Republic of North Macedonia
Ministry of Environment and Physical Planning

Assessment of the potential of climate friendly cooling solutions

D-2: Green Cooling Report – Market Assessment

14 December 2020

ECO. DEEPER THINKING

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1. Introduction

1.1 Background

According to the International Energy Agency, cooling is the fastest-growing end use in buildings, as its energy demand more than tripled between 1990 and 2018. Despite that, cooling is still a blind spot in energy and climate debate, including N. Macedonian policies, legislation, and analysis of potential for climate change mitigation. In N. Macedonia, energy consumption in households and "other" areas was approximately 8.0 TWh in 2019 – of which over 4.5 TWh were from electricity. This electricity is often used for both cooling and heating in many households, meaning improving the efficiency of cooling (and heating) systems could result in significant energy savings and related greenhouse gas emissions.

There are a number of potential policy measures which could be implemented to improve the efficiency and reduce the environmental footprint – notably related to energy and greenhouse gas emissions in N. Macedonia. These include policies related to:

- Requirements / incentives for the improvement of energy performance of buildings;
- Requirements / incentives for improved efficiencies for household appliances such as air conditioning (cooling) units, units which provide both heating and cooling, and for building-level (and even district-level) cooling.

This market study has been carried out to assess the technical potential / financial potential for "green" cooling technologies and practices in the Republic of North Macedonia and – in a separate deliverable - to provide recommendations on policies and measures that could promote the uptake of these technologies and practices.

The overall objective of this deliverable is to use baseline data and modelling to assess the market potential for efficient and "green" cooling technologies and practices in the Republic of North Macedonia.

1.2 Scope

This analysis focuses on the technical potential for improved cooling technologies and assessing the likely financial, energy and greenhouse gas aspects of shifting to these technologies. It is estimated at a country-wide scale in North Macedonia.

It is important to note that since heating devices are often the same technology as cooling devices (i.e. reversible air conditioning units that can both heat and cool). Therefore, where appropriate, the impact of switching technologies in terms of energy consumption (and expenses) are also estimated for heating.

2. Methodology and key assumptions

2.1 Characteristics of energy supply and demand

The energy sector of North Macedonia is highly dependent on imports of liquid fuels, gas fuels and electricity. Since cooling mostly uses electricity as the source of energy, the following characteristics of the systems are of great importance in assessing the impact of sustainable cooling development:[1]

- In 2019, the total electricity consumption in the household and other sectors amounted to 4.56 TWh of final energy
- The electricity system (including transformation / transmission / distribution) has a significant amount of losses. Analysis of the system results in a primary emissions factor of 3.2 – meaning that for every 1 MWh of final energy consumed in electricity, 3.2 MWh of primary are consumed.
- The N. Macedonian electricity system is heavily reliant upon coal-fired power plants meaning that the grid emissions factor for electricity is high at 0.739 tCO2eq/MWh[2].
- N. Macedonia imported over 2.4 TWh of electricity in 2019 – indicating that there is a heavy reliance on foreign sources of electricity.

A breakdown of the building sector and its use of electricity for heating equipment is provided below. Within this, a certain sub-section are assumed to have cooling technology in place – which would grow over the course of the next 20 years.

Residential sector	Unit	Amount
Number of households where electricity is used as the primary source of energy for heating	#	159,915
Number of households with other types of energy sources used for primary heating	#	399,273
Detached single-family building with electric heating	#	93,007
Collective residential building with electric heating	#	66,908
Detached single-family building with other heating	#	232,218
Collective residential building with other heating	#	167,055
Source: MAKSTAT (2020) Statistical yearbook, 2020		
Stores		

[1] MAKSTAT (2020) Energy Balances (http://makstat.stat.gov.mk/PXWeb/pxweb/en/MakStat/MakStat__Energija__EnergetBilansi/?rxid=46ee0f64-2992-4b45-a2d9-cb4e5f7ec5ef)

[2] EIB Project Carbon Footprint Methodologies - Methodologies for the Assessment of Project GHG Emissions and Emission Variations. EIB, July 2020

Stores	#	18,266
Stores with electric heating	%	44%
Stores with other heating	%	56%
Stores with electric heating	#	8,118
Stores with other heating	#	10,148
Source: Census of capacities in retail trade, 2016		
Large public health facilities		
University clinical center	m2	120,000
General hospitals	m2	165,445
Special hospitals	m2	66,877
Total	m2	352,322
Hospitals with electric heating	m2	-
Hospitals with other heating	m2	352,322
Offices		
Assumed average size of office	m2	75
Private offices and premises	m2	4,000,000
Private offices and premises with electric heating	%	54%
Privat offices and premises with other heating	%	46%
Private offices and premises	#	53,333
Offices with electric heating	#	28,556
Offices with other heating	#	24,777

2.2 Methodology of analysis

The analysis in this report was developed through the following series of steps:

1) **Assessment of the current market situation** - This included analysing statistical information about the building stock, energy consumption, and working to assess what products are currently sold on the market at what prices and with what level of efficiencies. Using this assessment, a "Business As Usual" (or "**Baseline**") scenario was modelled to assess likely future energy consumption without any additional policies. Within this step, interviews were held with distributors of cooling equipment throughout the country to understand what percentage of which type of product were typically sold and installed in N. Macedonia. This step also assessed the prices of various options for cooling (and reversible cooling / heating) technologies. A list of interviews carried out and interview questions is included in Annexes B and C.
2) **Assessing the potential impact of switching to greener forms of cooling** - This involved developing a **"Green"** scenario which would reflect the implementation of EU established

regulations requiring certain level of energy efficiency amongst cooling sources[3] as well as requiring labelling on cooling appliances when sold[4]. The scenario also assumes some level of support / incentives for more efficient appliances. This scenario reflects a change in dynamics of the level of efficiency of appliances purchased based on experience in EU countries. Three types of cooling (and reversible cooling / heating systems) were evaluated: Low efficiency models which do not comply with ecodesign standards, medium efficiency models which are compliant but not top-of-the-line technology, and high efficiency models which exceed standards. Nine different types of building set-ups were analysed according to different types of building and cooling / heating technology as follows:

a) **Cooling only - residential – houses -** Individual houses with district / biomass / light fuel oil heating but which use reversible cooling / heating devices for a small period of the year to "top-up" the main heating sources in addition to cooling.
b) **Cooling only - residential – apartments -** Individual apartments with district heating but which use reversible cooling / heating devices for a small period of the year to "top-up" the main heating sources in addition to cooling.
c) **Cooling only - commercial - office buildings -** Offices without central HVAC and with district heating but which use reversible cooling / heating devices for a small period of the year to "top-up" the main heating sources in addition to cooling.
d) **Cooling only - commercial – retail -** Shops without central HVAC and with district heating but which use reversible cooling / heating devices for a small period of the year to "top-up" the main heating sources in addition to cooling.
e) **Cooling only - commercial - hospitals -** Existing hospitals all have central heating systems and use cooling systems for cooling only
f) **Cooling and heating - residential – houses -** Individual houses with electric heating typically using inefficient electric radiators for heating but also using cooling systems separately
g) **Cooling and heating - residential – apartments -** Individual apartments with electric heating typically using inefficient electric radiators for heating but also using cooling systems separately
h) **Cooling and heating - commercial - office buildings -** Offices without central HVAC or district heating typically using inefficient electric radiators for heating but also using cooling systems separately
i) **Cooling and heating - commercial – retail -** Shops without central HVAC or central heating typically using inefficient electric radiators for heating but also using cooling systems separately

Specific levels of efficiency, market penetration, market dynamics, and costs / savings per type of building are described in the Baseline scenario and Green scenario are provided in Annex A.

[3] Commission Regulation (EU) No 206/2012 of 6 March 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans (https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1440597932045&uri=CELEX%3A32012R0206)

[4] Commission Delegated Regulation (EU) No 626/2011 of 4 May 2011 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of air conditioners (https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32011R0626)

3. Impact analysis of energy efficient air conditioners

3.1 Key aspects of the analysis

This section describes the expected impact of the growth in market penetration of energy efficient air conditioners[5] including – where applicable - heat pumps in various types of buildings. Energy savings have been modelled along with potential GHG reductions and costs and benefits.

As mentioned in the previous section, the categories examined include:

1. Single-family houses
2. Apartments
3. Offices
4. Shops
5. Hospitals

In all cases except for hospitals, we have looked separately at those that currently have heating using non-electric sources and those that have electric heating. For hospitals, since there are no hospitals using electricity for heating, we have looked only at cooling issues. For each category, the analysis includes three levels of efficiency – low, which is equivalent to the current baseline technology, medium, which is an improved model compared to the baseline and compliant with minimum requirements under the EU's Ecodesign regulations[6], and high efficiency as defined by the "best in the market" according to analysis carried out of the market.

In the case of buildings with non-electric heating we have assumed that the air conditioners are used for mostly cooling – but in practice they are also used to top up other sources of heating (for example before the district heating is turned on or if other heating sources are insufficient).

In the case of buildings with electric heating, we have assumed that air conditioners are used for cooling, but the high efficiency case is for the installation of heat pumps that are used as the main technology for heating as well as for cooling. In these cases, the medium-efficiency scenario does not involve a change in the heating technology since replacing inefficient radiators with efficient duct air conditioners which include heating and cooling is unlikely to be implemented without major renovations – as new pipes must be lain between the rooms to allow for effective heating and cooling distribution.

[5] Air conditioning in this context means both heating and cooling.

[6] Most notably Commission Regulation (EU) No 206/2012 of 6 March 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1440597932045&uri=CELEX%3A32012R0206

3.2 Key Conclusions

The results of the assessment are summarised in Table 1 as well as in more depth in Table 2 and Table 3. The base-year case and business as usual / baseline scenario was estimated using input from expert knowledge of the market and interviews with stakeholders. Based on these assumptions (described in Annex A), it is estimated that building cooling and heating using electricity in the building types considered accounts for about 32% of electricity use in the households and "other" sectors as defined in the energy balances of 2019. This is logical since electricity is used for heating in 29% of households.[7] Figure 1 shows the primary energy consumption in the Business-as-usual (BAU) scenario, the primary energy consumption in the energy efficient scenario and the cumulative savings of the energy efficient scenarios compared to BAU – in the situation where heating demand is taken into account. Figure 2 shows the same, where heating demand is not taken into account.

The following conclusions are noteworthy from the results:

- Consumption of electricity from buildings which have cooling devices is estimated to be 1.7 TWh in the base year and grow to over 5 TWh by 2040. For cooling only (excluding the same appliances used for heating), the consumption is estimated to be 0.321 TWh in 2021 and growing to 0.816 TWh in 2040 – so more than doubling.
- The associated GHG emissions in all cases are expected to more than double from buildings which have cooling devices.
- Savings are estimated to be around 34% to 35% per year by 2040 with the introduction of appropriate measures in 2021.
- The financial benefits from implementing efficient cooling is not as large as the marginal investments when only cooling is considered - € 221 million savings over the period through 2040 versus € 512 million additional investment over the period.
- However, when the use of the same equipment for heating is included the analysis, the value of savings is huge – over € 3.8 billion in savings over the period through 2040 versus the same € 512 million additional investment.
- At a per-building level, this is also demonstrated, where, when there is heating by the various types of equipment, the replacement with more efficient sources makes the payback period fairly attractive.
- For buildings which only use air conditioning devices for a small amount of heating, the financial benefits of choosing more efficient devices is reasonably attractive (payback periods of 5 to 12 years depending on the specific case) though the extra benefits of very efficient appliances do not seem to justify the costs (with payback periods mostly over 15 years).
- For buildings which use electricity for both cooling and heating, when purchasing new equipment, the purchase of efficient appliances which only are used for cooling instead of inefficient devices has a reasonable payback period (usually around 12 to 13 years) but it is not very attractive as an investment.
- For buildings using electricity for both cooling and heating and which are undergoing renovation and can implement heat-pump based duct systems to replace both heating

[7] State Statistical Office of the Republic of Macedonia (2020) Statistical yearbook.

and cooling aspects the investments are very attractive – with payback periods between 3 and 5 years.

- The results are sensitive to changes in the number of hours of usage of devices for cooling. A sensitivity analysis was carried out to gauge the impact of an increase and decrease of the number of hours against what was used in the model and it showed a 1:1 correlation between an increase in the number of cooling hours and the financial savings and energy savings in the cooling only case and similarly in the case where the number of cooling and heating hours were increased or decreased (see Table 4).

Policy implications of the analysis will be explored in a separate document but two key messages are worth mentioning in this study:

1. **Cooling is a significant and growing contributor to energy consumption -** notably electricity consumption in N. Macedonia – expected to increase by approximately 3x over the next 20 years. Because cooling uses electricity, its impact on primary energy consumption and / or imports is higher on a per MWh basis than, for example, transport fuel.
2. **Investments in efficient cooling yield positive energy savings / GHG reductions on their own, but when implemented in a way which also addresses heating demand, they are extremely beneficial**. Given that N. Macedonia has a lot of heating which is carried out using electricity, it would be logical to have policies in place which support more efficient solutions for both heating and cooling at the same time.

Table 1: Comparison of BAU and Green scenarios in 2021, 2040, and cumulatively over the period.

	Unit	Cooling and heating		Cumulative through 2040	Cooling only		Cumulative through 2040
		2021	2040		2021	2040	
BAU							
Final energy consumption	GWh	1,712	5,189	80,375	100	255	4,071
Primary energy consumption	GWh	5,479	16,603	257,200	321	816	13,027
GHG emissions	ktCO2eq	1,265	3,834	59,397	74	188	3,008
Green scenario							
Final energy consumption	GWh	1,712	3,439	65,167	100	165	3,209
Primary energy consumption	GWh	5,479	11,005	208,535	321	527	10,269
GHG emissions	ktCO2eq	1,265	2,541	48,158	74	122	2,372
Savings							
Final energy consumption	GWh	0	1,750	15,208	0	90	862
Primary energy consumption	GWh	0	5,599	48,666	0	289	2,758
GHG emissions	ktCO2eq	0	1,293	11,239	0	67	637
%			34%	19%		35%	21%

Table 2: Summary of analysis of energy savings, costs and benefits from increased market penetration of energy efficient air conditioners and heat pumps – including heating demand

Product group	Units	Cooling only - residential - houses	Cooling only - residential - apartments	Cooling only - commercial - office buildings	Cooling only - commercial - retail	Cooling only - commercial - hospitals	Cooling and heating - residential - houses	Cooling and heating - residential - apartments	Cooling and heating - commercial - office buildings	Cooling and heating - commercial - retail	Total
# of appliances	#	74,897	58,469	8,672	5,074	505,142	29,997	21,580	9,995	4,059	**212,743**
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	42,621	19,833	3,829	3,088	23,608	1,066,185	420,874	95,338	36,689	**1,712,065**
% of final energy consumption by the household and "other" sectors	%	0.5%	0.2%	0.05%	0.04%	0.29%	13.3%	5.3%	1.2%	0.46%	**21.4%**
% of electricity consumption by the household and "other" sectors	%	0.9%	0.4%	0.1%	0.1%	0.5%	23.3%	9.2%	2.1%	0.8%	**37.5%**
Expected new savings in 2030											
Average primary energy savings per year	MWh	65,707	38,429	5,827	3,421	14,103	1,139,324	646,649	81,859	31,735	**2,027,053**
Average final energy savings per year	MWh	20,533	12,009	1,821	1,069	4,407	356,039	202,078	25,581	9,917	**633,454**
Expected new savings in 2040											
Average primary energy savings per year	MWh	130,121	52,099	11,036	5,354	27,560	2,910,481	1,055,926	199,164	62,381	**4,454,122**
Average final energy savings per year	MWh	40,663	16,281	3,449	1,673	8,612	909,525	329,977	62,239	19,494	**1,391,913**
Average annual GHG emission reductions	tonnes	17,215	7,776	1,489	771	3,684	350,542	181,822	24,658	8,000	**595,957**

Product group	Units	Cooling only - residential - houses	Cooling only - residential - apartments	Cooling only - commercial - office buildings	Cooling only - commercial - retail	Cooling only - commercial - hospitals	Cooling and heating - residential - houses	Cooling and heating - residential - apartments	Cooling and heating - commercial - office buildings	Cooling and heating - commercial - retail	Total
Additional (marginal) investment in EE in appliances - annual	1,000 EUR/ year	2,480	1,577	296	134	376	11,406	4,147	1,680	544	**€ 22,639**
Value of financial savings from energy saved - annual	1,000 EUR/ year	1,467	699	179	95	439	28,446	12,421	2,843	940	**€ 47,530**
Additional (marginal) investment in EE in appliances - cumulative	1,000 EUR/ year	54,170	35,416	6,559	3,197	9,923	255,804	95,116	38,603	13,351	**€ 512,137**
Value of financial savings from energy saved - cumulative	1,000 EUR/ year	110,806	46,497	13,252	6,590	32,929	2,395,583	909,040	231,681	73,502	**€ 3,819,879**
Investment cost per MWh saved - lifetime	EUR	€38	€55	€54	€50	€33	€9	€55	€19	€20	
Payback period for medium efficiency versus low efficiency model	year	8	12	7	7	5	12	20	12	13	
Payback period for high efficiency versus low efficiency model	year	17	20	17	16	9	3	3	5	5	
% of market with appliance in base year		32%	35%	35%	50%	90%	32%	32%	35%	50%	
% of market with appliance in 2040	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	

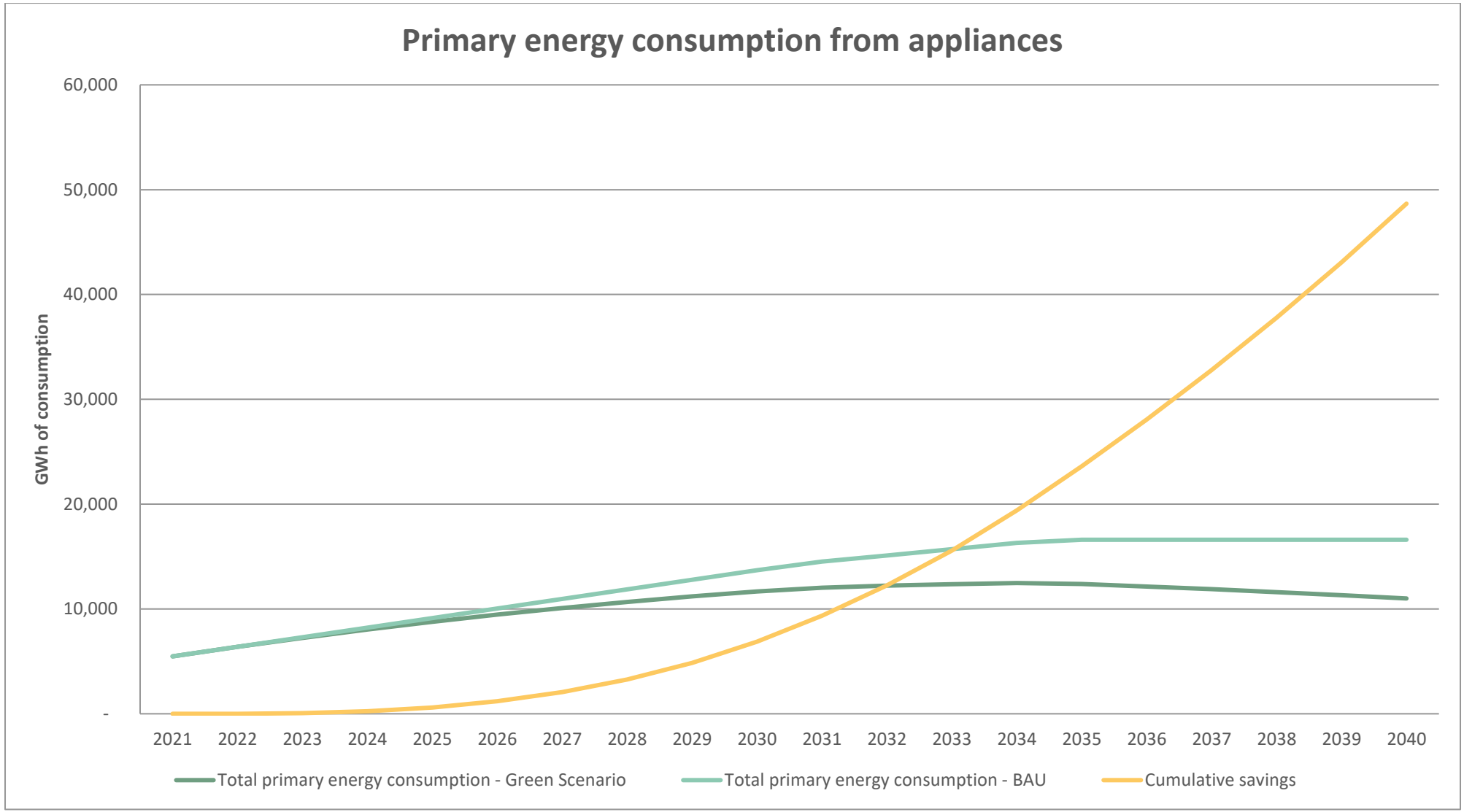

Figure 1: Primary energy consumption by air conditioners – including heating demand

Table 3: Summary of analysis of energy savings, costs and benefits from increased market penetration of energy efficient air conditioners and heat pumps – not including heating demand

Product group	Units	Cooling only - residential - houses	Cooling only - residential - apartments	Cooling only - commercial - office buildings	Cooling only - commercial - retail	Cooling only - commercial - hospitals	Cooling and heating - residential - houses	Cooling and heating - residential - apartments	Cooling and heating - commercial - office buildings	Cooling and heating - commercial - retail	Total
# of appliances	#	74,897	58,469	8,672	5,074	505,142	29,997	21,580	9,995	4,059	**212,743**
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	33,768	12,928	2,787	2,284	23,608	15,078	4,772	3,212	1,965	**100,403**
% of final energy consumption by the household and "other" sectors	%	0.4%	0.2%	0.03%	0.03%	0.29%	0.2%	0.1%	0.0%	0.02%	**1.3%**
% of electricity consumption by the household and "other" sectors	%	0.7%	0.3%	0.1%	0.1%	0.5%	0.3%	0.1%	0.1%	0.0%	**2.2%**
Expected new savings in 2030											
Average primary energy savings per year	MWh	48,951	22,812	3,903	2,265	14,103	20,182	8,937	3,880	2,101	**127,134**
Average final energy savings per year	MWh	15,297	7,129	1,220	708	4,407	6,307	2,793	1,213	656	**39,729**
Expected new savings in 2040											
Average primary energy savings per year	MWh	100,276	31,879	7,707	3,682	27,560	44,470	12,794	7,424	3,500	**239,292**
Average final energy savings per year	MWh	31,336	9,962	2,409	1,151	8,612	13,897	3,998	2,320	1,094	**74,779**
Average annual GHG emission reductions	tonnes	13,090	4,671	1,022	520	3,684	5,676	2,372	1,004	485	**32,525**

Product group	Units	Cooling only - residential - houses	Cooling only - residential - apartments	Cooling only - commercial - office buildings	Cooling only - commercial - retail	Cooling only - commercial - hospitals	Cooling and heating - residential - houses	Cooling and heating - residential - apartments	Cooling and heating - commercial - office buildings	Cooling and heating - commercial - retail	Total
Additional (marginal) investment in EE in appliances - annual	1,000 EUR/ year	2,480	1,577	296	134	376	11,406	4,147	1,680	544	**€ 22,639**
Value of financial savings from energy saved - annual	1,000 EUR/ year	1,108	417	122	64	439	475	167	121	59	**€ 2,973**
Additional (marginal) investment in EE in appliances - cumulative	1,000 EUR/ year	54,170	35,416	6,559	3,197	9,923	255,804	95,116	38,603	13,351	**€ 512,137**
Value of financial savings from energy saved - cumulative	1,000 EUR/ year	84,968	28,242	9,197	4,499	32,929	37,369	11,332	8,921	4,246	**€ 221,704**
Investment cost per MWh saved - lifetime	EUR	€50	€92	€78	€75	€33	€548	€92	€467	€335	
Payback period for medium efficiency versus low efficiency model	year	12	20	12	13	5	12	20	12	13	
Payback period for high efficiency versus low efficiency model	year	20	20	20	20	9	20	20	20	20	
% of market with appliance in base year		32%	35%	35%	50%	90%	32%	32%	35%	50%	
% of market with appliance in 2040	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	

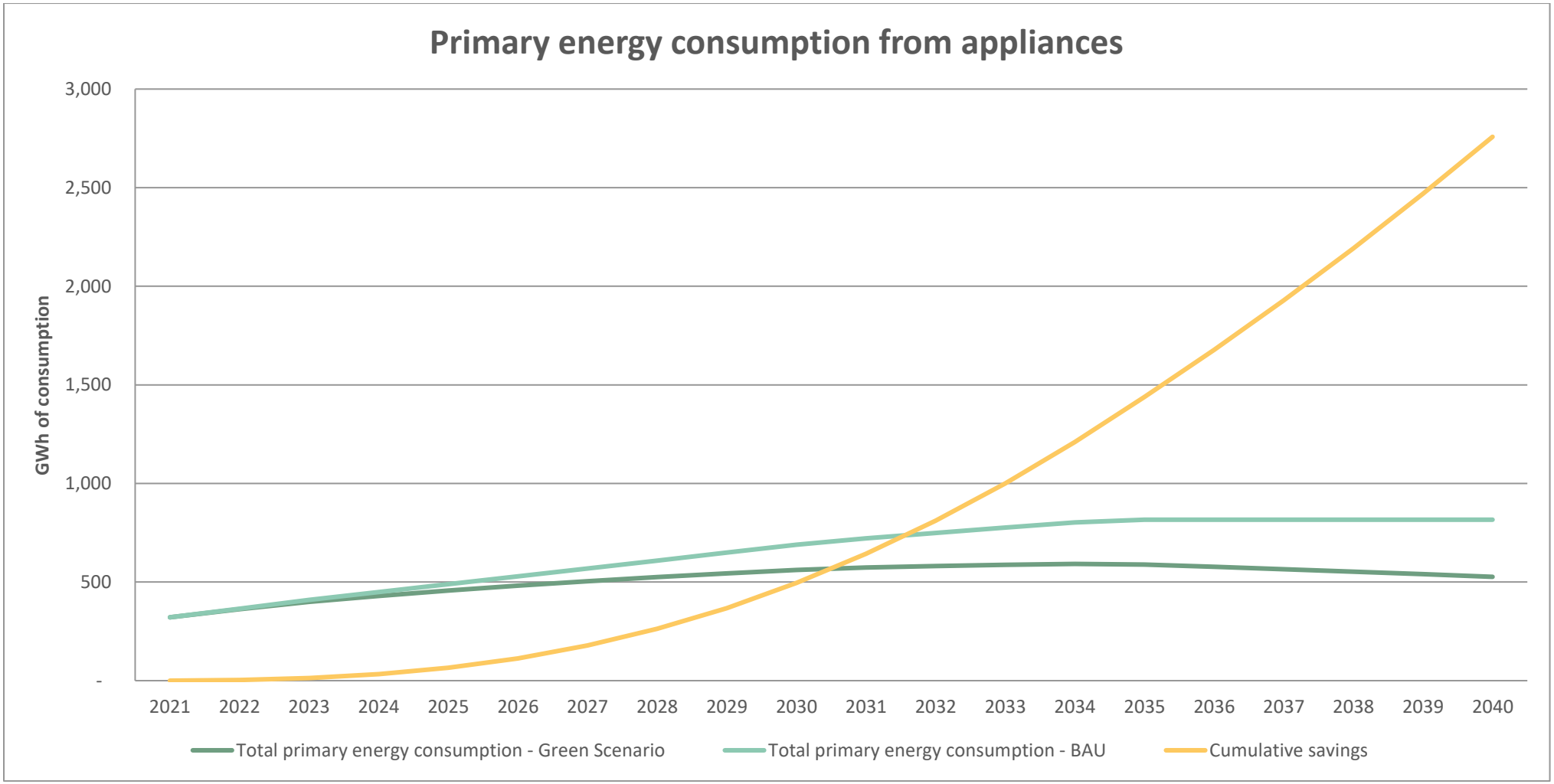

Figure 2: Primary energy consumption by air conditioners – excluding uses for heating

Table 4: Sensitivity analysis – changes in the estimated impacts of improved cooling (cooling only) in case of increased or decreased number of hours using cooling technology

Hours of usage (i.e. over / under 300 hours per year for residential, 436 hours for offices, 1800 hours per year for hospitals)	Average annual GHG emission reductions	Value of financial savings from energy saved - cumulative
100%	32,525	€ 221,704
70%	22,768	€ 155,193
85%	27,647	€ 188,449
100%	32,525	€ 221,704
115%	37,404	€ 254,960
130%	42,283	€ 288,216

Annex A. Impact summaries and assumptions for calculations of the sectors analysed

This annex includes the various assumptions based upon which the calculations on energy savings, marginal cost increases, financial savings, etc. are based.

Based on a Primary Energy Factor (PEF) for electricity in buildings in North Macedonia of 3.2, we used a ratio of 31.3% final energy to primary energy. This ratio was used to calculate primary energy consumption savings.

The electricity grid emissions factor used was 0.739 tonnes of CO_2eq per MWh[8].

Sources utilised are described for each type of building situation in the tables and in general are as follows where numers are referenced:

1: Topten EU website - http://www.topten.eu/

2: Italian topten site http://www.eurotopten.it/ - Note price range for A+++ models - from 1700 to 4000 EUR

3: Market analysis by the consultant

The dynamics for percentage of new appliances to be purchased on the market each year through 2040 are available in the accompanying excel-based model with summaries included below 6 years after regulatory adoption of ecodesign / energy labelling regulations (assumed to occur in 2021) with some level of incentive for improvement.

[8] *EIB Project Carbon Footprint Methodologies - Methodologies for the Assessment of Project GHG Emissions and Emission Variations*. EIB, July 2020. Emission factor for electricity consumption/ Network losses LV grid +7%

A.1 Single family houses with non-electric heating

	Unit	Value	Notes, Source of information
Current penetration rates			
% of market with appliance	%	32%	3
# of appliances	#	74,897	Calculated
Estimated annual growth in portion of market with the appliance	%	5%	Assumption - growing to 100% market penetration
Low efficiency model	%	50%	Assumption
Medium efficiency model	%	40%	Assumption
High efficiency model	%	10%	Assumption
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	42,621	Calculated
% of final energy consumption by the household and "other" sectors	%	0.5%	Calculated
Projected rates of new models purchased in improved energy efficiency scenario after 6 years			
Low efficiency model	%	5%	Assumption
Medium efficiency model	%	60%	Assumption
High efficiency model	%	35%	Assumption
Technical characteristics			
Number of days in a year	days/year	365	
Cooling hours per year	hours/year	300	Assumption: 5 hours per day for 60 days
Heating hours per year	hours/year	100	Assumption - topping up other heating sources
Typical cooling capacity	kW	7.0	Assumption - to cool a 120m sq space
Typical heating capacity	kW	3.5	Assumption
Low efficiency model			
Lifetime	year	13	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	3.21	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	2.50	3
Energy label equivalent - cooling	Label	E	As per Energy labelling regulations
Energy label equivalent - heating	Label	E	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	554	Calculated
Expected annual energy consumption - heating	kWh	163	Calculated
Total annual energy consumption	kWh	718	Calculated

	Unit	Value	Notes, Source of information
Price	EUR	€300	3
Medium efficiency model			
Lifetime	year	13	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	5.86	Average of Low and High efficiency
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	3.41	3 / Requirement of ecodesign regulations
Energy label equivalent - cooling	Label	A+	As per Energy labelling regulations
Energy label equivalent - heating	Label	A	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	382	Calculated
Expected annual energy consumption - heating	kWh	73	Calculated
Total annual energy consumption	kWh	455	Calculated
Price	EUR	€500	3
High efficiency model			
Lifetime	year	13	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	8.51	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	5.75	3
Energy label equivalent - cooling	Label	A+++	As per Energy labelling regulations
Energy label equivalent - heating	Label	A+++	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	209	Calculated
Expected annual energy consumption - heating	kWh	71	Calculated
Total annual energy consumption	kWh	280	Calculated
Price	EUR	€1,000	3
Expected savings			
Average primary energy savings per year	MWh	74,544	Calculated
Average final energy savings per year	MWh	23,295	Calculated
Annual GHG emission reductions	Tonnes	17,215	Calculated
Additional (marginal) investment in EE in appliances - annual	EUR/ year	€2,479,812	For the years 2021 - 2040 (19 years)
Value of financial savings from energy saved - annual	EUR/ year	€1,466,746	For the years 2021 - 2040 (19 years)
Additional (marginal) investment in EE in appliances - cumulative	EUR	€54,169,901	Over lifetime of investments
Value of financial savings from energy saved	EUR	€110,806,153	Over lifetime of investments

	Unit	Value	Notes, Source of information
Investment cost per MWh saved	EUR	€38.25	Calculated
Payback period for medium versus low efficiency model	year	8	Calculated
Payback period for high efficiency versus low efficiency model	year	17	Calculated

A.2 Apartments with non-electric heating

	Unit	Value	Notes, Source of information
Current penetration rates			
% of market with appliance	%	35.0%	3
# of appliances	#	58,469	Calculated
Estimated annual growth in portion of market with the appliance	%	7.0%	Assumption - growing to 100% market penetration
Low efficiency model	%	50.0%	Assumption
Medium efficiency model	%	35.0%	Assumption
High efficiency model	%	15.0%	Assumption
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	19,833	Calculated
% of final energy consumption by the household and "other" sectors	%	0.2%	Calculated
Projected rates of new models purchased in improved energy efficiency scenario after 6 years			
Low efficiency model	%	5%	Assumption
Medium efficiency model	%	55%	Assumption
High efficiency model	%	40%	Assumption
Technical characteristics			
Number of days in a year	days/year	365	
Cooling hours per year	hours/year	300	Assumption: 5 hours for 60 days
Heating hours per year	hours/year	100	Assumption - topping up other heating sources
Typical cooling capacity	kW	3.5	Assumption - to cool a 70-75m sq space

	Unit	Value	Notes, Source of information
Typical heating capacity	kW	3.5	Assumption - to heat a 70-75m sq space
Low efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	3.2	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	2.5	3
Energy label equivalent - cooling	Label	E	As per Energy labelling regulations
Energy label equivalent - heating	Label	E	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	277	Calculated
Expected annual energy consumption - heating	kWh	163	Calculated
Total annual energy consumption	kWh	441	Calculated
Price	EUR	€300	3
Medium efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	5.86	Average of Low and High efficiency
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	3.41	3 / Requirement of ecodesign regulations
Energy label equivalent - cooling	Label	A+	As per Energy labelling regulations
Energy label equivalent - heating	Label	A	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	191	Calculated
Expected annual energy consumption - heating	kWh	73	Calculated
Total annual energy consumption	kWh	264	Calculated
Price	EUR	€500	3
High efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	8.51	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	5.75	3
Energy label equivalent - cooling	Label	A+++	As per Energy labelling regulations
Energy label equivalent - heating	Label	A+++	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	105	Calculated
Expected annual energy consumption - heating	kWh	71	Calculated

	Unit	Value	Notes, Source of information
Total annual energy consumption	kWh	176	Calculated
Price	EUR	€1,000	3
Expected savings			
Average primary energy savings per year	MWh	33,673	Calculated
Average final energy savings per year	MWh	10,523	Calculated
Annual GHG emission reductions	Tonnes	7,776	Calculated
Additional (marginal) investment in EE in appliances - annual	EUR/ year	€1,577,235	For the years 2021 - 2040 (19 years)
Value of financial savings from energy saved - annual	EUR/ year	€699,446	For the years 2021 - 2040 (19 years)
Additional (marginal) investment in EE in appliances - cumulative	EUR	€35,416,003	Over lifetime of investments
Value of financial savings from energy saved	EUR	€46,496,897	Over lifetime of investments
Investment cost per MWh saved	EUR	€55	Calculated
Payback period for medium versus low efficiency model	year	12	Calculated
Payback period for high efficiency versus low efficiency model	year	20	Calculated

A.3 Offices with non-electric heating

	Unit	Value	Notes, Source of information
Current penetration rates			
% of market with appliance	%	35.0%	3
# of appliances	#	8,672	Calculated
Estimated annual growth in portion of market with the appliance	%	5.0%	Assumption - growing to 100% market penetration
Low efficiency model	%	50.0%	Assumption
Medium efficiency model	%	35.0%	Assumption
High efficiency model	%	15.0%	Assumption
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	3,829	Calculated
% of final energy consumption by the household and "other" sectors	%	0.05%	Calculated
Projected rates of new models purchased in improved energy efficiency scenario after 6 years			
Low efficiency model	%	5%	Assumption
Medium efficiency model	%	55%	Assumption

	Unit	Value	Notes, Source of information
High efficiency model	%	40%	Assumption
Technical characteristics			
Number of days in a year	days/year	365	
Cooling hours per year	hours/year	436	Assumption: 6 hours per day, 5 days per week, 2 months + 4 hours per day for 2 months
Heating hours per year	hours/year	100	Assumption - topping up other heating sources
Typical cooling capacity	kW	3.5	Assumption - to cool a 30-40m sq space
Typical heating capacity	kW	3.5	Assumption - to heat a 30-40m sq space
Low efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	3.21	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	2.50	3
Energy label equivalent - cooling	Label	E	As per Energy labelling regulations
Energy label equivalent - heating	Label	E	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	403	Calculated
Expected annual energy consumption - heating	kWh	168	Calculated
Total annual energy consumption	kWh	571	Calculated
Price	EUR	€300	3
Medium efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	5.86	Average of Low and High efficiency
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	3.41	3 / Requirement of ecodesign regulations
Energy label equivalent - cooling	Label	A+	As per Energy labelling regulations
Energy label equivalent - heating	Label	A	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	277	Calculated
Expected annual energy consumption - heating	kWh	73	Calculated
Total annual energy consumption	kWh	351	Calculated
Price	EUR	€500	3
High efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	8.51	3

	Unit	Value	Notes, Source of information
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	5.90	3
Energy label equivalent - cooling	Label	A+++	As per Energy labelling regulations
Energy label equivalent - heating	Label	A+++	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	152	Calculated
Expected annual energy consumption - heating	kWh	71	Calculated
Total annual energy consumption	kWh	223	Calculated
Price	EUR	€1,100	3
Expected savings			
Primary energy savings per year	MWh	6,447	Calculated
Average final energy savings per year	MWh	2,015	Calculated
Annual GHG emission reductions	Tonnes	1,489	Calculated
Additional (marginal) investment in EE in appliances - annual	EUR/ year	€295,931	For the years 2021 - 2040 (19 years)
Value of financial savings from energy saved - annual	EUR/ year	€179,338	For the years 2021 - 2040 (19 years)
Additional (marginal) investment in EE in appliances - cumulative	EUR	€6,558,553	Over lifetime of investments
Value of financial savings from energy saved	EUR	€13,252,087	Over lifetime of investments
Investment cost per MWh saved	EUR	€54	Calculated
Payback period for medium versus low efficiency model	year	7	Calculated
Payback period for high efficiency versus low efficiency model	year	17	Calculated

A.4 Retail premises with non-electric heating

	Unit	Value	Notes, Source of information
Current penetration rates			
% of market with appliance	%	50.0%	3
# of appliances	#	5,074	Calculated
Estimated annual growth in portion of market with the appliance	%	5.0%	Assumption - growing to 100% market penetration
Low efficiency model	%	40.0%	Assumption
Medium efficiency model	%	50.0%	Assumption
High efficiency model	%	10.0%	Assumption
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	3,088	Calculated

	Unit	Value	Notes, Source of information
% of final energy consumption by the household and "other" sectors	%	0.04%	Calculated
Projected rates of new models purchased in improved energy efficiency scenario after 6 years			
Low efficiency model	%	0%	Assumption
Medium efficiency model	%	70%	Assumption
High efficiency model	%	30%	Assumption
Technical characteristics			
Number of days in a year	days/year	365	
Cooling hours per year	hours/year	436	Assumption: 6 hours per day, 5 days per week, 2 months + 4 hours per day for 2 months
Heating hours per year	hours/year	100	Assumption - topping up other heating sources
Typical cooling capacity	kW	5	Assumption - to cool a 80-100m sq space
Typical heating capacity	kW	5	Assumption - to heat a 80-100m sq space
Low efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	3.2	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	2.5	3
Energy label equivalent - cooling	Label	E	As per Energy labelling regulations
Energy label equivalent - heating	Label	E	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	576	Calculated
Expected annual energy consumption - heating	kWh	240	Calculated
Total annual energy consumption	kWh	815	Calculated
Price	EUR	€400	3
Medium efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	5.9	Average of Low and High efficiency
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	3.4	3 / Requirement of ecodesign regulations
Energy label equivalent - cooling	Label	A+	As per Energy labelling regulations
Energy label equivalent - heating	Label	A	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	396	Calculated

	Unit	Value	Notes, Source of information
Expected annual energy consumption - heating	kWh	105	Calculated
Total annual energy consumption	kWh	501	Calculated
Price	EUR	€700	3
High efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	8.5	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	5.9	3
Energy label equivalent - cooling	Label	A+++	As per Energy labelling regulations
Energy label equivalent - heating	Label	A+++	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	217	Calculated
Expected annual energy consumption - heating	kWh	102	Calculated
Total annual energy consumption	kWh	319	Calculated
Price	EUR	€1,500	3
Expected savings			
Primary energy savings per year	MWh	3,338	Calculated
Average final energy savings per year	MWh	1,043	Calculated
Annual GHG emission reductions	Tonnes	771	Calculated
Additional (marginal) investment in EE in appliances - annual	EUR/ year	€134,147	For the years 2021 - 2040 (19 years)
Value of financial savings from energy saved - annual	EUR/ year	€95,462	For the years 2021 - 2040 (19 years)
Additional (marginal) investment in EE in appliances - cumulative	EUR	€3,197,166	Over lifetime of investments
Value of financial savings from energy saved	EUR	€6,589,856	Over lifetime of investments
Investment cost per MWh saved	EUR	€50	Calculated
Payback period for medium versus low efficiency model	year	7	Calculated
Payback period for high efficiency versus low efficiency model	year	16	Calculated

A.5 Hospitals

	Unit	Value	Notes, Source of information
Current penetration rates			
% of market with appliance	%	90.0%	3
Conditioned floorspace area	m2	505,142	Calculated

	Unit	Value	Notes, Source of information
Estimated annual growth in portion of market with the appliance	%	5.0%	Assumption - growing to 100% market penetration
Low efficiency model	%	40.0%	Assumption
Medium efficiency model	%	40.0%	Assumption
High efficiency model	%	20.0%	Assumption
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	23,608	Calculated
% of final energy consumption by the household and "other" sectors	%	0.3%	Calculated
Projected rates of new models purchased in improved energy efficiency scenario after 6 years			
Low efficiency model	%	0%	Assumption
Medium efficiency model	%	60%	Assumption
High efficiency model	%	40%	Assumption
Technical characteristics			
Number of days in a year	days/year	365	
Cooling hours per year	hours/year	1,800	12 hours per day, 5 months of the year
Heating hours per year	hours/year	-	N/A
Cooling capacity	kW/m2	0.12	Assumption based on standard guidance for AC sizing
Typical heating capacity	kW	-	N/A
Low efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	3.2	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	2.5	3
Energy label equivalent - cooling	Label	E	As per Energy labelling regulations
Energy label equivalent - heating	Label	E	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	67	Calculated
Expected annual energy consumption - heating	kWh	-	Calculated
Total annual energy consumption	kWh	67	Calculated
Price	EUR / m2	40	3
Medium efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	5.9	Average of Low and High efficiency

	Unit	Value	Notes, Source of information
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	3.4	Requirement of ecodesign regulation
Energy label equivalent - cooling	Label	A+	As per Energy labelling regulations
Energy label equivalent - heating	Label	A	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	37	Calculated
Expected annual energy consumption - heating	kWh	-	Calculated
Total annual energy consumption	kWh	37	Calculated
Price	EUR / m2	60	3
High efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	8.5	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	5.9	3
Energy label equivalent - cooling	Label	A+++	As per Energy labelling regulations
Energy label equivalent - heating	Label	A+++	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	25	Calculated
Expected annual energy consumption - heating	kWh	-	Calculated
Total annual energy consumption	kWh	25	Calculated
Price	EUR / m2	90	3
Expected savings			
Primary energy savings per year	MWh	15,953	Calculated
Average final energy savings per year	MWh	4,985	Calculated
Annual GHG emission reductions	Tonnes	3,684	Calculated
Additional (marginal) investment in EE in appliances - annual	EUR/ year	€375,560	Calculated
Value of financial savings from energy saved - annual	EUR/ year	€439,225	Calculated
Additional (marginal) investment in EE in appliances - cumulative	EUR	€9,922,678	Over lifetime of investments
Value of financial savings from energy saved	EUR	€32,929,265	Over lifetime of investments
Investment cost per MWh saved	EUR	€33	Calculated
Payback period for medium versus low efficiency model	year	5	Calculated
Payback period for high efficiency versus low efficiency model	year	9	Calculated

A.6 Single family houses with electric heating

	Unit	Value	Notes, Source of information
Current penetration rates			
% of market with appliance	%	32.3%	3
# of appliances	#	29,997	Calculated
Estimated annual growth in portion of market with the appliance	%	5.0%	Assumption - growing to 100% market penetration
Low efficiency model	%	70.0%	Assumption
Medium efficiency model	%	30.0%	Assumption
High efficiency model	%	0.0%	Assumption
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	1,066,185	Calculated
% of final energy consumption by the household and "other" sectors	%	13.3%	Calculated
Projected rates of new models purchased in improved energy efficiency scenario after 6 years			
Low efficiency model	%	25%	Assumption
Medium efficiency model	%	50%	Assumption
High efficiency model	%	25%	Assumption
Technical characteristics			
Number of days in a year	days/year	365	
Cooling hours per year	hours/year	300	Assumption: 5 hours for 60 days
Heating hours per year	hours/year	2,190	Assumption: 6 months, 12 hours per day
Typical cooling capacity	kW	7.0	Assumption - to cool a 120m sq space
Typical heating capacity	kW	16.0	2
Low efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	3.2	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	1.0	3
Energy label equivalent - cooling	Label	E	As per Energy labelling regulations
Energy label equivalent - heating	Label	G	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	554	Calculated
Expected annual energy consumption - heating	kWh	35,040	Calculated
Total annual energy consumption	kWh	35,594	Calculated
Price	EUR	300	3
Medium efficiency model			
Lifetime	year	13.0	1

	Unit	Value	Notes, Source of information
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	5.9	Average of Low and High efficiency
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	1.0	3 / Requirement of ecodesign regulations
Energy label equivalent - cooling	Label	A+	As per Energy labelling regulations
Energy label equivalent - heating	Label	G	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	382	Calculated
Expected annual energy consumption - heating	kWh	35,040	Calculated - Heating with electric heat pumps
Total annual energy consumption	kWh	35,422	Calculated
Price	EUR	500	3
High efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	8.5	3
Seasonal Coefficient of Performance (SCOP) - heating	Ratio	5.9	3
Energy label equivalent - cooling	Label	A+++	As per Energy labelling regulations
Energy label equivalent - heating	Label	A+++	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	209	Calculated
Expected annual energy consumption - heating	kWh	7,115	Calculated - Heating with electric heat pumps
Total annual energy consumption	kWh	7,324	Calculated
Price	EUR	9,000	3
Expected savings			
Primary energy savings per year	MWh	1,517,907	Calculated
Average final energy savings per year	MWh	474,346	Calculated
Annual GHG emission reductions	Tonnes	350,542	Calculated
Additional (marginal) investment in EE in appliances - annual	EUR/ year	€11,405,509	For the years 2021 - 2040 (19 years)
Value of financial savings from energy saved - annual	EUR/ year	€28,445,809	For the years 2021 - 2040 (19 years)
Additional (marginal) investment in EE in appliances - cumulative	EUR	€255,803,633	Over lifetime of investments
Value of financial savings from energy saved	EUR	€2,395,582,928	Over lifetime of investments
Investment cost per MWh saved	EUR	€9	Calculated
Payback period for medium versus low efficiency model	year	12	Calculated
Payback period for high efficiency versus low efficiency model	year	3	Calculated

A.7 Apartments with electric heating

	Unit	Value	Notes, Source of information
Current penetration rates			
% of market with appliance	%	32.3%	3
# of appliances	#	21,580	Calculated
Estimated annual growth in portion of market with the appliance	%	7.0%	Assumption - growing to 100% market penetration
Low efficiency model	%	50.0%	Separate heater and air conditioner
Medium efficiency model	%	35.0%	
High efficiency model	%	15.0%	High efficiency air source heat pump
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	420,874	Calculated
% of final energy consumption by the household and "other" sectors	%	5.26%	Calculated
Projected rates of new models purchased in improved energy efficiency scenario after 6 years			
Low efficiency model	%	5%	Assumption
Medium efficiency model	%	55%	Assumption
High efficiency model	%	40%	Assumption
Technical characteristics			
Number of days in a year	days/year	365	
Cooling hours per year	hours/year	300	Assumption: 5 hours for 60 days
Heating hours per year	hours/year	2,190	Assumption: 6 months, 12 hours per day
Typical cooling capacity	kW	3.5	Assumption - to cool a 70-75m sq space
Typical heating capacity	kW	10.0	Assumption - to heat a 70-75m sq space
Low efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	3.2	3
Seasonal Coefficient of Performance (SCOP) - Heating	Ratio	1.0	3
Energy label equivalent - cooling	Label	E	As per Energy labelling regulations
Energy label equivalent - heating	Label	G	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	277	Calculated
Expected annual energy consumption - heating	kWh	21,900	Calculated - Heating with electric heaters
Total annual energy consumption	kWh	22,177	Calculated
Price	EUR	€ 300	3
Medium efficiency model			

	Unit	Value	Notes, Source of information
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	5.9	Average of Low and High efficiency
Seasonal Coefficient of Performance (SCOP) - Heating	Ratio	1.0	3 / Requirement of ecodesign regulations
Energy label equivalent - cooling	Label	A+	As per Energy labelling regulations
Energy label equivalent - heating	Label	G	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	191	Average of A+++ and B
Expected annual energy consumption - heating	kWh	21,900	Heating with electric heat pumps
Total annual energy consumption	kWh	22,091	Calculated
Price	EUR	€ 500	3
High efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	8.5	3
Seasonal Coefficient of Performance (SCOP) - Heating	Ratio	5.9	3
Energy label equivalent - cooling	Label	A+++	As per Energy labelling regulations
Energy label equivalent - heating	Label	A+++	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	105	Calculated
Expected annual energy consumption - heating	kWh	4,447	Heating with electric heat pumps
Total annual energy consumption	kWh	4,552	Calculated
Price	EUR	€ 5,500	3
Expected savings			
Primary energy savings per year	MWh	621,568	Calculated
Average final energy savings per year	MWh	194,240	Calculated
Annual GHG emission reductions	Tonnes	181,822	Calculated
Additional (marginal) investment in EE in appliances - annual	EUR/ year	€4,147,211	For the years 2021 - 2040 (19 years)
Value of financial savings from energy saved - annual	EUR/ year	€12,421,171	For the years 2021 - 2040 (19 years)
Additional (marginal) investment in EE in appliances - cumulative	EUR	€95,115,551	Over lifetime of investments
Value of financial savings from energy saved	EUR	€909,039,623	Over lifetime of investments
Investment cost per MWh saved	EUR	€55	Calculated
Payback period for medium versus low efficiency model	year	20	Calculated
Payback period for high efficiency versus low efficiency model	year	3	Calculated

A.8 Office premises with electric heating

	Unit	Value	Notes, Source of information
Current penetration rates			
% of market with appliance	%	35.0%	3
# of appliances	#	9,995	Calculated
Estimated annual growth in portion of market with the appliance	%	5.0%	Assumption - growing to 100% market penetration
Low efficiency model	%	40.0%	Assumption
Medium efficiency model	%	55.0%	Assumption
High efficiency model	%	5.0%	Assumption
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	95,338	Calculated
% of final energy consumption by the household and "other" sectors	%	1.2%	Calculated
Projected rates of new models purchased in improved energy efficiency scenario after 6 years			
Low efficiency model	%	0%	Assumption
Medium efficiency model	%	75%	Assumption
High efficiency model	%	25%	Assumption
Technical characteristics			
Number of days in a year	days/year	365	
Cooling hours per year	hours/yea r	436	Assumption: 6 hours per day, 5 days per week, 2 months + 4 hours per day for 2 months
Heating hours per year	hours/yea r	960	Assumption: only additional heating 6 hours x 30 days
Typical cooling capacity	kW	3.5	Assumption - to cool a 30-40m sq space
Typical heating capacity	kW	10.0	Assumption - to heat a 30-40m sq space
Low efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	3.2	3
Seasonal Coefficient of Performance (SCOP) - Heating	Ratio	1.0	3
Energy label equivalent - cooling	Label	E	As per Energy labelling regulations
Energy label equivalent - heating	Label	G	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	403	Calculated
Expected annual energy consumption - heating	kWh	9,600	Calculated - Heating with electric heaters
Total annual energy consumption	kWh	10,003	Calculated
Price	EUR	€ 300	3

Medium efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	5.9	Average of Low and High efficiency
Seasonal Coefficient of Performance (SCOP) - Heating	Ratio	1.0	3 / Requirement of ecodesign regulations
Energy label equivalent - cooling	Label	A+	As per Energy labelling regulations
Energy label equivalent - heating	Label	G	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	277	Average of A+++ and B
Expected annual energy consumption - heating	kWh	9,600	Calculated - Heating with electric heaters
Total annual energy consumption	kWh	9,877	Calculated
Price	EUR	€ 500	3
High efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	8.5	3
Seasonal Coefficient of Performance (SCOP) - Heating	Ratio	5.9	3
Energy label equivalent - cooling	Label	A+++	As per Energy labelling regulations
Energy label equivalent - heating	Label	A+++	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	152	Calculated
Expected annual energy consumption - heating	kWh	1,949	Calculated
Total annual energy consumption	kWh	2,101	Calculated
Price	EUR	€ 5,500	3
Expected savings			
Primary energy savings per year	MWh	106,774	Calculated
Average final energy savings per year	MWh	33,367	Calculated
Annual GHG emission reductions	Tonnes	24,658	Calculated
Additional (marginal) investment in EE in appliances - annual	EUR/ year	€1,680,325	For the years 2021 - 2040 (19 years)
Value of financial savings from energy saved - annual	EUR/ year	€2,843,191	For the years 2021 - 2040 (19 years)
Additional (marginal) investment in EE in appliances - cumulative	EUR	€38,603,307	Over lifetime of investments
Value of financial savings from energy saved	EUR	€231,680,785	Over lifetime of investments
Investment cost per MWh saved	EUR	€19	Calculated
Payback period for medium versus low efficiency model	year	12	Calculated
Payback period for high efficiency versus low efficiency model	year	5	Calculated

A.9 Shops with electric heating

	Unit	Value	Notes, Source of information
Current penetration rates			
% of market with appliance	%	50.0%	3
# of appliances	#	4,059	Calculated
Estimated annual growth in portion of market with the appliance	%	5.0%	Assumption - growing to 100% market penetration
Low efficiency model	%	50.0%	Assumption
Medium efficiency model	%	49.0%	Assumption
High efficiency model	%	1.0%	Assumption
Current estimated final energy consumption of all air conditioners in this sub-sector	MWh/ year	36,689	Calculated
% of final energy consumption by the household and "other" sectors	%	0.5%	Calculated
Projected rates of new models purchased in improved energy efficiency scenario after 6 years			
Low efficiency model	%	5%	Assumption
Medium efficiency model	%	69%	Assumption
High efficiency model	%	26%	Assumption
Technical characteristics			
Number of days in a year	days/year	365	
Cooling hours per year	hours/year	436	Assumption: 6 hours per day, 5 days per week, 2 months + 4 hours per day for 2 months
Heating hours per year	hours/year	1,440	Assumption: only additional heating 6 hours x 30 days
Typical cooling capacity	kW	5.0	Assumption
Typical heating capacity	kW	5.0	Assumption
Low efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	3.2	3
Seasonal Coefficient of Performance (SCOP) - Heating	Ratio	1.0	3
Energy label equivalent - cooling	Label	E	As per Energy labelling regulations
Energy label equivalent - heating	Label	G	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	576	Calculated
Expected annual energy consumption - heating	kWh	8,626	Calculated - Heating with electric heaters
Total annual energy consumption	kWh	9,202	Calculated
Price	EUR	€400	3

Medium efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	5.9	Average of Low and High efficiency
Seasonal Coefficient of Performance (SCOP) - Heating	Ratio	1.0	3 / Requirement of ecodesign regulations
Energy label equivalent - cooling	Label	A+	As per Energy labelling regulations
Energy label equivalent - heating	Label	G	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	396	Average of A+++ and B
Expected annual energy consumption - heating	kWh	8,626	Calculated - Heating with electric heaters
Total annual energy consumption	kWh	9,022	Calculated
Price	EUR	€700	3
High efficiency model			
Lifetime	year	13.0	1
Seasonal Energy efficiency rating (SEER) - cooling	Ratio	8.5	3
Seasonal Coefficient of Performance (SCOP) - Heating	Ratio	5.9	3
Energy label equivalent - cooling	Label	A+++	As per Energy labelling regulations
Energy label equivalent - heating	Label	A+++	As per Energy labelling regulations
Expected annual energy consumption - cooling	kWh	217	Calculated
Expected annual energy consumption - heating	kWh	1,462	Calculated
Total annual energy consumption	kWh	1,679	Calculated
Price	EUR	€5,500	3
Expected savings			
Primary energy savings per year	MWh	34,641	Calculated
Average final energy savings per year	MWh	10,825	Calculated
Annual GHG emission reductions	Tonnes	8,000	Calculated
Additional (marginal) investment in EE in appliances - annual	EUR/ year	€543,660	For the years 2021 - 2040 (19 years)
Value of financial savings from energy saved - annual	EUR/ year	€939,793	For the years 2021 - 2040 (19 years)
Additional (marginal) investment in EE in appliances - cumulative	EUR	€13,350,643	Over lifetime of investments
Value of financial savings from energy saved	EUR	€73,501,664	Over lifetime of investments
Investment cost per MWh saved	EUR	€20	Calculated
Payback period for medium versus low efficiency model	year	13	Calculated
Payback period for high efficiency versus low efficiency model	year	5	Calculated

Annex B: List of vendors interviewed

Brand	Contact Name	Vendor name	Email	Phone	Address	City
LG	Kristina Prilepchanska	FMS	kristina.prilepchanska@fms.mk	+389 71 990.033	Filip Vtori Makedonski #3 Soravia Center Skopje	Skopje
Daikin	Marko Kermichiev	Almakos	kermichiev.m@almakos.mk	+389 78 262 888	JNA #316A/4	Gostivat
Vaillant	Dean Naumovski	Vaillant Representative Office North Macedonia	dean.naumovski@vaillant.com	+389 70 243.993	Sv. Kiril i Metodij #20	Skopje
Ferroli	Kostadin Megleshev	Beli Euroteknika	k.maglesev@euroteknika.com.mk	+389 78 229.567	Kliment Ohridski #288	Strumica
Haier, Toshiba, Carrier	Vasil Ciconkov	Energija	vasil.ciconkov@energija.com.mk	+389 70 377.721	Londonska #1A	Skopje
Cooper & Hunter	Zdravko Delidinkov	Mepring Servisi	zdravko@mepserv.mk	389 70 380.170	Jurij Gagarin #73B	Skopje
IDM Energie	Darko Jakimovski	Eneks Group Engineering	darko.jakimovski@live.com	+389 70 837 892	Vangel Todorovski #17-1/7	Skopje
Daikin	Katerina Vasileva	ICS Group	katerina@icsgroup.mk	+389 2 3109949	Str. 164 #46A	Skopje

Annex C: Interview questions

Key issues to be discussed with a Distributor / Importer / Supplier

Regarding the Market readiness assessment of products for developing programmes to encourage sustainable cooling

Introduction and purpose of the meeting

E Co. Ltd – a private consultant firm specialized in sustainable energy and energy efficiency projects – is conducting a study on behalf of UNDP in cooperation with the N. Macedonia Ministry of Environment and Physical Planning supported by the Global Environment Facility (GEF) to assess the potential for implementing programmes to encourage sustainable cooling.

As part of this study, E Co. Ltd is contacting various stakeholders active in dealing with the market import, supply, distribution, and installation of cooling appliances to gain a better understanding of the readiness of the market for implementing potential initiatives to encourage more sustainable cooling. The purpose of the conversation is to:

- Provide brief overview of the concept of sustainable / efficient cooling – including existing and planned regulations such as those related to ecodesign and energy labelling;
- Gain insight from your organization about your role in the market for various types of appliances;
- Gain insight from your organization about what you see as the potential barriers and opportunities of introduction of programmes to promote more efficient / green cooling

Proposed agenda for the meeting

- Introductions (5 minutes)
- Brief background presentation on the study (5 minutes)
- Semi-structured discussion of the questions outlined below (40 minutes)

Questions to be discussed during the meeting

The proposed issues for discussion are as follows:

1. Can you describe your activities in the appliance sector related to the following product groups?

Type of product	Import (include main exporting countries)	Distribute	Total volume of turnover per year (number of units)			Typical energy characteristics (Coefficient of performance, rated kW, etc.) and price per piece of equipment including installation (MKD or EUR)	Is this number increasing (by how much per year)?
			<100	100 - 1000	>1000		
Air Conditioning units (<12kW) and comfort fans (<125W) for households / apartments							

High-efficiency							
Medium-efficiency							
Low-efficiency							
Air Conditioning units (<12kW) and comfort fans (<125W) for commercial buildings / offices / other							
High-efficiency							
Medium-efficiency							
Low-efficiency							
Combined space heating and cooling devices for households / apartments							
High-efficiency							
Medium-efficiency							
Low-efficiency							
Combined space heating and cooling devices for commercial buildings / offices / other							
High-efficiency							
Medium-efficiency							
Low-efficiency							
Larger scale installations for air conditioning units for commercial buildings / offices / other							
High-efficiency							
Medium-efficiency							
Low-efficiency							
Larger scale installations for combined heating and cooling installations for commercial buildings / offices / other							
High-efficiency							
Medium-efficiency							
Low-efficiency							

2. In your opinion, based on the introduction of energy labelling, how prepared are your customers to pay additional up-front costs in order to have energy efficient appliances?

3. Related to the regulatory framework for appliances, can you provide your opinion on whether you agree with the following statements (1 = strongly disagree, 5 = strongly agree)?

	1 - 5	Comments?
We are very aware of the regulatory framework, how it has been changing, and how it impacts our business and the products we sell?		
There is sufficient motivation/ legal requirement for businesses to promote energy efficient appliances?		
This legislation / regulations are enforced?		
There is sufficient motivation / legal requirement for customers to purchase energy efficient appliances?		
The implementation of the energy labelling laws has been difficult to achieve?		
The implementation of the energy labelling laws has resulted in customers shifting their behaviour?		

4. What do you think are the biggest issues to overcome to ensure effective implementation of existing / planned regulations?

	1 - 5	Comments?
Enforcement by the Government / Inspection Agencies		
Insufficient understanding of the concepts by the importers / suppliers / distributors		
Expensive financing options / high upfront costs for purchasing efficient appliances		
Insufficient information available at the point of sale on benefits of efficient appliances		
Insufficient general public awareness on benefits of efficient appliances		
Other (please specify)		

5. In influencing the purchase of energy efficient appliances, how effective do you believe the following mechanisms would be in influencing the purchasing behaviour of consumers (1 = highly ineffective, 5 = highly effective)?

	1 - 5	Comments?
Elimination of least efficient appliances from the legal market		
Stricter enforcement of the legal code to reduce sales via the grey / black market		
Provision of grants via local banks for purchase of more efficient appliances		
Provision of grants via local distributors for purchase of more efficient appliances		
Provision of grants geared towards poorer households for purchase of efficient appliances		
More information for customers about economic benefits of efficient appliances		
More information for customers about environmental benefits of efficient appliances		

6. Are there any other comments you would like to make?

7. Name / title / contact information of the interviewee: