marginal reduction costs per kWh saved. First, the total investment costs are annualized based on the 3% discount rate and the lifetimes specified in Table 2.1.

$$Cost_{year} = \frac{I * r}{(1-(1+r)^{n})}$$

After finding the annualized costs, these are divided by the savings highlighted in Tables 2.3-2.5 as well. By organizing each building type according to which saving is the cheapest, the graphs and tables highlight a desired progression. To identify the x coordinate for each step, the analysis uses the average between the heat consumption before and after the renovation. The results are shown in Table 2.2 that divides savings into “marginal” and “total” costs. “Marginal” costs are costs only related to energy improvements indicative of situations in which the buildings are being renovated anyway, whereas “total” costs reflect situations in which the initial renovation is included.

Table 2.2. Prioritizing savings in existing buildings.

Marginal				**Total**			
Type	Year	kWh/m^2	DKK/kWh	Type	Year	kWh/m^2	DKK/kWh
-	-	131.76	0.33	-	-	131.76	0.48
Terrace house	1931-1950	131.20	0.34	Terrace house	1931-1950	131.20	0.50
Terrace house	1850-1930	129.75	0.36	Terrace house	1951-1960	130.03	0.53
Terrace house	1951-1960	128.25	0.36	Farmhouse	1931-1950	128.83	0.64
Terrace house	Before 1850	127.54	0.40	Terrace house	1850-1930	127.36	0.64

Single-family house	1931-1950	122.91	0.42	Single-family house	1931-1950	121.93	0.66
Farmhouse	1931-1950	117.79	0.42	Terrace house	Before 1850	117.30	0.70
Farmhouse	1850-1930	113.54	0.44	Terrace house	1961-1972	116.30	0.74
Farmhouse	1951-1960	109.68	0.44	Single-family house	1951-1960	111.96	0.78
Single-family house	1951-1960	106.05	0.44	Farmhouse	1951-1960	108.32	0.79
Farmhouse	Before 1850	102.19	0.44	Terrace house	1973-1978	107.55	0.83
Single-family house	1850-1930	93.34	0.45	Single-family house	1850-1930	98.54	0.85
Single-family house	Before 1850	84.23	0.47	Farmhouse	Before 1850	89.69	0.85
Terrace house	1961-1972	82.65	0.49	Farmhouse	1850-1930	85.61	0.87
Farmhouse	1961-1972	81.59	0.56	Single-family house	Before 1850	81.27	0.87
Terrace house	1973-1978	80.86	0.57	Single-family house	1961-1972	73.20	0.89
Single-family house	1961-1972	72.89	0.57	Farmhouse	1961-1972	65.66	0.90
Farmhouse	1973-1978	65.40	0.62	Single-family house	1973-1978	61.99	0.97
Single-family house	1973-1978	61.79	0.64	Terrace house	1979-1998	57.10	1.00
Terrace house	1979-1998	56.90	0.66	Farmhouse	1973-1978	55.63	1.04
Farmhouse	1999-2006	55.49	0.67	Single-family house	1979-1998	53.57	1.06
Farmhouse	1979-1998	55.33	0.70	Farmhouse	1979-1998	51.50	1.07

Single-family house	1979-1998	53.26	0.71	Farmhouse	1999-2006	51.35	1.15
Terrace house	1999-2006	50.97	0.83	Terrace house	1999-2006	50.97	1.23
Single-family house	1999-2006	50.05	0.84	Single-family house	1999-2006	50.05	1.25

When plotting these two developments into a graph, Figure 2.1 represents the marginal and total costs of improving the heat efficiency in existing buildings.

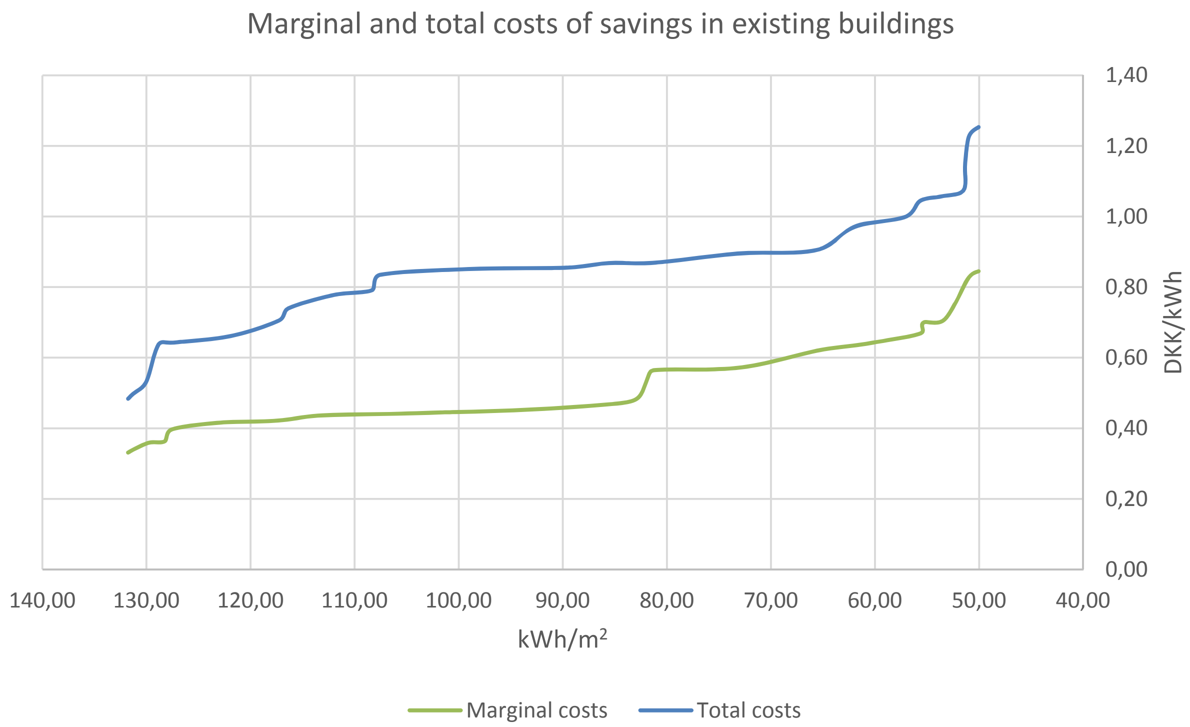


Figure 2.1. Costs of heat savings in existing buildings.

Figure 2.1 has been calculated with a discount rate of 3%. Figure 2.2 shows the sensitivity of the results to the interest rate, testing for 1% and 5% discount rate, respectively. The results are quite sensitive to the interest rate, as they are only investment costs. However, because energy savings are long-term investments, the interest rate should be rather low – around 3%.

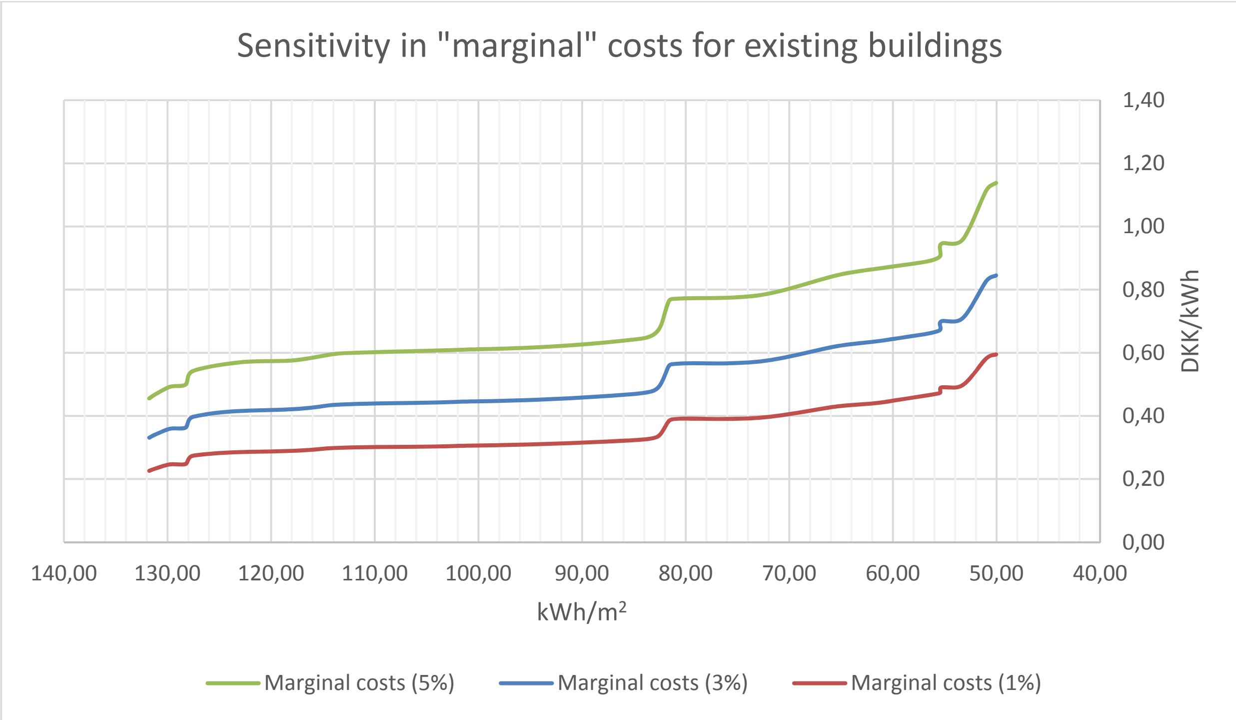


Figure 2.2. Sensitivity to the discount rate when performing heat savings in existing buildings.

Table 2.3. Data on savings in existing single-family houses

Single family house														Loss					Costs (total/marginal)					
		Distribution of heat flows						Saving				Hot water	Total consum	Roof	Floor	Outer walls	Windows	Ventilation	Roof	Floor	Outer walls	Windows	Ventilation	
		Roof	Floor	Outer walls	Windows	Ventilation	Sum	LivArea	TJ	kWh/m2	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	DKK/m²					
Before 1850	Reno	0,159	0,410	0,299	0,210	0,076	1,154	2967838,333	1002,501	93,830	38,489	13,733	52,222	5,309	13,673	9,983	7,003	2,521	754,744	135,115	96,147	374,354	624,000	Total
	Orig	0,230	0,453	0,804	0,438	0,378	2,302	2967838,333			132,319	13,733	146,052	13,230	26,015	46,178	25,172	21,724	220,215	118,226	96,147	0,000	624,000	Marginal
1850-1930	Reno	0,140	0,396	0,315	0,210	0,076	1,137	33739545,000	12474,714	102,704	37,063	13,733	50,796	4,560	12,904	10,286	6,848	2,465	876,261	138,335	111,848	374,086	624,000	Total
	Orig	0,309	0,550	0,725	0,443	0,378	2,405	33739545,000			139,767	13,733	153,500	17,969	31,985	42,120	25,721	21,972	255,670	121,043	111,848	0,000	624,000	Marginal
1931-1950	Reno	0,141	0,442	0,321	0,210	0,076	1,190	15889515,000	6713,852	117,370	47,830	13,733	61,563	5,661	17,777	12,913	8,439	3,038	616,330	140,279	148,042	374,111	624,000	Total
	Orig	0,311	0,666	0,759	0,435	0,378	2,549	15889515,000			165,200	13,733	178,933	20,185	43,139	49,178	28,197	24,502	278,704	122,744	148,042	0,000	624,000	Marginal
1951-1960	Reno	0,158	0,486	0,340	0,210	0,076	1,269	12661489,000	5086,942	111,601	54,652	13,733	68,385	6,801	20,929	14,623	9,043	3,256	807,671	155,467	159,269	373,658	624,000	Total
	Orig	0,316	0,652	0,780	0,435	0,378	2,561	12661489,000			166,253	13,733	179,986	20,506	42,319	50,646	28,241	24,541	267,078	136,033	159,269	0,000	624,000	Marginal
1961-1972	Reno	0,175	0,401	0,260	0,210	0,071	1,117	38355326,000	10929,686	79,155	41,485	13,733	55,218	6,500	14,889	9,642	7,801	2,652	504,535	135,912	99,299	373,796	624,000	Total
	Orig	0,272	0,442	0,545	0,438	0,336	2,033	38355326,000			120,640	13,733	134,373	16,153	26,208	32,346	25,993	19,940	240,713	118,923	99,299	0,000	624,000	Marginal
1973-1978	Reno	0,180	0,328	0,220	0,195	0,071	0,994	22036992,000	5202,842	65,582	30,876	13,733	44,609	5,604	10,177	6,820	6,058	2,218	401,043	100,314	59,073	374,903	624,000	Total
	Orig	0,247	0,341	0,414	0,416	0,336	1,753	22036992,000			96,458	13,733	110,191	13,583	18,758	22,765	22,863	18,488	216,455	87,775	59,073	0,000	624,000	Marginal
1979-1998	Reno	0,184	0,267	0,224	0,180	0,067	0,921	17697027,000	2904,286	45,587	24,595	13,733	38,327	4,901	7,125	5,969	4,806	1,794	152,255	13,236	16,769	374,183	624,000	Total
	Orig	0,193	0,274	0,301	0,387	0,294	1,449	17697027,000			70,181	13,733	83,914	9,360	13,254	14,580	18,746	14,241	100,382	11,581	16,769	0,000	624,000	Marginal
1999-2006	Reno	0,150	0,218	0,209	0,182	0,067	0,825	7347267,000	875,354	33,094	20,744	13,733	34,477	3,771	5,470	5,250	4,563	1,689	33,804	0,000	0,000	360,190	624,000	Total
	Orig	0,150	0,218	0,226	0,299	0,294	1,186	7347267,000			53,839	13,733	67,572	6,812	9,880	10,242	13,555	13,351	22,287	0,000	0,000	0,000	624,000	Marginal
After 2007	Reno	0,120	0,190	0,167	0,180	0,067	0,724	4080967,000	418,297	28,472	6,602	13,733	20,335	1,095	1,729	1,524	1,642	0,613	3,848	0,000	0,000	282,852	624,000	Total
	Orig	0,112	0,153	0,189	0,242	0,294	0,989	4080967,000			35,074	13,733	48,807	3,966	5,420	6,696	8,565	10,427	2,537	0,000	0,000	0,000	624,000	Marginal

Table 2.4. Data on savings in existing farmhouses

Farmhouse														Loss					Costs (total/marginal)					
		Distribution of heat flows						Saving			Consumption	Hot water	Total consum	Roof	Floor	Outer walls	Windows	Ventilation	Roof	Floor	Outer walls	Windows	Ventilation	
		Roof	Floor	Outer walls	Windows	Ventilation	Sum	LivArea	TJ	kWh/m2	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	DKK/m²					
Before 1850	Reno	0,172	0,391	0,254	0,210	0,076	1,102	1715297,364	617,828	100,052	34,261	13,733	47,994	5,353	12,146	7,883	6,529	2,350	814,939	158,842	110,975	374,743	624,000	Total
	Orig	0,413	0,505	0,589	0,452	0,378	2,337	1715297,364			134,313	13,733	148,046	23,747	29,031	33,866	25,947	21,723	195,425	138,986	110,975	0,000	624,000	Marginal
1850-1930	Reno	0,151	0,396	0,273	0,210	0,076	1,107	14277615,000	5418,004	105,410	34,628	13,733	48,361	4,737	12,400	8,554	6,572	2,366	952,343	150,576	119,911	374,450	624,000	Total
	Orig	0,374	0,552	0,655	0,449	0,378	2,408	14277615,000			140,038	13,733	153,771	21,777	32,125	38,068	26,084	21,984	228,375	131,754	119,911	0,000	624,000	Marginal
1931-1950	Reno	0,139	0,387	0,281	0,210	0,076	1,093	2160196,000	863,942	111,094	39,397	13,733	53,130	5,001	13,961	10,137	7,572	2,726	483,889	137,378	123,276	373,420	624,000	Total
	Orig	0,321	0,581	0,658	0,440	0,378	2,378	2160196,000			150,490	13,733	164,223	20,321	36,783	41,660	27,809	23,918	253,510	120,205	123,276	0,000	624,000	Marginal
1951-1960	Reno	0,140	0,387	0,278	0,210	0,076	1,090	736696,000	292,355	110,235	39,198	13,733	52,931	5,017	13,904	10,008	7,550	2,718	835,951	153,523	138,703	374,065	624,000	Total
	Orig	0,345	0,556	0,655	0,432	0,378	2,366	736696,000			149,433	13,733	163,166	21,799	35,138	41,339	27,283	23,873	267,240	134,332	138,703	0,000	624,000	Marginal
1961-1972	Reno	0,152	0,339	0,238	0,210	0,071	1,011	790234,000	229,652	80,726	32,308	13,733	46,041	4,867	10,832	7,610	6,716	2,283	547,009	145,231	99,376	374,350	624,000	Total
	Orig	0,262	0,392	0,512	0,442	0,336	1,945	790234,000			113,034	13,733	126,767	15,238	22,788	29,765	25,715	19,528	231,293	127,077	99,376	0,000	624,000	Marginal
1973-1978	Reno	0,154	0,267	0,192	0,195	0,071	0,878	634035,000	147,552	64,644	20,891	13,733	34,624	3,659	6,339	4,557	4,638	1,698	498,226	100,715	53,961	370,724	624,000	Total
	Orig	0,227	0,284	0,356	0,425	0,336	1,627	634035,000			85,535	13,733	99,268	11,922	14,910	18,711	22,323	17,669	185,129	88,126	53,961	0,000	624,000	Marginal
1979-1998	Reno	0,152	0,206	0,193	0,180	0,067	0,798	972585,000	160,276	45,776	13,919	13,733	27,652	2,648	3,593	3,365	3,141	1,173	171,832	15,433	17,771	375,000	624,000	Total
	Orig	0,168	0,217	0,262	0,387	0,294	1,327	972585,000			59,695	13,733	73,428	7,542	9,763	11,767	17,403	13,221	90,158	13,504	17,771	0,000	624,000	Marginal
1999-2006	Reno	0,128	0,148	0,156	0,235	0,067	0,735	460395,000	69,294	41,809	12,492	13,733	26,225	2,176	2,520	2,654	4,000	1,142	47,494	0,000	0,000	526,776	624,000	Total
	Orig	0,128	0,148	0,180	0,440	0,294	1,191	460395,000			54,301	13,733	68,034	5,841	6,764	8,220	20,067	13,408	24,920	0,000	0,000	0,000	624,000	Marginal
After 2007	Reno	0,093	0,122	0,127	0,176	0,067	0,586	324443,000	34,526	29,560	-3,319	13,733	10,414	-0,529	-0,693	-0,722	-0,994	-0,381	2,352	0,000	0,000	319,576	624,000	Total
	Orig	0,093	0,122	0,134	0,264	0,294	0,908	324443,000			26,242	13,733	39,975	2,698	3,536	3,878	7,632	8,499	1,234	0,000	0,000	0,000	624,000	Marginal

Table 2.5. Data on savings in existing terrace houses.

Terrace house		Distribution of heat flows						Saving						Loss					Costs (total/marginal)					
		Roof	Floor	Outer walls	Windows	Ventilation	Sum	LivArea	TJ	kWh/m2	Consumption	Hot water	Total consur	Roof	Floor	Outer walls	Windows	Ventilation	Roof	Floor	Outer walls	Windows	Ventilation	
											kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	DKK/m²					
Before 1850	Reno	0,137	0,362	0,344	0,210	0,076	1,129	400971,231	137,234	95,070	36,422	13,733	50,155	4,411	11,682	11,112	6,777	2,440	463,403	94,362	85,386	373,162	624,000	Total
	Orig	0,230	0,453	0,804	0,438	0,378	2,302	400971,231			131,492	13,733	145,225	13,147	25,853	45,889	25,015	21,588	108,202	82,567	85,386	0,000	624,000	Marginal
1850-1930	Reno	0,123	0,375	0,368	0,210	0,076	1,152	3237711,000	1316,785	112,973	38,293	13,733	52,026	4,102	12,456	12,240	6,982	2,514	540,933	126,618	114,140	374,240	624,000	Total
	Orig	0,279	0,547	0,898	0,444	0,378	2,546	3237711,000			151,266	13,733	164,999	16,586	32,515	53,336	26,374	22,454	126,305	110,791	114,140	0,000	624,000	Marginal
1931-1950	Reno	0,129	0,439	0,347	0,210	0,076	1,201	1864919,000	829,793	123,597	48,767	13,733	62,500	5,250	17,823	14,098	8,527	3,070	257,047	110,978	169,100	373,679	624,000	Total
	Orig	0,265	0,710	0,846	0,432	0,378	2,632	1864919,000			172,364	13,733	186,096	17,382	46,532	55,395	28,296	24,759	126,635	97,106	169,100	0,000	624,000	Marginal
1951-1960	Reno	0,149	0,431	0,340	0,210	0,076	1,206	2161159,000	907,230	116,608	49,156	13,733	62,889	6,075	17,569	13,866	8,563	3,083	239,408	151,183	156,684	373,114	624,000	Total
	Orig	0,321	0,601	0,820	0,435	0,378	2,555	2161159,000			165,764	13,733	179,497	20,857	38,992	53,172	28,221	24,523	113,378	132,285	156,684	0,000	624,000	Marginal
1961-1972	Reno	0,147	0,357	0,258	0,210	0,071	1,044	4605842,000	1339,178	80,766	35,166	13,733	48,899	4,968	12,021	8,694	7,076	2,406	242,067	146,950	98,363	373,216	624,000	Total
	Orig	0,260	0,411	0,542	0,429	0,336	1,978	4605842,000			115,932	13,733	129,665	15,246	24,107	31,751	25,139	19,689	100,217	128,581	98,363	0,000	624,000	Marginal
1973-1978	Reno	0,161	0,282	0,218	0,195	0,071	0,928	3747869,000	854,997	63,369	25,138	13,733	38,871	4,356	7,651	5,910	5,285	1,935	154,861	111,255	46,096	374,051	624,000	Total
	Orig	0,233	0,294	0,386	0,413	0,336	1,661	3747869,000			88,507	13,733	102,240	12,420	15,643	20,560	21,981	17,904	85,071	97,348	46,096	0,000	624,000	Marginal
1979-1998	Reno	0,172	0,247	0,217	0,180	0,067	0,883	12921675,000	2023,056	43,490	21,332	13,733	35,065	4,155	5,971	5,237	4,346	1,623	67,446	0,000	0,000	374,336	624,000	Total
	Orig	0,172	0,247	0,267	0,407	0,294	1,387	12921675,000			64,822	13,733	78,555	8,043	11,559	12,478	19,000	13,742	38,717	0,000	0,000	0,000	624,000	Marginal
1999-2006	Reno	0,153	0,197	0,213	0,161	0,067	0,791	4096682,000	485,657	32,930	17,619	13,733	31,352	3,410	4,384	4,754	3,575	1,497	11,120	0,000	0,000	358,061	624,000	Total
	Orig	0,153	0,197	0,230	0,276	0,294	1,150	4096682,000			50,550	13,733	64,282	6,731	8,653	10,105	12,134	12,926	6,384	0,000	0,000	0,000	624,000	Marginal
After 2007	Reno	0,112	0,153	0,181	0,170	0,067	0,682	1843805,000	187,073	28,183	4,864	13,733	18,597	0,798	1,090	1,288	1,209	0,479	3,951	0,000	0,000	272,624	624,000	Total
	Orig	0,112	0,153	0,189	0,242	0,294	0,989	1843805,000			33,047	13,733	46,780	3,737	5,107	6,309	8,070	9,825	2,268	0,000	0,000	0,000	624,000	Marginal

New buildings

When constructing a new building, one has the option of determining the level of insulation and types of elements such as windows and ventilation. Therefore, this part of the analysis examines the development of the marginal cost gradually, by looking at the impacts of choosing a higher level of insulation or installing more energy efficient windows.

The analysis uses two sets of data. One that describes the marginal costs per kWh when building a house with natural ventilation, and one that does the same for the construction of a house with mechanical ventilation. Both houses are 150 m^2 and the progression in choosing new elements and increasing the energy efficiency is the same in both houses. The argument for looking at the houses separately is that mechanical ventilation can be seen as a cost tied to improving the indoor climate and not only increasing the energy efficiency. The analysis also investigates cases with lower prices of insulation and components which must be expected in the future. The analysis only looks at single-family houses.

Tables 2.6-2.7 show the initial data used for this analysis.

Table 2.6. Data on new single-family houses with natural ventilation.

Single Family - DH											
Natural ventilation											
				Expected heating consumption							
Gross floor area	150,0	m²		Higher fix point	100	kWh/m²	0	% additional consumption			
Discount rate (real, macro	3,0	% pa. net		Lower fix point	40	kWh/m²	0	% additional consumption			
Today prices											
Code	Measure	Lifetime	NPV factor	Marginal Price	Unit	Init. Invest.		Heating	Addition	Heating	Simple saving costs
		years		DKK/Unit	No.-m²	DKK/m²		kWh/m²	%	kWh/m²	DKK/kWh
						Excl. VAT		Normative		Expected	
SF.DH.401.C.NV.No	No							84,87	0,0	84,87	
SF.DH.401.B.NV.No	Windows B	40	23,1	114	33	25,08		79,73	0,0	79,73	0,21
SF.DH.501.B.NV.No	Loft 220 mm insulation	60	27,7	14	150	14,00		78,00	0,0	78,00	0,29
SF.DH.511.B.NV.No	Wall 150 mm insulation	60	27,7	22	112	16,43		75,87	0,0	75,87	0,28
SF.DH.521.B.NV.No	Wall 190 mm insulation	60	27,7	42	112	31,36		73,40	0,0	73,40	0,46
SF.DH.521.A.NV.No	Windows A	40	23,1	295	33	64,90		70,40	0,0	70,40	0,94
SF.DH.621.A.NV.No	Loft 245 mm insulation	60	27,7	42	150	42,00		68,93	0,0	68,93	1,03
SF.DH.622.A.NV.No	Slap 200 mm insulatior	60	27,7	60	128	51,20		67,27	0,0	67,27	1,11
SF.DH.722.A.NV.No	Loft 290 mm insulation	60	27,7	80	150	80,00		65,13	0,0	65,13	1,35
SF.DH.822.A.NV.No	Loft 315 mm insulation	60	27,7	25	150	25,00		64,20	0,0	64,20	0,97
SF.DH.842.A.NV.No	Wall 250 mm insulation	60	27,7	130	112	97,07		62,13	0,0	62,13	1,69
SF.DH.942.A.NV.No	Loft 340 mm insulation	60	27,7	12	150	12,00		61,40	0,0	61,40	0,59
SF.DH.1042.A.NV.No	Loft 365 mm insulation	60	27,7	36	150	36,00		60,80	0,0	60,80	2,17
Price estimate in 3-5 years, when being core market solutions. Insulation solutions -20%. Component solutions -50%.											
Code	Measure	Lifetime	NPV factor	Marginal Price	Unit	Init. Invest.		Heating	Addition	Heating	Simple saving costs
		years		DKK/Unit	No.-m²	DKK/m²		kWh/m²	%	kWh/m²	DKK/kWh
						Excl. VAT		Normative		Expected	
SF.DH.401.C.NV.No	No							84,87	0,0	84,87	
SF.DH.401.B.NV.No	Windows B	40	23,1	57,00	33	12,54		79,73	0,0	79,73	0,11
SF.DH.501.B.NV.No	Loft 220 mm insulation	60	27,7	11,20	150	11,20		78,00	0,0	78,00	0,23
SF.DH.511.B.NV.No	Wall 150 mm insulation	60	27,7	17,60	112	13,14		75,87	0,0	75,87	0,22
SF.DH.521.B.NV.No	Wall 190 mm insulation	60	27,7	33,60	112	25,09		73,40	0,0	73,40	0,37
SF.DH.521.A.NV.No	Windows A	40	23,1	147,50	33	32,45		70,40	0,0	70,40	0,47
SF.DH.621.A.NV.No	Loft 245 mm insulation	60	27,7	33,60	150	33,60		68,93	0,0	68,93	0,83
SF.DH.622.A.NV.No	Slap 200 mm insulatior	60	27,7	48,00	128	40,96		67,27	0,0	67,27	0,89
SF.DH.722.A.NV.No	Loft 290 mm insulation	60	27,7	64,00	150	64,00		65,13	0,0	65,13	1,08
SF.DH.822.A.NV.No	Loft 315 mm insulation	60	27,7	20,00	150	20,00		64,20	0,0	64,20	0,78
SF.DH.842.A.NV.No	Wall 250 mm insulation	60	27,7	104,00	112	77,65		62,13	0,0	62,13	1,36
SF.DH.942.A.NV.No	Loft 340 mm insulation	60	27,7	9,60	150	9,60		61,40	0,0	61,40	0,48
SF.DH.1042.A.NV.No	Loft 365 mm insulation	60	27,7	28,80	150	28,80		60,80	0,0	60,80	1,73

Table 2.7. Data on new single-family houses with natural ventilation.

Single Family - DH											
Balanced mechanical ventilation											
				Expected heating consumption							
Gross floor area	150,0	m²		Higher fix point	100	kWh/m²	0	% additional consumption			
Discount rate (real, macro	3,0	% pa. net		Lower fix point	40	kWh/m²	0	% additional consumption			
Today prices											
Code	Measure	Lifetime	NPV factor	Marginal Price	Unit	Init. Invest.		Heating	Addition	Heating	Simple saving costs
		years		DKK/Unit	No.-m²	DKK/m²		kWh/m²	%	kWh/m²	DKK/kWh
						Excl. VAT		Normative		Expected	
SF.DH.401.C.MV.No	No							67,13	0,0	67,13	
SF.DH.401.B.MV.No	Windows B	40	23,1	114	33	25,08		62,20	0,0	62,20	0,22
SF.DH.501.B.MV.No	Loft 220 mm insulation	60	27,7	14	150	14,00		60,53	0,0	60,53	0,30
SF.DH.511.B.MV.No	Wall 150 mm insulation	60	27,7	22	112	16,43		58,53	0,0	58,53	0,30
SF.DH.521.B.MV.No	Wall 190 mm insulation	60	27,7	42	112	31,36		56,13	0,0	56,13	0,47
SF.DH.521.A.MV.No	Windows A	40	23,1	295	33	64,90		53,20	0,0	53,20	0,96
SF.DH.621.A.MV.No	Loft 245 mm insulation	60	27,7	42	150	42,00		51,80	0,0	51,80	1,08
SF.DH.622.A.MV.No	Slap 200 mm insulatior	60	27,7	60	128	51,20		50,07	0,0	50,07	1,07
SF.DH.722.A.MV.No	Loft 290 mm insulation	60	27,7	80	150	80,00		48,00	0,0	48,00	1,40
SF.DH.822.A.MV.No	Loft 315 mm insulation	60	27,7	25	150	25,00		47,07	0,0	47,07	0,97
SF.DH.842.A.MV.No	Wall 250 mm insulation	60	27,7	130	112	97,07		45,13	0,0	45,13	1,81
SF.DH.942.A.MV.No	Loft 340 mm insulation	60	27,7	12	150	12,00		44,40	0,0	44,40	0,59
SF.DH.1042.A.MV.No	Loft 365 mm insulation	60	27,7	36	150	36,00		43,87	0,0	43,87	2,45
Price estimate in 3-5 years, when being core market solutions. Insulation solutions -20%. Component solutions -50%.											
Code	Measure	Lifetime	NPV factor	Marginal Price	Unit	Init. Invest.		Heating	Addition	Heating	Simple saving costs
		years		DKK/Unit	No.-m²	DKK/m²		kWh/m²	%	kWh/m²	DKK/kWh
						Excl. VAT		Normative		Expected	
SF.DH.401.C.MV.No	No							67,13	0,0	67,13	
SF.DH.401.B.MV.No	Windows B	40	23,1	57,00	33	12,54		62,20	0,0	62,20	0,11
SF.DH.501.B.MV.No	Loft 220 mm insulation	60	27,7	11,20	150	11,20		60,53	0,0	60,53	0,24
SF.DH.511.B.MV.No	Wall 150 mm insulation	60	27,7	17,60	112	13,14		58,53	0,0	58,53	0,24
SF.DH.521.B.MV.No	Wall 190 mm insulation	60	27,7	33,60	112	25,09		56,13	0,0	56,13	0,38
SF.DH.521.A.MV.No	Windows A	40	23,1	147,50	33	32,45		53,20	0,0	53,20	0,48
SF.DH.621.A.MV.No	Loft 245 mm insulation	60	27,7	33,60	150	33,60		51,80	0,0	51,80	0,87
SF.DH.622.A.MV.No	Slap 200 mm insulatior	60	27,7	48,00	128	40,96		50,07	0,0	50,07	0,86
SF.DH.722.A.MV.No	Loft 290 mm insulation	60	27,7	64,00	150	64,00		48,00	0,0	48,00	1,12
SF.DH.822.A.MV.No	Loft 315 mm insulation	60	27,7	20,00	150	20,00		47,07	0,0	47,07	0,78
SF.DH.842.A.MV.No	Wall 250 mm insulation	60	27,7	104,00	112	77,65		45,13	0,0	45,13	1,45
SF.DH.942.A.MV.No	Loft 340 mm insulation	60	27,7	9,60	150	9,60		44,40	0,0	44,40	0,48
SF.DH.1042.A.MV.No	Loft 365 mm insulation	60	27,7	28,80	150	28,80		43,87	0,0	43,87	1,96

These tables do not include the costs for electricity and maintenance of the mechanical ventilation but this will not affect the marginal costs in the mechanically ventilated house, since these costs are constant.

The "simple savings costs" are the marginal costs per kWh of the savings. By using the numbers for expected heating before and after each efficiency increase, the average forms the x coordinate for each marginal cost. By combining this with the marginal savings costs, it becomes possible to generate the figures shown in Table 2.8.

Table 2.8. Progression of heat savings in new buildings. Divided into natural ventilation and mechanical ventilation and current prices and future prices. All costs are marginal, meaning that the costs for increasing the performance are introduced in one step at a time.

Measure	Natural ventilation house			Mechanical ventilation house		
	Energy use [kWh/m^2]	MC Current prices [DKK/kWh]	MC New prices [DKK/kWh]	Energy use [kWh/m^2]	MC Current prices [DKK/kWh]	MC New prices [DKK/kWh]
No	84.87	0.17	0.04	67.13	0.18	0.04
Windows B	79.73	0.21	0.11	62.20	0.22	0.11
Loft 220 mm insulation	78.00	0.29	0.23	60.53	0.30	0.24
Wall 150 mm insulation	75.87	0.28	0.22	58.53	0.30	0.24
Wall 190 mm insulation	73.40	0.46	0.37	56.13	0.47	0.38
Windows A	70.40	0.94	0.47	53.20	0.96	0.48
Loft 245 mm insulation	68.93	1.03	0.83	51.80	1.08	0.87
Slap 200 mm insulation	67.27	1.11	0.89	50.07	1.07	0.86
Loft 290 mm insulation	65.13	1.35	1.08	48.00	1.40	1.12
Loft 315 mm insulation	64.20	0.97	0.78	47.07	0.97	0.78
Wall 250 mm insulation	62.13	1.69	1.36	45.13	1.81	1.45
Loft 365 mm insulation	60.80	1.30	1.04	43.87	1.38	1.10

Figure 2.3 and 2.4 show these two progressions for the two different price levels.

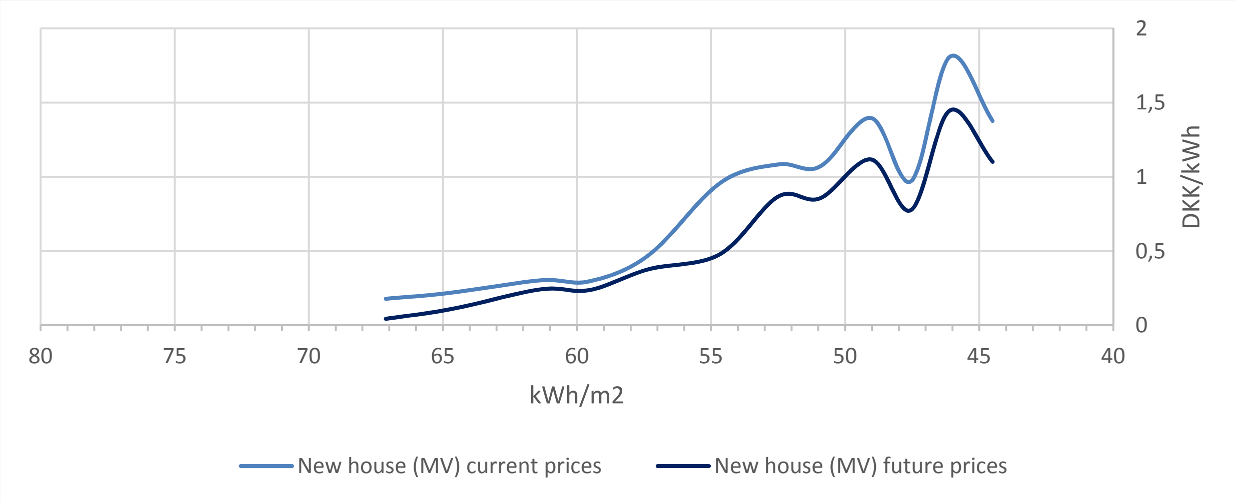


Figure 2.3. Costs for heat savings in new buildings with mechanical ventilation

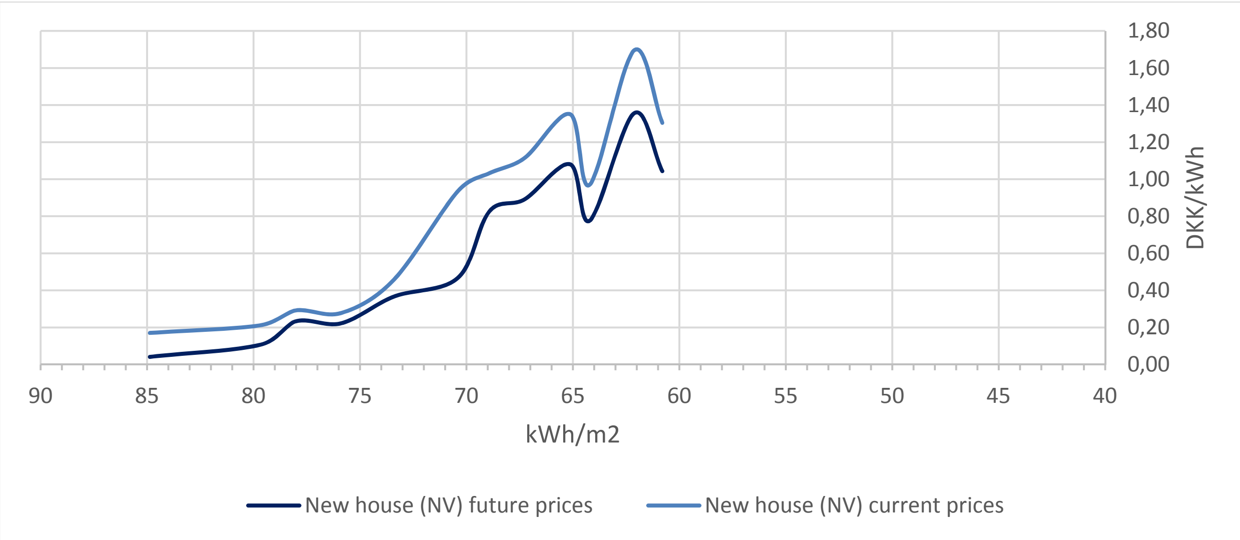


Figure 2.4. Costs for heat savings in new buildings with natural ventilation

These curves are also tested for sensitivity to the interest rate. Once again, 1% and 5% are compared to the used 3% interest rate. Figure 2.5 shows the sensitivity of current prices in new buildings with mechanical ventilation. Since new buildings are also based on investments, the results are sensitive to the interest rate. However, as buildings are long-term investments, the further analysis assumes an interest rate of 3%.

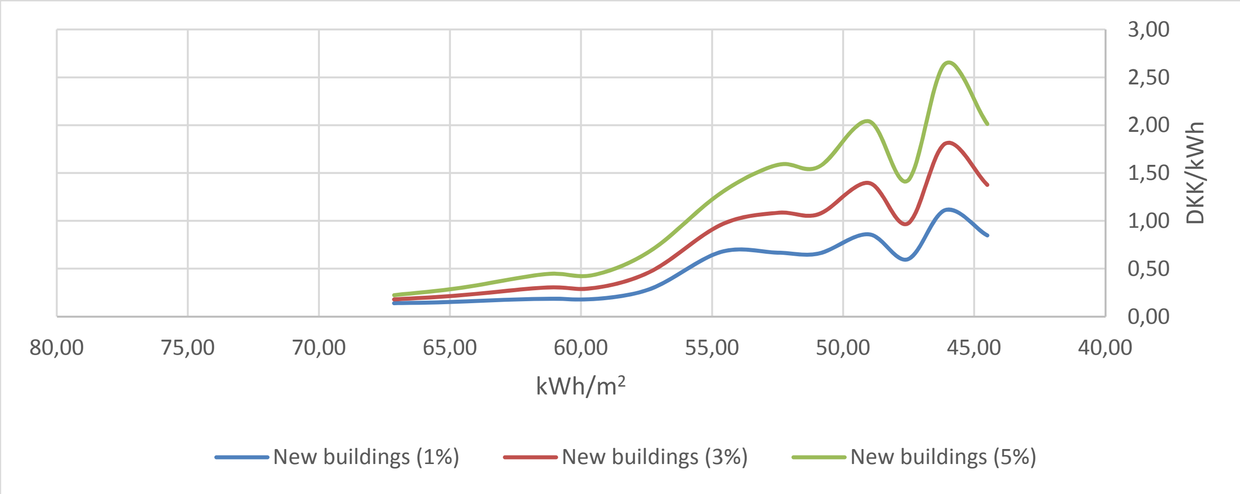


Figure 2.5. The sensitivity to the interest rate for new buildings with mechanical ventilation based on current costs.

To investigate how a change from natural ventilation to mechanical ventilation affects the curves, and to illustrate the "bulge" described in the main paper, the two curves have been combined resulting in Figures 2.6 and 2.7. Here, the maintenance and electricity costs have to be included since the scenario changes.

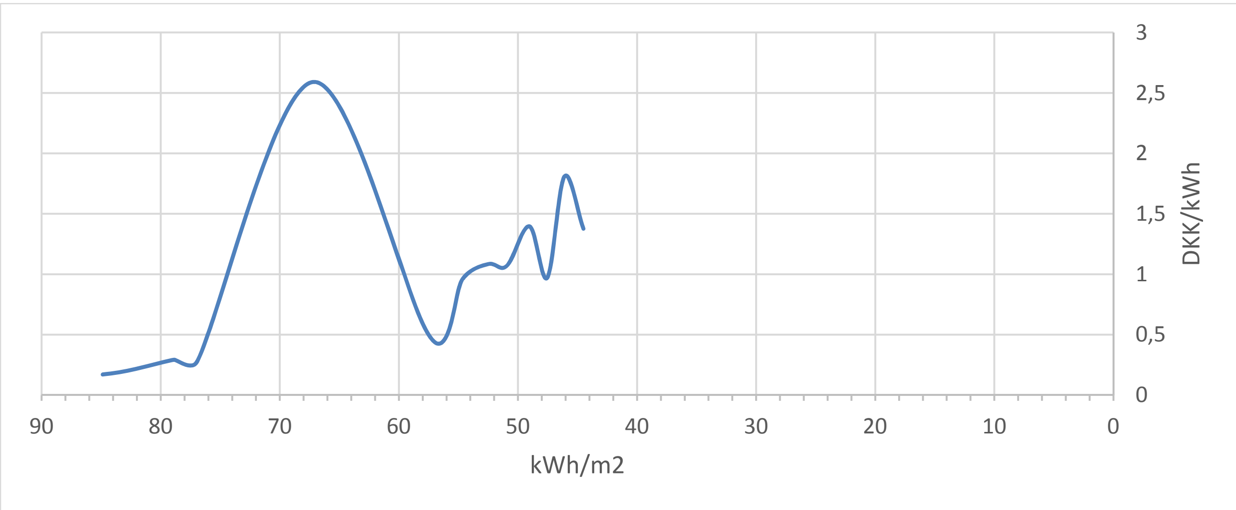


Figure 2.6. The consequences of implementing mechanical ventilation as a marginal cost when improving energy efficiency in buildings under conservative cost assumptions.

Conservative parameters used for Figure 2.6 based on [2].

- Electricity consumption for ventilation: 4.25 kWh/m^2
- Electricity price: 1 DKK/kWh
- Investment in ventilation: 88,826 DKK/unit
- Maintenance: 1000 DKK/unit
- Lifetime: 25 years

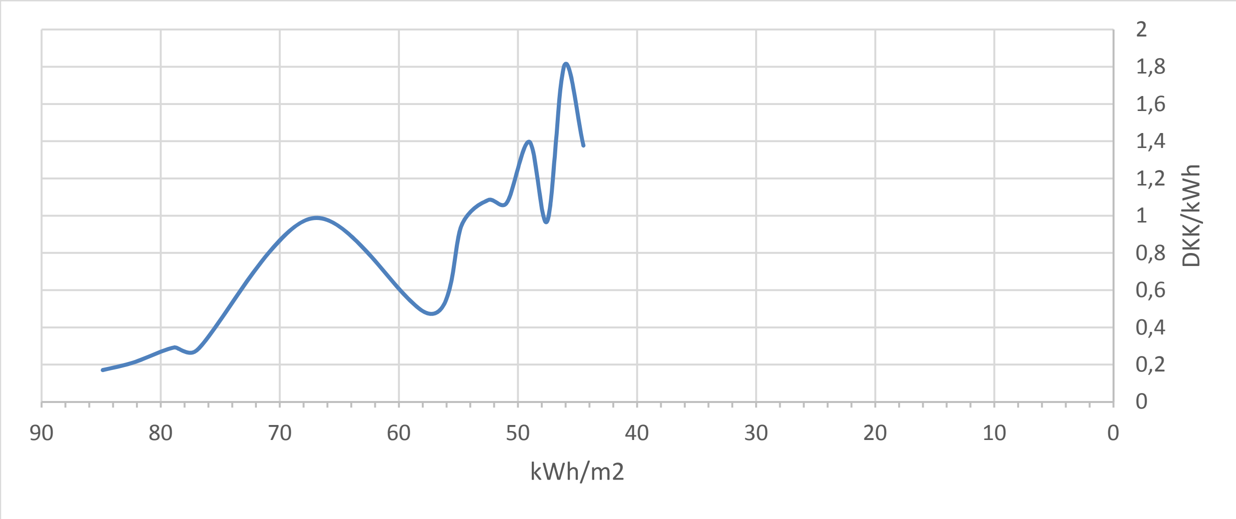


Figure 2.7. The consequences of implementing mechanical ventilation as a marginal cost when improving energy efficiency in buildings under optimistic cost assumptions.

Optimistic parameters used for Figure 2.7, based on author's experience:

- Electricity consumption for ventilation: 4.25 kWh/m^2
- Electricity price: 1 DKK/kWh
- Investment in ventilation: 40,000 DKK/unit
- Maintenance: 200 DKK/unit
- Lifetime: 40 years

Figures 2.6 and 2.7 highlight how the bulge is sensitive to the assumption for savings; however, the bulge remains present, also with optimistic assumptions. Still, as described in the main text, the way forward is to assume the development described in Figure 2.3, under the assumption that mechanical ventilation is built no matter what. Figures 2.6 and 2.7 are important to understanding the necessary discussion of mechanical ventilation in the energy refurbishment of buildings.

Standardizing the curves to the expected energy consumption

The former analysis in this appendix highlights the marginal costs dependent on the consumption per m^2. To be able to understand this in the context of total energy consumption, the curves have to be altered and combined to better describe the marginal development of the energy consumption in buildings.

For both new and existing buildings, even though the calculations are made for only single-family houses, terrace houses and farmhouses, the curves are assumed to describe the development of the total building mass. Thus, the total heat demand is lowered in these calculations and not only for single-family housing.

As mentioned in Appendix 1, this analysis is based on a current heat demand in buildings of 50 TWh/year. With no improvement in energy efficiency, this number is expected to rise to 70 TWh/year in 2050. New buildings thus account for 20 TWh. The curves defined on the previous pages illustrate the development of the savings.

Therefore, by using the following formula, the development of savings achieved by only increasing the efficiency of the current buildings can be estimated as:

$$x = 50TWh * \left(\frac{E_p}{E_i}\right) + 20TWh$$

Where:

- x is the total energy consumption for all buildings at an E_p level saving
- E_p is the consumption per square meter at the given point
- E_i is the consumption per square meter at 70 TWh, which is assumed to be 131.76 kWh/m^2 in this case.

By assuming a constant heat demand of 20 TWh for new buildings, the development illustrates savings in only current buildings.

Table 2.9 and Figure 2.8 illustrate the results of this development.

Table 2.9. The marginal costs for heat savings, only refurbishing existing buildings, standardized to the expected heat consumption in 2050

kWh/m^2	DKK/kWh	TWh/year
131.76	0.33	70.00
131.20	0.34	69.79
129.75	0.36	69.24
128.25	0.36	68.67
127.54	0.40	68.40
122.91	0.42	66.64
117.79	0.42	64.70
113.54	0.44	63.09
109.68	0.44	61.62
106.05	0.44	60.24
102.19	0.44	58.78
93.34	0.45	55.42
84.23	0.47	51.96
82.65	0.49	51.36
81.59	0.56	50.96
80.86	0.57	50.68
72.89	0.57	47.66
65.40	0.62	44.82
61.79	0.64	43.45
56.90	0.66	41.59
55.49	0.67	41.06
55.33	0.70	41.00
53.26	0.71	40.21
50.97	0.83	39.34
50.05	0.84	38.99

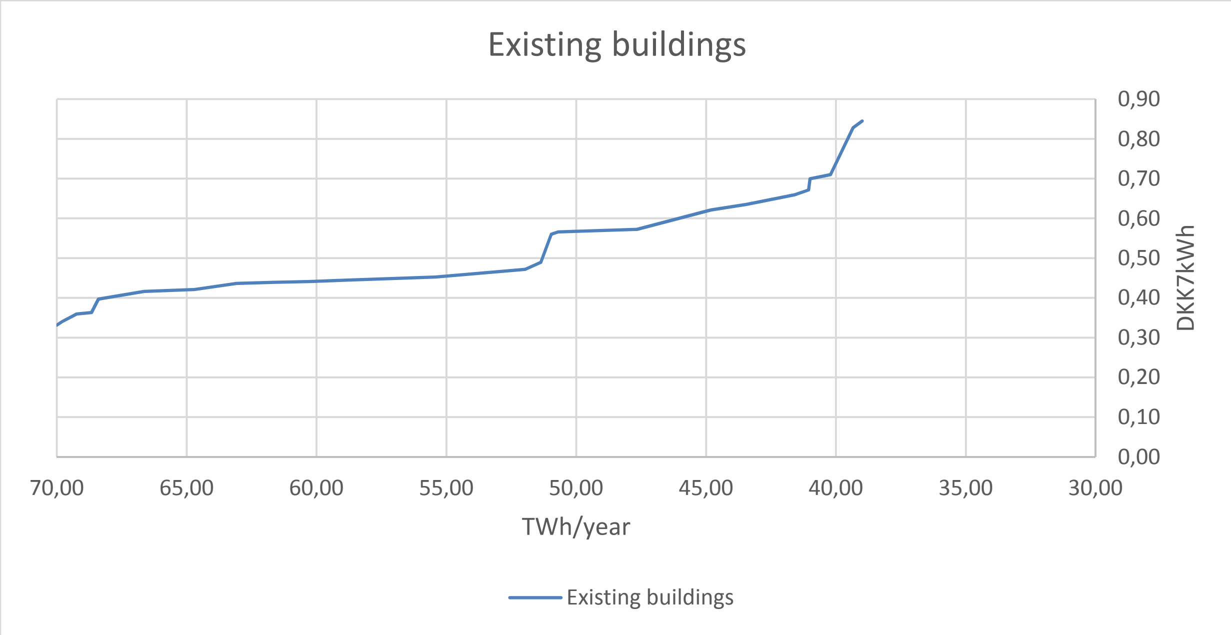


Figure 2.8. The marginal costs for heat savings, only refurbishing existing buildings, standardized to the expected heat consumption in 2050

For new buildings, the following formula is used. Here, the heat demand before savings is assumed to be 20 TWh and the development illustrated by the curve defines the progress of savings. The buildings are, however, from the beginning performing better than 122 kWh/m^2, as described in the main report, which correspond to the current overall kWh/m^2 consumption in Denmark. Thus 122 kWh/m^2 is equivalent to 70 TWh/year in this case.

$$x = 20TWh * \left(\frac{E_p}{122\ kWh/m^2}\right) + 50TWh$$

Where:

- x is the total energy consumption in all buildings at E_P level saving
- E_p is the per square meter consumption at the given point

By adding 50 TWh, the development only highlights what happens when constructing increasingly efficient buildings. Table 2.10 and Figure 2.9 illustrate this.

Table 2.10. The marginal costs for heat savings, only refurbishing new buildings, standardized to the expected heat consumption in 2050

kWh/m²	DKK/kWh	TWh/year
122.00	0.00	70.00
67.13	0.18	61.00
64.67	0.22	60.60
61.37	0.30	60.06
59.53	0.30	59.76
57.33	0.47	59.39
54.67	0.96	58.96
52.50	1.08	58.61
50.94	1.07	58.35
49.04	1.40	58.04
47.54	0.97	57.79
46.10	1.81	57.56
44.50	1.38	57.30

Figure 2.9. The marginal costs for heat savings, only refurbishing new buildings, standardized to the expected heat consumption in 2050.

The final curve illustrates what happens when these two curves are combined and compares this combination to the production curves.

This is done by identifying how much each increase in efficiency subtracts from the initial 70 TWh. The analysis identifies the desired development of yearly heat consumption in the system, by organizing the savings according to least marginal cost, combined with the fact that the new houses have to follow a certain development described previously in this appendix.

In total, this gives the development illustrated in Table 2.11 and Figure 2.10.

Table 2.11. The marginal costs for heat savings standardized to the expected heat consumption in 2050.

Marginal cost [DKK/kWh]	Energy consumption [TWh/year]	Step	Construction year
0	70.00	Nothing	-
0.18	61.00	SF.DH.401.C.MV.No	-
0.22	60.60	SF.DH.401.B.MV.No	-
0.30	60.06	SF.DH.501.B.MV.No	-
0.30	59.76	SF.DH.511.B.MV.No	-
0.34	59.55	Terrace house	1931-1950
0.36	59.00	Terrace house	1850-1930
0.36	58.43	Terrace house	1951-1960
0.40	58.16	Terrace house	Before 1850
0.42	56.40	Single-family house	1931-1950
0.42	54.46	Farmhouse	1931-1950
0.44	52.85	Farmhouse	1850-1930
0.44	51.38	Farmhouse	1951-1960
0.44	50.00	Single-family house	1951-1960
0.44	48.54	Farmhouse	Before 1850
0.45	45.18	Single-family house	1850-1930
0.47	41.72	Single-family house	Before 1850
0.47	41.36	SF.DH.521.B.MV.No	-
0.49	40.76	Terrace house	1961-1972
0.56	40.36	Farmhouse	1961-1972
0.57	40.08	Terrace house	1973-1978

0.57	37.06	Single-family house	1961-1972
0.62	34.22	Farmhouse	1973-1978
0.64	32.84	Single-family house	1973-1978
0.66	30.99	Terrace house	1979-1998
0.67	30.45	Farmhouse	1999-2006
0.70	30.40	Farmhouse	1979-1998
0.71	29.61	Single-family house	1979-1998
0.83	28.74	Terrace house	1999-2006
0.84	28.39	Single-family house	1999-2006
0.96	27.95	SF.DH.521.A.MV.No	-
1.08	27.60	SF.DH.621.A.MV.No	-
1.07	27.34	SF.DH.622.A.MV.No	-
1.40	27.03	SF.DH.722.A.MV.No	-
0.97	26.79	SF.DH.822.A.MV.No	-
1.81	26.55	SF.DH.842.A.MV.No	-
1.38	26.29	SF.DH.1042.A.MV.No	-

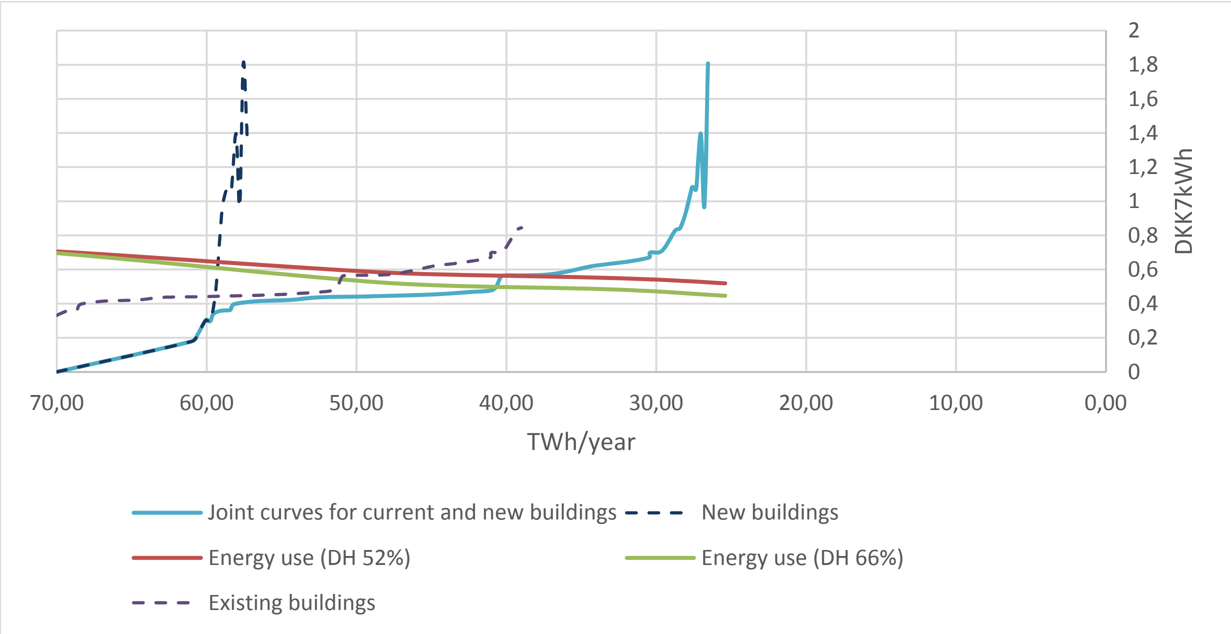


Figure 2.10. The marginal costs for heat savings standardized to the expected heat consumption in 2050, combined with results from Appendix 1.

Figure 2.10 and a combination of Figures 2.1 and 2.3 are used for the conclusions found in the main text.

[1] Wittchen KB, Kragh J. Heat demand in danish buildings in 2050. 2010; http://www.sbi.dk/miljo-og-energi/energibesparelser/danske-bygningers-energibehov-i-2050.

[2] Aggerholm S. Cost-optimal levels of minimum energy performance requirements in the Danish Building Regulations. (SBi 2013:25)(2013). http://www.sbi.dk/miljo-og-energi/energibesparelser/cost-optimal-levels-of-minimum-energy-performance-requirements-in-the-danish-building-regulations/cost-optimal-levels-of-minimum-energy-performance-requirements-in-the-danish-building-regulations.

[3] Aagaard N, Brandt E, Aggerholm S, Haugbølle K, Aagaard N, Brandt E et al. Levetider af bygningsdele ved vurdering af bæredygtighed og totaløkonomi; Levetider af bygningsdele ved vurdering af bæredygtighed og totaløkonomi. : SBI forlag, 2013.

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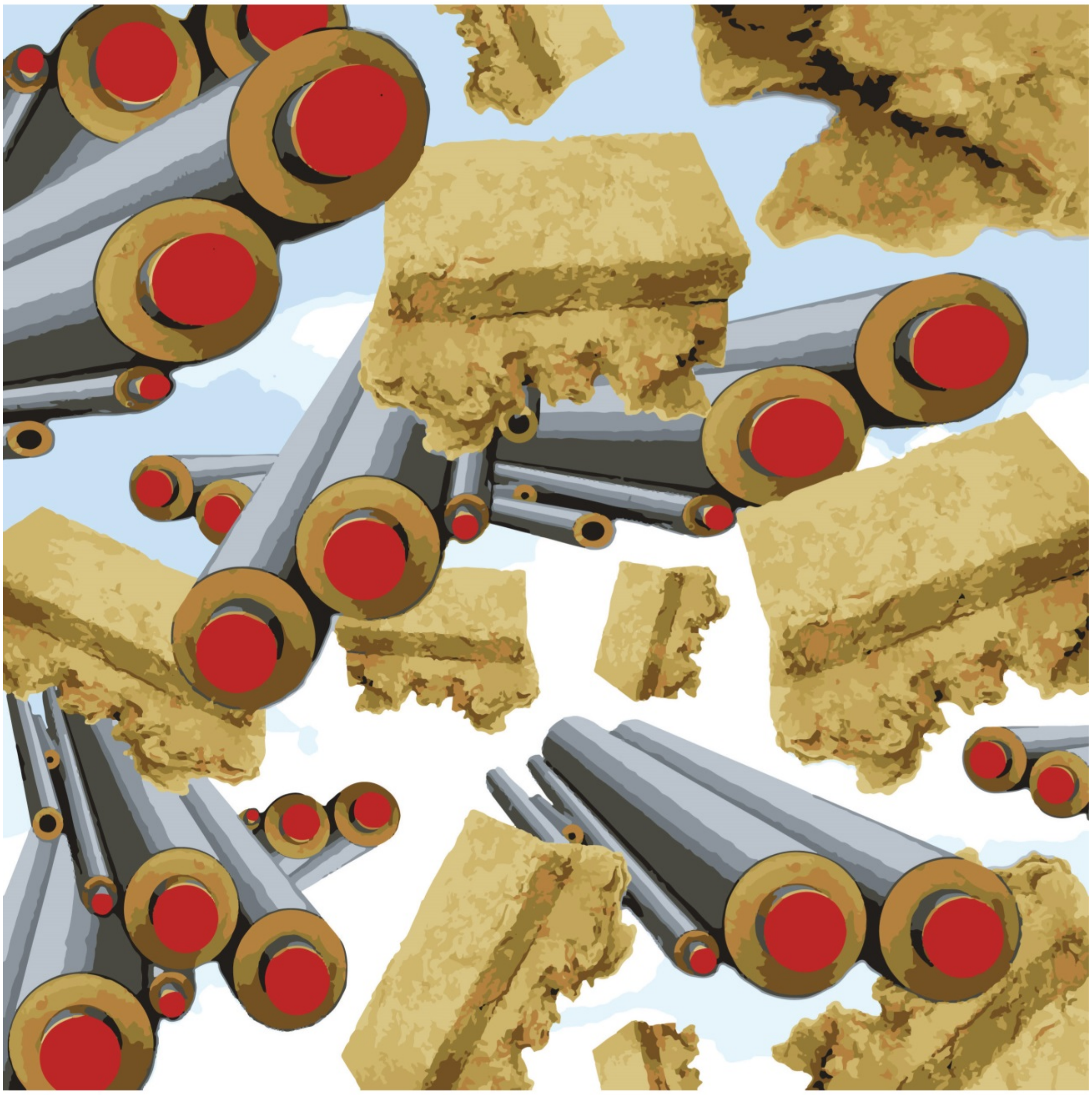

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