2050 Heat Roadmap Europe
A low-carbon heating and cooling strategy

Review of the cost variation in energy plants across the 14 MSs

D6.2

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Author(s)/editor(s):	Max Gunnar Ansas Guddat, Simon Stendorf Sørensen, Daniel Trier (PlanEnergi) Susana Paardekooper (AAU)
Reviewer(s):	Rasmus Søgaard Lund (AAU)
Project coordinator:	Brian Vad Mathiesen (AAU)

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Contact:

PlanEnergi
A.C. Meyers Vænge 15
Copenhagen, 2450
Denmark

E-mail: dt@planenergi.dk
Heat Roadmap Europe website: www.heatroadmap.eu

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1. Introduction

In the Heat Roadmap Europe 4 project (HRE4) one of the main outcomes are heating and cooling scenarios of the fourteen EU member state (MS) countries with the highest heating and cooling (H&C) demands in EU28[1]. These scenarios are used to derive strategies for each of the countries describing (and quantifying) how they can move towards low-carbon H&C sectors.

To develop such H&C scenarios, the models to analyse the countries needs inputs in the form of assumptions for the cost of various options to supply energy. These may vary over time which is why data for the years 2015, 2030 and 2050 are provided. Since the cost of these options (i.e. technologies such as CHP plants, heat pumps etc.) is not necesserily similar all across Europe, individual cost levels for each included technology has been derived for all the 14 MSs. The outcome is gathered in one “cost database” for heat and electricity producing units.

[1] The countries investigated in HRE4 are: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, the Netherlands, Poland, Romania, Spain, Sweden and the United Kingdom.

2. Methodology

In the following, the development of the cost database covering the 14 MSs of HRE4 is described. In this section, the chosen approach is explained, whereas the results are found in section 4 and "Annex I – Cost database tables". This annex also includes lifetimes for the various technologies as well as the estimated O&M costs.

2.1. Overview of the chosen approach

2.1.1. Technologies included

Below is seen an overview of the technologies included in this analysis. For each technology the costs for investments, O&M costs and lifetime are provided for the years 2015, 2030 and 2050.

Heat and electricity	Renewable energy	Liquid and gas fuels	Heat infrastructure
Small CHP plants	Onshore wind power	Biogas plant	Individual boilers - Coal - Oil - Natural gas - Biomass
Large CHP plants	Offshore wind power	Gasification plant	Individual CHP
Heat storage CHP	Photo voltaic	Biogas upgrade	Individual HP - Ground source - Air source
Waste CHP	Wave power	Gasification upgrade	Individual electric heating
Absorption HP (waste)	Tidal power	CO_2 hydrogenation	Individual solar thermal
Decentral DH HP	CSP solar power	Electrolysis	
Central DH HP	River hydro	Hydrogen storage	
Electric DH boilers	Hydro power	Gas storage	
Large power plants	Hydro storage	Oil storage	
Nuclear plants	Hydro pump	Methanol storage	
Interconnection	Geothermal electricity		
Hydro pump	Geothermal heating		
Pumped storage	Solar thermal		
Industrial CHP - electricity - heating	Heat storage solar		
	Industrial excess heat		

2.1.2. Steps involved in the process

The six steps illustrated below indicate the steps towards the “14 MSs energy plants cost database”. The first step is defining the methodology. This is followed by data acquisition and the deriving of country-specific cost estimations. Cross-checking is included to validate the outcome e.g. by comparison with other data sources or by review of technical experts within a specific field. These steps are further explained in the following sub-sections.

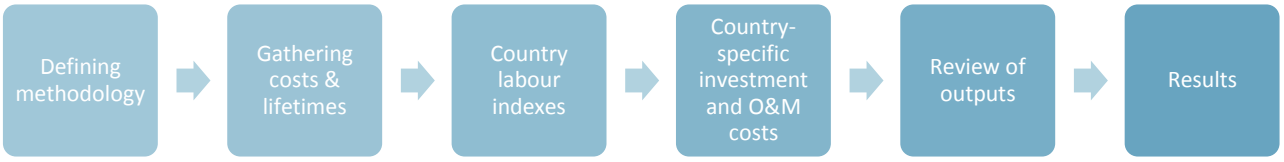

Figure 1. The six steps of the process when developing the cost database of energy plants for the 14 MSs.

2.2. Defining methodology

The required data for the listed technologies, for all the 14 countries and for the years 2015, 2030 and 2050 respectively, adds up to more than 2,000 entries in the database, each with three different inputs (investment, O&M and lifetime), i.e. over 6,000 parameters. For the task in question, it is not feasible to target all entries separately to aquire references of more than 2,000 actual examples. Also, single examples may not represent average values and 2,000 examples may therefore not be enough. Instead, the aim has been to estimate costs based as far as possible on well-established sources i.e. from reliable organisations, and adjusting these to country-specific conditions by introducing a formula to take labour cost differences into account. Since not all technologies are expected to have an equal level of impact on the future heating and cooling scenarios, the technologies with the expected main impact have been given top priority in terms of a validation process to be as exact as possible. A lower prioritisation does not mean that the technologies are insignificant, but simply indicate that the estimated costs are not expected to have a high impact on the overall conclusions of the H&C scenarios (e.g. because the implementation of wave power is assumed to be smaller than wind power).

2.3. Data acquisition

2.3.1. Sources

The data is in general gathered from one well-established source representing a “base region” i.e. which country the costs are representative for. Examples of such sources are JRC’s "ETRI 2014 - Energy Technology Reference Indicator projections for 2010-2050" [1] and the Danish Energy Agency’s, “Technology Data for Energy Plants” [2]. A complete list of the sources used can be found in section 6. Since hands-on experience with some of the technologies are present within the consortium, the data is in some cases defined directly from consulting experts without getting a preliminary (written) data source such as [1] or [2].

The overall tendency is that especially the cost level in the reference source (“base region”) is critical for the outcome which is highly dependent on reliability and applicability[2] of the data source, size of the technology (i.e. what is a “typical” size), and the type of output format (e.g. in cost *per power output* or *per unit* for a typical size). Secondly, the methodology of deriving country-specific costs including the labour cost shares assumed (see section 2.4.2) has an important impact on the outputs. When considering the final cost result level, other assumptions such as the type of labour (i.e. skill level) has a lower impact compared to the beforementioned points.

2.3.2. Lifetimes

The sources are also used to gather the associated lifetimes of the various technologies. The lifetimes are assumed to be the same across all countries and the numbers are therefore the same for all 14 MSs in “Annex I – Cost database tables”. Most technologies are well-established and are not expected to improve on lifetimes when moving from 2015 to 2030 and 2050. When no data on expected lifetime increase is gathered, the lifetimes are assumed the same for 2015, 2030 and 2050 respectively.

2.4. Labour indexes and country-specific costs

2.4.1. Country labour index

Differences in labour costs do not only apply to various type of labour work, but also between the countries. Based on Eurostat data [3] it is possible to adjust the share of the total costs associated with *installation* of the technology (i.e. requiring labour work) according to the labour costs of the given country. This “labour cost ratio” is assumed uniform throughout the years if the source does not provide specific data for 2015, 2030 and 2050 respectively.

The ratios between the labour cost in the reference country and the other countries are assumed the same for all years. This mean that in case of a fixed “labour cost ratio” for all years and a reduced total investment cost in 2030/2050 compared to 2015, then the differences between the countries will decrease in 2030/2050.

[2] Applicability in this case refer to how well the source definition of the technology matches how EnergyPLAN understands and uses the same technology.

2.4.2. Investment costs incl. labour cost differences

A general method to derive costs for all 14 MSs are based on the principle that all the investigated costs consist of two parts; one part being the component (i.e. physical materials) and one part covering the expenses in relation to the installation until the system is operating normally. After this point, continuous monitoring and maintenance are covered by the O&M costs.

In many cases the cost sources provide the two abovementioned parts (component and installation) separately, i.e. with one part of the cost relating to the materials (the unit), and the other part relating to the labour cost associated to the installation of the unit. The labour cost ratio (i.e. the labour cost share of the total installation cost) is based on the same source as the general cost wherever possible. In cases where this has not been possible, a typical 80/20 relation between the component cost and the labour cost has been used (i.e. a labour cost ratio of 20 %) for the reference (source). The formula below is used to derive the total investment cost for a given country ("country X").

$$C_x = C_{ref} \cdot r_{labour} \cdot I_{country,labour} + C_{ref} \cdot (1 - r_{labour})$$

where

- C_X is the total cost of the unit in question in MS "X"[3]
- C_{ref} is the (total) cost of the unit in question from the identified reference
- r_{labour} is the ratio between the share of the total costs related to labour costs and the total cost of the unit (i.e. between 0 and 1)
- $I_{country,labour}$ is an index number representing the ratio between the labour costs of MS "X" and the labour costs in the country representing the reference cost (i.e. between 0 and 1)

2.4.3. Operation and maintenance

The operation and maintenance (O&M) costs are defined as a percentage of the investment cost and are not depending on the operating hours or supply of energy. Variable O&M costs are included at a later stage in the modelling (for which the results in this report are to be used). This means that the differences in investment costs between the countries are also reflected in the O&M costs – corresponding to the assumption that the ratio between labour related and non-labour related costs are the same for investment costs and O&M costs respectively.

2.5. Reviewing outputs

Several sources are used to compare the various investment costs, lifetimes and O&M costs e.g. on a global level from IRENA [4] [5] or IEA [6]. These are used to check the variations between the different sources. As this provides the option of double-checking the background for any significant deviations observed when comparing different sources, this creates a more solid reliability of the chosen final data source.

[3] ISO country codes are used to refer to the 14 different MSs. (However, UK is used for United Kingdom to indicate that Northern Ireland is included.)

Besides this, selected experts have been consulted to provide general comments on the numbers within their field of expertise, e.g. EHPA for heat pump costs and typical sizes. Based on this, it has been possible to adjust the specific reference source choice (e.g. the exact HP size to be used in the database for a typical unit).

It should be noted that although there have been sought to achieve the most accurate results, there will naturally be some deviation from reality, since there are differences between the various real-life cases – even within a given country for a given technology – as well as between the references in the sources. Especially for the future projections, price levels become increasingly uncertain. Hence, there is no guarantee that the data presented covers the way any energy system model would use the technology (in terms of accumulated capacity as well as operating hours) which will also affect actual cost(s) for each technology.

2.6. Output format

The results are given in the form required for the EnergyPLAN tool which is used for the development of the H&C scenarios mentioned in section 1. This is not in a uniform format since the most suitable unit vary for the different technologies. One example is the unit M€/MW_e for concentrating solar power (CSP). For each technology the unit is listed in “Annex I – Cost database tables”.

3. Limitations and assumptions

3.1. Cost definitions

The investment costs represent total overnight installation costs and are given in EUR in 2015-price level.

The stated O&M (annual) costs are average costs during the lifetime and are given as a percentage of the investment costs. Fuel costs are not included and own electricity consumption is included for heat only technologies, except for heat pumps.

3.2. European single market

The component share of the costs are assumed to be equal for all 14 MSs thus representing a perfect “European Single Market”, whereas the labour costs are assumed to be directly associated with the given country. While a perfect “single market” is not the reality for all technologies and all countries, the free movement of workers within EU can counterbalance this to some extent.

In reality workers are also able to move between countries which will in principle mean that the ratio between the labour costs will be somewhat lower in practice. On the other hand, investment costs may be subject to price levels derived by companies’ knowledge of what costumers are willing to pay, thus increasing the differences between countries due to income level. A general trend of labour cost differences being in line with such variations is assumed. Hence the two abovementioned counterarguments will to some extend outweigh each other.

4. Results

The results of the (~2,000) cost estimates can be found in “Annex I – Cost database tables” and exist also as an Excel file representing the “cost database” for heat and electricity producing units. This database will be used as an input for the development of heating and cooling scenarios of the fourteen HRE4 target countries in order to derive strategies for each country on how they can move towards low-carbon H&C sectors.

Below is seen a few examples indicating the variations between the country investment costs for two different technologies.

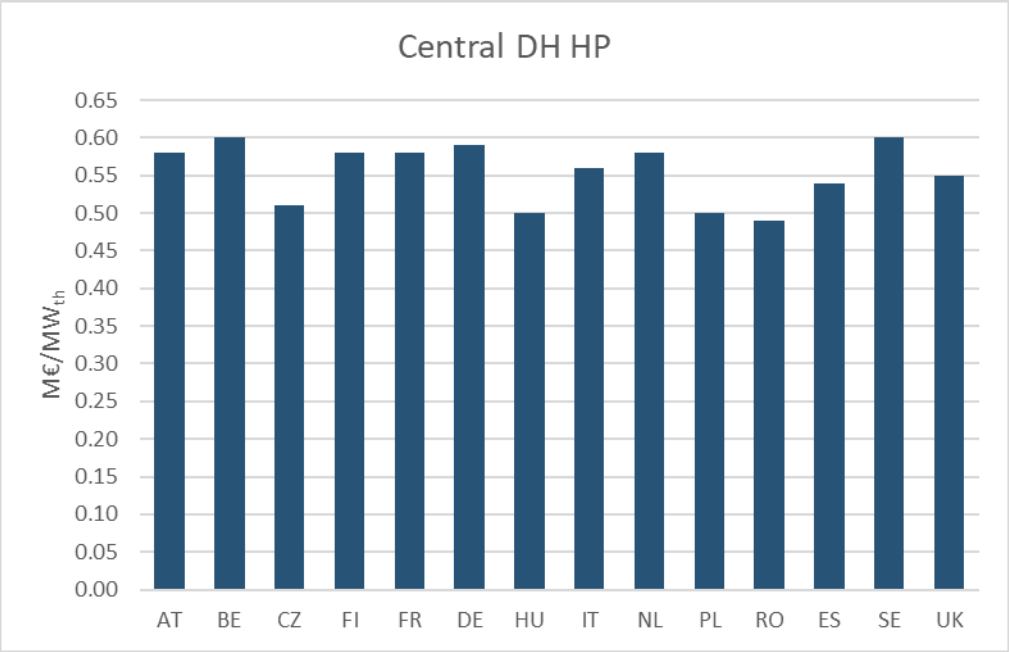

Figure 2. Examples of cost of central (large scale) DH-connected heat pumps estimated for each of the 14 HRE4 target countries.

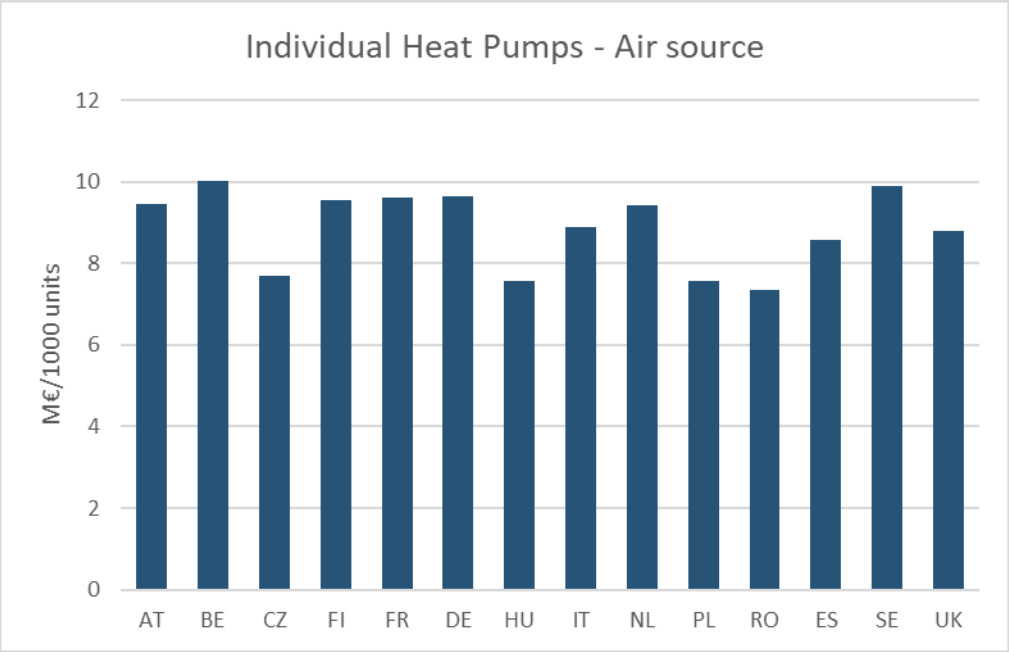

Figure 3. Examples of cost of individual (small scale) air source heat pumps (air-to-water) estimated for each of the 14 HRE4 target countries.

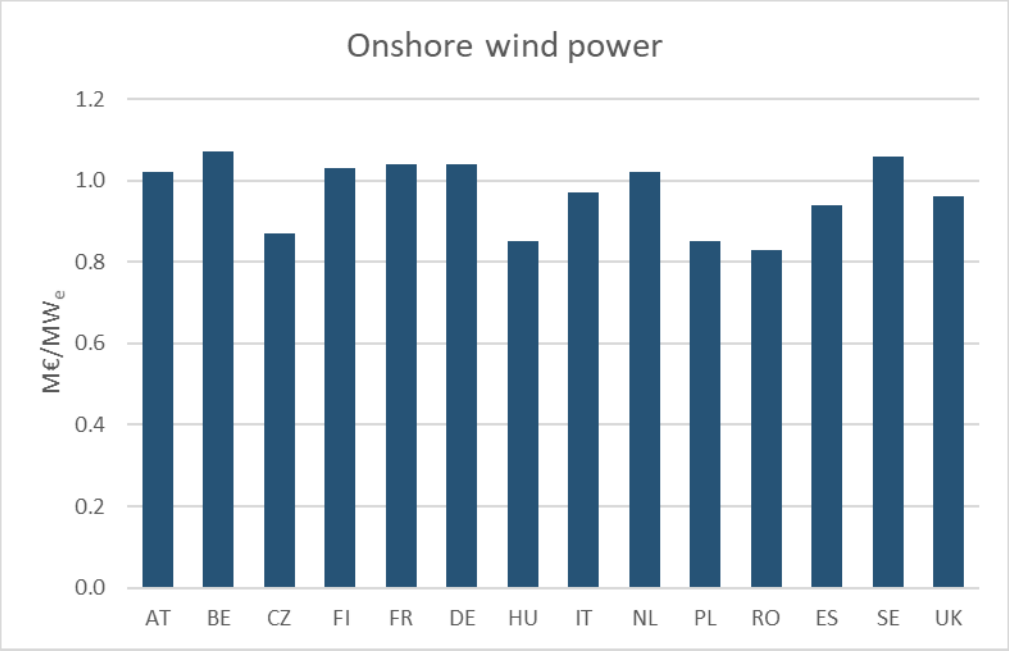

Figure 4. Examples of cost of onshore wind power (wind farms) estimated for each of the 14 HRE4 target countries.

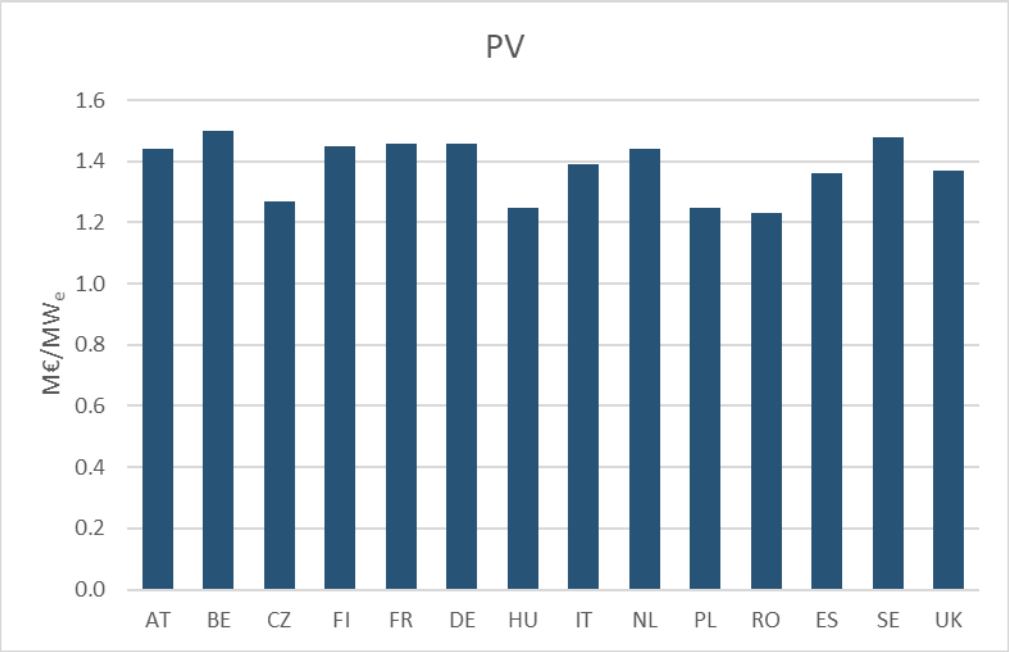

Figure 5. Examples of cost of photovoltaic (large scale) systems estimated for each of the 14 HRE4 target countries.

5. Abbreviations

AAU: Aalborg University

C_X: Total cost of the unit in question in MS “X” (X being the country code)

C_{ref}: Total cost of the unit in question from the identified reference (source)

CHP: Combined heat and power

CSP: Concentrating solar power

DEA: Danish Energy Agency

DG-Ener: Directorate-General Energy

DH: District heating

EU28: The combined 28 member states of the European Union as of 2017.

FLH: Full load hours

H&C: Heating and cooling

HP: Heat pump(s)

HRE4: Fourth Heat Roadmap Europe (project)

HV: High voltage

$I_{country,labour}$: Ratio between labour costs of MS “X” and labour costs in the country representing the reference cost (i.e. between 0 and 1)

IEA: International Energy Agency

IRENA International Renewable Energy Agency

JRC: Joint Research Centre

M€: Million Euro

MS: Member state of the European Union

MW_e: Megawatt - electric

MW_{th}: Megawatt – thermal

MWh: Megawatt-hours

NEA: Nuclear Energy Agency

PHES: Pumped hydro energy storage

PTES: Pit thermal energy storage

r_{labour}: Share of total costs related to labour costs (between 0 and 1)

ST: Solar thermal

TWh: Terawatt-hours

6. References

Note that data sources associated with the cost database in “Annex I – Cost database tables” refer to the numbering below.

[1] JRC, "ETRI 2014 - Energy Technology Reference Indicator projections for 2010-2050", 2014, https://setis.ec.europa.eu/system/files/ETRI_2014.pdf

[2] DEA, “Technology Data for Energy Plants – August 2016 with updates June, October and November 2017”, 2017, https://ens.dk/sites/ens.dk/files/Analyser/technology_data_catalogue_for_energy_plants_-_aug_2016_update_oct_nov_2017.pdf

[3] Eurostat, “Labour costs in the EU”, 2017, p. 4, “Labour costs per hour in €, breakdown by economic activity, 2016” – column for “Industry”, http://ec.europa.eu/eurostat/documents/2995521/7968159/3-06042017-AP-EN.pdf/6e303587-baf8-44ca-b4ef-7c891c3a7517

[4] IRENA, “Renewable power generation costs in 2014”, 2015, http://irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_RE_Power_Costs_2014_report.pdf

[5] IRENA, “Electricity storage and renewables costs and markets to 2030”, 2017, http://irena.org/-/media/Files/IRENA/Agency/Publication/2017/Oct/IRENA_Electricity_Storage_Costs_2017.pdf

[6] IEA/NEA “Projected Costs of Generating Electricity”, 2015, https://www.oecd-nea.org/ndd/pubs/2015/7057-proj-costs-electricity-2015.pdf

[7] DEA, "Technology data for energy plants - individual heating plants and energy transport”, 2012, https://ens.dk/sites/ens.dk/files/Analyser/c_teknologikatalog_for_individuelle_varmeanlaeg_og_energitransport_2012.pdf

[8] DEA, “Technology data for energy plants - Generation of Electricity and District Heating, Energy Storage and Energy Carrier Generation and Conversion”, 2012, https://energiatalgud.ee/img_auth.php/4/42/Energinet.dk._Technology_Data_for_Energy_Plants._2012.pdf

[9] DEA, “Technology Data for Energy Plants - Generation of Electricity and District Heating, Energy Storage and Energy Carrier Generation and Conversion”, 2015, https://ens.dk/sites/ens.dk/files/Analyser/technologydata_for_energy_plants_-_may_2012._updated_2015_ver_nov2017.pdf

[10] DEA, “Technology Data for Individual Heating Plants and Energt Transport”, 2017, https://ens.dk/sites/ens.dk/files/Analyser/technology_data_catalogue_for_individual_heating_plants_october_2017.pdf

[11] PlanEnergi, expert consultation, 2017

[12] AAU, “EnergyPLAN cost database 3.0”, http://energyplan.eu

[13] EC DG-ENER, “Mapping and analyses of the current and future (2020 - 2030) heating/cooling fuel deployment (fossil/renewables)”, 2016, https://ec.europa.eu/energy/sites/ener/files/documents/Report%20WP2.pdf

Annex I – Cost database tables

This annex include tables with the values included in the 14 MSs energy plants cost database, i.e. investment costs, fixed (part of) O&M costs and lifetimes for 2015, 2030 and 2050 respectively.

	2015 Baseline					2015 Baseline		2015 Baseline								2015 Baseline			2015 Baseline		
		Reference		Unit for typical capacity	Price in base region	r_labour		Austria	Belgium	Czech Republic	Finland	France	Germany	Hungary	Italy	Netherlands	Poland	Romania	Spain	Sweden	United Kingdom
Category	Technology	no.	Base region				Units	AT	BE	CZ	FI	FR	DE	HU	IT	NL	PL	RO	ES	SE	UK
Heat and Electricity	Small CHP plants	2	DK	MW-e	1	0.35	M€/MWe	0.94	1	0.73	0.95	0.96	0.96	0.72	0.87	0.93	0.72	0.69	0.84	0.99	0.86
	Large CHP plants	2	DK	MW-e	0.9	0.22	M€/MWe	0.86	0.9	0.75	0.87	0.87	0.88	0.74	0.83	0.86	0.74	0.73	0.81	0.89	0.82
	Heat Storage CHP	9	DK	GWh	1.6	0.2	M€/GWh	1.52	1.58	1.34	1.53	1.54	1.54	1.32	1.46	1.52	1.33	1.3	1.43	1.57	1.45
	Waste CHP	9	DK	tonne/hour	8.5	0.2	M€/MWe	8.19	8.51	7.2	8.24	8.28	8.3	7.12	7.88	8.17	7.13	7	7.7	8.44	7.81
	Absorption HP (waste)	2	DK	MW-th	0.6	0.5	M€/MWth	0.55	0.6	0.37	0.55	0.56	0.57	0.36	0.49	0.54	0.36	0.33	0.46	0.59	0.48
	Decentral DH HP	2	DK	MW-e	0.2	0.5	M€/MWe	0.18	0.2	0.12	0.18	0.19	0.19	0.12	0.16	0.18	0.12	0.11	0.15	0.2	0.16
	Central DH HP	11	DK	MW-th	0.6	0.2	M€/MWth	0.58	0.6	0.51	0.58	0.58	0.59	0.5	0.56	0.58	0.5	0.49	0.54	0.6	0.55
	Electric DH boilers	2	DK	MW-e	0.1	0.25	M€/MWe	0.07	0.07	0.06	0.07	0.07	0.07	0.06	0.06	0.07	0.06	0.05	0.06	0.07	0.06
	Large Power plants	11	EU28	MW-e	1.1	0.36	M€/MWe	1.25	1.37	0.87	1.27	1.29	1.29	0.84	1.13	1.24	0.84	0.79	1.06	1.35	1.1
	Nuclear plants	1	EU28	MW-e	4.5	0.2	M€/MWe	4.82	5.1	3.95	4.86	4.9	4.91	3.88	4.54	4.79	3.89	3.77	4.39	5.03	4.48
	Interconnection	7	DK	MW-e	0.2	0.2	M€/MWe	0.16	0.17	0.14	0.16	0.17	0.17	0.14	0.16	0.16	0.14	0.14	0.15	0.17	0.16
	Hydro pump	8	DK	MW-e	0.6	0.2	M€/MWe	0.58	0.6	0.51	0.58	0.58	0.59	0.5	0.56	0.58	0.5	0.49	0.54	0.6	0.55
	Pumped storage	8	DK	MW-e	4	0.2	M€/MWe	3.86	4.01	3.39	3.88	3.9	3.91	3.35	3.71	3.84	3.35	3.29	3.62	3.97	3.67
	Industrial CHP electricity	12	DK	TWh/a	68.3	0.2	M€/TWh/year	65.84	68.39	57.84	66.18	66.56	66.71	57.22	63.29	65.62	57.28	56.23	61.89	67.8	62.73
	Industrial CHP heating	11	DK	MW-th	0.1	0.35	M€/MWth	0.09	0.1	0.07	0.09	0.09	0.09	0.07	0.08	0.09	0.07	0.07	0.08	0.1	0.08
Renewable energy	Onshore wind power	2	DK	MW-e	1.07	0.25	M€/MWe	1.02	1.07	0.87	1.03	1.04	1.04	0.85	0.97	1.02	0.85	0.83	0.94	1.06	0.96
	Offshore wind power	2	DK	MW-e	2.4	0.55	M€/MWe	2.16	2.41	1.39	2.2	2.23	2.25	1.33	1.92	2.14	1.34	1.23	1.78	2.35	1.86
	Photo Voltaic	2	DE	MW-e	1.5	0.18	M€/MWe	1.44	1.5	1.27	1.45	1.46	1.46	1.25	1.39	1.44	1.25	1.23	1.36	1.48	1.37
	Wave power	8	DK	MW-e	7.8	0.55	M€/MWe	7.03	7.83	4.52	7.14	7.25	7.3	4.32	6.23	6.96	4.34	4.01	5.79	7.64	6.05
	Tidal Power	1	EU28	MW-e	10.7	0.2	M€/MWe	11.46	12.12	9.39	11.54	11.64	11.68	9.23	10.8	11.4	9.24	8.97	10.43	11.96	10.65
	CSP solar power	1	EU28	MW-e	5.6	0.2	M€/MWe	6	6.34	4.91	6.04	6.09	6.11	4.83	5.65	5.97	4.84	4.69	5.46	6.26	5.57
	River hydro	1	EU28	MW-e	5.5	0.2	M€/MWe	5.89	6.23	4.83	5.93	5.98	6	4.74	5.55	5.86	4.75	4.61	5.36	6.15	5.48
	Hydro power	1	EU28	MW-e	2.5	0.2	M€/MWe	2.62	2.77	2.15	2.64	2.67	2.67	2.11	2.47	2.61	2.12	2.05	2.39	2.74	2.44
	Hydro storage	1	EU28	MW-e	0.9	0.2	M€/MWe	0.91	0.96	0.75	0.92	0.92	0.93	0.73	0.86	0.91	0.73	0.71	0.83	0.95	0.85
	Hydro pump	1	EU28	MW-e	0.7	0.2	M€/MWe	0.7	0.74	0.57	0.7	0.71	0.71	0.56	0.66	0.69	0.56	0.54	0.63	0.73	0.65
	Geothermal Electricity	1	EU28	MW-e	5.5	0.2	M€/MWe	5.92	6.26	4.85	5.97	6.02	6.04	4.77	5.58	5.89	4.78	4.64	5.39	6.18	5.51
	Geothermal heating	11	DK	TWh/a	175	0.25	M€/TWh/year	167.13	175.3	141.51	168.22	169.42	169.92	139.52	158.96	166.43	139.72	136.33	154.47	173.41	157.16
	Solar thermal	11	DK	TWh/a	380	0.15	M€/TWh/year	369.74	380.39	336.37	371.17	372.73	373.38	333.78	359.1	368.83	334.04	329.62	353.25	377.92	356.76
	Heat storage solar	11	DK	GWh	0.50	0.3	M€/GWh	0.47	0.5	0.39	0.48	0.48	0.48	0.38	0.44	0.47	0.38	0.37	0.43	0.49	0.44
	Industrial excess heat	11	DK	MW-th	0.02	0.35	M€/MWth	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.02	0.02
Liquid and gas fuels	Biogas plant	9	DK	TWh/a	189.1	0.2	M€/TWh/year	182.29	189.36	160.15	183.24	184.28	184.71	158.43	175.23	181.69	158.6	155.67	171.35	187.72	173.68
	Gasification plant	9	DK	MW-Syngas	0.5	0.2	M€/MW-Syngas	0.48	0.5	0.42	0.48	0.49	0.49	0.42	0.46	0.48	0.42	0.41	0.45	0.5	0.46
	Biogas upgrade	9	DK	MW-CH4	0.2	0.2	M€/MW-CH4	0.19	0.2	0.17	0.19	0.19	0.2	0.17	0.19	0.19	0.17	0.16	0.18	0.2	0.18
	Gasification upgrade	12	DK	MW	0.3	0.2	M€/MW	0.29	0.3	0.25	0.29	0.29	0.29	0.25	0.28	0.29	0.25	0.25	0.27	0.3	0.28
	CO2 hydrogenation	12	DK	MW	0.9	0.2	M€/MW	0.87	0.9	0.76	0.87	0.88	0.88	0.75	0.83	0.86	0.75	0.74	0.82	0.89	0.83
	Electrolyser	8	DK	MW-e	1.4	0.2	M€/MWe	1.35	1.4	1.19	1.36	1.36	1.37	1.17	1.3	1.35	1.17	1.15	1.27	1.39	1.29
	Hydrogen storage	8	DK	GWh	17	0.2	M€/GWh	16.39	17.02	14.4	16.47	16.57	16.61	14.24	15.75	16.33	14.26	13.99	15.4	16.88	15.61
	Gas storage	9	DK	GWh	0.05	0.2	M€/GWh	0.04	0.05	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04
	Oil storage	12	DK	GWh	0.0	0.2	M€/GWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Methanol storage	12	DK	GWh	0.1	0.2	M€/GWh	0.1	0.1	0.08	0.1	0.1	0.1	0.08	0.09	0.1	0.08	0.08	0.09	0.1	0.09
Heat infrastructure	Individual boilers																				
	Coal	13	DE	MW-th	0.28	0.2	M€/MW-th	0.28	0.29	0.24	0.28	0.28	0.28	0.24	0.26	0.27	0.24	0.23	0.26	0.29	0.26
	Oil	11	DE	Unit	5.5	0.05	M€/1000 units	5.48	5.54	5.3	5.49	5.5	5.5	5.28	5.42	5.48	5.29	5.26	5.39	5.52	5.41
	Ngas	11	DE	Unit	4.3	0.1	M€/1000 units	4.27	4.36	3.98	4.28	4.29	4.3	3.96	4.18	4.26	3.96	3.93	4.13	4.34	4.16
	Biomass	11	DE	Unit	13	0.05	M€/1000 units	12.95	13.09	12.52	12.97	12.99	13	12.49	12.82	12.94	12.49	12.44	12.74	13.06	12.79
	Individual CHP	11	DE	Unit	20.7	0.05	M€/1000 units	20.63	20.84	19.94	20.65	20.69	20.7	19.89	20.41	20.61	19.89	19.8	20.29	20.79	20.36
	Individual Heat Pumps																				
	Ground source	10	DK	Unit	16	0.35	M€/1000 units	14.99	16.04	11.71	15.13	15.29	15.35	11.46	13.95	14.9	11.48	11.05	13.37	15.8	13.72
	Air source	10	DK	Unit	10	0.3	M€/1000 units	9.46	10.02	7.7	9.54	9.62	9.65	7.57	8.9	9.41	7.58	7.35	8.59	9.89	8.78
	Individual electric heating	9	DK	Unit	3	0.3	M€/1000 units	2.84	3.01	2.31	2.86	2.89	2.9	2.27	2.67	2.82	2.27	2.2	2.58	2.97	2.63
	Individual solar thermal	11	DE	Unit	4.9	0.15	M€/TWh/year	4.85	5	4.36	4.87	4.89	4.9	4.32	4.69	4.83	4.33	4.26	4.61	4.97	4.66

2030 Baseline																														
Category	Technology	Reference no.	Base region	Unit for typical capacity	Price in base region	r_labour	Units	Austria AT	Belgium BE	Czech Rep. CZ	Finland FI	France FR	Germany DE	Hungary HU	Italy IT	Netherlands NL	Poland PL	Romania RO	Spain ES	Sweden SE	United Kingdom UK
Heat and Electricity	Small CHP plants	2	DK	MW-e	0.9	0.39	M€/MWe	0.94	1	0.73	0.95	0.96	0.96	0.96	0.72	0.87	0.93	0.72	0.69	0.84	0.99	0.86
	Large CHP plants	2	DK	MW-e	0.8	0.23	M€/MWe	0.86	0.89	0.75	0.86	0.87	0.87	0.87	0.74	0.82	0.86	0.74	0.72	0.8	0.89	0.82
	Heat Storage CHP	9	DK	GWh	1.6	0.20	M€/GWh	1.52	1.58	1.34	1.53	1.54	1.54	1.54	1.32	1.46	1.52	1.33	1.3	1.43	1.57	1.45
	Waste CHP	9	DK	tonne/hour	8.5	0.20	M€/MWe	8.19	8.51	7.2	8.24	8.28	8.3	7.12	7.88	8.17	7.13	7	7.7	8.44	7.81
	Absorption HP (waste)	2	DK	MW-th	0.5	0.50	M€/MWth	0.51	0.56	0.36	0.52	0.52	0.53	0.35	0.46	0.51	0.35	0.33	0.44	0.55	0.45
	Decentral DH HP	2	DK	MW-e	0.2	0.50	M€/MWe	0.17	0.18	0.12	0.17	0.17	0.17	0.12	0.15	0.16	0.12	0.11	0.14	0.18	0.15
	Central DH HP	11	DK	MW-th	0.6	0.20	M€/MWth	0.58	0.6	0.51	0.58	0.58	0.59	0.5	0.56	0.58	0.5	0.49	0.54	0.6	0.55
	Electric DH boilers	2	DK	MW-e	0.1	0.20	M€/MWe	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.06	0.06
	Large Power plants	11	EU28	MW-e	1.0	0.34	M€/MWe	1.19	1.3	0.85	1.2	1.22	1.23	0.82	1.08	1.18	0.82	0.78	1.02	1.27	1.06
	Nuclear plants	1	EU28	MW-e	4.1	0.20	M€/MWe	4.71	4.96	3.92	4.74	4.78	4.8	3.86	4.46	4.69	3.86	3.76	4.32	4.9	4.4
	Interconnection	7	DK	MW-e	0.2	0.20	M€/MWe	0.16	0.17	0.14	0.16	0.17	0.17	0.14	0.16	0.16	0.14	0.14	0.15	0.17	0.16
	Hydro pump	8	DK	MW-e	0.6	0.20	M€/MWe	0.58	0.6	0.51	0.58	0.58	0.59	0.5	0.56	0.58	0.5	0.49	0.54	0.6	0.55
	Pumed storage	8	DK	MW-e	4.0	0.20	M€/MWe	3.86	4.01	3.39	3.88	3.9	3.91	3.35	3.71	3.84	3.35	3.29	3.62	3.97	3.67
	Industrial CHP electricity	12	DK	TWh/a	68.3	0.20	M€/TWh/year	65.84	68.39	57.84	66.18	66.56	66.71	57.22	63.29	65.62	57.28	56.23	61.89	67.8	62.73
	Industrial CHP heating	11	DK	MW-th	0.1	0.35	M€/MWth	0.09	0.1	0.07	0.09	0.09	0.09	0.07	0.08	0.09	0.07	0.07	0.08	0.1	0.08
Renewable energy	Onshore wind power	2	DK	MW-e	0.9	0.25	M€/MWe	0.99	1.03	0.86	0.99	1	1	0.85	0.95	0.99	0.85	0.83	0.92	1.02	0.94
	Offshore wind power	2	DK	MW-e	2.0	0.55	M€/MWe	1.98	2.18	1.34	2	2.03	2.05	1.29	1.77	1.96	1.29	1.21	1.66	2.13	1.73
	Photo Voltaic	2	DE	MW-e	0.7	0.18	M€/MWe	1.31	1.34	1.23	1.32	1.32	1.32	1.22	1.29	1.31	1.22	1.21	1.27	1.33	1.28
	Wave power	8	DK	MW-e	3.4	0.55	M€/MWe	5.02	5.37	3.94	5.07	5.12	5.14	3.86	4.68	4.99	3.87	3.72	4.49	5.29	4.6
	Tidal Power	1	EU28	MW-e	3.1	0.20	M€/MWe	9.4	9.59	8.8	9.42	9.45	9.46	8.75	9.21	9.38	8.76	8.68	9.1	9.55	9.17
	CSP solar power	1	EU28	MW-e	3.8	0.20	M€/MWe	5.51	5.74	4.77	5.54	5.57	5.59	4.72	5.27	5.49	4.72	4.63	5.15	5.69	5.22
	River hydro	1	EU28	MW-e	5.6	0.20	M€/MWe	5.92	6.27	4.84	5.97	6.02	6.04	4.75	5.57	5.89	4.76	4.62	5.38	6.19	5.5
	Hydro power	1	EU28	MW-e	2.6	0.20	M€/MWe	2.65	2.81	2.16	2.67	2.69	2.7	2.12	2.49	2.64	2.12	2.06	2.41	2.77	2.46
	Hydro storage	1	EU28	MW-e	0.9	0.20	M€/MWe	0.91	0.96	0.75	0.92	0.92	0.93	0.73	0.86	0.91	0.73	0.71	0.83	0.95	0.85
	Hydro pump	1	EU28	MW-e	0.7	0.20	M€/MWe	0.7	0.74	0.57	0.7	0.71	0.71	0.56	0.66	0.69	0.56	0.54	0.63	0.73	0.65
	Geothermal Electricity	1	EU28	MW-e	4.5	0.20	M€/MWe	5.63	5.91	4.77	5.67	5.71	5.73	4.7	5.36	5.61	4.71	4.6	5.21	5.85	5.3
	Geothermal heating	11	DK	TWh/a	166.6	0.25	M€/TWh/year	165.4	173.18	141.02	166.45	167.59	168.06	139.12	157.63	164.74	139.31	136.09	153.36	171.38	155.92
	Solar thermal	11	DK	TWh/a	354.5	0.15	M€/TWh/year	366.61	376.54	335.48	367.94	369.4	370	333.05	356.68	365.76	333.3	329.18	351.23	374.24	354.5
	Heat storage solar	11	DK	GWh	0.5	0.30	M€/GWh	0.47	0.5	0.39	0.48	0.48	0.48	0.38	0.44	0.47	0.38	0.37	0.43	0.49	0.44
	Industrial excess heat	11	DK	MW-th	0.0	0.35	M€/MWth	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
Liquid and gas fuels	Biogas plant	9	DK	TWh/a	198.1	0.20	M€/TWh/year	183.77	191.17	160.58	184.76	185.85	186.3	158.77	176.37	183.14	158.95	155.88	172.31	189.46	174.75
	Gasification plant	9	DK	MW-Syngas	0.3	0.20	M€/MW-Syngas	0.45	0.46	0.41	0.45	0.45	0.45	0.41	0.44	0.45	0.41	0.41	0.43	0.46	0.44
	Biogas upgrade	9	DK	MW-CH4	0.2	0.20	M€/MW-CH4	0.19	0.2	0.17	0.19	0.19	0.19	0.17	0.18	0.19	0.17	0.16	0.18	0.2	0.18
	Gasification upgrade	12	DK	MW	0.3	0.20	M€/MW	0.29	0.3	0.25	0.29	0.29	0.29	0.25	0.28	0.29	0.25	0.25	0.27	0.3	0.28
	CO2 hydrogenation	12	DK	MW	0.9	0.20	M€/MW	0.87	0.9	0.76	0.87	0.88	0.88	0.75	0.83	0.86	0.75	0.74	0.82	0.89	0.83
	Electrolyser	8	DK	MW-e	1.0	0.20	M€/MWe	1.28	1.32	1.17	1.29	1.29	1.3	1.16	1.25	1.28	1.16	1.14	1.23	1.31	1.24
	Hydrogen storage	8	DK	GWh	17.0	0.20	M€/GWh	16.39	17.02	14.4	16.47	16.57	16.61	14.24	15.75	16.33	14.26	13.99	15.4	16.88	15.61
	Gas storage	9	DK	GWh	0.0	0.20	M€/GWh	0.04	0.05	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04
	Oil storage	12	DK	GWh	0.0	0.20	M€/GWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Methanol storage	12	DK	GWh	0.1	0.20	M€/GWh	0.1	0.1	0.08	0.1	0.1	0.1	0.08	0.09	0.1	0.08	0.08	0.09	0.1	0.09
Heat infrastructure	Individual boilers																				
	Coal	13	DE	MW-th	0.3	0.20	M€/MW-th	0.28	0.29	0.24	0.28	0.28	0.28	0.24	0.26	0.27	0.24	0.23	0.26	0.29	0.26
	Oil	11	DE	Unit	5.5	0.05	M€/1000 units	5.48	5.54	5.3	5.49	5.5	5.5	5.28	5.42	5.48	5.29	5.26	5.39	5.52	5.41
	Ngas	11	DE	Unit	4.3	0.10	M€/1000 units	4.27	4.36	3.98	4.28	4.29	4.3	3.96	4.18	4.26	3.96	3.93	4.13	4.34	4.16
	Biomass	11	DE	Unit	14.0	0.05	M€/1000 units	13	13.15	12.54	13.02	13.04	13.05	12.5	12.85	12.99	12.5	12.44	12.77	13.11	12.82
	Individual CHP	11	DE	Unit	20.7	0.05	M€/1000 units	20.63	20.84	19.94	20.65	20.69	20.7	19.89	20.41	20.61	19.89	19.8	20.29	20.79	20.36
	Individual Heat Pumps																				
	Ground source	10	DK	Unit	14.0	0.35	M€/1000 units	14.42	15.33	11.55	14.54	14.67	14.73	11.33	13.5	14.34	11.35	10.97	13	15.12	13.3
	Air source	10	DK	Unit	8.5	0.35	M€/1000 units	9.44	10	7.7	9.51	9.6	9.63	7.56	8.88	9.39	7.58	7.35	8.58	9.87	8.76
	Individual electric heating	9	DK	Unit	3.0	0.30	M€/1000 units	2.84	3.01	2.31	2.86	2.89	2.9	2.27	2.67	2.82	2.27	2.2	2.58	2.97	2.63
	Individual solar thermal	11	DE	Unit	4.4	0.15	M€/TWh/year	4.78	4.92	4.34	4.8	4.82	4.83	4.31	4.64	4.77	4.31	4.25	4.56	4.88	4.61

2050 Baseline

Category	Technology	Reference no.	Base region	Unit for typical capacity	Price in base region	r_labour	Units	Austria AT	Belgium BE	Czech Rep. CZ	Finland FI	France FR	Germany DE	Hungary HU	Italy IT	Netherlands NL	Poland PL	Romania RO	Spain ES	Sweden SE	United Kin UK
Heat and Electricity	Small CHP plants	2	DK	MW-e	0.9	0.35	M€/MWe	0.89	0.95	0.72	0.9	0.91	0.91	0.91	0.71	0.84	0.89	0.71	0.68	0.81	0.94	0.83
	Large CHP plants	2	DK	MW-e	0.8	0.24	M€/MWe	0.86	0.9	0.75	0.86	0.87	0.87	0.87	0.74	0.82	0.86	0.74	0.72	0.8	0.89	0.82
	Heat Storage CHP	9	DK	GWh	1.6	0.20	M€/GWh	1.52	1.58	1.34	1.53	1.54	1.54	1.54	1.32	1.46	1.52	1.33	1.3	1.43	1.57	1.45
	Waste CHP	9	DK	tonne/hour	8.5	0.20	M€/MWe	8.19	8.51	7.2	8.24	8.28	8.3	7.12	7.88	8.17	7.13	7	7.7	8.44	7.81
	Absorption HP (waste)	2	DK	MW-th	0.5	0.50	M€/MWth	0.49	0.53	0.35	0.49	0.5	0.5	0.34	0.45	0.48	0.34	0.33	0.42	0.52	0.44
	Decentral DH HP	2	DK	MW-e	0.1	0.50	M€/MWe	0.15	0.17	0.12	0.15	0.16	0.16	0.11	0.14	0.15	0.11	0.11	0.13	0.16	0.14
	Central DH HP	11	DK	MW-th	0.6	0.20	M€/MWth	0.58	0.6	0.51	0.58	0.58	0.59	0.5	0.56	0.58	0.5	0.49	0.54	0.6	0.55
	Electric DH boilers	2	DK	MW-e	0.1	0.20	M€/MWe	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.06	0.06
	Large Power plants	11	EU28	MW-e	1.0	0.34	M€/MWe	1.19	1.3	0.85	1.2	1.22	1.23	0.82	1.08	1.18	0.82	0.78	1.02	1.27	1.06
	Nuclear plants	1	EU28	MW-e	3.8	0.20	M€/MWe	4.62	4.85	3.89	4.65	4.68	4.69	3.83	4.38	4.6	3.84	3.74	4.26	4.79	4.33
	Interconnection	7	DK	MW-e	0.2	0.20	M€/MWe	0.16	0.17	0.14	0.16	0.17	0.17	0.14	0.16	0.16	0.14	0.14	0.15	0.17	0.16
	Hydro pump	8	DK	MW-e	0.6	0.20	M€/MWe	0.58	0.6	0.51	0.58	0.58	0.59	0.5	0.56	0.58	0.5	0.49	0.54	0.6	0.55
	Pumed storage	8	DK	MW-e	4.0	0.20	M€/MWe	3.86	4.01	3.39	3.88	3.9	3.91	3.35	3.71	3.84	3.35	3.29	3.62	3.97	3.67
	Industrial CHP electricity	12	DK	TWh/a	68.3	0.20	M€/TWh/year	65.84	68.39	57.84	66.18	66.56	66.71	57.22	63.29	65.62	57.28	56.23	61.89	67.8	62.73
	Industrial CHP heating	11	DK	MW-th	0.1	0.35	M€/MWth	0.09	0.1	0.07	0.09	0.09	0.09	0.07	0.08	0.09	0.07	0.07	0.08	0.1	0.08
Renewable energy	Onshore wind power	2	DK	MW-e	0.8	0.25	M€/MWe	0.97	1.01	0.85	0.98	0.98	0.99	0.84	0.93	0.93	0.97	0.84	0.83	0.91	1	0.93
	Offshore wind power	2	DK	MW-e	1.7	0.55	M€/MWe	1.85	2.03	1.3	1.87	1.9	1.91	1.26	1.68	1.84	1.26	1.19	1.58	1.99	1.64
	Photo Voltaic	2	DE	MW-e	0.6	0.18	M€/MWe	1.29	1.31	1.22	1.29	1.29	1.3	1.22	1.27	1.29	1.22	1.21	1.26	1.31	1.26
	Wave power	8	DK	MW-e	1.6	0.55	M€/MWe	4.23	4.4	3.72	4.25	4.28	4.29	3.68	4.07	4.07	4.22	3.68	3.61	3.98	4.36	4.03
	Tidal Power	1	EU28	MW-e	1.9	0.20	M€/MWe	9.07	9.19	8.71	9.09	9.11	9.11	8.68	8.96	9.06	8.68	8.63	8.89	9.16	8.93
	CSP solar power	1	EU28	MW-e	3.4	0.20	M€/MWe	5.4	5.61	4.74	5.43	5.46	5.47	4.69	5.19	5.38	4.7	4.61	5.08	5.56	5.14
	River hydro	1	EU28	MW-e	5.6	0.20	M€/MWe	5.92	6.27	4.84	5.97	6.02	6.04	4.75	5.57	5.89	4.76	4.62	5.38	6.19	5.5
	Hydro power	1	EU28	MW-e	2.6	0.20	M€/MWe	2.65	2.81	2.16	2.67	2.69	2.7	2.12	2.49	2.64	2.12	2.06	2.41	2.77	2.46
	Hydro storage	1	EU28	MW-e	0.9	0.20	M€/MWe	0.91	0.96	0.75	0.92	0.92	0.93	0.73	0.86	0.91	0.73	0.71	0.83	0.95	0.85
	Hydro pump	1	EU28	MW-e	0.7	0.20	M€/MWe	0.7	0.74	0.57	0.7	0.71	0.71	0.56	0.66	0.69	0.56	0.54	0.63	0.73	0.65
	Geothermal Electricity	1	EU28	MW-e	3.6	0.20	M€/MWe	5.4	5.62	4.7	5.43	5.46	5.48	4.65	5.18	5.38	4.65	4.56	5.06	5.57	5.13
	Geothermal heating	11	DK	TWh/a	158.3	0.25	M€/TWh/year	163.7	171.09	140.53	164.69	165.77	166.22	138.73	156.31	163.07	138.91	135.85	152.25	169.38	154.68
	Solar thermal	11	DK	TWh/a	334.7	0.15	M€/TWh/year	364.17	373.55	334.78	365.43	366.8	367.37	332.49	354.79	363.37	332.72	328.83	349.65	371.37	352.73
	Heat storage solar	11	DK	GWh	0.5	0.30	M€/GWh	0.47	0.5	0.39	0.48	0.48	0.48	0.38	0.44	0.47	0.38	0.37	0.43	0.49	0.44
	Industrial excess heat	11	DK	MW-th	0.0	0.35	M€/MWth	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.02	0.02
Liquid and gas fuels	Biogas plant	9	DK	TWh/a	198.1	0.20	M€/TWh/year	183.77	191.17	160.58	184.76	185.85	186.3	158.77	176.37	183.14	158.95	155.88	172.31	189.46	174.75
	Gasification plant	9	DK	MW-Syngas	0.3	0.20	M€/MW-Syngas	0.45	0.46	0.41	0.45	0.45	0.45	0.41	0.44	0.45	0.41	0.41	0.43	0.46	0.44
	Biogas upgrade	9	DK	MW-CH4	0.2	0.20	M€/MW-CH4	0.19	0.2	0.17	0.19	0.19	0.19	0.17	0.18	0.19	0.17	0.16	0.18	0.19	0.18
	Gasification upgrade	12	DK	MW	0.3	0.20	M€/MW	0.29	0.3	0.25	0.29	0.29	0.29	0.25	0.28	0.29	0.25	0.25	0.27	0.3	0.28
	CO2 hydrogenation	12	DK	MW	0.9	0.20	M€/MW	0.87	0.9	0.76	0.87	0.88	0.88	0.75	0.83	0.86	0.75	0.74	0.82	0.89	0.83
	Electrolyser	8	DK	MW-e	1.0	0.20	M€/MWe	1.28	1.32	1.17	1.29	1.29	1.3	1.16	1.25	1.28	1.16	1.14	1.23	1.31	1.24
	Hydrogen storage	8	DK	GWh	17.0	0.20	M€/GWh	16.39	17.02	14.4	16.47	16.57	16.61	14.24	15.75	16.33	14.26	13.99	15.4	16.88	15.61
	Gas storage	9	DK	GWh	0.0	0.20	M€/GWh	0.04	0.05	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04
	Oil storage	12	DK	GWh	0.0	0.20	M€/GWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Methanol storage	12	DK	GWh	0.1	0.20	M€/GWh	0.1	0.1	0.08	0.1	0.1	0.1	0.08	0.09	0.1	0.08	0.08	0.09	0.1	0.09
Heat infrastructure	Individual boilers				0.0	0.00															
	Coal	13	DE	MW-th	0.3	0.20	M€/MW-th	0.28	0.29	0.24	0.28	0.28	0.28	0.24	0.26	0.27	0.24	0.23	0.26	0.29	0.26
	Oil	11	DE	Unit	5.5	0.05	M€/1000 units	5.48	5.54	5.3	5.49	5.5	5.5	5.28	5.42	5.48	5.29	5.26	5.39	5.52	5.41
	Ngas	11	DE	Unit	4.3	0.10	M€/1000 units	4.27	4.36	3.98	4.28	4.29	4.3	3.96	4.18	4.26	3.96	3.93	4.13	4.34	4.16
	Biomass	11	DE	Unit	14.0	0.05	M€/1000 units	13	13.15	12.54	13.02	13.04	13.05	12.5	12.85	12.99	12.5	12.44	12.77	13.11	12.82
	Individual CHP	11	DE	Unit	20.7	0.05	M€/1000 units	20.63	20.84	19.94	20.65	20.69	20.7	19.89	20.41	20.61	19.89	19.8	20.29	20.79	20.36
	Individual Heat Pumps				0.0	0.00															
	Ground source	10	DK	Unit	12.0	0.35	M€/1000 units	13.84	14.63	11.39	13.95	14.06	14.11	11.19	13.06	13.78	11.21	10.89	12.63	14.45	12.89
	Air source	10	DK	Unit	7.6	0.40	M€/1000 units	9.49	10.06	7.71	9.57	9.65	9.69	7.57	8.93	9.44	7.59	7.35	8.61	9.93	8.8
	Individual electric heating	9	DK	Unit	3.0	0.30	M€/1000 units	2.84	3.01	2.31	2.86	2.89	2.9	2.27	2.67	2.82	2.27	2.2	2.58	2.97	2.63
	Individual solar thermal	11	DE	Unit	3.3	0.15	M€/TWh/year	4.62	4.73	4.3	4.64	4.65	4.66	4.27	4.52	4.62	4.27	4.23	4.46	4.7	4.5

2015 Baseline			
Category	Technology	Reference	Fixed part of O&M costs
Heat and Electricity	Small CHP plants	2	1.0%
	Large CHP plants	2	3.3%
	Heat Storage CHP	12	0.7%
	Waste CHP	9	0.0%
	Absorption HP (waste)	2	0.3%
	Decentral DH HP	2	0.3%
	Central DH HP	11	1.0%
	Electric DH boilers	2	5.0%
	Large Power plants	11	2.4%
	Nuclear plants	1	2.0%
	Interconnection	7	0.9%
	Hydro pump	1	1.5%
	Pumped storage	1	1.5%
	Industrial CHP electricity	12	7.3%
	Industrial CHP heating	11	3.7%
Renewable energy	Onshore wind power	2	2.4%
	Offshore wind power	2	2.0%
	Photo Voltaic	2	0.9%
	Wave power	1	3.6%
	Tidal Power	1	3.4%
	CSP solar power	1	4.0%
	River hydro	1	1.5%
	Hydro power	1	1.3%
	Hydro storage	1	1.5%
	Hydro pump	1	1.5%
	Geothermal Electricity	1	1.4%
	Geothermal heating	12	0.0%
	Solar thermal	11	0.0%
	Heat storage solar	12	0.7%
	Industrial excess heat	11	3.7%
Liquid and gas fuels	Biogas plant	-	-
	Gasification plant	-	-
	Biogas upgrade	-	-
	Gasification upgrade	12	15.8%
	CO2 hydrogenation	12	2.5%
	Electrolyser	8	4.0%
	Hydrogen storage	12	0.5%
	Gas storage	9	2.6%
	Oil storage	12	0.6%
	Methanol storage	12	0.6%
Heat infrastructure	Individual boilers		
	Coal	12	1.8%
	Oil	11	3.3%
	Ngas	11	5.2%
	Biomass	11	3.6%
	Individual CHP	12	0.0%
	Individual Heat Pumps		
	Ground source	10	1.8%
	Air source	10	2.9%
	Individual electric heating	9	0.8%
	Individual solar thermal	11	2.3%

2030 Baseline			
Category	Technology	Reference	Fixed part of O&M costs
Heat and Electricity	Small CHP plants	2	1.0%
	Large CHP plants	2	3.3%
	Heat Storage CHP	12	0.7%
	Waste CHP	12	-
	Absorption HP (waste)	2	0.4%
	Decentral DH HP	2	0.3%
	Central DH HP	11	1.0%
	Electric DH boilers	2	1.0%
	Large Power plants	11	5.3%
	Nuclear plants	1	1.9%
	Interconnection	7	0.9%
	Hydro pump	8	1.5%
	Pumed storage	8	1.5%
	Industrial CHP electricity	12	7.3%
	Industrial CHP heating	11	3.7%
Renewable energy	Onshore wind power	2	2.5%
	Offshore wind power	2	1.9%
	Photo Voltaic	2	1.3%
	Wave power	-	-
	Tidal Power	1	3.8%
	CSP solar power	1	4.0%
	River hydro	1	1.5%
	Hydro power	1	1.3%
	Hydro storage	1	1.5%
	Hydro pump	1	1.5%
	Geothermal Electricity	1	1.8%
	Geothermal heating	12	0.0%
	Solar thermal	11	0.0%
	Heat storage solar	12	0.7%
	Industrial excess heat	11	3.7%
Liquid and gas fuels	Biogas plant	-	-
	Gasification plant	-	-
	Biogas upgrade	-	-
	Gasification upgrade	12	15.8%
	CO2 hydrogenation	12	2.5%
	Electrolyser	8	4.0%
	Hydrogen storage	12	0.5%
	Gas storage	9	2.6%
	Oil storage	12	0.6%
	Methanol storage	12	0.6%
Heat infrastructure	Individual boilers		
	Coal	13	1.8%
	Oil	11	3.3%
	Ngas	11	5.2%
	Biomass	11	3.6%
	Individual CHP	12	0.0%
	Individual Heat Pumps		
	Ground source	10	1.8%
	Air source	10	3.0%
	Individual electric heating	9	0.8%
	Individual solar thermal	11	2.3%

2050 Baseline			
Category	Technology	Reference	Fixed part of O&M costs
Heat and Electricity	Small CHP plants	2	1.0%
	Large CHP plants	2	3.3%
	Heat Storage CHP	12	0.7%
	Waste CHP	-	-
	Absorption HP (waste)	2	0.4%
	Decentral DH HP	2	0.3%
	Central DH HP	11	1.0%
	Electric DH boilers	2	0.9%
	Large Power plants	11	5.3%
	Nuclear plants	1	1.6%
	Interconnection	7	0.9%
	Hydro pump	8	1.5%
	Pumed storage	8	1.5%
	Industrial CHP electricity	12	7.3%
	Industrial CHP heating	11	3.7%
Renewable energy	Onshore wind power	2	2.6%
	Offshore wind power	2	1.9%
	Photo Voltaic	2	1.4%
	Wave power	-	-
	Tidal Power	1	4.9%
	CSP solar power	1	4.0%
	River hydro	1	1.5%
	Hydro power	1	1.3%
	Hydro storage	1	1.5%
	Hydro pump	1	1.5%
	Geothermal Electricity	1	2.2%
	Geothermal heating	12	0.0%
	Solar thermal	11	0.0%
	Heat storage solar	12	0.7%
	Industrial excess heat	11	3.7%
Liquid and gas fuels	Biogas plant	-	-
	Gasification plant	-	-
	Biogas upgrade	-	-
	Gasification upgrade	12	15.8%
	CO2 hydrogenation	12	2.5%
	Electrolyser	8	4.0%
	Hydrogen storage	12	0.5%
	Gas storage	9	2.6%
	Oil storage	12	0.6%
	Methanol storage	12	0.6%
Heat infrastructure	Individual boilers		0
	Coal	12	1.8%
	Oil	11	3.3%
	Ngas	11	5.2%
	Biomass	11	3.6%
	Individual CHP	12	0.0%
	Individual Heat Pumps		0
	Ground source	10	2.0%
	Air source	10	3.1%
	Individual electric heating	9	0.8%
	Individual solar thermal	11	2.3%

2015 Baseline			
Category	Technology	Reference	Lifetime in years
Heat and Electricity	Small CHP plants	2	25
	Large CHP plants	2	25
	Heat Storage CHP	12	20
	Waste CHP	9	20
	Absorption HP (waste)	2	25
	Decentral DH HP	2	25
	Central DH HP	11	25
	Electric DH boilers	2	20
	Large Power plants	11	35
	Nuclear plants	1	60
	Interconnection	7	45
	Hydro pump	8	50
	Pumed storage	8	50
	Industrial CHP electricity	12	25
	Industrial CHP heating	11	25
Renewable energy	Onshore wind power	2	25
	Offshore wind power	2	25
	Photo Voltaic	2	30
	Wave power	8	10
	Tidal Power	1	20
	CSP solar power	1	30
	River hydro	1	60
	Hydro power	1	60
	Hydro storage	1	60
	Hydro pump	1	60
	Geothermal Electricity	1	30
	Geothermal heating	11	25
	Solar thermal	11	30
	Heat storage solar	11	20
	Industrial excess heat	11	25
Liquid and gas fuels	Biogas plant	9	20
	Gasification plant	9	25
	Biogas upgrade	9	15
	Gasification upgrade	12	15
	CO2 hydrogenation	12	20
	Electrolyser	8	25
	Hydrogen storage	8	30
	Gas storage	12	50
	Oil storage	12	50
	Methanol storage	12	50
Heat infrastructure	Individual boilers	0	
	Coal	13	20
	Oil	11	20
	Ngas	11	22
	Biomass	11	20
	Individual CHP	12	10
	Individual Heat Pumps	0	
	Ground source	10	20
	Air source	10	18
	Individual electric heating	9	30
	Individual solar thermal	12	25

2030 Baseline			
Category	Technology	Reference	Lifetime in years
Heat and Electricity	Small CHP plants	2	25
	Large CHP plants	2	25
	Heat Storage CHP	12	20
	Waste CHP	9	20
	Absorption HP (waste)	2	25
	Decentral DH HP	2	25
	Central DH HP	11	25
	Electric DH boilers	2	20
	Large Power plants	11	35
	Nuclear plants	1	60
	Interconnection	7	45
	Hydro pump	8	50
	Pumed storage	8	50
	Industrial CHP electricity	12	25
	Industrial CHP heating	11	25
Renewable energy	Onshore wind power	2	30
	Offshore wind power	2	30
	Photo Voltaic	2	40
	Wave power	8	25
	Tidal Power	1	20
	CSP solar power	1	30
	River hydro	1	60
	Hydro power	1	60
	Hydro storage	1	60
	Hydro pump	1	60
	Geothermal Electricity	1	30
	Geothermal heating	11	30
	Solar thermal	11	30
	Heat storage solar	11	20
	Industrial excess heat	11	25
Liquid and gas fuels	Biogas plant	9	20
	Gasification plant	9	25
	Biogas upgrade	9	15
	Gasification upgrade	12	15
	CO2 hydrogenation	12	20
	Electrolyser	8	30
	Hydrogen storage	8	30
	Gas storage	12	50
	Oil storage	12	50
	Methanol storage	12	50
Heat infrastructure	Individual boilers		
	Coal	12	20
	Oil	11	20
	Ngas	11	22
	Biomass	11	20
	Individual CHP	12	10
	Individual Heat Pumps		
	Ground source	10	20
	Air source	10	18
	Individual electric heating	9	30
	Individual solar thermal	12	25

2050 Baseline			
Category	Technology	Reference	Lifetime in years
Heat and Electricity	Small CHP plants	2	25
	Large CHP plants	2	25
	Heat Storage CHP	12	20
	Waste CHP	9	20
	Absorption HP (waste)	2	25
	Decentral DH HP	2	25
	Central DH HP	11	25
	Electric DH boilers	2	20
	Large Power plants	11	35
	Nuclear plants	1	60
	Interconnection	7	45
	Hydro pump	8	50
	Pumed storage	8	50
	Industrial CHP electricity	12	25
	Industrial CHP heating	11	25
Renewable energy	Onshore wind power	2	30
	Offshore wind power	2	30
	Photo Voltaic	2	40
	Wave power	8	30
	Tidal Power	1	20
	CSP solar power	1	30
	River hydro	1	60
	Hydro power	1	60
	Hydro storage	1	60
	Hydro pump	1	60
	Geothermal Electricity	1	30
	Geothermal heating	11	30
	Solar thermal	11	30
	Heat storage solar	11	20
	Industrial excess heat	11	25
Liquid and gas fuels	Biogas plant	9	20
	Gasification plant	9	25
	Biogas upgrade	9	15
	Gasification upgrade	12	15
	CO2 hydrogenation	12	20
	Electrolyser	8	30
	Hydrogen storage	8	30
	Gas storage	12	50
	Oil storage	12	50
	Methanol storage	12	50
Heat infrastructure	Individual boilers		0
	Coal	13	20
	Oil	11	20
	Ngas	11	22
	Biomass	11	20
	Individual CHP	12	10
	Individual Heat Pumps		0
	Ground source	10	20
	Air source	10	18
	Individual electric heating	9	30
	Individual solar thermal	12	25

Annex II – List of technologies included

Below is seen a list of the different technologies included in this task.

- Individual heat pumps
  - Ground source
  - Air source
- Heat pumps – DH connected
  - Decentral
  - Central
- Absorption heat pumps (waste)
- Waste CHP
- Individual CHP
- CHP plants
  - Small
  - Large
- Heat storage connected to CHP
- Large power (only) plants
- Industrial CHP
  - Electricity
  - Heating
- Individual electric heating
- Electric DH boilers
- Individual boilers
  - Coal
  - Oil
- Wind power
  - Onshore
  - Offshore
- Geothermal heating
- Geothermal electricity
- Photo voltaic
- CSP (solar power)
- Solar thermal (large scale)
- Heat storage (PTES for large scale solar thermal)
- Industrial excess heat
- Individual solar thermal
- Nuclear plants
- Interconnection (HV power lines)
- Pump for PHES
- PHES
- River hydro power (run-of river hydro power)

- Hydro power station
- Hydro power storage (reservoir)
- Hydro power pump for pump-back
- Electrolysis
- Hydrogen storage (high pressure tanks incl. converter)
- Wave power
- Tidal power
- Biogas plant
- Gasification plant
- Biogas upgrade
- Gasification upgrade
- CO_2 hydrogenation
- Gas storage
- Oil storage
- Methanol storage