European Commission

JRC SCIENCE FOR POLICY REPORT

Cost-benefit analysis for the potential of high-efficiency cogeneration in Cyprus

Administrative Arrangement N° SI2.241078

Between SRSS and JRC

LIMITED DISTRIBUTION

Marta Santamaria

Konstantinos Kavvadias

Mindaugas Jakubcionis

2016

Joint Research Centre

LIMITED DISTRIBUTION

Contact information

Johan Carlsson

Address: Joint Research Centre, P.O. Box 2, 1755 ZG Petten, The Netherlands

E-mail: johan.carlsson@ec.europa.eu

Tel.: +31 224 56 5341

JRC Science Hub
https://ec.europa.eu/jrc

JRC100312

Abstract
Cost-benefit analysis for the potential of high-efficiency co-generation in Cyprus
This report evaluations the economic energy efficiency potential of Cyprus in the heating and cooling sector according to the Article 14 of the Energy Efficiency Directive (2012/27/EU).

Executive summary[1]

Identification of demand

The energy demand for heating and cooling in Cyprus is analysed for 4 sectors (industry, residential, commercial, agriculture) and for a total of 18 subsectors. Each sector is further disaggregated to energy vectors and only the heating and cooling related vectors are examined in this report i.e. heating, cooling, hot water and process heat. The national energy balances and specific sector indicators are used for this task.

The base year selected for this study is 2013. For the residential sector the energy demand is 6.06 PJ, 5.19 PJ and 1.88 PJ for cooling, heating and hot water respectively. For the service sector the energy demand is 5.85 PJ, 2.24 PJ and 0.72 PJ for cooling, heating and hot water respectively. For the industrial sector the energy demand is 5.15 PJ, 6.89 PJ for heating and other applications respectively. For the agriculture sector the energy demand is 1.44 PJ for heating.

Definition of system boundaries

The geographical dimension is also considered for this task. The smallest entity of heat demand (i.e. base heat demand area) is selected to be the postal code with over 850 postal codes examined. The postal codes are aggregated using energy demand density (kWh/m^2) as a criterion to establish high and low energy dense areas.

Based on that, four system boundaries of high energy density are identified in Cyprus. These systems are in the wider urban areas of: [i] Nicosia; [ii] Paphos; [iii] Limassol and [iv] Larnaca. The demand of these four systems constitute the 'heating and cooling demand that could be satisfied by district heating and cooling' in Cyprus. This demand in terms of heat-equivalent is 14.07 PJ. Within the four high demand density system boundaries, Limassol and Larnaca have a nearby exploitable waste heat source. Postal codes that do not belong to these four wider city areas are grouped in another single system boundary that encompasses the postal codes of the rest of Cyprus, thus forming a part of one 'low demand density system'. In this system boundary, only individual solutions are examined. The demand of the five system boundaries constitute the 'heating and cooling demand that could be satisfied by high-efficiency cogeneration, including residential micro-cogeneration'. This demand is 25.01 PJ.

Technical potential of efficient heating and cooling solutions

A range of 14 high efficiency heating and cooling solutions to satisfy heating and cooling demand of different sub-sectors have been identified and tested in this study. 13 high efficiency heating and cooling solutions have been considered applicable for centralized systems (which means, using district heating/cooling systems to distribute thermal energy). Split unit heat pumps (air conditioners) are considered only as individual solutions. 13 solutions are considered applicable as individual systems (which means producing heating and cooling in situ). Heat recovery from power plants (centralized cogeneration power plants) is analysed only for centralised energy supply options.

The technical potential of these solutions has been assessed for the period 2013-2050. As an example, Figure E.1 shows the technical potential of efficient heating and cooling solutions in Cyprus for 2013. The figures refer to the technical potential of individual solutions (for all solutions except for heat recovery) as those are always higher than the one of centralised solutions. The solutions with the highest technical potential are: those using conventional fossil fuels as resource (such as gas oil with CHP; light fuel oil with CHP and LPG with CHP); solar and heat pumps (both split units and normal). Heat recovery from power plants has a technical potential that is approximately seven times

[1] This executive summary also recaps information from previous deliverables D I.1.1 (Heating and cooling demand forecast in Cyprus) and D I.2.1 (Energy efficiency potential).

lower than the mentioned solutions. The solutions with a significantly smaller technical potential are based on biomass resources, such as: solid biomass; municipal waste and livestock/industrial waste.

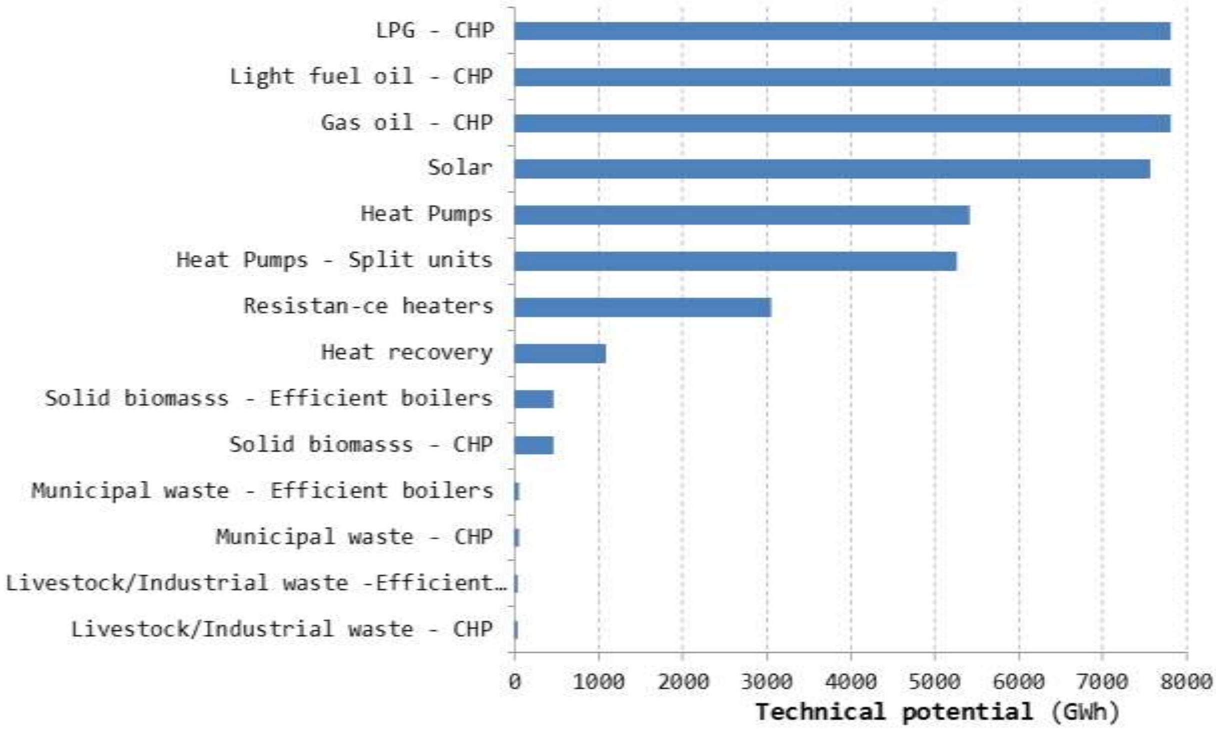


Figure E.1 Technical potential of efficient heating and cooling solutions in Cyprus, 2013

Construction of scenarios

The purpose of the baseline is 'to serve as a reference point, to which the alternative scenarios are evaluated'. The baseline scenario describes the most likely development of existing energy demand, supply and transformation based on current knowledge, technological development and policy measures. The baseline scenarios are prepared for all analysed sub-sectors and the demand evolution during the period 2013-2050 is taken from forecast estimations.

The alternative scenarios are built to evaluate the effects of expanding each technical solution to their maximum extent (i.e. taking into account its technical potentials). As a consequence, in each system boundary the number of alternative scenarios constructed is equal to the technically viable solutions identified during the technical potential identification exercise. For all solutions it is assumed that they cover as much heating and cooling demand (considering the three end uses: heating; sanitary hot water and cooling) as is technically possible. When the technical potential of a solution is lower than the demand, the rest of the demand is covered by the mix of technologies of the baseline scenario using the same shares of those technologies.

Cost-benefit analysis

A CBA is conducted in order to assess the changes in costs and benefits between baseline and alternative scenarios. Once the baseline and the alternative scenarios for each system boundary are defined, relevant effects derived from each scenario (in terms of costs and benefits) are quantified and monetised. Once the information on total cost and total benefit is collected, the scenarios are evaluated using Net Present Value (NPV).

The NPV is a unique estimate of the expected benefits minus the costs, both suitably discounted (by using a discount rate). This indicator provides information about the "net benefit" of the different alternative scenarios considered. This study uses the time frame 2013-2050 to capture the long lifetime of district heating networks.

The Cost-benefit analysis is conducted both from a financial and an economic perspective: [i] the financial analysis tackles the analysis from a private investor's point of view and the [ii] economic analysis tackles the analysis from the point of view of the society. Both perspectives, the economic and financial analyses are applied to assess the efficient heating and cooling options in Cyprus. The aim of conducting the analysis from both perspectives is to identify potential areas for policy influence based on gaps between the financial suitability of an initiative and its convenience from a society's perspective.

Results

The aim of the Cost-benefit analysis is to identify those parts of the technical potential that can economically be met by efficient heating and cooling solutions. Those parts of the technical potential that provide positive NPV, when compared to the baseline scenario, indicate that they are cost-effective and so constitute the economic potential of that technology. In the context of the EED, the NPV has to be calculated for the different alternative scenarios, each one represents a different technical solution. The analysis has been done for all alternative scenarios within the five system boundaries identified: Nicosia; Paphos; Limassol; Larnaca and the rest of Cyprus.

The results of the CBA show that when technical solutions can be applied for both individual and centralised systems, individual systems provide higher economic NPV (ENPV) than centralised solutions. Based on these results, it can be concluded that individual systems are generally better candidates to be promoted as cost-efficient heating and cooling solutions in Cyprus, rather than centralised ones. It can also be concluded that individual systems without water based heating systems are more competitive than individual systems with water based heating systems due to that the latter has increased installation costs in sectors that do not already have pipelines.

The combination of technologies that provide a scenario with the highest ENPV vary from one system boundary to another:

- In Nicosia, Paphos and Limassol the solution that provides the highest ENPV is the split unit heat pumps (air conditioners). Heat pumps and solar are also positive in some residential sectors and in healthcare.
- In Larnaca: heat recovery provides the highest ENPV compared to individual solutions. The second highest NPV is achieved by using split unit heat pumps.
- In the rest of Cyprus: the combination of technologies that provide a scenario with the highest ENPV encompasses the use of split unit heat pumps in residential and service sectors; municipal waste with CHP in all industrial subsectors except in 'other industries', where solar provides the highest ENPV.

Based on the results of the CBA, the economic potential of the identified technical solutions has been assessed for the period 2013–2050. As an example, Figure E.2 shows the economic potential of efficient heating and cooling solutions in Cyprus for 2013. The solutions with the highest economic potential are: autonomous split unit heat pumps (that do not need a water-based piping in the building), solar followed by normal heat pumps. Heat recovery has an economic potential three times lower than the first solution. The solutions with a significantly smaller economic potential are: municipal waste, either with CHP or efficient boilers; and livestock/industrial waste.

In order to identify areas of policy influence, the Primary Energy Savings were estimated by scenario. This comparison shows that solar, followed by solid biomass CHP and heat pumps, presents significantly higher fossil Primary Energy Savings than any other options. This aspect should be taken into account when designing future heating and cooling policies and strategies for Cyprus, giving priority to those solutions with a higher Primary Energy Savings when the costs are similar.

The study has been conducted both from the economic and financial perspectives. The aim is to identify potential areas for policy influence based on gaps between the financial suitability and its convenience from a society's perspective of a solution. In the case of Cyprus, most of the solutions with positive ENPV present positive FNPV. Few cases of solutions with positive ENPV and negative FNPV have been identified.

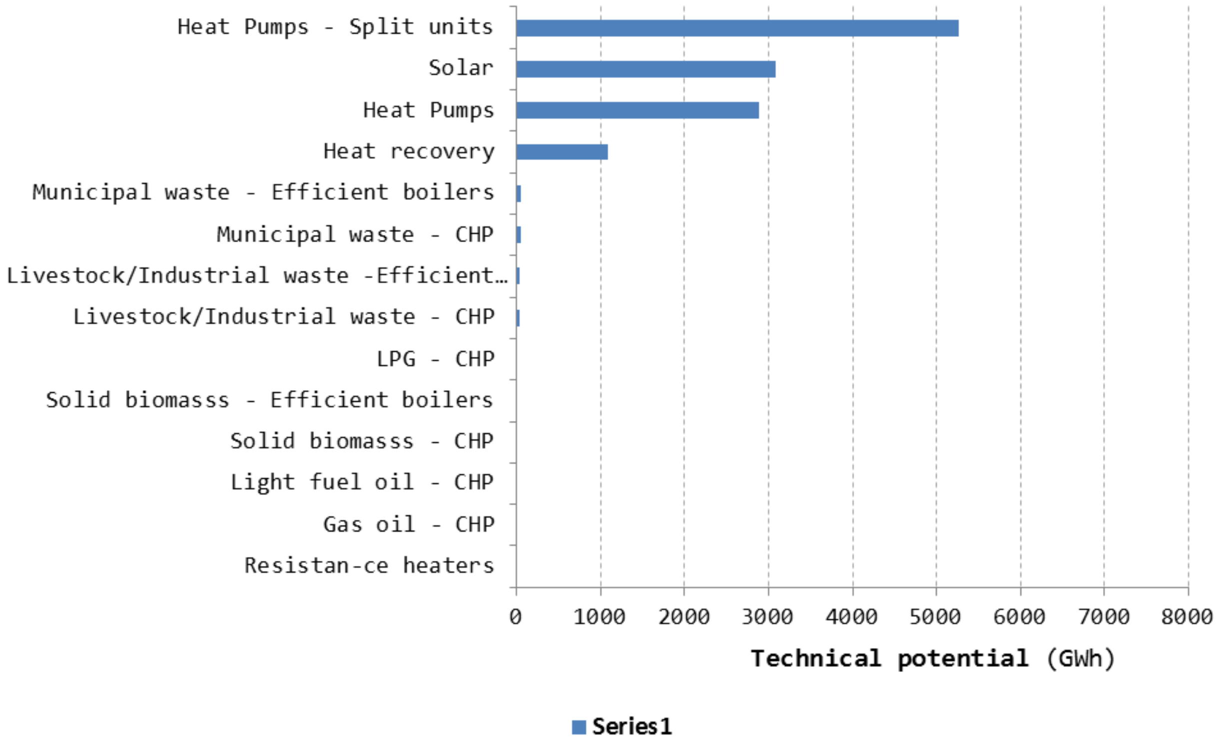


Figure E.2 Economic potential of efficient heating and cooling solutions in Cyprus, 2013

Finally, since the results of all CBAs are very sensitive to fuel prices and to the economic conditions, a sensitivity analysis is conducted modifying the fuel prices and the discount rate.

Table of Contents

Acknowledgements

This report was made possible through contributions from the colleagues, who have been working on the implementation of this AA:

- Marta Santamaria
- Kostas Kavvadias
- Mindaugas Jakubcionis
- Ronald Piers de Raveschoot
- Johan Carlsson

Christodoulos Ellinopoulos of the Ministry of Energy, Commerce, Industry and Tourism of the Republic of Cyprus has provided data and useful feedback on assumptions made.

1 Construction of scenarios

1.1 Setting the baseline scenario

The purpose of the baseline as defined in Annex IX of Energy Efficiency Directive is 'to serve as a reference point, to which the alternative scenarios are evaluated'.

A more detailed description of the definition of a baseline scenario is provided in the Commission Staff Working Document. According to it, the baseline scenario should describe the present situation and its likely evolution as if no parameters of the existing situation are changed. The CSWD also calls this scenario business-as-usual (BAU) or reference scenario.

Other sources usually describe baseline scenario as the most likely development of existing energy demand, supply and transformation based on current knowledge, technological development and policy measures. Baseline should take into account foreseen higher penetration of renewable energy as well as expected improvements in energy generation efficiency.

The baseline scenarios were prepared for all analysed sub-sectors and then generalised baselines are prepared for the main sectors by aggregating data. The electricity mix evolution is assumed to follow the latest available European energy scenario analysis (EC, 2013). Demand evolution during analysed period was taken from forecast report, prepared as a part of this project.

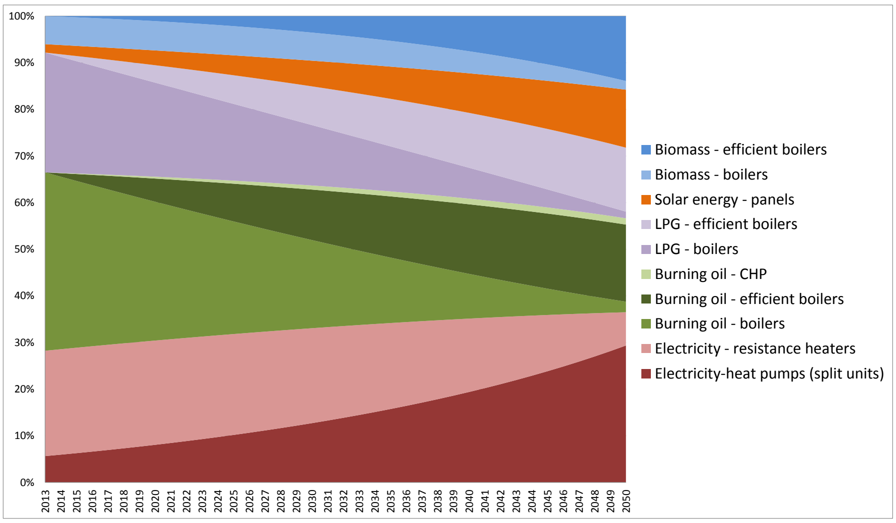
1.1.1 Baseline for residential sector

The baseline development of technologies used to provide heating and cooling to residential sector buildings is presented in the following figures. Detailed information can found in Annex 4. Fig.1.1 a) shows the baseline development of technologies used to provide space heating to residential sector. It is assumed that the penetration of renewables in residential heating will increase, especially in the case of solar heating and electricity consumption in heat pumps. Higher penetration of solar heating is assumed to occur in apartment buildings. Consumption of electricity is assumed to increase gradually due to the increase in "green" electricity availability and higher penetration of heat pumps, especially in single and row houses. Consumption of fossil fuels was assumed to decrease significantly but still be considerable due to the increases in the efficiency of energy generation equipment.

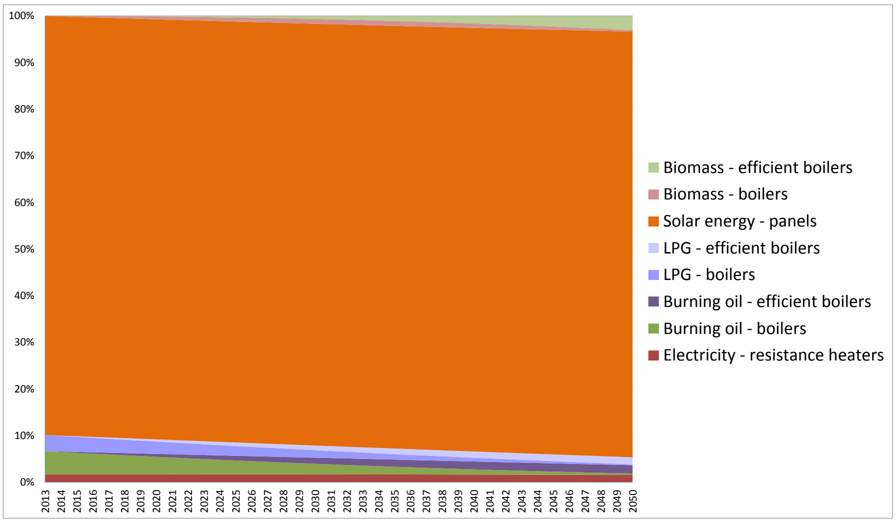
The baseline development of technologies used to provide sanitary hot water to residential sector buildings is presented in Fig.1.1 b). No major changes in sanitary hot water preparation in residential sector are foreseen, although the use of solar energy, which is already dominating technology, will gradually increase mainly at the expense of fossil fuels.

The baseline development of technologies used to provide space cooling to residential sector buildings is presented in Fig. 1.1 c). Although it is assumed that electrically driven air conditioners will be the main source of space cooling throughout the analysed period, some penetration of solar energy based cooling is foreseen.

a) Baseline of space heating



b) Baseline of sanitary hot water



c) Baseline of space cooling

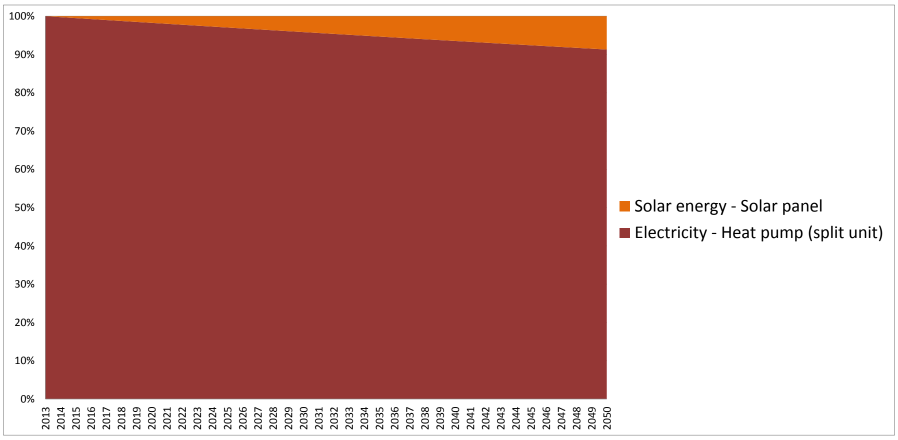


Figure 1.1 Baseline development of shares of technologies used for different end uses in

residential sector (final energy consumption) (%)

1.1.2 Baseline for service sector

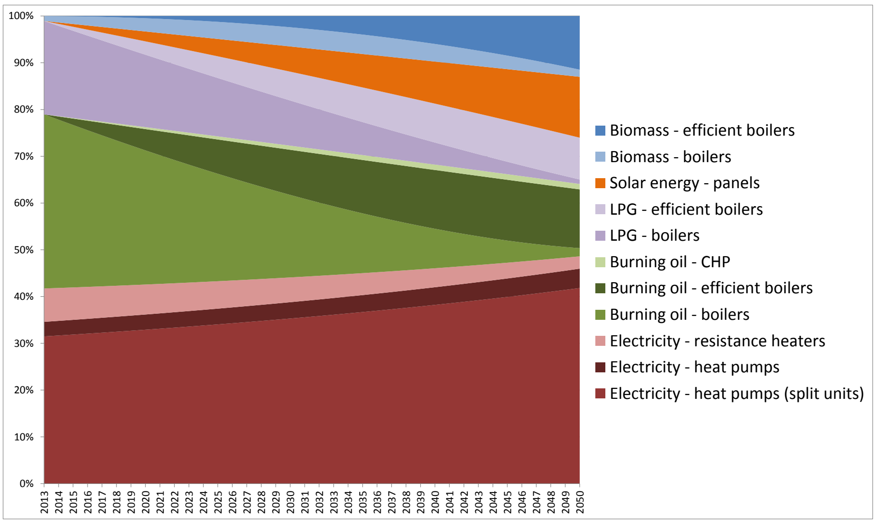
The baseline development of technologies used to provide heating and cooling to service sector buildings is presented in the following figures. Detailed information can be found in Annex 4. Fig.1.2 a) shows the baseline development of technologies used to provide space heating to service sector. It is assumed that the use of biomass for the space heating of the service sector buildings will gradually increase while at the same time more efficient biomass combustion technologies will be introduced. The biggest increase is foreseen in the case of solar heating. It was foreseen that the biggest penetration of solar heating will occur in hotels, followed by office buildings, supermarkets and shopping malls.

The use of electricity is foreseen to gradually increase due to the gradual increase in the availability of "green" electricity.

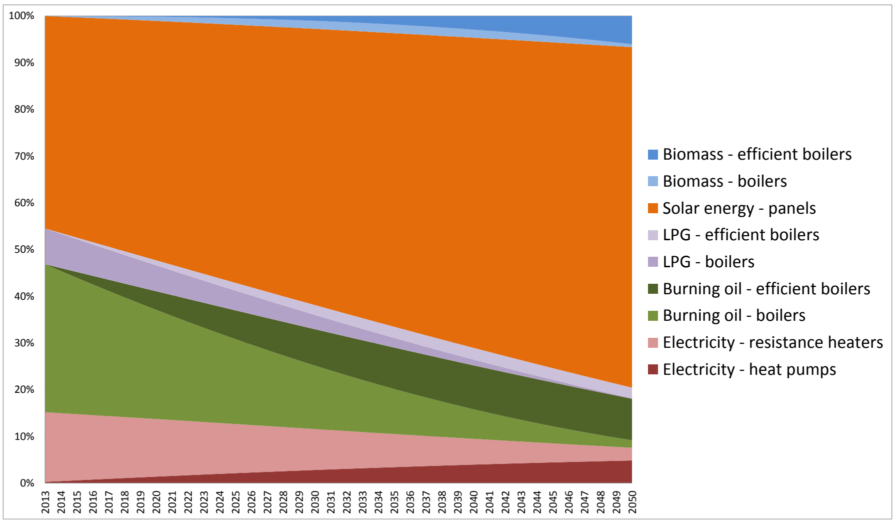
Share of fossil fuels in space heating is foreseen to decrease significantly although it will still remain significant due to the introduction of higher efficiency energy conversion technologies, such as CHP and advanced boilers. The baseline development of technologies used to provide sanitary hot water to service sector buildings is presented in Fig. 1.2 b). Similar to space heating, significant increase in solar energy use is foreseen for sanitary hot water as well. While the use of solar energy for water heating is already significant in some sub-sectors, such as hotels, it is foreseen that its penetration will increase in other sub-sectors with high hot water consumption, such as sport facilities, catering establishments and healthcare institutions. While some increase in biomass use is also foreseen, the use of this resource will remain lower than in the case of space heating. Slight decrease of electricity consumption is foreseen, mainly due to the higher penetration of renewable heating sources. The biggest decrease is foreseen in the share of fossil fuels although the share of heating oil will still remain significant.

The baseline development of technologies used to provide space cooling to residential sector buildings is presented in Fig. 1.2 c). Significant penetration is foreseen in the case of solar based cooling, especially in sub-sectors containing large buildings, such as hotels and office buildings. However, electricity is foreseen to remain the source of most space cooling provided, especially with the increase in availability of renewables based electricity.

a) Baseline of space heating



b) Baseline of sanitary hot water



c) Baseline of space cooling

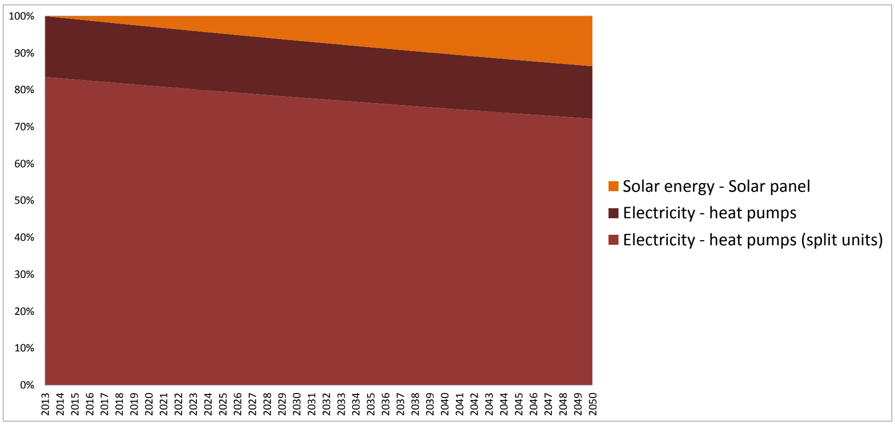


Figure 1.2. Baseline development of shares of technologies used for different end uses in service sector (final energy consumption) (%)

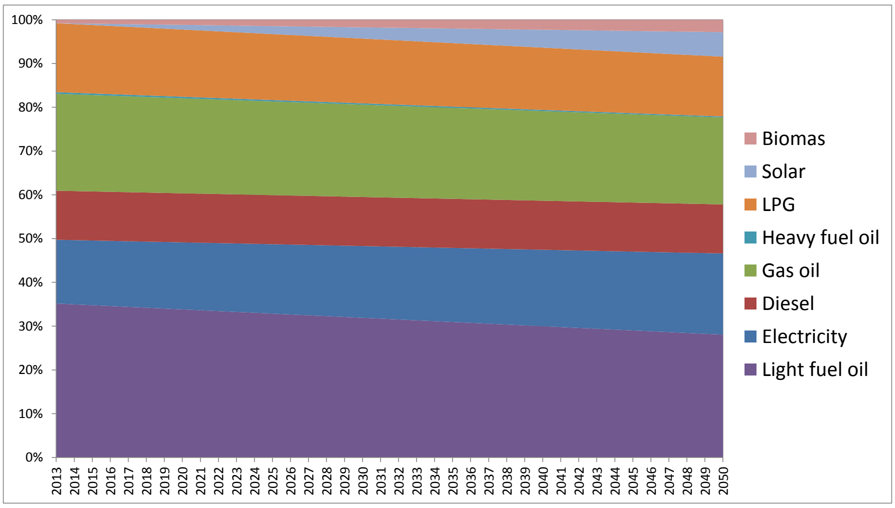
5.1.3 Baseline for industrial sector

The baseline development of technologies used to provide heat to the industrial sector consumers is presented in the following figures. Detailed information can be found in Annex 4. Fig.1.3 a) shows the baseline development of technologies used to provide low temperature heat. This graph does not contain development in consumption of peat coke which is used mainly by cement industry. It is assumed that the changes in energy stream distribution will not be extensive, but renewable energy sources, such as biomass and solar energy will be replacing fossil fuels, albeit at significantly slower pace than in residential and service sectors.

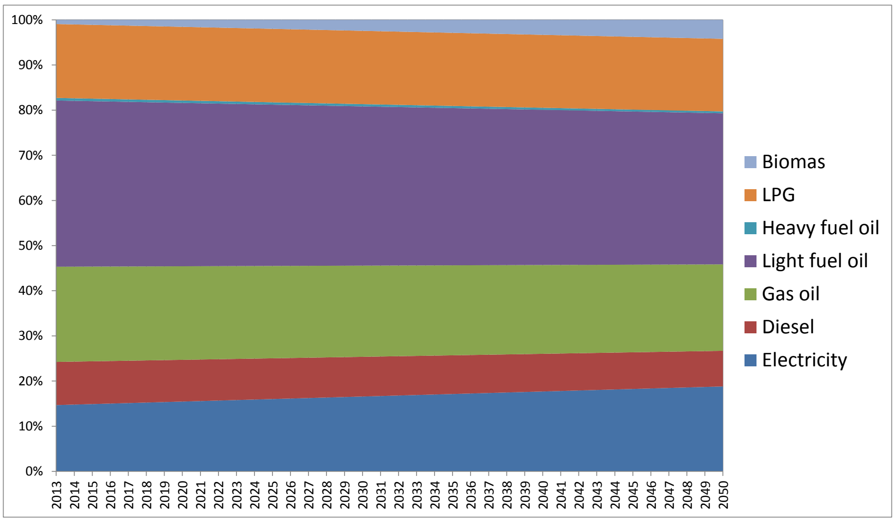
The baseline development of shares of energy streams used to provide medium temperature (100 to 400 °C) heat to industrial sector consumers is presented in Fig. 1.3 b). It is foreseen that the changes in energy stream shares used to provide medium temperature heat will be insignificant. Some biomass penetration is foreseen at the expense of fossil fuels but no solar energy penetration is expected.

The baseline development of shares of energy streams used to provide high temperature (more than 400 °C) heat to industrial sector consumers is presented in Fig. 5.3 c). Even less changes are foreseen to occur in the supply of high temperature heat. Although some penetration of renewables (mostly biomass combustion) is foreseen, fossil fuel and electricity are expected to provide the largest shares of heat.

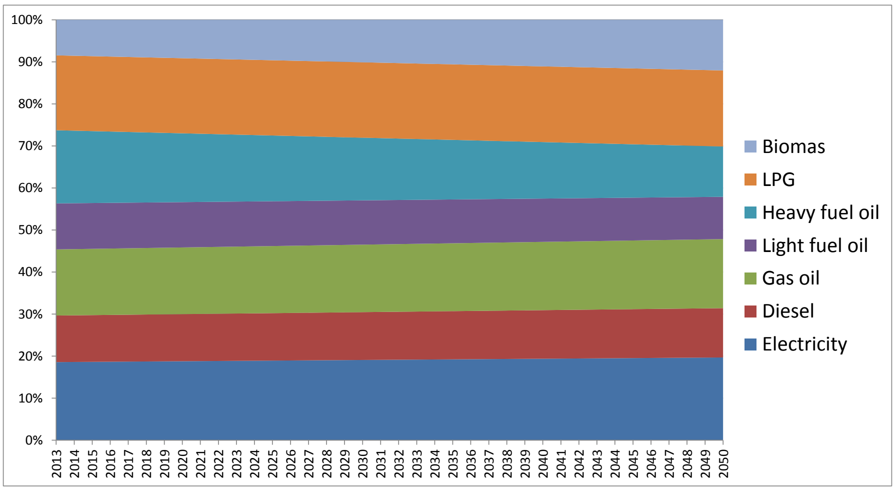
a) Baseline of low temperature (<100 °C) heat



0b) Baseline of medium temperature (100 to 400 °C) heat



c) Baseline of high temperature (> 400 °C) heat



Figures 1.3. Baseline development of shares of technologies used for different end uses in industrial sector (final energy consumption) (%)

1.1.4 Baseline for agricultural sector

The baseline development of technologies used to provide heating and cooling to agricultural sector heat consumers is presented in the following figure. Detailed information can found in Annex 4. It is foreseen that gas oil will remain the dominating energy stream for heat provision in the agricultural sector. Slight penetration of solar energy is foreseen in the livestock subsector but mainly in greenhouses, which are the biggest agricultural energy consumers in Cyprus. The possibilities to use solar energy are limited in this sector. Share of biomass is expected to increase significantly in all agricultural subsectors, especially in livestock sub-sector due to the availability of agricultural waste. It is also assumed that currently fuels in agricultural sector are consumed in regular boilers.

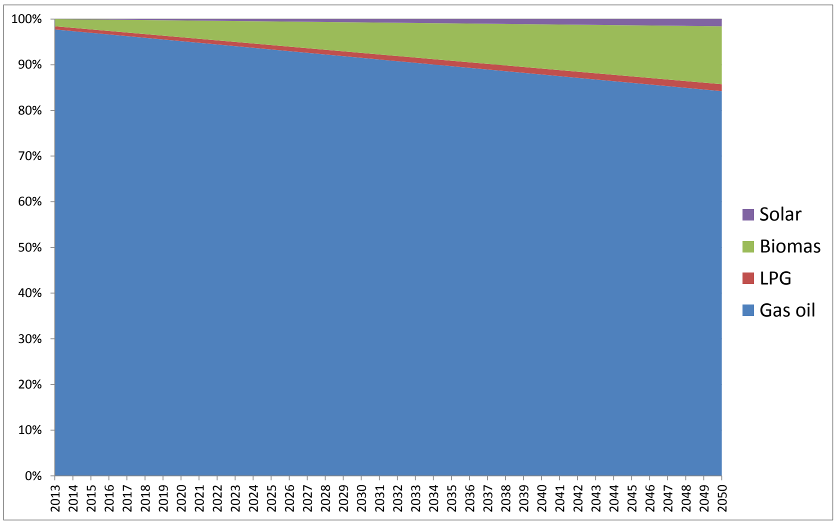


Figure 1.4 Baseline development of shares of energy streams used to provide heat to agricultural sector consumers (final energy consumption) (%)

1.2 Construction of alternative scenarios

Among others, the aim of the Comprehensive Assessment is to estimate "*the potential for the application of high-efficiency cogeneration and efficient district heating and cooling*". Since these general categories include many different technologies utilising different energy streams, a set of alternative scenarios was constructed.

The input data which was used to define alternative scenarios was the forecast of the heat demand, the technical potential of each efficient solution and a set of assumptions. Each scenario was built to evaluate the effects of expanding each technical solution to their maximum extent (i.e. taking into account its technical potentials and other considerations) with the aim of, later on, identifying the economic potential of that solution. For all solutions it is assumed that they would cover all the annual demand for all three energy uses, respecting technical potential cap.

In the first instance and in those cases when the technical potential of a solution is lower than the demand, the rest of the demand is covered by other technologies. This adjustment is required in order to make the baseline and the alternative scenario comparable, with the aim of assessing the economic potential of the solution later on. Due to that the gap of demand was covered by the mix of technologies of the baseline scenario using the same shares of those technologies. When a technology that has been evaluated in the alternative scenario was also present in the baseline, the gap was filled with the other technologies but without an additional contribution of the technology evaluated (because the technical potential has been already covered till its maximum extent).

As a consequence, in each system boundary the number of alternative scenarios constructed is equal to the technically viable solutions identified during the technical potential identification exercise.

2 Cost-benefit analysis

Conducting a CBA implies assessing the changes in cost and benefits between baseline and alternative scenarios and integrating them in a common framework analysis to compare them along time and arrive to conclusions about its profitability. The CBA is based on the discounted cash flow analysis. Once the baseline and the alternative scenarios for each system boundary are defined, relevant effects derived from each scenario (in terms of costs and benefits) are quantified and monetised. This analysis considers also the distribution of those costs and benefits along the time horizon of the analysis. Quantifying the cost and benefits in both scenarios is required to assess the changes in cost and benefits between baseline and an alternative scenario. There are different categories of costs and benefits that will be described below. The process consists of, for each cost category (*i*), to estimate the change of costs between the baseline and the alternative scenario, on a year basis (t), as indicated by the expression:

$$Cost_{i,t} = [Cost_{i,t}]_{Alternative} - [Cost_{i,t}]_{Baseline}$$

The total cost of each year is the result of summing the value of all those costs categories:

$$Cost_t = \sum_{i=1}^{n} Cost_{i,t}$$

In the same manner, for each benefit category (*i*), the change of them between the baseline and the alternative scenario is estimated, in a year basis (t)*:*

$$Benefit_{i,t} = [Benefit_{i,t}]_{Alternative} - [Benefit_{i,t}]_{Baseline}$$

The total benefit of each year is the result of summing the value of all those benefit categories:

$$Benefit_t = \sum_{i=1}^{n} Benefit_{i,t}$$

Those costs and benefits that remain constant in both scenarios do not have to be accounted as, when assessing its change between both scenarios, they will become null. That is the case, for example, of the value of heating and cooling used. Heating and cooling consumption is the same in both scenarios, so quantifying its value is not necessary.

Once the information on total cost and total benefit is collected, the Net Present Value is evaluation criteria required by the EED. The NPV in a unique estimate the expected benefits minus the costs, both suitably discounted (by using a discount rate, r). This indicator provides information about the "net benefit" of the different alternative scenarios considered.

$$NPV_x = \sum_{t=0}^{n} \frac{Benefit_t - Cost}{(1+r)^t} = \frac{B_0 - C_0}{(1+r)^0} + \frac{B_1 - C_1}{(1+r)^1} + \cdots + \frac{B_n - C_n}{(1+r)^n}$$

The lifetime of technological solutions in the framework of the efficient heating and cooling varies from one technology to other. When appraising the alternative scenarios, the time frame used represents the lifetime of the longest living asset. So, in order to standardise the appraisals with respect to high efficiency cogeneration and efficient heating and cooling, the time frame 2013-2050 has been used to capture the long lifetime of district heating networks. When the lifetime of other assets fall short of the appraisal time horizon, it is assumed that these assets are replaced where appropriate.

The Cost-benefit analysis is conducted both from a *financial* and an *economic* perspective:

- The financial analysis tackles the analysis from a private investor's point of view using the conventional discounted cash flow approach to assess net returns.
- The economic analysis tackles the analysis from the point of view of the society, so the analysis encompasses the changes to the welfare of the society as a whole.

Both perspectives, the economic and financial analyses are applied to assess the efficient heating and cooling options. As both analyses are carried, once the financial analysis is done, some adjustments are introduced into the analysis to reflect the social perspective. The usefulness of conducting the analysis from both perspectives is to identify potential areas for policy influence based on gaps between the financial suitability of an initiative and its convenience from a society's perspective. Based on that gap, public deciders can adopt measures to support or promote (by difference mechanisms) those initiatives, as well as removing existing or planned support mechanisms when the evaluation shows that are not justified in social terms.

As described in the previous expression, the NPV estimation requires the use of a parameter known as 'discount rate'. The discount rate is a parameter that reflects the value for the society of future cost and benefits compared to the present ones. The financial analysis uses a financial discount rate (FDR), while the economic analysis will use a social discount rate (SDR).

2.1 Financial analysis

The financial analysis has been done following some rules (EC, 2014c):

- Carried out in constant (real) prices with prices fixed at the base-year (2013).
- Net of VAT, both on purchase (cost) and sales (revenues), when is recoverable by the project promoter. On the contrary, when VAT is not recoverable, it is included.
- Including direct taxes on the prices of inputs (i.e., electricity, labour, etc).

The main costs and benefits considered in the financial analysis are described below. The different categories of costs and benefits do not apply to all technologies. Their value would be zero when they do not apply to a specific technology.

2.1.1 Costs

The cost categories taken into account in the financial analysis include the followings:

- **Capital cost of heating and cooling supply**

Capital costs of heating and cooling systems comprise the amount of resources devoted for acquiring fixed assets. These costs take place when new capacity is added to the energy system or when existing capacity is replaced. This information is defined within the scenario definition, as demand data was converted into load data (see Annex 2). Capital costs and other techno-economic data are summarized in Table 2.1 and Table 2.2.

The possible costs for installation of heat and cooling distribution system inside of the building were taken into account when applying efficient energy generation and supply solutions. Currently in Cyprus, large share of the buildings has no central heat and cooling distribution systems and those services are provided using portable or locally installed heaters and coolers. Only buildings belonging to some subsectors (such as hospitals and higher than 3 star hotels) use extensively central energy distribution systems. In order to use efficient heating and cooling technologies, such systems, containing distribution pipelines or air ducts, radiators, air coil fans, etc., would need to be installed. The costs for installation of such systems inside of the buildings were estimated on the information provided in Poyry (2009). Since cost estimates in Poyry (2009) were for heating system only and since it was assumed that distribution system would be used to provide both heating and cooling, thus the costs per dwelling, assumed in Poyry (2009) were doubled. The cost estimation was done taking into account typical heating and cooling load of dwelling in Cyprus and thus costs of distribution system installation were estimated to be equal to 1250 EUR/kW of building load. Those costs will be considered when the alternative scenario implies a transition from non-water based to water-based technologies. More specifically this will occur in the following two cases:

- when replacing split unit heat pumps with water based alternative technologies such as fossil fuel based boilers or CHP in any scenario;
- when replacing small portable heating systems with water based alternative technologies such as fossil based boilers or CHP in any scenario;
- when replacing resistance heaters with water based alternative technologies such as fossil fuel based boilers or CHP in any scenario.

Solar thermal heating and cooling systems cannot provide all the energy throughout the year due to climatic variances, namely lack of intensive sunshine during some periods of the year. Therefore a back up energy generation system would need to be installed alongside solar thermal which would ensure continuous energy supply in such periods. This study considers light fuel oil boilers as back-up of solar systems, considering this addition into the capital costs. The duration of periods in which the back-up system will supply energy was calculated taking into account average count of "no sunshine" days in Larnaca for 20 year period (1996 – 2015) during heating and cooling seasons. It was determined that the energy thus lacking would amount to approx. 20 % of the total energy demand of a particular building. Thus it was assumed that fuel consumption of back-up energy generation system would be equal to 20 % of total energy consumption of particular building.

In the case of centralized options, capital costs have to be adjusted based on a scaling factor. Specific costs (EUR/kW) of larger power plants are usually smaller than that of smaller plants. This is also known as economies of scale and expressed by the following equation:

$$\frac{C_1}{C_2} = \left(\frac{A_1}{A_2}\right)^n$$

Where C_1, C_2 are the investment costs of plant 1 and 2 respectively and A1, A2 the capacities of plant 1 and two respectively. The scale factor n, represents the effect of the economies of scale. If n=1 then the costs of two plants is directly proportional (no economies of scale). The lower the *n is*, the bigger the effect of economies of scale. In this study n=0.9 was used as a conservative figure. As reference size for individual consumers, 10 kW was assumed for residential sector and 500 kW for service and commercial sectors.

Capital costs of district heating and cooling networks consist of several components, most important being pipelines, additional and auxiliary equipment such as valves, bends, etc., pipeline installation works, including earth works, and heating substations (in case of district heating) or adsorption chillers (in case of district cooling). In order to calculate installation costs of pipelines it is necessary to know the extent of the network. Length of pipelines was estimated based on the dependence of average linear heat density (MWh/m of pipeline) within given system boundary on heat density (kWh/m² of land) which was determined for each postal code area of Cyprus. Capital costs of a district heating and cooling network within each system boundary was calculated by multiplying the length of calculated district heating pipelines by the average assumed price of installation of 1 m of pipeline (560 EUR/m).

- **Operation and maintenance costs** (excluding fuel costs).

The operating costs are those associated to the consumption of materials; maintenance; administration; labour, etc. As mentioned before, the information regarding operating cost is included on the techno-economic data of different technologies summarized in Table 2.1.

Table 2.1 Techno-economic data of solutions on service sector, industry and agriculture

Resource	Technology	Investments costs (EUR/kW)	FIXOM (euro/kW)	Lifetime (years)	Heat efficiency	Electric efficiency	Cooling efficiency
Electricity	Heat pumps	810	16.2	20	3.00	0.00	4.00
Electricity	Split unit - Heat pumps	810	16.2	20	3.00	0.00	4.00
Electricity	Resistance heaters	98	1.1	15	0.90	0.00	0.63
Gas oil	Boilers	77	3.9	20	0.77	0.00	0.54
Gas oil	CHP	1200	16.1	20	0.47	0.34	0.33
Gas oil	Efficient boilers	314	15.7	20	0.90	0.00	0.63
Kerosene	Boilers	77	3.9	20	0.77	0.00	0.54
Kerosene	Efficient boilers	314	15.7	20	0.90	0.00	0.63
Light fuel oil	Boilers	77	3.9	20	0.77	0.00	0.54
Light fuel oil	CHP	1200	16.1	20	0.47	0.34	0.33
Light fuel oil	Efficient boilers	314	15.7	20	0.90	0.00	0.63
Livestock/Industrial waste	CHP	1200	16.1	20	0.47	0.34	0.33
Livestock/Industrial waste	Efficient boilers	316	22.1	20	0.96	0.00	0.67
LPG	Boilers	182	9.1	20	0.66	0.00	0.46
LPG	Efficient boilers	316	22.1	20	0.96	0.00	0.67
LPG	CHP	1200	16.1	20	0.47	0.34	0.33
Municipal waste	CHP	1400	19.0	20	0.47	0.34	0.33
Municipal waste	Efficient boilers	702	7.9	20	0.81	0.00	0.57
Solar	Solar panels	863	17.3	20	6.54	0.00	4.58
Solid biomasss	Boilers	338	16.9	20	0.77	0.00	0.54
Solid biomasss	CHP	1400	19.0	20	0.47	0.34	0.33
Solid biomasss	Efficient boilers	702	7.9	20	0.81	0.00	0.57
Heat	Absorption Chiller	364	2.3	20	1.35	0.00	0.00

Table 2.2 Techno-economic data of solutions on residential sector

Resource	Technology	Investments costs (EUR/kW)	FIXOM (euro/kW)	Lifetime (years)	Heat efficiency	Electric efficiency	Cooling efficiency
Electricity	Heat pumps	1221	9.0	20	3.79	0.00	2.65
Electricity	Split unit - Heat pumps	1221	9.0	20	3.79	0.00	2.65
Electricity	Resistance heaters	176	1.9	15	0.90	0.00	0.63
Gas oil	Boilers	209	10.5	20	0.77	0.00	0.54
Gas oil	CHP	1500	21.4	10	0.50	0.40	0.35
Gas oil	Efficient boilers	314	15.7	20	0.96	0.00	0.67
Kerosene	Boilers	209	10.5	20	0.77	0.00	0.54
Kerosene	Efficient boilers	314	15.7	20	0.96	0.00	0.67
Light fuel oil	Boilers	209	10.5	20	0.77	0.00	0.54
Light fuel oil	CHP	1500	21.4	10	0.50	0.40	0.35
Light fuel oil	Efficient boilers	314	15.7	20	0.96	0.00	0.67
LPG	Boilers	182	9.1	20	0.77	0.00	0.54
LPG	Efficient boilers	418	20.9	20	0.96	0.00	0.67
LPG	CHP	1500	21.4	10	0.50	0.40	0.35
Solar	Solar panels	1151	23.0	20	6.54	0.00	4.58
Solid biomasss	Boilers	487	24.4	20	0.77	0.00	0.54
Solid biomasss	CHP	1700	27.0	10	0.50	0.40	0.35
Solid biomasss	Efficient boilers	926	23.3	20	0.85	0.00	0.60
Heat	Absorption Chiller	722	4.6	20	1.35	0.00	0.00

- **Fuel (and electricity) costs**

This section describes the sources of data used to assess fuel prices and electricity prices for the period 2013-2050. The Annex 5 provides the detailed figures for all the sectors and energy products considered within the financial and the economic analysis within the CBA.

In general, the assessment approach consists on using:

i. For 2013-2015: real data of energy prices from different sources of information.
ii. For 2016-2050: trends of prices provided by *EU Energy, transport and GHG emissions trends to 2050* (EC, 2013).

The main sources of information used to assess the fuel and electricity prices are:

i. For period 2013-2015

a) Petroleum products prices

The main source used for petroleum products is the input data provided by the Energy Service of Cyprus. Table 2.3 show these values.

Table 2.3 Prices of petroleum products with VAT, 2013-2015

Year	Domestic heating gasoil (€/1000 lt)	Kerosene (€/1000 lt)	LFO (€/1000 lt)	LPG (€/tn)	Heating gasoil for CHP units generating >100MWehr per year (€/1000 lt)
2013	1041	1108	879	1255	907
2014	995	1055	865	1213	871
2015	812	850	677	1032	654

Source: Energy Services

Data regarding Taxes and Duties of petroleum products in Cyprus has been taken from the report on *Excise duties -Part II-Energy products and Electricity* (EC, 2015). Table 2.4 shows the Excise duties and taxes considered in the CBA, by sector. In the absence of information, it has been considered that the values remain constant all the period.

Table 2.4 Excise duties and taxes petroleum products, 2013-2050

	Kerosene (€/1000 lt)		Heating Gasoil (€/1000 lt)		Light Fuel Oil (€/1000 lt)	Liquefied Petroleum Gases (€/tn)	
	Industry	Resid. & Serv.	Industry	Resid. & Serv.	Industry	Industry	Resid. & Serv.
Excises	124.7	124.7	124.7	124.7	15	0	0
Indirect taxes	10.7	10.7	10.7	10.7	2.7	0	0
VAT (%)	19%	19%	19%	19%	19%	5%	5%

Source: Based on EC (2015) *Excise duties -Part II-Energy products and Electricity*

b) Electricity prices

The *Industrial Statistics* (Statistical Service, 2013) provide data of electricity prices for all sectors for 2013. This information has been completed with data from EUROSTAT for domestic and industrial electricity prices for 2013-2015. EUROSTAT provides information of prices by semester. For the second semester of 2015, and based on the evolution of petrol prices, a reduction of 12% has been assumed. Table 2.5 show the values of electricity prices used based on EUROSTAT database.

Table 2.5 Prices of electricity, 2013-2015 (€/kWh)

		By semester						Average		
		2013S1	2013S2	2014S1	2014S2	2015S1	2015S2	2013	2014	2015
Domestic	Excluding taxes and levies	0.23	0.20	0.19	0.19	0.16	0.14	0.215	0.19	0.15
	Excluding value added tax and levy for RES promotion	0.24	0.21	0.19	0.20	0.17	0.15	0.22	0.20	0.16
	ALL taxes and levies included	0.28	0.25	0.23	0.24	0.20	0.17	0.26	0.23	0.18
Industrial	Excluding taxes and levies	0.20	0.19	0.17	0.18	0.13	0.12	0.197	0.18	0.12
	Excluding value added tax and levy for RES promotion	0.21	0.20	0.17	0.19	0.14	0.12	0.20	0.18	0.13
	ALL taxes and levies included	0.24	0.24	0.21	0.23	0.16	0.14	0.24	0.22	0.15

Source: EUROSTAT and own elaboration

c) Other fuel prices

The main assumptions and sources of information for other fuels are summarized below:

✓ For solid biomass, in the absence of detailed information about the cost of solid biomass in Cyprus, as a reference value has been used the DEPV Index of pellet prices in Germany, provided by the Quellenangabe Deutsches Pelletinstitut GmbH (DEPI)[2].

✓ For biogas from livestock and industrial waste, the cost of biogas has been estimated based on the data regarding investment cost on a biogas plant data provided by the *Assessment of National Potential for Cogeneration in Cyprus* (MECIT, 2009).

ii. For period 2016-2050

The trends of fuel and electricity prices provided by the report *EU Energy, Transport and GHG Emissions. Trends to 2050* (EC, 2013) has been used to estimate the forecast of:

a) *Petroleum products prices:* the trend of fuel oil has been used to assess their evolution.

b) *Electricity prices.* The forecast of the *EU Energy, Transport and GHG Emissions* are made based on a significant shift of fuels (from petroleum products to natural gas) from 2020.

In the absence of information for solid biomass prices, flat trends along the period 2016-2050 has been assumed. The cost of biogas is assumed to be constant through all the period.

2.1.2 Benefits

- **Electricity production**

This benefit category only applies to CHP units. The wholesale price of electricity is used. No Feed in Tariff (FIT) is considered on them.

- **Subsidies**

The analysis takes into account that the energy products used for electricity production with a generation rate of more than 100MWh per year are exempted from the indirect taxation in Cyprus[3].

Any other subsidies or public incentives are not taken into account as there is a prerequisite to participate in the scheme to renovate the building envelope and there is not available information about the willing of participation in that scheme.

[2] http://www.depv.de/de/home/marktdaten/pellets_preisentwicklung/

[3] According to article 15 (1c) of 2003/96/EU Member States may apply under fiscal control total or partial exemptions or reductions in the level of taxation to energy products and electricity used for combined heat and power generation.

- **Residual value**

When the lifetime of some assets is shorter than the lifetime of the appraisal time horizon, these assets are replaced where appropriate. At the end of the time horizon of the CBA, the value of those assets is taken into account among the revenues. Residual value is understood as the liquidation value of assets in the case they were sold out at the end year.

2.1.3 Financial discount rate

The financial discount rate reflects the opportunity cost of capital, which means the potential return that could have been obtained by investing the same capital in an alternative project. This study has considered an 8% financial discount rate.

2.2 Economic analysis

Once the financial analysis has been done, some adjustments are introduced in the analysis to reflect a social perspective:

- Fiscal corrections are applied as they are mainly transfers between agents within the economy and do not reflect real impacts on the economic welfare. The prices of inputs (including labour) are net of taxes within the economic analysis. On the contrary, the economic analysis is conducted gross of subsidies because they are a cost for the society that should be accounted for.
- The externalities or impacts on society welfare are included in the analysis. These are not taken into account in the financial analysis as they do not generate a real cash flow for investors. In the context of the CBA, the main externalities to consider are derived from the environmental and health impact associated with the combustion of fuels.

Some of the main costs and benefits considered within the economic analysis are described below.

2.2.1 Costs

- **Capital cost**

Capital cost of heating and cooling supply are the same that were accounted for in the financial analysis.

- **Operation and maintenance costs**

Operation and maintenance costs of heating and cooling supply are the same that are accounted for in the financial analysis.

- **Fuel (and electricity) costs.**

Fuel and electricity costs are the same that are accounted for in the financial analysis but considering them net of direct taxes.

- **Environmental and health externalities.**

Energy production causes different types of environmental impacts as a consequence of the emission of pollution; land occupation and resources consumption (fuels, water, etc.) during the energy production process. The general approach of the environmental valuation methods is based on the "Impact pathway approach"[4], that aims at modelling the causal relationships from the pressure induced on the environment (e.g. emissions) to the impacts generated on different receptors, by assessing changes in environmental

[4] The 'Impact Pathway Approach' was designed within the context of the ExternE project. This project was launched in 1991 by the European Commission and the US Department of Energy. Since then, the European Commission has continuously supported this research field through several projects.

quality. Once these impacts are assessed in physical units, then the damages or value of the impacts using are estimated by applying economic valuation methods (EC, 2005).

The whole implementation of the environmental valuation process is data demanding and resource consuming. Nevertheless, as a result of the implementation of some initiatives and projects[5,6], there are several databases that provide '*environmental damage factors*'.

The source of information used to obtain environmental damage factors per unit of energy produced for different heat and electricity technologies is the report on 'Subsidies and costs of EU energy' (Alberici *et al.*, 2014). This report provides environmental damage factors that were estimated considering the Life cycle emission data[7] and considering the following environmental impact categories: Climate change; ozone depletion; terrestrial acidification; freshwater eutrophication; marine eutrophication; human toxicity; photochemical oxidant formation; particulate matter formation; terrestrial ecotoxicity; freshwater ecotoxicity; marine ecotoxicity; ionising radiation; agricultural land occupation; urban land occupation; natural land transformation; water depletion; metal depletion and depletion of energy resources.

Table 2.7 shows the damage factors used for different heat technologies

Table 2.7. Environmental external cost of heat technologies [EUR/MWhth]

Fuel	Technology	External cost (EUR/MWh_{th})
Electricity	Heat pumps	12.5
Electricity	Split unit - Heat pumps	12.5
Electricity	Resistance heaters	41.7
Gas oil	Boilers	32.0
Gas oil	CHP	17.8
Gas oil	Efficient boilers	27.2
Kerosene	Boilers	32.0
Kerosene	Efficient boilers	27.2
Light fuel oil	Boilers	32.0
Light fuel oil	CHP	17.8
Light fuel oil	Efficient boilers	27.2
Livestock/Industrial waste	CHP	4.3
Livestock/Industrial waste	Efficient boilers	11.2
LPG	Boilers	32.0
LPG	Efficient boilers	27.2
LPG	CHP	17.8
Municipal waste	CHP	10.1
Municipal waste	Efficient boilers	11.2
Solar	Solar panels	9.6
Solid biomasss	Boilers	13.2
Solid biomasss	CHP	4.3
Solid biomasss	Efficient boilers	11.2

[5] Some examples are the projects supported by the European Commission as , e.g. NEEDS Project (New Energy Externalities Development for Sustainability) and CASES project (Cost Assessment for Sustainable Energy Systems).
[6] Life cycle emission data were provided by Ecoinvent database.
[7] Life cycle emission data were provided by Ecoinvent database.

2.2.2 Benefits

Electricity production

They are the same as in the financial analysis.

Residual value

They are the same as in the financial analysis.

2.2.3 Social discount rate (SDR)

The Social Discount Rate (SDR) reflects the social view on how future benefits and costs should be valued against present ones[8]. This study uses a 3% discount rate following the suggestions of (EC, 2014c).

---

[8] There are different approaches to estimate the social discount rate, which are described in more detail in Annex II of EC (2014c).

3 Results

3.1. Results of the CBA

As indicated in the SWD (18), once the technical potential of the solutions has been assessed, the next step consists of conducting a Cost-Benefit Analysis to identify those parts of the technical potential that can economically be met by efficient heating and cooling solutions. The economic potential is defined as 'the subset of technical potential that is economically cost-effective as compared to conventional supply-side energy resources' (NAPEE, 2007). Within the context of the Comprehensive Assessment, the conventional supply-side resources are those that constitute the baseline scenario. The alternative scenarios have been built to test the effects of realising the technical potential of various technology solutions to cover the heat demand. Once the effects have been quantified and valued in economic terms, those parts of the technical potential that provide positive NPV, when compared to the baseline scenario, indicate that they are cost-effective and so constitute the economic potential of that technology. The analysis uses the output of the economic analysis, so the economic NPV (ENPV).

In the context of the EED, the NPV has to be calculated for the different alternative scenarios, each one represents a different technical solution. The following tables collect information of the ENPV of all the alternative scenarios by sector for each of the five system boundaries identified: Nicosia; Paphos; Limassol; Larnaca and the rest of Cyprus. Positive ENPV informs about technical solutions that are cost competitive compared to the baseline scenario.

3.1.1. Nicosia

Table 3.1 collects information of the ENPV by sector of the different individual solutions considered in Nicosia. Those solutions with positive ENPV are highlighted in green. These are cost-effective solutions from the perspective of society while the rest of the solutions are not cost-effective options compared to the baseline. As can be seen in Table 3.1, the cost-effective individual solutions in Nicosia are:

- Heat pumps, for row and single houses, as well as healthcare, hotels and schools within the service sector.
- Split units-heat pumps, for any subsector of residential and service sector
- Solar, for row and single houses, as well as healthcare and schools within the service sector.

Table 3.1 ENPV of alternative scenarios of individual solutions in Nicosia (mill.EUR2013)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels
Residential									
Apartments	-599	-109	499	-2054	-1907	-2335	-170	-156	-92
Row	-221	48	211	-560	-512	-652	-66	-55	92
Single	-268	47	276	-767	-703	-889	-101	-80	89
Service									
Airports	0	0	0	0	0	0	0	0	0
Catering	-37	-12	19	-125	-116	-141	-26	-19	-8
Healthcare	-63	37	64	-183	-166	-216	-19	-13	49
Hotels	-16	3	8	-98	-91	-110	-23	-16	-8
Offices	-201	-112	111	-851	-796	-955	-84	-64	-112
Other	-65	-32	51	-310	-290	-350	-29	-22	-28
Schools	-20	1	42	-137	-127	-157	-16	-12	3
Shopping	-69	-91	58	-530	-499	-588	-35	-29	-109
ENPV	-1559	-221	1338	-5615	-5207	-6393	-569	-465	-126

Table 3.2 collects information of the ENPV of the different alternative scenarios of centralised solutions considered in Nicosia. The technical solutions are the same as

presented before, except the heat pumps-split units[9], but these technical solutions are combined with a district heating and cooling system for the distribution of the useful energy. In the case of centralised solutions, the results presented incorporate the whole system boundary (without making distinctions between sectors) because the decision of implementing a district heating and cooling network will affect all the sectors as a block. The size of the centralized plant that will provide heating and cooling for Nicosia is 325 MW, based on the sizing procedure described in Annex 2. As can be seen in Table 3.2, there are no cost-effective centralised solutions in Nicosia.

Table 3.2 ENPV of alternative scenarios of centralised solutions in Nicosia (mill.EUR2013)

	Electricity Resistance heaters	Electricity Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels
ENPV	-2344	-974	-6199	-5791	-6977	-868	-780	-870

It can be concluded that each individual technology solution provides higher ENPV than the equivalent centralised solution. Based on these results, it can be concluded that individual systems are better candidates to be promoted as cost-efficient heating and cooling solutions, rather than centralised ones.

Once the competitive technologies and most beneficial systems of distribution have been identified, the technology which provides a scenario with the highest ENPV can be identified. This analysis should be done by sector and subsector. Figure 3.1 represents the same results showed in Table 3.1 in order to facilitate the comparison. As can be seen:

- Split units-heat pumps provide the highest ENPV for all subsectors.

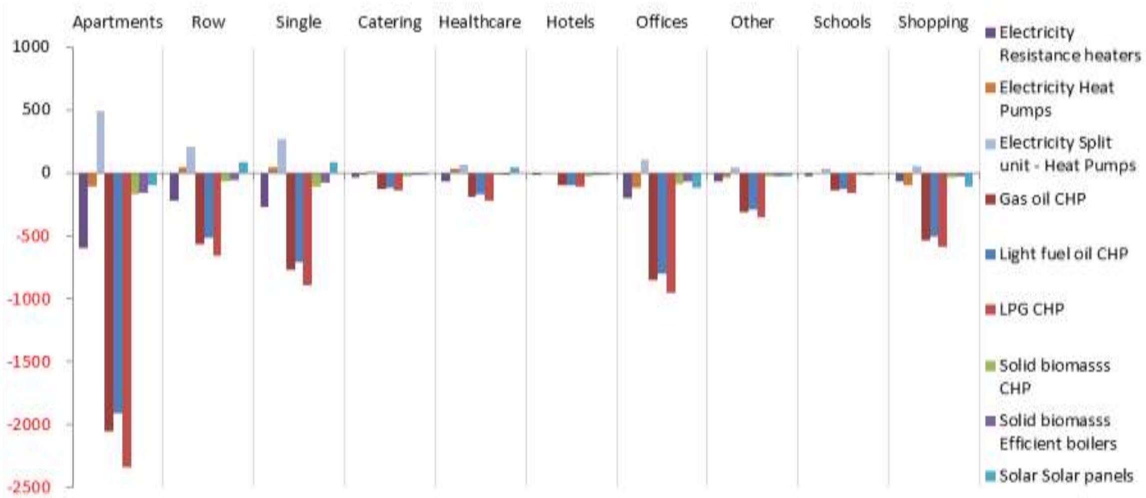


Figure 3.1 ENPV of alternative scenarios of individual solutions in Nicosia (mill.EUR2013)

3.1.2. Paphos

Table 3.3 collects information of the ENPV by sector of the different alternative scenarios of individual solutions considered in Paphos. As can be seen in Table 3.3, the cost-effective individual solutions in Paphos are:

---

[9] This solution is removed because this option was modelled to not require water base systems to distribute the useful energy. This fact makes this solution incompatible with district heating/cooling network.

- Heat pumps with water based heating system, for row and single houses, as well as healthcare, hotels and schools within the service sector.
- Split units-heat pumps without water based heating system, for any subsector of residential and service sector
- Solar, for row and single houses, as well as healthcare and schools within the service sector.

Table 3.3 ENPV of alternative scenarios of individual solutions in Paphos (mill.EUR2013)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels
Residential									
Apartments	-149	-25	125	-506	-470	-576	-42	-38	-20
Row	-48	10	45	-121	-110	-140	-14	-12	20
Single	-52	7	54	-156	-144	-181	-21	-17	14
Service									
Airports	0	0	0	0	0	0	0	0	0
Catering	-29	-9	15	-99	-92	-112	-12	-9	-6
Healthcare	-15	7	16	-59	-54	-69	-8	-5	8
Hotels	-105	20	53	-655	-611	-738	-28	-21	-56
Offices	-27	-12	13	-99	-93	-112	-24	-17	-11
Other	-6	-3	5	-30	-28	-34	-8	-6	-3
Schools	-4	2	8	-19	-17	-22	-4	-3	3
Shopping	-16	-38	22	-205	-194	-227	-13	-11	-48
ENPV	-450	-41	357	-1950	-1813	-2210	-174	-138	-99

Table 3.4 collects information of the ENPV of the different alternative scenarios of centralised solutions considered in Paphos. The size of the centralized plant that will provide heating and cooling for Paphos is 68 MW, based on the sizing procedure described in Annex 2. As can be seen in Table 3.4, there are no cost-effective centralised solutions in Paphos.

Table 3.4 ENPV of alternative scenarios of centralised solutions in Paphos (mill.EUR2013)

	Electricity Resistance heaters	Electricity Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels
ENPV	-708	-335	-2238	-2101	-2498	-284	-253	-425

It can be concluded that each individual technology solution provides higher ENPV than the equivalent centralised solution. Based on these results, it can be concluded that individual systems are better candidates to be promoted as cost-efficient heating and cooling solutions, rather than centralised ones.

Once the competitive technologies and most beneficial systems of distribution have been identified, the technology which provides a scenario with the highest ENPV can be identified. As can be seen in Figure 3.2:

- Split units-heat pumps provide the highest ENPV for all subsectors.

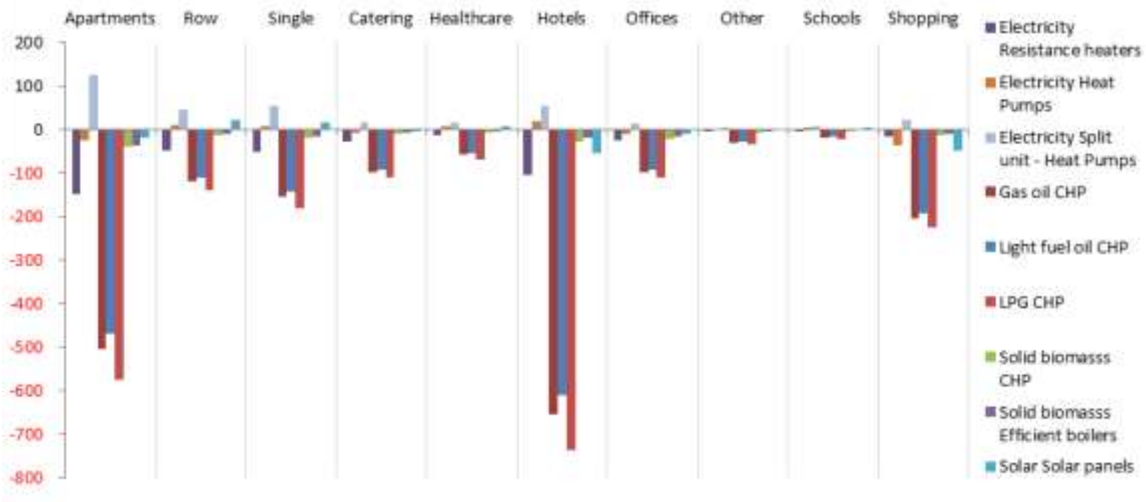


Figure 3.2 ENPV of alternative scenarios of individual solutions in Paphos (mill.EUR2013)

3.1.3. Limassol

Table 3.5 collects information of the ENPV by sector of the different alternative scenarios of individual solutions considered in Limassol. As can be seen in Table 3.5, the competitive individual solutions in Limassol are:

- Heat pumps with water based heating system, for row and single houses, as well as hotels within the service sector.
- Split units-heat pumps without water based heating system, for any subsector of residential and service sector.
- Solar, for row and single houses.

Table 3.5 ENPV of alternative scenarios of individual solutions in Limassol (mill.EUR2013)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels
Residential									
Apartments	-349	-74	292	-1236	-1149	-1403	-103	-94	-69
Row	-173	33	173	-474	-434	-551	-52	-44	63
Single	-207	26	216	-635	-584	-733	-76	-62	54
Service									
Airports	0	0	0	0	0	0	0	0	0
Catering	-36	-12	18	-123	-115	-139	-15	-11	-7
Healthcare	-6	-2	10	-69	-64	-77	-7	-5	-7
Hotels	-37	7	19	-231	-216	-261	-23	-16	-20
Offices	-91	-53	52	-397	-371	-445	-43	-33	-54
Other	-35	-15	27	-160	-150	-181	-15	-12	-13
Schools	-11	-1	24	-83	-77	-95	-9	-7	-0
Shopping	-41	-50	33	-296	-278	-329	-19	-16	-60
ENPV	-987	-142	864	-3705	-3438	-4214	-364	-299	-113

Table 3.6 collects information of the ENPV of the different alternative scenarios of centralised solutions considered in Limassol. The size of the centralized plant that will provide heating and cooling for Limassol is 210 MW, based on the sizing procedure described in Annex 2. As can be seen in Table 3.6, the competitive centralised solution in Limassol is:

- Heat recovery from power plants

Table 3.6 ENPV of alternative scenarios of centralised solutions in Limassol (mill.EUR2013)

	Electricity Resistance heaters	Electricity Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels	Heat recovery
ENPV	-1351	-472	-3931	-3664	-4440	-493	-439	-451	342

Once the competitive technologies and most beneficial systems of distribution have been identified, the solution which provides a scenario with the highest ENPV can be identified. The ENPV of heat recovery for the whole system boundary is smaller than applying individual split-unit-heat pumps in the whole system boundary. So the scenario that would provide the highest ENPV would be (see Figure 3.3):

- Split unit-heat pumps for all subsectors.

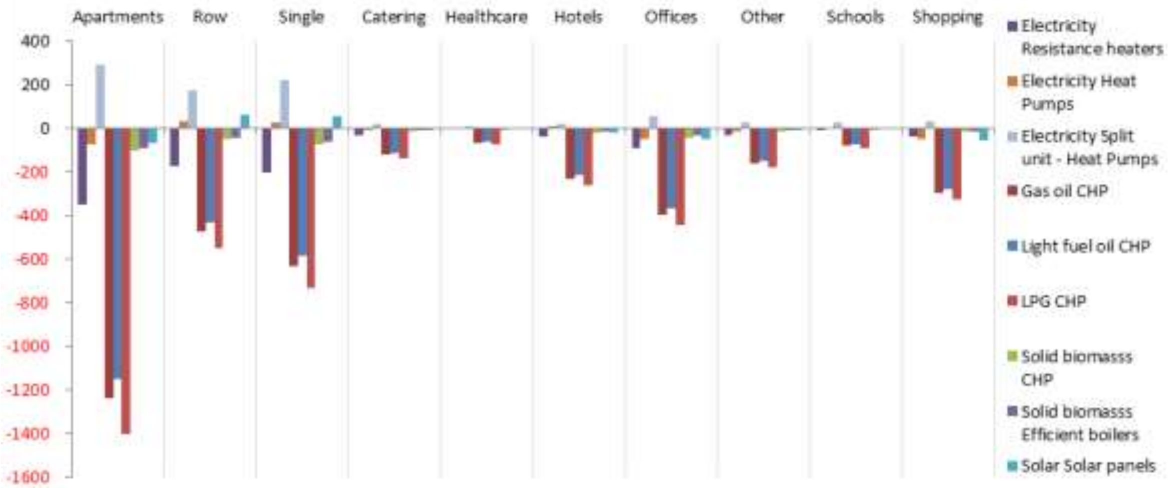


Figure 3.3 ENPV of alternative scenarios of individual solutions in Limassol (mill.EUR2013)

3.1.4 Larnaca

Table 3.7 collects information of the ENPV by sector of the different alternative scenarios of individual solutions considered in Larnaca. As can be seen in Table 3.7, the competitive individual solutions in Larnaca are:

- Heat pumps with water based heating system, for row and single houses, as well as healthcare, hotels and schools within the service sector.
- Split units-heat pumps without water based heating system, for any subsector of residential and service sector.
- Solar, for row and single houses, as well as healthcare and schools within the service sector.

Table 3.7 ENPV of alternative scenarios of individual solutions in Larnaca (mill.EUR2013)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels
Residential									
Apartments	-154	-36	129	-557	-517	-631	-45	-41	-34
Row	-65	14	62	-165	-151	-192	-19	-16	27
Single	-44	5	46	-135	-124	-156	-19	-15	11
Service									
Airports	0	0	0	0	0	0	0	0	0
Catering	-12	-4	6	-41	-38	-46	-6	-4	-2
Healthcare	-17	9	18	-55	-50	-64	-5	-3	12
Hotels	-9	2	5	-55	-51	-62	-9	-6	-4
Offices	-32	-19	18	-141	-132	-158	-16	-12	-19
Other	-14	-4	10	-55	-51	-62	-6	-5	-2
Schools	-3	2	7	-18	-16	-21	-3	-2	2
Shopping	-14	-17	11	-103	-97	-114	-7	-6	-21
ENPV	-364	-48	312	-1323	-1227	-1506	-134	-110	-30

Table 3.8 collects information of the ENPV of the different alternative scenarios of centralised solutions considered in Larnaca. The size of the centralized plant that will provide heating and cooling for Nicosia is 76 MW, based on the sizing procedure described in Annex 2. As can be seen in Table 3.8, the competitive centralised solution in Larnaca is:

- Heat recovery

Table 3.8 ENPV of alternative scenarios of centralised solutions in Larnaca (mill.EUR2013)

	Electricity Resistance heaters	Electricity Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels	Heat recovery
ENPV	-554	-240	-1371	-1386	-1665	-213	-192	-221	366

Once the competitive technologies and most beneficial systems of distribution have been identified, the technology which provides a scenario with the highest ENPV can be identified. Heat recovery is the technical solution that provides the highest ENPV compared to individual solutions.

3.1.5 Rest of Cyprus

The rest of Cyprus encompasses all the consumers located outside high demand density areas. Within this system boundary, only individual solutions are considered as alternatives and not centralised options.

High heat demand density areas are located in densely populated locations so no agriculture is considered in previous system boundaries but it appears as a potential consumer sector in this system boundary. In the case of industry, a similar situation occurs. Besides this, it was considered that industry was not a candidate for district heating because the industrial producers need to have control on the heat, as relevant factor in their process of production.

The list of technical options is longer than the ones in previous system boundaries as there are some technical solutions (especially some biomass options as livestock/ industrial waste and municipal waste) whose resources were allocated only to agriculture and industry, as explained in Section 4.2.3.1 of D I.2.1.

Table 3.9 collects information of the ENPV by sector of the different alternative scenarios of individual solutions considered in the rest of Cyprus. As can be seen in Table 3.9, the competitive individual solutions in the rest of Cyprus are:

- Heat pumps with water based heating system, for row and single houses as well as healthcare, hotels and schools within the service sector.
- Split unit-heat pumps without water based heating system, for all subsectors of the residential and service sector.

- Solar, for row and single houses as well as healthcare and schools within the service sector.
- Livestock/industrial waste with CHP for greenhouses.
- Livestock/industrial waste with efficient boilers for greenhouses.
- Municipal waste with CHP, for any subsector of industrial sector.
- Municipal waste with efficient boilers, for any subsector of industrial sector.

Once the competitive technologies have been identified, the technology which provides a scenario with highest ENPV can be identified. As can be seen in Figure 3.4:

- Split unit-heat pumps provide the highest ENPV in all residential and all service subsectors.
- Solar panels provide the highest ENPV in the subsector of other industries.
- Municipal waste with CHP provides the highest ENPV in all industrial subsectors except other industries.

Table 3.9 ENPV of alternative scenarios of individual solutions in the rest of the Cyprus (mill.EUR2013)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels	Livestock/Indus- CHP	Livestock/Indus- Efficient boilers	Municipal CHP	Municipal Efficient boilers
Residential													
Apartments	-427	-54	354	-1384	-1282	-1577	-163	-136	-35	-98	-98	-98	-98
Row	-402	71	336	-935	-855	-1088	-123	-96	165	-84	-84	-84	-84
Single	-1467	330	1457	-3821	-3492	-4449	-431	-359	610	-348	-348	-348	-348
Service													
Airports	-16	-15	9	-91	-86	-102	-5	-4	-17	-2	-2	-2	-2
Catering	-126	-41	64	-428	-398	-484	-54	-40	-26	-14	-14	-14	-14
Healthcare	-41	23	40	-115	-104	-135	-28	-17	31	-5	-5	-5	-5
Hotels	-307	58	154	-1877	-1752	-2116	-105	-76	-156	-34	-34	-34	-34
Offices	-223	-136	129	-1000	-936	-1121	-133	-100	-140	-31	-31	-31	-31
Other	-83	-43	65	-407	-380	-458	-48	-36	-40	-14	-14	-14	-14
Schools	-27	11	53	-143	-131	-166	-24	-17	17	-10	-10	-10	-10
Shopping	-89	-114	73	-663	-625	-737	-54	-43	-136	-19	-19	-19	-19
Agriculture													
Greenhouses	-95	-3	-6	-347	-317	-403	-304	-154	-6	34	40	-6	-6
Other	-3	-3	0	-3	-3	-143	-3	-3	-4	-3	-3	-3	-3
Industry													
Other indust	-11	-0	0	-26	-20	-37	-0	-0	42	-0	-0	37	28
Chemicals	-2	-0	0	-3	-3	-5	-0	-0	4	-0	-0	5	4
Cement	-1	-0	0	-2	-1	-2	-0	-0	2	-0	-0	5	4
Other minera	-2	-0	0	-2	-1	-2	-0	-0	2	-0	-0	5	4
Food, tobacc	-21	-1	0	-75	-58	-107	-1	-1	105	-1	-1	114	87
ENPV	-3342	82	2730	-11322	-10446	-13132	-1477	-1083	419	-630	-624	-505	-543

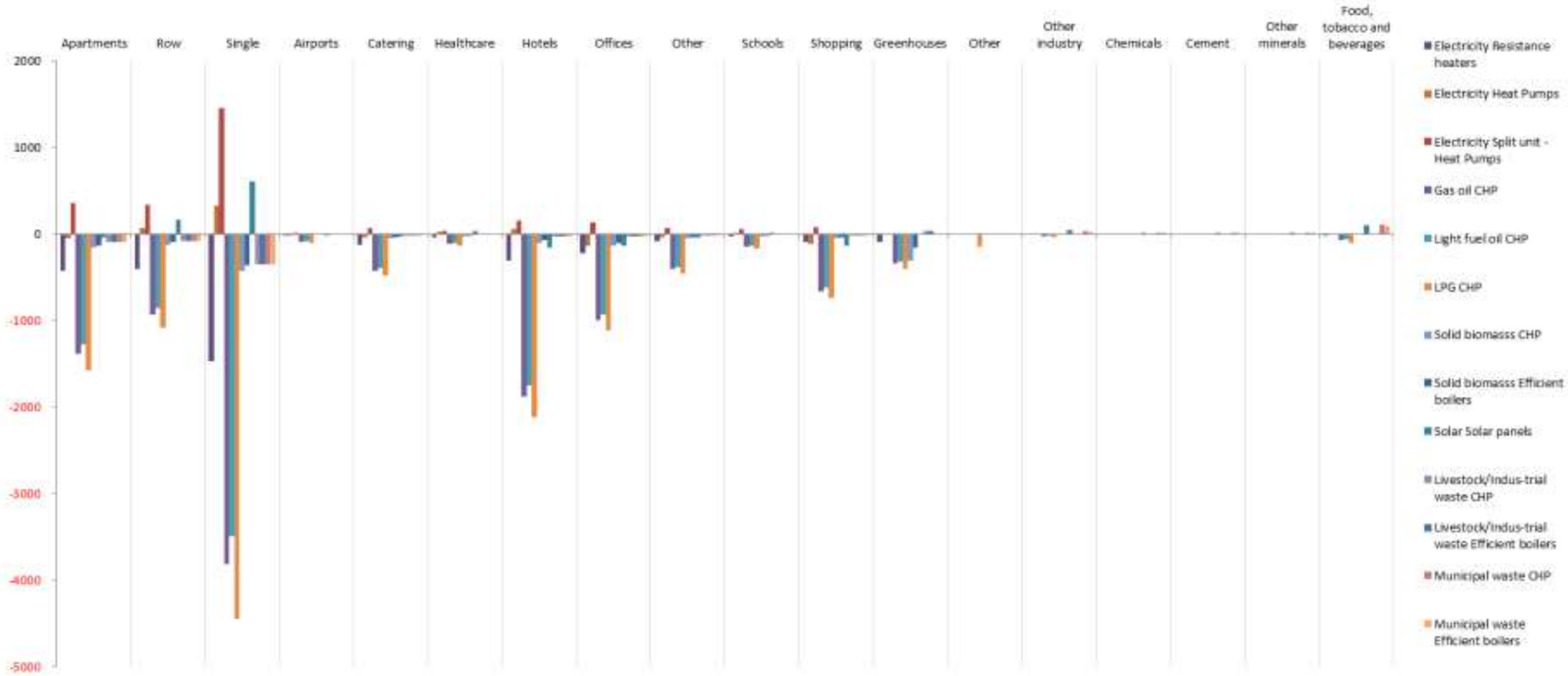


Figure 3.4 ENPV of alternative scenarios of individual solutions in the rest of the Cyprus (mill.EUR$_{2013}$)

3.2. Identification of economic potential

From the previous results, it can be estimated the economic potential of the different technical solutions. Figure 3.5 shows the results of the economic potential of efficient heating and cooling solutions in Cyprus in 2013 (GWh), which is compared also with the technical potential of those solutions. Table 3.10 collects detailed data of the economic potential of all solutions for the period 2013-2050. Annex 6 present the economic potentials of efficient heating and cooling solutions by system boundary.

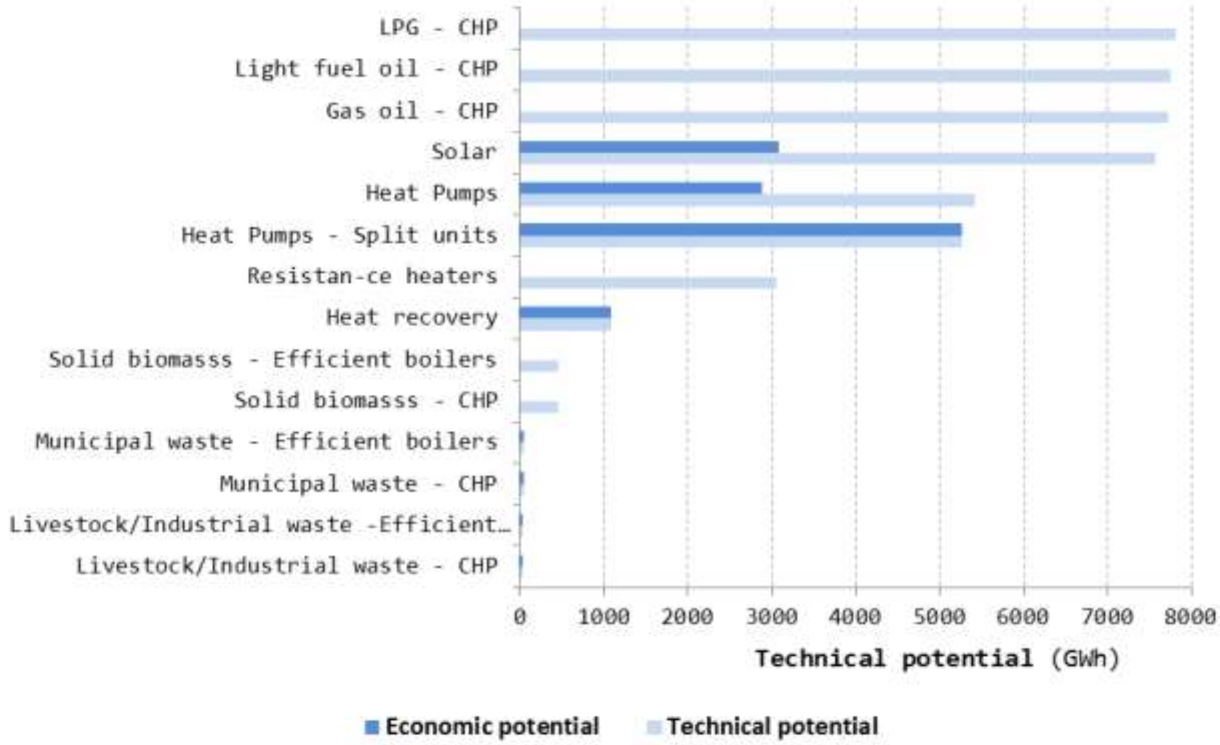


Figure 3.5 Technical vs. economic potential of efficient heating and cooling solutions in Cyprus, 2013 (GWh)

Table 3.10 Economic potential of efficient heating and cooling solutions in Cyprus (GWh)

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/Industrial waste - CHP	Livestock/Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	2882	0	0	0	38	38	42	42	0	0	3090	1079	0	5263
2014	3003	0	0	0	40	40	43	43	0	0	3257	1094	0	5446
2015	2960	0	0	0	41	41	43	43	0	0	3261	1088	0	5341
2016	3017	0	0	0	42	42	44	44	0	0	3341	1097	0	5442
2017	3050	0	0	0	44	44	45	45	0	0	3389	1104	0	5506
2018	3092	0	0	0	45	45	45	45	0	0	3448	1111	0	5581
2019	3132	0	0	0	47	47	46	46	0	0	3507	1113	0	5653
2020	3162	0	0	0	48	48	47	47	0	0	3552	1115	0	5710
2021	3199	0	0	0	50	50	47	47	0	0	3606	1117	0	5777
2022	3230	0	0	0	52	52	48	48	0	0	3652	1119	0	5835
2023	3265	0	0	0	54	54	49	49	0	0	3702	1120	0	5898
2024	3299	0	0	0	55	55	50	50	0	0	3752	1122	0	5961
2025	3333	0	0	0	57	57	50	50	0	0	3803	1124	0	6024
2026	3371	0	0	0	59	59	51	51	0	0	3859	1126	0	6092
2027	3400	0	0	0	61	61	52	52	0	0	3902	1127	0	6147
2028	3434	0	0	0	63	63	53	53	0	0	3953	1129	0	6210
2029	3469	0	0	0	65	65	53	53	0	0	4004	1131	0	6275
2030	3504	0	0	0	68	68	54	54	0	0	4055	1133	0	6340
2031	3541	0	0	0	70	70	55	55	0	0	4110	1135	0	6408
2032	3568	0	0	0	72	72	56	56	0	0	4152	1136	0	6461
2033	3601	0	0	0	75	75	56	56	0	0	4201	1138	0	6522
2034	3634	0	0	0	77	77	57	57	0	0	4251	1140	0	6582
2035	3666	0	0	0	80	80	58	58	0	0	4300	1141	0	6641
2036	3699	0	0	0	83	83	59	59	0	0	4350	1143	0	6702
2037	3723	0	0	0	86	86	60	60	0	0	4388	1144	0	6749
2038	3752	0	0	0	89	89	61	61	0	0	4434	1145	0	6804
2039	3782	0	0	0	92	92	62	62	0	0	4479	1147	0	6860
2040	3811	0	0	0	95	95	63	63	0	0	4525	1148	0	6914
2041	3840	0	0	0	98	98	63	63	0	0	4570	1150	0	6970
2042	3869	0	0	0	101	101	64	64	0	0	4614	1150	0	7026
2043	3898	0	0	0	105	105	65	65	0	0	4659	1151	0	7081
2044	3927	0	0	0	108	108	66	66	0	0	4704	1151	0	7136
2045	3956	0	0	0	112	112	67	67	0	0	4748	1152	0	7191
2046	3984	0	0	0	116	116	68	68	0	0	4791	1152	0	7245
2047	4012	0	0	0	120	120	69	69	0	0	4834	1152	0	7298
2048	4039	0	0	0	124	124	70	70	0	0	4877	1153	0	7351
2049	4067	0	0	0	128	128	71	71	0	0	4920	1153	0	7403
2050	4093	0	0	0	133	133	72	72	0	0	4962	1153	0	7454

3.3. Identification of areas for policy influence

3.3.1 Based on primary energy savings

As stated on Article 14 (4), based on the output of the cost-benefit analysis, MS will have to define adequate strategies, policies and measures. As is described in the section 3.1, the results of the ENPV allow identifying those solutions with the highest NPV. Nevertheless, in some cases, the ENPV difference of some scenarios is not significant so another criteria such as 'energy efficiency' of each scenario can be used to enhance the identification of areas of increased interest.

"Primary energy savings" is a very important metric of energy efficiency. It shows how much the consumption of (fossil) fuels is reduced per alternative scenario compared to the baseline. For the definition of the primary energy the following elements were considered:

- Fossil fuels that are directly consumed for heating and cooling purposes. That is gas oil, Light fuel oil, Kerosene, LPG, oil for backup heaters in case of solar
- Fossil fuels that are consumed from the electricity power generation of Cyprus corresponding to the consumption of the electric-driven technologies for heating and cooling (e.g heat pumps, resistance heaters etc). For this figure the efficiency of the power system had to be estimated. The share of electricity generation assumptions is derived by PRIMES. Figure 3.6 shows the evolution of the efficiency used in this study[10].

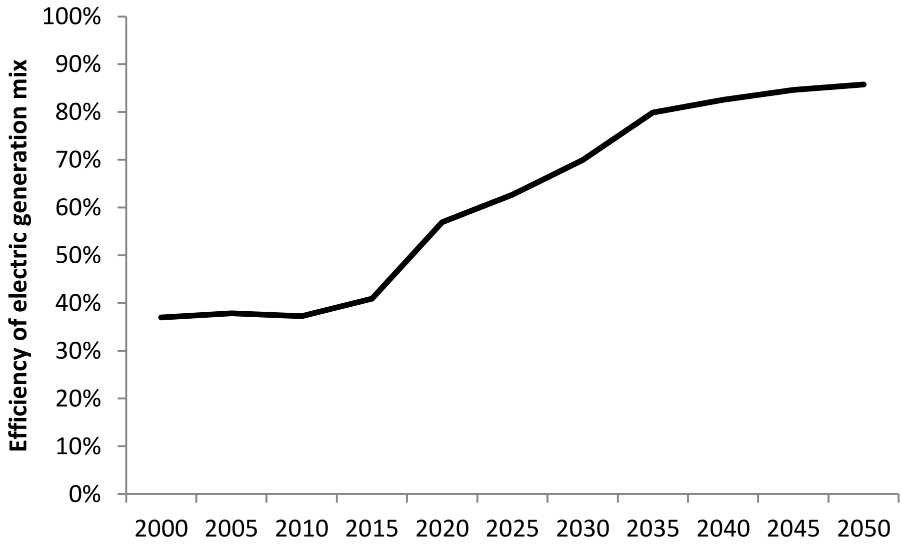


Figure 3.6. Evolution of efficiency of electric generation mix.

According to the above, we define the lifetime "primary energy savings ratio" as the relative difference of primary energy of each alternative scenario compared to the baseline, as follows:

$$PESR = \sum_i \frac{E_{baseline,i} - E_{alternative,i}}{E_{baseline}} = \sum_i 1 - \frac{E_{alternative,i}}{E_{baseline,i}}$$

[10] 90% of efficiency implies that 100 units of fuel generate 90 units of electricity. The higher the share of renewables (which have virtual infinite fossil fuel efficiency) the bigger the efficiency.

$$E_i = E_{fossil,i} + \frac{E_{electricity,consumed,i} - E_{electricity,CHP,i}}{\eta_i}$$

where E is the primary energy consumed and the subscript i refers to each year of the examined lifespan. This amount is calculated for fossil fuel consumed by heat-driven units, electricity consumed by electric-driven units and electricity produced by CHP units. η_i is the electricity generation mix efficiency for year i.

Figure 3.7 shows the results of Primary Energy Savings per alternative scenario for individual solutions. As can be seen, the solar and biomass based technologies (solid biomass and any type of waste) provide the most significant Primary Energy Savings followed by heat pumps. Figure 7.8 shows the results of Primary Energy Savings per alternative scenario for centralised solutions. Solar technologies can provide the largest Primary Energy Savings. Also solid biomass, heat recovery and heat provide positive results in terms el Primary Energy Savings.

It has to be noted that the value of Primary Energy Savings is already incorporated in the CBA via fuel costs and externalities. Nevertheless, there are other impacts on the welfare of society derived from fuel imports –as, for example, the fact of being exposed to suffer increases of fuel prices or having significant deficits on the external trade balance– whose complex relationships with the economic activity requires the use of consistent macro-economic models that are not available within time constraints of the fulfilment of the Comprehensive Assessment under the EED.

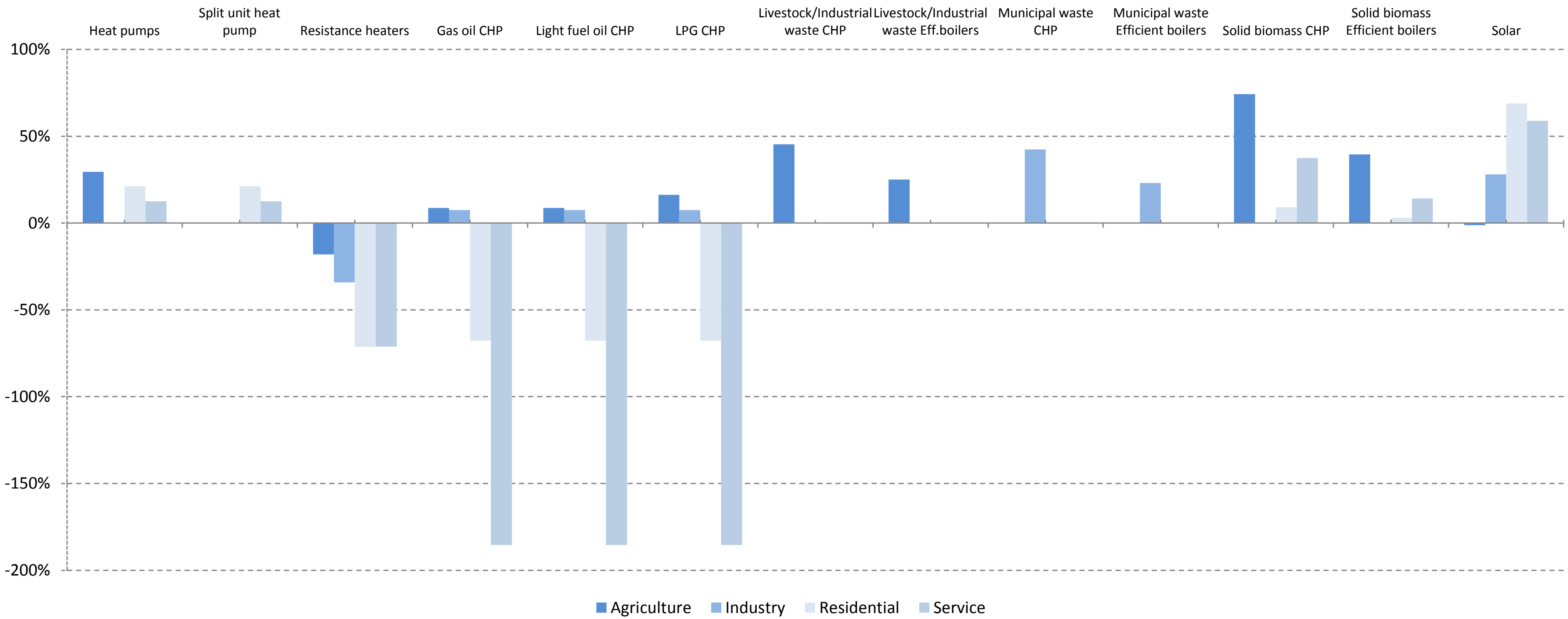


Figure 3.7. Average Primary Energy savings per alternative scenario for individual solutions (all system boundaries)

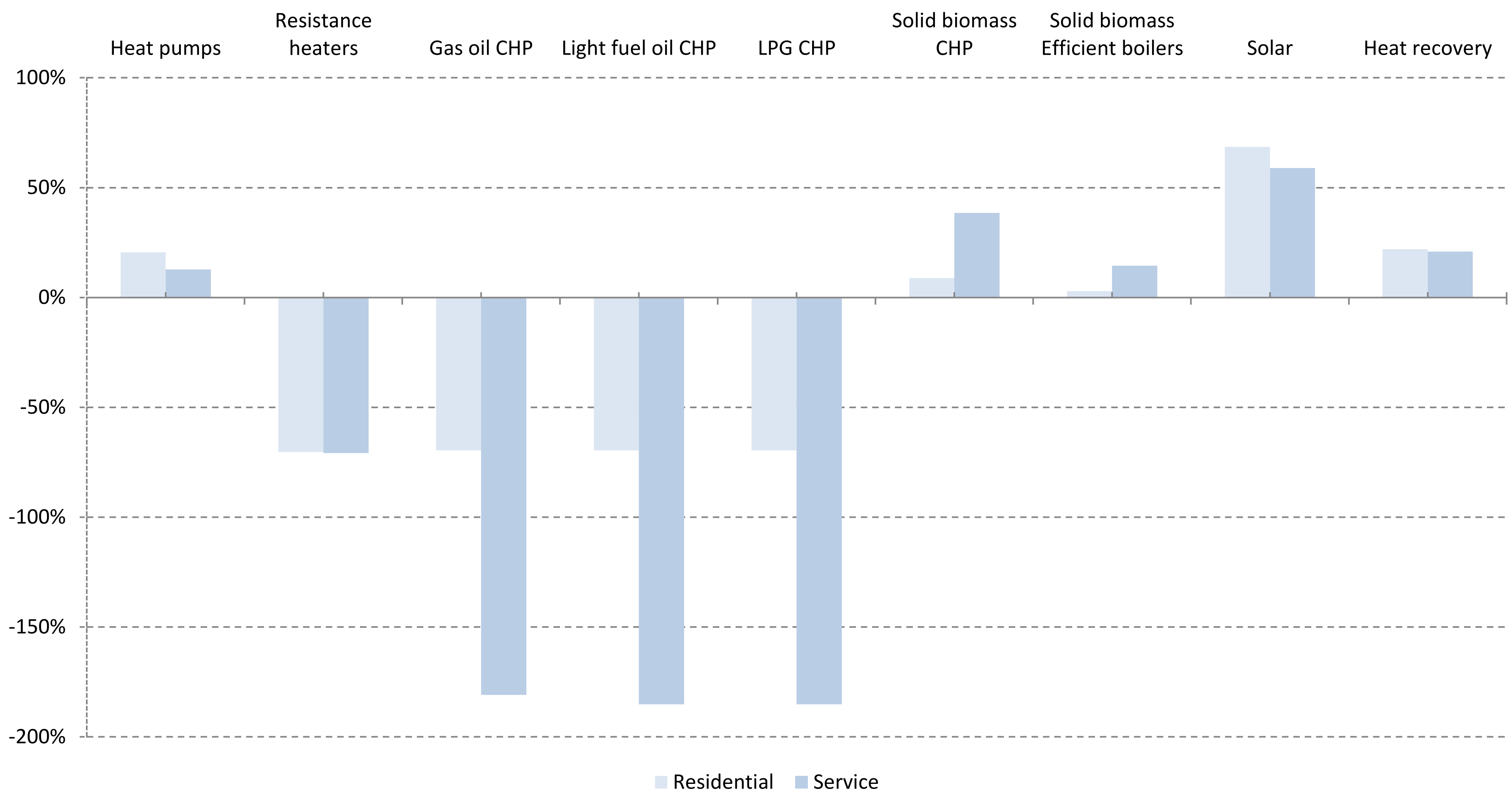


Figure 3.8 Average Primary Energy savings per alternative scenario for centralized solutions (high energy density boundaries)

3.3.2 Based on discrepancy of financial and economic net present value

The CSWD Guidance on EED suggests conducting the CBA both from the economic and financial perspectives. So, at the end of the CBA, two kinds of indicators are obtained: [i] the financial rate of return (FNPV) and [ii] the economic rate of return (ENPV). The usefulness of conducting the analysis from both perspectives is to identify potential areas for policy influence based on gaps between the financial suitability of a solution and its convenience from a society's perspective. Based on that gap, strategies, policies and measures to support or promote those solutions can be adopted, as well as remove existing or planned measures when the evaluation shows that they are not justified in social terms.

In the case of Cyprus, most of the solutions with positive ENPV present positive FNPV. Annex 7 collects information of the FNPV of individual solutions of the five system boundaries evaluated in Cyprus. Based on the results of the FNPV, few cases of solutions with positive ENPV and negative FNPV have been identified. They are the following ones:

- In Nicosia, Larnaca and Paphos:
    - Heat pumps in row, single houses, hotels and schools
    - Solar in schools
- In Limassol:
    - Heat pumps in row, single houses and hotels
- In the rest (low energy density areas):
    - Heat pumps in row, single houses, hotels and schools
    - Solar in schools
    - Livestock/industrial waste with CHP or efficient boilers

Detailed graphs illustrating the ENPV and FNPV evolutions can be found in Annex 9.[11]

[11] Separate document.

4 Sensitivity Analysis

A sensitivity analysis is conducted in order to explore the impact of the most critical and uncertain variables to the results. The following two cases have been considered:

- As the results are very sensitive to fuel prices, a sensitivity analysis is conducted considering an increase of +30% to all fossil fuels, electricity and solid biomass.
- Another important factor that affects all results is the discount rate. A sensitivity analysis is conducted considering an economic discount rate of 5% (instead of 3%).

Tables 4.1 and 4.2 show the relative change of the economic NPV for these two cases. The results of the sensitivity analysis are also presented by assessing the impact of these changes on the economic potential of the base case. Figure 8.1 shows the economic potential for base case and sensitivity analysis cases results of different technology solutions. Only solutions with positive economic potential in the base case and/or sensitivity analysis cases are presented. Detailed information can be found on Annex 8. As can be observed, an inverse situation exists:

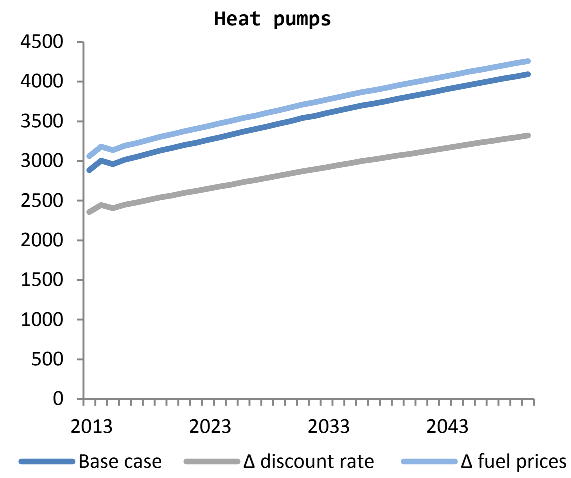
- Alternative scenarios that include high efficiency technologies (heat pumps) or renewable energy sources (this is the case of solar) are benefiting from the increase in fuel prices, so the economic NPV and consequently the economic potential is higher than the base case. However in most of the solutions the economic potential (in terms of energy) is not affected because it was already at the maximum technical potential level in the base case.
- In contrary to above, technologies that are more capital intensive with low variable costs (due to their increased efficiency), compared to those in the baseline, are affected in a negative way when the discount rate increases as their net present value is decreasing. This is the case of split unit heat pumps, normal heat pumps and solar (see Table 4.2).

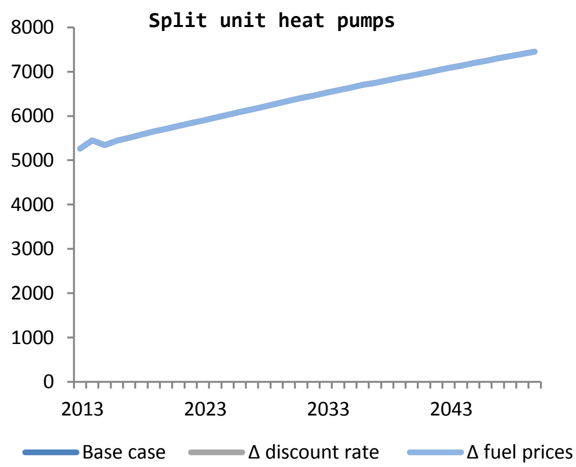
Table 4.1 Relative increase (or decrease) in the economic NPV for the case of increased fuel costs for the individual solution on a country level

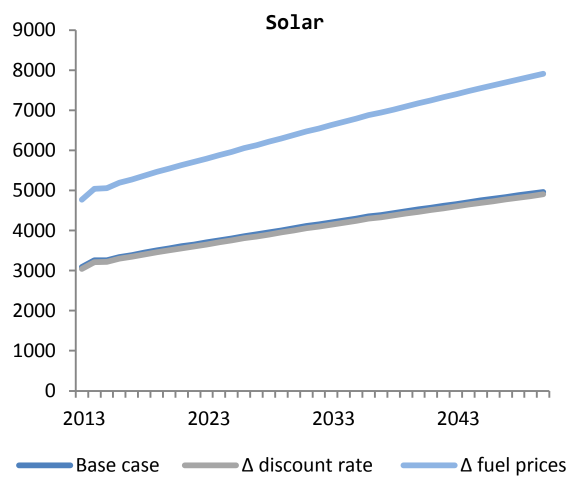
	Electricity	Electricity	Electricity	Gas oil	Light fuel oil	LPG	Solid biomasss	Solid biomasss	Solar	Livestock/Indus-trial waste	Livestock/Indus-trial waste	Municipal waste	Municipal waste
	Resistance heaters	Heat Pumps	Split unit - Heat Pumps	CHP	CHP	CHP	CHP	Efficient boilers	Solar panels	CHP	Efficient boilers	CHP	Efficient boilers
Residential													
Apartments	-17%	57%	8%	-30%	-30%	-30%	-4%	-1%	172%	0%	0%	0%	0%
Row	-20%	76%	13%	-34%	-34%	-33%	-5%	0%	67%	0%	0%	0%	0%
Single	-19%	95%	10%	-33%	-34%	-33%	-6%	-1%	93%	0%	0%	0%	0%
Service													
Airports	-4%	0%	0%	-6%	-6%	-6%	-2%	-1%	3%	0%	0%	0%	0%
Catering	-20%	13%	7%	-33%	-33%	-33%	-20%	-10%	80%	0%	0%	0%	0%
Healthcare	-20%	33%	12%	-38%	-38%	-36%	-25%	-11%	43%	0%	0%	0%	0%
Hotels	-19%	30%	7%	-33%	-33%	-32%	-22%	-12%	43%	0%	0%	0%	0%
Offices	-19%	6%	6%	-31%	-31%	-31%	-16%	-9%	30%	0%	0%	0%	0%
Other	-19%	16%	8%	-32%	-32%	-32%	-18%	-9%	75%	0%	0%	0%	0%
Schools	-20%	210%	12%	-35%	-36%	-34%	-15%	-4%	409%	0%	0%	0%	0%
Shopping	-16%	1%	2%	-29%	-29%	-29%	-12%	-6%	12%	0%	0%	0%	0%
Agriculture													
Greenhouses	-4%	480%	0%	-4%	-4%	-4%	-4%	0%	0%	18%	20%	0%	0%
Other	0%	0%	-101%	0%	0%	-4%	0%	0%	98%	0%	0%	0%	0%
Industry													
Other industry	-2%	0%	0%	-10%	-11%	-9%	0%	0%	6%	0%	0%	5%	6%
Chemicals	-2%	0%	0%	-9%	-9%	-8%	0%	0%	6%	0%	0%	5%	6%
Cement	50%	0%	0%	-7%	-7%	-7%	0%	0%	7%	0%	0%	6%	7%
Other minerals	0%	-1%	0%	-8%	-9%	-8%	0%	0%	6%	0%	0%	5%	7%
Food, tobacco and bever	-1%	0%	0%	-10%	-11%	-9%	0%	0%	6%	0%	0%	5%	6%
Average increase	-8%	56%	-1%	-21%	-22%	-21%	-8%	-4%	64%	1%	1%	1%	2%

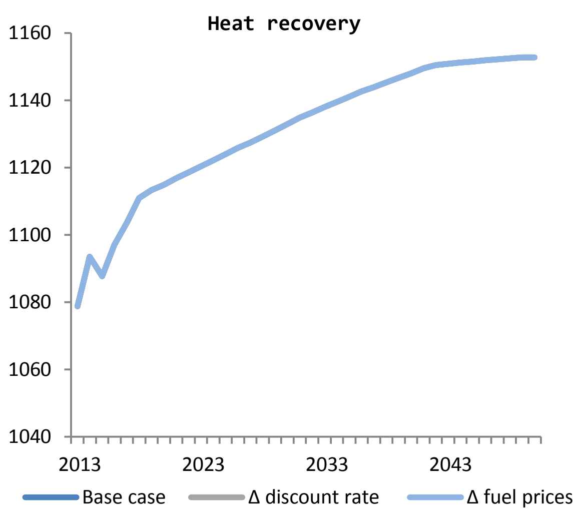
Table 4.2 Relative increase (or decrease) in the economic NPV for the case of increased discount rate for the individual solution on a country level

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	Solid biomasss Efficient boilers	Solar Solar panels	Livestock/Indus-trial waste CHP	Livestock/Indus-trial waste Efficient boilers	Municipal waste CHP	Municipal waste Efficient boilers
Residential													
Apartments	24%	-44%	-21%	25%	25%	25%	21%	20%	-65%	22%	22%	22%	22%
Row	22%	-89%	-25%	24%	24%	24%	20%	18%	-53%	21%	21%	21%	21%
Single	22%	-104%	-23%	25%	25%	25%	19%	17%	-61%	21%	21%	21%	21%
Service													
Airports	5%	-1%	-5%	4%	4%	4%	4%	4%	0%	5%	5%	5%	5%
Catering	23%	-16%	-21%	22%	22%	23%	18%	17%	-39%	26%	26%	26%	26%
Healthcare	22%	-49%	-25%	23%	23%	24%	18%	17%	-35%	23%	23%	23%	23%
Hotels	23%	-76%	-33%	22%	22%	23%	19%	18%	-21%	25%	25%	25%	25%
Offices	23%	-9%	-23%	21%	21%	22%	17%	16%	-12%	25%	25%	25%	25%
Other	23%	-22%	-22%	22%	21%	22%	18%	17%	-45%	25%	25%	25%	25%
Schools	24%	-249%	-22%	22%	22%	23%	16%	15%	-287%	22%	22%	22%	22%
Shopping	23%	-3%	-23%	21%	20%	21%	19%	19%	-1%	26%	26%	26%	26%
Agriculture													
Greenhouses	2%	-386%	0%	2%	1%	2%	1%	-1%	0%	-16%	-13%	5%	5%
Other	23%	-22%	-22%	22%	21%	22%	18%	17%	-45%	25%	25%	25%	25%
Industry													
Other industry	2%	7%	0%	5%	4%	5%	7%	7%	-6%	7%	7%	-5%	-6%
Chemicals	1%	7%	0%	5%	4%	5%	7%	7%	-6%	7%	7%	-6%	-6%
Cement	-49%	7%	0%	4%	4%	4%	7%	7%	-5%	7%	7%	-6%	-6%
Other minerals	-3%	7%	0%	5%	5%	5%	7%	7%	-5%	7%	7%	-5%	-5%
Food, tobacco and bever	1%	7%	0%	5%	4%	5%	7%	7%	-6%	7%	7%	-5%	-5%
Average increase	12%	-57%	-15%	15%	15%	16%	14%	13%	-38%	16%	16%	13%	13%









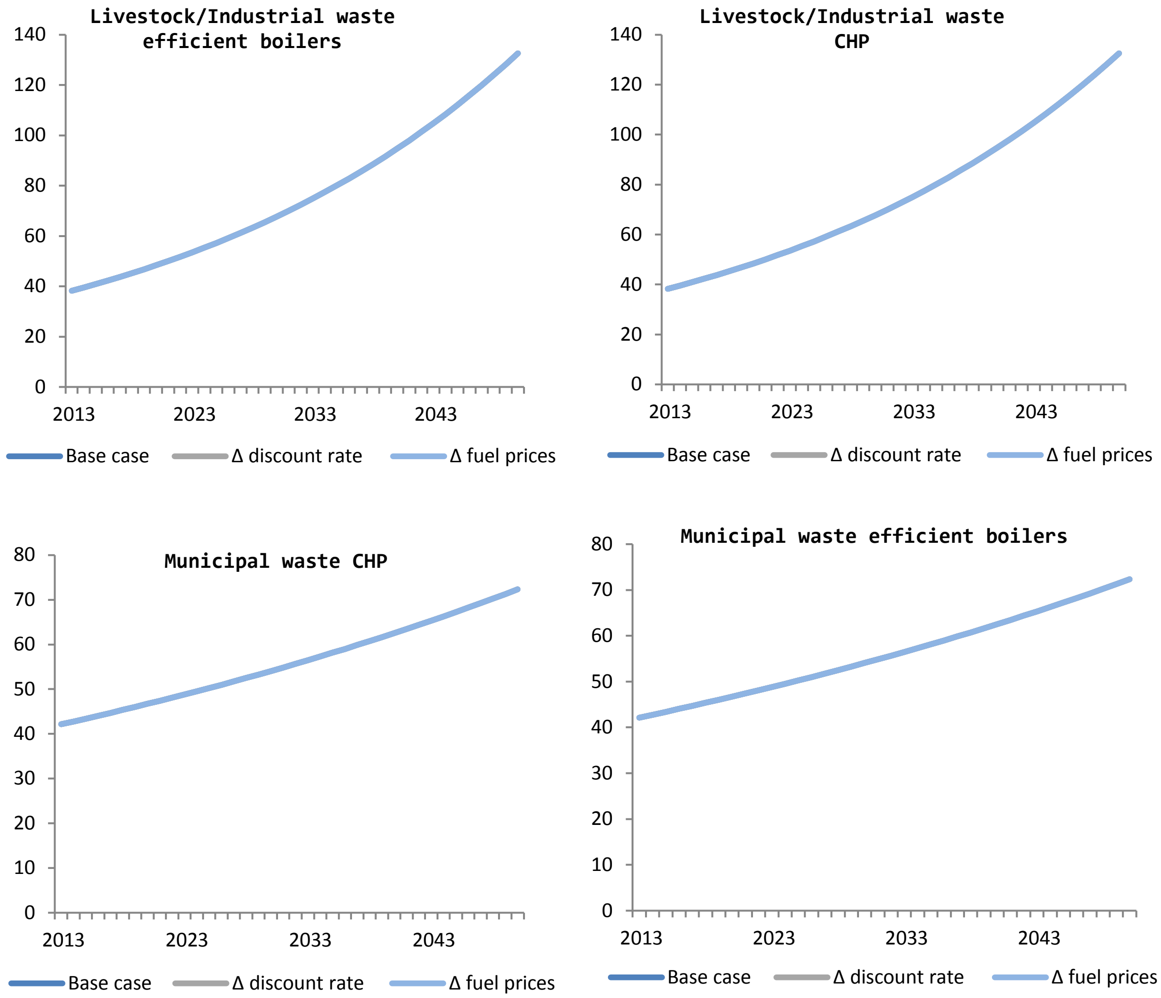


Figure 4.3 Economic potential of base case and sensitivity analysis cases, by solution (GWh)

5. Conclusions

Four system boundaries of high energy density have been identified in Cyprus. These systems are in the wider urban areas of: [i] Nicosia; [ii] Paphos; [iii] Limassol and [iv] Larnaca. The demand of these four systems constitute the 'heating and cooling demand that could be satisfied by district heating and cooling' in Cyprus. Within the four high demand density system boundaries, Limassol and Larnaca have a nearby exploitable waste heat source. Postal codes that do not belong to these four wider city areas are grouped in another single system boundary that encompasses the postal codes of the rest of Cyprus, thus forming a part of one 'low demand density system'. In this system boundary, only individual solutions are examined. The demand of the five system boundaries constitute the 'heating and cooling demand that could be satisfied by high-efficiency cogeneration, including residential micro-cogeneration'.

A range of 14 high efficiency heating and cooling solutions to satisfy heating and cooling demand of different sub-sectors have been identified and tested in this study. Any technical solution has been considered applicable for centralized systems (which means, using district heating/cooling systems to distribute thermal energy). Heat recovery from power plants is analysed only for centralised energy supply options. The rest of the technical solutions identified (so, 13 solutions) are also considered applicable as individual systems (which means producing heating and cooling in situ).

The technical potential of these solutions has been assessed for the period 2013-2050. The solutions with the highest technical potential are: those using conventional fossil fuels as resource (such as gas oil with CHP; light fuel oil with CHP and natural gas with CHP); solar and heat pumps. Heat recovery has a technical potential seven times lower than the mentioned solutions. The solutions with a significant smaller technical potential are based on biomass resources, such as: solid biomass; municipal waste and livestock/industrial waste.

The results of the CBA show that when technical solutions can be applied both individually and with centralised systems, individual systems provide higher economic NPV (ENPV) than centralised solutions.. Based on this, it can be concluded that individual systems are better candidates to be promoted as efficient heating and cooling solutions (rather than centralised ones) for solutions that are applicable with both distribution systems. Also, individual systems without water based heating systems are more competitive than individual systems with water based heating systems due to the increased installation costs in sectors that do not already have pipelines.

The combination of technologies that provide a scenario with the highest ENPV vary from one system boundary to other:

- In Nicosia, Paphos and Limassol: the combination of technologies that provide a scenario with the highest ENPV encompasses the use of heat pumps and solar. There are slight differences between system boundaries on the selections of sub-sectors in which to apply these solutions. However, these are the two technical solutions that clearly would provide the maximum welfare.
- In Larnaca: heat recovery provides the highest ENPV compared to individual solutions.
- In the rest of Cyprus: the combination of technologies that provide a scenario with the highest ENPV encompasses the use of heat pumps, solar,and municipal waste with CHP.

Based on the results of the CBA, the economic potential of the identified technical solutions has been assessed for the period 2013-2050. The solutions with the highest economic potential are: solar and heat pumps. Heat recovery has an economic potential seven times lower than the mentioned solutions. The solutions with a significantly smaller economic potential are: natural gas with CHP; municipal waste, either with CHP or efficient boilers and solid biomass.

In order to identify areas of policy influence, the information on non-renewable Primary Energy Savings has been compared with the ENPV. This comparison shows that solar, as well as heat recovery present a significantly higher non-renewable Primary Energy Savings than any other options. This aspect should be taken into account when designing future heating and cooling policies and strategies for Cyprus, giving priority to those solutions with a higher Primary Energy Savings when the costs are similar.

The study has been conducted both from the economic and financial perspectives. The aim is to identify potential areas for policy influence based on gaps between the financial suitability and its convenience from a society's perspective of a solution. In the case of Cyprus, most of the solutions with positive ENPV present positive FNPV. Few cases of solutions with positive ENPV and negative FNPV have been identified.

References

- Batista e Silva, F., Gallego, J., & Lavalle, C. (2013). A high-¬-resolution population grid map for Europe. Journal of Maps.
- CSS (2014). Cyprus Statistical Service. Health and hospital statistics 2012. December 2014.
- CYSTAT. (2011). Households, Geographical Distribution.
- CYSTAT. (2013). Final energy consumption in households.
- Dascalaki, E., Droutsa, P., & Balaras, C. (2011). On the Use of Building Typologies to Assess the Energy Performance of the Hellenic Residential Building Stock. 3rd Int. Conference on Renewable Energy Sources & Energy Efficiency. Nicosia, Cyprus.
- DG ENER (2001). Energy Savings by CHCP plants in the Hotel Sector. Energy Audits – Cyprus.
- EC (European Commission) (2006) Waste incineration. Integrated Pollution Prevention and Control. Reference Document on the Best Available Techniques. August 2006.
- EC (European Commission) (2013) EU European study on EU Energy Transport and GHG emission – Trends to 2050 update 2013.
- ECOHEATCOOL (2006) The European Heat Market. Final report. Work package 1
- Elbersen, B., Startisky, I., Hengeveld, G., Schelhaas, M.J., Naeff, H. Böttcher, H. (2012) Atlas of EU biomass potentials. D3.3. Spatially detailed and quantified overview of EU biomass potential taking into account the main criteria determining biomass availability from different sources.
- European Commission. (1999). Energy Efficiency Indicators: The European Experience. Paris: Ademe Editions.
- Eurostat (2015) Electricity consumption by industry, transport activities and households/services.
- Eurostat (2015) Final energy consumption by industrial sector
- Gallego, F. J. (2010). A population density grid of the European Union. Population and Environment, 31(6), 460-473.
- IDAE (Instituto para la Diversificación y el Ahorro de la Energía) (2011) Evaluación del potencial de climatización con energía solar térmica en edificios. Estudio técnico del PER 2011-2020. Madrid, 2011
- IEA (International Energy Agency) (2002) Potential for Building Integrated Photovoltaics. Report IEA-PVPS T7-4:2002.
- International Energy Agency. (2004). 30 Years of energy use in IEA countries.
- IRENA (2014) Renewable Energy Roadmap for the Republic of Cyprus.
- IRENA. (2014). Renewable Energy Roadmap.
- Joint Research Centre - IPTS. (2015, April). Integrated Database on the European Energy Sector (IDEES).
- Joint Research Centre. (2012). Heat and cooling demand and market perspectives. Luxembourg.
- JRC (Joint Research Centre) (2015) Integrated Database on the European Energy Sector (IDEES), April 2015
- JRC-IDEES (2015) – Integrated database of the European Energy System (2000-2010).
- JRC-IPTS (2015). Integrated Database of the European Energy Sector.
- Kalogirou, S. (2003) The potential of solar industrial process heat applications. Applied Energy, 76: 337-361.
- Katafygioutou and Serghides (2014). Analysis of structural elements and energy consumption of school building stock in Cyprus: Energy simulations and upgrade scenarios of a typical school. Energy and Buildings, 2014.
- Kythreotou, N., Tassou, S. A., Florides, G. (2010) An assessment of the potential of Cyprus for energy production. Asia-Pacific Forum on Renewable Energy 2011. Volume 47, Issue 1, November 2012, Pages 253–261
- Martins, M. d., Sousa, A. M., & Fragoso, R. M. (2012). Redistributing Agricultural Data by a Dasymetric Mapping Methodology. Agricultural and Resource Economics Review, 41(3), 351–366.

- MCIT (2013). Calculation for Setting the Minimum Energy Performance Requirements at Cost Optimal Levels According to Article 5 of the Directive 2010/31/EE for the Energy Performance of Buildings. April 2013.
- MCIT (Ministry pf Commerce, Industry and Tourism) (2009) Assessment of national potential for cogeneration in Cyprus. Final report.
- MCIT (Ministry pf Commerce, Industry and Tourism) (2010) National Renewable Action Plan (NREAP)
- MECIT (2010) Ministry of Commerce, Industry and Tourism of Republic of Cyprus. National renewable energy action plan (2010-2020). June 2010.
- MECIT. (2012). Definition of the Nearly Zero Energy Building in Cyprus.
- MECIT. (2014). 3rd National Energy Efficiency Action Plan Of Cyprus.
- Michael and Phocas (2011). Energy Performance Evaluation and Heat Insulation Measures for Typical Educational Buildings in Cyprus.
- Pardo,, N., Vatopoulos, K, Krook-Riekkola, A., Moya, J.A., Perez, A. (2012) Heat and cooling demand and market perspective. JRC, 2012
- Poyry (2009) Poyry Energy (Oxford) Ltd. The potential costs of district heating networks. A report to the Department of Energy and Climate Change, April 2009.
- SMEC (2015a). Cyprus Ministry of Education and Culture. Registry of private secondary schools.
- SMEC (2015b). Cyprus Ministry of Education and Culture. Registry of private primary schools.
- SMEC (2015c). Cyprus Ministry of Education and Culture. Registry of private pre-school education facilities.
- Statistical Service of Cyprus (2013) Industrial Statistics Report, 2013

List of abbreviations and definitions

CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CHP	Combined heat and power
CPI	Current Policy Initiatives
CSWD	Commission Staff Working Document
DHC	District Heating and Cooling
EED	Energy Efficiency Directive
EU-ETS	European Union Energy Trading Scheme
GDP	Gross Domestic Product
GHG	Green House Gases
NPV	Net Present Value
O&M	Operation and Maintenance
SHW	Sanitary Hot Water

Baseline scenario	Assumed evolution of heating and cooling system taking into consideration existing technical or policy measures and their most likely developments without the intervention of new policies
Alternative scenario	Possible evolution of heating and cooling system to be compared to the baseline scenario, where selected technologies are implemented
System boundary	Part of country territory, encompassing one or more base heat demand areas and heat source(s), used as an object for the Cost-Benefit Analysis
Technical potential	The amount of demand (measured in terms of useful energy, MWh/a) that could be covered by the technology solution or energy resource being evaluated, considering its maximum achievable penetration within the considered timeframe, considering technical or practical limitations, including topographic limitations, environmental, and land-use constraints, without taking into consideration economic criteria.. It can also be expressed in terms of the corresponding installed capacity of the technology (MW).
Economic potential	Economic potential is the subset of technical potential that is economically cost-effective as compared to conventional supply-side energy resources. The economic potential can be

	expressed in both (MWh/a) and (MW).
Cost-efficient potential	The cost-efficient potential is the contribution of a technical solution to the combination of solutions that provides the most cost-efficient way of supplying heating and cooling needs with efficient solutions. The economic potential can be expressed in both (MWh/a) and (MW).
Energy demand	Amount of useful energy required to satisfy end-users needs (e.g. heating/cooling needs) (MWh)
Energy consumption	Amount of energy effectively used to satisfy the demand, including, where appropriate, transformation, transport and distribution losses (MWh).
Primary energy	Energy in the form as it is found in the nature i.e. before transformation, transport or distribution (MWh). When calculating primary energy consumption, conventional rules are used for the non-fossil energy sources (e.g. renewables).
Final (or secondary) energy	Energy supplied to the end-user's door (MWh), including energy from renewable energy sources produced and consumed locally by the end-user.
Useful energy	Energy available to the end-users (e.g. heating, cooling) after the last conversion made in the end-user energy conversion equipment, hence final energy consumption minus conversion losses (MWh).
Peak load	The highest power/heat capacity required (MW)
Average load	Typical power/heat capacity required (MW)
Efficiency	Useful energy generated per primary energy input, e.g. by a boiler (%)
Thermal efficiency (for CHP)	Heat generated (not for electricity) per primary energy input from Cogeneration plant (%)
Electrical efficiency (for CHP)	Electricity generated per primary energy input for Cogeneration plant (%)
Technical lifetime	Period of time during which component or system can technically function before it must be replaced [hours or years]

Annex 1. Detailed data and results of heating and cooling demand of industry

Table A1.1: Final energy consumption by end use category and industrial sector, 2013 (TJ)

	PROCESS HEAT	PROCESS COOLING	OTHERS
Mining and quarrying	174.30	0.00	56.60
Water supply	26.02	0.00	467.84
Food, beverages and tobacco	822.88	52.41	436.52
Textiles	1.41	0.00	16.70
Wood	9.92	0.00	18.27
Paper and pulp	44.32	0.00	56.46
Chemicals	59.15	0.00	131.74
Plastic products	33.16	0.00	82.75
Other non-metallic minerals	461.56	0.00	32.72
Cement industry	3896.67	0.00	429.54
Basic metals	76.16	0.00	56.03
Machinery and equipment	10.72	0.00	7.61
Electrical & optical equipment	0.50	0.00	2.70
Transport equipment	2.99	0.00	3.15
Other industry	7.38	0.00	59.40

Table A1.2: Efficiency factors – IDEES-Database extract

EFFICENCY FACTORS	PROCESS HEATING			PROCESS COOLING	OTHER	
	Fossil	Electricity	Biomass	Electricity	Fossil	Electricity
Cement	0.51	-	0.64			0.51
Ceramics & other NMM	0.42	0.57				0.49
Food, beverages and tobacco	-	0.45		0.75		0.49
Other chemicals	-	0.57		0.99		0.50
Pharmaceutical products etc.	-	0.57		1.06		0.51
Printing and reproduction of recorded media	-	0.00				0.54
Transport Equipment	-	0.62				0.54
Machinery Equipment	-	0.64				0.55
Textiles and leather	-	-				0.49
Wood and wood products	-	0.44				0.50
Other Industrial Sectors	0.25	0.34			0.49	0.47

Table A1.3: Useful energy consumption by end use category and industrial sector, 2013 (TJ)

	PROCESS HEAT			PROCESS COOLING	OTHERS
	Low temperature (< 100°C)	Medium temperature (100 °C - 400°C)	High temperature (> 400 °C)		
Mining and quarrying	25.71	18.36	0.00	0.00	26.71
Water supply	5.06	3.70	0.00	0.00	220.08
Food, beverages and tobacco	143.68	90.92	0.00	39.24	215.46
Textiles	0.14	0.22	0.08	0.00	7.86
Wood	1.46	0.71	0.36	0.00	8.59
Paper and pulp	3.89	5.47	2.05	0.00	26.58
Chemicals	6.20	3.18	6.11	0.00	62.00
Plastic products	3.49	1.79	3.44	0.00	38.94
Other non-metallic minerals	12.15	11.29	176.01	0.00	16.02
Cement industry	120.75	112.28	1749.87	0.00	219.22
Basic metals	1.72	0.86	16.83	0.00	26.39
Machinery and equipment	3.23	1.06	0.48	0.00	4.18
Electrical & optical equipment	0.08	0.04	0.02	0.00	1.27
Transport equipment	0.68	0.23	0.09	0.00	1.48
Other industry	1.24	0.60	0.30	0.00	27.94

Table A1.4: Number of facilities by NACE code (extract of MECIT Database)

NACE code	Industrial activity	Number of facilities
8	Mining and Quarrying	57
10	Manufacture of food products	1001
11	Manufacture of beverages	92
12	Manufacture of tobacco products	1
13	Manufacture of textiles	122
14	Manufacture of wearing apparel	207
15	Manufacture of leather and related products	38
16	Manufacture of wood and wood products	945

17	Manufacture of paper and paper products	54
18	Printing and reproduction of recorded media	288
19	Manufacture of coke and refined petroleum products	4
20	Manufacture of chemicals and chemical products	71
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	15
22	Manufacture of rubber and plastic products	92
23	Manufacture of other non-metallic mineral products	417
24	Manufacture of basic metals	6
25	Manufacture of fabricated metal products, except machinery and equipment	1242
26	Manufacture of computer, electronic and optical products	9
27	Manufacture of electrical equipment	100
28	Manufacture of machinery and equipment n.e.c.	68
29	Manufacture of motor vehicles, trailers and semi-trailers	78
30	Manufacture of other transport equipment	11
31	Manufacture of furniture	380
32	Other manufacturing	332
33	Repair and installation of machinery and equipment	244

Table A1.5: Relation between NACE codes and industrial categories of the IDEES Database / Energy Balance

NACE code	Industrial categories
8	Mining and Quarrying
10, 11 and 12	Manufacture of food, beverages and tobacco products
13, 14 and 15	Manufacture of textiles, wearing apparel, leather and related products
16	Manufacture of wood and wood products
17 and 18	Manufacture of paper, paper products and printing media
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
23	Manufacture of other non-metallic mineral products
24	Manufacture of basic metals
28	Manufacture of machinery and equipment n.e.c.
29 and 30	Manufacture of other transport equipment
19, 22, 25,26,27, 31,32 and 33	Other manufacturing

Annex 2. Conversion of heat demand into heat load

The data collection exercise resulted in heat demand data for different uses by different subsectors, expressed in energy units (MWh/a). In order to estimate capital investments into technologies, demand data was converted into load data, as described below.

Average heat load of a building or group of buildings for heating was calculated according to the formula:

$$Q_{AVG}^{h} = \frac{Q_{annual}^{h}}{24 \cdot n_h} \quad (3.1.1)$$

here Q_{AVG}^{h} – average heat load of buildings for space heating, MW; Q_{annual}^{h} – annual demand of heat for space heating, MWh/a; n_h - average duration of heating season in Cyprus, days (assuming that heating was used on the days when outside air temperature was below 18 °C).

Average heat load of a building or group of buildings for preparation of domestic hot water was calculated according to the formula:

$$Q_{AVG}^{h/w} = \frac{Q_{annual}^{h/w}}{24 \cdot 365} \quad (3.1.2)$$

here $Q_{AVG}^{h/w}$ – average heat load of buildings for preparation of SHW, MW; $Q_{annual}^{h/w}$ – annual demand of heat for SHW preparation, MWh/a.

Average heat load of a building or group of buildings for space cooling was calculated according to the formula:

$$Q_{AVG}^{c} = \frac{Q_{annual}^{c}}{24 \cdot n_c} \quad (3.1.3)$$

here Q_{AVG}^{c} – average heat load of buildings for space cooling, MW; Q_{annual}^{c} – annual demand of heat for space cooling, MWh/a; n_h - average duration of cooling season in Cyprus, days (assuming that cooling was used on the days when outside air temperature was above 20 °C).

Maximum heat load of buildings for space heating was calculated according to the formula:

$$Q_{MAX}^{h} = Q_{AVG}^{h} \cdot \frac{\theta_C - \theta_{min}}{\theta_C - \theta_{avg}} \quad (3.1.4)$$

here Q_{MAX}^{h} – maximum space heating load of the buildings, MW; θ_C – base temperature (assumed to be 18 °C), °C; θ_{avg} – average outside air temperature throughout heating season (during n_h days), °C; θ_{min} – average minimum outside air temperature in Cyprus, °C.

Maximum heat load of buildings for preparation of SHW was calculated according to the formula:

$$Q_{MAX}^{h/w} = k_w \cdot Q_{AVG}^{h/w} \quad (3.1.5)$$

here k_w – coefficient, which estimates the peak in hot water consumption (assumed to be equal to 3).

Maximum heat load of buildings for space cooling was calculated according to the formula:

$$Q_{MAX}^{c} = Q_{AVG}^{c} \cdot \frac{\theta_{max} - \theta_c}{\theta_{avg} - \theta_c} \quad (3.1.4)$$

here Q_{MAX}^{c} – maximum space heating load of the buildings, MW; θ_C – base temperature (assumed to be 20 °C), °C; θ_{avg} – average outside air temperature throughout cooling season (during n_c days), °C; θ_{max} – average maximum outside air temperature in Cyprus, °C.

Calculated heat loads were used for sizing of the heat generation equipment.

Annex 3. Identification of technical potentials by system boundary

Table A3.1 Technical potential of efficient heating and cooling solution in Nicosia (GWh)

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	1225	638	1756	1756	0	0	0	0	73	73	1756	0	1756	1225
2014	1268	662	1815	1815	0	0	0	0	73	73	1815	0	1815	1268
2015	1245	648	1785	1785	0	0	0	0	72	72	1785	0	1785	1245
2016	1269	656	1824	1824	0	0	0	0	72	72	1824	0	1824	1269
2017	1284	658	1851	1851	0	0	0	0	72	72	1851	0	1851	1284
2018	1303	663	1881	1881	0	0	0	0	72	72	1881	0	1881	1303
2019	1320	667	1911	1911	0	0	0	0	72	72	1911	0	1911	1320
2020	1334	670	1934	1934	0	0	0	0	72	72	1934	0	1934	1334
2021	1350	674	1962	1962	0	0	0	0	71	71	1962	0	1962	1350
2022	1364	676	1986	1986	0	0	0	0	71	71	1986	0	1986	1364
2023	1379	680	2012	2012	0	0	0	0	71	71	2012	0	2012	1379
2024	1394	683	2038	2038	0	0	0	0	71	71	2038	0	2038	1394
2025	1410	686	2064	2064	0	0	0	0	71	71	2064	0	2064	1410
2026	1426	690	2093	2093	0	0	0	0	71	71	2093	0	2093	1426
2027	1440	692	2116	2116	0	0	0	0	70	70	2116	0	2116	1440
2028	1455	695	2143	2143	0	0	0	0	70	70	2143	0	2143	1455
2029	1470	698	2169	2169	0	0	0	0	70	70	2169	0	2169	1470
2030	1486	701	2197	2197	0	0	0	0	70	70	2197	0	2197	1486
2031	1503	704	2225	2225	0	0	0	0	70	70	2225	0	2225	1503
2032	1516	706	2248	2248	0	0	0	0	70	70	2248	0	2248	1516
2033	1530	708	2274	2274	0	0	0	0	69	69	2274	0	2274	1530
2034	1545	711	2300	2300	0	0	0	0	69	69	2300	0	2300	1545
2035	1559	713	2325	2325	0	0	0	0	69	69	2325	0	2325	1559
2036	1574	715	2351	2351	0	0	0	0	69	69	2351	0	2351	1574
2037	1586	717	2372	2372	0	0	0	0	69	69	2372	0	2372	1586
2038	1599	718	2396	2396	0	0	0	0	69	69	2396	0	2396	1599
2039	1613	720	2420	2420	0	0	0	0	68	68	2420	0	2420	1613
2040	1626	722	2444	2444	0	0	0	0	68	68	2444	0	2444	1626
2041	1640	723	2469	2469	0	0	0	0	68	68	2469	0	2469	1640
2042	1653	725	2493	2493	0	0	0	0	68	68	2493	0	2493	1653
2043	1667	727	2517	2517	0	0	0	0	68	68	2517	0	2517	1667
2044	1680	728	2541	2541	0	0	0	0	68	68	2541	0	2541	1680
2045	1694	730	2566	2566	0	0	0	0	68	68	2566	0	2566	1694
2046	1707	731	2589	2589	0	0	0	0	67	67	2589	0	2589	1707
2047	1719	732	2613	2613	0	0	0	0	67	67	2613	0	2613	1719
2048	1732	734	2636	2636	0	0	0	0	67	67	2636	0	2636	1732
2049	1745	735	2659	2659	0	0	0	0	67	67	2659	0	2659	1745
2050	1757	735	2682	2682	0	0	0	0	67	67	2682	0	2682	1757

Table A3.2 Technical potential of efficient heating and cooling solution in Paphos (GWh)

Year	Heat Pumps	Resistance heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	406	184	607	607	0	0	0	0	29	29	607	0	607	406
2014	415	189	619	619	0	0	0	0	28	28	619	0	619	415
2015	403	184	601	601	0	0	0	0	28	28	601	0	601	403
2016	409	186	611	611	0	0	0	0	28	28	611	0	611	409
2017	414	187	620	620	0	0	0	0	28	28	620	0	620	414
2018	420	188	629	629	0	0	0	0	28	28	629	0	629	420
2019	425	190	638	638	0	0	0	0	28	28	638	0	638	425
2020	429	190	645	645	0	0	0	0	28	28	645	0	645	429
2021	434	191	653	653	0	0	0	0	28	28	653	0	653	434
2022	438	192	661	661	0	0	0	0	28	28	661	0	661	438
2023	443	193	669	669	0	0	0	0	28	28	669	0	669	443
2024	447	194	676	676	0	0	0	0	28	28	676	0	676	447
2025	452	195	684	684	0	0	0	0	28	28	684	0	684	452
2026	457	196	693	693	0	0	0	0	27	27	693	0	693	457
2027	461	197	700	700	0	0	0	0	27	27	700	0	700	461
2028	466	198	708	708	0	0	0	0	27	27	708	0	708	466
2029	470	199	716	716	0	0	0	0	27	27	716	0	716	470
2030	475	200	725	725	0	0	0	0	27	27	725	0	725	475
2031	480	201	733	733	0	0	0	0	27	27	733	0	733	480
2032	484	201	740	740	0	0	0	0	27	27	740	0	740	484
2033	489	202	748	748	0	0	0	0	27	27	748	0	748	489
2034	493	203	756	756	0	0	0	0	27	27	756	0	756	493
2035	498	204	764	764	0	0	0	0	27	27	764	0	764	498
2036	502	204	771	771	0	0	0	0	27	27	771	0	771	502
2037	506	205	778	778	0	0	0	0	27	27	778	0	778	506
2038	510	206	785	785	0	0	0	0	27	27	785	0	785	510
2039	514	206	793	793	0	0	0	0	26	26	793	0	793	514
2040	518	207	800	800	0	0	0	0	26	26	800	0	800	518
2041	522	207	807	807	0	0	0	0	26	26	807	0	807	522
2042	527	208	815	815	0	0	0	0	26	26	815	0	815	527
2043	531	209	822	822	0	0	0	0	26	26	822	0	822	531
2044	535	209	830	830	0	0	0	0	26	26	830	0	830	535
2045	539	210	837	837	0	0	0	0	26	26	837	0	837	539
2046	543	210	845	845	0	0	0	0	26	26	845	0	845	543
2047	548	211	852	852	0	0	0	0	26	26	852	0	852	548
2048	552	211	859	859	0	0	0	0	26	26	859	0	859	552
2049	556	212	867	867	0	0	0	0	26	26	867	0	867	556
2050	560	212	874	874	0	0	0	0	26	26	874	0	874	560

Table A3.3 Technical potential of efficient heating and cooling solution in Limassol (GWh)

Year	Heat Pumps	Resistance heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	784	394	1138	1138	0	0	0	0	45	45	1138	670	1138	784
2014	814	411	1179	1179	0	0	0	0	44	44	1179	670	1179	814
2015	801	402	1163	1163	0	0	0	0	44	44	1163	670	1163	801
2016	817	407	1189	1189	0	0	0	0	44	44	1189	670	1189	817
2017	828	409	1207	1207	0	0	0	0	44	44	1207	670	1207	828
2018	840	412	1227	1227	0	0	0	0	44	44	1227	670	1227	840
2019	852	414	1247	1247	0	0	0	0	44	44	1247	670	1247	852
2020	861	416	1263	1263	0	0	0	0	44	44	1263	670	1263	861
2021	872	418	1282	1282	0	0	0	0	43	43	1282	670	1282	872
2022	881	420	1298	1298	0	0	0	0	43	43	1298	670	1298	881
2023	891	422	1316	1316	0	0	0	0	43	43	1316	670	1316	891
2024	901	424	1333	1333	0	0	0	0	43	43	1333	670	1333	901
2025	912	426	1351	1351	0	0	0	0	43	43	1351	670	1351	912
2026	923	428	1370	1370	0	0	0	0	43	43	1370	670	1370	923
2027	932	429	1386	1386	0	0	0	0	43	43	1386	670	1386	932
2028	942	431	1404	1404	0	0	0	0	43	43	1404	670	1404	942
2029	952	433	1422	1422	0	0	0	0	42	42	1422	670	1422	952
2030	963	435	1440	1440	0	0	0	0	42	42	1440	670	1440	963
2031	974	437	1460	1460	0	0	0	0	42	42	1460	670	1460	974
2032	982	438	1475	1475	0	0	0	0	42	42	1475	670	1475	982
2033	992	439	1493	1493	0	0	0	0	42	42	1493	670	1493	992
2034	1002	441	1510	1510	0	0	0	0	42	42	1510	670	1510	1002
2035	1012	442	1527	1527	0	0	0	0	42	42	1527	670	1527	1012
2036	1022	444	1545	1545	0	0	0	0	42	42	1545	670	1545	1022
2037	1029	444	1559	1559	0	0	0	0	41	41	1559	670	1559	1029
2038	1039	445	1575	1575	0	0	0	0	41	41	1575	670	1575	1039
2039	1048	446	1592	1592	0	0	0	0	41	41	1592	670	1592	1048
2040	1057	447	1608	1608	0	0	0	0	41	41	1608	670	1608	1057
2041	1066	448	1625	1625	0	0	0	0	41	41	1625	670	1625	1066
2042	1075	449	1641	1641	0	0	0	0	41	41	1641	670	1641	1075
2043	1084	450	1657	1657	0	0	0	0	41	41	1657	670	1657	1084
2044	1093	451	1674	1674	0	0	0	0	41	41	1674	670	1674	1093
2045	1102	452	1690	1690	0	0	0	0	40	40	1690	670	1690	1102
2046	1111	452	1706	1706	0	0	0	0	40	40	1706	670	1706	1111
2047	1119	453	1722	1722	0	0	0	0	40	40	1722	670	1722	1119
2048	1128	454	1738	1738	0	0	0	0	40	40	1738	670	1738	1128
2049	1137	455	1754	1754	0	0	0	0	40	40	1754	670	1754	1137
2050	1145	455	1769	1769	0	0	0	0	40	40	1769	670	1769	1145

Table A3.4 Technical potential of efficient heating and cooling solution in Larnaca (GWh)

Year	Heat Pumps	Resistance heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	285	148	409	409	0	0	0	0	17	17	409	409	409	285
2014	295	153	424	424	0	0	0	0	17	17	424	424	424	295
2015	291	150	418	418	0	0	0	0	17	17	418	418	418	291
2016	297	152	427	427	0	0	0	0	17	17	427	427	427	297
2017	300	153	434	434	0	0	0	0	17	17	434	434	434	300
2018	305	154	441	441	0	0	0	0	17	17	441	441	441	305
2019	309	155	449	449	0	0	0	0	17	17	449	444	449	309
2020	312	155	454	454	0	0	0	0	17	17	454	445	454	312
2021	316	156	461	461	0	0	0	0	17	17	461	447	461	316
2022	320	157	467	467	0	0	0	0	17	17	467	449	467	320
2023	323	158	473	473	0	0	0	0	17	17	473	451	473	323
2024	327	158	480	480	0	0	0	0	17	17	480	453	480	327
2025	331	159	486	486	0	0	0	0	17	17	486	454	486	331
2026	335	160	493	493	0	0	0	0	17	17	493	456	493	335
2027	338	160	498	498	0	0	0	0	17	17	498	458	498	338
2028	342	161	505	505	0	0	0	0	17	17	505	460	505	342
2029	345	162	511	511	0	0	0	0	17	17	511	461	511	345
2030	349	163	518	518	0	0	0	0	17	17	518	463	518	349
2031	353	163	525	525	0	0	0	0	16	16	525	465	525	353
2032	356	164	531	531	0	0	0	0	16	16	531	467	531	356
2033	360	164	537	537	0	0	0	0	16	16	537	468	537	360
2034	363	165	543	543	0	0	0	0	16	16	543	470	543	363
2035	367	165	549	549	0	0	0	0	16	16	549	472	549	367
2036	371	166	556	556	0	0	0	0	16	16	556	473	556	371
2037	373	166	561	561	0	0	0	0	16	16	561	474	561	373
2038	377	167	567	567	0	0	0	0	16	16	567	476	567	377
2039	380	167	573	573	0	0	0	0	16	16	573	477	573	380
2040	383	168	578	578	0	0	0	0	16	16	578	478	578	383
2041	387	168	584	584	0	0	0	0	16	16	584	480	584	387
2042	390	168	590	590	0	0	0	0	16	16	590	481	590	390
2043	393	169	596	596	0	0	0	0	16	16	596	481	596	393
2044	396	169	602	602	0	0	0	0	16	16	602	482	602	396
2045	400	169	608	608	0	0	0	0	16	16	608	482	608	400
2046	403	170	614	614	0	0	0	0	16	16	614	482	614	403
2047	406	170	619	619	0	0	0	0	16	16	619	483	619	406
2048	409	170	625	625	0	0	0	0	16	16	625	483	625	409
2049	412	171	631	631	0	0	0	0	16	16	631	483	631	412
2050	415	171	636	636	0	0	0	0	16	16	636	483	636	415

Table A3.5 Technical potential of efficient heating and cooling solution in the rest of Cyprus (GWh)

Year	Heat Pumps	Resistance heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	2721	1692	3901	3901	38	38	41	41	292	292	3657	0	3901	2563
2014	2811	1754	4020	4020	40	40	41	41	291	291	3777	0	4020	2654
2015	2759	1725	3951	3951	41	41	42	42	290	290	3707	0	3951	2602
2016	2806	1745	4026	4026	42	42	43	43	289	289	3782	0	4026	2649
2017	2835	1752	4078	4078	44	44	43	43	288	288	3834	0	4078	2679
2018	2870	1764	4137	4137	45	45	44	44	287	287	3893	0	4137	2714
2019	2903	1776	4194	4194	47	47	44	44	286	286	3950	0	4194	2748
2020	2929	1783	4239	4239	48	48	45	45	286	286	3995	0	4239	2774
2021	2960	1793	4293	4293	50	50	46	46	285	285	4049	0	4293	2805
2022	2986	1801	4340	4340	52	52	47	47	284	284	4096	0	4340	2832
2023	3015	1809	4390	4390	54	54	47	47	283	283	4146	0	4390	2861
2024	3044	1818	4441	4441	55	55	48	48	282	282	4196	0	4441	2891
2025	3073	1827	4492	4492	57	57	49	49	281	281	4247	0	4492	2920
2026	3104	1837	4546	4546	59	59	49	49	280	280	4302	0	4546	2952
2027	3129	1843	4591	4591	61	61	50	50	279	279	4347	0	4591	2977
2028	3158	1851	4642	4642	63	63	51	51	278	278	4398	0	4642	3006
2029	3187	1859	4694	4694	65	65	52	52	277	277	4450	0	4694	3036
2030	3217	1867	4747	4747	68	68	52	52	277	277	4502	0	4747	3066
2031	3248	1876	4802	4802	70	70	53	53	276	276	4557	0	4802	3098
2032	3272	1882	4846	4846	72	72	54	54	275	275	4601	0	4846	3122
2033	3300	1889	4896	4896	75	75	55	55	274	274	4651	0	4896	3150
2034	3327	1896	4945	4945	77	77	55	55	273	273	4700	0	4945	3178
2035	3354	1902	4994	4994	80	80	56	56	272	272	4749	0	4994	3205
2036	3382	1909	5044	5044	83	83	57	57	271	271	4799	0	5044	3233
2037	3403	1913	5083	5083	86	86	58	58	270	270	4839	0	5083	3255
2038	3428	1919	5130	5130	89	89	59	59	270	270	4885	0	5130	3280
2039	3452	1924	5176	5176	92	92	60	60	269	269	4930	0	5176	3305
2040	3477	1929	5221	5221	95	95	61	61	268	268	4976	0	5221	3330
2041	3502	1934	5268	5268	98	98	62	62	267	267	5023	0	5268	3356
2042	3527	1939	5315	5315	101	101	62	62	266	266	5069	0	5315	3381
2043	3552	1944	5361	5361	105	105	63	63	265	265	5116	0	5361	3407
2044	3577	1949	5407	5407	108	108	64	64	264	264	5162	0	5407	3432
2045	3602	1954	5453	5453	112	112	65	65	264	264	5208	0	5453	3457
2046	3625	1958	5498	5498	116	116	66	66	263	263	5253	0	5498	3481
2047	3649	1963	5543	5543	120	120	67	67	262	262	5298	0	5543	3505
2048	3673	1967	5588	5588	124	124	68	68	261	261	5343	0	5588	3530
2049	3696	1971	5633	5633	128	128	69	69	260	260	5387	0	5633	3554
2050	3719	1974	5676	5676	133	133	70	70	259	259	5431	0	5676	3577

Annex 4. Detailed information on baseline scenario

Table A4.1 Baseline development of shares of technologies used for space heating in residential sector (% of final energy consumption)

Year	Electricity - heat pumps (split units)	Electricity - resistance heaters	Burning oil - boilers	Burning oil - efficient boilers	Burning oil - CHP	LPG - boilers	LPG - efficient boilers	Solar energy - panels	Biomass - boilers	Biomass - efficient boilers
2013	6	23	38	0	0	26	0	2	6	0
2014	6	23	37	1	0	25	1	2	6	0
2015	6	23	36	1	0	24	1	2	6	0
2016	7	23	35	2	0	23	2	2	6	0
2017	7	23	33	3	0	22	2	3	6	1
2018	7	23	32	4	0	22	3	3	6	1
2019	8	22	31	4	0	21	3	3	6	1
2020	8	22	30	5	0	20	4	3	6	1
2021	8	22	29	6	0	19	4	3	6	1
2022	9	22	27	6	1	19	5	4	6	1
2023	9	22	26	7	1	18	5	4	6	2
2024	10	22	25	7	1	17	6	4	6	2
2025	10	22	24	8	1	16	6	4	6	2
2026	11	21	23	9	1	16	7	5	6	2
2027	11	21	22	9	1	15	7	5	6	3
2028	12	21	21	10	1	14	7	5	6	3
2029	12	21	20	10	1	14	8	5	6	3
2030	13	20	19	11	1	13	8	6	6	4
2031	13	20	18	11	1	12	9	6	6	4
2032	14	20	17	12	1	12	9	6	6	4
2033	14	19	16	12	1	11	9	6	6	5
2034	15	19	15	13	1	10	10	7	6	5
2035	16	18	14	13	1	10	10	7	6	5
2036	16	18	13	14	1	9	11	7	5	6
2037	17	17	12	14	1	8	11	8	5	6
2038	18	17	11	14	1	8	11	8	5	7
2039	19	16	10	15	1	7	11	8	5	7
2040	19	16	10	15	1	7	12	8	5	8
2041	20	15	9	15	1	6	12	9	5	8
2042	21	14	8	15	1	5	12	9	4	9
2043	22	14	7	16	1	5	13	10	4	9
2044	23	13	6	16	1	4	13	10	4	10
2045	24	12	6	16	1	4	13	10	4	10
2046	25	11	5	16	1	3	13	11	3	11
2047	26	10	4	16	1	3	13	11	3	12
2048	27	9	4	16	1	2	13	12	3	12
2049	28	8	3	17	1	2	14	12	2	13
2050	29	7	2	17	1	1	14	12	2	14

Table A4.2 Baseline development of shares of technologies used for hot water in residential sector (% of final energy consumption)

Year	Electricity - resistance heaters	Burning oil - boilers	Burning oil - efficient boilers	LPG - boilers	LPG - efficient boilers	Solar energy - panels	Biomass - boilers	Biomass - efficient boilers
2013	2	5	0	3	0	90	0	0
2014	2	5	0	3	0	90	0	0
2015	2	5	0	3	0	90	0	0
2016	2	4	0	3	0	90	0	0
2017	2	4	0	3	0	90	0	0
2018	2	4	0	3	0	90	0	0
2019	2	4	1	3	0	90	1	0
2020	2	4	1	3	0	90	1	0
2021	1	4	1	3	1	90	1	0
2022	1	3	1	2	1	90	1	0
2023	1	3	1	2	1	90	1	0
2024	1	3	1	2	1	90	1	0
2025	1	3	1	2	1	90	1	0
2026	1	3	1	2	1	90	1	0
2027	1	3	1	2	1	90	1	0
2028	1	3	1	2	1	90	1	0
2029	1	2	1	2	1	90	1	1
2030	1	2	1	2	1	90	1	1
2031	1	2	1	2	1	90	1	1
2032	1	2	1	1	1	91	1	1
2033	1	2	1	1	1	91	1	1
2034	1	2	1	1	1	91	1	1
2035	1	2	2	1	1	91	1	1
2036	1	2	2	1	1	91	1	1
2037	1	1	2	1	1	91	1	1
2038	1	1	2	1	1	92	1	1
2039	1	1	2	1	1	92	1	1
2040	1	1	2	1	1	92	1	2
2041	1	1	2	1	1	92	1	2
2042	1	1	2	1	1	92	1	2
2043	1	1	2	1	1	92	1	2
2044	1	1	2	1	1	92	1	2
2045	1	1	2	0	1	92	1	2
2046	1	1	2	0	1	92	1	2
2047	1	1	2	0	1	92	1	3
2048	1	0	2	0	1	92	0	3
2049	1	0	2	0	2	92	0	3
2050	1	0	2	0	2	92	0	3

Table A4.3 Baseline development of shares of technologies used for space cooling in residential sector (% of final energy consumption)

Year	Electricity - Air conditioner (spilt unit)	Solar energy - Solar panel
2013	100	0
2014	100	0
2015	99	1
2016	99	1
2017	99	1
2018	99	1
2019	99	1
2020	98	2
2021	98	2
2022	98	2
2023	98	2
2024	97	3
2025	97	3
2026	97	3
2027	97	3
2028	96	4
2029	96	4
2030	96	4
2031	96	4
2032	95	5
2033	95	5
2034	95	5
2035	95	5
2036	94	6
2037	94	6
2038	94	6
2039	94	6
2040	94	6
2041	93	7
2042	93	7
2043	93	7
2044	93	7
2045	92	8
2046	92	8
2047	92	8
2048	92	8
2049	92	8
2050	91	9

Table A4.4 Baseline development of shares of technologies used for space heating in service sector (% of final energy consumption)

Year	Electricity - heat pumps (split	Electricity - heat pumps	Electricity - resistance	Burning oil - boilers	Burning oil - efficient boilers	Burning oil - CHP	LPG - boilers	LPG - efficient boilers	Solar energy - panels	Biomass - boilers	Biomass - efficient boilers
2013	31	3	7	37	0	0	20	0	0	1	0
2014	32	3	7	36	1	0	19	0	0	1	0
2015	32	3	7	35	1	0	19	1	1	2	0
2016	32	3	7	33	2	0	18	1	1	2	0
2017	32	3	7	32	3	0	17	2	1	2	0
2018	32	3	7	31	3	0	17	2	1	2	0
2019	33	3	7	30	4	0	16	2	2	3	0
2020	33	3	6	29	5	0	15	3	2	3	0
2021	33	3	6	28	5	0	15	3	2	3	1
2022	33	3	6	26	6	1	14	4	3	3	1
2023	34	3	6	25	6	1	14	4	3	3	1
2024	34	3	6	24	7	1	13	4	3	4	1
2025	34	3	6	23	7	1	12	5	4	4	1
2026	34	3	6	22	8	1	12	5	4	4	1
2027	35	3	6	21	8	1	11	5	4	4	2
2028	35	3	6	20	9	1	11	6	5	4	2
2029	35	3	5	19	9	1	10	6	5	4	2
2030	35	3	5	18	10	1	10	6	5	4	2
2031	36	4	5	17	10	1	9	6	6	4	3
2032	36	4	5	16	10	1	9	7	6	4	3
2033	36	4	5	15	11	1	8	7	6	4	3
2034	36	4	5	14	11	1	8	7	7	4	4
2035	37	4	5	13	11	1	7	7	7	4	4
2036	37	4	5	12	12	1	7	8	8	4	4
2037	37	4	4	11	12	1	6	8	8	4	5
2038	38	4	4	10	12	1	6	8	8	4	5
2039	38	4	4	9	12	1	5	8	9	4	6
2040	38	4	4	8	13	1	5	8	9	4	6
2041	39	4	4	8	13	1	4	8	9	4	6
2042	39	4	4	7	13	1	4	9	10	3	7
2043	39	4	4	6	13	1	3	9	10	3	7
2044	40	4	4	5	13	1	3	9	11	3	8
2045	40	4	3	5	13	1	3	9	11	3	8
2046	40	4	3	4	13	1	2	9	11	3	9
2047	41	4	3	3	13	1	2	9	12	2	10
2048	41	4	3	3	13	1	2	9	12	2	10
2049	41	4	3	2	13	1	1	9	13	2	11
2050	42	4	3	2	13	1	1	9	13	2	11

Table A4.5 Baseline development of shares of technologies used for sanitary hot water preparation in service sector (% of final energy consumption)

Year	Electricity - heat pumps	Electricity - resistance	Burning oil - boilers	Burning oil - efficient boilers	LPG - boilers	LPG - efficient boilers	Solar energy - panels	Biomass - boilers	Biomass - efficient boilers
2013	0	15	32	0	8	0	45	0	0
2014	0	15	30	1	7	0	46	0	0
2015	1	14	29	1	7	0	47	0	0
2016	1	14	28	2	7	0	48	0	0
2017	1	13	27	2	6	1	49	1	0
2018	1	13	26	3	6	1	50	1	0
2019	1	13	24	3	6	1	50	1	0
2020	1	12	23	4	6	1	51	1	0
2021	2	12	22	4	5	1	52	1	0
2022	2	12	21	5	5	1	53	1	0
2023	2	11	20	5	5	1	54	1	0
2024	2	11	19	6	4	2	54	1	0
2025	2	11	18	6	4	2	55	1	0
2026	2	10	17	7	4	2	56	1	1
2027	2	10	16	7	4	2	57	2	1
2028	3	9	15	7	4	2	58	2	1
2029	3	9	14	8	3	2	58	2	1
2030	3	9	14	8	3	2	59	2	1
2031	3	8	13	8	3	2	60	2	1
2032	3	8	12	8	3	2	61	2	1
2033	3	8	11	9	2	2	61	2	1
2034	3	7	10	9	2	2	62	2	2
2035	3	7	10	9	2	2	63	2	2
2036	4	7	9	9	2	2	64	2	2
2037	4	6	8	9	2	2	64	2	2
2038	4	6	8	9	2	2	65	2	2
2039	4	6	7	9	1	2	66	2	3
2040	4	6	6	9	1	3	66	2	3
2041	4	5	6	9	1	3	67	2	3
2042	4	5	5	9	1	3	68	2	3
2043	4	5	5	9	1	3	68	2	4
2044	4	4	4	9	1	2	69	1	4
2045	4	4	4	9	1	2	70	1	4
2046	5	4	3	9	0	2	70	1	5
2047	5	4	3	9	0	2	71	1	5
2048	5	3	2	9	0	2	72	1	5
2049	5	3	2	9	0	2	72	1	6
2050	5	3	2	9	0	2	73	1	6

Table A4.6 Baseline development of shares of technologies used for space cooling in service sector (% of final energy consumption)

Year	Electricity - Air conditioner	Electricity - Air conditioner	Solar energy - Solar panel
2013	83	16	0
2014	83	16	0
2015	83	16	1
2016	82	16	1
2017	82	16	2
2018	82	16	2
2019	81	16	2
2020	81	16	3
2021	81	16	3
2022	81	16	4
2023	80	16	4
2024	80	16	4
2025	80	16	5
2026	79	16	5
2027	79	16	5
2028	79	16	6
2029	78	15	6
2030	78	15	7
2031	78	15	7
2032	77	15	7
2033	77	15	8
2034	77	15	8
2035	76	15	8
2036	76	15	9
2037	76	15	9
2038	76	15	9
2039	75	15	10
2040	75	15	10
2041	75	15	11
2042	74	15	11
2043	74	15	11
2044	74	15	12
2045	74	15	12
2046	73	14	12
2047	73	14	13
2048	73	14	13
2049	72	14	13
2050	72	14	14

Table A4.7 Baseline development of shares of technologies used for low temperature (<100 °C) processes in industrial sector (% of final energy consumption)

Year	Electricity	Diesel	Gas oil	Light fuel oil	Heavy fuel oil	LPG	Solar	Biomass
2013	15	11	22	35	0	16	0	1
2014	15	11	22	35	0	16	0	1
2015	15	11	22	35	0	16	0	1
2016	15	11	22	35	0	16	0	1
2017	15	11	22	34	0	16	1	1
2018	15	11	22	34	0	15	1	1
2019	15	11	22	34	0	15	1	1
2020	15	11	22	34	0	15	1	1
2021	15	11	22	34	0	15	1	1
2022	16	11	22	33	0	15	1	1
2023	16	11	22	33	0	15	2	1
2024	16	11	21	33	0	15	2	1
2025	16	11	21	33	0	15	2	1
2026	16	11	21	33	0	15	2	2
2027	16	11	21	32	0	15	2	2
2028	16	11	21	32	0	15	2	2
2029	16	11	21	32	0	15	2	2
2030	16	11	21	32	0	15	3	2
2031	17	11	21	32	0	15	3	2
2032	17	11	21	32	0	15	3	2
2033	17	11	21	31	0	15	3	2
2034	17	11	21	31	0	15	3	2
2035	17	11	21	31	0	15	3	2
2036	17	11	21	31	0	14	3	2
2037	17	11	21	31	0	14	4	2
2038	17	11	21	30	0	14	4	2
2039	17	11	21	30	0	14	4	2
2040	17	11	20	30	0	14	4	2
2041	18	11	20	30	0	14	4	2
2042	18	11	20	30	0	14	4	2
2043	18	11	20	29	0	14	5	2
2044	18	11	20	29	0	14	5	3
2045	18	11	20	29	0	14	5	3
2046	18	11	20	29	0	14	5	3
2047	18	11	20	29	0	14	5	3
2048	18	11	20	28	0	14	5	3
2049	18	11	20	28	0	14	5	3
2050	19	11	20	28	0	14	6	3

Table A4.8 Baseline development of shares of technologies used for medium temperature (100 to 400 °C) processes in industrial sector (% of final energy consumption)

Year	Electricity	Diesel	Gas oil	Light fuel oil	Heavy fuel oil	LPG	Solar	Biomass
2013	15	11	22	35	0	16	0	1
2014	15	11	22	35	0	16	0	1
2015	15	11	22	35	0	16	0	1
2016	15	11	22	35	0	16	0	1
2017	15	11	22	34	0	16	1	1
2018	15	11	22	34	0	15	1	1
2019	15	11	22	34	0	15	1	1
2020	15	11	22	34	0	15	1	1
2021	15	11	22	34	0	15	1	1
2022	16	11	22	33	0	15	1	1
2023	16	11	22	33	0	15	2	1
2024	16	11	21	33	0	15	2	1
2025	16	11	21	33	0	15	2	1
2026	16	11	21	33	0	15	2	2
2027	16	11	21	32	0	15	2	2
2028	16	11	21	32	0	15	2	2
2029	16	11	21	32	0	15	2	2
2030	16	11	21	32	0	15	3	2
2031	17	11	21	32	0	15	3	2
2032	17	11	21	32	0	15	3	2
2033	17	11	21	31	0	15	3	2
2034	17	11	21	31	0	15	3	2
2035	17	11	21	31	0	15	3	2
2036	17	11	21	31	0	14	3	2
2037	17	11	21	31	0	14	4	2
2038	17	11	21	30	0	14	4	2
2039	17	11	21	30	0	14	4	2
2040	17	11	20	30	0	14	4	2
2041	18	11	20	30	0	14	4	2
2042	18	11	20	30	0	14	4	2
2043	18	11	20	29	0	14	5	2
2044	18	11	20	29	0	14	5	3
2045	18	11	20	29	0	14	5	3
2046	18	11	20	29	0	14	5	3
2047	18	11	20	29	0	14	5	3
2048	18	11	20	28	0	14	5	3
2049	18	11	20	28	0	14	5	3
2050	19	11	20	28	0	14	6	3

Table A4.9 Baseline development of shares of technologies used for high temperature (> 400 °C) processes in industrial sector (% of final energy consumption)

Year	Electricity	Diesel	Gas oil	Light fuel oil	Heavy fuel oil	LPG	Biomass
2013	15	10	21	37	1	16	1
2014	15	10	21	37	1	16	1
2015	15	9	21	37	1	16	1
2016	15	9	21	37	1	16	1
2017	15	9	21	36	1	16	1
2018	15	9	21	36	1	16	1
2019	15	9	21	36	1	16	1
2020	15	9	21	36	1	16	2
2021	16	9	21	36	1	16	2
2022	16	9	21	36	1	16	2
2023	16	9	21	36	1	16	2
2024	16	9	21	36	1	16	2
2025	16	9	20	36	1	16	2
2026	16	9	20	36	1	16	2
2027	16	9	20	36	1	16	2
2028	16	9	20	35	1	16	2
2029	16	9	20	35	1	16	2
2030	17	9	20	35	0	16	2
2031	17	9	20	35	0	16	3
2032	17	9	20	35	0	16	3
2033	17	9	20	35	0	16	3
2034	17	9	20	35	0	16	3
2035	17	9	20	35	0	16	3
2036	17	9	20	35	0	16	3
2037	17	8	20	35	0	16	3
2038	17	8	20	35	0	16	3
2039	18	8	20	34	0	16	3
2040	18	8	20	34	0	16	3
2041	18	8	20	34	0	16	3
2042	18	8	20	34	0	16	4
2043	18	8	20	34	0	16	4
2044	18	8	19	34	0	16	4
2045	18	8	19	34	0	16	4
2046	18	8	19	34	0	16	4
2047	18	8	19	34	0	16	4
2048	19	8	19	34	0	16	4
2049	19	8	19	34	0	16	4
2050	19	8	19	33	0	16	4

Table A4.10 Baseline development of shares of energy streams used to provide heat to agricultural sector consumers (% of final energy consumption)

Year	Gas oil	LPG	Biomass	Solar
2013	98	1	2	0
2014	97	1	2	0
2015	97	1	2	0
2016	97	1	2	0
2017	96	1	3	0
2018	96	1	3	0
2019	96	1	3	0
2020	95	1	4	0
2021	95	1	4	0
2022	94	1	4	0
2023	94	1	5	0
2024	94	1	5	0
2025	93	1	5	1
2026	93	1	5	1
2027	93	1	6	1
2028	92	1	6	1
2029	92	1	6	1
2030	92	1	7	1
2031	91	1	7	1
2032	91	1	7	1
2033	90	1	8	1
2034	90	1	8	1
2035	90	1	8	1
2036	89	1	8	1
2037	89	1	9	1
2038	89	1	9	1
2039	88	1	9	1
2040	88	1	10	1
2041	88	1	10	1
2042	87	1	10	1
2043	87	1	11	1
2044	86	1	11	1
2045	86	1	11	1
2046	86	1	11	1
2047	85	1	12	1
2048	85	1	12	1
2049	85	2	12	2
2050	84	2	13	2

Annex 5. Detailed fuel and electricity prices used in the CBA

Table A5.1 Fuel and electricity prices for the FINANCIAL analysis, by sector for 2013-2050 (EUR2013/MWh)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048
SERVICE																																				
Electricity	210	186	140	131	121	112	103	94	93	93	93	93	93	93	93	93	93	93	94	95	95	96	97	98	98	98	98	99	98	98	98	98	98	99	99	99
Gas oil	104	99	81	81	82	82	82	83	83	83	83	83	84	84	85	86	87	87	88	88	89	89	90	91	92	94	95	96	97	97	98	98	99	100	101	101
Light fuel oil	87	86	67	68	68	68	69	69	69	69	69	70	70	70	71	72	72	73	73	74	74	74	75	76	77	78	79	80	81	81	82	82	83	83	84	85
Kerosene	115	109	88	89	89	90	90	91	91	91	91	91	91	92	93	94	95	95	96	96	97	98	98	100	101	102	104	105	106	106	107	108	108	109	110	111
LPG	93	90	77	77	78	78	79	79	79	79	79	80	80	80	81	82	82	83	84	84	85	85	86	87	88	89	90	92	92	93	93	94	94	95	96	97
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid biomass	92	87	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Municipal waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
RESIDENTIAL																																				
Electricity	262	232	184	172	160	147	135	123	123	123	122	122	122	122	122	122	122	122	123	124	125	127	128	128	128	129	129	129	129	129	129	129	129	130	130	131
Gas oil	123	118	96	96	97	98	98	99	99	99	99	99	99	100	101	102	103	104	104	105	106	106	107	108	110	111	113	114	115	116	116	117	118	119	120	121
Light fuel oil	104	102	80	80	81	81	82	82	82	83	83	83	83	84	84	85	86	87	87	88	88	89	89	90	92	93	94	95	96	97	97	98	98	99	100	101
Kerosene	137	130	105	105	106	107	107	108	108	108	108	109	109	110	111	112	112	113	114	115	115	116	117	118	120	122	123	125	126	126	127	128	129	130	131	132
LPG	93	90	77	77	78	78	79	79	79	79	79	80	80	80	81	82	82	83	84	84	85	85	86	87	88	89	90	92	92	93	93	94	94	95	96	97
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid biomass	92	87	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Municipal waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
INDUSTRY																																				
Electricity	205	183	131	118	110	101	93	85	84	84	84	84	84	84	84	84	84	84	84	85	86	87	88	88	88	88	89	89	89	89	89	89	89	89	89	90
Gas oil	103	99	81	81	82	82	82	83	83	83	83	83	84	84	85	86	87	87	88	88	89	89	90	91	92	94	95	96	97	97	98	98	99	100	101	101
Light fuel oil	104	102	80	80	81	81	82	82	82	83	83	83	83	84	84	85	86	87	87	88	88	89	89	90	92	93	94	95	96	97	97	98	98	99	100	101
Kerosene	115	109	88	89	89	90	90	91	91	91	91	91	91	92	93	94	95	95	96	96	97	98	98	100	101	102	104	105	106	106	107	108	108	109	110	111
LPG	93	90	77	77	78	78	79	79	79	79	79	80	80	80	81	82	82	83	84	84	85	85	86	87	88	89	90	92	92	93	93	94	94	95	96	97
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid biomass	92	87	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Municipal waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
AGRICULTURE																																				
Electricity	197	175	132	123	114	106	97	88	88	88	88	88	87	87	87	87	87	87	88	89	90	91	92	92	92	92	93	93	93	93	93	93	93	93	93	94
Gas oil	104	99	81	81	82	82	82	83	83	83	83	83	84	84	85	86	87	87	88	88	89	89	90	91	92	94	95	96	97	97	98	98	99	100	101	101
Light fuel oil	87	86	67	68	68	68	69	69	69	69	69	70	70	70	71	72	72	73	73	74	74	74	75	76	77	78	79	80	81	81	82	82	83	83	84	85
Kerosene	115	109	88	89	89	90	90	91	91	91	91	91	91	92	93	94	95	95	96	96	97	98	98	100	101	102	104	105	106	106	107	108	108	109	110	111
LPG	93	90	77	77	78	78	79	79	79	79	79	80	80	80	81	82	82	83	84	84	85	85	86	87	88	89	90	92	92	93	93	94	94	95	96	97
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid biomass	92	87	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Municipal waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Table A5.2 Fuel and electricity prices for the ECONOMIC analysis, by sector for 2013-2050 (EUR2013/MWh)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	20
SERVICE																																					
Electricity	202	178	135	126	117	108	99	90	90	90	90	90	90	90	90	90	89	89	90	91	92	93	94	94	94	95	95	95	95	95	95	95	95	95	96	96	9
Gas oil	90	85	70	70	70	71	71	72	72	72	72	72	72	73	73	74	75	75	76	76	77	77	78	79	80	81	82	83	84	84	84	85	85	86	87	88	8
Light fuel oil	85	84	66	66	67	67	67	68	68	68	68	68	68	69	69	70	71	71	72	72	73	73	73	74	75	77	78	79	79	79	80	80	81	82	82	83	8
Kerosene	101	97	78	78	79	79	80	80	80	80	80	81	81	81	82	83	84	84	85	85	86	86	87	88	89	90	92	93	93	94	94	95	96	96	97	98	9
LPG	93	90	77	77	78	78	79	79	79	79	79	80	80	80	81	82	82	83	84	84	85	85	86	87	88	89	90	92	92	93	93	94	94	95	96	97	9
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid biomass	92	87	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	8
Municipal waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	1
RESIDENTIAL																																					
Electricity	215	189	150	140	130	120	111	101	100	100	100	100	100	100	100	100	100	100	101	102	103	104	105	105	105	105	106	106	106	106	106	106	106	106	106	107	10
Gas oil	90	85	70	70	70	71	71	72	72	72	72	72	72	73	73	74	75	75	76	76	77	77	78	79	80	81	82	83	84	84	84	85	85	86	87	88	8
Light fuel oil	85	84	66	66	67	67	67	68	68	68	68	68	68	69	69	70	71	71	72	72	73	73	73	74	75	77	78	79	79	79	80	80	81	82	82	83	8
Kerosene	101	97	78	78	79	79	80	80	80	80	80	81	81	81	82	83	84	84	85	85	86	86	87	88	89	90	92	93	93	94	94	95	96	96	97	98	9
LPG	93	90	77	77	78	78	79	79	79	79	79	80	80	80	81	82	82	83	84	84	85	85	86	87	88	89	90	92	92	93	93	94	94	95	96	97	9
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid biomass	92	87	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	8
Municipal waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.
INDUSTRY																																					
Electricity	197	175	124	115	107	99	91	82	82	82	82	82	81	81	81	81	81	81	82	83	84	85	85	86	86	86	86	86	86	86	86	86	86	86	87	87	8
Gas oil	90	85	70	70	70	71	71	72	72	72	72	72	72	73	73	74	75	75	76	76	77	77	78	79	80	81	82	83	84	84	84	85	85	86	87	88	8
Light fuel oil	85	84	66	66	67	67	67	68	68	68	68	68	68	69	69	70	71	71	72	72	73	73	73	74	75	77	78	79	79	79	80	80	81	82	82	83	8
Kerosene	101	97	78	78	79	79	80	80	80	80	80	81	81	81	82	83	84	84	85	85	86	86	87	88	89	90	92	93	93	94	94	95	96	96	97	98	9
LPG	93	90	77	77	78	78	79	79	79	79	79	80	80	80	81	82	82	83	84	84	85	85	86	87	88	89	90	92	92	93	93	94	94	95	96	97	9
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid biomass	92	87	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	8
Municipal waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	1
AGRICULTURE																																					
Electricity	189	167	125	116	108	100	91	83	83	82	82	82	82	82	82	82	82	82	83	84	84	85	86	86	86	86	87	87	87	87	87	87	87	87	87	88	8
Gas oil	90	85	70	70	70	71	71	72	72	72	72	72	72	73	73	74	75	75	76	76	77	77	78	79	80	81	82	83	84	84	84	85	85	86	87	88	8
Light fuel oil	85	84	66	66	67	67	67	68	68	68	68	68	68	69	69	70	71	71	72	72	73	73	73	74	75	77	78	79	79	79	80	80	81	82	82	83	8
Kerosene	101	97	78	78	79	79	80	80	80	80	80	81	81	81	82	83	84	84	85	85	86	86	87	88	89	90	92	93	93	94	94	95	96	96	97	98	9
LPG	93	90	77	77	78	78	79	79	79	79	79	80	80	80	81	82	82	83	84	84	85	85	86	87	88	89	90	92	92	93	93	94	94	95	96	97	9
Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid biomass	92	87	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	8
Municipal waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biogas	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	1

Annex 6. Economic potential of efficient heating and cooling solutions

Table A6.1 **Economic potential of efficient heating and cooling solutions in Nicosia (GWh)**

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/Industrial waste - CHP	Livestock/Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	461	0	0	0	0	0	0	0	0	0	592	0	0	1225
2014	482	0	0	0	0	0	0	0	0	0	619	0	0	1268
2015	476	0	0	0	0	0	0	0	0	0	616	0	0	1245
2016	485	0	0	0	0	0	0	0	0	0	630	0	0	1269
2017	491	0	0	0	0	0	0	0	0	0	639	0	0	1284
2018	498	0	0	0	0	0	0	0	0	0	650	0	0	1303
2019	504	0	0	0	0	0	0	0	0	0	661	0	0	1320
2020	509	0	0	0	0	0	0	0	0	0	669	0	0	1334
2021	516	0	0	0	0	0	0	0	0	0	679	0	0	1350
2022	521	0	0	0	0	0	0	0	0	0	687	0	0	1364
2023	526	0	0	0	0	0	0	0	0	0	696	0	0	1379
2024	532	0	0	0	0	0	0	0	0	0	705	0	0	1394
2025	538	0	0	0	0	0	0	0	0	0	715	0	0	1410
2026	544	0	0	0	0	0	0	0	0	0	725	0	0	1426
2027	549	0	0	0	0	0	0	0	0	0	733	0	0	1440
2028	554	0	0	0	0	0	0	0	0	0	742	0	0	1455
2029	560	0	0	0	0	0	0	0	0	0	752	0	0	1470
2030	566	0	0	0	0	0	0	0	0	0	761	0	0	1486
2031	572	0	0	0	0	0	0	0	0	0	771	0	0	1503
2032	577	0	0	0	0	0	0	0	0	0	779	0	0	1516
2033	582	0	0	0	0	0	0	0	0	0	788	0	0	1530
2034	587	0	0	0	0	0	0	0	0	0	797	0	0	1545
2035	593	0	0	0	0	0	0	0	0	0	806	0	0	1559
2036	598	0	0	0	0	0	0	0	0	0	815	0	0	1574
2037	602	0	0	0	0	0	0	0	0	0	822	0	0	1586
2038	607	0	0	0	0	0	0	0	0	0	830	0	0	1599
2039	612	0	0	0	0	0	0	0	0	0	839	0	0	1613
2040	617	0	0	0	0	0	0	0	0	0	847	0	0	1626
2041	622	0	0	0	0	0	0	0	0	0	855	0	0	1640
2042	627	0	0	0	0	0	0	0	0	0	864	0	0	1653
2043	631	0	0	0	0	0	0	0	0	0	872	0	0	1667
2044	636	0	0	0	0	0	0	0	0	0	880	0	0	1680
2045	641	0	0	0	0	0	0	0	0	0	889	0	0	1694
2046	645	0	0	0	0	0	0	0	0	0	897	0	0	1707
2047	650	0	0	0	0	0	0	0	0	0	904	0	0	1719
2048	655	0	0	0	0	0	0	0	0	0	912	0	0	1732
2049	659	0	0	0	0	0	0	0	0	0	920	0	0	1745
2050	663	0	0	0	0	0	0	0	0	0	928	0	0	1757

Table A6.2. Economic potential of efficient heating and cooling solutions in Paphos (GWh)

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/Industrial waste - CHP	Livestock/Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	224	0	0	0	0	0	0	0	0	0	126	0	0	406
2014	227	0	0	0	0	0	0	0	0	0	132	0	0	415
2015	219	0	0	0	0	0	0	0	0	0	131	0	0	403
2016	222	0	0	0	0	0	0	0	0	0	134	0	0	409
2017	224	0	0	0	0	0	0	0	0	0	136	0	0	414
2018	227	0	0	0	0	0	0	0	0	0	138	0	0	420
2019	229	0	0	0	0	0	0	0	0	0	140	0	0	425
2020	231	0	0	0	0	0	0	0	0	0	142	0	0	429
2021	234	0	0	0	0	0	0	0	0	0	144	0	0	434
2022	236	0	0	0	0	0	0	0	0	0	146	0	0	438
2023	238	0	0	0	0	0	0	0	0	0	148	0	0	443
2024	241	0	0	0	0	0	0	0	0	0	150	0	0	447
2025	243	0	0	0	0	0	0	0	0	0	152	0	0	452
2026	245	0	0	0	0	0	0	0	0	0	154	0	0	457
2027	247	0	0	0	0	0	0	0	0	0	156	0	0	461
2028	250	0	0	0	0	0	0	0	0	0	158	0	0	466
2029	252	0	0	0	0	0	0	0	0	0	160	0	0	470
2030	254	0	0	0	0	0	0	0	0	0	162	0	0	475
2031	257	0	0	0	0	0	0	0	0	0	164	0	0	480
2032	259	0	0	0	0	0	0	0	0	0	165	0	0	484
2033	261	0	0	0	0	0	0	0	0	0	167	0	0	489
2034	263	0	0	0	0	0	0	0	0	0	169	0	0	493
2035	265	0	0	0	0	0	0	0	0	0	171	0	0	498
2036	268	0	0	0	0	0	0	0	0	0	173	0	0	502
2037	269	0	0	0	0	0	0	0	0	0	175	0	0	506
2038	271	0	0	0	0	0	0	0	0	0	176	0	0	510
2039	273	0	0	0	0	0	0	0	0	0	178	0	0	514
2040	275	0	0	0	0	0	0	0	0	0	180	0	0	518
2041	278	0	0	0	0	0	0	0	0	0	182	0	0	522
2042	280	0	0	0	0	0	0	0	0	0	184	0	0	527
2043	282	0	0	0	0	0	0	0	0	0	185	0	0	531
2044	284	0	0	0	0	0	0	0	0	0	187	0	0	535
2045	286	0	0	0	0	0	0	0	0	0	189	0	0	539
2046	288	0	0	0	0	0	0	0	0	0	191	0	0	543
2047	290	0	0	0	0	0	0	0	0	0	192	0	0	548
2048	292	0	0	0	0	0	0	0	0	0	194	0	0	552
2049	294	0	0	0	0	0	0	0	0	0	196	0	0	556
2050	296	0	0	0	0	0	0	0	0	0	197	0	0	560

Table A6.3 Economic potential of efficient heating and cooling solutions in Limassol (GWh)

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/Industrial waste - CHP	Livestock/Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	320	0	0	0	0	0	0	0	0	0	371	670	0	784
2014	336	0	0	0	0	0	0	0	0	0	394	670	0	814
2015	334	0	0	0	0	0	0	0	0	0	397	670	0	801
2016	342	0	0	0	0	0	0	0	0	0	408	670	0	817
2017	346	0	0	0	0	0	0	0	0	0	415	670	0	828
2018	351	0	0	0	0	0	0	0	0	0	423	670	0	840
2019	356	0	0	0	0	0	0	0	0	0	431	670	0	852
2020	360	0	0	0	0	0	0	0	0	0	437	670	0	861
2021	365	0	0	0	0	0	0	0	0	0	444	670	0	872
2022	369	0	0	0	0	0	0	0	0	0	450	670	0	881
2023	373	0	0	0	0	0	0	0	0	0	457	670	0	891
2024	377	0	0	0	0	0	0	0	0	0	464	670	0	901
2025	382	0	0	0	0	0	0	0	0	0	471	670	0	912
2026	387	0	0	0	0	0	0	0	0	0	479	670	0	923
2027	390	0	0	0	0	0	0	0	0	0	484	670	0	932
2028	395	0	0	0	0	0	0	0	0	0	491	670	0	942
2029	399	0	0	0	0	0	0	0	0	0	498	670	0	952
2030	403	0	0	0	0	0	0	0	0	0	505	670	0	963
2031	408	0	0	0	0	0	0	0	0	0	513	670	0	974
2032	412	0	0	0	0	0	0	0	0	0	518	670	0	982
2033	416	0	0	0	0	0	0	0	0	0	525	670	0	992
2034	420	0	0	0	0	0	0	0	0	0	532	670	0	1002
2035	424	0	0	0	0	0	0	0	0	0	539	670	0	1012
2036	428	0	0	0	0	0	0	0	0	0	546	670	0	1022
2037	431	0	0	0	0	0	0	0	0	0	551	670	0	1029
2038	435	0	0	0	0	0	0	0	0	0	557	670	0	1039
2039	439	0	0	0	0	0	0	0	0	0	563	670	0	1048
2040	443	0	0	0	0	0	0	0	0	0	570	670	0	1057
2041	447	0	0	0	0	0	0	0	0	0	576	670	0	1066
2042	450	0	0	0	0	0	0	0	0	0	582	670	0	1075
2043	454	0	0	0	0	0	0	0	0	0	588	670	0	1084
2044	458	0	0	0	0	0	0	0	0	0	594	670	0	1093
2045	461	0	0	0	0	0	0	0	0	0	600	670	0	1102
2046	465	0	0	0	0	0	0	0	0	0	606	670	0	1111
2047	469	0	0	0	0	0	0	0	0	0	612	670	0	1119
2048	472	0	0	0	0	0	0	0	0	0	618	670	0	1128
2049	476	0	0	0	0	0	0	0	0	0	624	670	0	1137
2050	479	0	0	0	0	0	0	0	0	0	630	670	0	1145

Table A6.4 Economic potential of efficient heating and cooling solutions in Larnaca (GWh)

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/Industrial waste - CHP	Livestock/Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	111	0	0	0	0	0	0	0	0	0	133	409	0	285
2014	115	0	0	0	0	0	0	0	0	0	140	424	0	295
2015	113	0	0	0	0	0	0	0	0	0	139	418	0	291
2016	116	0	0	0	0	0	0	0	0	0	142	427	0	297
2017	117	0	0	0	0	0	0	0	0	0	144	434	0	300
2018	119	0	0	0	0	0	0	0	0	0	146	441	0	305
2019	120	0	0	0	0	0	0	0	0	0	149	444	0	309
2020	121	0	0	0	0	0	0	0	0	0	151	445	0	312
2021	123	0	0	0	0	0	0	0	0	0	153	447	0	316
2022	124	0	0	0	0	0	0	0	0	0	155	449	0	320
2023	125	0	0	0	0	0	0	0	0	0	157	451	0	323
2024	127	0	0	0	0	0	0	0	0	0	159	453	0	327
2025	128	0	0	0	0	0	0	0	0	0	161	454	0	331
2026	129	0	0	0	0	0	0	0	0	0	163	456	0	335
2027	131	0	0	0	0	0	0	0	0	0	165	458	0	338
2028	132	0	0	0	0	0	0	0	0	0	167	460	0	342
2029	133	0	0	0	0	0	0	0	0	0	169	461	0	345
2030	135	0	0	0	0	0	0	0	0	0	172	463	0	349
2031	136	0	0	0	0	0	0	0	0	0	174	465	0	353
2032	137	0	0	0	0	0	0	0	0	0	176	467	0	356
2033	139	0	0	0	0	0	0	0	0	0	178	468	0	360
2034	140	0	0	0	0	0	0	0	0	0	180	470	0	363
2035	141	0	0	0	0	0	0	0	0	0	182	472	0	367
2036	142	0	0	0	0	0	0	0	0	0	184	473	0	371
2037	143	0	0	0	0	0	0	0	0	0	185	474	0	373
2038	144	0	0	0	0	0	0	0	0	0	187	476	0	377
2039	146	0	0	0	0	0	0	0	0	0	189	477	0	380
2040	147	0	0	0	0	0	0	0	0	0	191	478	0	383
2041	148	0	0	0	0	0	0	0	0	0	193	480	0	387
2042	149	0	0	0	0	0	0	0	0	0	195	481	0	390
2043	150	0	0	0	0	0	0	0	0	0	197	481	0	393
2044	151	0	0	0	0	0	0	0	0	0	199	482	0	396
2045	153	0	0	0	0	0	0	0	0	0	201	482	0	400
2046	154	0	0	0	0	0	0	0	0	0	202	482	0	403
2047	155	0	0	0	0	0	0	0	0	0	204	483	0	406
2048	156	0	0	0	0	0	0	0	0	0	206	483	0	409
2049	157	0	0	0	0	0	0	0	0	0	208	483	0	412
2050	158	0	0	0	0	0	0	0	0	0	209	483	0	415

Table A6.5 Economic potential of efficient heating and cooling solutions in the rest of Cyprus (GWh)

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/Industrial waste - CHP	Livestock/Industrial waste - Efficient boilers	Municipal waste - CHP	Municipal waste - Efficient boilers	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP	Heat Pumps - Split units
2013	1766	0	0	0	38	38	42	0	0	0	1867	0	0	2563
2014	1843	0	0	0	40	40	43	0	0	0	1972	0	0	2654
2015	1818	0	0	0	41	41	43	0	0	0	1978	0	0	2602
2016	1853	0	0	0	42	42	44	0	0	0	2027	0	0	2649
2017	1873	0	0	0	44	44	45	0	0	0	2056	0	0	2679
2018	1898	0	0	0	45	45	45	0	0	0	2091	0	0	2714
2019	1922	0	0	0	47	47	46	0	0	0	2127	0	0	2748
2020	1940	0	0	0	48	48	47	0	0	0	2154	0	0	2774
2021	1963	0	0	0	50	50	47	0	0	0	2186	0	0	2805
2022	1981	0	0	0	52	52	48	0	0	0	2214	0	0	2832
2023	2002	0	0	0	54	54	49	0	0	0	2244	0	0	2861
2024	2022	0	0	0	55	55	50	0	0	0	2274	0	0	2891
2025	2043	0	0	0	57	57	50	0	0	0	2305	0	0	2920
2026	2066	0	0	0	59	59	51	0	0	0	2338	0	0	2952
2027	2083	0	0	0	61	61	52	0	0	0	2364	0	0	2977
2028	2104	0	0	0	63	63	53	0	0	0	2395	0	0	3006
2029	2124	0	0	0	65	65	53	0	0	0	2425	0	0	3036
2030	2145	0	0	0	68	68	54	0	0	0	2456	0	0	3066
2031	2168	0	0	0	70	70	55	0	0	0	2489	0	0	3098
2032	2184	0	0	0	72	72	56	0	0	0	2514	0	0	3122
2033	2204	0	0	0	75	75	56	0	0	0	2543	0	0	3150
2034	2223	0	0	0	77	77	57	0	0	0	2573	0	0	3178
2035	2242	0	0	0	80	80	58	0	0	0	2603	0	0	3205
2036	2262	0	0	0	83	83	59	0	0	0	2633	0	0	3233
2037	2276	0	0	0	86	86	60	0	0	0	2655	0	0	3255
2038	2294	0	0	0	89	89	61	0	0	0	2682	0	0	3280
2039	2311	0	0	0	92	92	62	0	0	0	2710	0	0	3305
2040	2329	0	0	0	95	95	63	0	0	0	2737	0	0	3330
2041	2346	0	0	0	98	98	63	0	0	0	2764	0	0	3356
2042	2364	0	0	0	101	101	64	0	0	0	2790	0	0	3381
2043	2381	0	0	0	105	105	65	0	0	0	2817	0	0	3407
2044	2398	0	0	0	108	108	66	0	0	0	2844	0	0	3432
2045	2415	0	0	0	112	112	67	0	0	0	2870	0	0	3457
2046	2432	0	0	0	116	116	68	0	0	0	2896	0	0	3481
2047	2448	0	0	0	120	120	69	0	0	0	2921	0	0	3505
2048	2464	0	0	0	124	124	70	0	0	0	2947	0	0	3530
2049	2481	0	0	0	128	128	71	0	0	0	2972	0	0	3554
2050	2497	0	0	0	133	133	72	0	0	0	2998	0	0	3577

Annex 7. Results of FNPV of individual solutions in the system boundaries

Table A7.1 FNPV of alternative scenarios of individual solutions in NICCOSIA (mill.EUR$_{2013}$)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	S. biomass Efficient boilers	Solar Solar panels
Residential									
Apartments	-329	-212	280	-1517	-1199	-1117	-101	-93	-133
Row	-125	-32	107	-449	-343	-316	-42	-36	20
Single	-151	-38	149	-592	-453	-417	-65	-53	20
Service									
Airports	0	0	0	0	0	0	0	0	0
Catering	-16	-16	10	-60	-63	-77	-18	-13	-13
Healthcare	-26	8	31	-79	-84	-112	-13	-9	14
Hotels	-7	-2	3	-47	-49	-59	-15	-10	-11
Offices	-92	-134	60	-426	-441	-529	-57	-44	-133
Other	-30	-45	27	-155	-161	-193	-20	-15	-41
Schools	-8	-13	22	-68	-71	-87	-11	-9	-12
Shopping	-32	-98	32	-275	-284	-333	-22	-18	-107
FNPV	-817	-583	720	-3667	-3147	-3240	-364	-300	-396

Table A7.2 FNPV of alternative scenarios of individual solutions in PAPHOS (mill.EUR$_{2013}$)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	S. biomass Efficient boilers	Solar Solar panels
Residential									
Apartments	-82	-51	70	-374	-295	-275	-25	-23	-31
Row	-27	-7	23	-97	-74	-68	-9	-8	4
Single	-29	-9	29	-119	-92	-85	-14	-11	2
Service									
Airports	0	0	0	0	0	0	0	0	0
Catering	-13	-13	8	-48	-50	-61	-8	-6	-10
Healthcare	-6	0	8	-27	-28	-36	-5	-4	0
Hotels	-47	-12	17	-314	-326	-396	-18	-13	-72
Offices	-12	-15	7	-49	-51	-62	-17	-13	-14
Other	-3	-4	3	-15	-16	-19	-6	-4	-4
Schools	-1	-1	4	-9	-10	-12	-3	-2	-0
Shopping	-7	-40	12	-108	-112	-130	-8	-7	-45
FNPV	-228	-151	182	-1160	-1053	-1142	-114	-91	-171

Table A7.3 FNPV of alternative scenarios of individual solutions in LIMASSOL (mill.EUR$_{2013}$)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	S. biomass Efficient boilers	Solar Solar panels
Residential									
Apartments	-192	-133	164	-911	-722	-674	-61	-56	-88
Row	-98	-24	92	-370	-283	-260	-32	-28	15
Single	-117	-36	119	-484	-372	-343	-48	-41	8
Service									
Airports	0	0	0	0	0	0	0	0	0
Catering	-16	-16	10	-59	-62	-75	-10	-8	-13
Healthcare	-3	-5	5	-34	-35	-42	-5	-3	-9
Hotels	-17	-4	6	-111	-115	-140	-16	-11	-25
Offices	-42	-63	28	-199	-206	-247	-30	-23	-63
Other	-16	-23	14	-80	-83	-100	-10	-8	-20
Schools	-5	-9	13	-41	-43	-53	-6	-5	-8
Shopping	-19	-54	18	-153	-158	-186	-12	-10	-59
FNPV	-523	-366	468	-2442	-2079	-2120	-232	-192	-263

Table A7.4 FNPV of alternative scenarios of individual solutions in LARNACA (mill.EUR$_{2013}$)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	S. biomass Efficient boilers	Solar Solar panels
Residential									
Apartments	-85	-61	73	-410	-325	-304	-26	-25	-42
Row	-37	-9	32	-132	-101	-93	-12	-10	6
Single	-25	-8	25	-103	-79	-73	-13	-10	2
Service									
Airports	0	0	0	0	0	0	0	0	0
Catering	-5	-5	3	-20	-20	-25	-4	-3	-4
Healthcare	-7	2	9	-24	-25	-33	-3	-2	3
Hotels	-4	-1	2	-26	-27	-33	-6	-4	-6
Offices	-15	-22	10	-71	-73	-88	-11	-8	-22
Other	-6	-7	5	-27	-28	-34	-4	-3	-5
Schools	-1	-1	4	-8	-9	-11	-2	-2	-1
Shopping	-7	-19	6	-53	-55	-65	-4	-4	-21
FNPV	-192	-132	168	-873	-743	-758	-85	-71	-90

Table A7.5 FNPV of alternative scenarios of individual solutions in the REST (mill.EUR$_{2013}$)

	Electricity Resistance heaters	Electricity Heat Pumps	Electricity Split unit - Heat Pumps	Gas oil CHP	Light fuel oil CHP	LPG CHP	Solid biomasss CHP	S. biomass Efficient boilers	Solar Solar panels	Heat recovery	Livestock/Industrial waste CHP	Livestock/Industrial waste Efficient boilers	Municipal waste CHP	Municipal waste Efficient boilers
Residential														
Apartments	-235	-132	199	-1026	-806	-750	-102	-86	-72	-56	-56	-56	-56	-56
Row	-227	-88	151	-782	-605	-559	-79	-65	12	-51	-51	-51	-51	-51
Single	-828	-207	749	-3050	-2329	-2144	-268	-232	133	-207	-207	-207	-207	-207
Service														
Airports	-8	-16	5	-47	-48	-57	-3	-3	-17	-1	-1	-1	-1	-1
Catering	-56	-56	35	-206	-215	-262	-37	-27	-45	-7	-7	-7	-7	-7
Healthcare	-17	4	19	-50	-53	-70	-21	-13	9	-3	-3	-3	-3	-3
Hotels	-137	-32	50	-899	-935	-1134	-69	-50	-204	-18	-18	-18	-18	-18
Offices	-102	-160	69	-502	-521	-622	-93	-70	-161	-16	-16	-16	-16	-16
Other	-38	-59	34	-203	-211	-254	-34	-25	-56	-7	-7	-7	-7	-7
Schools	-10	-8	28	-68	-72	-91	-18	-13	-5	-6	-6	-6	-6	-6
Shopping	-41	-122	40	-344	-356	-417	-36	-28	-134	-9	-9	-9	-9	-9
Agriculture														
Greenhouses	-38	-118	-3	-260	-269	-319	-279	-171	-3	-3	-25	-9	-3	-3
Other	-2	-2	0	-2	-2	-112	-2	-2	-1	-2	-2	-2	-2	-2
Industry														
Other indust	-2	-0	0	-10	-22	-20	-0	-0	18	-0	-0	-0	17	12
Chemicals	-0	-0	0	-1	-3	-3	-0	-0	2	-0	-0	-0	2	2
Cement	1	-0	0	-1	-2	-1	-0	-0	1	-0	-0	-0	2	2
Other minera	0	-0	0	-1	-2	-1	-0	-0	1	-0	-0	-0	2	2
Food, tobacc	-2	-0	0	-32	-67	-63	-0	-0	43	-0	-0	-0	51	38
FNPV	-1742	-996	1376	-7485	-6516	-6881	-1041	-786	-482	-387	-408	-393	-313	-331

Annex 8. Results: Economic potential and sensitivity analysis

CASE: Base case
TYPE: Individual

Year	Heat Pumps	Resistance heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Effic	Municipal waste - CHP	Municipal waste - Efficient boile	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	LPG - CHP	Heat Pumps - Split units
2013	2882	0	0	0	38	38	42	42	0	0	3090	0	5263
2014	3003	0	0	0	40	40	43	43	0	0	3257	0	5446
2015	2960	0	0	0	41	41	43	43	0	0	3261	0	5341
2016	3017	0	0	0	42	42	44	44	0	0	3341	0	5442
2017	3050	0	0	0	44	44	45	45	0	0	3389	0	5506
2018	3092	0	0	0	45	45	45	45	0	0	3448	0	5581
2019	3132	0	0	0	47	47	46	46	0	0	3507	0	5653
2020	3162	0	0	0	48	48	47	47	0	0	3552	0	5710
2021	3199	0	0	0	50	50	47	47	0	0	3606	0	5777
2022	3230	0	0	0	52	52	48	48	0	0	3652	0	5835
2023	3265	0	0	0	54	54	49	49	0	0	3702	0	5898
2024	3299	0	0	0	55	55	50	50	0	0	3752	0	5961
2025	3333	0	0	0	57	57	50	50	0	0	3803	0	6024
2026	3371	0	0	0	59	59	51	51	0	0	3859	0	6092
2027	3400	0	0	0	61	61	52	52	0	0	3902	0	6147
2028	3434	0	0	0	63	63	53	53	0	0	3953	0	6210
2029	3469	0	0	0	65	65	53	53	0	0	4004	0	6275
2030	3504	0	0	0	68	68	54	54	0	0	4055	0	6340
2031	3541	0	0	0	70	70	55	55	0	0	4110	0	6408
2032	3568	0	0	0	72	72	56	56	0	0	4152	0	6461
2033	3601	0	0	0	75	75	56	56	0	0	4201	0	6522
2034	3634	0	0	0	77	77	57	57	0	0	4251	0	6582
2035	3666	0	0	0	80	80	58	58	0	0	4300	0	6641
2036	3699	0	0	0	83	83	59	59	0	0	4350	0	6702
2037	3723	0	0	0	86	86	60	60	0	0	4388	0	6749
2038	3752	0	0	0	89	89	61	61	0	0	4434	0	6804
2039	3782	0	0	0	92	92	62	62	0	0	4479	0	6860
2040	3811	0	0	0	95	95	63	63	0	0	4525	0	6914
2041	3840	0	0	0	98	98	63	63	0	0	4570	0	6970
2042	3869	0	0	0	101	101	64	64	0	0	4614	0	7026
2043	3898	0	0	0	105	105	65	65	0	0	4659	0	7081
2044	3927	0	0	0	108	108	66	66	0	0	4704	0	7136
2045	3956	0	0	0	112	112	67	67	0	0	4748	0	7191
2046	3984	0	0	0	116	116	68	68	0	0	4791	0	7245
2047	4012	0	0	0	120	120	69	69	0	0	4834	0	7298
2048	4039	0	0	0	124	124	70	70	0	0	4877	0	7351
2049	4067	0	0	0	128	128	71	71	0	0	4920	0	7403
2050	4093	0	0	0	133	133	72	72	0	0	4962	0	7454

CASE: Increase of discount rate (5%)
TYPE: Individual

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Effic	Municipal waste - CHP	Municipal waste - Efficient boile	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	LPG - CHP	Heat Pumps - Split units
2013	2354	0	0	0	38	38	42	42	0	0	3041	0	5263
2014	2445	0	0	0	40	40	43	43	0	0	3207	0	5446
2015	2404	0	0	0	41	41	43	43	0	0	3214	0	5341
2016	2449	0	0	0	42	42	44	44	0	0	3294	0	5442
2017	2476	0	0	0	44	44	45	45	0	0	3342	0	5506
2018	2510	0	0	0	45	45	45	45	0	0	3400	0	5581
2019	2542	0	0	0	47	47	46	46	0	0	3458	0	5653
2020	2566	0	0	0	48	48	47	47	0	0	3503	0	5710
2021	2596	0	0	0	50	50	47	47	0	0	3557	0	5777
2022	2621	0	0	0	52	52	48	48	0	0	3602	0	5835
2023	2649	0	0	0	54	54	49	49	0	0	3652	0	5898
2024	2676	0	0	0	55	55	50	50	0	0	3702	0	5961
2025	2704	0	0	0	57	57	50	50	0	0	3752	0	6024
2026	2734	0	0	0	59	59	51	51	0	0	3808	0	6092
2027	2758	0	0	0	61	61	52	52	0	0	3850	0	6147
2028	2785	0	0	0	63	63	53	53	0	0	3901	0	6210
2029	2813	0	0	0	65	65	53	53	0	0	3951	0	6275
2030	2841	0	0	0	68	68	54	54	0	0	4002	0	6340
2031	2871	0	0	0	70	70	55	55	0	0	4057	0	6408
2032	2894	0	0	0	72	72	56	56	0	0	4098	0	6461
2033	2920	0	0	0	75	75	56	56	0	0	4147	0	6522
2034	2946	0	0	0	77	77	57	57	0	0	4196	0	6582
2035	2972	0	0	0	80	80	58	58	0	0	4245	0	6641
2036	2999	0	0	0	83	83	59	59	0	0	4295	0	6702
2037	3019	0	0	0	86	86	60	60	0	0	4332	0	6749
2038	3042	0	0	0	89	89	61	61	0	0	4377	0	6804
2039	3066	0	0	0	92	92	62	62	0	0	4422	0	6860
2040	3090	0	0	0	95	95	63	63	0	0	4468	0	6914
2041	3114	0	0	0	98	98	63	63	0	0	4512	0	6970
2042	3137	0	0	0	101	101	64	64	0	0	4556	0	7026
2043	3161	0	0	0	105	105	65	65	0	0	4600	0	7081
2044	3185	0	0	0	108	108	66	66	0	0	4645	0	7136
2045	3208	0	0	0	112	112	67	67	0	0	4689	0	7191
2046	3231	0	0	0	116	116	68	68	0	0	4732	0	7245
2047	3253	0	0	0	120	120	69	69	0	0	4774	0	7298
2048	3276	0	0	0	124	124	70	70	0	0	4816	0	7351
2049	3299	0	0	0	128	128	71	71	0	0	4859	0	7403
2050	3320	0	0	0	133	133	72	72	0	0	4901	0	7454

CASE: Increase of fuel prices (30%)
TYPE: Individual

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Effic	Municipal waste - CHP	Municipal waste - Efficient boile	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	LPG - CHP	Heat Pumps - Split units
2013	3059	17	0	0	38	38	42	42	0	0	4771	0	5263
2014	3180	17	0	0	40	40	43	43	0	0	5037	0	5446
2015	3135	17	0	0	41	41	43	43	0	0	5059	0	5341
2016	3192	17	0	0	42	42	44	44	0	0	5190	0	5442
2017	3225	17	0	0	44	44	45	45	0	0	5272	0	5506
2018	3267	18	0	0	45	45	45	45	0	0	5370	0	5581
2019	3307	18	0	0	47	47	46	46	0	0	5467	0	5653
2020	3337	18	0	0	48	48	47	47	0	0	5543	0	5710
2021	3373	18	0	0	50	50	47	47	0	0	5632	0	5777
2022	3404	18	0	0	52	52	48	48	0	0	5709	0	5835
2023	3438	18	0	0	54	54	49	49	0	0	5792	0	5898
2024	3472	19	0	0	55	55	50	50	0	0	5876	0	5961
2025	3506	19	0	0	57	57	50	50	0	0	5961	0	6024
2026	3544	19	0	0	59	59	51	51	0	0	6054	0	6092
2027	3572	19	0	0	61	61	52	52	0	0	6126	0	6147
2028	3606	19	0	0	63	63	53	53	0	0	6211	0	6210
2029	3641	20	0	0	65	65	53	53	0	0	6296	0	6275
2030	3675	20	0	0	68	68	54	54	0	0	6382	0	6340
2031	3712	20	0	0	70	70	55	55	0	0	6474	0	6408
2032	3740	20	0	0	72	72	56	56	0	0	6544	0	6461
2033	3772	20	0	0	75	75	56	56	0	0	6627	0	6522
2034	3804	20	0	0	77	77	57	57	0	0	6710	0	6582
2035	3836	21	0	0	80	80	58	58	0	0	6793	0	6641
2036	3869	21	0	0	83	83	59	59	0	0	6878	0	6702
2037	3893	21	0	0	86	86	60	60	0	0	6941	0	6749
2038	3922	21	0	0	89	89	61	61	0	0	7018	0	6804
2039	3951	21	0	0	92	92	62	62	0	0	7095	0	6860
2040	3980	21	0	0	95	95	63	63	0	0	7173	0	6914
2041	4009	22	0	0	98	98	63	63	0	0	7248	0	6970
2042	4038	22	0	0	101	101	64	64	0	0	7323	0	7026
2043	4067	22	0	0	105	105	65	65	0	0	7399	0	7081
2044	4095	22	0	0	108	108	66	66	0	0	7475	0	7136
2045	4124	22	0	0	112	112	67	67	0	0	7550	0	7191
2046	4151	22	0	0	116	116	68	68	0	0	7623	0	7245
2047	4179	23	0	0	120	120	69	69	0	0	7695	0	7298
2048	4206	23	0	0	124	124	70	70	0	0	7768	0	7351
2049	4233	23	0	0	128	128	71	71	0	0	7841	0	7403
2050	4259	23	0	0	133	133	72	72	0	0	7912	0	7454

CASE: Base case
TYPE: Centralised

Year	Heat Pumps	Resistance heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Effic	Municipal waste - CHP	Municipal waste - Efficient boile	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP
2013	120	0	0	0	0	0	0	0	0	0	2588	1079	0
2014	119	0	0	0	0	0	0	0	0	0	2733	1094	0
2015	113	0	0	0	0	0	0	0	0	0	2742	1088	0
2016	114	0	0	0	0	0	0	0	0	0	2810	1097	0
2017	115	0	0	0	0	0	0	0	0	0	2851	1104	0
2018	116	0	0	0	0	0	0	0	0	0	2901	1111	0
2019	117	0	0	0	0	0	0	0	0	0	2950	1113	0
2020	118	0	0	0	0	0	0	0	0	0	2989	1115	0
2021	119	0	0	0	0	0	0	0	0	0	3035	1117	0
2022	120	0	0	0	0	0	0	0	0	0	3073	1119	0
2023	120	0	0	0	0	0	0	0	0	0	3116	1120	0
2024	121	0	0	0	0	0	0	0	0	0	3158	1122	0
2025	122	0	0	0	0	0	0	0	0	0	3201	1124	0
2026	123	0	0	0	0	0	0	0	0	0	3248	1126	0
2027	124	0	0	0	0	0	0	0	0	0	3285	1127	0
2028	125	0	0	0	0	0	0	0	0	0	3328	1129	0
2029	126	0	0	0	0	0	0	0	0	0	3371	1131	0
2030	127	0	0	0	0	0	0	0	0	0	3414	1133	0
2031	128	0	0	0	0	0	0	0	0	0	3460	1135	0
2032	129	0	0	0	0	0	0	0	0	0	3495	1136	0
2033	130	0	0	0	0	0	0	0	0	0	3537	1138	0
2034	131	0	0	0	0	0	0	0	0	0	3579	1140	0
2035	131	0	0	0	0	0	0	0	0	0	3621	1141	0
2036	132	0	0	0	0	0	0	0	0	0	3663	1143	0
2037	133	0	0	0	0	0	0	0	0	0	3695	1144	0
2038	134	0	0	0	0	0	0	0	0	0	3733	1145	0
2039	135	0	0	0	0	0	0	0	0	0	3772	1147	0
2040	136	0	0	0	0	0	0	0	0	0	3811	1148	0
2041	137	0	0	0	0	0	0	0	0	0	3848	1150	0
2042	137	0	0	0	0	0	0	0	0	0	3886	1150	0
2043	138	0	0	0	0	0	0	0	0	0	3923	1151	0
2044	139	0	0	0	0	0	0	0	0	0	3961	1151	0
2045	140	0	0	0	0	0	0	0	0	0	3999	1152	0
2046	141	0	0	0	0	0	0	0	0	0	4035	1152	0
2047	142	0	0	0	0	0	0	0	0	0	4071	1152	0
2048	143	0	0	0	0	0	0	0	0	0	4107	1153	0
2049	144	0	0	0	0	0	0	0	0	0	4143	1153	0
2050	144	0	0	0	0	0	0	0	0	0	4179	1153	0

CASE: Increase of discount rate (5%)
TYPE: Centralised

Year	Heat Pumps	Resistan-ce heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Effic	Municipal waste - CHP	Municipal waste - Efficient boile	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP
2013	1766	0	0	0	38	38	0	0	0	0	1950	1079	0
2014	1843	0	0	0	40	40	0	0	0	0	2054	1094	0
2015	1818	0	0	0	41	41	0	0	0	0	2055	1088	0
2016	1853	0	0	0	42	42	0	0	0	0	2105	1097	0
2017	1873	0	0	0	44	44	0	0	0	0	2135	1104	0
2018	1898	0	0	0	45	45	0	0	0	0	2171	1111	0
2019	1922	0	0	0	47	47	0	0	0	0	2207	1113	0
2020	1940	0	0	0	48	48	0	0	0	0	2235	1115	0
2021	1963	0	0	0	50	50	0	0	0	0	2268	1117	0
2022	1981	0	0	0	52	52	0	0	0	0	2296	1119	0
2023	2002	0	0	0	54	54	0	0	0	0	2327	1120	0
2024	2022	0	0	0	55	55	0	0	0	0	2358	1122	0
2025	2043	0	0	0	57	57	0	0	0	0	2389	1124	0
2026	2066	0	0	0	59	59	0	0	0	0	2424	1126	0
2027	2083	0	0	0	61	61	0	0	0	0	2450	1127	0
2028	2104	0	0	0	63	63	0	0	0	0	2481	1129	0
2029	2124	0	0	0	65	65	0	0	0	0	2512	1131	0
2030	2145	0	0	0	68	68	0	0	0	0	2544	1133	0
2031	2168	0	0	0	70	70	0	0	0	0	2578	1135	0
2032	2184	0	0	0	72	72	0	0	0	0	2603	1136	0
2033	2204	0	0	0	75	75	0	0	0	0	2633	1138	0
2034	2223	0	0	0	77	77	0	0	0	0	2664	1140	0
2035	2242	0	0	0	80	80	0	0	0	0	2694	1141	0
2036	2262	0	0	0	83	83	0	0	0	0	2725	1143	0
2037	2276	0	0	0	86	86	0	0	0	0	2748	1144	0
2038	2294	0	0	0	89	89	0	0	0	0	2776	1145	0
2039	2311	0	0	0	92	92	0	0	0	0	2804	1147	0
2040	2329	0	0	0	95	95	0	0	0	0	2832	1148	0
2041	2346	0	0	0	98	98	0	0	0	0	2859	1150	0
2042	2364	0	0	0	101	101	0	0	0	0	2886	1150	0
2043	2381	0	0	0	105	105	0	0	0	0	2913	1151	0
2044	2398	0	0	0	108	108	0	0	0	0	2941	1151	0
2045	2415	0	0	0	112	112	0	0	0	0	2968	1152	0
2046	2432	0	0	0	116	116	0	0	0	0	2994	1152	0
2047	2448	0	0	0	120	120	0	0	0	0	3020	1152	0
2048	2464	0	0	0	124	124	0	0	0	0	3047	1153	0
2049	2481	0	0	0	128	128	0	0	0	0	3073	1153	0
2050	2497	0	0	0	133	133	0	0	0	0	3099	1153	0

CASE: Increase of fuel prices (30%)
TYPE: Centralised

Year	Heat Pumps	Resistance heaters	Gas oil - CHP	Light fuel oil - CHP	Livestock/ Industrial waste - CHP	Livestock/ Industrial waste - Effic	Municipal waste - CHP	Municipal waste - Efficient boile	Solid biomasss - CHP	Solid biomasss - Efficient boilers	Solar	Heat recovery	LPG - CHP
2013	2718	0	0	0	38	38	0	0	0	0	3445	1079	0
2014	2837	0	0	0	40	40	0	0	0	0	3637	1094	0
2015	2809	0	0	0	41	41	0	0	0	0	3648	1088	0
2016	2863	0	0	0	42	42	0	0	0	0	3740	1097	0
2017	2893	0	0	0	44	44	0	0	0	0	3796	1104	0
2018	2931	0	0	0	45	45	0	0	0	0	3864	1111	0
2019	2968	0	0	0	47	47	0	0	0	0	3931	1113	0
2020	2996	0	0	0	48	48	0	0	0	0	3984	1115	0
2021	3030	0	0	0	50	50	0	0	0	0	4046	1117	0
2022	3058	0	0	0	52	52	0	0	0	0	4099	1119	0
2023	3089	0	0	0	54	54	0	0	0	0	4156	1120	0
2024	3120	0	0	0	55	55	0	0	0	0	4214	1122	0
2025	3152	0	0	0	57	57	0	0	0	0	4272	1124	0
2026	3187	0	0	0	59	59	0	0	0	0	4337	1126	0
2027	3213	0	0	0	61	61	0	0	0	0	4387	1127	0
2028	3244	0	0	0	63	63	0	0	0	0	4445	1129	0
2029	3276	0	0	0	65	65	0	0	0	0	4504	1131	0
2030	3307	0	0	0	68	68	0	0	0	0	4562	1133	0
2031	3342	0	0	0	70	70	0	0	0	0	4626	1135	0
2032	3367	0	0	0	72	72	0	0	0	0	4674	1136	0
2033	3396	0	0	0	75	75	0	0	0	0	4731	1138	0
2034	3426	0	0	0	77	77	0	0	0	0	4788	1140	0
2035	3456	0	0	0	80	80	0	0	0	0	4845	1141	0
2036	3486	0	0	0	83	83	0	0	0	0	4903	1143	0
2037	3508	0	0	0	86	86	0	0	0	0	4947	1144	0
2038	3535	0	0	0	89	89	0	0	0	0	4999	1145	0
2039	3561	0	0	0	92	92	0	0	0	0	5052	1147	0
2040	3588	0	0	0	95	95	0	0	0	0	5105	1148	0
2041	3615	0	0	0	98	98	0	0	0	0	5157	1150	0
2042	3641	0	0	0	101	101	0	0	0	0	5208	1150	0
2043	3667	0	0	0	105	105	0	0	0	0	5260	1151	0
2044	3694	0	0	0	108	108	0	0	0	0	5311	1151	0
2045	3720	0	0	0	112	112	0	0	0	0	5363	1152	0
2046	3745	0	0	0	116	116	0	0	0	0	5413	1152	0
2047	3770	0	0	0	120	120	0	0	0	0	5462	1152	0
2048	3795	0	0	0	124	124	0	0	0	0	5512	1153	0
2049	3820	0	0	0	128	128	0	0	0	0	5561	1153	0
2050	3844	0	0	0	133	133	0	0	0	0	5610	1153	0

Annex 9. Detailed graphs for alternative scenarios presenting results from CBA

See separate document called D I.4.1 Annex 9.

Europe Direct is a service to help you find answers to your questions about the European Union
Free phone number (*): 00 800 6 7 8 9 10 11
(*) Certain mobile telephone operators do not allow access to 00 800 numbers or these calls may be billed.

A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server http://europa.eu

How to obtain EU publications

Our publications are available from EU Bookshop (http://bookshop.europa.eu),
where you can place an order with the sales agent of your choice.

The Publications Office has a worldwide network of sales agents.
You can obtain their contact details by sending a fax to (352) 29 29-42758.

JRC Mission

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.

Serving society
Stimulating innovation
Supporting legislation

Publications Office