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TECHNOLOGICAL TRENDS

D.1.4

PART OF WORK PACKAGE 1: MAPPING OF ENERGY EFFICIENCY POLICY INSTRUMENTS AND AVAILABLE TECHNOLOGIES IN BUILDINGS AND TRANSPORT

NATIONAL REPORT FOR BELGIUM

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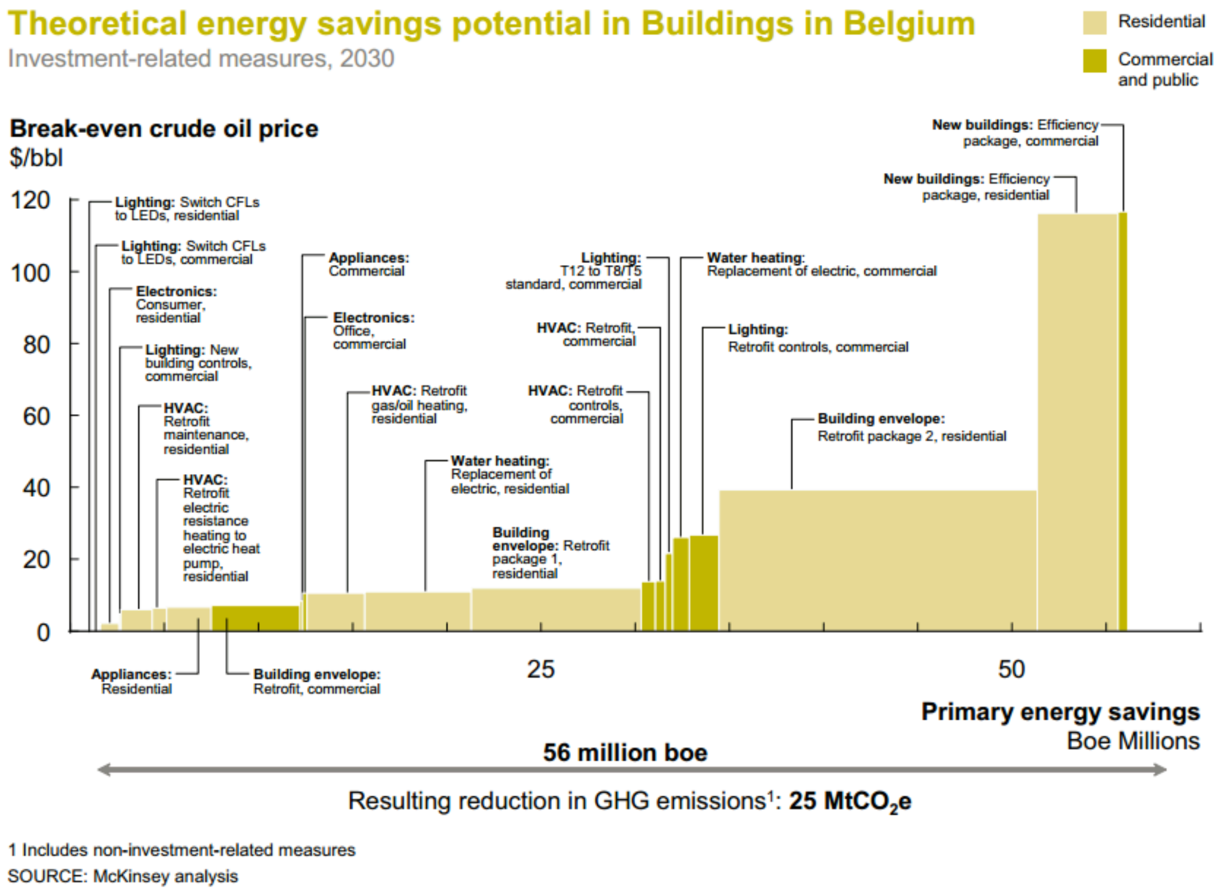
CHAPTER 1: TECHNOLOGICAL TRENDS IN THE BUILDING AND TRANSPORT SECTOR

1.1 ENERGY EFFICIENCY POTENTIAL

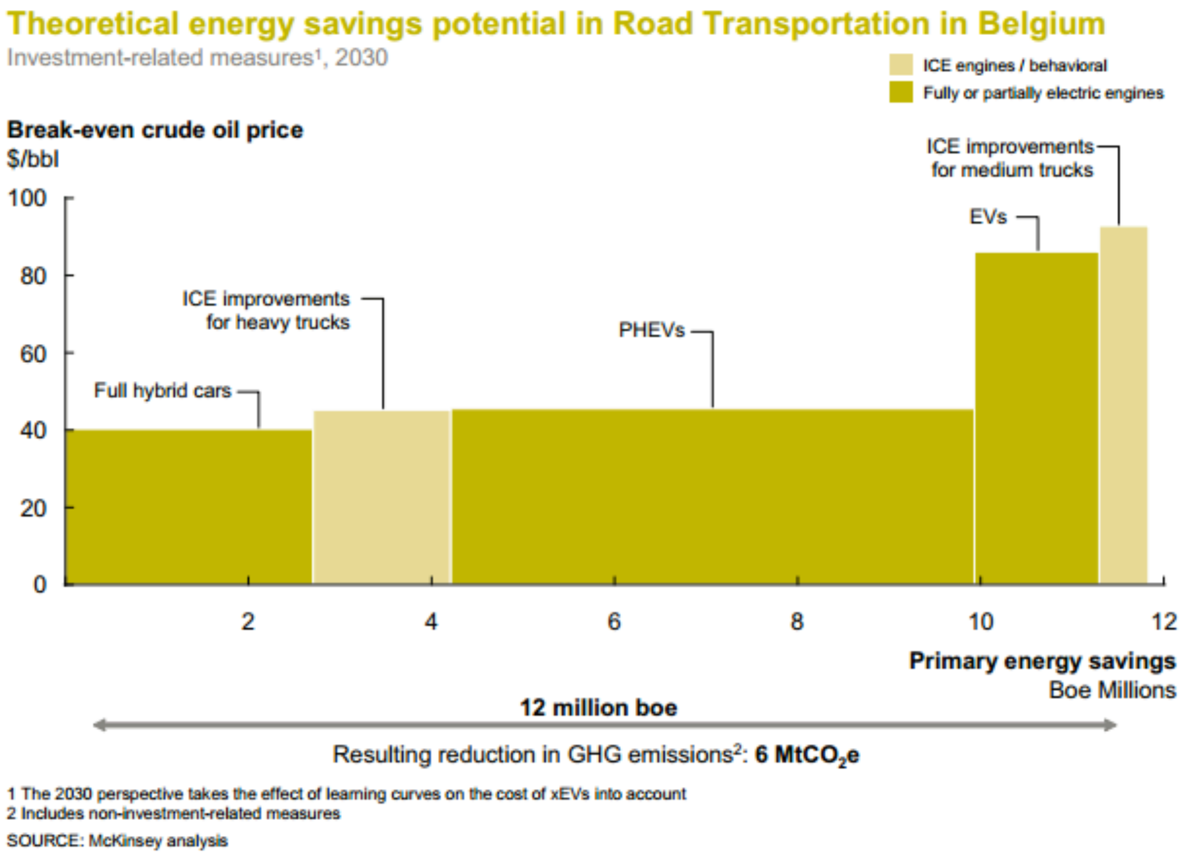
McKinsey [2009] estimates a theoretical energy savings potential of 71 million boe from the buildings sector by 2030. This represents 48% of the primary energy consumption expected by 2030 in the BAU scenario. 65 million boe would come from investment related measures, of which 51 million boe apply to residential buildings. The remaining 5 million ton boe of savings would come from behavioural changes.

Figure 1 Energy efficiency potential in the buildings sector in Belgium according to McKinsey.



McKinsey [2009] estimates a theoretical energy savings potential of 15 million boe from road transportation by 2030. Savings from investment-related measures amount to 12 million boe; savings from non-investment-related measures amount to 3 million boe. Energy improvement measures include conventional vehicle measures (technical improvements applied to conventional internal combustion engines), additional vehicle measures (mostly hybrid and electric vehicles), road infrastructure measures; and behavioural measures.

Figure 2 Energy efficiency potential in the transport sector in Belgium according to McKinsey.



1.2 TECHNOLOGIES AND POLICY INSTRUMENTS

There are numerous policies in Belgium which by means of regulation or subsidies encourage the use of energy efficiency technologies in the "sustainable construction" or "green building" sector. Some of those policies and measures include:

- The amendment to the Regulation on Energy Performance of Buildings (EPB), by the Flemish Region, the Walloon Region and the Brussels-Capital Region.
- The (reduced) support for energy saving investments by the Federal Government. 40 % tax rebates on amounts invested in energy-saving work such as boiler replacements, solar panel installation, double glazing and other insulation work. As from the 2013 tax year, the tax rebate for low-energy, passive and zero-energy dwellings has been removed, along with all tax rebates for energy-saving costs, with the exception of loft insulation, where the rebate has been reduced;
- The "*Energierenovatieprogramma 2020*" in the Flemish Region;
- The Marshall Plan 2.Green in the Walloon region;
- The employment-environment alliance (EEA) in the Brussels-Capital Region;

From 1 January 2014, it is no longer possible to build a house in Flanders without having a system to generate renewable energy. One of the possibilities to achieve this is to install a heat pump. It can be expected that the heat pump market in Belgium will benefit from the new regulation [European Heat Pump Association ehpa, 02.01.2014]. "*Strict rules regarding the renewable energy share of new houses have had a positive impact on the number of GSHP (Ground Source Heat Pumps) being installed in Flanders.*" [Loveless et al, 2015, p. 1]. "*GSHP comprise by far the greatest proportion of* *geothermal applications in Belgium. Many new medium to large buildings in the public sector are now equipped with GSHP. The total number of GSHP is expected to increase from 13,085 in 2010 to 22,613 in 2015, with total installed capacity increasing from 157 MWt to 218 MWt. The majority (estimated 80%) of applications are BTES (Borehole Thermal Energy Storage) systems, only 5% ATES (Aquifer Thermal Energy Storage) and the remaining 15% horizontal loop systems. … The growth of the shallow geothermal industry over the last 5 years is reflected in and promoted by a growing number of associated SMEs. R&D and training of the workforce for shallow geothermal energy has resulted in the establishment of a growing shallow geothermal market. Regional, national and international programmes were designed to transfer skills and education within the sector and to identify technical and legislative best practice across Europe. Stronger market growth is hindered by weak financial support, which results in relatively high payback times, particularly important for residential buildings. Environmental permitting can also be a problem in certain regions of the country. The foreseen changes to legislation and policy should lead to stronger market growth in the coming years*." [Loveless et al, 2015, p. 2].

"*Grid connected PV applications are seen as the largest potential in Belgium, in particular building applied or integrated applications on single family houses, apartment buildings, commercial and office buildings. … The public interest for building applied PVs is very high, especially in Flanders where almost 80 % of the PV power is installed.*" [APERe, 2013, p. 8] The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. In Flanders in 2012 303 MW were installed before 1 August 2012, and only 22 MW after, for a total installed capacity of 2,076 MW. In Wallonia in 2012 installed capacity doubled from 274 MWp to 547 MWp. In both instances, the announced abolition of the tax credit of the Federal Government end 2011 and various reductions in the guaranteed price of Green Certificates caused a peak in the number of installations in the first half of 2012. In Brussels, installed capacity increased from 8.3 MWp to 18.1 MWp, thanks to stable legislations and a high support scheme guaranteeing a 7-year ROI [APERe, 2013]. Net metering on annual base for small installations (< 10 kVA for Flanders and Wallonia, < 5 kVA for Brussels) was not questioned in Belgium during 2012 but distribution system operators (DSO')s started to point that net metering generates loss of income for the maintenance of the grid. DSO's from Flanders introduced a fixed tariff for all PV owners in 2013, but this was abolished in 2014 [Neyens, 2014]. Belgium was beginning to experience the effects of obliging prosumers to contribute to grid costs for their self-consumed electricity, even from existing systems [Solar Power Europe, 2015].

There are a number of incentives for electric vehicles in Belgium. There is a federal tax credit calculated as 15% of the purchase price, with a maximum of 4,940 EUR for quadricycles or 3,010 EUR for motorcycles or tricycles. The federal tax credit for electric passenger cars no longer exists. Companies can deduct 120% of the purchase cost for zero-emission vehicles. If the car is put at the disposal of an employee, the company pays a CO_2 solidarity tax. For electric vehicles, this tax is limited to 25.10 EUR per month (from 1 January 2015). Employees who use a company car in Belgium are taxed under the "benefit in kind" regulation. The tax calculation is made by using a formula that includes the percentage of CO_2 in the exhaust. For non-hybrid electric vehicles the lowest CO_2 percentage (4%) is used. The yearly vehicle tax and the car registration tax vary by Region. In Flanders, EVs and PHEVs are exempt from the registration tax. Owners of EVs pay the lowest tariff of the circulation tax in all three Regions. In Wallonia the "Eco-bonus" of up to 2,500 EUR for electric vehicles no longer exists. In Flanders, the "Ecology premiums" for companies investing in the purchase of pure electric, plug-in hybrid and extended range electric vehicles no longer exist. In Belgium, in 2013, sales growth of hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV) and electric vehicles (EV) was slower than expected. Sales of electric passenger cars (PHEVs and EVs combined) decreased by 15% in 2013 compared to 2012. In 2013 769 electric passenger cars were sold, for a total fleet of 1,795 electric passenger cars. The use of hybrid buses increased. In 2013 79 buses, or 3.5% of the bus fleet of the Flemish Public Transport Operator "*De Lijn*", are hybrids. This sector is the largest growing market within electric mobility. In Belgium, in 2013, more than 400,000 bicycles were sold, of witch about 50,000 electric bicycles. Electric bicycles are also increasingly being used in bike sharing systems, like Bluebike [IEA, 2014].

1.3 Market Perspectives due to Technological Trends

The Belgian construction market is one of the country's largest sectors. It is also a very diverse sector that includes many actors and specializations.

There is a strong need for "green building" in Belgium, as the energy efficiency of its buildings is one of the lowest in Europe. The building sector has thus become an area where new technology plays an important role in terms of energy efficiency [CTCS, 2014]. According to a survey conducted in 2010, some 70 % of the sector's entrepreneurs stated that they were active in *sustainable construction*. According to a survey conducted by the Flemish Construction Union of 205 residential construction companies, insulation of roofs, walls and floors, air tightness, insulation joinery as well as energy-efficient facilities for heating, cooling and ventilation are always regarded as more important.

Figure 3 Number and share of "green building" aspects that are part of the activities of a company in the Belgian construction sector (multiple answers possible).

Answer	Total	Percentage of answers	%
Thermic super-insulation of floors, walls, roofs, windows...	591		62 %
Acoustic confort (acoustic insulation of floors, walls, roofs, windows...)	329		35 %
Use of renewable raw materials (certified woord, recyclable or recycled material, rain water...)	326		34 %
Processing or reuse of waste products (seperated types of waste on the construction site, recycling of materials, treatment of water...)	321		34 %
Super energy efficient equipment (heating, ventilation, warm water, lighting)	302		32 %
Safety in buildings	235		25 %
Reduction of maintenance costs	222		23 %
Alternative energy (solar energy, wind energy, geothermal energy...)	193		20 %
Adaptation to needs of disabled persons (accessibility, sanitary fittings...)	147		15 %
Air quality (use of materials without solvents, air purfication...)	138		14 %
Modular construction	33		3 %
Others	55		6 %
Total number of answars: 952		0% 20% 40% 60% 80%	

Source: IDEA Consult, 2010, p. 45.

The Belgian building sector accordingly has a significant potential for "green employment". In 2012, the 277,200 jobs in the construction industry represented 6.1% of all employment. Around 11% of those are likely to be "green", primarily people employed within public transport infrastructure and energy efficiency. The Planning Bureau anticipates that 9,500 new jobs will be created in the sector by 2017. This should include an increasing proportion of green jobs [Plasman, 2013, p. 2].

The renovation of existing buildings creates opportunities [Plasman, 2013 p. 5]:

- In 2009, the "Central Economic Council" and the "National Labour Council" estimated that the replacement of 10 000 old boilers, the technical renovation of half of Belgium's housing stock and the replacement of all single glazing with double glazing could create work for 34,700 people for one year;
- In 2011, the Belgian Construction Federation estimated that the energy renewal of existing buildings (excluding wall and floor work) should provide jobs for a total of 13,500 people over the next 10 years. More rigorous criteria will result not only in an increase in green jobs but also in a greening of existing employment, given that these regulations have an impact on the working methods and kinds of activities required by these jobs (technological modifications, choice of materials, replacing the maintenance of heating systems with that of a far more substantial ventilation system in passive houses, etc.).

The construction of new buildings likewise offers opportunities [CTCS, 2014]:

- Passive construction has become a reality in the construction of new buildings. Across all sectors, today there are about two thousand passive buildings in Belgium, of which around 700 are certified. Just five years ago, passive construction was a rather marginal phenomenon, whereas now it is a recognized construction standard. A new set of rules governing the Energy Performance of Buildings for 2015 in the Brussels-Capital Region state that all new construction or major renovation projects must comply with the passive standard from 2015.

The building market in Belgium is highly competitive among the domestic producers and other suppliers. However, there are opportunities for exporters to Belgium in specific market niches in the Belgian construction materials market. The Belgian trade federation FEMA is interested in opening the Belgian market to competitive foreign building materials, including green building products. The Belgian construction market values high-quality materials and products that are often only imported from abroad. Belgium's principle importing countries for building construction include Germany, Luxembourg, Spain and France [USA International Business Publications; 2012].

Despite the Belgian tradition of building in brick, new materials have been introduced. More in particular, there is a growing interest in wood construction. Over the last ten years, the field of timber construction has boomed. Building in wood is not only healthy and environmentally friendly, but also ideal for meeting the high demands of energy-efficient buildings. A survey conducted by Houtinfobois covering the years 2011-2012 shows that more than 200 Belgian companies are putting up wooden buildings. The market share for timber construction was 8.1% in 2012, a growth rate of 36.7% over the previous year, despite the recession and the decline in the number of building permits granted. A large percentage (70%) of the wood used in construction in Belgium is imported. The species most commonly used in Belgium for timber construction are: Douglas Europe or Oregon pine, from North America, spruce and pine. Competition is tough, especially for laminated flooring (there are a large number of Belgian suppliers) and wood (there are a large number of Scandinavian, Austrian, German and Russian suppliers). In total, 90% of the wood used in Belgium is of European origin. The main issues in timber construction currently relate to acoustics (especially bass), stability, fire safety, air tightness and construction joints. These elements can be a hindrance to the development of collective and multi-stage housing, which is a growth market in Belgium, so that design and implementation must be adapted to meet the relevant building standards [CTCS, 2014].

Products and materials that demonstrate a high level of innovation and quality do well in the Belgian building sector. To attract interest in the Belgian market, the unique ecological character of a particular material, both in terms of its rarity and its innovativeness, is an important selection criterion. A new technology monitoring site run by the Confederation Construction provides current information about the latest ideas and innovative products in the Belgian construction sector (www.technologywatch.be). [USA International Business Publications; 2012]

Exporters to and potential investors in Belgium should pay particular attention to the standards in force in Belgium. All construction products are subject to the rules of free movement of goods within the European Union. Construction products must meet the standards associated with labels, safety (CE), methods of construction and energy [[CTCS, 2014].

Belgium excels in exporting and plays an important role as a transit and distribution centre for other member states of the European Union. In recent years, exports have accounted for 9% of average sales in the construction sector. In addition, 50% of these exports are carried out by the five largest Belgian construction groups [Canadian Trade Commissioner Services, 2014].

1.4 DATA FOR THE BUILDINGS SECTOR

RESIDENTIAL BUILDINGS

In Belgium, in 2011, there are 3,448,779 single family buildings and 160,787 multi-family buildings, for a total of 3,609,566 buildings. The residential building stock in Belgium is relatively old and not so compact.

Figure 4 Compactness and age of the residential building stock in Belgium (2011)

	Single family dwellings			Multi-family dwellings	Others	Total	%
Number of buildings constructed	TH	SDH	DH			TH	SDH
before 1900	282.766	163.563	135.160	11.335	127.251	720.075	16%
from 1900 to 1918	183.445	68.869	42.050	7.986	48.099	350.449	8%
from 1919 to 1945	296.869	141.396	88.255	15.310	90.228	632.058	14%
from 1946 to 1961	170.668	174.034	145.433	24.795	110.326	625.256	14%
from 1962 to 1970	71.454	101.265	161.958	25.876	86.652	457.205	10%
from 1971 to 1981	77.456	116.383	272.954	23.899	115.110	605.802	14%
post 1981	81.551	156.598	516.652	51.586	196.934	1,003,321	23%
Total	1,164,209	922.108	1,362,462	160.787	784.600	4,394,166	100%

TH = Terraced House; SD = Semi-detached House ; DH = Detached House

Source: [BUILD UP Skills Belgium, 2013].

The average total surface area of a Belgian dwelling is 207 m²; the heated surface area 101 m² [].

The energy efficiency of residential buildings in Belgium is currently among the lowest in Europe. The total energy consumption of a home is accounted for mainly by consumption for heating, the ventilation or air conditioning system, hot water consumption and electricity. [BUILD UP SKILLS, 2012, p. 16].

Total housing-related energy consumption has remained more or less stable since the nineties, despite a rise in the number of families (+15% since 1990) [].

Figure 5 Net energy requirement for heating (NER-H) and primary energy consumption (PE) of dwelling type (in kWh/y.m²).

	< 1946		1946-1970		1971-1990		1991-2005		> 2005	
	PE	NER-H	PE	NER-H	PE	PE	NER-H	PE	NER-H	PE
Detached house	334	603	343	603	238	499	165	311	103	157
Semi-detached housing	295	477	300	486	221	463	145	278	92	144
Terraced house	231	385	234	384	167	368	119	232	77	125
Self-contained apartment	140	252	134	243	99	264	93	197	60	112
Non self-contained apartment	341	560	333	549	204	488	163	319	99	159

Source: [BUILD UP Skills Belgium, 2013, p. 8].

Space heating accounts for 71.0% of total heat demand, compared to 18.9% for domestic hot water and 0.10% for space cooling [CLIMACT,2012].

Table 1 heating systems in the residential building stock in Belgium in 2010 (shares)

Heating systems		Natural Gas	Fuel Oil				
84%	Central heating	%	%				
	Condensing boiler	35%	25%				
	High efficiency boiler	26%	9%				
	Other boiler	39%	66%				
		100%	**100%**				
		Natural gas	Fuel oil	Electric	Coal	Wood	Other
16%	Local heating	%	%	%	%	%	%
	Stove	35%	6%		7%	7%	
	Electric accumulator			18%			
	Direct electric convector			17%			
	Electric floor heating			1%			
	Other (e.g hearth)						9%
100%							**100%**

Source: [Jespers et al, 2012]

There are no cross-data linking types of dwellings with types of heating systems.

The majority (84%) of Belgian households in 2010 use individual (71%) or collective (13%) central heating. Central heating is preferred to local heating because of its ease of use. Some 61% of the natural gas fired boilers are either high efficiency or condensing boilers, compared to 34% for the fuel oil fired boilers. The share of heat pumps is marginal. Local electric heating accounts for 36% of total local heating.

In Flanders old central heating boilers have to be replaced by condensing boilers. Suppose a Belgian household would like to replace a more than 20 year old natural gas fired boiler with a seasonal efficiency of 65% and an annual natural gas consumption of 3000 m³ with a natural gas fired condensing boiler. The investment costs (installations costs and VAT included) would be 3.816 EUR. With an efficiency of 95%, and a natural gas price of 5.54 eurocent/kWh, the household would save 525 EUR energy costs per year. The investments costs for an equivalent fuel oil fired condensing boiler would be 4770 EUR (installation costs and VAT included), and with a fuel oil price of 5.68 eurocent/kWh the annual energy costs savings would be around 538 EUR. (source: “energy calculator” at www.energiesparen.be).

Table 2 import and export of heating systems in Belgium, 2012

	EXPORT quantity	EXPORT value	IMPORT quantity	IMPORT value

Boilers for central heating	..	42441410	..	218437020
Heat pumps other than airco	..	7922730	..	35037890
Other electric space heaters	329263	13336750	350077	9446540

Source: EUROSTAT

Belgium is a net importer of boilers for central heating, as well as of heat pumps.

Some 61% of Belgian households use a combination heating – domestic hot water system. The efficiency of the DHW system thus depends on the efficiency of the space heating generator.

Table 3 Type of domestic hot water (DHW) in Belgium

	%
Instantaneous (on-demand) – combi	34%
Storage – combi	27%
Storage – electric	24%
Storage – natural gas	6%
Storage – butane / propane	1%
Storage – fuel oil l	1%
Storage – coal	0%
Instantaneous (on-demand) – natural gas	5%
Instantaneous (on-demand) – butane / propane	1%
Instantaneous (on-demand) – electric	1%
	100%

Source: [Jespers et al, 2012]

Belgium is a net importer of stand-alone non-electric water heaters, and a net exporter of electric instantaneous water heaters.

Table 4 import and export of domestic hot water systems in Belgium, 2012

	EXPORT quantity	EXPORT value	IMPORT Quantity	IMPORT value
Electric instantaneous water heaters	339717	37012390	110455	8059810
Non-electric instantaneous or storage water heaters	..	20148510	..	38515760

Source: EUROSTAT

Brown and white appliance account for 80% of the total electricity consumption of appliances and lighting. White appliances consist of refrigerators/freezers, washing machines, clothes dryers and dishwashers.

Table X: electricity consumption for lighting and appliances in Belgian households in 2010

	%	kWh/household
Brown appliances	41%	1744
White appliances	39%	1668
Lighting	13%	556
Electric cooking	7%	309
	100%	**4277**

Source: CLIMACT, 2012.

Some 59% of Belgian households have a freezer, of which 65% with an A,A+ or A++energy efficiency label . Belgian households use refrigerators and freezers for cold storage, because of its ease of use.

Table 5 share of energy efficient freezers in Belgium in 2010

Freezer - energy label	Share (%)
A++	14%
A+	26%
A	25%
B	5%
C	2%
D	1%
E	0%
F	0%
G	0%
No label	28%
	100%

Source: [Jespers et al, 2012]

The prices of freezers on the Belgian market range from 97 EUR to 1890 EUR, with an average price of 549 EUR. Prices of course depend on, amongst other things, the size, which varies from 30 litre to 495 litre. The average energy consumption is 212 kWh per year; or 1,43 kWh per litre per year, but with a large standard deviation.

Table 6 Prices, sizes and energy consumption of freezers on the Belgian market,2015.

Number of types on the market	**365**				
	MIN	MAX	AVG	STD	MED
Price (EUR)	98 €	1.890 €	549 €	317 €	489 €
Size (litre)	30	495	182	96	188
Energy consumption (kWh/year)	101	566	212	58	204
Energy consumption (kWh/liter.year)	0,40	4,90	1,43	0,82	1,20

MIN = Minimum; MAX = Maximum; AVG = Average; STD = Standard Deviation: MED = Median.

Source: University of Antwerp, own calculations.

Belgium is a net importer of refrigerator/ freezers.

Table 7 import and export of refrigerators and freezers in Belgium, 2012

	EXPORT quantity	EXPORT value	IMPORT quantity	IMPORT value
Combined refrigerators-freezers, with separate external doors	92767	20722380	248367	59523130
Household-type refrigerators (including compression-type, electrical absorption-type) (excluding built-in)	263538	35199890	470134	65268020
Compression-type built-in refrigerators	57559	6077190	180007	38504410

Source: EUROSTAT.

Some 48% of Belgian households have a dishwasher, of which 72% with an A,A+ or A++ energy efficiency label . Belgian households use dishwashers because of its ease of use.

Table 8 share of energy efficient dishwashers in Belgium in 2010

Dishwasher - energy label	%
A++	17%

A+	27%
A	28%
B	6%
C	1%
D	1%
E	0%
F	0%
G	0%
No label	20%
	100%

Source: [Jespers et al, 2012]

Belgium is a net importer of both domestic and non-domestic dish-washers.

Table 9 import and export of dishwashers in Belgium, 2012

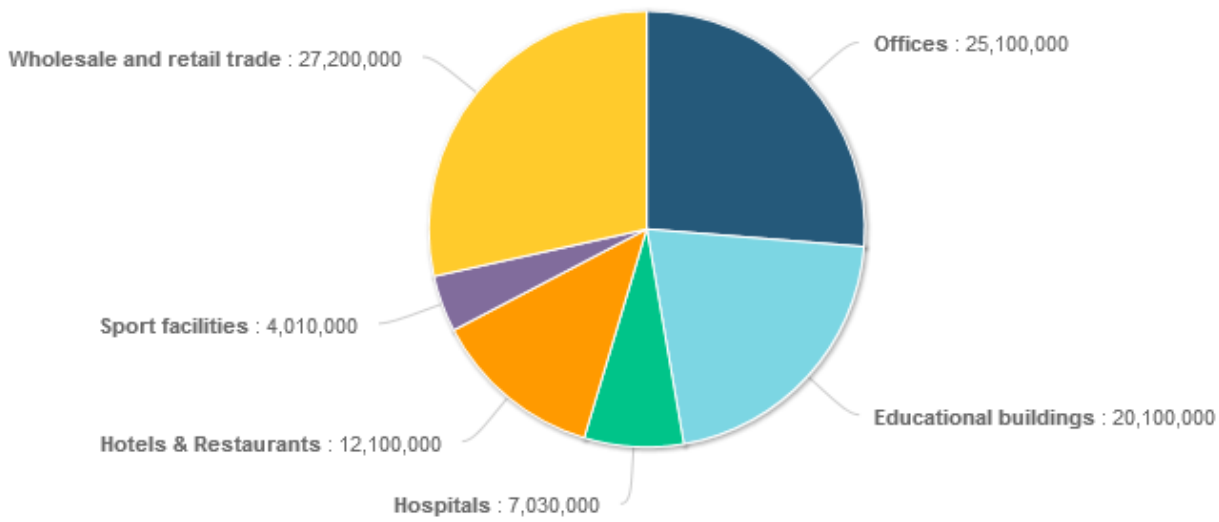
	EXPORT quantity	EXPORT value	IMPORT quantity	IMPORT value
Household dishwashing machines	163065	27255600	407445	88883110
Non-domestic dish-washing machines	2637	5618420	6377	14282430

Source: EUROSTAT

NON-RESIDENTIAL BUILDINGS

Data for the non-residential building sector in Belgium are virtually non-existent. There are some 91, 930 non-residential buildings in Belgium.

Figure 6 breakdown of the non-residential building stock in Belgium by building type



Source: retrieved from www.buildingsdata.eu

Table 10 Age of non-residential buildings in Belgium in 2010

Age	Number
1996 and after	201004
1991 to 1995	197015
1981 to 1990	2867788
1971 to 1980	485735
1961 to 1970	439829
1946 to 1960	484432
1919 to 1945	525282

Source: [JRC, 2011, p. 10]

The breakdown of heat demand in the Belgian non-residential building sector Is highly tentative.

Table 11 : breakdown of heat demand in the services sector

Energy service	%
Space heating	88%
Domestic hot water	10%
Space cooling	2%
	100%

Source: [CLIMACT, 2012].

Domestic hot water has a share of 10% of total fuel consumption. Space cooling has a share of 3.5% of total electricity consumption

Likewise, the breakdown of electricity consumption in the tertiary sector is very uncertain.

Table 12 breakdown of electricity consumption for lighting and appliances in the services sector

Energy service	%	GWh per M€ added value
Office lighting	27%	0.0344
Street lighting	4%	0.0045
Appliances	66%	0.0845
	97%	0.1234

Source: [CLIMACT,2012].

1.5 Data for the Transport Sector

In 40 years time (1970-2010) the length of railways has decreased by 15%; whereas the length of all roads increased by 64%. The length of motorways even increased by a factor of 3.6 in that same period.

Table 13 : Length and density of transport infrastructure in Belgium

	Length (in km)					density (km per 1000 m²)
	1970	1980	1990	2000	2010	s.d.
Railways	4232	3971	3479	3471	3578	117
Inland navigation	1553	1510	1513	1534	1532	50
All roads	94218	124589	140241	147121	154575	
of witch motorways	488	1251	1666	1702	1763	58

Source: FEBIAC.

Concerning passenger transport, commuting, socializing and shopping explain 70% of the reasons why Belgians make trips.

Table 14 : trip purposes in Belgium

Trip purpose	%
Commuting and work related	24%
Education	9%
Major shopping	20%
Special events	5%
Socializing	26%
Dining out	3%
Recreation	9%
Joyriding	4%
	100%

[Source: CLIMACT, 2012]

The respective inland passenger modal shares are 82% by private car, 9% by buses and coaches, 7% by railways and 2% by tram and metro [Towards an Energy Union Belgium, 2015, p. 7] The modal shares are based on passenger-km, and refer to 2012. Belgians make use of cars, because of its ease of use.

Table 15 passenger transport by car in Belgium, in thousand million passenger-km

	1970	1980	1990	2000	2010	2011	2012	2013
Belgium	**41**	**65**	**89**	**103**	**109**	**110**	**110**	**110**
Brussels-Capital Region	-	-	4	4	4	4	4	4
Flemish Region	-	-	51	58	62	63	64	63
Walloon Region	-	-	34	41	43	43	43	43

Source: FEBIAC

In Belgium, in 2010, the average occupancy level of passenger cars is 1.373 passengers per vehicle.

Table X: passenger transport by car in Belgium, in thousand million vehicle-km

	1970	1980	1990	2000	2010	2011	2012	2013
Belgium	**24**	**41**	**60**	**72**	**78**	**79**	**79**	**80**

Brussels-Capital Region	-	-	3	3	3	3	3	3
Flemish Region	-	-	35	42	45	45	46	47
Walloon Region	-	-	22	27	30	31	30	30

Source: FEBIAC

Public transport by bus and tram is regionalized in Belgium.

Table 16 number of travellers making use of public transport in Belgium, in millions.

	2000	2005	2006	2007	2008	2009	2010	2011
De Lijn (Flanders)								
Total	238	449	463	483	508	531	551	549
MIVB (Brussels)								
Bus	58	72	76	76	77	81	80	92
Metro	103	115	123	128	136	133	151	126
Tram	62	69	71	73	74	76	81	112
Total	223	255	269	277	286	291	312	330
TEC (Wallonia)								
Total	144	192	213	225	242	262	278	289

De Lijn = buses & trams in Flanders. MIVB = buses, trams and metro in Brussels. TEC = buses & trams in Wallonia.

Source: Planbureau

The Belgian railway company NMBS/SNCB is an autonomous government company and as such a federal competence. Passenger trains are for 93% electric driven.

Table 17 number of vehicle-km by passenger trains in Belgium

		2000	2005	2006	2007	2008	2009
Locomotives	Diesel	4136	26	22	16	34	19
	Electric	16539	17560	18013	18837	19004	21293
Motor coaches	Diesel	1049	5027	5089	5279	5645	5436
	Electric	51124	50676	50931	51364	50773	49845
Thalys	Electric	3321	3022	3025	2774	2784	2762
TGV	Electric	347	317	325	445	525	521
EUROSTAR	Electric	606	536	569	577	570	572
ICE train	Electric	--	331	332	327	326	320
Total	**Diesel**	**5185**	**5053**	**5111**	**5295**	**5679**	**5455**
	Electric	**71937**	**72442**	**73195**	**74324**	**73982**	**75313**

Source: Planbureau.

The inland freight modal shares are 72% by road, 17% by rail, 6% by inland waterways and 5% by pipelines.. The modal shares are based on tonne-km, and refer to 2012. Compared to the European average, Belgium reports a higher use of inland waterways in freight transport, given the existence of navigable rivers and canals in the country [Towards an Energy Union Belgium, 2015, p. 7].

Table 18 evolution of modal shares of freight transport in Belgium, in million tonne-km.

	2000	2001	2002	2003	2004	2005	2010	2011
Road - light freight	1874	2005	2097	2195	2332	2526	48242	47340
Road - heavy freight	47280	49576	48737	47646	50042	50157		

Railways	7674	7081	7297	7293	7691	8130	6268	-
Inland navigation	7313	7732	8148	8302	8459	8720	9071	9251

Source: Planbureau and FEBIAC.

In 25 years time the total number of vehicles has increased by a factor of 1.5. The share of cars has decreased from 83% to 78%; whereas the share of light duty trucks (LDT) has increased from 5% to 9%.

Table 19 Vehicle park in Belgium (in numbers and share)

	1990		2000		2010		2014	
		%		%		%		%
Cars	3833294	83	4628949	81	5279110	78	5511080	78
Light Duty Trucks (≤ 3,5 t)	235637	5	399562	7	594750	9	656691	9
Motorcycles	137816	3	274880	5	390141	6	424891	6
Tractors for agriculture	146591	3	156568	3	174014	3	180804	3
Heavy Duty Trucks (> 3,5 t)	112946	2	108348	2	103810	2	99724	1
Other (incl. buses & coaches)	138477	3	174293	3	197973	3	219463	3
	4604761	100	5742600	100	6739798	100	7092653	100

From 1985 to 2010 the share of diesel cars increased at the expense of petrol cars, in large part due to fiscal incentives from the Federal Government. Since 2010, the share of diesel cars remains constant at around 62%. The share of hybrid, CNG and electric cars in Belgium remains marginal.

Table 20 Evolution of car park by drivetrain

	Petrol		Diesel		LPG		Electric	CNG	Hybrid	Unknown	Total
		%		%		%					
1985	2637251	80	554218	17	66959	2	-	-	-	20337	3278765
1990	2758646	72	1028115	27	26633	1	-	-	-	19900	3833294
1995	2831095	67	1372087	32	16181	0	-	-	-	19688	4239051
2000	2719604	59	1847934	40	41841	1	-	-	-	19570	4628949
2005	2386582	49	2420883	50	51905	1	18	2	-	18943	4878333
2010	2021518	38	3201047	61	33482	1	61	81	4016	18905	5279110
2011	1980883	37	3319086	62	29979	1	321	138	9732	18875	5359014
2012	1970820	37	3361880	62	26346	0	824	218	13961	18860	5392909
2013	1991291	37	3386307	62	22265	0	1202	344	19036	18850	5439295
2014	2042731	37	3400191	62	19648	0	2203	1232	26220	18855	5511080

Source: FEBIAC

The fuel efficiency of petrol and diesel cars has gradually improved.

Table 21 Evolution of the fuel efficiency of petrol and diesel cars in Belgium (in litre/100 km).

Year	Petrol	Diesel
1995	8	7
1996	8	7
1997	8	6
1998	8	6
1999	8	6

2000	8	6
2001	8	6
2002	7	6
2003	7	6
2004	7	6
2005	7	6
2006	7	6
2007	7	6
2008	7	5
2009	6	5
2010	6	5
2011	6	5

Source: Planbureau.

The automotive sector has always been one of the most important industrial sectors in Belgium. The country still hosts two car assembly plants, namely Audi in the Brussels-Capital Region and Volvo Cars Gent in the Flemish Region. The European headquarters, logistics centre, and technical R&D centre of Toyota Motor Europe are located in Belgium. In addition, there are assembly plants for buses (Van Hool and VDL Jonckheere) and trucks (Volvo Europa Trucks) [IEA, 2014, p. 97].

Table 22 Evolution of vehicles assembled in Belgium and exported

	Assembly	Export
1980	929005	883774
1985	1034864	955564
1990	1252196	1192851
1995	1272534	1218799
2000	1033294	993698
2005	926528	868801
2010	555302	526054
2011	596461	575233
2012	538848	520724
2013	503504	480848
2014	516831	490053

Source: FEBIAC.

The drop in production (assembly) after 2005 was caused by the closure of a large factory in the Flemish Region, Opel Antwerp. Ford Genk in the Flemish Region recently closed. The introduction or implementation of electric mobility in the Flemish region may help strengthen its economy [IEA, 2014, p. 97].

Figure 7 Belgium fleet numbers of electric and fuel cell vehicles in 2013

Fleet Totals per 01 January 2014					
Vehicle Type	EV Fleet	HEV Fleet	PHEV Fleet	FCV Fleet	Total Fleet
Bicycles (no driver's license)	[a]				
Motorbikes	170	0	0	0	421,061
Quadricycles	559	0	0	0	23,679
Passenger vehicles	1,205	25,493	590	1	5,505,332
Light commercial vehicles	430	0	0	0	641,225
Buses[b]	3	56	0	0	16,261
Trucks[b]	7	4	0	0	150,229
Industrial vehicles	1,482	0	0	0	249,207
Total	**3,856**	**25,553**	**590**	**1**	**7,006.994**

a = no official registration of bicycles. b = hybrid buses and trucks are sometimes categorized under non-hybrid vehicles.

EV = Electric Vehicle. HEV = Hybrid Electric Vehicle. PHEV = Plug-in Hybrid Electric Vehicle. FCV = Fuel Cell Vehicle.

Source: [IEA, 2014, p. 105].

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Prepared by: “Black Sea Energy Research Centre”

TECHNOLOGICAL TRENDS

D.1.4

PART OF WORK PACKAGE 1: MAPPING OF ENERGY EFFICIENCY POLICY INSTRUMENTS AND AVAILABLE TECHNOLOGIES IN BUILDINGS AND TRANSPORT

NATIONAL REPORT FOR BULGARIA

Date: 21 July 2015

HERON project

“Forward-looking socio-economic research on Energy Efficiency in EU countries”

Institution: Black Sea Energy Research Centre

Steering Committee member (1): Lulin Radulov

Prepared by: Valentin Vassilev and Cvetoslava Spassova, BSERC

(1) The Steering Committee member has the responsibility for ensuring the quality of the report.

HERON: Forward – looking socio-economic research on Energy Efficiency in EU countries

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Contents

ACRONYMS

CNG	Compressed natural gas
EDTWA	Excise Duties and Tax Warehouse Act
EEA	Energy Efficiency Act
ERSA	Energy from Renewable Sources Act
EWRC	Energy and Water Regulatory Commission
FEC	Final energy consumption
HPI	High policy intensity
ktoe	kiloton oil equivalent
kWh	kilowatt hour
LPI	Low policy intensity
MRDPW	Ministry of Regional Development and Public Works
NSI	National Statistical Institute
NZEB	Nearly zero energy buildings
OPT	Operational Programme "Transport"
PPA	Public Procurement Agency
REECL	Residential Energy Efficiency Credit Line
RES	Renewable Energy Sources
SCOP	Seasonal Condition of Performance
SEDA	Sustainable Energy Development Agency
SG	State Gazette
sq.m.	square metre
VAT	Value Added Tax

EXECUTIVE SUMMARY

The economic high policy intensity (HPI) potential in building and transport sectors in Bulgaria during the period 2012 - 2020 is evaluated at 550 ktoe/a additional energy savings over the baseline scenario (Eichhammer, W. et al 2009).

Buildings

The perspectives for the market penetration of energy efficient insulation and windows are based on the following assumptions: financial support with 75 – 100% grants for households and mandatory renovation of public buildings (MRDPW 2015a).

The national definition of a "Nearly zero energy consumption building" was adopted with the last amendment of the Energy Efficiency Act (EEA 2015).

According to it, the "Nearly zero energy consumption building" (NZEB) is a building that meets both of the following conditions:

a) energy consumption of the building, defined as primary energy, corresponds to class A of the scale of energy classes for the type of buildings;

b) not less than 55 percent of the energy consumed (supplied) for heating, cooling, ventilation, domestic hot water and lighting is energy from renewable sources produced on-site at the building level or near the building.

After 2018 all new public buildings, and after 2020 all new residential buildings must be NZEB.

The consumption of biomass (firewood, wood pellets, chips etc.) is high and its share in the final energy consumption of households is 33% (2013), which is an increase of more than 3 times in less than 10 years. More than 70% of this biomass is firewood, burned in low efficiency old stoves (NSI 2015a). The market trends are directed towards accelerated penetration of efficient boilers for firewood, wood pellets and other solid fuels (coal).

The share of households equipped with air conditioners increased from 5% in 2003 to 32,6% in 2014, and the main purpose of purchase is space heating and the reason is the suppressed electricity price in the country (NSI 2015c). It is expected that the fast penetration of air conditioners will continue. Currently 100% of the air conditioners are imported.

Almost 100% of the dwellings in multifamily buildings connected to the district heating network have individual metering in the form of thermostatic valves and heat allocators (temperature integrators). These meters are currently being replaced by remote metering devices.

The penetration of smart meters and remote metering devices has been limited until now and therefore import data are not available.

Practically all already installed heat allocators and thermostatic valves are imported from Denmark, Germany etc.

The boilers for straw are imported, but a substantial share of the efficient boilers for firewood and wood pellets are locally produced under license. The exact share of imported biomass boilers is not known.

Straw boilers are imported mainly from Denmark and the wood and pellets boilers - from Germany and Czech Republic.

Efficient lighting is quickly penetrating into both the residential and public sectors. Currently 100% of the lamps and devices in the country are imported from China and the EU.

Transport

In 2013 the consumption of biofuels and natural gas was respectively 4,3% and 3,2% of the final energy consumption of the road transport (NSI 2015a).

The penetration of natural gas in motor vehicles is stimulated by its low price compared to other motor fuels. Natural gas is used in retrofitted existing cars.

The natural gas and methane stations, and the installations for retrofitting cars are imported mainly from Germany and Italy.

The wide utilization of biofuels is promoted through introduction of obligatory share in the transport fuels stipulated in the Energy from Renewable Sources Act (ERSA 2014).

The development of public transport, including metro transport in the capital city - Sofia relies on financing from European funds.

The modern and efficient public transport vehicles are imported mainly from Germany and the Czech Republic. Also, German technology is used for the building of the underground transport infrastructure used.

The perspectives for the market penetration of energy efficient vehicles will be based on the approach that will be taken for their promotion and the trends in motor fuel prices.

The National Action Plan for the Promotion of the Production and Accelerated Penetration of Ecological Vehicles, including Electric Mobility 2012-2014 (Council of Ministers 2012) proposes the following approaches for the increase of the use of efficient vehicles:

- Exemption from annual tax;
- Lower fees for initial registration;
- Exemption from (or relief on) tolls for the use of road infrastructure;
- Grant for the purchase of new green vehicles.

CHAPTER 1: TECHNOLOGICAL TRENDS IN THE BUILDING AND TRANSPORT SECTOR

1.1 Energy Efficiency Potential

Three forecast scenarios are developed for the energy efficiency potential in Bulgaria (Eichhammer,W. et al 2009):

- Low policy intensity (LPI) - policy of low priority on energy efficiency;
- High policy intensity (HPI) – policy of high priority on energy efficiency;
- Technical potential - what can be achieved with the best available technology at the time, without limitation on costs and prices.

All the assessments contained in the national documents, including the national energy strategy, show high energy intensity of the GDP and import of more than 50% of the necessary energy resources.

This requires the application of HPI scenario in the field of energy efficiency.

For the period 2012 - 2020 the economic HPI and the technical energy saving potential in Bulgaria in the relevant sectors are, as follows in ktoe/year (additional energy savings above the baseline scenario) (Eichhammer, W. et al 2009):

Table 1: Economic HPI and technical potential of Bulgaria 2012-2020, (ktoe/year)

Sector	Economic HPI	Technical
Transport	92	117
Households	295	451
Services	163	226

http://www.eepotential.eu/esd.php

Remark: This potential is the difference between the baseline scenario and HPI or technical scenarios for the period 2012-2020 (Eichhammer,W. et al 2009).

1.2 Technologies And Policy Instruments

Buildings

The existing technologies for improvement of energy efficiency in buildings supported by policy instruments are the following:

Energy efficient windows, insulation of walls, roofs and floors

These technologies are cost effective in long-term but the initial investment is high – about 60 EUR/ m^2 floor area, according to the assessment for the program “Support for energy efficiency in multifamily buildings” under the Operational Programme “Regional Development 2007-2013” (MRDPW 2011). This cost calculation includes the implementation of all four technologies

The payback period of the improvement of insulation of existing buildings depends on the initial state of the insulation, but usually exceeds 10 years. Often the cost includes structural reinforcement of the buildings and other measures that are not linked to energy efficiency, which significantly increases the amount of the necessary investment and, since this does not lead to energy savings - the payback period is further prolonged.

Without policy support, these technologies in the residential and public sectors will be limited. The principal policy instruments supporting the renovation of residential and public buildings, including the improvement of their insulation, are:

- "National energy efficiency program for multifamily residential buildings" (MRDPW 2015a)

  The program is a financial policy instrument and provides subsidy of 100% for the energy audit and the implementation of energy efficiency measures. The total budget of the program is 500 million euro. This includes financing of all improvements in windows, insulation of walls, roofs and floors but also structural reinforcement of buildings and other repairs if necessary.

- "Support for energy efficiency in multifamily buildings" (MRDPW 2011)

  The project was launched in 2011 under the Operational Programme "Regional Development" and will be closed in 2016. It finances 100% of the energy audit and 75% (100% since 2015) of the implementation of the energy efficiency measures for renovation of multifamily residential buildings in 36 Bulgarian towns. The total budget is 25 million EUR.

- Residential Energy Efficiency Credit Line (REECL 2015)

  The REECL facility is providing loans and incentive grants through local participating banks to any household or Association of Owners in multifamily buildings to improve energy efficiency. The incentives include grants of 20%, 30% or 35% respectively toward the cost of the energy saving project once it has been completed. Applicants need to use eligible products and materials to qualify for the incentive grants.

- Updated requirements for referent U values, W/m^2K of the walls, floors, roofs and windows and building elements (MRDPW 2015b)

  The requirements for the minimum insulation of buildings are regulated in Ordinance №7 of 2004 on energy efficiency, heat and energy savings in buildings (last supplemented in State Gazette, issue 31/28.04.2015). There is a methodology for calculation of minimum performance of the insulation depending on the type and characteristics of the elements of the construction – external walls, glazing, ceilings, floors etc.

- Mandatory annual renovation of 3% of the total area of the central government buildings (SEDA 2014a)

  The measure implements the requirements of Article 4 of Directive 2012/27/EC according to which each Member State shall ensure that, as from 1 January 2014, 3% of the total floor area of heated and/or cooled buildings owned and occupied by its central government is renovated each year to meet at least the minimum energy performance requirements that it has set in application of Article 4 of Directive 2010/31/EU (Directive 2012/27/EC).

The current price ranges and characteristics of the products and technologies presented below are result of BSERC's market research.

Gas boilers and gasification of households

The penetration of this technology is limited as a consequence of the high price of natural gas as an energy resource compared to other resources and the Bulgarian level of prices. The price of natural gas for households in July 2015 was 366 - 456 EUR/1000 nm^3 or 42 - 50 EUR/MWh including VAT (EWRC 2015)[1]. The price of a condensing gas boiler with capacity of 24 - 40 kW is 1200 – 1800

[1] All prices of fuels and energy are taken from EWRC (EWRC 2015)

EUR. In 2013 natural gas constituted only 2% (NSI 2015a) of the final energy consumption of the households in Bulgaria.

The principal policy instrument supporting this technology is the Residential Energy Efficiency Credit Line, which provides grants of up to 20 - 35% which is not enough to make this technology attractive to consumers (REECL 2015).

Biomass fuelled room heaters, stoves and boiler systems

The price of firewood is about 20 EUR/MWh and of wood pellets 27 – 30 EUR/MWh.

The price of high efficiency heating boilers of 25 – 44 kW fuelled with firewood is 1500 – 2200 EUR and of 22 – 52 kW capacity fuelled with wood pellets 2200 – 3000 EUR.

The efficient biomass boilers are supported by grants through the Residential Energy Efficiency Credit Line (REECL 2015).

Solar thermal systems

The price of conventional solar collectors is 80 – 110 EUR/m^2 and of heat pipe collectors - about 150 EUR/m^2. The penetration of the technology is supported by the Residential Energy Efficiency Credit Line with grants.

Air conditioners for space heating and cooling

The price of the electricity for households is about 0,09 EUR/kWh (day tariff with VAT). The price of an efficient air conditioner with Seasonal Condition of Performance (SCOP) of 4,06 and heating capacity of 4,8 kW is 430 EUR.

The penetration of efficient air conditioners is supported by the Residential Energy Efficiency Credit Line in the household sector and the Rules for Green Public Procurement in the service sector.

The Executive Director of the Sustainable Energy Development Agency (SEDA), jointly with the Executive Director of the Public Procurement Agency (PPA) issue rules for determining the obligatory criteria for the energy consumption of equipment and transport means, subject to supply through public procurement.

Space heating regulation and individual billing of heat energy from district heating in multifamily residential buildings

Individual distributors and thermostatic valves for heat energy regulation are installed practically on all heating radiators in the residential buildings connected to district heating. If devices for share distribution are not installed by the consumers, heating energy is calculated on the basis of the installed capacity of the radiators multiplied by the maximum specific consumption of the building.

Individual billing and payment of heating energy costs in multifamily residential buildings connected to district heating is stipulated in the following documents:

- Energy Act (EA 2006);
- Ordinance on regulating the prices of heat supply (MEE 2008);
- Ordinance № 16-334 since 06.04.2007 on district heating (MEE 2015).

Buildings with nearly zero energy consumption

In Bulgaria, there is a pilot program for nearly zero energy consumption of public buildings.

The measure is part of the activities for determination of the National Target for buildings with nearly zero energy consumption. In the first stage a definition of the national parameters for buildings with nearly zero energy consumption is elaborated. A simple definition of "Nearly zero energy consumption building" was adopted with the new Energy Efficiency Act (EEA 2015):

"Nearly zero energy consumption building" is a building that meets both of the following conditions:

a) energy consumption of the building, defined as primary energy, corresponds to class A of the scale of energy classes for the type of buildings;

b) not less than 55 percent of the energy consumed (supplied) for heating, cooling, ventilation, domestic hot water and lighting is energy from renewable sources produced on-site at the building level or near the building."

The second step is to set the national target for NZEB.

Efficient lightning

The typical energy saving bulb in households is 19 W, 900 lm and costs 3 - 4 EUR (including VAT), and street lighting LED Street Light, 18 W, 2100 lm and price of 30 - 40 EUR.

The price of the electricity is about 0,09 EUR/kWh.

The penetration of efficient lighting is supported by the "Program for street lightning modernization in the service sector", which is set as a measure in the NEEAP and launched in 2012 under the Rural Development Programme of the Ministry of Agriculture and Food (SEDA 2014a). The program foresaw renovation of street lightning in municipalities with new energy efficient lamps from the highest class (at the moment of the measure implementation) and equipped with lighting control systems.

Transport

Efficient vehicles – cars, busses, etc.

The efficient vehicles are supported by the "National action plan to promote production and accelerated entry of environmental vehicles including electrical mobility in Bulgaria 2012 - 2014" (Council of Ministries 2012).The efficient and environment friendly cars in the scope of the plan are:

- electric vehicles - vehicles that use electric motor with full power and do not have an internal combustion engine;
- hybrid cars - vehicles that use two or more power systems of different types - an electric motor and an internal combustion engine (petrol or diesel);
- vehicles - passenger cars emitting CO_2 emissions to 120 g/km; vans - up to 175 g/km; buses - requirements EURO V.

As of the end of 2014, the number of electric cars was 497 and of the hybrid cars - 1031 (ME & MOEW 2015).

Biofuels and compressed natural gas in transport

The consumption of biofuels in transport sector in 2013 was 104 ktoe (NSI 2015b) and of natural gas 79 ktoe (NSI 2015a). This was 4% and 3,2% respectively of the final energy consumption of the road transport. The price of compressed natural gas (CNG) is about 0,8 EUR/kg and the consumption of a personal car is 5,5 EUR/100 km. The price of the CNG installation on a car is 500 – 600 EUR.

Biodiesel and bioethanol are promoted by mandatory shares in the fuels for transport introduced in the Energy from Renewable Sources Act (ERS 2015). Compressed natural gas is supported with excise and tax relief as a clean fuel (EDTW 2011).

Modal shift to more energy efficient interurban and urban transport

The Operational Programme "Transport" 2007 - 2013 (OPT 2015) is one of the seven operational programmes in the Republic of Bulgaria, financed by the Structural and the Cohesion Funds of the EU.

The goal of OPT is the development of railway, road and waterway infrastructure, expansion of metro transport and development of intermodal transport.

Under the Operational Program "Regional Development 2007 – 2013" (OPRD 2013) projects for the modernization of public transport had been conducted in seven major cities in Bulgaria: Sofia, Burgas, Plovdiv, Varna, Stara Zagora, Ruse and Pleven. Their main objective is to ensure accessibility and cohesion through efficient and sustainable urban transport systems, including the use of intelligent transport systems.

1.3 Market Perspectives due to Technological Trends

Energy efficient windows, insulation of walls, roofs, and floors

The perspectives for the market penetration of efficient insulation and windows are based on:

- "National energy efficiency program for multifamily residential buildings". As a result of the program residential buildings with about 8,5 mil.m^2 floor area (4% off the floor area of all residential buildings) will be renovated. After exhausting of the funds, the program will be continued (MRDPW 2011).
- Mandatory annual renovation of 3% of the total area of the central government buildings. The number of the buildings owned or occupied by the central government in Bulgaria is 2 329 with total floor area of 7 522 284,31 m^2. The total annually needed investments for the 3% of the floor area renovation is evaluated at 7 million EUR (SEDA 2014a).
- National program for "Nearly zero energy consumption building" (SEDA 2014b).

Part of the insulation materials and windows are imported.

The market perspective is a significant increase of the market penetration of energy efficient windows, insulation of walls and of all other elements of building envelope.

After 2020 this trend can be accelerated with the requirement for all new residential buildings to be NZEB and to correspond to class A of the scale of energy classes.

Biomass fuelled room heaters, stoves and boiler systems

The consumption of biomass (firewood, wood pellets, chips etc.) is high and its share in the final energy consumption of the households is 33% (2013) and increased more than 3 times in less than 10 years (NSI 2015a). More than 70% of this biomass is firewood, burned in low efficiency old stoves.

The market perspective is an accelerated penetration of efficient boilers for firewood and wood pellets and other solid fuels (coal).

Practically all modern biomass or solid fuel boilers are imported or built under license in Bulgaria.

Solar thermal systems

The penetration of solar thermal energy is limited – only 9 ktoe (0,4%) of the final energy consumption (FEC) in households and 10 ktoe (1%) of FEC in service sector (hotels, some hospitals) (NSI 2015b). All efficient heat pipe collectors are imported.

After 2020 the share of solar thermal systems is expected to increase in relation to the requirement for all new residential buildings to be NZEB and not less than 55 percent of the energy consumed (supplied) for heating, cooling, ventilation, domestic hot water and lighting to come from renewable sources produced on-site or near the building.

Air conditioners for space heating and cooling

In 2013, in the households sector about 194 ktoe (13%) of the FEC was electricity used for space heating and 115 ktoe (8%) for cooling (Expert evaluation based on ODYSSEE-MURE project data).

The share of households equipped with air conditioners increased from 5% in 2003 to 32,6% in 2014. The number of conditioners increased from 148 000 to 798 000 in the same period, and the main purpose of purchase is space heating and the reason is the supressed electricity price in the country (NSI 2015c).

The market perspective is for fast penetration of air conditioners. The air conditioners are 100% imported in Bulgaria.

Space heating regulation and individual billing of heat energy from district heating in multifamily residential buildings

District heating constitutes 318 ktoe (14%) of the final energy consumption in the households and 103 ktoe (10,7%) of the final energy consumption in service sector (NSI 2015a).

Almost 100% of the residential multifamily buildings have installed individual metering in the form of thermostatic valves and heat allocators (temperature integrators). They are in a process of replacement by devices with remote metering.

The market penetration of thermostatic valves and heat allocators is already high and the forecast is that the demand will remain at this level due to the necessary replacement of the existing devices.

As new buildings have individual heat supply of each apartment, the demand of individual heat meters will gradually replace the heat allocators.

Efficient lightning

The electricity for lighting amounts to about 52 ktoe (2,3%) of the final energy consumption in households (Expert evaluation based on ODYSSEE - MURE project data).

Accelerated penetration of efficient lighting in residential and in public sectors is ongoing.

All lamps and devices are imported from China and the EU.

Efficient vehicles – cars, busses, etc

The final energy consumption of the road transport is 2 394 ktoe or 92% of the consumption of the transport sector (NSI 2015a).

Possible approaches to promote efficient vehicles are:

- For electric vehicles - exemption from annual tax;
- Hybrid cars - exemption from annual tax (not less than 5 years);
- Introduction of preferential fees for initial registration for electric and hybrid cars;
- Release/relief of tolls for the use of road infrastructure;
- Providing single grants for individuals and legal persons for the purchase of new green vehicles.

Biofuels and compressed natural gas in transport

In 2013 the consumption of biofuels in transport was 104 ktoe (NSI 2015b) and of natural gas 79 ktoe (NSI 2015a). This was 4,3% and 3,2% respectively of the final energy consumption of the road transport.

Biofuels are produced in Bulgaria mainly for export.

Natural gas, methane stations and the installations for retrofitting cars are imported. The perspective now is for an increase of the share of natural gas in transport but this will depend on the prices of gas and oil and the security of supply of natural gas that are difficult to predict.

The penetration of biofuels depends entirely on the legal requirements for share of biofuels in the fuels for transport.

The penetration of electric and hybrid cars will depend entirely on the measures to promote these vehicles. Presently they are not, and in the near future they will not be competitive to other cars.

1.4 Data for the Buildings Sector

1.4.1 Residential Sector

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Space heating**
Technology	Biomass boilers
Number of technology used	33% of the FEC for all houses
Origin of technology	100% imported product
Cost of purchase	Range: Firewood 1500 – 2200 EUR for 25 – 44 kW Wood pellets 2200 – 3000 EUR for 22 – 52 kW
Cost per kWh	Fuel price Firewood - 0,02 EUR Wood pellets - 0,027 – 0,030 EUR Space heating cost Firewood - 0,03 EUR Wood pellets – 0,036 – 0,04
Energy consumption	966 kWh/year for space heating
Advantages / disadvantages of use	Energy saving: 2600 kWh/year Advantages: • Relatively low fuel prices; • Providing comfort living environment. Disadvantages: • Need of regular maintaining during the day and night; • Need of space for storing the fuel.
Easiness to use	Space heating by firewood requires regular boiler feeding and maintenance of the system, such as cleaning and loading. On the other hand wood pellets are used in automated boilers and no regular feeding by person is needed.

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Space heating**
Technology	Air conditioner; EU Energy class A++/A+; SCOP 3,7 Space heating: 4,8 kW
Number of technology used	798 000 (2012)
Origin of technology	100% imported product (source: www.climamarket.bg)

Cost of purchase	430 EUR (including VAT)
Cost per kWh	Electricity price average 0,09 EUR (including VAT) Space heating cost: 0,023 EUR
Energy consumption	966 kWh/year for space heating
Advantages / disadvantages of use	Energy saving: 2600 kWh/year Advantages: • Easy maintenance; • Attractive correlation price/service. Disadvantages: • Possibility of consumers to get cold of the cold air stream; • Not efficient for heating more rooms when placed in one of them.

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Water heating**
Technology	Electric boiler – 80 litres
Origin of technology	All products of brands “Eldom”, Tessy” and “Diplomat” are produced in Bulgaria (source: www.pazaruvaj.com)
Cost of purchase	Range: 80 ÷ 100 EUR (including VAT)
Cost per kWh	Average 0,09 EUR (including VAT)
Average energy consumption	Depending on capacity (1,5 – 8,5 kW) and hot water consumption
Advantages / disadvantages of use	D: electricity generation efficiency is low and about 50% - from fossils
Easiness to use	Easy

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Cooking**
Technology	Cooker with oven – EU energy class A; 38 litres
Origin of technology	In main imported (source: www.technomarket.bg)
Energy consumption	0,78 kWh/cycle
Cost of purchase	Range: 130 ÷ 150 EUR
Cost per kWh	Average 0,09 EUR (including VAT)

Advantages / disadvantages of use	Low efficiency of electricity generation
Easiness to use	Easy

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Lighting**
Technology	Energy saving bulbs 19 W; 900 Lm
Origin of technology	Imported product, including from China (source: www.tecnomarket.bg)
Cost of purchase	Range: 3 ÷ 4 EUR (including VAT)
Cost per kWh	Average 0,09 EUR (including VAT)
Energy consumption	41,61 kWh/a
Advantages / disadvantages of use	Advantages: • Energy saving; • Long life – average 50 000 h
Easiness to use	Yes

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Refrigeration**
Technology	Two-door refrigerator with freezer (225+52 litres), EU Energy class A++
Origin of technology	Products of "Liebherr" (80% produced by Bulgarian branch of "Liebherr") (source: www.tecnomarket.bg)
Cost of purchase	Range: 320 ÷ 340 EUR (including VAT)
Cost per kWh	Average 0,09 EUR (including VAT)
Energy consumption	202 kWh/year
Advantages / disadvantages of use	Advantages: • Very efficient; • Low level of noise; • Additional food preservation systems as No Frost, etc.
Easiness to use	Yes

Sector	**Buildings**
Sub-sector	**Residential sector**

Category	Washing machines
Technology	Washing machine, capacity 6 litres, EU Energy class A+
Cost of purchase	Range: 240 ÷ 260 EUR (including VAT)
Cost per kWh	Average 0,09 EUR (including VAT)
Energy consumption	194 kWh/year
Advantages / disadvantages of use	Advantages: • Energy efficient; • Water efficient; • Offers short laundry programmes for saving energy, water and time.
Easiness to use	Nothing specific for comment

1.4.2 Commercial / services sector

Sector	Buildings
Sub-Sector	**Commercial / services sector**
Category	**Space heating**
Technology	Central heating
Number of technology used	318 ktoe (2013)
Origin of technology	Radiators, thermostatic valves, pipes, distributors, are imported or produced under license in Bulgaria
Cost of purchase	Please state in EUR
Cost per kWh	Range: 38 ÷ 43 EUR (without VAT)
Energy consumption	Average: 6000 - 7000 kWh/a per dwelling for space heating and water heating
Advantages / disadvantages of use	Comfortable, clean, effective
Easiness to use	Yes

Sector	Buildings
Sub-Sector	**Commercial / services sector**
Category	**Air conditioning**
Technology	Air conditioner; EU Energy class A++/A+
Number of technology used	No information
Origin of technology	100% imported product (source: www.climamarket.bg)
Cost of purchase	Average 950 ÷ 1000 EUR (including VAT)
Cost per kWh	Electricity average 0,09 EUR (including VAT)

	Space heating: 0,023 EUR
Energy consumption	770 kWh/year
Advantages / disadvantages of use	D: Uneven temperature distribution, danger from cold
Easiness to use	Yes

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Water heating**
Technology	Central heating
Number of technology used	No information
Origin of technology	National product
Cost of purchase	Please state in EUR: 70 - 100 EUR with VAT
Cost per kWh	Range: 38 ÷ 43 EUR (without VAT)
Energy consumption	Please state in kWh/a
Advantages / disadvantages of use	More comfortable than other means of heating
Easiness to use	Easy

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Refrigeration**
Technology	Vitrine refrigerator; 500 litres; 0,28 kW
Origin of technology	Imported prevailing
Cost of purchase	Range: 900 ÷ 1200 EUR (including VAT)
Cost per kWh	Average 0,09 EUR
Energy consumption	100 – 200 kWh
Advantages / disadvantages of use	No comments
Easiness to use	No comments

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Public street lighting**
Technology	LED Street Light; 18 W; 2100 lm
Origin of technology	Produced by Bulgarian branch of “Romtech” (source: www.rommtech – 3s.com)

Cost of purchase	Range: 30 ÷ 40 EUR
Cost per kWh	Average 0,09 EUR (including VAT)
Energy consumption	Under the normal condition of 4 000 h/y the expected consumption is 72 kWh/a
Advantages / disadvantages of use	Very high efficiency – 117 lm/W
Easiness to use	Nothing significant to note

1.5 Data for the Transport Sector

Sector	**Transport**
Sub-sector	**Passenger transport**
Category	**Road transport:** • passenger transport: • cars for long and short distances
Technology	Compressed natural gas (CNG)
Number of technology used	Consumption of CNG – 79 ktoe or 3,2% of the consumption in road transport (2013)
Origin of technology	Natural gas, methane stations and the installations for retrofitting cars are imported
Cost of purchase	Retrofit of the car 500 - 600 EUR
Cost per kWh	The price of compressed natural gas (CNG) is about 0,8 EUR/kg
Energy consumption	Cost of travel for personal car - 5,5 EUR/100 km
Advantages / disadvantages of use	The fuel is cheap and the GHG emissions are reduced
Easiness to use	No difference from liquid fuel cars

Sector	**Transport**
Sub-sector	**Passenger transport**
Category	**Road transport:** • passenger urban transport: • trolleybuses
Technology	Electric urban transport Euro V standard, 15 - 30% recuperation of brake energy
Number of technology used	New 50 trolleybuses in Sofia
Origin of technology	The new 50 trolleybuses for Sofia urban transport are imported from the Czech Republic
Cost of purchase	550 000 EUR per trolleybus

Cost per kWh	Electricity price 0,075 EUR/kWh (without VAT)
Energy consumption	N/A
Advantages / disadvantages of use	Clean and comfortable
Easiness to use	Easy

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HERON project (No: 649690)

TECHNOLOGICAL TRENDS

D.1.4

PART OF WORK PACKAGE 1: MAPPING OF ENERGY EFFICIENCY POLICY INSTRUMENTS AND AVAILABLE TECHNOLOGIES IN BUILDINGS AND TRANSPORT

NATIONAL REPORT FOR ESTONIA

DATE: 12.AUGUST 2015

Partner: ***Stockholm Environment Institute Tallinn Centre***

HERON project

"Forward-looking socio-economic research on Energy Efficiency in EU countries"

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Institution: Stockholm Environment Institute Tallinn Centre
Steering Committee member (1): Tiit Kallaste

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(1) The Steering Committee member has the responsibility for ensuring the quality of the report.

HERON: Forward – looking socio-economic research on Energy Efficiency in EU countries

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Acronyms

AAU	- Assigned Amount Units under UN FCCC
EIC	- Environmental Investment Centre
ELMO	- Estonian Electro-Mobility Programme
ENMAK	- Estonian National Energy Sector Development Plan
EPBD	- Energy Performance of Buildings
EPD	- Energy Performance Directive
EV	- Electric Vehicle
GIS	- Green Investment Scheme
KredEx	- Credit and Export Guarantee Fund
LEB	- Low-Energy Building
LED	- Light Emitting Diode
MEUR	- Million Euros
MiEV	- Mitsubishi innovative Electric Vehicle
nZEB	- nearly Zero-Energy Buildings
ODEX	- Energy efficiency index of industry

EXECUTIVE SUMMARY

Estonian buildings sector (without industrial buildings) consumes approximately 16-17 TWh annually, which constitutes to 50% of total final energy use of the country. From the overall buildings stock, majority (31%) are multi-store apartment buildings and 1-2 floor detached houses (24%), followed by the industrial buildings (15%). Rest of the buildings stock are the buildings used by service sector and other type of dwellings. The technical energy saving potential of the Estonia's buildings sector has been calculated to be 9.3 TWh heat and ca 0.2 TWh electricity annually. The economic energy efficiency potential of the buildings sector in Estonia would be ca 5 TWh per annum, mostly on reducing heat consumption.

Estonian buildings sector is using only few energy efficiency technologies and lesser number of technologies are supported by the national policy measures. Complex renovation of the multi-store dwellings for increasing energy performance of the buildings, replacement of the heating systems of the detached private houses, installation of the micro-energy production equipment in the private buildings and reconstruction of the street lightning – replacement of the incandescent bulbs with LED lamps are the main energy efficiency technologies and measures supported by the Government. Highest potential for energy efficiency technology market, is for further installation and use of energy efficient (LED) lightning, both street and in-house lightning; further deployment of use of heat-pumps for heating and installation and use of heat-recovering ventilation systems.

Transport sector accounts for a quarter of Estonian final energy demand (8.3 TWh/33 000 TJ) and energy demand has been rising over 33% during the last 15 years primarily due to economic growth, rapid increase in private car use and road freight, urban sprawl and decreasing share of public transport and walking in daily mobility. Road transport has increased at the same pace as economic growth which puts Estonia as one of the most transport and energy intensive economies in the EU. 60% of the energy in road transport is consumed by passenger cars, which has been the fastest growing transport mode in Estonia. Contrary to EU average and most other sectors' trends in Estonia the overall energy efficiency (based on aggregated ODEX indicator) in transport decreased in 1996-2010 by more than 15%.

The high energy efficiency potential of transport sector has been recognized only recently. Background studies commissioned in the framework of preparing new national energy development plan (ENMAK 2030+) concluded that in case all the instruments are implemented, a 40% (-19 000 TJ/a) reduction of energy consumption could be achieved compared to the reference scenario. Ca 20% of the overall energy saving potential until 2030 can be reached with more fuel efficient conventional and hybrid passenger cars, while the role of electric vehicles remains still relatively marginal (175 TJ). Developing public transport (1300 TJ/a), integrated spatial planning (2900 TJ/a), eco-driving (1400 TJ/a), parking management (1100 TJ/a), congestion charging (1300 TJ/a), electrification of railways (450 TJ/a), energy efficient lorries (1000 TJ), developing cycling infrastructure (360 TJ/a) would all contribute substantially to the energy saving. This paper presents the case of Estonian transport sector the Electro-mobility Program, a four year support scheme that has brought more than 1200 EV-s on Estonian roads and covered the whole country with quick EV-charging network. Financially supported purchase of electrical cars have a total annual mileage of 11 million vehicle-km, with an estimated energy saving of ca 25 TJ/y, which, however remains very marginal compared to the overall energy consumption in the transport sector.

Energy-efficiency technologies used in both buildings and transport sectors, are mostly imported. Estonian domestic energy efficiency technology production is concentrated on production and export of construction materials used for renovation of the buildings for increasing energy performance of the buildings. Main products are energy efficient windows, pre-fabricated wall elements and houses and insulation materials.

CHAPTER 1: TECHNOLOGICAL TRENDS IN THE BUILDING AND TRANSPORT SECTOR

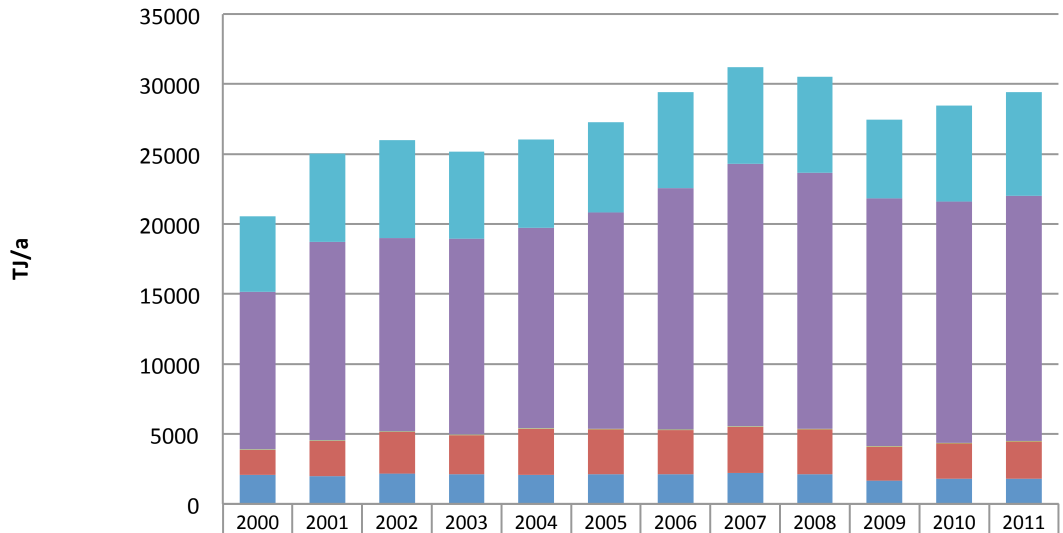
1.1 ENERGY EFFICIENCY POTENTIAL

1.1.1 Buildings sector

Estonian buildings sector (without industrial buildings) consumes approximately 50% (16-17 TWh annually) of total final energy use of the country (ENMAK 2030). From the overall buildings stock, majority (31%, 27385 units, 34 281 629 m^2) are multi-store apartment buildings and 1-2 floor detached houses (24%, 190 460 units, 26 447 774 m2), followed by the industrial buildings (15%, 17 832 units, 4 133 084 m^2). Rest of the buildings stock are buildings used by service sector and other type of dwellings. 96% of Estonian housing belongs to private persons. By the National Buildings Register, there is together 3 006 708 buildings with controlled inner climate and with overall floor surface of 110 241 726 m^2. 77% of the housing was built before 1992 and 58% during the Soviet period (1946-1990) with relatively low energy standards. Annual energy use of average dwelling house in Estonia is 250 kWh/m^2. According to the development plan of Estonian housing sector 2030+, its analysis of current situation, the potential technical energy saving in Estonia is 9.3 TWh of heat annually and ca 0.2 TWh of electricity annually. The potential to save heat as much as ca 10 TWh annually, makes up about one third out of all the final energy consumption in Estonia, being 33-34TWh annually. Energy saving potential for new buildings, if built according to nearly zero energy performance requirements, would be annually 0.5 TWh heat and 0.4 TWh electricity, compared with building by minimum energy efficiency standards. Global cost calculations (EQUA, 2011) for construction concepts from business as usual construction to passive house building envelope level combined with all possible technical systems showed that cost optimal in the reference detached house was between 120-140 kWh/(m^2 a) primary energy and in reference office buildings about 140 kWh/(m^2 a) primary energy. Expanding these results to whole building stock, the economic energy efficiency potential of the buildings sector in Estonia would be ca 5 TWh per annum, mostly on reducing heat consumption. The cost of the energy saving in case of complex renovation of the typical multi-store dwellings would be 1290-1340 €/MWh/a. In case of complex renovation (both insulation and renovation of technological systems) of detached house the cost of the energy saving could be between 723-1240 €/MWh/a (ENMAK 2030, 2014).

1.1.2 Transport sector

Transport sector accounts for a quarter of Estonian final energy demand (8.3 TWh/33 000 TJ of which 94 per cent is cars and trucks) and energy demand has been rising over 33% during the last 15 years primarily due to economic growth, rapid increase in private car use and road freight, urban sprawl and decreasing share of public transport and walking in daily mobility (Jüssi et al., 2014). Road transport has increased at the same pace as economic growth which puts Estonia as one of the most transport and energy intensive economies in the EU. 60% of the energy in road transport is consumed by passenger cars, which has been the fastest growing transport mode in Estonia. Ca' 44% of the fuel consumed on Estonian roads can be associated with local roads and streets, which shows that the local level plays a big role in energy efficiency policies (Jüssi et al., 2014). Contrary to EU average and most other sectors' trends in Estonia the overall energy efficiency (based on aggregated ODEX indicator) in transport decreased in 1996-2010 by more than 15% (Energy …, 2012). For more detailed overview of Estonian transport sector energy consumption structure and trends, see D.2.1.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Heavy Duty Vehicle	5417	6312	6982	6244	6304	6460	6841	6878	6846	5626	6889	7400
Car	11242	14198	13815	13984	14314	15480	17258	18797	18287	17683	17238	17500
Motorcycle	25	26	28	31	54	18	32	47	51	45	46	43
Light Duty Vehicle	1779	2512	2971	2811	3264	3233	3187	3272	3208	2425	2504	2652
Bus	2094	2006	2182	2122	2097	2100	2101	2210	2127	1670	1796	1810

Figure 1 Energy consumption in Estonian road transport by mode 2000-2011

Source: Jüssi et al., 2014

Two background studies commissioned in the framework of National Energy Development 2030+ (ENMAK 2030+), Jüssi et al., (2014) and Jüssi et Rannala (2014) – assessed the energy saving potential of 24 policy instruments ranging from fiscal measures, public transport development to eco-driving and car-sharing and analyzed the policies and final energy demand in the transport sector in two alternative scenarios. The reports concluded that in case all the instruments are implemented, about 40% (-19 000 TJ/a) reduction of energy consumption could be achieved compared to the reference scenario. Approximately 20% of the overall energy saving potential until 2030 can be reached with more fuel efficient conventional and hybrid passenger cars, while the role of electric vehicles remains still relatively marginal (175 TJ). Developing public transport (1300 TJ/a), integrated spatial planning (2900 TJ/a), eco-driving (1400 TJ/a), parking management (1100 TJ/a), congestion charging (1300 TJ/a), electrification of railways (450 TJ/a), energy efficient lorries (1000 TJ), developing cycling infrastructure (360 TJ/a) would all contribute substantially to the energy saving.

1.2 Technologies And Policy Instruments

1.2.1 Buildings sector

In the buildings sector the only energy efficiency technologies supported by the relevant national policy instruments are complex energetic renovation of the multi-store dwellings for increasing energy performance of the buildings, replacement of the heating systems of the detached private houses, installation of the micro-energy production equipment in the private buildings and reconstruction of the street lightning – replacement of the incandescent bulbs with LED lamps.

Main national policy instrument has been subsidy (between 17-35 % from renovation costs, depending on expected savings, average 24%) for complex renovation of the multi-store dwellings as well loan guarantees and support to the housing cooperatives for pre renovation audits and on-site inspections of renovation works by the state foundation KREDEX. Complex renovation of typical multi-store dwelling consists the additional insulation of the perimeter of the house, reconstruction and insulation of the roof, replacement of the windows, replacement of heat piping and radiators with thermostats-regulators, installation of the ventilation with heat exchange. Cost of complex renovation of the multi-store dwellings has been as average costing 91 EUR/m^2 (highest cost was 382 EUR/m^2) and the support for renovation from KREDEX has been as average 23 EUR/m^2 (KREDEX, 2014). Progress of the use of subsidies has been moderate as there have been barriers for implementation: main barrier being the difficulties to reach agreement between the members of the housing cooperatives for taking renovation loan and low income of owners. During the period 2010 (first year of implementation)-2014, support has been given for renovation of to 663 housing cooperatives in total amount of 38,0 MEUR. Most actively subsidy has been used in 2 of the biggest cities, where income of inhabitants have been higher than in other regions. Some correlation of renovation activity can be drawn with heat prices in the cities and regions. Number of applicants was peaking in 2012 with 310 renovation projects and has decreased to 57 renovated houses in 2014. With regards to cost-effectiveness, energy savings in Estonian houses in 2013 after the implementation of KredEx investment fund was estimated to be approximately as high as 2,5 MEUR. An overview to energy savings achieved both in kWh-s and euros in 2013 can be seen from the below provided Table 1:

Table 1. Energy savings in Estonian houses in 2013 after the implementation of KredEx renovation fund

	Number of houses	2013 savings in kWh	Savings in euros
Tallinn	153	18 835 839	1 488 031
Tartu	31	4 367 870	279 544
Harjumaa	43	3 566 858	267 514
Tartumaa	19	1 667 597	125 070
Pärnumaa	20	1 288 205	96 615
Ida-Virumaa	6	998 427	74 882
Lääne-Virumaa	7	895 827	67 187
Raplamaa	10	638 517	47 889
Valgamaa	4	626 060	46 955
Viljandimaa	6	402 608	30 196
Jõgevamaa	5	246 233	18 467
Saaremaa	2	226 290	16 972
Läänemaa	3	197 523	14 814
Järvamaa	2	116 447	8 734
Põlvamaa	1	65 253	8 734
Võrumaa	1	45 793	3 434
Hiiumaa	1	22 453	1 684
Total	314	34 207 800	2 592 882

Source: Lauri, M., KredEx, 2014, lk. 21-22.

For detached private houses the policy instrument used in Estonia is subsidy for the renovation of the heating system – switching from oil heated boilers to heat pumps and biomass based boilers. Subsidy has been limited to 40 % of the equipment purchase and installation cost, but not exceeding 4000 EUR per household. Progress cannot be reported jet as measure started rather recently at the end of 2014 and has been more widely in practice since the beginning of 2015. Amount of the subsidy during the period 2015-2017 will be 5 MEUR and from this amount there is expected that oil fueled boilers will be replaced in more than 2000 detached houses. Both above measures are planned to be continued until 2030.

In 2012 KREDEX provided support for renovation of the detached private houses for the purchase and installation of the equipment for local renewable micro-energy supply and replacement of heating systems with heat-pumps and biomass boilers. Amount of the subsidy was 4.5 MEUR and whole amount was earmarked during couple weeks from start of disbursement. Applications exceeded many times the support available. This shows the keen interest of households sector to improve the energy efficiency in a way of using renewable energy sources or alternative possibilities of generating energy. Altogether 212 projects were supported from which 146 were including replacement of the heat supply equipment (50% for earth-heat pumps, 40% for air-heat pumps and 10% for wood use, mainly pellets). Average investment cost per project was 7500-10500 EUR for heat pumps and 6000 EUR for wood based boilers.

Estonian Environmental Investment Centre (EIC) has provided during the period of 2012-2015 support for renovation of street lightning in seven mid-size cities. Support scheme has been based on the bilateral agreement with Estonia and Austria on sales of the Assigned Amount Units (AAU). According to the agreement earnings were allocated in the National Green Investments Scheme (GIS) for the replacement of the old street lamps with modern and energy efficient LED lamps. EIC support covered 90% (16.2 MEUR) and own financing of the local governments was 10% (1.8 MEUR) of the project cost. Altogether 12 253 lightning spots were installed together with control systems renovated and as result 5 GWh electricity saved annually, making about 0.3-0.4 MEUR saved annually.

The "New technology shift" measure, started in 29.06.2015 and managed by the KREDEX, is the support mechanism for renovation of old (3x220V) electrical wiring and control systems to new 3x230/400 V) system in multi-store buildings belonging to housing cooperatives and in private households. Support is given up to 30% of the replacement costs, but not more than 200 EUR by flat of multi-store building and not more than 800 EUR for a private house. Support scheme is limited only to Tallinn City inhabitants. Amount of the subsidy during the initial period (2015) will be 300 000 EUR, and measure is expected to be continuing in 2016. Due to its fresh implementation, it is not possible yet to know the cost-effectiveness of that measure.

1.2.2 Transport sector

As to energy efficiency and technology it is the ELMO program, lasting from 2011 until the end of 2014 (described in WP1 deliverable 1.1) that supports the take-up of electric vehicles in Estonia, providing direct support for purchasing electric vehicles (EV-s) and developing a quick-charging network all over Estonia. In total, KredEx has supported 657 (339 for private persons and 318 for company's) car purchase and 350 home chargers. During the program period KredEx has allocated grants in the total amount of EUR 10.5 million; the average grant per car has been EUR 16 500 (Kredex press release, 2014), which represents ca 35-50% of subsidy compared to the full price of an average EV. In addition the government purchased 507 Mitshubishi i-MiEV-s for social workers. According to Kredex ELMO program (Parve, 2015) the reported total annual mileage of the EV-s supported by Kredex were 7.2 million kilometres (2014), and social workers i-MieV 3.8 million (2013) with a total annual mileage of EV-s of 11 million vehicle-km.

As of May, 2015, there were 1221 registered EV-s in Estonia. Coming to the launch of EV- era, one can see that in 2010 there were all in all 8 registered EV-s only in Estonia. Figure 2 shows the yearly registration of EV-s in the period 2011-2015. (Estonian Road Administration, 2015)

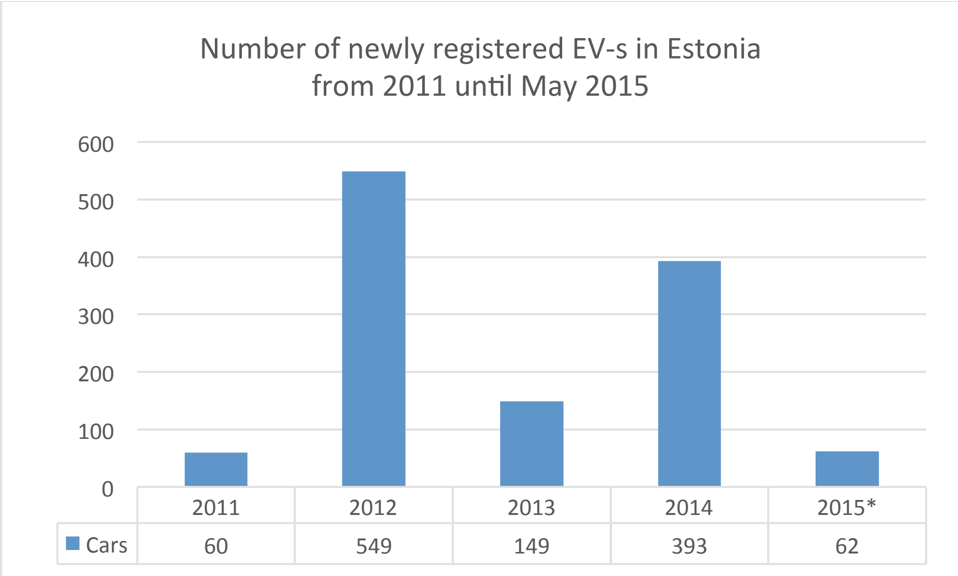


Figure 2. Number of newly registered EV-s in Estonia from 2011-2015.

*Data for 2015 represents first 5 months.

Source: Estonian Road Administration, 2015

The annual energy saving per car (15 000 km) is estimated compared to average car and similar sized car (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). In addition to electricity costs the EV-s need a replacement battery in 5-7 years in use, adding about 5000 € to the 10-15 year lifetime costs and 2000-5000 € additional costs during purchase compared to similar sized average car. Annual energy saving for the consumer is 5800-8400 kWh/y, monetary saving 1100-1500€/y (see **Fehler! Verweisquelle konnte nicht gefunden werden.**). The total annual energy saving with current EV fleet is 4000-6000 MWh/y, remaining marginal compared to the overall energy consumption in the transport sector (8.3 TWh/y, see D.2.1)

Table 2. Comparison of average energy and fuel costs for Nissan Leaf and average petrol car in Estonia and annual mileage of 15 000 km.

	Energy consumption (kWh/km)	Energy consumption (kWh/year)	Fuel consumption (l/year)	Energy and fuel cost	Energy and fuel costs €/year	Annual Saving (€)	Annual Energy Saving (kWh/y)	Retail price (€)	Price at 50% support
				€/kWh					
Nissan Leaf	0,173-0,212	2595		0,0475	123	1100-1500	5800-8400	34 000	17000
				€/l					
Average petrol car	0,77	11550	1269	1,3	1650	1499	8370	10-20 000	-
Similar sized car	0,6	9000	989		1286	1135	5820		-

Sources: Authors' calculations, Average energy consumption based on: Nissan Europe (2015), Parve (2015), Jüssi et al. (2014).

1.3 Market Perspectives due to Technological Trends

1.3.1 Buildings sector

In the Estonian buildings sector, highest potential for energy efficiency technology market, is for further installation and use of energy efficient (LED) lightning, both street and in-house lightning; further deployment of use of heat-pumps for heating and installation and use of heat-recovering ventilation systems. Development and use of above technologies are motivated in order to meet the near-zero energy performance criteria for new buildings in the framework for implementation of the EPD directive of EU.

Energy-efficiency technologies are mostly imported. E.g. from 25 companies, listed as members of the Estonian Heat-pumps Association there is only one company (Movek Ltd) which is producer / compiler of heat-pumps, others are selling and installing imported pumps from international (mostly originated in Nordic Countries, Japan, et al.) producers.

According to the Estonian Heat-pumps Association, heat-pumps have been installed in Estonia since 1992. If in early years heat-pump use was exclusive then during 2005-2007 installed number of heat-pumps already doubled annually. During the period of 1993-2013 there has been installed ca' 88,200 heat-pumps from which ca 78,200 were air heat pumps and ca 10000 earth heat pumps. Total capacity of installed heat pumps in Estonia is about 530 MW. Up to year 2013 there was installed 14,000 heat pumps and in 2015 the overall number of heat-pumps in operation is expected to exceed 100,000 units (Soojuspumpade..., 2014).

As for the energy efficiency materials, the domestic producers are oriented to isolation materials used for renovation of the buildings for increasing energy performance of the buildings. Main products are energy efficient windows, pre-fabricated wall elements and houses and insulation materials. This type of production is also exported in quite a volume.

1.3.2 Transport sector

All the cars supported by the ELMO program are imported. Almost half of the EV-s in Estonia are Mitsubishi iMiEV-s, more than 30% are Nissan Leaf. The distribution of EV stock across different car brands is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 3. EV brands and units supported by the ELMO program 2011-2014

Mitsubishi i-MiEV	546*
Nissan Leaf	367
Volkswagen e-Up	43
Mia Electrics	36
Tesla S	32
Polaris Ranger	30
Tazzari Citysport	24
Micro-Vett Fiorino	19
Renault Zoe	15
Nissan e-NV200	13
Opel Ampera	11
Mitsubishi Outlander PHEV	10

BMW i3	6
Volkswagen e-Golf	4
Citroen C-Zero	3
Peugeot iON	2
Toyota Prius Plug-In	2
Porche Panamera e-Hybrid	1

*Including 507 i-MiEVs for social workers all over Estonia
Source: http://elmo.ee/quick-facts/ (02.08.2015)

1.4 Data for the Buildings Sector

According to the Estonian Statistics Board in 2010 there were 567 769 households from which 41 152 (72.5 %) were located in urban areas and 156269 (27.5%) were located in rural area. 139 616 households (24.6% from total households) were living in detached (single-family) houses and rest in multi-family houses. From single-family houses, majority (63%; 87817 households) were living in rural areas and rest (37%, 51799 households) were in urban areas. In urban areas, majority (84.7%) of households are living in multi store houses. All data in following tables of technology use is taken from the study of the Estonian Statistics Board on 2012 energy consumption of households (Leibkondade, 2013). There is no data available on the energy consumption of the commercial/public sector buildings.

Table 4. Use of main technologies in buildings

Sector	Buildings
Sub-sector	Residential sector: • Space heating • Water heating • Cooking • Lighting • Refrigeration • Washing machines Commercial/services sector: • Space heating • Water heating • Cooking • Refrigeration • Lighting • Public street lighting

1.4.1 Residential Sector

<table>
<tr><td>Sector</td><td>Buildings</td></tr>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Space Heating</td></tr>
<tr><td>Technology</td><td>Central heating supply (65 % of total households)</td></tr>
<tr><td>Number of technology used</td><td>Single family houses in urban areas
<table><tr><td>Total</td><td>Stock</td><td>New buildings</td></tr><tr><td>51 799</td><td>n.a.</td><td>n.a.</td></tr></table>
Single family houses in rural areas
<table><tr><td>Total</td><td>Stock</td><td>New buildings</td></tr><tr><td>87 817</td><td>n.a.</td><td>n.a.</td></tr></table>
Multi-family houses
<table><tr><td>Total</td><td>Stock</td><td>New buildings</td></tr><tr><td>428 153</td><td>n.a.</td><td>n.a.</td></tr></table>
</td></tr>
<tr><td>Origin of technology</td><td>Central heating supply differs in size and technologies used and origin cannot be specified, the technology origin can be quoted partly domestic.</td></tr>
<tr><td>Cost of purchase</td><td>EUR 5100 – 6400</td></tr>
<tr><td>Cost per kWh</td><td>EUR 0,052-0,086</td></tr>
<tr><td>Energy consumption per household</td><td>kWh/a 10 608</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>Advantage is easiness of the use/disadvantage - prices cannot be influenced</td></tr>
<tr><td>Easiness to use</td><td>Extremely easy for consumers to use</td></tr>
</table>

<table>
<tr><td>Sector</td><td>Buildings</td></tr>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Space Heating</td></tr>
<tr><td>Technology</td><td>Firewood oven (30% from total households)</td></tr>
<tr><td>Number of technology used</td><td>Single family houses in urban areas
<table><tr><td>Total</td><td>Stock</td><td>New buildings</td></tr></table>
</td></tr>
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<tr><td></td><td>
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</td></tr>
<tr><td>Origin of technology</td><td>Firewood based ovens are mostly local origin, export share is about 30%</td></tr>
<tr><td>Cost of purchase</td><td>EUR 5 800 – 7 000</td></tr>
<tr><td>Cost per kWh</td><td>EUR 0.046-0.049</td></tr>
<tr><td>Energy consumption per household</td><td>kWh/a 15 960</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>Adv.: availability of suppliers/ Disadv.: needs storage and manual work</td></tr>
<tr><td>Easiness to use</td><td>Use is difficult as lot of logistics and manual work required</td></tr>
</table>

<table>
<tr><td>Sector</td><td>Buildings</td></tr>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Space heating</td></tr>
<tr><td>Technology</td><td>Heat pumps (3% of total households)</td></tr>
<tr><td>Number of technology used</td><td>
Single family houses in urban areas
<table><tr><td>Total</td><td>Stock</td><td>New buildings</td></tr><tr><td>51 799</td><td>n.a.</td><td>n.a</td></tr></table>
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<table><tr><td>Total</td><td>Stock</td><td>New buildings</td></tr><tr><td>428 153</td><td>n.a.</td><td>n.a.</td></tr></table>
</td></tr>
<tr><td>Origin of technology</td><td>Imported 99%</td></tr>
<tr><td>Cost of purchase</td><td>EUR 3 500-15 000</td></tr>
</table>

Cost per kWh	EUR 0.045-0.086
Energy consumption per household	kWh/a 7000
Advantages / disadvantages of use	Adv.: easiness of use, automated steering; Disadv.: costly, needs additional heat source for case of power cut.
Easiness to use	Extremely easy to use, automated control, maintenance free.

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Water Heating**
Technology	**Together with central heating** (53.4% of total households)
Origin of technology	See Central heating
Cost of purchase	See Central heating
Cost per kWh	See Central heating
Average energy consumption	2 138 kWh per household/year
Advantages / disadvantages of use	Adv.: easy to use; Disadv.: high cost
Easiness to use	Extremely easy to use, maintenance free

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Water Heating**
Technology	**Electric boiler** (35,4 % of total households)
Origin of technology	100 % imported
Cost of purchase	EUR 50-2500
Cost per kWh	EUR 0.14-0.12
Average energy consumption	2 138 kWh per household/year
Advantages / disadvantages of use	10.2% of total households have no hot water supply, in rural areas 22.7%
Easiness to use	Easy to use, no extra burden

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Water Heating**

Technology	**Heat pumps** (1 % of total households)
Origin of technology	See heat pumps
Cost of purchase	See heat pumps
Cost per kWh	See heat pumps
Average energy consumption	2 138 kWh per household/year
Advantages / disadvantages of use	Adv.: easy to install and use; Disadv.: high running cost
Easiness to use	Extremely easy to use, maintenance free

<table>
<tr><td>Sector</td><td>Buildings</td></tr>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Cooking</td></tr>
<tr><td>Technology</td><td>Oven, gas or electricity, A+ (72 % households)</td></tr>
<tr><td>Origin of technology</td><td>100 % imported</td></tr>
<tr><td>Cost of purchase</td><td>Range: 600 – 1100 EUR (source: internet search for the products displayed at: www.topten.eu</td></tr>
<tr><td>Cost per kWh</td><td>EUR 0.10-0.12</td></tr>
<tr><td>Average energy consumption (kWh/a)</td><td><table><tr><td colspan="5">Persons per household</td></tr><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>>4</td></tr><tr><td>198</td><td>396</td><td>440</td><td>595</td><td>595</td></tr></table>
(source: rwi 2013, data for 2011/2012)</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>Cookers with gas have 50% less conversion losses than cookers with electricity. Cookers with gas are less expensive. (source: www.ecotopten.de)</td></tr>
<tr><td>Easiness to use</td><td>If there is no gas connection for the cooker available, you have to use gas bottles. (source: www.ecotopten.de)</td></tr>
</table>

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Cooking**
Technology	**Firewood Oven** (28% households)
Origin of technology	Both domestic (hand-made) and imported, share

<table>
<tr><td></td><td>n.a.</td></tr>
<tr><td>Cost of purchase</td><td>Range: 300 – 1700 EUR (source: internet research for the products displayed at www.hinnavaatlus.ee)</td></tr>
<tr><td>Cost per kWh</td><td>EUR 0,046-0,049</td></tr>
<tr><td>Average energy consumption (kWh/a)</td><td><table><tr><td colspan="5">Persons per household</td></tr><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>>4</td></tr><tr><td>198</td><td>396</td><td>440</td><td>595</td><td>595</td></tr></table>
(source: rwi 2013, data for 2011/2012)</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>Additional heat supply/ lot of maintenance and hands-on work</td></tr>
<tr><td>Easiness to use</td><td>Average easiness</td></tr>
</table>

<table>
<tr><td>Sector</td><td>Buildings</td></tr>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Cooking</td></tr>
<tr><td>Technology</td><td>Microwave oven (61 % households)</td></tr>
<tr><td>Origin of technology</td><td>100 % imported</td></tr>
<tr><td>Cost of purchase</td><td>Range: 48 – 1020 EUR (source: internet research for the products displayed at www.hinnavaatlus.ee)</td></tr>
<tr><td>Cost per kWh</td><td>EUR 0,010-0,012</td></tr>
<tr><td>Average energy consumption (kWh/a)</td><td><table><tr><td colspan="5">Persons per household</td></tr><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>>4</td></tr><tr><td>198</td><td>396</td><td>440</td><td>595</td><td>595</td></tr></table>
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<tr><td>Easiness to use</td><td>If there is no gas connection for the cooker available, you have to use gas bottles. (source: www.ecotopten.de)</td></tr>
</table>

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Lighting**
Technology	**Incandescent lamps**
Origin of technology	100% imported
Cost of purchase	EUR 0.3-0.5
Cost per kWh	EUR 0.10-0.12
Energy consumption per household	kWh/year 437 (source: NEGAVATT, 2013)
Advantages / disadvantages of use	D: energy consuming, short lifespan
Easiness to use	Easy to use

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Lighting**
Technology	CFL lamps
Origin of technology	100% imported
Cost of purchase	EUR 2-5
Cost per kWh	EUR 0.10-0.12
Energy consumption per household	kWh/year 102
Advantages / disadvantages of use	A:Energy effective/ D:light quality
Easiness to use	Please describe

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Lighting**
Technology	LEDs
Origin of technology	100% imported
Cost of purchase	EUR 3.5-20
Cost per kWh	EUR 0.10-0.12
Energy consumption per household	kWh/year 60
Advantages / disadvantages of use	A:Energy effective, long life span/D: light quality
Easiness to use	Easy to use

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Refrigeration** (average 1 pcs per household)
Technology	Single-door refrigerator without freezer, small (156 liters), EU Energy class A+++
Origin of technology	100% imported
Cost of purchase	EUR 125 - 288
Cost per kWh	EUR 0.10-0.12
Energy consumption	kWh/year 64
Advantages / disadvantages of use	None
Easiness to use	Extremely easy to use

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Washing machines**
Technology	n.a.
Origin of technology	100% imported
Cost of purchase	EUR
Cost per kWh	EUR 0.10-0.12
Energy consumption	kWh/a n.a.
Advantages / disadvantages of use	n.a.
Easiness to use	n.a.

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Laundry Dryer**
Technology	n.a.
Origin of technology	100% imported
Cost of purchase	EUR
Cost per kWh	EUR 0.10-0.12
Energy consumption	kWh/a n.a.
Advantages / disadvantages of use	n.a.
Easiness to use	n.a.

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Dishwasher**
Technology	n.a.
Origin of technology	100% imported
Cost of purchase	EUR
Cost per kWh	EUR 0.10-0.12
Energy consumption	kWh/a n.a.
Advantages / disadvantages of use	n.a.
Easiness to use	n.a.

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Other electrics**
Technology	n.a.
Origin of technology	100% imported
Cost of purchase	EUR
Cost per kWh	EUR 0.10-0.12
Energy consumption	kWh/a n.a.
Advantages / disadvantages of use	n.a.
Easiness to use	n.a.

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Other energy use**
Technology	n.a.
Origin of technology	100% imported
Cost of purchase	EUR
Cost per kWh	EUR 0.10-0.12
Energy consumption	kWh/a n.a.
Advantages / disadvantages of use	n.a.
Easiness to use	n.a.

1.4.2 Commercial / services sector

Data on energy technologies use in commercial sector in Estonia is not available. Same data as for technology use in households can be applied.

1.5 DATA FOR THE TRANSPORT SECTOR

Table 5. Overview of EV-s supported by ELMO program

Sector	**Transport**
Sub-sector	Passenger transport • Vehicle efficiency • Road transport (cars)
Category	Road transport: • passenger transport: ○ car short distance, ○ car long distance,
Technology	Electric vehicles
Number of technology used	1164 EV-s
Origin of technology	Imported, for brands see **Fehler! Verweisquelle konnte nicht gefunden werden.**.
Cost of purchase	34 000 (with 50% support, 17 000) per average EV
Cost per kWh	0.0475 €/kWh, for saving see **Fehler! Verweisquelle konnte nicht gefunden werden.**.
Energy consumption	2 595 kWh/a per car (15000 km)
Advantages / disadvantages of use	Advantages: Low operating costs, low noise, 0-emissions, easy to maneuver, compactness, good acceleration. Disadvantages: Short battery life/ short range during winter months, cold and icy during winter months, 30% of users are dissatisfied with the quick charging network (Kredex, 2013).
Easiness to use	According to the EV user survey commissioned by Kredex (2013) 73% of users are satisfied or very satisfied with EV-s.

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HERON (No: 649690): Deliverable D.1.4

TECHNOLOGICAL TRENDS

PART OF WORK PACKAGE 1: MAPPING OF ENERGY EFFICIENCY POLICY INSTRUMENTS AND AVAILABLE TECHNOLOGIES IN BUILDINGS AND TRANSPORT

NATIONAL REPORT FOR GERMANY

2015-08-13

Partner: ***Wuppertal Institute for Climate, Environment, Energy***

Institution: Wuppertal Institute for Climate, Environment, Energy

Steering Committee member (1): Dr. Ralf Schüle

Prepared by: Thomas Adisorn, Hanna Hüging, Dr. Ralf Schüle, Lena Tholen, Maike Venjakob

(1) The Steering Committee member has the responsibility for ensuring the quality of the report.

HERON: Forward – looking socio-economic research on Energy Efficiency in EU countries

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ACRONYMS

BAFA – Bundesamt für Wirtschaft und Ausfuhrkontrolle, Federal Office for Economic Affairs and Export Control

BEV – Battery Electric Vehicle

Dena – Deutsche Energieagentur, German Energy Agency

EMS – Energy Management System

EnEV – Energieeinsparverordnung, Energy Saving Ordinance

KfW – Kreditanstalt für Wiederaufbau, Bank for Reconstruction

PHEV – Plug-in Hybrid Electric Vehicle

PJ - petajoule

HEV – Hybrid Electric Vehicle

ICE – Internal Combustion Engine

IPEEC – International Partnership for Energy Efficiency Cooperation

WHR – Waste heat recovers

Pkm – passenger kilometers

Vkm – vehicle kilometers

Tkm – ton kilometers

VgV – Vergabeverordnung, Public procurement ordinance

EXECUTIVE SUMMARY

The present report identifies relevant energy efficiency technologies that are already used in Germany and promoted by corresponding energy efficiency policy instruments.

The German **building stock** consumes around 40% of German's final energy. At the same time, studies found that the sector has huge energy saving opportunities in different sub-sectors. However, in order to realize energy savings in the building sector, policy support is key. Germany's energy efficiency policy package in the building sector, which is described in detail in the German deliverables D.1.1 and D.1.2, includes regulatory instruments, instruments that promote the dissemination and awareness, economic tools, capacity building support as well as support for the uptake of energy services and research and development promotion. Most of the measures used in Germany do not focus on a single technology. They either address a set of technologies or are even cross-cutting. The building section concludes with an overview of selected technologies that have been supported directly or indirectly through the policy tool-kit.

The **transport sector** has currently a share of 28% of the final energy consumption in Germany. Several studies identified significant potential for energy efficiency improvements in the German transport sector. According to these studies, efficiency increases of up to 50% are possible till mid of the century. Besides modal shift for passenger and goods transport, improvements in vehicle technology are a key factor for overall efficiency increase. Design, material composition, and engine technology as well as more efficient vehicle components and equipment can reduce the specific energy consumption. In addition to efficient gasoline and diesel vehicles, hybrid electric and electric vehicles play a key role for efficiency improvements. Therefore, the German government developed an electric mobility strategy and implemented several policies to promote efficient vehicles in general and electric vehicles in particular. There are also energy efficiency technologies available for non-road transport, but these technologies play a smaller role in realizing strong efficiency improvements in the German transport sector.

Chapter 1: Technological Trends in the Building and Transport Sector

In this task, for each country relevant technologies that are already used and promoted by corresponding energy efficiency policy instruments will be presented.

1.1 Energy Efficiency Potential

1.1.1 Energy Efficiency Potential in the German Buildings Sector

The German building stock has a substantial energy saving potential. For residential buildings, IFEU et al. (2009) suggest that building refurbishment and the exchange of boilers will result in significant savings (154 PJ) by 2020. In comparison to that, the construction of new energy-efficient buildings will only yield marginal savings by 2020. For the commerce and services sector, highly efficient lighting has the highest saving potential with almost 50% (or 33 PJ) in the sector, while the saving potential for building refurbishment and the exchange of boilers can be neglected. A newer study carried out by IFEU (2011) also identifies the enormous energy saving potential in building refurbishment for 2020 and 2030. However, this time energy consumption can be lowered in both, the residential sector and the commerce and services sector.

Fraunhofer ISI (2012b) found that energy-efficient appliances and lighting can result in energy savings in the residential sector, but compared to other options their contribution is rather small. In particular, building-related measures like water heating systems are opportunities to cut energy consumption large-scale. Increasing fuel prices make such investments profitable within shorter periods. However, the study concludes, “they need to be activated by political measures that address in particular also behavioural barriers such as high up-front investments” (Fraunhofer ISI 2012, p. 15).

Table 1: Overview of the energy efficiency potential in buildings in different studies

Study	Scope	Efficiency improvement	Details
IFEU, et al. 2009	Germany; till 2020	Reductions in 2020 amounting to 534PJ	Private households: 254 PJ, commerce and services: 68 PJ, industry: 212 PJ Study based on energy efficiency potentials of 33 instruments
IFEU 2011	Germany; till 2030	For 2020, energy saving estimates range between 630 PJ to 1262 PJ and for 2030, between 954 PJ to 2078 PJ	Private households: 58 – 388 PJ by 2020 and 127 – 622 PJ by 2030 Commerce and services: 94 - 247 PJ by 2020 and 141 – 409 PJ by 2030 Industry: 181 – 278 PJ by 2020 and 258 – 417 PJ by 2030; Study based on energy efficiency potentials of 43 instruments
Fraunhofer	Germany	Overall savings can	Household sector: compared to

ISI 2012b		amount to 57% compared to baseline projections; estimates for cost-efficient savings are slightly lower at 52%	baseline 71% or 207 Mtoe of final energy demand reduction possible by 2050; Tertiary sector: compared to baseline 61% or 90 Mtoe of final energy demand reduction possible by 2050; Industry sector: compared to baseline 52% or 192 Mtoe of final energy demand reduction possible by 2050;

1.1.2 Energy Efficiency Potential in the German Transport Sector

The energy efficiency potential in transport is high as indicated by several studies (Table 2). The efficiency potential does not lie solely in technical improvements, but also in mode shift as highlighted by Fraunhofer ISI (2012a). Despite efficiency improvements in terms of energy consumption per distance travelled, the total energy demand from the transport sector is also determined by the development of the transport demand. Ifeu (2012) assume efficiency improvements for all modes, but according to their assumption increasing transport demand outweighs efficiency improvements and leads to a net increase of transport energy demand.

Table 2: Overview of the energy efficiency potential in transport in different studies

Study	Scope	Efficiency improvement	Details
Fraunhofer ISI 2012a	Germany; Developments till 2030 (also data for EU 27)	47% reduction of transport energy demand compared to the baseline	Origin of the energy savings: 43% from passenger transport (technical and mode shift); 40% from goods transport (technical and behaviour change) 11% from air traffic
Shell 2014	Germany,; Till 2040 Covers only passenger cars	Reduction in energy consumption from passenger cars: Trend-scenario 45% , Alternative scenario 52%	Stronger market penetration of alternative fuels in the “Alternative scenario” Average efficiency improvements of new vehicles in 2040 compared to 2013: Trend-scenario 44%; Alternative-scenario 52%
Ifeu 2012	Germany, till 2030	The primary energy consumption of the transport sector is projected to increase due to and rising transport volume.	Efficiency improvements are outweighed by an increase in transport demand. Specific fuel consumption for buses and heavy-duty vehicles is projected to decrease by 8%. Efficiency improvements in rail transport of 10% for diesel traction

			and of 20% for electric traction Specific energy consumption in air transport decreases by 20%
DLR et al.2012 (Leitstudie 2011)	Germany, till 2050	Final energy consumption is reduced by 40 to 47% (compared to 2005) depending on the scenario	Energy efficiency improvement is assumed to reach 55% in 2050 (compared to 2005) for gasoline cars and 50% for diesel cars.

1.2 Technologies And Policy Instruments

1.2.1 Technologies and Policy Instruments for Buildings

The following table provides an overview showing which policy instruments already described in D1.2. support certain technologies.

Table 3: Overview of technologies supported by policy instruments

	German policy instruments for the buildings sector	Technologies that are supported
Regulatory policy instruments	• Energy Saving Ordinance (EnEV)	Exchange of certain boilers, inspections of air-conditioning systems, lighting systems
	• Inspections of boilers and heating/cooling installations	Boilers, air-conditioning systems (<12 kw)
	• Heating Cost Regulation	Boilers
	• Energy performance certificate	Records information on the type of cooling system, space- and room heating and can provide recommendations for a variety of energy efficiency enhancement measures
Dissemination and awareness	• Seal of Quality Efficiency House	By taking into account two criteria, primary energy consumption and loss of transmission heat, the measure addresses building equipment such as boilers but also the building envelope
	• On-side energy consultation	Space- and water heating technologies as well as building envelope, doors and windows
	• Energy checks	All types of household appliances and ICT equipment, walls, windows, doors, roofs, heating and distribution systems; gas- and oil-based heating systems can also be scrutinised

	• Energy consultation for SMEs (KfW)	Advisory services address the building envelope, building equipment as well as the user behaviour
	• KfW construction monitoring	Monitoring consultants plan energetic building concepts holistically and accompany the realisation process, which may also include the uptake / exchange of heating and cooling systems
Economic policy instruments	• KfW Energy-efficient Construction	Energetic building enhancement in line with Efficiency House standards
	• KfW Energy Efficient Refurbishment	Insulation of walls and roofs, windows and exterior doors, renewal or optimisation of heating and ventilation systems
	• Market incentive programme to promote the use of renewable energies in the heating market	Solar thermal collectors, biomass, heat pumps
	• Energy tax	Targets excessive energy consumption and, hence, indirectly addresses a variety of energy saving measures including the exchange of heating and ventilation systems, inefficient appliances etc.
	• BAFA cross-cutting technologies	Electrical motors, pumps, ventilation systems as well as certain heat recovery systems and systems for compressed-air production
Capacity building	• Energy efficiency Networks Initiative	Seeks to comprehensively spot energy leaks due to energy-inefficient buildings, building equipment, processes or behaviour
	• Promotion of energy management systems (EMS)	Directly supports the uptake and certification of an EMS as well as technologies and software that help to establish an EMS; indirectly, the measure promotes the feedback on energy consumption in businesses, which may result in the installation of new energy-efficient technologies including heating and ventilation systems, lighting etc.
	• Funding for the retraining as an energy consultant	Supports the uptake of energy efficient technologies only indirectly as soon as consultants have completed retraining

	• Requirement guidelines for energy consultants and list of certified energy consultants	Supports the uptake of energy efficient technologies only indirectly as soon as consultants meet guidelines and are included in the registry; since consultants are then allowed to be employed for KfW and BAFA programmes, the measures indirectly focus on the building envelope, building equipment (heating and ventilation systems)
	• IPEEC (International Partnership for Energy Efficiency Cooperation)	Rather focuses on information exchange and knowledge enhancement; the technological focus is quite unspecific due to a variety of initiatives realised; initiated measures such as SEAD have taken into account air conditioning, ceiling fans, electric motors, transformers, computers, networked devices, televisions, interior lighting, street lighting, commercial refrigeration and residential refrigeration
Promotion of energy services	• Competence centre for public buildings (incl. default guarantees)	Facilitates energy services, which, in turn, result in the installation of energy efficient heating and ventilation systems, etc.
Research and development	• Low energy buildings project (dena) and efficiency house Plus	Exchange or installation of very energy-efficient heating (and cooling) systems as well as energy-efficient building material; both instruments take into account comprehensive energy efficiency measures in buildings and, hence, do not have a technological focus
	• Research initiative "Zukunft Bau" and Research for energy-optimised construction	The focus of the research initiative "Zukunft Bau" is also relatively unspecific from an technological point of view; it facilitates technologies and techniques for energy efficient construction and efficient building equipment, which may include heating and cooling systems The research programme for energy-optimised construction targets water heating, ventilation, air-conditioning, lighting and pumps; moreover, technologies and concepts for zero-energy buildings in the residential sector are fostered

	• Public procurement guidelines	All technologies that have a "bearing on energy consumption or are necessary for the provision of a service" (BMWI 2014a, p. 25; see also VgV §4(4), §6(2))
	• 6. energy research programme	A detailed overview of technologies promoted has not be available, but the general focus is building technologies and on energy efficiency in the industrial, commercial and services sector; energy efficiency concentrates (for more information see BMWI 2014b)

Most of these instruments do not target only one specific technology but rather seek to reduce the energy consumption in buildings through multiple technologies. Obviously, some measures such as retraining support for becoming an energy advisor only target the deployment of energy-efficient technology indirectly.

The innovation or energetic improvement of technologies is supported by the research-based measures such as the 6. Energy Research Programme or the research initiative "Zukunft Bau" and Research for energy-optimised construction. The market breakthrough of such innovations is pushed forward by, for instance, the KfW refurbishment and construction programmes, whose incentives increase the uptake of energy-efficient building material and building equipment.

1.2.2 Technologies and Policy Instruments for Transport

Table 4 summarizes key technologies for energy efficiency in the transport sector and policy instruments that support these technologies, without any claim to be comprehensive. The selection of technologies is based on their potential for efficiency improvements that are estimated in the studies listed in Table 2 and on political priorities as reflected by the policy instrument that support the penetration of the identified technologies (see e.g. BMWI 2014a, BMUB 2014a). The largest absolute potential for technical efficiency improvements is seen in individual motorized transport (especially by car). Strong improvements are expected due to the penetration of electric vehicles and reduction in specific energy consumption by gasoline and diesel vehicles (see e.g. DLR et al. 2012). For goods transport, efficiency improvements due to mode shift are seen to play a larger role compared to technical improvements. In aviation, optimized routing by a "Single European Sky" is seen to yield the potential for efficiency improvements (BMWI 2014a). More details on the selected technologies are provided in section 1.5.

Table 4: Overview about selected existing policies and existing technologies in the transport sector

Policy instruments identified in D1.2	Technology supported
CO_2-related motor vehicle taxation	- BEV vehicles[1]
CO_2 emission standards of new	

[1] Battery electric vehicle (BEV) Vehicle with an electric propulsion system that relies exclusively on electricity from the grid)

vehicles Passenger car labelling	- PHEV vehicles[2] - HEV vehicles[3] - Natural gas vehicles - Efficient ICE[4] vehicles - Light-weight design for road vehicles
"Elektromobilitätsgesetz"	- BEV vehicles - PHEV vehicles
Tax reduction for natural gas in the transport sector	- Natural gas vehicles
Government electro mobility programme (funding for electric mobility in model regions, financial support for R&D)	- BEV vehicles - PHEV vehicles - HEV vehicles
HGV toll (Government plans to introduce staggered charges based on the vehicles' energy consumption)	- Aerodynamic improvements (for HDV) - Low rolling-resistance tyres
National cycling plan	- Pedelects, E-bikes
Government Programme Electric Mobility;	- Light-weight design for road vehicles
Voluntary agreement with German National Railways: specific CO2 reduction targets for the period 2006-2020	- Hybridization of diesel traction (rail)
Additional policy instruments	**Technology supported (less efficiency potential)**
Lower electricity consumption tax for shore-side electricity in navigation (BMUB 1014a)	- Shore-side electricity provision
Funding programme for low emission engines for navigation (BMVBS 2013a)	- Waste heat recovery - LNG in navigation
Research programme for civil aviation (programme line eco-	- Efficient airplane design and construction

[2] Plug-in hybrid electric vehicle (PHEV): Vehicle with an internal combustion engine and an electric engine that can run either on electricity or on petrol/diesel and can be charged by electricity from the grid

[3] Hybrid electric vehicles (HEV): Vehicle with an internal combustion engine and an electric engine. The battery is only charged on-board by regenerative braking and while driving on engine power.

[4] Internal Combustion Engine (ICE)

efficient aviation)	
National derogation for long heavy vehicles	- Long heavy vehicles
EU tyre labelling and phase out	- Low rolling-resistance tyres
Funding programme for hybrid electric and plug-in hybrid electric buses for public transport (BMUB, 2014b)	- Plug-in hybrid electric buses - Hybrid electric buses

In 2009, the German government adopted the "National development plan for electric vehicles". The plan forms the strategic basis for funding programmes and other instruments that have been implemented since 2009 to support the development and market penetration of electric vehicles. The plan was specified by the governmental program on electric mobility in 2011 (DLR and Wuppertal Institute, 2014). Since 2009, a significant increase in annual registrations of BEV and PHEV can be observed (see Figure 1). Besides the implementing policy instruments, other factors contributed to the penetration of electric vehicles. An important factor is the technological progress in terms of battery and vehicle technology that can be observed in the same period. In addition, before 2009, there very only very few electrified vehicle models on the market, while major German manufactures released new models after 2010.

The existing policy framework plays a key role for the cost competiveness of electric vehicles. Purchasing cost for BEVs or PHEVs are higher than for diesel or gasoline vehicles. Whether the high purchasing prices can be compensated by lower operation costs is strongly influenced by fuel and electricity prices, which in turn are influences by taxation levels. As shown by ICCT (2004), electric vehicles are only cost competitive in those countries that implemented direct subsidies or tax incentives for electric vehicles such as Norway, Denmark or the Netherlands. In Germany, BEV and PHEV are not yet cost competitive for most users. However, the cost competiveness is also influenced by annual millage, battery lifetime and residual market value on the used car market. At a very high annual millage (above 18,000 km), electric vehicles can be cost competitive according to (Plötz, 2013).

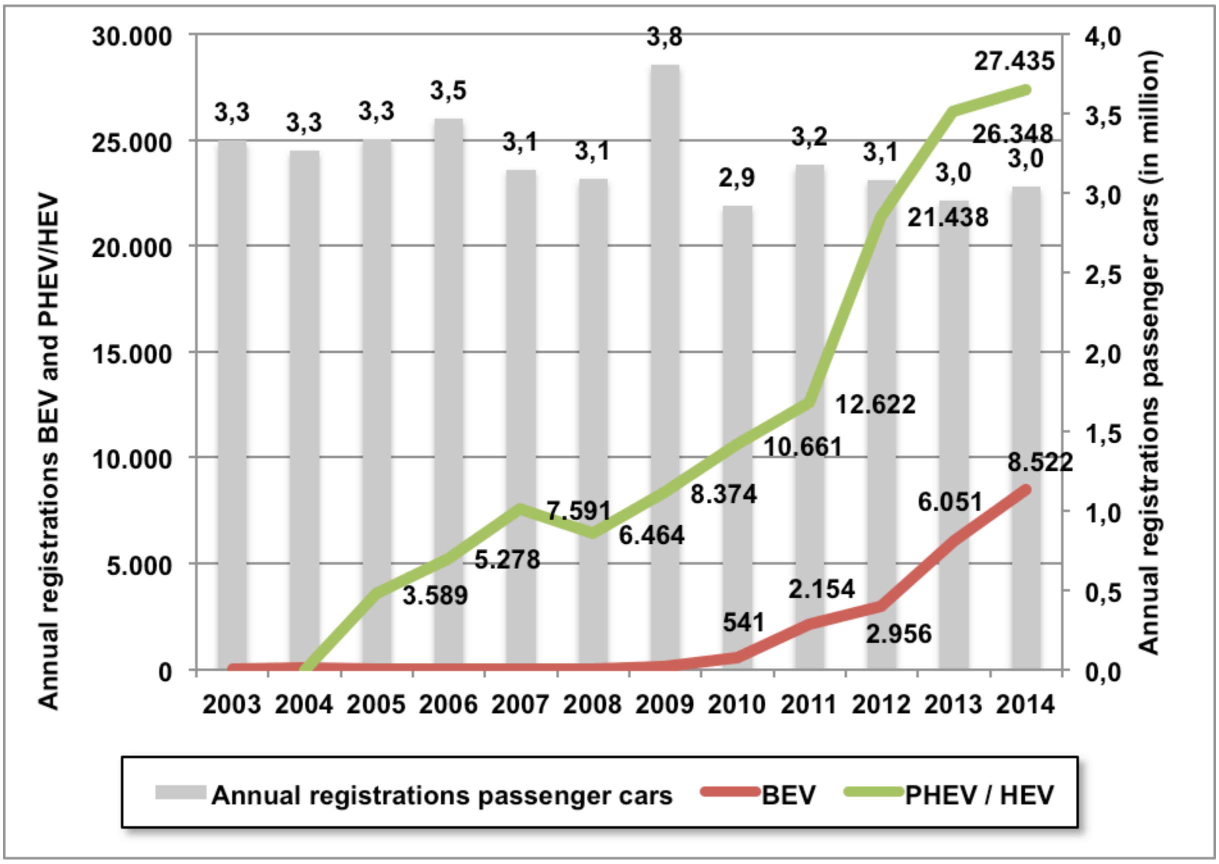


Figure 1: Annual registrations electric passenger cars in Germany and total registrations. Source: KBA 2015.

1.3 Market Perspectives due to Technological Trends

1.3.1 Introduction to the German energy efficiency market

The German Green Tech market is expected to grow: for the period of 2013 to 2025 an average annual growth rate of 6.6% is forecasted. This would mean, that the market volume would increase from EUR 344 billion in 2013 to EUR 470 billion in 2025 (BMUB 2014c). This Green Tech market does of course not only include energy efficiency in buildings and transport[5], however, it has a big share: with a current market volume of EUR 100 billion, energy efficiency is the biggest of the green tech lead markets. The market volume of sustainable mobility accounts for EUR 53 billion.

Nearly half of the lead market for energy efficiency (EUR 45 billion) belongs to energy-efficient buildings and energy-efficient appliances. Most important technologies are the following (BMUB 2014)c:

[5] Six green tech lead markets can be regarded: energy efficiency; sustainable water management; environmentally friendly power generation, storage and distribution; material efficiency; sustainable mobility; and waste management and recycling (BMUB 2014c)

Energy-efficient buildings:

- Thermal insulation
- Building automation
- Efficient heating, ventilation and air-conditioning systems
- Passive houses / PlusEnergy houses

Energy-efficient appliances:

- Energy-efficient white goods
- Green IT
- Energy-efficient lighting
- Energy-efficient consumer electronics

The lead market for sustainable mobility shows the fastest growth among the lead markets, on the national as well as on the global market. The following shows the market segments and their most important technologies:

Figure 2: Market segments and key technology lines in the lead market for sustainable mobility

Sustainable mobility

Market segments	Key technology lines
Alternative drive technologies	• Hybrid drive systems • Electric drive systems • Fuel cell drive systems
Renewable fuels	• Bioethanol • Biodiesel • Biomethane • Hydrogen from renewable resources • Biokerosene
Technologies to increase efficiency	• Efficiency gains in combustion engines • Lightweight engineering technologies • Energy-saving tires
Transportation infrastructure and traffic management	• Rail vehicles and infrastructure • Traffic control systems • Filling station infrastructure for alternative drive systems • Public transport • Car sharing • Cycle paths

Source: Roland Berger (BMUB 2014c)

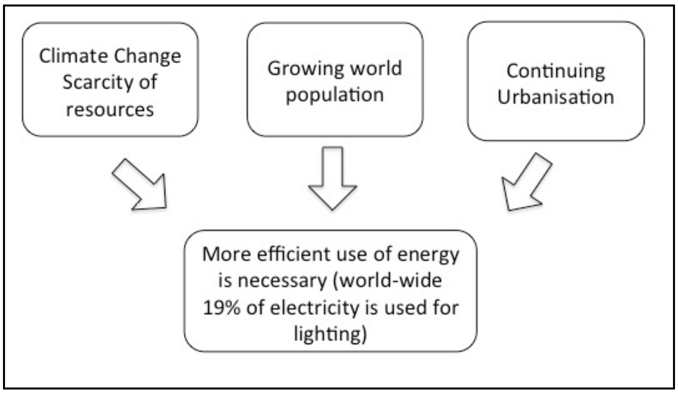
1.3.2 TECHNOLOGIES WITH COMPARATIVE ADVANTAGE IN GERMANY

1.3.2.1 LIGHTING

One example for a technology with comparative advantage in Germany is **lighting**, especially LEDs and OLEDs (BayernLB 2014).

Drivers for the development of the lighting market are:

Figure 3: Drivers for the development of the lighting market



Source: BayernLB 2014

<u>Exports / imports</u>
German Lighting Industry:
Turnover in 2014: 5,6 billion EUR (ZVEI Electrical and Electronic Industry in Numbers May 2015)
Exports in 2014: 4,4 billion EUR (ZVEI Electrical and Electronic Industry in Numbers May 2015)
Imports in 2014: n.a.

<u>Development of the German energy efficiency market for Lighting</u>
More than 40% of the world market for lighting is occupied by Asia, 25% by the EU and another 25% by the USA (BayernLB 2014). China accounts for around one third of world production and is next to the world's biggest producer also the world's biggest market for the lighting industry.

The German share on the world market for lighting technology has been falling in the last years and is now at around 4%. However, the lighting division of the ZVEI expects an upswing of the market in 2014 with an increase in turnover of up to 5%.

The share of **LED**-technology at the turnover in Germany is currently at about 25% and is expected to grow. Especially in the field of indirect lighting, in the premium segment of the automobile industry and in public buildings the share is already high. Potential for development can be seen in the tertiary sector and in consumer electronics (from washing machines to smart phones).

Regarding experts' estimation, LED technology will have a share of 70% in lighting worldwide in 2020.

Next to LEDs, also **OLEDs** (organic light-emitting diodes) are expected to have a huge development potential. The German lighting industry shows a big interest in this technology as they invest high sums in the production.

Another growing market could be intelligent lighting management in **Smart Homes**.

1.3.2.2 ELECTRIC DRIVE SYSTEMS

Germany is the third largest producer of passenger cars and light commercial vehicles globally (OICA, undated). Most German automobile manufactures are active in the field of electrified vehicles and launched respective models on the market. In total, 17 serial models were released till end of 2014 and 12 additional models are expected to be released in 2015 (NPE, 2014). Most models of German brands were released since 2010. Accordingly, German manufactures were not among the pioneering manufactures such as Toyota, Nissan or Tesla, but due to the strong technical expertise and strong R&D investments, both private and public, German manufactures are well positioned in the global market of electric vehicles (NPE, 2010; DLR and Wuppertal Institute, 2014).

In 2013, 3,291 electric passenger cars were manufactured in Germany. In addition, 7,185 electric cars were imported to Germany and 5,783 vehicles were exported. [6] Thus, in terms of electric cars there was an import surplus. In contrast, there is an overall export surplus in terms of new passenger cars: about 1.9 million passenger cars were imported, while passenger car exports encompassed about 4.5 vehicles (VDA, 2014). The German platform on electric mobility (NPE – Nationale Platform Elektromobilität) rates Germany as important leading supplier of electric vehicles. This is based on investments in R&D and the development of advanced technologies and services related to electric mobility (NPE 2014). According to the NPE assessment Germany, performs better than other important manufacturing countries like Japan, France or China. Only the USA performs slightly better than Germany.

According to Proff and Kilian (2012), Germany is in a very good competitive position concerning the production of electric engines as being one of the most important exporters of electric motors globally. For instance, the German suppliers like Bosch and Siemens are developing and producing electric motors. Furthermore, German companies have a high competence in the field of power electronics (Proff and Kilian, 2012).

Despite the comparative advantage in terms of development of electric vehicles and related components, the domestic market of electric vehicles is not as developed as in other European countries. In Germany, shares of BEV and PHEV among new vehicle registration are lower than in Norway, the Netherlands, France or Denmark (DLR and Wuppertal Institute 2014).

1.4 DATA FOR THE BUILDINGS SECTOR - GERMANY

Having presented the market perspectives and technological trends, the subsequent sections focus on energy-efficient technologies in the residential sector, on the one hand, and the commercial and services, on the other hand.

1.4.1 RESIDENTIAL SECTOR

The following tables provide an overview of energy-efficient technologies in Germany. A variety of measures, most of which were presented in D.1.2. and very briefly in Chapter 1.2.1. of this document, have a direct or indirect impact on the uptake of these energy-efficient technologies.

[6] Please note: not all vehicles released by German brands are manufactured in Germany, e.g. the smart fortwo electric drive is manufactured in France.

For instance, the EnEV regulates the energy performance of space heating systems in new and existing buildings. Moreover, as space and water heating require have a substantial energy demand in Germany, they are also addressed by further policies, such as on-side energy consultation or KfW construction monitoring. With respect to appliances for cooking, refrigeration lighting or washing, energy checks help households to identify energy leaks. On the international level, Germany's participation in the IPEEC enhances the Government's capacity to install tailor-made policy instruments to promote energy reduction in appliances. Some policies such as the energy taxation are cross-cutting since it raises the price for energy, in general, affecting all energy-consuming technologies.

Sector	Buildings
Sub-Sector	Residential sector
Category	Space Heating
Technology	Gas condensing central heating boilers, multi-family buildings, technology for heating and hot water, 20-90kW, energy label A
Number of technology used	According to AGEB (2015) the market share of gas-based heating in new buildings declined from 76% in 2000 to around 50% in 2014 compared to other technologies; of which in particular heat pumps and long-distance heating gained momentum. However, for new buildings latest figures show a rising trend in market shares for gas-based heating systems, whose all-time low was in 2013 (48%). In comparison to that, AGEB figures for existing buildings show that gas-based heating is very stable and even increased between 2000 (44.5%) and 2014 (49.2%). The exchange of inefficient heating systems in residential buildings is funded by KfW's energy efficient refurbishment programme, which may contribute to the continuing popularity of gas-based heating in the sector (see Diefenbach et al. 2014).
Origin of technology	Gas condensing heating boilers have a market share of 60% with 360.000 products sold per annum. The main manufacturers are Buderus, Junkers, Vaillant, Wolf and Viessmann. In 2014, approximately 9 million gas-heating units were in use in Germany (Statista 2015a)
Cost of purchase	Range: EUR 6000-8000
Cost per kWh	Depends on gas price
Energy consumption	Depends on size of the building, around 10000-20000 kWh/a per household
Advantages / disadvantages of use	Low investment and energy costs, low emission technology, annual maintenance is recommended
Easiness to use	Only experts are allowed to maintenance the heating systems

Sector	**Buildings**

Sub-Sector	**Residential sector**
Category	**Air Conditioning**
Technology	Monosplit, 3-4kW, energy class A+++, primary for cooling purpose
Number of technology used	According to UBA (2011 based on Ecodesign 2008), a marginal number of split-units (<50,000), including mono- or multi-split systems, are used in German residential buildings. In contrast, more than 400,000 moveable units are installed. Detailed information on the distribution in single-family and multi-family have not been identified.
Origin of technology	Main manufacturers are Remko, De'Longhi, Whirlpool, Einhell, Stiebel Eltron According to the environmental federal agency (UBA), 140,000 air-conditioners are sold every year. The products are mainly imported.
Cost of purchase	Range: EUR 400-800
Cost per kWh	Depends on electricity price, on average 0,29 EUR / kWh in Germany
Energy consumption	Range: 140-150 kWh/year
Advantages / disadvantages of use	Temperature and humid control Due to climate conditions in Germany an air conditioning system is not needed (in comparison to south European countries) and have a negative environmental impact. The products are only used for ca. 30 days per year.
Easiness to use	Easy to use

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Water Heating**
Technology	**Electric water heaters combined with a heat pump**
Origin of technology	See heating system
Cost of purchase	Around EUR 2,000 (Erdwärmepumpe.de 2015)
Cost per kWh	See heating system
Average energy consumption	According to topten.ch, an electric heat pump for water heating may consume on average around 1,500 kWh/a.
Advantages / disadvantages of use	The installation of the heat pump is easy and can be combine with PV. Particularly, in old buildings subject to refurbishment, heat pumps can have a positive side-effect through cooling or dehumidifying the basement.
Easiness to use	

<table>
<tr><td>Sector</td><td>Buildings</td></tr>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Cooking</td></tr>
<tr><td>Technology</td><td>Oven without steamer, gas or electricity, A+</td></tr>
<tr><td>Origin of technology</td><td>National product (% of imports?); brands of 50% of electricity ovens in place in Germany in 2012 (ranked by number): AEG/Elektrolux, Siemens, Bosch, Bauknecht, Miele (Statista 2015a)</td></tr>
<tr><td>Cost of purchase</td><td>Range: 600 – 1100 EUR (source: internet research for the products displayed at www.topten.eu</td></tr>
<tr><td>Cost per kWh</td><td>Depends on gas / electricity price</td></tr>
<tr><td>Average energy consumption (kWh/a)</td><td><table><tr><td colspan="5">Persons per household</td></tr><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>>4</td></tr><tr><td>198</td><td>396</td><td>440</td><td>595</td><td>595</td></tr></table>
(source: rwi 2013, data for 2011/2012)</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>Cookers with gas have 50% less conversion losses than cookers with electricity. Cookers with gas are less expensive. (source: www.ecotopten.de)</td></tr>
<tr><td>Easiness to use</td><td>If there is no gas connection for the cooker available, you have to use gas bottles. (source: www.ecotopten.de)</td></tr>
</table>

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Lighting**
Technology	LED, E27, bright, energy class E+, Power 5-10 W, Lamp life time 20,000 hours, switching cycles 50,000, not dimmable, warm white
Origin of technology	The most relevant LED manufacturers worldwide (data for Germany is not available) are Nichita Corporation (Japan), Samsung LED (Korea), Osram (Germany), LG Innotek (Korea) and Seoul Semiconductor LED (Korea) (Statista 2015a)
Cost of purchase	Range 3-20 EUR
Cost per kWh	Depends on electricity price, on average 0,29 EUR / kWh in Germany
Energy consumption	5-10 W
Advantages /	Advantages are the less electricity costs, a long lifetime, they are made of solid

disadvantages of use	material with no filament or bulb to break, they have no warm-up period, LEDs contain no mercury or other hazardous substances, the life time of LEDs is 20,000 hours and more. Disadvantages are that they are currently more expensive than other conventional lamps and LEDs can shift colour due to age and temperature
Easiness to use	It is easy to use

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Refrigeration**
Technology	Single-door refrigerator without freezer, small (156 litres), in-built, EU Energy class A+++
Origin of technology	Brands of 50% of refrigerators in place in Germany in 2012 (ranked by number): AEG/Elektrolux, Bosch, Siemens, Liebherr, Quelle/Privileg (Statista 2015a)
Cost of purchase	Range: 300-500 EUR
Cost per kWh	Depends on electricity price, on average 0,29 EUR / kWh in Germany
Energy consumption	62 kWh/year
Advantages / disadvantages of use	Low electricity costs, no disadvantages
Easiness to use	Very easy to use, some refrigerators have manual defrosting system and automatic temperature control

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Washing machines**
Technology	Front loader, capacity 7kg, spinning speed 1400 rpm, cold wash available, EU energy efficiency class A+++
Origin of technology	Brands of 50% of refrigerators in place in Germany in 2012 (ranked by numbers): Miele, Bosch, Bauknecht, Siemens, AEG/Elektorlux (Statista 2015a)
Cost of purchase	Range: 450-600 EUR
Cost per kWh	Depends on electricity price, on average 0,29 EUR / kWh in Germany. In addition there are costs for water demand
Energy consumption	Range: 120-140 kWh/a
Advantages / disadvantages of	Low electricity costs, cold wash available, saves a lot of time in comparison to

use	hand wash
Easiness to use	Very easy to use, under some circumstances (back problems) it might be easier to use a top loader

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Tumble Dryer**
Technology	Heat Pump dryer, capacity 7 kg, energy class A+++,
Origin of technology	Brands of 50% of refrigerators in place in Germany in 2012 (ranked by numbers): Miele, Bosch, Siemens, AEG/Elektrolux (Statista 2015a)
Cost of purchase	Range: 600 – 1000 EUR
Cost per kWh	Depends on electricity price, on average 0,29 EUR / kWh in Germany
Energy consumption	160 kWh/a
Advantages / disadvantages of use	Disadvantage is the high electricity costs in comparison to air drying
Easiness to use	The appliances are often built with a display with time remaining indicator which makes it easy to use the product. A wide choice of programmes makes it easy to find the right drying programme for the laundry.

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Dishwasher**
Technology	Freestanding, width 60 cm, water consumption 2000-2800 l, energy efficiency class A+++
Origin of technology	Brands of 50% of refrigerators in place in Germany in 2012 (ranked by numbers): Siemens, AEG/Elektrolux, Bosch, Miel (Statista 2015)
Cost of purchase	Range: 500-1000 EUR
Cost per kWh	Depends on electricity price, on average 0,29 EUR / kWh in Germany
Energy consumption	194-240 kWh/a
Advantages / disadvantages of use	Advantages: it saves time, water and energy. Automatic dishwashers clean better than washing by hand. According to a study by the Bonn university automatic dishwashers use in average 15-22 litre water per wash. Manual dishwashers use more than 100 litres
Easiness to use	It is easy to use, a range of different programmes makes it easy to find the right programme. Dishwashing could save up to 3 weeks compared to washing by hand.

1.4.2 Commercial / services sector

The following section presents energy-saving technologies, which are addressed by one or several policy instruments. For instance, the uptake of heat pumps installed in new non-residential buildings has been increasing in recent years. According to the Federal Association Heat Pumps (BWP 2013), the installation of heat pumps is competitive with other technologies. In buildings, that are subject to refurbishment, heat pumps pay for themselves only at a later stage. In order to reduce upfront investment costs and, eventually, to facilitate the installation of heat pumps in existing buildings, the Government established, for instance, the Market Incentive Programme (see Chapter ###) available to SMEs in Germany. Moreover, BAFA facilitates the uptake of energy efficient cooling and air-conditioning systems (BAFA 2015). According to the BMVBS (2011), data on the stock of air conditioning systems installed in Germany are *de facto* not available – even manufacturer associations do not have any in-depth information. The energy demand for air conditioning in non-residential buildings is considered to be between 15 TWh to 23 TWh. LED lamps have been facilitated through the BAFA Cross Cutting Technologies Programme. However, BAFA closed the support for only installing LED lamps was completed in April 2015. But if SMEs opt for a systemic energy efficiency optimisation, meaning that more than one measure has to be taken up (including LED lamps), funding is still available.

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Space Heating**
Technology	Heat pumps
Number of technology used	In absolute terms, the uptake of heat pumps in new non-residential buildings has constantly been increasing since 1992. Back then 28 non-residential buildings were erected using heat pumps for heating purposes. This figure increased to 1,050 in 2010 (Statista 2015b). According to dena's building report, the market share of heat pumps in new non-residential buildings increased from below 1% in 1993 to around 10% in 2013 (dena 2015). Information on the use of heat pumps in the non-residential sector, in general (including existing and new non-residential buildings), has not been available.
Origin of technology	Some of the main players in the German heat pump market are Viessmann (Germany), Vaillant (Germany), Stiebel-Eltron (Germany), Dimplex (Ireland/Germany) and others (Geothermie Zentrum Bochum 2010). Information on the percentage of imports of heat pumps in Germany have not been available.
Cost of purchase	Costs of purchase are unknown and, probably, depend on the building type.
Cost per kWh	Information is not available.
Energy consumption	Total energy consumption of heat pumps is estimated to be around 2 TWh (DLR, Fraunhofer IWES, IfnE 2012).
Advantages / disadvantages of use	In general, heat pumps require electricity to produce heat. Hence, the more efficient, the better. However, the fact that today's German electricity mix still consists of coal-based electricity production may raise concerns regard the use of heat pumps. Moreover, noise pollution may also considered a disadvantage

	with some heat pump types. Further advantages and disadvantages are product specific.
Easiness to use	Heat pumps do not require excessive maintenance and, thus, are easy to use. However, installation has to be carried out by an expert.

Sector	Buildings
Sub-Sector	Commercial / services sector
Category	Air conditioning
Technology	Refrigeration compression-types (5-150kw), air-conditioning compression-types (10-150kw) achieving 95% on the Energy-Efficiency Certificate for Refrigeration- and Air-Conditioning Systems using natural coolants
Number of technology used	Only very rough data are available for the air-conditioning and cooling market. A 2011 report (using 2005 data sets) shows that more than one million air conditioning systems are available in office and commerce buildings. The market is dominated by moveable a/c systems (~450,000) and split-units only for cooling purposes (~600,000). However, the study expects a substantial rise of reversible split-units (for cooling and heating) as well as for moveables by 2030. Cooling-only split units will be phased out by then.
Origin of technology	Information is not available.
Cost of purchase	Information is not available.
Cost per kWh	Information is not available.
Energy consumption	Information is not available.
Advantages / disadvantages of use	In general, at hot working days, air-conditioning systems in non-residential buildings can help employees to work in a less exhausting environment. Hence, energy-efficient A/Cs can save energy costs (compared to less efficient equipment) and increase productivity of workers. Since heat is not so much a problem like in Southern Europe, the investment only makes sense for a few days. Apart from electricity consumption, the compression type systems also include coolants harmful to the environment. Complex systems require installation and inspections.
Easiness to use	Air-conditioning systems are easy to use, but the installation of more complex systems require an expert and inspections.

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Water heating**
Technology	Solar thermal collectors
Number of technology used	The number of solar thermal collectors used in a specific sector has not been available. The total number of such installations increased constantly from 265

	in 1999 to 2,051 in 2014 (Statista 2015c).
Origin of technology	Statista (2015c) lists the most important manufacturers of solar thermal collectors for Europe in terms of units produced. The top-five manufacturers are GreenOneTec (Austria), Bosch (Germany), Viessmann (Germany), Vaillant (Germany) and BDR Thermea Group (the Netherlands).
Cost of purchase	Information for non-residential buildings is not available. However, as a rule of thumb, Aktion Solar (2015) notes that a flat plate collector with an area of 5 m2 costs around EUR 3,200 and a tube collector of the same size around EUR 4,000. For investors, it is critical do assess how much water is to be heated through the collectors.
Cost per kWh	Please state in EUR
Energy consumption	Please state in kWh/a
Advantages / disadvantages of use	The installation of solar water heaters has to be carried out by an expert. Periodic checks are necessary. However, costs for warm water heating can be reduced substantially. In general, operation and maintenance costs are low (Aktion Solar 2015).
Easiness to use	Solar thermal collectors are easy to use.

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Cooking**
Technology	Combi-steamer (electric), use of steam and hot air
Origin of technology	Information on the trade of commercial cooking appliances is not available for the EU in general. Manufactureres of combi-steamers are mainly located in Germany, Rational AG is the leader, with around 50% of the EU market. The estimated production of electric combi-steamer in 2007 and 2008 was much less than 70,000 products (source: Ecodesign preparatory study Lot 22).
Cost of purchase	6.000-20.000 EUR
Cost per kWh	Depends on electricity price
Energy consumption	9,266 kWh/a (source: Ecodesign preparatory study Lot 22)
Advantages / disadvantages of use	
Easiness to use	It is easy to use and provides a number of features like a cleaning programme, intelligent cooking control, self learning operation, cool down function, individual programming of the cooking programme. The functions depend on the product. A training programme might be useful

Sector	**Buildings**
Sub-Sector	**Commercial sector**
Category	**Refrigeration**
Technology	Cold vending machines, most vending machines are sealed appliances, spiral machine (vending food and/or drinks)
Origin of technology	Germany is the second biggest market for commercial refrigerator exports and the third biggest European market for imports in the EU. UK has the biggest number of vending machine manufacturers followed by Germany. In 2005 the production volume for commercial refrigerators in Germany was approximately 400 million EUR. In 2004 the total stock was estimated to 502,000 units in Germany. 30,000-35,000 units are sold per year (source: Ecodesign preparatory study Lot 12)
Cost of purchase	3,500 EUR on average (source: Ecodesign preparatory study Lot 12)
Cost per kWh	Depends on electricity price
Energy consumption	Please state in kWh/a (lighting can account for 30-40% of the total energy use)
Advantages / disadvantages of use	Maintenance practices are the cleaning of the condenser and the replacement of lamps if necessary
Easiness to use	The appliances are typically in operation 24/7. They are equipped with a payment system, selection buttons, display screens

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Lighting**
Technology	LED lamps: according to a survey (n = 64) carried out between June and September 2013 and published at Statista (2015d) only 24% non-food retailers used LED lighting. In contrast to that, only halve of all food-retailers in Germany still made use of conventional lighting technology.
Origin of technology	Based on an anonymous study, it was found that two manufacturers dominate the German market with a 50% market share. These are probably Philips and Osram (Institute für Applied Ecology 2013).
Cost of purchase	EUR 18 to 160 (Institute für Applied Ecology 2013); please note that the price for LED lighting has been showing a downward trend, in general (Fraunhofer ISI 2015).
Cost per kWh	Depends on electricity price, on average 0,29 EUR / kWh in Germany
Energy consumption	For an energy efficient office lamp, the Institute für Applied Ecology (2013) assumes an annual energy consumption of 89 kWh/a, which is 21 kWh/a less compared to less energy efficient office lamp.
Advantages / disadvantages of	As with residential buildings; Advantages are the less electricity costs, a long lifetime, they are made of solid material with no filament or bulb to break, they

use	have no warm-up period, LEDs contain no mercury or other hazardous substances, the life time of LEDs is 20,000 hours and more. Disadvantages are that they are currently more expensive than other conventional lamps and LEDs can shift colour due to age and temperature
Easiness to use	Lamps are easy to use.

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Public street lighting**
Technology	**LED – using only 20% of the energy of conventional street lamps. The market share of LED-based street lighting is around 2% (dena 2013).**
Origin of technology	No information available.
Cost of purchase	Information is not available. However, in an evaluation carried out by PWC (2015), 35% of communities assessed the technology's cost-benefit-ratio as "rather bad," which is probably due to increased upfront costs. After a few years, the costs of purchase are amortised.
Cost per kWh	Depends on electricity price, on average 0,29 EUR / kWh in Germany
Energy consumption	Please state in kWh/a
Advantages / disadvantages of use	LED street lighting uses substantially less energy than ordinary street lamps.
Easiness to use	The use of LED public street lighting is similar conventional street lamps.

1.5 Data for the Transport Sector

Key technologies for energy efficiency in the German transport sector have been identified. The selection of technologies is based on their potential for efficiency improvements that are estimated in the studies listed in Table 2 and on political priorities as reflected by the policy instrument that support the penetration of the identified technologies (see e.g. BMWI 2014, BMUB 2014a). Furthermore, it was indented to identify at least one important technological option for energy efficiency improvements for each sector. As outlined in section 1.2.2, strongest potential for vehicle efficiency improvements are seen in the passenger car segment. There is no claim for completeness of the listed technologies and products.

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport:
Technology	**Battery Electric Vehicles**
Number of technology used	18,948 BEV registered as of January 2015 (KBA 2015)
Origin of technology	National and imported BEV available. In 2014, 35,957 electric vehicles (including HEV, PHEV and BEV passenger cars) were newly registered in Germany. About 27 percent of these were from German brands, but not necessarily manufactured in Germany. For instance, in 2013, about 3,200 BEV were produced in Germany (VDA, 2014), while about 6,000 BEV were newly registered.
Cost of purchase	Examples: BMW i3 – about EUR 35,000 Smart fortwo electric drive about EUR 19,000
Cost per kWh	Costs depend on the electricity price (average price for private households in Germany 28.81 EUR-cent per kWh as of April 2015) (BDEW, 2015)
Energy consumption	Energy consumption depends on the annual mileage; Private cars in Germany have an average annual mileage of 12,500 km (Hacker et al. 2011). For example, for the BMW i3 as an official consumption rate 12.9 kWh/100 km is provided, for the Smart fortwo electric drive a consumption rate of 15 kWh/100 km is indicated (VCD 2015).
Advantages / disadvantages of use	Advantages: noise reduction, strong acceleration, use of renewable energy Disadvantages: costs, range limitations, charging duration
Easiness to use	Range limitations, charging duration and availability of charging infrastructure are seen as barriers for BEV deployment (besides costs).

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport:

Technology	**Plug-in Hybrid Electric Vehicles (PHEV)**
Number of technology used	Separate data for PHEV passenger cars is only available since 2013. Between January 2013 and June 2015, about 10,900 PHEV passenger cars were newly registered in Germany (KBA 2015).
Origin of technology	National and imported PHEV available. In 2014, 35,957 electric vehicles (including HEV, PHEV and BEV) were newly registered in Germany. About 27 percent of these were from German brands, but not necessarily manufactured in Germany. In 2013, about 29,500 HEV and PHEV were manufactured in Germany. In the same year, about 27,000 HEV/PHEV were newly registered in Germany (VDA 2014 / KBA 2015).
Cost of purchase	Example: Opel Ampera – EUR 38,600, battery capacity 16 kWh BMW i3 range extender EUR 39,500, batter capacity 18,8 kWh
Cost per kWh	Costs depend on the electricity price (average price for private households in Germany 28.81 EUR-cent per kWh as of April 2015) (BDEW, 2015).
Energy consumption	Annual energy consumption depends on the annual mileage; Private cars in Germany have an average annual mileage of 12,500 km (Hacker et al. 2011). For example, for the Opel Ampera in electric drive modus electricity consumption rate is 13.5 kWh/100 km the average fuel consumption rate is 1,24 l/100 km.
Advantages / disadvantages of use	Advantages: noise reduction, acceleration, use of renewable energy Disadvantages: costs, charging duration
Easiness to use	Relatively easy to use as range limitations are not an issue. Frequent charging is necessary to exploit the full efficiency potential.

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport:
Technology	**Hybrid Electric Vehicles (HEV)**
Number of technology used	As of January 2015, 107,754 HEV passenger cars were registered in Germany (KBA 2015).
Origin of technology	National and imported PHEV available. In 2014, 35,957 electric vehicles (including HEV, PHEV and BEV) were newly registered in Germany. About 27 percent of these were from German brands, but not necessarily manufactured in Germany. In 2013, about 29,500 HEV and PHEV were manufactured in Germany. In the same year, about 27,000 HEV/PHEV were newly registered in Germany (VDA 2014 / KBA 2015).
Cost of purchase	Example: VW Jetta 1,4 TSI Hybrid: EUR 31,700
Cost per kWh	HEV use conventional fuels; Average fuel costs in Germany in 2014: diesel:

	135.05 EUR-cent, gasoline 152.83 EUR-cent
Energy consumption	Energy consumption depends on the annual mileage. Private cars in Germany have an average annual mileage of 12,500 km (Hacker et al. 2011). For example, for the VW Jetta 1,4 TSI Hybrid the indicated fuel consumption rate is 4,1 l/100 km)
Advantages / disadvantages of use	Advantage: More fuel-efficient than conventional vehicles. Disadvantage: Fully relying on conventional fuels.
Easiness to use	Very easy to use as characteristics are similar to a conventional vehicle.

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport:
Technology	**Natural Gas vehicles**
Number of technology used	81,423 CNG passenger cars were registered in Germany as of January 2015
Origin of technology	Models from domestic manufacturers (VW eco up, Audi A3 g-tron) as well as imported model available
Cost of purchase	Example: VW eco up costs about 13,000 Euro. According to Krail (2013) the surcharge for a CNG vehicle compared to a petrol vehicle is about 2,400 EUR.
Cost per kWh	One kg of CNG currently costs about 1.10 EUR in Germany (NGVA, 2014)
Energy consumption	Fuel consumption 2.9 kg/100 km
Advantages / disadvantages of use	Natural gas provides advantages compared to petrol and diesel in terms of local pollutants (reduction of hydrocarbon emissions, nitrogen oxide and sulphur dioxide). Disadvantage: Refuelling infrastructure is scarce in rural areas. Currently, about 840 public CNG refuelling stations are available in Germany (NGVA, 2014).
Easiness to use	Please describe

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport:
Technology	**Efficient ICE vehicles**
Number of technology used	No data available
Origin of technology	Efficient diesel and gasoline vehicles are available from domestic manufactures and also imported from European and non-European manufacturers.

Cost of purchase	Examples: The BMW 116d EfficientDynamics Edition costs 26,200 Euro (BMW, undated)
Cost per kWh	Average diesel costs in Germany in 2014: 135.05 EUR-cent
Energy consumption	Depends on the annual mileage; Private cars in Germany have an average annual mileage of 12,500 km (Hacker et al. 2011). For example, for the BMW 116d ED consumes 3,4 - 3,8 l/100 km (BMW, undated).
Advantages / disadvantages of use	Efficient ICE vehicles combine several technological and design approaches to reduce the specific fuel consumption. For instance, in the BMW 116d EfficientDynamics Edition the following efficiency improvements are applied: i) regenerative breaking, ii) automatic start-stop system, iii) low iv) rolling resistance tyres, v) aerodynamic improvements, vi) direct injection and vii) displacement reduction (BMW, undated).
Easiness to use	No differences compared to other vehicles.

Sector	**Transport**
Sub-sector	Passenger transport / Freight transport
Category	Road transport:
Technology	**Pedelecs / E-bikes**
Number of technology used	480,000 electric bikes were sold in 2014 in Germany. In 2014, the total fleet of electric bikes reached 1,4 million vehicles (ZIV 2015)
Origin of technology	254,000 electric bikes were produced in Germany in 2014; 102,000 domestically produced bikes were exported and additional 230,000 electric bikes were imported (mainly from other European countries and Asia) (ZIV 2015)
Cost of purchase	Most electric bikes have a purchasing price between EUR 2,000 and EUR 3,000. Cheaper versions are available for EUR 1,000 (VCD undated).
Cost per kWh	Costs depend on the electricity price (average price for private households in Germany 28.81 EUR-cent per kWh as of April 2015) (BDEW, 2015).
Energy consumption	156 kWh per year based on the substitution of a car with an annual millage of 17,000 km
Advantages / disadvantages of use	Can substitute passenger cars and delivery vehicles on certain trips and have possible application that go beyond regular bicycles: Electric bikes provide the opportunity to use bicycles for longer distances and in hilly regions; increase the mobility options for elderly or other groups with reduced physical fitness; allow to transport heavy goods.
Easiness to use	Electric bikes are easy to use and charge. However, the lack secure bicycle parking options can impede their deployment.

Sector	**Transport**

Sub-sector	Passenger transport / Freight transport
Category	Road transport:
Technology	**Light-weight design for road vehicles**
Number of technology used	In the passenger car segment compressed carbon fibres are currently used by BMW i3 and BMW i8.
Origin of technology	Carbon fibres for BMW are produced in Germany
Cost of purchase	BMW i3 (electric vehicle with light weight design) costs about EUR 35,000. According to Krail (2013) the additional costs for lightweight can be expected to amount to 1,600 EUR for a passenger car. For a semi-trailer truck (40t) cost for a 3% weight reduction are assumed to amount to 1,900 EUR (IFEU and TU Graz 2015)
Cost per kWh	Cost depend on the electricity price (average price for private households in Germany 28.81 EUR-cent per kWh as of April 2015) (BDEW, 2015)
Energy consumption	For example, for the BMW i3 as an official consumption rate 12.9 kWh/100 km is provided. According to Krail (2013) efficiency improvement of about 10% can be achieved through lightweight design.
Advantages / disadvantages of use	Some lightweight materials are very costly and require new manufacturing processes (e.g. carbon fibre)
Easiness to use	There is little difference for the end-user, however manufacturing processes can be more elaborate.

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport (System efficiency)
Technology	**Electronic traffic guidance system**
Number of technology used	Not available – electronic traffic guidance system are already implemented in several German cities
Origin of technology	National product or imported? Please provide a percentage of imports for the technology in the national market if this is available.
Cost of purchase	The software alone costs about 1.6 million EUR.
Cost per kWh	Not available
Energy consumption	Not available
Advantages / disadvantages of use	Can be combined with variable traffic signs, speed indicators, and dynamic car parking guidance. Improved traffic flows and better information on parking availability can also lead to induced traffic.
Easiness to use	The information is easily accessible for vehicle drivers.

Sector	**Transport**
Sub-sector	Passenger transport
Category	Rail transport
Technology	**Hybridization of diesel traction**
Number of technology used	No data available
Origin of technology	In Germany, the French company ALSTROM was very active in developing hybrid locomotives. The BR 203H hybrid locomotive from ALSTROM is produced in Germany.
Cost of purchase	Data not available
Cost per kWh	
Energy consumption	A cut in energy consumption by about 30% is possible (BMWI 2010)
Advantages / disadvantages of use	Relevant for shunting locomotive and vehicles on those routes that are not electrified (i.e. 40 percent of the rail infrastructure net, but only 8 percent of the rail traffic) (BMVBS 2013b)
Easiness to use	

Sector	**Transport**
Sub-sector	Freight transport
Category	Road transport (Vehicle efficiency)
Technology	**Low rolling resistance tyres**
Number of technology used	Data not available
Origin of technology	The technology is used by national and international tire manufactures.
Cost of purchase	Improving rolling resistance of all tires of a vehicle by one EU RRC label class means additional investment costs of about 200 EUR for a semi-trailer truck (UBA 2015).
Cost per kWh	Not applicable
Energy consumption	An improvement of one RRC label class can reduce fuel consumption by 1 to 4 percent.
Advantages / disadvantages of use	Low rolling resistance tyres can lead to longer breaking distances.
Easiness to use	No difference in use compared to conventional tires.

Sector	Transport
Sub-sector	Freight transport
Category	Road transport (Vehicle efficiency)
Technology	**Aerodynamic improvements (for heavy duty vehicles)**
Number of technology used	Data not available
Origin of technology	National product or imported? Please provide a percentage of imports for the technology in the national market if this is available.
Cost of purchase	Side panels and underbody panels for a semi-trailer truck cost about 1,100 to 1,700 EUR. Truncated rear end cost between 500 and 1,200 EUR (UBA 2015).
Cost per kWh	Not applicable
Energy consumption	Energy consumption is reduced by 4 to 6% (IFEU and TU Graz 2015).
Advantages / disadvantages of use	Aerodynamic improvements can lead to small reductions in vehicle load volume.
Easiness to use	Aerodynamic devices have to be in line with current regulations on vehicle length and height.

Sector	Transport
Sub-sector	Freight transport
Category	Road transport (Travel efficiency)
Technology	**Long heavy vehicles** (maximum length 25.24 m, maximum weight 44 t)
Number of technology used	Currently 119 long heavy vehicles are used in Germany (participate in trial)
Origin of technology	Not available
Cost of purchase	Not available
Cost per kWh	Average fuel costs in Germany in 2014: diesel: 135.05 EUR-cent, gasoline 152.83 EUR-cent
Energy consumption	Efficiency improvement of about 15 percent per tkm and 14 percent per effective volume (l/ m^3 km) BaSt 2014)
Advantages / disadvantages of use	Disadvantages: Concern regarding traffic safety, alter the competitive environment to the detriment of railways, currently only aloud on specific routes, One long heavy truck can substitute 1.5 conventional trucks (BaSt 2014)
Easiness to use	Currently, long heavy vehicles are only allowed in specific regions or on specific routes. Specific driving experience is required (minimum of five years experience of heavy vehicle driving).

Sector	**Transport**
Sub-sector	Freight transport
Category	Navigation
Technology	**LNG vessels**
Number of technology used	Only some vessels are used in inland navigation in the context of pilot studies on the Rhine river.
Origin of technology	not available
Cost of purchase	Not available
Cost per kWh	About 49 ct/l
Energy consumption	Not available
Advantages / disadvantages of use	Advantage: Emission reduction (SO2, NOx, PM) Disadvantage: LNG infrastructure is lacking (in maritime as well as inland navigation)
Easiness to use	The technology is available (a mono-fuel engines relying solely on LNG or as duel-fuel engine that can be run on diesel or LNG), but due to lack of infrastructure difficult to apply (Wurster et al. 2014). LNG is used in inland navigation in pilot studies, but several regulative amendments are required. In maritime transport major changes in the regulative framework are required as well as infrastructure investments.

Sector	**Transport**
Sub-sector	Freight transport
Category	Navigation
Technology	**Waste heat recovery (WHR)**
Number of technology used	The technology is currently applied in container ships and cruising ships
Origin of technology	The technology is available from domestic manufactures (e.g. Siemens, MAN))
Cost of purchase	Not available
Cost per kWh	Not available
Energy consumption	Efficiency improvements of around 15% can be realised through WHR (Seum et al. 2011)
Advantages / disadvantages of use	Waste heat is used to generate electricity that can be used for on-board appliances or support the drive system with an additional electric motor. Low investments in advanced technologies for ships and long lifetime of ships lead to slow penetration of WHR.

Easiness to use	A WHR system can be retrofitted or integrated in new vessels.

Sector	**Transport**
Sub-sector	Passenger transport / Freight transport
Category	Navigation
Technology	Shoreside electricity (SEE) provision
Number of technology used	SEE stations are available at the German ports Kiel and Lübeck. Currently, SEE infrastructure is developed at the cruiser terminal in Hamburg-Altona. For inland navigation, SEE infrastructure is available on three German channels (Wesel-Datteln-Kanal, Dortmund-Ems-Kanal, Küstenkanal) (Ecofys, 2014)
Origin of technology	Not available
Cost of purchase	In the fictive inland bulk port case from Ecofys (2014), shore side costs amount to 100,000 EUR (10,000 EUR per quay). Ship side cost are about 1,000 EUR per ship.
Cost per kWh	The German government reduced the tax rate for electricity to the European minimum rate of € 0.50/MWh for shore-side electricity supply of commercially-used ships and vessels (Ecofys 2014)
Energy consumption	Ecofys (2014) calculated the energy consumption for a fictive inland bulk port: SEE provision would require 30 Mwh per year for a port with a throughput of 800,000 tonnes/year.
Advantages / disadvantages of use	Reduction of emissions and vibration. Applicable to inland shipping and maritime transport. High investments needed for appropriate equipment for both the shore and the ship side.
Easiness to use	Ports do not have experiences with shore-side electricity provision. Inland ships spend more time in the waiting area then in the berthing areas, thus SSE has to be provided in the waiting areas as well (Ecofys 2014)

Sector	**Transport**
Sub-sector	Passenger transport / Freight transport
Category	Aviation
Technology	**Efficient airplane design and construction (aerodynamic and light-weight)**
Number of technology used	The technology is for instance applied in the A350. Up to June 2015, 5 A350 are in operation (Airbus, undated).
Origin of technology	The A350 is partly manufactured in Germany (also in France, Spain and UK).
Cost of purchase	The A350 costs between 269,5 and 351,9 million USD.
Cost per kWh	Not available

Energy consumption	More efficient aerodynamics can be realised by winglets or adaptive wings and by applying foil, which imitates the structure of sharkskin to reduce air resistance. Low resistance foil can reduce the fuel consumption by 1 to 3%; winglets can induce efficiency improvements of about 5% (BMWI 2010). Light-weight materials such as carbon-fibre composites reduce the vehicle weight and can lead to additional kerosene savings.
Advantages / disadvantages of use	Reduced operational costs due to fuel savings.
Easiness to use	No differences in use.

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TECHNOLOGICAL TRENDS

D.1.4

PART OF WORK PACKAGE 1: MAPPING OF ENERGY EFFICIENCY POLICY INSTRUMENTS AND AVAILABLE TECHNOLOGIES IN BUILDINGS AND TRANSPORT

Partner: *Energy Policy & Development Centre – National & Kapodistrian University of Athens*

NATIONAL REPORT HELLAS, AUGUST 2015

Institution: *Energy Policy & Development Centre – National & Kapodistrian University of Athens*

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HERON: Forward – looking socio-economic research on Energy Efficiency in EU countries

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Acronyms

ACEA	European Automobile Manufacturers Association
BAT	Building Automation Technology
BEMS	Building Energy Management System
BEV	Battery Electric Vehicles
CFD	Computational Fluid Dynamics
CHP	Combined Heat and Power
CNG	Clean Natural Gas
CRES	Centre for Renewable Energy Sources & Saving
DSHWS	Domestic Solar Hot Water Systems
DWT	Deadweight Tonnage
EE	Energy Efficiency
E-REV	Extended Range Electric Vehicles
EPC	Energy Performance Certificate
EU	European Union
FCEV	Fuel Cells Electric Vehicles
GRT	Gross Registered Tonnage
GSRT	General Secretariat of Research and Technology
HEMS	Home Energy Management System
HEV	Hybrid Electric Vehicles
ICE	Internal Combustion Engine
ICT	Information and Communication Technologies
IEA	International Energy Agency
IRR	Internal Return Rate
KENAK	Greek abbreviation for Regulation for the Energy Efficiency of Buildings
LPG	Liquefied Petroleum Gas
MEECC	Ministry of Environment, Energy and Climate Change
NEEAP	National Energy Efficiency Action Plan
PC	Personal Computer
PHEV	Plug-in Hybrid Electric Vehicle
PV	Photovoltaic
SCR	Selective Catalytic Reduction
SME	Small and Medium-sized Enterprises
TRVs	Thermostatic radiator valves
UNEP	United Nations Environmental Program
YPEKA	(Greek interpretation) Ministry of Environment, Energy and Climate Change

Executive Summary

The Hellenic building and transport sectors show significant energy saving potential. In 2012, the buildings sector (residential and tertiary) accounted for 45% of the total final energy consumption, while the transport sector for 37%. The activities with the highest energy saving potential in building sector are the end-uses of space heating-cooling, hot water production and lighting, while in the transport sector, the passenger and freight road transport (private cars, trucks).

For the exploitation of energy efficiency potential, the national energy efficiency policy instruments promote cost-efficient, mature and innovative technologies. For the Hellenic sector of building construction, these are: improved building materials and construction systems, bioclimatic elements, solar and hybrid cooling and heating systems, software tools for calculating the energy efficiency of buildings and BEMS. Respectively, for the Hellenic transport sector, these are the electric and hybrid cars, and intelligent networks.

The energy services market shows great potential of development. Companies that develop new competitive products in the EE sector are those producing building materials, insulation materials, solar thermal systems, smart home applications and have obtained a significant market share in the country and abroad. On the other hand, the transport EE technologies market in Hellas is limited. Especially for navigation sector, where Hellas has one of the world's biggest shares, issues of energy efficiency are examined in the context of the world competition in trade transportation and IMO regulations.

More specifically, the EE technologies available for the building (residential & tertiary) sector are:

Sub-sector	Technologies
Thermal insulation	Materials: extruded polystyrene, polystyrene and mineral wool and other fibrous minerals & Energy efficient glazing: double, coated, with vacuum, etc.
Space heating-cooling	Gas condensing boilers, heat pumps (mainly air source), biomass systems (mainly energy efficient fireplaces and pellet boilers), energy efficient electric systems (such as air-conditions/inverter technology at least A++), CHP systems, trigeneration systems (power-heating-cooling).
Air Conditioning	Inverter A++, A+++
Water heating	Electric water heater, solar thermal systems (water heaters)
Cooking	Electric and gas cooking devices
Lighting	LEDs, Magnetic induction lamps
Refrigeration, Washing machines, Laundry dryers, dishwashers, other electrics	Appliances with EU Energy class A+++ and A++
Other	Building Energy Management System (BEMS), Building automation systems

The EE technologies available for the transport sector are:

Sub-sector	Technologies
Passenger road	Electric & hybrid cars, Euro 5-6 cars, CNG buses, e-bikes, tyres with Rolling Resistance Coefficient (RRC) of "A" class
Freight road	Heavy and light trucks Euro 5-6, tyres with Rolling Resistance Coefficient (RRC) of "A" class
Passenger & Freight rail	Diesel, Electric, Steam
Passenger & Freight aviation	New generation, fuel efficient A320/321 and A319 aircrafts
Passenger & Freight navigation	Computational fluid dynamics (CFD) analysis and trim/draft optimization, Optimization of hull dimensions, waste heat recovery systems, ballast water treatment systems, energy saving devices such as: Propulsion Improving Devices (Wake Equalizing and Flow Separation Alleviating Devices, Pre-swirl and Post-swirl Devices, High-efficiency Propellers), Main Engine Performance Measurement and Control devices.

CHAPTER 1: TECHNOLOGICAL TRENDS IN THE BUILDING AND TRANSPORT SECTOR

1.1 ENERGY EFFICIENCY POTENTIAL

The Hellenic building and transport sectors show significant potential for energy savings. In 2009, 45% of the total final energy consumption was attributed to the *transport sector*, followed by the *residential sector* with 24% of total final energy consumption (2nd NEEAP, 2011). In 2012, the rank was reversed, with the buildings sector (residential and tertiary together) accounting for 45% of the total final energy consumption, while the transport sector had a 37% share (YPEKA, 2014). The 1st National Energy Efficiency Action Plan (NEEAP) presented analytically the energy efficiency potential for the two sectors (Tables 1, 2, 3 and 4).

The activities of the *residential* sector with the highest energy saving potential are: i) space heating that covers 57% (reaching even 3,3TWh) of the total possible energy savings in 2016, out of which 60% is attributed mainly to building envelope improvements (1st NEEAP, 2008); ii) use of hot water by 22% (1,2TWh is mainly due to the penetration of solar collectors) (1st NEEAP, 2008) and iii) lighting by 9% (0,5TWh is mostly due to replacement of conventional lamps with more energy efficient ones) (1st NEEAP, 2008). For the *tertiary* sector the space heating is expected to contribute by 70% in the total energy savings of this sector, lighting by 15% and space cooling by 13% (1st NEEAP, 2008). These are presented in Tables 2 and 3.

Table 1: Potential of energy savings per buildings and transport sector as presented in Hellenic NEEAPs.

Sectors	1st NEEAP, 2008		3rd NEEAP, 2014	
	Energy savings (in GWh)		Energy savings (in ktoe)	Energy savings (in GWh)
	2010	2016	2014-2024	2014-2024
Residential	1.679	5.533	793	9.223
Tertiary	1.529	5.715		
Transport	1.787	6.731	109	1.268
Total	**4.995**	**17.979**	**902**	**10.491**

Note: The 2nd NEEAP used the same potential for the target of year 2016 (which is 16,46TWh for all sectors) and the target for year 2020 in the 3rd NEEAP (18,4 Mtoe of final energy consumption) (2nd NEEAP, 2011; YPEKA, 2014).

Table 2: Energy savings potential in GWh per end-use in the residential sector until 2016.

Activities	Energy savings in GWh for the time period 2008-2016								
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Cooking	0	0	13	20	27	33	39	44	49
Dish washing	0	24	52	71	76	75	74	73	73
Water heating	31	253	628	690	828	964	1.116	1.276	1.298
Washing machines	0	47	98	132	144	153	152	151	149
Lighting	18	106	207	302	392	425	453	477	499
Freezing	27	67	109	153	182	177	172	167	163
Air conditioning	20	40	69	97	126	136	146	156	161
Space heating	56	276	503	706	1.200	1.696	2.185	2.737	3.142
Total	**152**	**814**	**1.679**	**2.171**	**2.974**	**3.659**	**4.337**	**5.082**	**5.533**

Source: 1st NEEAP, 2008; Remaco SA, 2010

Table 3: Energy savings potential in GWh per end-use in the tertiary sector until 2016.

Activities	Energy savings in GWh for the time period 2008-2016								
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Cooking	0	0	0	3	3	6	6	6	6
Space cooling	16	52	116	232	339	450	598	793	862
Lighting	85	179	278	391	514	608	694	771	829
Hot water use	43	77	107	187	288	411	540	672	745
Space heating (conventional equipment)	611	800	1.096	1.450	1.919	2.350	2.794	3.209	3.369
CHP	0	122	130	137	149	162	178	179	202
Electricity from CHP	-	58	62	66	72	80	89	93	106
Total	**755**	**1.044**	**1.529**	**2.192**	**2.986**	**3.743**	**5.543**	**5.365**	**5.715**

Source: 1st NEEAP, 2008.

Table 4: Energy savings potential in GWh per end-use in the transport sector until 2016.

Sub-sectors	Energy savings in GWh for the time period 2008-2016								
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Public buses	0	18	17	17	32	49	45	43	41
Private cars	0	316	983	1.615	2.235	2.866	3.435	4.014	4.957
Trucks	0	283	596	980	1.171	1.345	1.330	1.313	1.459
Small trucks	0	116	191	255	283	280	278	276	274
Total	**0**	**734**	**1.781**	**2.865**	**3.720**	**4.540**	**5.088**	**5.646**	**6.731**

Source: 1st NEEAP, 2008.

Table 5: Energy savings potential per activity for the Hellenic building sector.

Type of activity	Energy saving in %	
	Thermal energy	Electric energy
Insulation of external walls	33-60	
Insulation of floor/ceiling	2-14	
Replacement of windows -and door -frames	14-20	
Maintenance of central heating systems	10-12	
Installation of new oil heating systems with high performance	<17	
Installation of central natural gas heating system	<21	
Installation of compensation and space thermostats	3-6	
Installation of external shading	10-20	
Installation of ceiling fans		<60
Installation of solar collectors for hot water use		50-80
Night ventilation		<10
Installation of lighting systems of high performance		<60
Installation of Building Management Systems	<20	<30
Air insulation	16-21	
Replacement of air conditioning with other of higher performance - thermal pumps		65-75
Use of geothermal pumps	<20	
Installation of green roofs	<10	<30
Usage of cold materials	<15	

(Source: YPEKA, 2014)

For the *transport* sector (Table 4) the highest energy savings potential is expected from the use of private cars (73% of the total energy savings of this sector) and from the freight transport using trucks (21% of the total energy savings of this sector) (2nd NEEAP, 2011; 1st NEEAP, 2008).

In the 3rd NEEAP energy savings are expected from: energy upgrade of buildings, replacement of old home appliances with more efficient ones, use of energy management systems, replacement of old vehicles with others of newer technology, shift of transport modals. Particularly for the building sector the energy saving potential is significant, but the largest part of it is unexploited (Gelegenis J. et al., 2014) (Table 5).

1.2 Technologies And Policy Instruments

Buildings sector

The following table presents the national policy instruments and the respective supported technologies for the building sector.

Table 6: Policy instruments/legislation and supported technologies in building sector.

Technologies supported by "Energy labeling" (Sources: National Laws presented in the national report of D.1.2, respective EU Directives (European Commission, 2015a; 2015b)):
- *Household appliances*: Solid fuel boiler (packages of a solid fuel boiler, supplementary heaters, temperature control, solar devices), Local space heaters, Professional refrigerated storage cabinets, Residential ventilation units, Domestic ovens and range hoods, Heaters and waters heaters (space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device), Vacuum cleaners, Electrical lamps and luminaires, Household tumble driers, Air conditioners, Televisions, Household washing machines, refrigerating appliances, dishwashers, electric ovens, combined washer-driers - *Office equipment*[1]: computers, computer monitors, photocopiers, printers, digital duplicators, faxes, franking machines, multifunction devices and scanners
Technologies supported by "Energy audits" (Sources: National Laws presented in the national report of D.1.2):
- *Technologies and practices for buildings*: Thermal insulation, Thermal bridges, Thermal installations and their insulation, Cooling installations and their insulation, Ventilation (natural and artificial) and air tightness, Building design and construction practices, Passive thermal systems, Solar systems
Technologies supported by "KENAK – Minimum requirements of energy performance for buildings" (Sources: National Laws presented in the national report of D.1.2, respective EU Directives (European Commission, 2015a; 2015b), (Ecofys, 2013)):
- *Building envelope*: reduction of heat transmission, improved air tightness of the building envelope with the intention of reducing transmission losses and losses from (uncontrolled) air-exchange, Bioclimatic design, Protection from sun, shading, Building Energy Management Systems (BEMS), Thermal bridges, indoor air-quality - *Space heating*: condensing boilers, heat pumps, thermal solar panels - *Passive solar systems* (photovoltaic, geothermal pumps for heating/cooling) - *Passive heating and cooling elements* (high level of insulation, very energy efficient windows, high tightness of the envelope and mechanical ventilation with heat recovery, thermal mass activation, higher ventilation rate during night times - *Usage of RES* - *Domestic hot water*: integrating solar energy systems with a generator using fuel or electricity, High efficient storage and distribution systems - *Ventilation systems* - *Cooling*: passive cooling systems such as shading devices, night ventilation coupled with exposed

[1] http://ec.europa.eu/enterprise/sectors/electrical/documents/additional-legislation/index_en.htm#h2-3 and http://www.eu-energystar.org/products.htm

mass
- *Lighting*: increase the use of daylight (e.g. light shelves, prismatic glazing, light pipes, etc.) and improvements for artificial lighting (e.g. higher efficiency light sources, finer tuned distribution of illuminance values according to visual tasks, etc.
- *Use of appliances with highest efficiency class* (maximum 20 kWh/m^{2}y for household appliances; smart meters.

Technologies supported by "Metering" (Sources: National Laws presented in the national report of D.1.2):

- *Smart metering devices*

Technologies supported by Energy inspectors/auditors (Sources: National Laws presented in the national report of D.1.2):

Same as the technologies supported by "KENAK- Minimum requirements of energy performance for buildings".

Technologies supported by "Eco-design requirements" (Sources: National Laws presented in the national report of D.1.2, respective EU Directives (European Commission, 2015a; 2015b):

Air conditioners and comfort fans circulators, Complex Set-Top Boxes, Computers (computers and computer servers), Domestic cooking appliances (domestic ovens, hobs and range hoods), Electric motors, Circulators (glandless standalone circulators and glandless circulators), External Power Supplies, Household dishwashers, Household tumble driers, Household washing machines, Imaging equipment, Industrial fans, Lighting Products in the Domestic and Tertiary Sectors (directional lamps, for light emitting diode lamps and related equipment, fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, ultraviolet radiation of non-directional household lamps, non-directional household lamps), Local space heaters, Heaters and water heaters (space heaters and combination heaters, space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device, water heaters and hot water storage tanks), Power transformers, Professional refrigerated storage cabinets (professional refrigerated storage cabinets, blast cabinets, condensing units and process chillers), Refrigerators and freezers, Simple Set-Top Boxes, Solid fuel boilers, Standby and off Mode Electric Power Consumption of Household and Office Equipment and network standby, Televisions, Vacuum cleaners, Ventilation units, Water pumps.

Technologies supported by "Energy management systems" (Sources: Draft Law for Directive 2012/27/EC; Waide Strategic Efficiency Limited, 2014):

- building automation technology (BAT) (electromechanical hardware of sensors, actuators and thermostats, ICT hardware controllers/outstations, programmers and central facilities such as Personal Computers (PCs) and data displays;
- building energy management systems (BEMS) for service sector (non-residential) buildings and home energy management systems (HEMS) for residential ones
  - mechanical heating and hot water systems,
  - mechanical ventilation,
  - cooling and air conditioning,
  - natural ventilation systems, particularly motorised windows and dampers, often combined with mechanical systems in 'mixed mode' design, and sometimes including motorised shading,
  - lighting, including timing, occupancy detection/sensors, mood-setting, dimming and daylight integration, together with exterior lighting,
  - electrical systems, including time control, demand management and standby systems,
  - metering and monitoring systems, including heat and flow meters where appropriate, environmental sensors (light levels: adjusting lighting and shading, temperature: adjusting heating/cooling/ventilation systems, humidity: adjusting ventilation and air-conditioning systems, air quality: adjusting ventilation systems),
  - communications, safety and security systems,
  - services to special areas and equipment, e.g. server rooms.

Technologies supported by "Energy Performance Certificate" (Source: National laws that were presented in national report of D.1.2):

Same as those for energy audits and energy auditors.
Technologies supported by "Taxation of energy products and electricity" (Source: National Laws that were presented in national report of D.1.2):
Fuel quality, fuel economy.
Technologies supported by "Green Fund – subsidies" (Source: National Laws that were presented in national report of D.1.2):
Any type of existing EE technologies (depends on the call).
Technologies supported by "Financial incentives" (Source: National Laws that were presented in national report of D.1.2):
Generally EE technologies.
Technologies supported by "Financial incentives for replacement of devices/systems" (Source: National Laws that were presented in national report of D.1.2):
Boilers and heating oil systems to natural gas ones.
Technologies supported by "Green Public Procurement" (Source: National Laws that were presented in national report of D.1.2):
Energy efficient technologies like those in eco-design and energy labeling.
Technologies supported by "Voluntary agreements" (Source: National Laws that were presented in national report of D.1.2):
No available information.
Technologies supported by "End-use efficiency and energy services (ESCOs)" (Source: National Laws that were presented in national report of D.1.2 and European Commission, 2014):
- Integrated energy efficiency services - RES solutions combined with building energy efficiency (building envelope and equipment).

Transport sector

The following table presents the national policy instruments and the respective supported technologies for the transport sector.

Table 7: Policy instruments/legislation and supported technologies in transport sector.

Technologies supported by "Cycling and pedestrianism in the city" (Source: National Laws that were presented in national report of D.1.2):
No technologies are supported.
Technologies supported by "Improvement of infrastructure for electric vehicles" (Source: National Laws that were presented in national report of D.1.2):
Promotion of: i) bioethanol, biodiesel, electric energy and hydrogen; ii) charging devices of electric vehicles' batteries.
Technologies supported by "Emission standards (Euro 5 and Euro 6) (Source: National Laws, EC Regulations that were presented in national report of D.1.2 and ACEA, 2015):
- variable valve timing[2], - direct fuel injection - improved and highly sophisticated engine management systems - commercial vehicles and larger diesel cars with Selective Catalytic Reduction (SCR) in combination with a urea-based additive to help reduce NO_x emissions. - NO_x-reducing technologies (lean NO_x catalysts) - New diesel cars and new trucks are fitted with particulate filters to meet tough new Euro 5/V and 6/VI standards[3]
Technologies supported by "Establishment of Permanent Committee on Green Transportation"

[2] http://www.acea.be/industry-topics/tag/category/euro-standards
[3] http://www.acea.be/industry-topics/tag/category/euro-standards

(Source: National Laws that were presented in national report of D.1.2, UNEP, 2011):
Green transport technologies (Intelligent Transportation Systems, integrated ticketing, Use of Information technologies for traffic management (smart infrastructure) Vehicle safety technologies such as tyre-pressure monitoring, Adaptive cruise control/collision mitigation, Emergency brake assist/collision mitigation).
Technologies supported by "Energy labeling for tyres in transport (Source: EC Regulations that were presented in national report of D.1.2):
Fuel-efficient and safe tyres with low noise levels.
Technologies supported by "Taxation of energy products and electricity" (Source: National Laws that were presented in national report of D.1.2): Fuel quality, fuel economy.
Technologies supported by "Registration tax exemption for electric and hybrid vehicles" (Source: National Laws that were presented in national report of D.1.2):
Electric and hybrid cars.
Technologies supported by "Circulation tax exemption for electric and hybrid vehicles" (Source: National Laws that were presented in national report of D.1.2):
Electric and hybrid cars.
Technologies supported by "Incentives to replace old technology cars and motorcycles (subsidies, tax exemptions)" (Source: National Laws that were presented in national report of D.1.2):
Same with those supported by "Emission standards (Euro 5 and Euro 6).
Technologies supported by "Green Public Procurements for Transport" (Source: National Laws that were presented in national report of D.1.2):
Intelligent Transportation Systems – same with those for "Establishment Permanent Committee on Green Transportation".
Technologies supported by "Consumer information on fuel economy and CO_2 emissions of new passenger cars (eco-labeling for cars)" (Source: National Laws that were presented in national report of D.1.2, IEA, 2012):
Thermal management, Variable valve actuation and lift, Auxiliary systems improvement, Thermodynamic cycle improvements, Strong downsizing, Dual clutch transmission, Strong weight reduction, Full hybrid: electric drive, Tyres: low rolling resistance, Reduced driveline friction, Combustion improvements, Aerodynamics improvement, Lightweight components other than BIW.
Technologies supported by "Eco-driving" (Source: National Laws that were presented in national report of D.1.2, IEA, 2012):
Energy labeling of tyres[4].

Policy instruments and innovative technologies

For the Hellenic sector of building construction the following are characterized as innovative technologies: improved building materials and construction systems, bioclimatic elements, solar and hybrid cooling and heating systems, software tools for calculating the energy efficiency of buildings (Ministry of Education and Religion, 2014). Respectively, for the Hellenic transport sector electric and hybrid cars, and intelligent networks are characterized as innovative technologies (Ministry of Education and Religion, 2014).

Based on the conducted work of D.1.2, there are no policy instruments that support directly either through research efforts or targeted investments, the aforementioned innovative technologies about energy efficiency in the buildings or the transport sector. Almost all policy instruments of Tables 6 and 7 promote the usage by the end-users of mature and innovative technologies in both sectors following European and international trends. As mentioned in D.2.1 the end-users are usually reluctant to proceed with investments in their

[4] http://www.ecodriving.gr/xrysoi-kanones-eco-driving/

household on energy efficient interventions whose initial cost is high. Furthermore, due to the economic recession emphasis for supporting innovative technologies is given in other sectors and under other relevant priorities through already implemented policy instruments or planned ones. This situation is formed by the following:

- Other target groups – not buildings or transport sector - are encouraged to support innovative technologies for EE ie i) SMEs active in manufacturing, tourism and trade services. They receive financial incentives for innovations, the environment and information technology (Third National Energy Efficiency Action Plan, 2014); ii) industries that are eligible to participate in the programme "Innovative Entrepreneurship, Supply Chain, Food, Beverages". For the same reason they receive business loans with favorable terms (Third National Energy Efficiency Action Plan, 2014).
- One of the basic priorities for development that were set for the Strategic planning of the Ministry of Environment, Energy and Climate Change (MEECC) was the promotion of EE in all national sectors (Ministry of Environment, Energy and Climate Change – Special Service for Coordinating Environmental Actions, 2013). For fulfilling this priority the MEECC identified the need to promote and exploit new technologies in the energy demand and supply sectors. The development of intelligent networks and metering devices is expected to contribute significantly in planning and coordination so as to balance demand with energy production and the development of new market mechanisms (ie flexible energy bills, programs for load management) (Ministry of Environment, Energy and Climate Change – Special Service for Coordinating Environmental Actions, 2013). Particularly for the transport sector the set aim was to promote: i) technologies that improve the energy efficiency of the vehicles and ii) non conventional fuels such as natural gas and bio-fuels (Ministry of Environment, Energy and Climate Change – Special Service for Coordinating Environmental Actions, 2013).
- According to General Secretariat of Research and Technology (GSRT) the orientation and usage of innovative technologies which are important for the transport sector and need to be supported for are about (GSRT, 2013): i) fuel economy; ii) development and trading of electric and hybrid vehicles (as a first step) and solar and hydrogen vehicles (as a second step). For the building sector, GSRT recognizes that one of the focus areas for national research efforts need to be: i) applications and systems for energy management of buildings; ii) new materials for development of energy smart constructions; iii) techniques for energy exchange between vehicles and network.

  For promoting these innovative technologies GSRT expresses the need to emphasize in supporting industries with continuous and intensive productive capacity (ie companies that produce construction materials, aluminum, thermal solar systems) and with: i) significant market share not only in the national market and ii) the potential to develop their productive activity and become competitive (GSRT, 2013).

  More specifically, the Hellenic industries activated in solar thermal systems need to stimulate their efforts towards the production of certified systems, the development of central solar systems and integrated innovative applications for solar cooling (GSRT, 2013). The expected gradual development of PV systems incorporated in buildings in combination with the high knowledge of Hellenic companies on construction materials and in windows -and door – frames may allow significant development perspectives of new Hellenic innovative products with added value and possibility of exported activity (GSRT, 2013).

- One of the barriers identified in D.2.1 was about the difficulties in the penetration of innovative EE technologies due to the lack of adequate information, training and education of citizens and professionals (YPEKA, 2014).

Cost efficient existing and innovative technologies

Buildings sector

Official information about the cost effectiveness of the existing and the innovative technologies is not available. Greek researchers have worked on this issue and based on their results the following tables reflect the situation under the Hellenic framework (see Tables 8, 9, 10 and 11).

In Table 8, EE technologies supported by the policy instruments of Table 6 are characterized about their cost effectiveness as low, medium and high. Indicative figures for the cost of such technologies for a typical detached house in Central Greece are in Tables 9 and 10. The low cost effective options are limited. The end-users prefer them mostly compared to others as this preference is reflected in Tables 11 and 12. These most common EE interventions in buildings (household and tertiary sectors) for an indicative sample were provided from the data of their Energy Performance Certificates. The interventions were under the framework of the programme "EXOIKONOMO KAT' OIKON" (see Deliverable D.1.1) (Droutsa P. et al., 2014).

Typical costs of EE interventions for the year 2014 concerning two types of buildings (detached household – monokatoikia and a multi-floor building – polikatoikia) are also presented in Tables 13 and 14.

Transport sector

The EE technologies for the Hellenic transport sector cannot be characterized as cost efficient. In Greece less than five electric vehicle models for the city are available because of the very high cost (Emmanouilidis G., 2011). It is indicative that the model: i) Mitsubishi i-MiEV, which is a four-seated car of 57hp was sold in Greece at 42.000 EUR during year 2011, while the same model was sold the same year at 27.000 EUR in the United Kingdom (Emmanouilidis G., 2011). ii) Nissan Leaf (109 hp, autonomy for 160 km) was sold at about 30.000 EUR (Emmanouilidis G., 2011).

Table 8: Cost-efficient technologies for the Hellenic building sector.

Technologies	Applicability	Cost effectiveness
Building envelope measures		
Replacement of windows -and door -frames	Old buildings	Low
Insulation of external walls	Old buildings	Medium
Double glazed windows	Old and new buildings	Medium
Repair of envelope (thermal bridges/ cracks)	Old buildings	High
Thermal insulation of roofs	Old buildings	High
Weather proofing of windows/ doors	Old buildings	High
Heating equipment and techniques		
Insulation of distribution network	Old buildings	Low
Digital programmable thermostats	Old and new buildings	Low
Independent heating t o multi- family dwellings	Old buildings	Low
Resizing boiler or use of modular units	Old buildings	Low
Combined heat and power production (μ-CHP)	Old and new buildings	Low
Balancing of central heating hydronic networks	Old and ne w buildings	Medium
Ambient temperature (weather) compensation	Old buildings	Medium
Thermostatic radiator valves (TRVs)	Old and new buildings	Medium
Replacement of hours run meters with heat meters	Old buildings	Medium
Switch t o natural gas	Old and new buildings	Medium
Heat pumps for heating and cooling	Old and new buildings	Medium
Use of condensing boiler	Old and new buildings	High
Use of VSD circulation pumps	Old buildings	High
Replacement of boiler	Old buildings	High
Cooling equipment and techniques		
Green roofs	Old and new buildings	Low
Evaporative cooling	Old and new buildings	Low
External shading	Old and new buildings	Medium
Night ventilation	Old and new buildings	Medium
Ceiling fans	Old and new buildings	High
Replacement of old AC units	Old buildings	High
Exploitation of Renewable Energy Sources		
Ground source heat pump	Old and new buildings	Low
Solar passive systems	New buildings	Medium
Solar collectors for water heating	Old and new buildings	Medium
Solar collectors t o support space heating	Old and new buildings	Medium
Photovoltaic panels	Old and new buildings	Medium
Biomass boiler	Old and new buildings	High
Energy efficient fireplaces	Old and new buildings	High
Integrated Energy Management	Old and new buildings	Medium
Building Energy Management Systems	Old and new buildings	Medium

Note: Cost effectiveness is defined according to the value of the Internal Rate of Return (IRR): High > 10%, 10%>Medium>5%, Low<5%. (Source: Gelegenis J. et al., 2014)

Table 9: Costs and benefits for various energy saving insulation measures (for detached house in Central Greece).

Type of insulation	Cost					
	Materials (€)	Secondary materials (€)	Labour (€)	Total initial investment (€)	Energy savings (%)	Benefits from investment (€/year)
Insulation of external walls	620	70	2160	2850	23.3	274
Insulation of pilotis	770	50	1980	2800	35.5	423
Insulation of roof	715	50	1440	2205	34.5	411
Replacement of windows and doorframes	2855	-	45	2900	7.0	84
Note: One front door costs 1070€, three large windows cost 1070€ totally and three windows cost 715€ totally.						

(Source: Nikolaidis Y. et al., 2009)

Table 10: Costs and benefits from upgrading of heating systems (for detached house in Central Greece).

Type of upgrading of heating systems	Cost					
	Natural Gas burner – Boiler (€)	Secondary material (€)	Connection (€)	Guarantee and fixed charge for 12 months (€)	Total initial investment (€)	Benefits from investment (€/year)
Use: heating →replacement of oil burner with a NG burner	810	475	525	135	1945	94
Use: heating and hot water production →replacement of both oil burner-boiler with NG ones	1725	475	525	135	2860	213
Use: heating, hot water production and cooking → replacement of (a) both oil burner-boiler with NG ones and (b) the electric cooker with a NG one	1725	1190	525	135	3575	388
Installing an automatic temperature control system	-	2100	-	-	2100	378

Note: Detached houses in Greece constitute about 30% of the entire houses' stock and the overwhelming majority of houses in the Greek provinces (Source: Nikolaidis Y. et al., 2009).

Table 11: Most common EE interventions in the Hellenic household sector.

Most common interventions in the household sector	Appearance frequency (in %)
Replacement of windows -and door -frames	42
Solar collector for use of hot water	19
Thermal insulation of floor/roof	9
External shading	6-8
Thermal insulation of walls	5-6
Heat pumps for heating/cooling	<5
Replacement of boiler	<5
Thermal insulation of floor	<5
Installation of natural gas	<5
Energy fireplace	<5
Replacement of thermal system	<5
Installation of biomass boiler	<5
Automatic system of heating/cooling	<5

(Source: Droutsa K.G. et al., 2014)

Table 12: Most commonly EE interventions in the Hellenic tertiary sector.

Most common intervention in the tertiary sector	Appearance frequency (in %)
Replacement of windows -and door -frames	29
Replacement of lighting systems	10-15
Thermal insulation of ceiling/roof	>10
Thermal insulation of external walls	5-10
Automatic lighting systems	5-6
Automatic systems of heating/cooling	<5
Installation of natural gas	<5
Ceiling fans	<5

(Source: Droutsa K.G. et al., 2014)

Table 13: Average production cost of construction elements and electro-mechanical systems for households that are related to the requirements of the Regulation for thermal insulation of buildings and the KENAK.

Cost of interventions under the Regulation for Thermal insulation of buildings (in EUR)				
Description of element	**Zone A**	**Zone B**	**Zone C**	**Zone D**
Insulation of elements in building envelope of monokatoikia	14.754	14.968	16.042	16.042
Insulation of elements in building envelope of polikatoikia	53.754	54.434	55.114	55.114
Windows -and door –frames for the monokatoikia	10.543	10.543	10.543	10.543
Windows -and door –frames for the polikatoikia	60.804	60.804	60.804	60.804
Installation of heating system in monokatoikia	3.716	3.901	4.098	4.326
Installation of heating system in polikatoikia	19.108	20.210	21.488	22.406
Costs for interventions under KENAK (in EUR)				
Insulation of elements in building envelope of monokatoikia	15.769	16.352	16.722	17.306
Insulation of elements in building envelope of polikatoikia	68.785	70.797	72.808	74.820
Windows -and door –frames for the monokatoikia	12.198	12.900	13.603	14.305
Windows -and door –frames for the polikatoikia	70.450	74.543	78.636	82.729
Installation of heating system in monokatoikia	4.560	4,808	5.219	5.444
Installation of heating system in polikatoikia	31.380	32.376	33.942	35.129
Installation of solar collectors at monokatoikia	750	809	960	960
Installation of solar collectors at polikatoikia	6.375	6.872	8.160	8.160

Note: Zones A, B, C and D are climatic zones that are defined in KENAK (Source: Gaglia A. et al., 2014)

Table 14: Additional production cost under KENAK, savings in operational costs after the KENAK implementation, payback period based on the reduced operational costs for energy.

Cost of interventions under the Regulation for Thermal insulation of buildings (in EUR)				
Monokatoikia	**Zone A**	**Zone B**	**Zone C**	**Zone D**
Additional cost for the construction of building envelope due to KENAK implementation (in EUR)	2.670	3.742	3.740	5.026
Additional cost for electro-mechanical construction due to KENAK implementation (in EUR)	1.594	1.715	2.082	2.079
Total additional cost due to KENAK implementation (in EUR)	4.264	5.457	5.821	7.105
Savings in operational costs due to KENAK implementation (in EUR)	890	1.114	1.542	1.977
Simple payback period (in years)	4,79	4,90	3,78	3,59
Polikatoikia	**Zone A**	**Zone B**	**Zone C**	**Zone D**
Additional cost for the construction of building envelope due to KENAK implementation (in EUR)	24.678	30.102	35.527	41.631
Additional cost for electro-mechanical construction due to KENAK implementation (in EUR)	18.648	19.038	20.615	20.882
Total additional cost due to KENAK implementation (in EUR)	43.325	49.140	56.141	62.513
Savings in operational costs due to KENAK implementation (in EUR)	1.977	3.502	5.797	8.639
Simple payback period (in years)	21,9	14,0	9,7	7,2

(Source: Gaglia A. et al., 2014)

Research and Innovation priorities in the energy efficiency issues

According to the *General Secretariat for Research and Technology under the Hellenic Ministry of Culture, Education and Religious Affairs*, the research and innovation in building sector is focused on (GSRT, 2012):

- the production of new or improved building materials and construction systems for building sector and urban renovation;
- the integration of bioclimatic elements, EE and CHP technologies;
- the improvement of energy performance of conventional heating, cooling and lighting systems, solar cooling systems, hybrid heating-cooling systems, energy management methods;
- Behavioral change of end-users towards EE;
- Smart cities.

Concerning the smart, green and integrated transport, the objectives of the research and innovation are focused on ICT technologies for road, rail and navigation and the facilitation of multimodal transportation (GSRT, 2012).

More specifically (GSRT, 2012):

— Road freight transport: development of applications for optimal routing & scheduling of the offered freight transport services and optimal fleet management.

— Navigation: development of smart systems and applications for the management, the use of LNG as fuel for ships, use of advanced or new traffic management technologies and their interconnection with existing port information systems (e.g. MIS), automation of port operations and use of technologies for EE improvement of port operations.

— Sustainable urban mobility: parking management systems, development of sensors for mobility management.

— Smart transport systems: increased use of nanotechnologies for smart road infrastructure, development and application of integrated architectures of smart transport systems in urban and national level.

Penetration of EE technologies

The economic recession of the recent years influenced significantly the penetration of energy efficient technologies in Hellas (Gelegenis J. et al., 2013).

Building sector

Concerning the residential sector, the investment on and the penetration of energy efficient technologies usually depends on the following determinants (Gelegenis J. et al., 2013):

- household income,
- energy prices,
- consumers' behavior (depending on ownership, age, education, environmental awareness etc.).
- characteristics of the buildings (location, orientation, age, design etc.).

A vast variety of energy efficiency technologies in buildings are commercially available. Specifically, through the policy instrument of EPCs, energy inspectors define and recommend the most appropriate cost-effective EE actions for buildings or apartments. The technical performance of each technology varies depending on: i) geographical location of the building; ii) characteristics of the building; iii) technical details of the equipment used, and iv) the operation mode (Gelegenis J. et al., 2013).

Through the implementation of EPCs, the most common recommended measures were the replacement of windows/door frames, in particular with aluminium frames – which was characterized by high costs and low cost-effectiveness – and the installation of solar water heating collectors (Gelegenis J. et al., 2013).

It is rather contradicting that from the existing technologies for improving EE (see Table 6) in buildings those that are related to RES demonstrate a higher market penetration.

More specifically, solar energy systems either as solar thermal systems or as photovoltaics have very high penetration rates in Greece (Tsalikis G. and Martinopoulos G., 2015). For year 2013, the Hellenic Photovoltaic (PV) market exceeded the 1GW mark, recording PV capacity of 1,04GW and ranking fifth in the European market behind Germany, United Kingdom, Italy and Romania (European Photovoltaic Industry Association, 2014). The residential segment of this market has developed rapidly from year 2012 to 2013 (European Photovoltaic Industry Association, 2014).

During year 2014, there were positive signs for the Hellenic solar thermal market which grew by 18,9% compared to year 2013 (European Solar Thermal Industry Federation, 2015). Domestic Solar Hot Water Systems (DSHWS) are characterized as mature and widely available technology, with installed capacity of 4,2 million m^2 (2.900 MW_{th}) at the end of 2013 from 4,1 million m^2 (2,8 MW_{th}) at the end of 2011 (Tsalikis G. and Martinopoulos G., 2015; Martinopoulos G. and Tsalikis G., 2014). In 2014, the total installed capacity reached the 3 GWth (4,3 million m^2), representing an increase of 2,6% over the previous year and providing an estimated energy supply of 2.989 GW_{th}, which corresponds to 52% of the indicative 2020 target (European Solar Thermal Industry Federation, 2015). The increase during the period 2013-2014 is attributed to investments in the Hellenic tourism sector (European Solar Thermal Industry Federation, 2015).

The newly installed capacity was 189 MW_{th}, representing 270.000 m^2 of newly installed collector area and the majority was for hot water supply in the tourism sector/islands (hotels, holiday lets, etc.) (European Solar Thermal Industry Federation, 2015). There was also a welcome market upturn for replacing old solar thermal systems with new ones (European Solar Thermal Industry Federation, 2015).

In 2014 Greece ranked second with 9% in the shares of the European Solar Thermal Market (Newly Installed Capacity) behind Germany with 31% (European Solar Thermal Industry Federation, 2015). In 2012, Greece was fifth with 7% in the shares of the European Solar Thermal Market (Newly Installed Capacity) (European Solar Thermal Industry Federation, 2013).

Although photovoltaics are characterized as a relatively new technology for the Hellenic residential market, more than 40.000 systems were installed in residential buildings up to 2013, resulting to increased installed capacity (from 47 MW_p in 2007 to 1.536 MW_p in 2012 and to 2.579 MW_p in 2013) (Tsalikis G. and Martinopoulos G., 2015). Greece is among the ten top PV markets globally (10^{th} in 2011 and 2012, 9^{th} in 2013)(IEA, 2014).

Transport sector

The efficiency improvement in road transport by 15,8% in 2010 compared to that of year 1990 was attributed to: i) the penetration of new, more energy efficient cars and heavy vehicles; ii) the more rational use of them because of the taxes in fuels which led to the increase of fuel costs, iii) the adoption of eco driving from the new drivers (CRES, 2012).

In 2010 the energy efficiency of air and rail transport also improved - compared to year 1990 - by 74% and 60% respectively (CRES, 2012). The reasons were: more efficient means and better management of routes schedules (reduction of routes per destination in accordance with the passenger traffic, etc.) (CRES, 2012).

Table 15: Penetration of energy efficient technologies in the Hellenic transport sector.

Year	Hybrid excl. PHEV	Electric/fuel cell incl. PHEV	Euro 5	Euro 6
	in %			
Passenger cars				
2013	0,7	0,01	98	1
2012	0,8	0	93	2
2011	1,0	0	68*	
2010	0,8	0	34	
2009	0,8	0	7	
2008	0,9	0	2	
2007	0,4	0	1	
2006	0,2	0	0	
2005	0,1	0	0	
2004	0,0	0	0	
Light-commercial vehicles				
2013	0	-	93	
2012	0	-	31	
2011	0	-	5	
2010	0	-	0	

Note: * the percentage concerns both categories (Euro 5 and Euro 6 together (Source: The International Council on Clean Transportation, 2014)

The penetration of electric vehicles in the Hellenic market was limited. In 2012 only three models were available: two electric vehicles with battery (Battery Electric Vehicles (BEV)) and one electric car with a unit for extending its autonomy (Extended Range Electric Vehicles (E-REV)) (Hellenic Republic, MEECC, 2012). These are: i) Mitsubishi i-MiEV – electric with purchase cost 36.700 EUR in 2012[5] (Hellenic Republic, MEECC, 2012); ii) Nissan- Leaf – electric with purchase cost 40.700 EUR in 2012[6] (Hellenic Republic, MEECC, 2012); iii) Opel Ampera – Electric REV with purchase cost is 43.000 EUR in 2012[7] (Hellenic Republic, MEECC, 2012).

There are estimations about the penetration of these technologies in the Hellenic market up to year 2050 (Table 17) (Hellenic Republic, MEECC, 2012).

Table 16: New passenger car registrations in the Hellenic market.

Types	Q4 2014	Q4 2013	% Change 14/13	Q1-Q4 2014	Q1-Q4 2013	% Change 14/13
Pure Electric Vehicles (PEV)*	0	0	n.a.	0	0	n.a
Electrically Charged cars other than PEV**	22	3	633,33	64	4	1.500
Total Electrically Charged Vehicles***	22	3	633,33	64	4	1.500

*Pure Electric Vehicles (Electric, All Electric, Battery Electric, Fully Electric Vehicle) = vehicle powered solely bya battery charged from mains electricity. Currently, typical pure-electric cars have a range of approximately 100 miles.

** Electrically Charged cars other than PEV = Extended-Range Vehicles + Plug-in-Hybrid Electric Vehicles

*** Total Electrically Charged vehicles = Pure Electric Vehicles + Extended-Range Vehicles + Plug-in-Hybrid Electric Vehicles

(Source: ACEA, 2015)

Table 17: Estimated penetration of the different types of electric vehicles in the Hellenic market.

Penetration level of technology	Low (%)	High (%)	High with emphasis on hydrogen use (%)
by year 2050			
FCEV	5	25	50
BEV	10	35	25
PHEV and E-REV	25	35	20
Conventional vehicles (ICE) and HEV	60	5	5
by year 2020			
FCEV	0,0	1,0	2,0
BEV	0,5	2,0	2,0
PHEV and E-REV	1,5	4,0	3,0
Conventional vehicles (ICE) and HEV	98,0	93,0	93,0

(Source: Hellenic Republic, MEECC, 2012)

[5] The purchase cost for the respective type of conventional car from the same company that needs diesel is 9.770 EUR (Hellenic Republic, MEECC, 2012)

[6] The purchase cost for the respective type of conventional car from the same company that needs diesel is 17.800 EUR (Hellenic Republic, MEECC, 2012)

[7] The purchase cost for the respective type of conventional car from the same company that needs diesel is 15.700 EUR (Hellenic Republic, MEECC, 2012)

1.3 MARKET PERSPECTIVES DUE TO TECHNOLOGICAL TRENDS

The Greek government in cooperation with competent national bodies is supporting sectors and areas of expertise that could boost the Greek market and create a fertile ground for investments and productivity growth.

In August 2010 a public consultation towards the document "Research and development actions aimed at the productive sector" started. Representatives from the business community, research institutions, ministries and the country's regions participated, in order to select sectors/areas of expertise. Among the selected sectors were those of energy and environment[8].

Building sector

The energy services market shows great potential of development. The EE products and services are part of a wider chain that is linked with the construction sector and is based on the qualified domestic scientific and technical staff (GSRT, 2012).

The retrofitting market is driven mostly by living styles, security and comfort matters (Gelegenis J. et al., 2013).

Companies that develop new competitive products in the EE sector are those producing building materials, aluminium, solar thermal systems and have obtained a significant market share in the country and abroad (GSRT, 2013).

According to the analysis of the institute "Roof of Hellenic Industry", the business perspectives in the building sector are related to new energy saving technologies in the building envelope, heating-cooling procedures and equipment (insulation, window/door frames) (GSRT, 2013).

Also, through the implementation of EPCs, as aforementioned, the most common recommended measures were the replacement of windows/door frames, in particular with aluminium frames, and the installation of solar water heating collectors. These market trends on the building retrofitting are significantly influenced by the existence of strong domestic industries producing aluminium profiles and solar collectors (Gelegenis J. et al., 2013).

Hellas is one of the largest European markets of **solar thermal systems**. For many years, over 70% of the relevant sales have come from Germany, Austria and Hellas (ESTIF, 2007). Greece has the second largest total installed capacity, after Germany and slightly below Austria (ESTIF, 2013).

The industry of solar collectors was activated during the mid of '70s with great development rates until 1987, after which it was stabilized with market size of 150-200 thousand m^2 annually (GSRT, 2013). In parallel, at the beginning of '90s this sector started to occupy a significant share in the European and world markets, with the domestic production overcoming the 400 thousand m^2 and exports being at the same level with the domestic sales (GSRT, 2013). In 2013, the overall installed capacity in Hellas reached the 4 million m^2, following Germany (14 million m^2) and Austria (4,6 million m^2) (GSRT, 2013). There is still great growth potential of the industry of solar collectors. In 2013, 99% of production concerns the hot water heating and only 1% the space heating and industrial use (GSRT, 2013).

In 2014 the Hellenic market grew by 18,9% (newly installed capacity 189MW_{th} which represents 270.000 m^2 of newly installed collector area) compared to 2013. This evolution derived from investments in the tourism sector of the country due to the increased number of tourists that visited Greece. These new installations were mainly for hot water supply in the tourism sector/ islands

[8] http://www.opengov.gr/ypepth/?type=done

(hotels, holiday lets, etc.). Greece reached a total installed capacity of 3 GW_{th} (4,3 million m^2)(ESTIF, 2015). This installed capacity provides an estimated energy supply of 2,989 GWh (ESTIF, 2015).

The national industry of **insulation materials** has a long history, but began to grow more rapidly after 1979, when the first Insulation Building Regulation was implemented. The Panhellenic Association of Insulation Companies[9] now includes more than 120 members, out of which at least 30 are involved, inter alia, in the domestic production of insulation materials. The leading position in thermal insulation materials in the country is held by the extruded polystyrene, followed by polystyrene and mineral wool and other fibrous minerals (GSRT, 2013).

The industry of **window/door frames** has also significantly been affected by the increasing requirements posed by the energy efficiency building regulations and is one of the most dynamic productive sectors of the Hellenic manufacturing industry with strong and increasing exports. The production of aluminum frames holds a dominant position in national industry due to the comparative advantage of domestic primary production of aluminum in the country. Other types of frames, such as the wooden frames hold much smaller percentages. Additional activity in the construction of frames is the production of **energy efficient glazing** (double, coated, with vacuum, etc.), some of which is being processed in domestic production units. The significant decline in construction activity had adverse effects on the national industry of frames which shows, during the recent years, significant decrease of sales in the domestic market. Indicatively, the production of semi-finished extruded aluminum (the majority of which relates profile) reached 120.000 tons in 2010, out of which 50% was exported (GSRT, 2013).

According to estimations by the Hellenic Aluminum Company, the same year 2 million aluminum frames were produced. A number of small businesses and SMEs currently operate in the final construction and installation of frames. Indicatively, the "Hellenic Association of Aluminum Manufacturers" includes more than 200 members, spread in all prefectures of the country. Moreover, the aluminum sector shows significant exports since the domestic demand has been drastically decreased over the last period. The rise of the market in these systems favors the industry, but the dynamics of the domestic market are questionable. Instead, abroad and especially in Western Europe, a significant increase in demand is recorded and exports have surpassed the domestic demand after decades (GSRT, 2013).

Production companies of **building materials** have a significant presence abroad, both in Balkan and Mediterranean countries, Middle East etc., while study offices and construction companies are operating abroad. The export activity emerged based on the strategy of these companies to expand their activity and now exports have increased up to a significant extent (70% exports compared to domestic sales) (GSRT, 2013).

Indicatively, the following Hellenic companies for building materials (GSRT, 2013) are mentioned: S&B Industrial Minerals S.A.[10], TITAN[11], Aluminium of Greece[12], HALYVOURGIKI[13], AGET Heracles/LAFARGE[14], VIOHALCO SA[15], ETEM[16], ISOMAT[17], NanoPhos SA[18], etc.

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[9] http://www.psem.gr/
[10] http://www.sandb.gr/
[11] http://www.titan-cement.com/
[12] http://www.alhellas.com/
[13] http://www.halyvourgiki.com/
[14] http://www.lafarge.gr/
[15] http://viohalco.com/el/
[16] http://www.etem.gr/el/home
[17] http://www.isomat.gr/
[18] http://www.nanophos.gr/

Indicatively, the following Hellenic companies for construction technologies (such as thermal insulation materials, solar thermal systems, lighting systems, intelligent building design, air conditioning, shading, etc.) are (GSRT, 2013): DAEDALUS INFORMATICS LTD[19], FIBRAN[20], KNAUF ABEE[21], SOLE S.A.[22], 4M SA[23], Dynatherm[24], BRIGHT special lighting SA[25], Chrysafis Bros G.P.[26], PITSOS[27], Qbus[28], INTELEN[29] (start-up), etc. Also, there are technological companies such as (GSRT, 2013):

1. BRITEHELLAS S.A.[30], which develops 3rd generation technology for solar panels based on new composite organic/inorganic lightweight nano-structured cells and produces transparent Solar Panels, called "PanePower (Solar Windows)", at very competitive cost for usage as power producing glass for greenhouses, homes and office buildings.
2. Organic Electronic Technologies-OET[31].

There are also new and dynamic companies with activity in designing and developing "smart home" applications and services. Indicatively these are (GSRT, 2013): Amitec Ltd, NOVOCAPTIS, Qplan.

In Hellas, there is significant growth in the sector of biodiesel production from approximately ten (10) companies, such as HELLABIOM[32]. Hellas was at the 19th place in Europe for the production of biodiesel in 2010 (GSRT, 2013).

The activities of the companies are supplemented by research and innovation laboratories of universities and research institutes, such as Foundation for Research and Technology, CRES, etc. (GSRT, 2013).

Transport sector

The number of e-vehicles in Greece is limited. By October 2012, it is estimated that 40 corporate e-cars, 15 e-bicycles for municipalities and a few private e-cars were available[33]. According to statistics provided from ACEA (European Automobile Manufacturers Association), the new registrations of passenger electrically charged vehicles[34] in Hellas was 4 in 2013 and 64 in 2014[35].

In 2009, the Athens Urban Transport Organisation (OASA) proceeded with the replacement of 520 old and polluting public buses with new “clean” ones, out of which 200 are natural-gas fired. Also, it purchased twelve (12) electrical buses, one (1) hybrid and one (1) hydrogen one (Zarkadoula M., 2009).

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19 http://www.daedalus.gr/
20 http://fibran.gr/frontend/index.php
21 http://www.knauf.gr/www/el/index.php
22 http://www.sole.gr/
23 http://www.4msa.com/
24 http://www.vassiliadisn.gr/intro/index.asp
25 http://www.bright.gr/
26 http://www.chrysafishadow.gr/en.html
27 http://www.pitsos.gr/
28 http://www.qbus.gr/
29 http://intelen.com/us/solutions/dig.html
30 http://www.britesolar.com/
31 http://oe-technologies.com/
32 http://www.hellabiom.gr/
33 Fact-sheet of Greece: http://emobilityworks.com/gr/λήψεις/category/1-national-factsheet.html
34 Total Electrically Charged Vehicles = Pure Electric Vehicles + Extended-Range Electric Vehicles + Plug-In Hybrid Electric Vehicles
35 http://www.acea.be/uploads/press_releases_files/ACEA_Electric_Vehicle_registrations_Q4_14-13.pdf

Concerning aviation, Aegean airlines, the biggest airline company in Greece, invested in the fleet modernization. In 2010, the last of the B737-400 of Aegean's fleet was retired. The aim of the company is to fly solely new generation, fuel efficient A320/321 and A319 aircrafts[36].

[36] http://en.aegeanair.com/all-about-us/corporate-responsibility/flight-and-enviroment/

1.4 DATA FOR THE BUILDINGS SECTOR

Based on the 2011 census and the information on the tertiary sector, the final building stock is shown in the table below (YPEKA, 2014).

Table 18: Building stock by type (2011 census).

Type	Number
Households	4.122.088
Hotels	8.309
Schools & educational centers	15.576
Offices & shops	152.550
Hospital & medical centers	1.742
Other	625.630
Total	**4.925.895**

(Source: YPEKA, 2014)

According to EUROSTAT, in 2012 the Hellenic households consumed 5,042 Mtoe, while on 1990 the consumption was 3,058 Mtoe (64,8% overall increase). The tertiary sector is the fastest growing sector in terms of energy consumption, as the energy consumption almost tripled in 2012 since 1990, growing by 6,7% per year. In 1990 the energy consumption was 0,652 Mtoe while in 2012 it was 2,233 Mtoe (YPEKA, 2014).

The following sections include the overview of technologies and their technical characteristics that are used in the residential and tertiary sectors (buildings) of the country.

Sector	**Buildings (residential and commercial)**
Category	**Thermal insulation**
Technology	Materials: extruded polystyrene, polystyrene and mineral wool and other fibrous minerals. Energy efficient glazing: double, coated, with vacuum, etc.
Number of technology used	According to a research of the Hellenic Statistical Authority, 42,1% of the households are thermal-insulated, 52,2% are not and for the rest (5,7%) their owners didn't know (ELSTAT, 2013). More information is given in Tables 11 and 12.
Origin of technology	National products.
Cost of purchase	The indicative cost for external thermal insulation is 50 EUR/m^2, while the indicative cost of glazing and change of frames is 200-250 EUR/m^2 (YPEKA, 2014). More information is given in Tables 13 and 14.

Cost per kWh	—
Energy consumption	—
Advantages / disadvantages of use	**Advantage**: These measures/technologies show medium to high cost-effectiveness (see Table 8). **Disadvantage**: There are insulation materials and solutions with low thermal conductivity values that increase thickness in the building envelopes. Nevertheless, very thick building envelopes are not desired due to space issues concerning economy, floor area, transport volumes, architectural restrictions and other limitations (Bjørn P. J., 2011). There are advantages and disadvantages in the properties (such as thermal conductivity, cost, water resistance etc.) of the several thermal building insulation materials and solutions, compared to each other (Bjørn P. J., 2011).
Easiness to use	—

Sector	**Buildings (residential and commercial)**
Category	**Space Heating - Cooling**
Technologies	Gas condensing boilers, heat pumps (mainly air source), biomass systems (mainly energy efficient fireplaces and pellet boilers), energy efficient electric systems (such as air-conditions/inverter technology at least A++), CHP systems, trigeneration systems (power-heating-cooling).
Number of technology used	According to the Hellenic Statistical Authority, the space heating accounts for 63,7% of the energy consumption of the households (YPEKA 2014). Concerning the space heating of households, in 2012, the natural gas and LPG heating systems accounted for 8,7%, the biomass systems for 12%, the electric systems for 12,4% (YPEKA, 2014). The residences with central heating system, which uses fuel oil only account for 35,5% of the total. The remaining 64% is self-heated houses using oil (25%), electricity (12%) and firewood (18%)[37]. The CHP and trigeneration systems are used in the industrial and tertiary sectors[38]. The micro- and small-scale CHP systems will be implemented in hotels, clinics, sport centres and large residential apartments. The economic potential of cogeneration is 24 MW_e and

[37] http://www.cres.gr/energy-saving/technologies_exikonomisis_ener.htm
[38] http://www.code2-project.eu/wp-content/uploads/CODE2_D5.1-Greece_final1.pdf

<table>
<tr><td></td><td>39 MW_{th} in the residential sector by 2020 (CODE2, 2014).</td></tr>
<tr><td>Origin of technology</td><td>National and imported products.</td></tr>
<tr><td>Cost of purchase</td><td>Gas condensing boilers: 900EUR - 3321EUR[39] (for 50-100 m^2)

Heat pumps - Cost range for power 11 - 16 KW ($80m^2$-120 m^2): 4500EUR - 7500EUR approximately (without labour costs)[40]

Biomass systems - Cost range for energy efficient fireplaces 11 - 16 KW ($80m^2$-$120m^2$): 1500EUR-4000EUR[41] while for pellet boilers, 2700 EUR-6000EUR[42]

Energy efficient electric systems: 750-2500 EUR approximately[43] (14000-18000 BTU)

CHP systems: the indicative cost for micro-CHP unit in an apartment house is 25000€[44].

Trigeneration systems (power-heating-cooling): the indicative cost for a hospital is 600.000EUR (515 kWe)</td></tr>
<tr><td>Cost per kWh</td><td>The cost depends on the gas/biomass/electricity prices. Indicatively, for household/tertiary sector the prices for 2009-2012 were (in €/MWh) (CODE2, 2014):
<table>
<tr><th>Year</th><th>Natural gas</th><th>Electricity</th></tr>
<tr><td>2009</td><td>38</td><td>105</td></tr>
<tr><td>2010</td><td>45</td><td>97</td></tr>
<tr><td>2011</td><td>59</td><td>102</td></tr>
<tr><td>2012</td><td>68</td><td>106</td></tr>
</table>
It was estimated that the cost per kWh for heat pumps is 0,057 – 0,069 EUR/kWh depending on the zone, for biomass system 0,086 EUR/kWh, for gas condensing boilers 0,089 EUR/kWh and for energy efficient fireplaces (closed cabin) 0,087 EUR/kWh (Kakaras E. et al., 2013).</td></tr>
</table>

[39]http://www.skroutz.gr/c/1406/levites/f/427614/%CE%91%CF%80%CF%8C-51-%CE%AD%CF%89%CF%82-100.html?keyphrase=%CE%BB%CE%B5%CE%B2%CE%B7%CF%84%CE%B5%CF%82+%CE%B1%CE%B5%CF%81%CE%B9%CE%BF%CF%85+%CF%83%CF%85%CE%BC%CF%80%CF%85%CE%BA%CE%BD%CF%89%CF%83%CE%B7%CF%82

[40] http://www.estiagreen.gr/14-antlies-thermotitas

[41] http://www.estiagreen.gr/301-energeiaka-tzakia

[42] http://www.estiagreen.gr/314-levites-pellet

[43]http://www.skroutz.gr/c/407/Oikiaka_klimatistika/f/6248_372700_372703_407349/Inverter-%CE%A4%CE%BF%CF%85%CE%BB%CE%AC%CF%87%CE%B9%CF%83%CF%84%CE%BF%CE%BD-A-%CE%88%CF%89%CF%82-20000-btu.html

[44] http://www.code2-project.eu/wp-content/uploads/CODE2-BPC-GR-Apartment-house-v1.pdf

Energy consumption	For each kW of electricity consumed by a heat pump, about 4kW of thermal energy is generated. This corresponds to 300% efficiency. In comparison to the other technologies[45]: Condensing gas/oil boiler: 90-96% efficiency; Conventional gas/oil boiler: 70-80% efficiency; Direct electric heating: 35-45% efficiency. Energy efficient electric systems: 1351 kWh/a – 563 kWh/a for heating purposes (e.g Mitsubishi 18000 BTU A++)[46] CHP systems: the indicative yearly generation of micro-CHP unit in an apartment house is 38,5 MWh/year of electricity and 14,5 MWh/year of heat[47].
Advantages / disadvantages of use	**Advantages**: Heat pumps, CHP and trigeneration can be also used for cooling and hot water production. The technologies showed in this table are more energy efficient and environmental friendly than the conventional ones. **Disadvantages**: They have high initial costs compared to the conventional ones.
Easiness to use	All technologies are relatively easy to use.

Sector	**Buildings (residential and commercial)**
Category	**Air Conditioning**
Technology	Inverter A++, A+++
Number of technology used	Although there is no access in specific figures, a statistic research made by the Hellenic Statistical Authority for the period October 2011 - September 2012, showed that 3% of electricity consumption by end use is for space heating in households and 4,9% respectively for space cooling. But, 28,2% of households use air-conditioning for supplemental heating system and 99,7% air conditions (split units) for central space cooling systems (ELSTAT, 2013). The energy consumption for household appliances, lighting and air conditioning amounts to 18% of the total energy balance[48].
Origin of technology	Imported products.

[45]http://www.ehpa.org/technology/key-facts-on-heat-pumps/ (EHPA: European Heat Pump Association
[46]http://www.kotsovolos.gr/site/air-condition-heaters/air-condition/7.000-to-15.000-btu/121850-mitsubishi-msz-sf50ve-plus
[47] http://www.code2-project.eu/wp-content/uploads/CODE2-BPC-GR-Apartment-house-v1.pdf
[48] http://www.cres.gr/energy-saving/technologies_exikonomisis_ener.htm

Cost of purchase	Range from 900€ to 2000€ approximately[49] for inverter A+++ 12.000BTU.
Cost per kWh	This depends on the electricity price.
Energy consumption	246 kWh/a for cooling purposes (e.g Mitsubishi 18000 BTU A++)[50]. An air-condition with energy class A+++ consumes 20%-25% less electricity than another one with energy class A[51].
Advantages / disadvantages of use	**Advantages:** Lower consumption compared to the conventional since it adjusts to the needs, lower noise levels due to their continuous operation at low speed. **Disadvantages:** More expensive that the conventional.
Easiness to use	High

Sector	**Buildings (residential and commercial)**
Category	**Water heating**
Technology	Electric water heater, solar thermal systems (water heaters)
Number of technology used	According to 2011-2012 statistics, 98,6% of households have a system/equipment for their water heating needs. More specifically, 74,5% of households uses electric water heaters, 37,6% uses solar water heaters and the remaining 25,2% uses the thermal system (boilers) (ELSTAT, 2013).
Origin of technology	National and imported products.
Cost of purchase	Electric heaters: 100-300 EUR[52] (100-150 lt). Solar thermal systems: 1000 EUR[53] approximately (for 150lt installed in residence).
Cost per kWh	For electric heaters, this cost depends on the electricity price.
Energy consumption	The solar heaters can cover 70% of energy needs for hot water annually[54].

[49] http://www.skroutz.gr/c/407/Oikiaka_klimatistika/f/372701_372702_407348/A-%CE%88%CF%89%CF%82-14000-btu.html
[50] http://www.kotsovolos.gr/site/air-condition-heaters/air-condition/7.000-to-15.000-btu/121850-mitsubishi-msz-sf50ve-plus
[51] http://www.gedsa.gr/basic-page/876/syhnes-erotiseis
[52] http://www.skroutz.gr/c/970/thermosifones/f/363605_407336/%CE%97%CE%BB%CE%B5%CE%BA%CF%84%CF%81%CE%B9%CE%BA%CF%8C%CF%82-%CE%98%CE%B5%CF%81%CE%BC%CE%BF%CF%83%CE%AF%CF%86%CF%89%CE%BD%CE%B1%CF%82-%CE%91%CF%80%CF%8C-75-%CE%AD%CF%89%CF%82-150-%CE%BB%CE%AF%CF%84%CF%81%CE%B1.html?price_max=300.001
[53] http://www.wsed.at/fileadmin/redakteure/WSED/2011/download_presentations/Travasaros.pdf

	Solar thermal systems: 1200 kWh/year[55] (for 150 lt installed in a single family house)
Advantages / disadvantages of use	**Advantages**: The solar water heaters have low price and maintenance and are easy to install. **Disadvantages**: -
Easiness to use	High

Sector	**Buildings (residential and commercial)**
Category	**Cooking**
Technology	Electric cooking devices, Gas cooking devices
Number of technology used	93,2% on the total of Hellenic households use electric cooker while 8,9% uses gas cooking devices and only 0,4% uses natural gas cooking devices.
Origin of technology	Imported products.
Cost of purchase	Electric cooking devices: 320EUR-1500EUR (energy class A)[56] Gas cooking devices: 230EUR-1700EUR (LPG devices with energy class A)[57]/250EUR-900EUR (natural gas)[58] The cost for professional cooking devices (restaurants, bakeries, hotels, etc.) can overcome the amount of 3000EUR.[59]
Cost per kWh	It depends on the electricity/gas prices.

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[54] https://www.google.gr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=10&ved=0CFsQFjAJahUKEwi0lN6PrNjHAhVGwBQKHeUkAEM&url=http%3A%2F%2Fthess.pde.sch.gr%2Fkpe%2Ffile_library%2FEisigisi_Energeia_2013_Gkanatsios_Akrivousi.ppt&usg=AFQjCNGNQqUglaAKugQzlI5VRO1hBJiTFg&cad=rja

[55] http://www.wsed.at/fileadmin/redakteure/WSED/2011/download_presentations/Travasaros.pdf

[56] http://www.skroutz.gr/c/403/kouzines/f/6106_488428/%CE%A4%CE%BF%CF%85%CE%BB%CE%AC%CF%87%CE%B9%CF%83%CF%84%CE%BF%CE%BD-%CE%91-%CE%A6%CE%BF%CF%8D%CF%81%CE%BD%CE%BF%CE%B9-%CE%BA%CE%AC%CF%84%CF%89-%CE%A0%CE%AC%CE%B3%CE%BA%CE%BF%CF%85-%CE%BC%CE%B5-%CE%95%CF%83%CF%84%CE%AF%CE%B5%CF%82.html?keyphrase=%CE%B7%CE%BB%CE%B5%CE%BA%CF%84%CF%81%CE%B9%CE%BA%CE%B5%CF%82+%CE%BA%CE%BF%CF%85%CE%B6%CE%B9%CE%BD%CE%B5%CF%82

[57] http://www.skroutz.gr/c/403/kouzines/f/6106_488425/%CE%A4%CE%BF%CF%85%CE%BB%CE%AC%CF%87%CE%B9%CF%83%CF%84%CE%BF%CE%BD-%CE%91-K%CE%BF%CF%85%CE%B6%CE%AF%CE%BD%CE%B5%CF%82.html?keyphrase=%CE%BA%CE%BF%CF%85%CE%B6%CE%B9%CE%BD%CE%B5%CF%82+%CF%85%CE%B3%CF%81%CE%B1%CE%B5%CF%81%CE%B9%CE%BF%CF%85&page=2

[58] http://www.skroutz.gr/c/403/kouzines/f/488425_489534/K%CE%BF%CF%85%CE%B6%CE%AF%CE%BD%CE%B5%CF%82-%CE%91%CE%B5%CF%81%CE%AF%CE%BF%CF%85.html?keyphrase=%CE%BA%CE%BF%CF%85%CE%B6%CE%B9%CE%BD%CE%B5%CF%82+%CF%86%CF%85%CF%83%CE%B9%CE%BA%CE%BF%CF%85+%CE%B1%CE%B5%CF%81%CE%B9%CE%BF%CF%85

[59] http://www.e-exoplismos.gr/index.php?cPath=220_222

Energy consumption	N/A
Advantages / disadvantages of use	**Advantages**: More energy-efficient and environmental friendly. **Disadvantages**: They have relatively higher cost that the conventional ones and the natural gas devices require connection of the building with the natural gas grid.
Easiness to use	High

Sector	**Buildings (residential and commercial)**
Category	**Lighting**
Technology A	**LEDs**
Origin of technology	National and imported products.
Cost of purchase	1EUR (0,5W, 40Lm) – 530EUR (150W, 15000Lm)[60]
Cost per kWh	Depends on energy price
Energy consumption	Efficiency: ≥85 Lumens/Watt[61]
Advantages / disadvantages of use	**Advantages**: Low energy consumption and lifetime of 30.000 hours of operation[62] **Disadvantages**: part of the light produced in the LED is back- reflected to the semiconductor in which it may be absorbed and transformed in additional heat[63].
Easiness to use	High
Technology B	**Magnetic induction lamps (18W – 70W)[64]**
Origin of technology	National and imported products.
Cost of purchase	Non available
Cost per kWh	Depends on electricity price
Energy consumption	Efficiency: ≥85 Lumens/Watt[65]
Advantages / disadvantages of use	**Advantages**: Lifetime of 100.000 hours of operation and high quality lighting[66] **Disadvantages**: more expensive than LEDs
Easiness to use	High

[60] http://www.skroutz.gr/c/786/lamptires.html?keyphrase=led
[61] http://www.skroutz.gr/c/786/lamptires.html?keyphrase=led
[62] Information from IM Constructions co. Ltd
[63] Information from IM Constructions co. Ltd
[64] http://ledgenesis.gr/el/index.php?about=65
[65] Information from IM Constructions co. Ltd
[66] Information from IM Constructions co. Ltd

Sector	Buildings (residential and commercial)
Category	**Refrigeration**
Technology	Refrigerator with freezer, 360lt, EU Energy class A+++ and A++
Origin of technology	Imported products.
Cost of purchase	278€ (A++, 172lt) – 1.890[67] € (A+++, 365lt)
Cost per kWh	Depends on electricity price
Energy consumption	146 kWh/year (A++, 172lt) – 190 kWh/year (A+++, 365lt) [68]
Advantages / disadvantages of use	Most efficient in energy consumption and electricity cost/ More expensive to purchase
Easiness to use	High

Sector	Buildings (residential and commercial)
Category	**Washing machines**
Technology	Appliances A+++
Origin of technology	Imported
Cost of purchase	270 – 2.100[69] EUR
Cost per kWh	Depends on electricity price
Energy consumption	153 – 196 kWh/year based on 220 standard washing cycles[70].
Advantages / disadvantages of use	Depends on device. Low energy consumption.
Easiness to use	High

[67] http://www.skroutz.gr/c/404/psigeia/f/342271_439992/A-%CE%A8%CF%85%CE%B3%CE%B5%CE%B9%CE%BF%CE%BA%CE%B1%CF%84%CE%B1%CF%88%CF%8D%CE%BA%CF%84%CE%B7%CF%82.html?page=2

[68] http://www.skroutz.gr/c/404/psigeia/f/342271_439992/A-%CE%A8%CF%85%CE%B3%CE%B5%CE%B9%CE%BF%CE%BA%CE%B1%CF%84%CE%B1%CF%88%CF%8D%CE%BA%CF%84%CE%B7%CF%82.html?page=2

[69] http://www.skroutz.gr/c/405/plynthria-rouxwn/f/6127_427003/%CE%A0%CE%BB%CF%85%CE%BD%CF%84%CE%AE%CF%81%CE%B9%CE%B1-A.html?page=8

[70] http://www.skroutz.gr/c/405/plynthria-rouxwn/f/6127_427003/%CE%A0%CE%BB%CF%85%CE%BD%CF%84%CE%AE%CF%81%CE%B9%CE%B1-A.html?page=8

Sector	**Buildings (residential and commercial)**
Category	**Laundry Dryer**
Technology	Devices A+++
Origin of technology	Imported
Cost of purchase	675 – 2.100[71] EUR
Cost per kWh	Depends on electricity price
Energy consumption	151 – 176 kWh/a[72]
Advantages / disadvantages of use	Depends on device
Easiness to use	Separate from washing machine, mostly high

Sector	**Buildings (residential and commercial)**
Category	**Dishwasher**
Technology	Devices A+++
Origin of technology	Imported
Cost of purchase	415 – 2.300[73] EUR
Cost per kWh	Depends on electricity price
Energy consumption	220 – 299 kWh/a[74]
Advantages / disadvantages of use	Depends on device
Easiness to use	Depending on size – mostly high

Sector	**Buildings (residential and commercial)**
Category	**Other electrics**
Technology	LED TVs, 15" – 50"
Origin of technology	Imported
Cost of purchase	103 – 2.500[75] EUR

[71] http://www.skroutz.gr/c/848/stegnwthria-rouxwn/f/426039/A.html?keyphrase=%CF%83%CF%84%CE%B5%CE%B3%CE%BD%CF%89%CF%84%CE%B7%CF%81%CE%B9%CE%BF
[72] http://www.skroutz.gr/c/848/stegnwthria-rouxwn/f/426039/A.html?keyphrase=%CF%83%CF%84%CE%B5%CE%B3%CE%BD%CF%89%CF%84%CE%B7%CF%81%CE%B9%CE%BF
[73] http://www.skroutz.gr/c/406/plynthria-piatwn/f/424634/A.html?keyphrase=%CF%80%CE%BB%CF%85%CE%BD%CF%84%CE%B7%CF%81%CE%B9%CE%BF+%CF%80%CE%B9%CE%B1%CF%84%CF%89%CE%BD&page=2
[74] http://www.skroutz.gr/c/406/plynthria-piatwn/f/424634/A.html?keyphrase=%CF%80%CE%BB%CF%85%CE%BD%CF%84%CE%B7%CF%81%CE%B9%CE%BF+%CF%80%CE%B9%CE%B1%CF%84%CF%89%CE%BD&page=2
[75] http://www.skroutz.gr/c/12/television/f/453890/LED.html?o=%CF%84%CE%B7%CE%BB%CE%B5%CE%BF%CF%81%CE%B1%CF%83%CE%B5%CE%B9%CF%82

Cost per kWh	Depends on electricity price
Energy consumption	Non available
Advantages / disadvantages of use	Compared to Plasma TVs, the LED TVs are[76]: • Best for bright rooms • Very bright • Very thin and light • Low power consumption • Not very good blacks • Motion blur on lower end models • Backlight uniformity issues • Limited viewing angle
Easiness to use	High

Sector	**Buildings (residential and commercial)**
Category	**Other**
Technology	Building Energy Management System (BEMS), Building automation systems
Number of technology used	The per capita sales in Western European markets are estimated twice higher than those in Eastern European markets (Waide Strategic Efficiency Limited, 2014). Indicative companies: Siemens Greece (KNX)
Origin of technology	National and imported products.
Cost of purchase	The cost depends on the extent of interventions, the size of the building and the type of automation systems. On average it is estimated that the cost to procure, install and operate BEMS is 28.70€/m^2 of service sector building floor area while for the residential sector it is estimated to be is 12.30€/m^2 of residential building floor area (based on literature review, analysis of product pricing and in-field experience) (Waide Strategic Efficiency Limited, 2014).
Cost per kWh	It depends on the fuel prices (electricity, gas, oil).
Energy consumption	Estimates of BEMS energy savings vary considerably: 5%-40% (up to 20% in space heating energy consumption and 10% for lighting and ventilation)[77].

[76] http://www.rtings.com/tv/learn/lcd-vs-led-vs-plasma
[77] https://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch6s6-4-6.html

	If BEMS were properly designed, installed, commissioned and operated, making using of all economically viable control-related end-uses, the average savings per commercial/public building would be approximately 37% (Waide Strategic Efficiency Limited, 2014).
Advantages / disadvantages of use	**Advantages**: Short payback period and high IRR (400%)[78] **Disadvantages**: Costly
Easiness to use	High

[78] http://library.tee.gr/digital/m2483/m2483_sofronis.pdf

1.5 Data for the Transport Sector

This section includes the overview of technologies and their technical characteristics that are used in the transport sector in the country.

Sector	**Transport**	
Sub-sector	Passenger	
Category	Road	
Technology	**Electric vehicles (BEV)**	**Hybrid vehicles**
Number of technology used	80 vehicles, of which 15 are for research purposes.	287 pieces in 2014-2015[79]
Origin of technology	Imported product. BMW Hellas [80]	Imported product. Companies with a share in the Hellenic market are Toyota[81], Honda and Lexus, Mercedes, VW, Porsche[82].
Cost of purchase	BMW i3: €36.150 to €40.800[83]	Cost range (from the cheapest to the most expensive): Toyota Yaris 1.5L Hybrid: €16.200[84] Porsche Cayenne S E-Hybrid: €115.000[85]
Cost per kWh	Depends on the electricity price. (Average household electricity in the 2nd half of 2014 was 17,9€/100kWh)[86].	Porsche Cayenne S E-Hybrid electricity consumption (combined): 20.8 kWh/km[87]
Energy consumption	BMW i3: 12,9kWh/ 100Km (2,3 € / 100km)[88]	Toyota Yaris 1.5L Hybrid: 3,3lt/100km[89] Porsche Cayenne S E-Hybrid: 3,4lt/100km[90]
Advantages/ disadvantages of use	**Advantages:** Low running cost, acceleration, less noise **Disadvantages:** Expensive; Absence of an extensive charging network; low charging duration	**Advantages**: Reduced consumption; Reduced emissions; Tax incentives and discounts/ advantages; Free access to city centres, bus lanes; Free parking in the centres and municipal facilities; Quiet

79 www.acea.be
80 www.bmw.gr
81 www.toyota.gr
82 http://www.porsche.com/international/_greece_/
83 www.bmw.gr
84 www.toyota.gr
85 http://www.porsche.com/international/_greece_/
86 www.dei.gr
87 http://www.porsche.com/international/_greece_/
88 www.bmw.gr
89 www.toyota.gr
90 http://www.porsche.com/international/_greece_/

		operation. **Disadvantages:** Expensive; Difficult to maintenance due to complexity of engine, unqualified garages.
Easiness to use	Medium. Charging duration and inefficient of charging infrastructure hamper the use.	High. Similar to conventional vehicles.

Sector	**Transport**		
Sub-sector	Passenger		
Category	Road		
Technology	E-bikes	CNG buses	Cars Euro 5-6
Number of technology used	N/A	610 pieces[91]	
Origin of technology	Both national and imported product.	Both national and imported product.	Imported product.
Cost of purchase	Range from 550€ to 3.000€[92]	N/A	€22,650[93]
Cost per kWh	0,08 € /kWh[94]	-	
Energy consumption	0,25 kWh[95]	-	5,4–5,0 lt[96]
Advantages / disadvantages of use	**Advantages:** cost effective compared to cars and motorbikes, available for all ages, minimize parking space, improve/maintain health / stamina, environmental friendly **Disadvantages:** Expensive to buy, 6-8 h charging time.	**Advantages:** economical, environmental friendly, reliable, conserve resources **Disadvantages:** not designed for villages or small cities.	**Advantages:** economical, environmental friendly / reduces CO2 emissions **Disadvantages: -**

[91] www.osy.gr/ethelsite/pages/physicalGas/php
[92] www.e-bikes.gr
[93] http://www.bmw.co.za/download/pdf/pricelist/F20_1_Series_Hatch_5door_Pricelist.pdf
[94] www.e-bikes.gr
[95] www.e-bikes.gr
[96] www.bmw.gr

Easiness to use	Easy to use & charge.	Easy to use	Easy to use

Sector	**Transport**	
Sub-sector	Freight	
Category	Road	
Technology	Light trucks Euro 5-6	Heavy trucks Euro 5-6
Number of technology used	19. 782 vehicles in 2011-2012[97]	3.545 vehicles in 2011-2012[98]
Origin of technology	Imported	Both imported and national (ELBO)
Cost of purchase	Fiesta VAN 1.6 D Econetic: 15.820€[99]	N/A
Cost per kWh	Not applicable	Not applicable
Energy consumption	FIESTA VAN 1.6 D Econetic: 3,6 lt/100 km[100]	N/A
Advantages / disadvantages of use	N/A	N/A
Easiness to use	Easy, Mostly used by professional (companies)	Medium

Sector	**Transport**
Sub-sector	Passenger & Freight
Category	Road
Technology	Tyres with Rolling Resistance Coefficient (RRC) of "A" class
Number of technology used	4.061.178 pieces[101] (2013)
Origin of technology	Imported product. (i.e Goodyear, Continental, Michelin, TOYO, BRIDGESTONE, Pirelli, etc.)
Cost of purchase	Cost difference between "A" class tyres compared to "G" class 271€-361€[102] for a set of four (or 195£-260£) (taking into account the higher price of "A" class tyres compared to "G" class)[103]

[97] http://www.seaa.gr/sites/seaa/files/final%20web%20version.pdf
[98] http://www.seaa.gr/sites/seaa/files/final%20web%20version.pdf
[99] www.ford.gr
[100] http://www.autotritipro.gr/data/newcars/times/FORD.asp
[101] www.ecoelastika.gr/news/annual_report_2013/

Cost per kWh	N/A
Energy consumption	The tyres account for 20-30% of a vehicle's fuel consumption. When choosing energy efficient tyres, this leads to fuel savings[104]. The fuel efficiency class is determined by the Rolling Resistance Coefficient (RRC) according to the scale "A" to "G". "A" is for most efficient and "G" for least efficient. The difference between the maximum "A" and minimum "G" coefficient corresponds up to 7,5% reduction in fuel consumption. For instance, switching from "G" tyres to "A" tyres could lead to reduction of fuel consumption by up to 9%. If the vehicle has a fuel consumption of 8 l/100km and covers 65.000 km with new tyres, this means a fuel saving of up to 440 liters over the lifetime of the tyres. With a fuel price of 1.50 € per liter, this equates to a cost saving of 660€ over the lifetime of the tyres[105]
Advantages/ disadvantages of use	**Advantages**: Reduction of fuel consumption by 60 lt/year and CO_2 emissions by 140kg/year [106] **Disadvantages:** Cost
Easiness to use	High. Same as conventional.

Sector	**Transport**
Sub-sector	Passenger & Freight
Category	Rail
Technology	Diesel, Electric, Steam
Number of technology used	Transport stock of the Hellenic Railways Organization (2012): 306[107] 143 — *Diesel locomotives* 30 — *Electric locomotives*[108] 108 — *Railcars* 5 — *Steam locomotives* 20 — *Electric railcars* Railway companies are using the same rolling stock for several decades, resulting to slow penetration of innovative, more sustainable rolling stock and technologies (Ministry of Transportation and Communications, 2006). The needs of this sub-sector are focused on modernized infrastructure such as electric and diesel locomotives with speeds of 220km/h, coaches of updated standards, high comfort and high speed and modern wagons for freight (Ministry

[102] 271€-361€ (exchange rate as of 21.08.2015 in the following link: http://www.xe.com/currencyconverter/convert/?From=GBP&To=EUR)
[103] http://ec.europa.eu/unitedkingdom/press/frontpage/2012/12_120_en.htm
[104] https://ec.europa.eu/energy/sites/ener/files/documents/FIN%20User%20guide%20-%20tyres.pdf
[105] http://ec.europa.eu/energy/en/topics/energy-efficient-products-and-labels/tyres
[106] http://www.michelin.gr/tyres/michelin-energy-saver-plus#tab-tyres-benefits
[107] http://www.statistics.gr/portal/page/portal/ESYE/PAGE-themes?p_param=A1101&r_param=SME12&y_param=TS&mytabs=0
[108] Regolamento Internationale Carozze: Vehicles that can be used for international transportation.

	of Transportation and Communications, 2006). New tilting trains are also needed for achieving a significant reduction of time without proceeding with the costly required investment in civil works due to the mountainous terrain of the country (Ministry of Transportation and Communications, 2006).
Origin of technology	Imported
Cost of purchase	N/A
Cost per kWh	It depends on the fuel prices (diesel, electricity).
Energy consumption	N/A

Sector	**Transport**
Sub-sector	Passenger & Freight
Category	Aviation
Technology	New generation, fuel efficient A320/321 and A319 aircrafts
Number of technology used	Concerning aviation, Aegean airlines, the biggest airline company in Greece, invested in the fleet modernization. In 2010, the last of the B737-400 of Aegean's fleet was retired. The aim of the company is to fly solely new generation, fuel efficient A320/321 and A319 aircrafts. Also, the company is aiming for a 1,5% reduction in fuel consumption attributed to fuel saving initiatives in 2011[109].
Origin of technology	Imported products.
Cost of purchase	A319: 85,8 million USD and A320/321: 93,9-110,1 million USD[110]
Cost per kWh	N/A
Fuel consumption	N/A

Sector	**Transport**
Sub-sector	Passenger & Freight
Category	Navigation
Technology	Computational fluid dynamics (CFD) analysis and trim/draft optimization[111], Optimization of hull dimensions, waste heat recovery systems, ballast water treatment systems, energy saving devices such as: Propulsion Improving Devices (Wake Equalizing and Flow Separation Alleviating Devices, Pre-swirl and Post-swirl Devices, High-efficiency Propellers), Main Engine Performance

[109] http://en.aegeanair.com/all-about-us/corporate-responsibility/flight-and-enviroment/

[110] http://www.airbus.com/presscentre/pressreleases/press-release-detail/detail/new-airbus-aircraft-list-prices-for-2014/

[111] http://www.nazo.gr/english/images/stories/News/BOOKLETGreenTechnologiesRetrofitsinGreece.pdf

<table>
<tr><td></td><td>Measurement and Control devices.</td></tr>
<tr><td>Number of technology used</td><td>The Greek fleet of 4.161 ships over 1.000 GRT in February 2009 accounted for 8,2% of the world fleet in number of vessels, 15,2% in DWT and 13,2% in gross registered tonnage[112]. The number of technologies used concerning Greek fleet is not available.</td></tr>
<tr><td>Origin of technology</td><td>National and imported products.</td></tr>
<tr><td>Cost of purchase</td><td>N/A</td></tr>
<tr><td>Cost per kWh</td><td>This depends on the fuel prices.</td></tr>
<tr><td>Energy savings</td><td> The Trim/Draft Optimization can lead to 1-2% reduction in propulsion fuel consumption (ABS, 2013). It is applicable to all ships, but biggest improvements occur for ships on long routes. The costs for the data development are estimated to 50.000USD - 100.000USD and the costs for the effective use of data include shipboard software tools 500USD to 5.000USD per ship (ABS, 2013).The trim optimization can lead to hull resistance and potential fuel savings averaging between 2 and 5%[113].
The optimization of hull dimensions can reduce the ship resistance. This is applicable to all newly built ship types and could lead to 5%-20% fuel reduction (Maddox, 2012)
The waste heat recovery systems can increase the energy output from a large low-speed diesel engine up to 11% by adding exhaust gas turbines and steam turbines (ABS, 2013).
The Main Engine Performance Measurement and Control devices can lead to 1-2% reduction in the specific fuel oil consumption for low- and medium-speed diesel engines (ABS, 2013). The cost varies from 5.000USD to 50.000USD depending on whether the equipment is portable equipment or fixed equipment (ABS, 2013).
Concerning Propulsion Improving Devices (ABS, 2013):
<table>
<tr><th>Device</th><th>Savings (reduction in propulsion fuel consumption)</th><th>Cost (depending on the device)</th></tr>
<tr><td>Wake Equalizing and Flow Separation Alleviating Devices</td><td>0-5%</td><td>Low to medium-low</td></tr>
<tr><td>Pre-swirl Devices</td><td>2-6%</td><td>Medium-low</td></tr>
<tr><td>Post-swirl Devices</td><td>2-6%</td><td>Medium-low</td></tr>
<tr><td>High-efficiency Propellers</td><td>3-10%</td><td>Medium-low</td></tr>
</table></td></tr>
</table>

[112] http://www.nee.gr/default.asp?t=GreekShipping
[113] http://www.nazo.gr/english/images/stories/News/BOOKLETGreenTechnologiesRetrofitsinGreece.pdf

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TECHNOLOGICAL TRENDS

D.1.4

PART OF WORK PACKAGE 1: MAPPING OF ENERGY EFFICIENCY POLICY INSTRUMENTS AND AVAILABLE TECHNOLOGIES IN BUILDINGS AND TRANSPORT

NATIONAL REPORT FOR ITALY

DATE

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ACRONYMS

CHP: Combined Heat and Power.

GSE: Gestore dei Servizi Energetici.

GWh: Gigawatt-hour.

ITS: Intelligent Transport System.

LED: Light-Emitting Diode.

LPG: Liquified Petroleum Gas.

M: Millions.

M€: Million euro

Mtoe: Million toe

MISE: Italian Ministry of Economic Development.

MWh: Megawatt-hour.

NEEAP: National Energy Efficiency Action Plan.

NG: Natural Gas.

PV: PhotoVoltaic.

PVC: Polyvinyl chloride.

SEAP: Sustainable Energy Action Plan.

SEN: Strategia Energetica Nazionale (National Energy Strategy).

SME: Small and Medium-sized Enterprise.

T: ton.

TEE: Titoli di Efficienza Energetica (Energy Efficiency Titles, other name for the White Certificates issued within the related system).

TEP: tonnellata equivalente di petrolio (tonnes of equivalent oil).

TOE: tonnes of equivalent oil.

TWh: Terawatt-hour.

UPS: Uninterruptible Power Supply.

Please note that throughout the report, "SEN, 2013" is used to refer to the following reference: Ministry of Economic Development. (2013). National Energy Strategy 2013. Available at: http://www.encharter.org/fileadmin/user_upload/Energy_policies_and_legislation/Italy_2013_National_Energy_Strategy_ENG.pdf

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EXECUTIVE SUMMARY

The energy efficiency is targeted as 'priority action' within the last National Energy Strategy (2013), with the purpose to boost the capability of Italy to compete within the international scenery and to assure a sustainable growth.

Within this framework, some of the latest and more efficient technologies are recently finding application in the building and transport sectors, where different policy instruments display specific long-term strategies and support proper actions for energy efficiency.

Particularly, within the building sector, in Italy there are four main policy instruments to support and promote the energy efficiency improvement actions: the 'thermal account', the tax deductions, the so called 'Energy Efficiency Titles' (or 'white certificates') and the 'Kyoto Fund'.

These policy instruments support proper actions involving thermal insulation of building envelopes, replacement of fixtures and heat generators, installation of building automation systems, replacement of lighting systems and use of renewable energy sources.

On the other side, energy savings within the transport sector may be achieved by introducing more efficient vehicles as well as shifting towards more sustainable mobility modes. The 'Mobility Management', at both local and company level, as well as technological and behavioural changes within the marine transport are particularly important.

Anyway, among the existing innovative energy efficiency technologies, only some can be recognized as 'cost efficient'. The assessment of the investment 'Pay-Back Time' related to the main technologies for the residential sector proves that, among the different technologies considered, only new efficient lighting systems, building automation, fixtures with high efficiency, condensing boilers and thermal solar have an 'acceptable' Pay-Back Time. Furthermore, there are some technologies that, even if theoretically not economically sustainable, yet are widely diffused due to the presence of proper incentives. Among these, we can mention efficient appliances, opaque building (walls and roofs) surfaces, photovoltaic and thermal solar.

With regard to the transport sector, the technologies offering the lower running costs imply the use of alternative fuels, such as methane gas, LPG, bio-fuels and full electric traction. Such technologies recorded a progressive increase in sales during the years 2007-2010 due to the support from national incentive schemes.

The above mentioned economic analysis led to the development of a national energy efficiency market. With regard to the residential sector, the best market potentials are offered by opaque building surfaces, heat pumps, biomass boilers and efficient appliances. As to the transport sector instead, the expected savings are to be delivered by the main measures/programmes, which comprise actions to renew the road vehicle fleet, promote sustainable mobility and develop the railway infrastructure as well as advanced logistics management systems.

The report ends with a detailed description, through specific tables, of the technical and economic indicators of each technology recorded for the two sectors analyzed.

CHAPTER 1: TECHNOLOGICAL TRENDS IN THE BUILDING AND TRANSPORT SECTOR

In this task, for each country relevant technologies that are already used and promoted by corresponding energy efficiency policy instruments will be presented.

1.1 ENERGY EFFICIENCY POTENTIAL

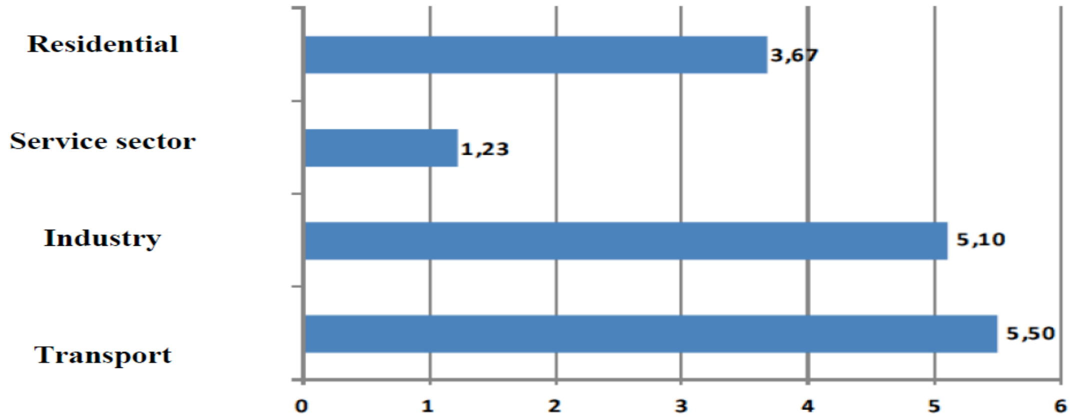
The National Energy Efficiency Action Plan (NEEAP) 2014, in line with the contents of the National Energy Strategy (SEN), sets out the national targets for the reduction of primary and end-use energy consumption and specifies the savings in end-uses of energy expected in 2020 by economic sector and by policy measures implemented for achieving them (Table A, Figure A).

Table A: Final energy savings (Mtoe/y) expected in 2020 by sector

Sector	PLANNED MEASURES FOR 2011-2020					CONVENTIONAL ENERGY DEMAND*	PRIMARY
	Regulatory standards	Measures and investments for mobility	Thermal account	Tax deductions	White certificates	SAVINGS EXPECTED by 2020	SAVINGS EXPECTED by 2020
Residential	1.60		0.54	1.38	0.15	**3.67**	**5.14**
Services	0.20		0.93		0.10	**1.23**	**1.72**
Public authorities	0.10		0.43		0.04	0.57	0.80
Private	0.10		0.50		0.06	0.66	0.92
Industry					5.10	**5.10**	**7.14**
Transport	3.43	1.97			0.10	**5.50**	**6.05**
TOTAL	**5.23**	**1.97**	**1.47**	**1.38**	**5.45**	**15.50**	**20.05**

Source: NEEAP, 2014

Figure A: Final energy savings (Mtoe/y) expected in 2020 by sector



Source: NEEAP, 2014

The following table (Table B) shows the estimates of electricity savings (GWh/y) and the economic energy efficiency potential expected in 2020 by sector.

Table B: Estimates of energy savings and economic energy efficiency potential expected in 2020 by sector

Sector	Primary energy consumption expected in 2020 (Mtoe/y)	Electricity savings expected in 2020 (GWh/y)	Economic energy efficiency potential[1] expected in 2020 (M€/y)
Industry	32,4	28.678	4.129
Transport	41,5	49.175	7.081
Residential	30,2	77.121	11.105
Services	19,6	29.698	4.276

Source: data processed by IEFE on ENEL, 2013

The key technologies for achieving energy efficiency in the *buildings sector* in Italy, as indicated in Energy Efficiency Report (Energy Strategy Group, 2013), are:

- *For space heating and air conditioning: heat pump, opaque building surfaces, fixtures with high efficiency, solar cooling, solar thermal;*
- *For energy production and energy saving: small wind turbines and photovoltaic;*
- *For water heating: building automation, condensing boilers and biomass boilers;*
- *For cooking, washing machines, laundry dryers and dishwashers: induction cooking and efficient and pre heated appliances;*
- *For lighting: efficient lighting systems.*

As regards the *transports sector*, the main fuel-efficient technologies, as identified by numerous sources (such as ENEL, 2013; ENEA, 2015; Marciani et al., 2014) are:

- For *road transport*: *low emission vehicles* (natural gas, hybrids, hydrogen and electric), *innovative vehicles based on automation*, *tire pressure monitoring*, awareness of "*eco-driving*" and *mobility management actions*;
- For *rail transport*: *power magnetic induction* and *recovering energy from braking*;
- For *navigation*: *hull antifouling systems*, *replacement of propeller and rudder*, *engine auto tuning*, *optimizers of hydro-dynamic flow*, *information system for the optimization of consumption*, *Air Cavity System* and *Waste Heat Recovery System*;
- For *aviation*: *biofuels, energy efficiency aircraft design*, *aerodynamic resistance reduction*, *high efficiency motors* and *aircraft with long life cycle.*

[1] Savings expected in 2020 have been calculated considering an average price of electricity in Italy for 2012 of 0,144 €/kWh. (Source: QualeEnergia, 2013. I prezzi dell'elettricità e del gas in Europa e in Italia. Available at *http://www.qualenergia.it/articoli/20130528-i-prezzi-dell-elettricit%C3%A0-e-del-gas-europa-e-italia*)

1.2 Technologies And Policy Instruments

Policy instruments

Buildings sector

Nowadays in Italy, existing technologies that enable an energy efficiency improvement within the buildings sector are supported by four main policy instruments: the so called 'thermal account', the tax deductions, the so called 'Energy Efficiency Titles' (or 'white certificates') and the 'Kyoto Fund'.

The following table (Table C) shows a summary view of the policy instruments supporting each existing energy efficiency technology.

Table C: Policy instruments for each existing energy efficiency technology (buildings sector)

Technologies	Policy instruments
Condensing boilers	Thermal account, tax deductions, white certificates, Kyoto fund
Heat pump	Thermal account, tax deductions, white certificates
Biomass boilers	Thermal account, tax deductions, white certificates, Kyoto fund
Fixtures with high efficiency	Thermal account, tax deductions, white certificates, Kyoto fund
Opaque building surfaces	Thermal account, tax deductions, white certificates, Kyoto fund
Solar Thermal	White certificates, Kyoto fund
Small wind turbines	White certificates, Kyoto fund
Solar cooling	Thermal account, white certificates
Building Integrated Photovoltaic BIPV	White certificates, Kyoto fund
Photovoltaic	Tax deductions, white certificates, Kyoto fund
Solar thermal	Thermal account, white certificates, Kyoto fund
Induction cooking	White certificates
Efficient appliances	White certificates, energy labeling of households appliances
Efficient lighting systems	White certificates, national Fund for Energy Efficiency (public lighting)
Combined Heat and Power (CHP)	Thermal account, tax deductions, white certificates, Kyoto fund
Uninterruptible Power Supply (UPS)	White certificates
Building automation	White certificates

Source: data processed by IEFE

In addition to the above mentioned technologies, new technologies and innovative systems are meeting an increasing success, such as building automation, the *'active building envelope'* and the *'smart buildings'*. In particular, among the innovative technologies we can mention:

- *Cool materials*: the use of 'cool materials' for the roofs and the façades of the buildings limits the solar amount and therefore the energy demand for cooling in the air conditioning;
- *Innovative cements* (es, *'I.light'*, *'TXD Active'*, *'Tx Aria'*), that allow a great energy efficiency improvement due to the low thermal conductivity, the high permeability to steam and the high thermal inertia;
- *Composite materials* (*'bio-bricks'*, chipboard panels, special clay blocks), that greatly reduce the building energy consumption and are produced through the recycling and reuse of waste materials.

Currently the use of such materials is supported by several policy instruments (thermal account, tax deductions, white certificates, Kyoto Fund), nevertheless it is still limited because we are in the initial phase of market penetration.

Transport sector

During the last years several actions have been taken, at both local and national level, aimed at the disincentivation of the private transport, the promotion of use of 'low emission' fuels, the purchase of 'low emission' vehicles, an increase of diversification in the offer of public transport.

Table D below displays a summary view of the energy efficiency technologies and policy instruments (described in Task 1.2) supporting them, within the transport sector.

Table D: Technologies and policy instrument supporting them (transport sector)

Sector	Technologies	Policy instruments
Road transport	*Electric and hybrid vehicles*	National infrastructure plan to set up electric vehicle charging points, Road tax, Renewable energy in transport sector (D.lgs 28/2011)
	Biofuel vehicles	Incentives for the promotion of biofuels in transport sector, Law n.81/2006
	Methane and LPG vehicles	Road tax, Guide to fuel saving and decreasing CO2 emission by cars
	ITS – Intelligent Transport System	National Action Plan for Intelligent Transport System (2014), National Law nr.221/2012, National Logistics Platform[2]
	Bike-sharing	Funding for energy efficiency, renewable energy and bike-sharing
	Mobility management actions[3]	Italy's National Plan for Logistics, Urban traffic plans, National "Smart Cities and Communities and Social Innovation" funds
	Car-pooling, car sharing and bike sharing	National electric car sharing project in cities
	Electric Bus	Five years bus fleet renewal plan, National funds for local public transports
	Innovative vehicles based on automation[4]	n.a.
	Eco-driving	Eco-driving Guide
Rail transport	*Power magnetic induction*	n.a.
	Recovering energy from braking	n.a.
Navigation	*Information system for the optimization of consumption*	National technological maritime platform
Aviation	*Biofuels*	n.a.
	Aircraft with long life cycle	n.a.

Source: data processed by IEFE

[2] https://www.uirnet.it/uirnet/

[3] For example: encouraging the use of bicycles and public transport; company buses, teleworking, company kindergarten and grocery shopping online, etc.

[4] Cyber car, personal rapid transport (PRT), high-tech bus, high-tech lorry and dual-mode vehicles.

With regard to the **road transport sector**, among the innovative technologies we can mention:

- *Low resistance tyres*, that together with the tyre pressure monitoring could lead to a 3% reduction of fuel consumptions[5];
- *Start & stop systems,* that turn on and off automatically the internal combustion engine to reduce the time in which the motor rotates and the car is stopped, so decreasing fuel consumption and reducing pollutant emissions;
- *Eco-driving* (changing gears as soon as possible, maintaining a steady speed, frequently checking the tire pressure and decelerating smoothly) allows to save on average 5-10% of fuel, in addition to ensuring an economic saving, reducing the likelihood of accidents, noise pollution and emissions[6].

These technologies are supported by an information and awareness instrument implemented by the Ministry of Economic Development: the *Eco-Driving Guide*.

As regards **navigation**, the ENEA annual energy efficiency report (2015) provides a mapping of main innovative technologies:

- *Hull antifouling systems;*
- *Replacement of propeller and rudder;*
- *Engine auto tuning;*
- *Optimizers of hydro-dynamic flow;*
- *Air Cavity System and Waste Heat Recovery System.*

Despite the implementation of some international actions (e.g. the Rules for CO_2 emission reduction from the overseas marine transport), the marine transport sector seems to suffer from the lack of a proper strategy supporting the design and building of true 'green ships', that is, ships capable to remarkably reduce the main environment polluting factors as well as, more in general, to reduce the overall external costs of the marine transport. Even the Legislative Decree nr. 102/2014 (actuating the Directive 2012/27/UE on the energy efficiency) does not foresee any specific measure supporting technology and management innovations for the marine sector focused on the reduction of energy consumption, despite the relevant potential energy savings offered by this sector[7].

Finally, with regard to the **road aviation** sector the innovative technologies, which are finding large development in recent years, are[8]:

- *Energy efficiency aircraft design.* The use of lightweight materials and the reduction of the weight of the non-essential components may lead to a decrease of fuel consumption equal to approximately 9%;
- *Aerodynamic resistance reduction.* The new models of simulation of aerodynamics allow for performance optimization;
- *High efficiency motors (e.g. use of open rotor).* Each new generation engine has provided improved efficiency ranging from 5% to 15%.

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[5] ENEA, 2011a.

[6] ECODRIVEN, 2008.

[7] ENEA annual energy efficiency report, 2015.

[8] Source: *http://www.fondazionesvilupposostenibile.org/f/Documenti/CO2+Trasporti/cap_10.pdf.*

Cost efficiency

Buildings sector

The energy efficiency improving technologies relevant to the buildings sector that are 'cost efficient' to the consumer have been recorded[9] in the 2013 Energy Efficiency Report (Energy Strategy Group, 2013). The assessment of the cost efficiency of each technology (Table E) has been made considering the following indicators:

- *Pay-Back Time*, which is the time period[10] when the investment in the energy efficiency improving solution is entirely paid back;
- *Average cost of kwh saved and produced* (c€/kWh), that is the ratio between the costs of the implementation and use of the energy efficiency improving solution (*Capex ed Opex*) and the amount of energy saved or produced by its use[11].

Table E: Cost efficiency for each energy efficiency existing technology (buildings sector)

Technology	Pay-Back Time (years)	Average cost of kwh saved and product (c€/kWh)
Efficient lighting systems	0,1-0,5	0,6-1
Building automation	2,9-4,6	4,8-7,2
Fixtures with high efficiency	13-15	12,4-21
Opaque building surfaces	8,5-11	10-13
Heat pump	6-9	7-9,5
Condensing boilers	4,5-7	2,7-4,1
Solar Thermal	5-7	6-13

Source: Energy Strategy Group, 2013

Table E shows that only the efficient lighting systems, the building automation, the fixtures with high efficiency, the condensing boilers and the solar thermal have an 'acceptable' Pay-Back Time. The resulting values for the Average cost of kwh saved or produced (c€/kWh) show that, with the only exception of the fixtures with high efficiency and the opaque building surfaces, all the current technologies prove to be cost-sustainable, even when the resulting Pay-Back Time is greater than the threshold value assumed as 'acceptable' (e.g. heat pumps, condensing boilers, solar thermal).

Transport sector

With regard to the transport sector, the following table (Table F) offers a comparison among the different traction fuel types (considering a 'Fiat Punto' city car). The table shows that the methane gas grants the longer journeys with a given expense (1 €).

Table F: Journey for 1 € for each traction fuel type

	Gasoline	Diesel	LPG	methane
Journey/1€	7.07 km	9.91 km	12.87 km	20.98 km

Source: FIAT, 2012[12]

[9] The recording refers to the case of voluntary replacement of a traditional technology in absence of incentives.

[10] The resulting values for this indicator are to be compared with a 'threshold' value that is equal to 4-6 years for the buildings sector.

[11] This indicator is to be compared with a 'threshold' value that for the buildings sector is equal to 19c€/kWh (electricity purchase cost) and 9 c€/kWh (heat generation cost) respectively.

Further to this table, we could also observe that a 'class B' electric vehicle would offer even longer journeys (40 km/1€). Anyway, the purchase cost of a full electric vehicle currently is 2-3 times higher than that of a traditional car, due to the cost of the batteries (e.g. a 30 kWh battery, adequate to a 'class C' car with journey about 150 km, will cost about 9,000 €). With regard to hybrid vehicles instead, the purchase extra-cost would be lower and easily paid back by the lower fuel consumption, but only when the kilometers traveled annually are greater than a certain 'threshold' value that depends from the current fuel prices[13].

As regards the navigation sector, the following table (ENEA, 2015) shows the energy and cost savings potential connected to the improvement of innovative technologies in maritime transport, with reference to three types of ships: containers, passengers and tanker.

Table G: expected energy and cost savings connected to the improvement of technologies

Technologies	**Types of ships**		
	containers	**passenger**	**tanker**
Hull antifouling systems	132 tons/years	511tons/years	295 tons/years
Replacing propeller and rudder	79 tons/years	307 tons/years	177 tons/years
Engine Auto Tuning	26 tons/years	102tons/years	59 tons/years
Optimizers flow hydro-dynamic	80 tons/years	310 tons/years	180 tons/years
Information system for the optimization of consumption	158 tons/years	614 tons/years	354 tons/years
Air Cavity System	92 tons/years	n.a.	207 tons/years
Waste Heat Recovery System	211 tons/years	818 tons/years	472 tons/years
Total fuel saved	200-780 tons/years	1200-2.660 tons/years	700-1.740 tons/years
Total costs savings	173.000-455.000 €/year	683.000- 1.456.000 €/year	364.000-856.000 €/year

Source: ENEA, 2015

Penetration grade of the different existing technologies

Buildings sector

With regard to the technologies performing a relevant penetration grade due to the support from proper incentives, reference is made to the report 'Stato e prospettiva dell'efficienza energetica in Italia' (*State-of-art and perspectives of the energy efficiency in Italy*) - ENEL, 2013. The report records the different technologies that, even if not economically sustainable, yet are widely diffused due to the presence of proper incentives and highlights which policy instrument has contributed to their diffusion. Among these:

- The *efficient appliances* with pre-heating for washing and cold, that recorded a remarkable diffusion (16% of the theoretical market potential) mainly due to the incentive scheme as well as effective communication & pricing policies;

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[12] *http://www.zavattarello.org/trasparenza/ambiente/campagna_auto.pdf.*

[13] ENEA, 2011a.

- The *opaque building (walls and roofs) surface* technologies recorded a good penetration grade (about 20% of the theoretical market potential) due to the support granted by the incentive scheme (tax deduction);
- The *photovoltaic* (PV) – with its high potential of savings through the purchase of electricity from the grid – 17 TWh – recorded a good penetration grade during these years, mainly due to incentivating scheme of the so called 'energy accounts' ("Conto Energia");
- The *solar thermal* followed - but with a lower performance - the trend of the 'PV', anyway a rapid increase could happen (about 11,5 TWh) due to the prolonged incentive regime and the development of proper 'heat storage' technologies that could help filling the gap between the generation and the use of thermal energy for heating.

Transport sector

Within the transport sector, the technologies with the best penetration grade due to the support from national incentive schemes are the LPG- and NG-fuelled vehicles, which recorded a progressive increase in sales during the years 2007-2010 (2010 is the year when the incentive schemes came to an end) (ENEA, 2011b).

1.3 Market Perspectives due to Technological Trends

Buildings sector

According to the Energy Efficiency Report 2013 (Energy Strategy Group, 2013), the potential saving displays the energy saved (TWh) through to the implementation of energy efficiency technology solutions. This potential has been assessed for the buildings sector, considering two different scenarios (Table H):

- 'Theoretical' scenario, referring to the implementation of energy efficient solutions to replace or integrate all the less efficient technologies currently used;
- 'Expected' scenario that reviews the estimates of the 'theoretical' potential on the basis of a reasonable penetration grade for each technology solution (related to the cost effectiveness, the technological maturity grade and the 'perception' of the market operators).

Table H: 'Theoretical' and 'expected' potential savings in 2020 (TWh) of each technology within the buildings sector

Technologies	'Theoretical' potential savings			'Expected' potential savings		
	Residential sector	Services	Total	Residential sector	Services	Total
Lighting	8,57	6,13	14,7	4,47	3,68	8,15
Building Automation	11,6	2	13,6	1,2	0,62	1,82
Fixtures with high efficiency	20,2	2,2	22,4	4,94	0,36	5,3
Opaque building surfaces	70,35	3,95	74,4	29,6	1,4	31
Heat pump	101	10	111	36,73	4,37	41,1
Condensing boilers	55,2	6,6	61,8	11,12	2,58	13,7
Solar thermal	17,5	4,4	21,8	5,39	0,65	6,34

Source: Elaboration data from Energy Strategy Group 2013

The residential sector is the buildings sector showing the greater 'expected' potential in 2020. The technologies related to the greater 'expected' potential savings are heat pumps (36,73 TWh per year) and condensing boiler (11,12 TWh per year).

A further analysis of the economic effects of the energy efficiency improvement actions has been made by ENEL with the report 'Stato e prospettive dell'efficienza energetica in Italia' (*State-of-art and perspectives of the energy efficiency in Italy*), 2013. Once again it has been investigated and assessed the business (M€) generated by the implementation of energy efficiency technologies in two different development scenarios: 'optimal' and 'moderate' (Table I).

Table I: Business (M€) generated by the implementation of energy efficiency technologies within the buildings sector in 2020

Technologies	Type of energy (energy vector)	**'Optimal' development scenario**		**'Moderate' development scenario**	
		Potential annual savings (TWh)	**2020 business (M€)**	**Potential annual savings (TWh)**	**2020 business (M€)**
Heat pump	Thermic	53,30	78,11	33,30	56,61
Condensing boilers	Thermic	34,70	31,75	22,10	22,84
Induction cooking	Electric	1,00	10,48	0,75	8,23
Building automation	Electric	2,74	0,76	2,06	0,63
	Thermic	13,36	3,84	10,04	3,22
Solar control	Thermic	12,40	56,20	4,00	18,13
Small wind turbines	Electric	3,90	15,60	2,70	10,80
Solar cooling	Electric	0,76	2,75	0,46	1,66
Building Integrated Photovoltaic BIPV	Electric	0,02	0,04	0,01	0,02
Opaque building surfaces	Thermic	63,40	115,68	39,60	72,26
Photovoltaic	Electric	17,00	33,79	11,30	22,46
Solar thermal	Thermic	11,40	32,18	7,60	23,85
Efficient appliances	Electric	3,70	37,75	3,00	31,44
Biomass boilers	Thermic	38,60	44,79	32,20	37,84
Efficient lighting systems	Electric	17,00	2,42	14,20	2,06
TOTAL		273,28	466,14	183,32	340,77

Source: ENEL, 2013

The picture shown above points out that about the 45% of the total business generated by the energy efficiency actions comes from the electric energy vector, while the other 55% comes from the thermal energy vector. With regard to the technologies granting relevant business figures, within the general framework we can mention opaque building surfaces (72,26 M€), heat pumps (56,61 M€), biomass boilers (37,84 M€) and efficient appliances (31,44 M€).

Transport sector

As to the transport sector, the NEEAP (2014) reports that the expected savings will be delivered by the main measures/programmes, which comprise actions to renew the road vehicle fleet, promote sustainable mobility and develop the railway infrastructure and advanced logistics management systems. In particular, the improved energy performance of the new cars and light commercial vehicles and implementation of the measures to encourage the uptake of low-emission and electric vehicles should, taken together, save about 3,43 Mtoe of energy by 2020. The measures for sustainable mobility will contribute by some 1.97 Mtoe, broken down into the following sectors: local public transport and renewal of the bus fleet (0,9 Mtoe), railway infrastructure (0,45 Mtoe), services of the National Logistics Platform (0,5 Mtoe), and the 2009 incentives for renewing the national car fleet 2009 (0,12 Mtoe) (see Table A, pag. 5). Considering an average price of the toe equal to 545€[14] the business (M€) generated by the implementation of energy efficiency technologies in transport sector is equal to 1.870 M€ for the measures which encourage the uptake of low-emission and electric vehicles and to 1.074 M€ for the measures for sustainable mobility.

1.4 DATA FOR THE BUILDINGS SECTOR

Sector	**Buildings**
Sub-Sector	Residential sector
Category	*Space heating*
Technology	***Condensing boilers***
Number of technology used	It is estimated that in mid-2013, about 20%-30% of total heating units in use (19 million units, including central heating systems) were condensing boilers Source: Energy Strategy Group, 2013
Origin of technology	Condensing boilers have a high rate of production in Italy (more than 60% of producers based in Italy) Source: ENEL, 2013
Cost of purchase	Condensing boilers are 35-40% more expensive than traditional boilers because of the higher costs of materials and design (es. the different models of Beretta Vaillan cost approximately 800-1.500€) Source: *http://www.caldaie-climatizzatori.com/prodotti.php?id=14*
Cost per kWh	2,7 - 4,1 c€/kWh Source: Energy Strategy Group, 2013
Energy consumption	24 - 33 KWh Source: *http://www.caldaie-climatizzatori.com/prodotti.php?id=14*
Advantages / disadvantages of use	The main advantage of the condensing boilers is in high yield (from 105% to 109%) compared to traditional boilers (from 90% to 93%) Source: Energy Strategy Group, 2013
Easiness to use	No difference with traditional boilers
Energy efficiency policies that supports this technology	Tax deductions, thermal account, white certificates, Kyoto fund

Sector	**Buildings**
Sub-Sector	Residential sector
Category	*Space heating*
Technology	***Heat pumps***
Number of technology used	Heat pumps are now in about 2% of the stock of production equipment installed in Italian buildings. There are indeed 400.000 installations of heat pumps compression and 150.000 installations of absorption heat pumps

[14] Value calculated by assuming an average oil price of 105 $/barrel and an exchange rate of 1,4 $/€. (Source: data processed by IEFE).

	Source: Energy Strategy Group, 2013 The number of sales of heat pumps for year is provided below: Annual sales of heat pumps for year: 2004: 12.131; 2005: 13.000; 2006: 17.165; 2007: 28.100; 2008: 28.092; 2009: 29.975 Source: EnerData, 2010
Origin of technology	The percentage of heat pumps producers based in Italy is between 30 and 60% Source: ENEL, 2013
Cost of purchase	A heat pump air-water for an apartment of 100 m^2, costs on average 8.000-12.000€ Source: *http://www.idraulicapiatti.org/2012/05/costo-di-una-pompa-di-calore.html*
Cost per kWh	7 - 9,5 c€/kWh Source: Energy Strategy Group, 2013
Energy consumption	5 - 20 KWh Source: *http://www.viessmann.it/it/prodotti/Pompe_di_calore.html*
Advantages / disadvantages of use	The heat pumps transfer more energy than non-renewable energy used to operate. Source: Energy Strategy Group, 2013
Easiness to use	The heat pumps require more maintenance than a traditional boiler
Energy efficiency policies that supports this technology	Tax deductions, thermal account, white certificates

Annual sales of heat pumps for year:

2004	2005	2006	2007	2008	2009
12.131	13.000	17.165	28.100	28.092	29.975

Sector	**Buildings**
Sub-Sector	Residential sector
Category	*Space heating*
Technology	***Opaque building surfaces***
Number of technology used	Currently in Italy about 50%-70% of buildings has levels of thermal insulation roofing, walls and ground higher than 1.5W/m^2K Source: Energy Strategy Group, 2013
Origin of technology	Opaque building surfaces have a high rate of production in Italy (more than 60% of producers based in Italy) Source: ENEL, 2013
Cost of purchase	(see table below)

Type	Cost (€/m^2)
Synthetic organic insulating materials	1,3-4
Insulation materials natural organic	1,4-2,5
Natural inorganic insulation materials	0,9-4,4
Synthetic inorganic insulation materials	1,2-4,5

	Source: Energy Strategy Group, 2013
Cost per kWh	10 - 13 c€/kWh Source: Energy Strategy Group, 2013
Energy consumption	-
Advantages / disadvantages of use	The opaque surfaces allow to reduce the heat exchange between the building and the outside. Source: ENEL, 2013
Easiness to use	No difference with traditional building surfaces
Energy efficiency policies that supports this technology	Tax deductions, white certificates, thermal account, Kyoto fund

Sector	**Buildings**
Sub-Sector	Residential sector
Category	*Space heating*
Technology	***Fixtures with high efficiency***
Number of technology used	Currently in Italy about 40%-60% of buildings has levels of thermal insulation closures windows more than $3W/m^2K$ Source: Energy Strategy Group, 2013
Origin of technology	The percentage of fixtures with high efficiency producers based in Italy is between 30 and 60% Source: ENEL, 2013
Cost of purchase	Type: Cost (€/door) Metal: 250-1000 Wood: 300-600 PolyVinyl Chloride (PVC): 150-350 Source: Energy Strategy Group, 2013
Cost per kWh	12,4 - 21 c€/kWh Source: Energy Strategy Group, 2013
Energy consumption	-
Advantages / disadvantages of use	The fixtures with high efficiency allows to reduce the heat exchange between the building and the outside Source: ENEL, 2013
Easiness to use	No difference with traditional fixtures
Energy efficiency policies that supports this	Tax deductions, thermal account, white certificates, Kyoto fund

technology	

Sector	Buildings
Sub-Sector	Residential sector
Category	*Water heating*
Technology	***Solar thermal***
Number of technology used	In 2013 Italy has a total installed 2,5-3 GW capacity of solar thermal for the production of domestic hot water and heat for heating Source: Energy Strategy Group, 2013.
Origin of technology	Solar thermal has a low rate of production in Italy (less than 30% of producers based in Italy) Source: ENEL, 2013
Cost of purchase	Type: Cost (€/door) Unglazed collectors: 70-100 Glazed collectors: 350-450 Vacuum collectors: 450-600 Source: Energy Strategy Group, 2013
Cost per kWh	6 - 13 c€/kWh Source: Energy Strategy Group, 2013
Energy consumption	-
Advantages / disadvantages of use	Solar thermal systems use solar radiation to produce heat, allowing a saving in consumption of gas or electricity Source: ENEL, 2013
Easiness to use	-
Energy efficiency policies that supports this technology	Thermal account, white certificates, Kyoto fund

Sector	Buildings
Sub-Sector	Residential sector
Category	*Water heating*
Technology	***Biomass boilers***
Number of technology used	In 2014, biomass boilers are 2,4% of the total water heating systems Source: ISTAT, 2014
Origin of technology	Biomass boilers have a high rate of production in Italy (more than 60% of producers based in Italy) Source: ENEL, 2013

Cost of purchase	3.000 - 4.000 € Source:*http://www.riscaldarecasa.it/category.php~idx~~~15~~CALDAIE+A+BIOMASSA+_POLICOMBUSTIBILI~.html*
Cost per kWh	-
Energy consumption	4 - 100 kWh Source: *http://www.viessmann.it/it/prodotti/Caldaie_a_biomassa.html*
Advantages / disadvantages of use	-
Easiness to use	Difficulty of use linked to the supply and storage of biomass
Energy efficiency policies that supports this technology	Thermal account, white certificates, tax deduction, Kyoto fund

Sector	**Buildings**
Sub-Sector	Residential sector
Category	*Energy production*
Technology	***Photovoltaic***
Number of technology used	The current situation of the photovoltaic market in Italy is characterized by the presence of more than 526.463 plants scattered throughout the country, with a capacity corresponding to 17.080.255 kW Source: Energy Strategy Group, 2013
Origin of technology	The percentage of photovoltaic producers based in Italy is between 30 and 60% Source: ENEL, 2013
Cost of purchase	The average price of a photovoltaic system ranges on average between 2.000 and 3.500 €/kW Source: *http://www.enerpoint.it/solare/fotovoltaico/costi-fotovoltaico.php*
Cost per kWh	0,33 c€/kWh Source: *http://www.tettosolare.it/?ids=9*
Energy consumption	-
Advantages / disadvantages of use	Advantages: photovoltaic panels requires little maintenance Disadvantages: intermittent energy production and dependent on seasons Source: *http://www.fotovoltaiconorditalia.it/idee/vantaggi-e-svantaggi-di-un-impianto-fotovoltaico*
Easiness to use	-
Energy efficiency policies that supports this	White certificates, tax deduction, Kyoto fund

technology	

Sector	Buildings
Sub-Sector	Residential sector
Category	*Cooking*
Technology	***Induction cooking***
Number of technology used	The induction cookers represent about 10% of the actual sale of kitchens Source: ENEL, 2013
Origin of technology	Induction cooking has a high rate of production in Italy (more than 60% of producers based in Italy) Source: ENEL, 2013
Cost of purchase	The price of induction cooking is about 800 - 1200 € Source: *http://taglialabolletta.it/il-piano-di-cottura-ad-induzione*
Cost per kWh	-
Energy consumption	1,8 - 3,3 KWh Source: *http://www.recensioni-piano-cottura-ad-induzione-magnetica.it/piano-cottura-induzione.asp*
Advantages / disadvantages of use	The main advantages of induction cookers are the high energy efficiency (90-95%) compared to traditional technologies (30-60%), greater security, the absence of domestic pollution and ability to control consumption. The disadvantages are the high initial cost, the high absorption of electrical power and the generation of electromagnetic fields. Source: ENEL, 2013
Easiness to use	-
Energy efficiency policies that supports this technology	White certificates

Sector	Buildings
Sub-Sector	Residential sector
Category	*Efficient appliances*
Technology	***Washing machines***
Number of technology used	The stock of washing machines (Millions) for years is provided below:

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
20,72	21,12	21,56	21,98	22,40	22,83	23,25	23,67	24,00	24,31	25,53

Source: EnerData 2010

The percentage of washing machines for class is (Source: ENEA, 2011b):

<table>
<tr><td></td><td>A++ (16.9%), A+ (31.9%), A (21.3%), other energy classes (29.2%)</td></tr>
<tr><td>Origin of technology</td><td>Washing machines have a high rate of production in Italy (more than 60% of producers based in Italy)
Source: ENEL, 2013</td></tr>
<tr><td>Cost of purchase</td><td>The cost of purchase depends on the brand and the energy class, as shown by the table below which lists the prices for major brands in the Italian market:
<table>
<tr><th>Brand</th><th>Price</th><th>Brand</th><th>Price</th></tr>
<tr><td>AEG (Electrolux)</td><td>€ 802,91</td><td>Miele</td><td>€ 1.392,97</td></tr>
<tr><td>Beko (Arcelik)</td><td>€ 291,38</td><td>Nardi Elettrodomestici</td><td>€ 378,00</td></tr>
<tr><td>BSH (Bosch)</td><td>€ 550,64</td><td>Ocean (Fagor-Brandt Italia)</td><td>€ 339,50</td></tr>
<tr><td>Candy (Candy Group)</td><td>€ 463,06</td><td>Rex (Electrolux)</td><td>€ 510,00</td></tr>
<tr><td>Electrolux</td><td>€ 689,00</td><td>Samsung</td><td>€ 484,72</td></tr>
<tr><td>Gorenje</td><td>€ 332,67</td><td>SanGiorgio (Fagor-Brandt Itali</td><td>€ 387,00</td></tr>
<tr><td>Haier</td><td>€ 248,75</td><td>Smeg</td><td>€ 620,76</td></tr>
<tr><td>Hoover (Candy Group)</td><td>€ 550,31</td><td>Whirlpool</td><td>€ 486,08</td></tr>
<tr><td>Hotpoint-Ariston (Indesit)</td><td>€ 512,86</td><td>Zoppas (Electrolux)</td><td>€ 419,15</td></tr>
<tr><td>Ignis (Whirlpool)</td><td>€ 340,78</td><td>Average price</td><td>€ 483</td></tr>
<tr><td>Indesit</td><td>€ 388,16</td><td>Maximum</td><td>€ 2.460</td></tr>
<tr><td>LG</td><td>€ 629,03</td><td>Minimum price</td><td>€ 116</td></tr>
</table>
Source: Marchi, Menconi, 2010</td></tr>
<tr><td>Cost per kWh</td><td>-</td></tr>
<tr><td>Energy consumption</td><td>300 KWh for 4 washes/week
Source: CESI ricerca, 2009.
Es. Washing machine 6 kg - 220 cycles/year
<table>
<tr><th>Class</th><th>Annual consumption (kWh/y)</th></tr>
<tr><td>A+++</td><td>153</td></tr>
<tr><td>A++</td><td>163</td></tr>
<tr><td>A+</td><td>185</td></tr>
<tr><td>A</td><td>212</td></tr>
<tr><td>B</td><td>242</td></tr>
<tr><td>C</td><td>273</td></tr>
</table>
Source: Ceceditalia http://www.ceceditalia.it/area-consumatori/risparmio/quanto_si_risparmia/1%2C614%2C1%2C</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>-</td></tr>
<tr><td>Easiness to use</td><td>-</td></tr>
<tr><td>Energy efficiency policies that supports this technology</td><td>White certificates</td></tr>
</table>

Sector	**Buildings**
Sub-Sector	Residential sector
Category	*Efficient appliances*
Technology	***Dishwashers***
Number of technology used	The stock of dishwashers (Millions) for years is provided below: 2000: 5,47; 2001: 5,93; 2002: 6,37; 2003: 6,88; 2004: 7,43; 2005: 8,01; 2006: 8,57; 2007: 9,06; 2008: 9,17; 2009: 9,27; 2010: 9,36 Source: EnerData, 2010 The percentage of dishwashers for class is (Source: ENEA, 2011b): A++ (9,7%), A+ (18,9%), A (13.3%), other energy classes (58,1%)
Origin of technology	Dishwashers have a high rate of production in Italy (more than 60% of producers based in Italy) Source: ENEL, 2013
Cost of purchase	The cost of purchase depends on the brand and the energy class
Cost per kWh	-
Energy consumption	314 KWh/y for 4-6 washes/week Source: CESI ricerca, 2009 Es. Dishwasher 60 cm - 280 cycles/year Class / Annual consumption (kWh/y): A+++ 230; A++ 245; A+ 275; A 309; B 348; C 393; D 416 Source: Ceceditalia *http://www.ceceditalia.it/area-consumatori/risparmio/quanto_si_risparmia/1%2C614%2C1%2C*
Advantages / disadvantages of use	-
Easiness to use	-
Energy efficiency policies that supports this technology	White certificates

Stock of dishwashers (Millions):

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
5,47	5,93	6,37	6,88	7,43	8,01	8,57	9,06	9,17	9,27	9,36

Class	Annual consumption (kWh/y)
A+++	230
A++	245
A+	275
A	309
B	348
C	393
D	416

Sector	**Buildings**

<table>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Efficient appliances</td></tr>
<tr><td>Technology</td><td>Freezers</td></tr>
<tr><td>Number of technology used</td><td>The stock of freezers (Millions) for years is provided below:
<table>
<tr><td>2000</td><td>2001</td><td>2002</td><td>2003</td><td>2004</td><td>2005</td><td>2006</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td></tr>
<tr><td>6,20</td><td>6,49</td><td>6,69</td><td>6,90</td><td>7,12</td><td>7,33</td><td>7,56</td><td>7,79</td><td>7,95</td><td>7,98</td><td>9,14</td></tr>
</table>
Source: EnerData 2010

The percentage of freezers for class is (Source: ENEA 2011):
A++ (4,9%), A+ (10,7%), A (8.3%), other energy classes (76,1%)</td></tr>
<tr><td>Origin of technology</td><td>Freezers have a high rate of production in Italy (more than 60% of producers based in Italy)
Source: ENEL, 2013</td></tr>
<tr><td>Cost of purchase</td><td>The cost of purchase depends on the brand and the energy class, as shown by the table below which lists the prices for major brands in the Italian market:
<table>
<tr><th>Brand</th><th>Price</th><th>Brand</th><th>Price</th></tr>
<tr><td>AEG (Electrolux)</td><td>€ 896,15</td><td>Nardi Elettrodomestici</td><td>€ 473,63</td></tr>
<tr><td>Beko (Arcelik)</td><td>€ 309,50</td><td>Rex (Electrolux)</td><td>€ 644,06</td></tr>
<tr><td>BSH (Bosch)</td><td>€ 664,26</td><td>SanGiorgio (Fagor-Brandt Itali</td><td>€ 416,00</td></tr>
<tr><td>Candy (Candy Group)</td><td>€ 506,95</td><td>Smeg</td><td>€ 709,59</td></tr>
<tr><td>DeDietrich (Fagor-Brandt Italia</td><td>€ 540,00</td><td>Whirlpool</td><td>€ 542,86</td></tr>
<tr><td>Electrolux</td><td>€ 848,50</td><td>Zoppas (Electrolux)</td><td>€ 466,00</td></tr>
<tr><td>Hoover (Candy Group)</td><td>€ 592,38</td><td>Average price</td><td>€ 568</td></tr>
<tr><td>Hotpoint-Ariston (Indesit)</td><td>€ 511,96</td><td>Maximum</td><td>€ 2.168</td></tr>
<tr><td>Ignis (Whirlpool)</td><td>€ 363,00</td><td>Minimum price</td><td>€ 239</td></tr>
<tr><td>Indesit</td><td>€ 423,54</td><td></td><td></td></tr>
<tr><td>LG</td><td>€ 490,00</td><td></td><td></td></tr>
<tr><td>Miele</td><td>€ 1.131,52</td><td></td><td></td></tr>
</table>
Source: Marchi, Menconi, 2010</td></tr>
<tr><td>Cost per kWh</td><td>-</td></tr>
<tr><td>Energy consumption</td><td>
<table>
<tr><td>Capacity (l)</td><td colspan="3">Annual consumption (kWh/y)</td></tr>
<tr><td>400</td><td>350</td><td>260</td><td>175</td></tr>
<tr><td>350</td><td>320</td><td>240</td><td>155</td></tr>
<tr><td>300</td><td>300</td><td>225</td><td>150</td></tr>
</table>
Source: CESI ricerca, 2009

Es. Static combined refrigerator, total capacity 300 l
<table>
<tr><td>Class</td><td>Annual consumption (kWh/y)</td></tr>
<tr><td>A+++</td><td>160</td></tr>
<tr><td>A++</td><td>200</td></tr>
<tr><td>A+</td><td>280</td></tr>
<tr><td>A</td><td>360</td></tr>
</table>
Source: Ceceditalia http://www.ceceditalia.it/area-consumatori/risparmio/quanto_si_risparmia/1%2C614%2C1%2C</td></tr>
</table>

Advantages / disadvantages of use	-
Easiness to use	-
Energy efficiency policies that supports this technology	White certificates

<table>
<tr><td>Sector</td><td>Buildings</td></tr>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Efficient appliances</td></tr>
<tr><td>Technology</td><td>Refrigerators</td></tr>
<tr><td>Number of technology used</td><td>
<table>
<tr><td colspan="11">The stock of refrigerators (Millions) for years is provided below:</td></tr>
<tr><td>2000</td><td>2001</td><td>2002</td><td>2003</td><td>2004</td><td>2005</td><td>2006</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td></tr>
<tr><td>21,11</td><td>21,46</td><td>21,79</td><td>22,13</td><td>22,46</td><td>22,79</td><td>23,12</td><td>23,45</td><td>23,80</td><td>24,07</td><td>27,69</td></tr>
</table>
Source: EnerData, 2010
The percentage of refrigerators for class is (Source: ENEA, 2011b):
A++ (5,4%), A+ (10,3%), A (9%), other energy classes (75,3%)
</td></tr>
<tr><td>Origin of technology</td><td>Refrigerators have a high rate of production in Italy (more than 60% of producers based in Italy)
Source: ENEL, 2013</td></tr>
<tr><td>Cost of purchase</td><td>The cost of purchase depends on the brand and the energy class, as shown by the table below which lists the prices for major brands in the Italian market:
<table>
<tr><td>Brand</td><td>Price</td><td>Brand</td><td>Price</td></tr>
<tr><td>AEG (Electrolux)</td><td>€ 1.113,54</td><td>Liebherr</td><td>€ 1.395,45</td></tr>
<tr><td>Beko (Arcelik)</td><td>€ 387,00</td><td>Miele</td><td>€ 1.013,40</td></tr>
<tr><td>BSH (Bosch)</td><td>€ 822,05</td><td>Nardi Elettrodomestici</td><td>€ 685,50</td></tr>
<tr><td>Candy (Candy Group)</td><td>€ 468,60</td><td>Rex (Electrolux)</td><td>€ 553,46</td></tr>
<tr><td>Electrolux</td><td>€ 440,00</td><td>Samsung</td><td>€ 489,00</td></tr>
<tr><td>Gorenje</td><td>€ 760,75</td><td>Sharp</td><td>€ 885,75</td></tr>
<tr><td>Haier</td><td>€ 748,25</td><td>Smeg</td><td>€ 1.125,77</td></tr>
<tr><td>Hoover (Candy Group)</td><td>€ 597,83</td><td>Whirlpool</td><td>€ 743,33</td></tr>
<tr><td>Hotpoint-Ariston (Indesit)</td><td>€ 628,32</td><td>Zoppas (Electrolux)</td><td>€ 516,00</td></tr>
<tr><td>Ignis (Whirlpool)</td><td>€ 553,50</td><td>Average price</td><td>€ 698</td></tr>
<tr><td>Indesit</td><td>€ 459,17</td><td>Maximum</td><td>€ 3.492</td></tr>
<tr><td>LG</td><td>€ 662,25</td><td>Minimum price</td><td>€ 330</td></tr>
</table>
Source: Marchi, Menconi, 2010</td></tr>
<tr><td>Cost per kWh</td><td>-</td></tr>
<tr><td>Energy consumption</td><td>
<table>
<tr><td>Capacity (l)</td><td colspan="3">Annual consumption (kWh/y)</td></tr>
<tr><td>400</td><td>350</td><td>400</td><td>350</td></tr>
</table>
</td></tr>
</table>

	350	320	350	320
	300	300	300	300
	Source: CESI ricerca, 2009			
Advantages / disadvantages of use	-			
Easiness to use	-			
Energy efficiency policies that supports this technology	White certificates			

Sector	**Buildings**
Sub-Sector	Residential sector
Category	*Energy saving*
Technology	***Building automation***
Number of technology used	Currently in Italy the Energy Management Systems record low uptake; thanks to the integration of wi-fi technologies, the Building Automation System counts about 150.000-250.000 applications Source: Energy Strategy Group, 2013
Origin of technology	Building automation has a low rate of production in Italy (less than 30% of producers based in Italy) Source: ENEL, 2013
Cost of purchase	The prices of the building automation systems in the residential sector are variable depending on the size, on average between 2,000 and 7,000 € Source: Energy Strategy Group, 2013
Cost per kWh	-
Energy consumption	-
Advantages / disadvantages of use	The building automation system (BA) allows to maximize the energy efficiency of a building, on the basis of the use of the building itself and the ambient conditions Source: Energy Strategy Group, 2013
Easiness to use	-
Energy efficiency policies that supports this technology	White certificates

<table>
<tr><td>Sector</td><td>Buildings</td></tr>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Lighting</td></tr>
<tr><td>Technology</td><td>Efficient lighting system</td></tr>
<tr><td>Number of technology used</td><td>To date in Italy, the lighting equipment in use is composed by about 15-18% gas lamps, LED lamps for 9-13% and for the remaining part fluorescent lamps
Source: Energy Strategy Group, 2013</td></tr>
<tr><td>Origin of technology</td><td>Efficient lighting system has a high rate of production in Italy (more than 60% of producers based in Italy)
Source: ENEL, 2013</td></tr>
<tr><td>Cost of purchase</td><td><table>
<tr><th>Technology</th><th>Light efficiency (lm/W)</th><th>Duration (h)</th><th>Price (€)</th></tr>
<tr><td>compact fluorescent</td><td>50-75</td><td>6.000-12.000</td><td>15</td></tr>
<tr><td>fluorescent tube</td><td>55-120</td><td>12.000-20.000</td><td>100</td></tr>
<tr><td>halides</td><td>40-100</td><td>12.000-20.000</td><td>100</td></tr>
<tr><td>high pressure sodium</td><td>70-150</td><td>10.000-12.000</td><td>100</td></tr>
<tr><td>low pressure sodium</td><td>125-200</td><td>10.000-12.000</td><td>100</td></tr>
<tr><td>LED</td><td>50-90</td><td>25.0000</td><td>10</td></tr>
</table>
Source: Energy Strategy Group, 2013</td></tr>
<tr><td>Cost per kWh</td><td>-</td></tr>
<tr><td>Energy consumption</td><td>-</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>-</td></tr>
<tr><td>Easiness to use</td><td>-</td></tr>
<tr><td>Energy efficiency policies that supports this technology</td><td>White certificates</td></tr>
</table>

Commercial/services sector

Sector	**Buildings**
Sub-Sector	Commercial/services sector
Category	*Energy saving*
Technology	***Uninterruptible Power Supply (UPS)***
Number of technology used	The number of UPS installed in Italy is estimated at between 250.000 and 300.000 units, of which 20-30% attributable to high-efficiency devices

<table>
<tr><td></td><td>Source: Energy Strategy Group, 2013</td></tr>
<tr><td>Origin of technology</td><td>UPS has a low rate of production in Italy (less than 30% of producers based in Italy)
Source: ENEL, 2013</td></tr>
<tr><td>Cost of purchase</td><td>The cost of purchase depends on size and efficiency class:
<table>
<tr><td></td><td colspan="4">Size (kVA)</td></tr>
<tr><td></td><td>10</td><td>40</td><td>80</td><td>160</td></tr>
<tr><td>average efficiency</td><td>3.500-4.000</td><td>5.500-6.500</td><td>8.500-9.500</td><td>16.000-17.000</td></tr>
<tr><td>high efficiency</td><td>4.000-5.000</td><td>7.500-8.500</td><td>10.500-11.500</td><td>17.500-18.500</td></tr>
</table>
Source: Energy Efficiency Report, 2013</td></tr>
<tr><td>Cost per kWh</td><td>5,5 - 8,2c€/kWh (GDO); 5,4 - 8 2c€/kWh (hotel); 14 - 20,6 c€/kWh (bank); 3,3 - 4,9 c€/kWh (hospital)
Source: Energy Strategy Group, 2013</td></tr>
<tr><td>Energy consumption</td><td>-</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>UPS ensures the continuity and quality of power supply to loads</td></tr>
<tr><td>Easiness to use</td><td>-</td></tr>
<tr><td>Energy efficiency policies that supports this technology</td><td>White certificates</td></tr>
</table>

<table>
<tr><td>Sector</td><td>Buildings</td></tr>
<tr><td>Sub-Sector</td><td>Commercial/services sector</td></tr>
<tr><td>Category</td><td>Space heating</td></tr>
<tr><td>Technology</td><td>Combined Heat and Power (CHP)</td></tr>
<tr><td>Number of technology used</td><td>Currently in Italy, cogeneration plants have an electrical power of about 10-12 GW
Source: Energy Strategy Group, 2013</td></tr>
<tr><td>Origin of technology</td><td>CHP has a low rate of production in Italy (less than 30% of producers based in Italy)
Source: ENEL, 2013</td></tr>
<tr><td>Cost of purchase</td><td>The cost of purchase (€/KW) depends on type and electrical power:
<table>
<tr><td>Power</td><td colspan="4">Type</td></tr>
<tr><td></td><td>steam plants (€/KW)</td><td>Gas turbines (€/KW)</td><td>combined cycles (€/KW)</td><td>internal combustion engines (€/KW)</td></tr>
<tr><td>> 1MW</td><td>500-1.300</td><td>500-1.000</td><td>800-1.500</td><td>800-1.100</td></tr>
<tr><td>< 1MW</td><td>800-1.500</td><td>1.300-1.600</td><td>10.5 0-11.500</td><td>500-1.300</td></tr>
</table></td></tr>
</table>

	Source: Energy Strategy Group, 2013
Cost per kWh	2 – 3 c€/kWh (GDO); 0,7 – 1,5 c€/kWh (hotel); 0,6 – 1,1 c€/kWh (hospital) Source: Energy Strategy Group, 2013
Energy consumption	-
Advantages / disadvantages of use	Advantages: low emissions, high efficiency, low noise Disadvantages: high cost, short useful life Source: Energy Strategy Group, 2013
Easiness to use	-
Energy efficiency policies that supports this technology	Thermal account, tax deductions, white certificates, Kyoto fund

1.5 Data for the Transport Sector

<table>
<tr><td>Sector</td><td>Transport</td></tr>
<tr><td>Sub-Sector</td><td>Vehicle efficiency for passenger and freight transport</td></tr>
<tr><td>Category</td><td>Road transport</td></tr>
<tr><td>Technology</td><td>Hybrid and electric vehicles</td></tr>
<tr><td>Number of technology used</td><td>According to data from CEI-CIVES circulating in Italy a total of about 53.150 hybrid and electric vehicles
Source: ACI-CENSIS, 2012

In 2014 the percentage of electric cars sold in Italy was 0.1% of total sales. Source: http://www.fierabolzano.it/klimamobility/mod_moduli_files /Klimamobility_2015_Pietro_Menga.pdf

The number of sales of hybrid and electric cars per year is provided below:
<table>
<tr><td>Type</td><td>2005</td><td>2006</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td><td>2012</td></tr>
<tr><td>Hybrid</td><td>1.112</td><td>2.192</td><td>3.467</td><td>3.354</td><td>7.621</td><td>4.845</td><td>5.127</td><td>5.165</td></tr>
<tr><td>Electric</td><td>28</td><td>27</td><td>23</td><td>132</td><td>62</td><td>114</td><td>302</td><td>438</td></tr>
</table>
Source: ACI-CENSIS, 2012</td></tr>
<tr><td>Origin of technology</td><td>-</td></tr>
<tr><td>Cost of purchase</td><td>15,450 € (Toyota Yaris Hyibrid Cool) – 64.000€ (Tesla mod. D).
For more car models consult: http://www.tuttogreen.it/auto-elettriche-2015-il-listino-completo/</td></tr>
<tr><td>Cost per kWh</td><td>400-800€/kWh
Source: ieri, oggi e domani della trazione elettrica stradale. ENEA, 2010</td></tr>
<tr><td>Energy consumption</td><td>Average consumption electric cars (final energy): 155.3 Wh/km
Source: CE Delft, 2011</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>Hybrid and electric vehicles allow a reduction in consumption and emissions. The main disadvantage is the cost of the batteries, for a 150 km-range battery, for example, the cost is estimated around 9.000€
Source: Marciani et al., 2014</td></tr>
<tr><td>Easiness to use</td><td>-</td></tr>
<tr><td>Energy efficiency policies that supports this technology</td><td>White certificates, national infrastructure plan to set up electric vehicle charging points, Road tax, Renewable energy in transport sector (D.lgs 28/2011)</td></tr>
</table>

<table>
<tr><td>Sector</td><td>Transport</td></tr>
<tr><td>Sub-Sector</td><td>Vehicle efficiency for passenger and freight transport</td></tr>
<tr><td>Category</td><td>Road transport</td></tr>
<tr><td>Technology</td><td>LPG and methane vehicles</td></tr>
<tr><td>Number of technology used</td><td>The number of sales of LPG and methane cars per year is provided below:
<table>
<tr><td>Type</td><td>2005</td><td>2006</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td><td>2012</td></tr>
<tr><td>LPG</td><td>1.826</td><td>3.482</td><td>29.991</td><td>74.247</td><td>339.596</td><td>280.720</td><td>56.399</td><td>106.596</td></tr>
<tr><td>Methane</td><td>22.679</td><td>26.617</td><td>60.659</td><td>79.171</td><td>127.171</td><td>65.713</td><td>38.350</td><td>45.063</td></tr>
</table>
Source: ACI-CENSIS, 2012</td></tr>
<tr><td>Origin of technology</td><td>-</td></tr>
<tr><td>Cost of purchase</td><td>A modern system of LPG costs 1.500 to 2.000€, while the cost of a good natural gas system varies between 2.000 and 2.600€</td></tr>
<tr><td>Cost per kWh</td><td>-</td></tr>
<tr><td>Energy consumption</td><td>-</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>Advantages: fuel economy
Disadvantages: long refueling times
Source: http://www.sicurauto.it/esperto-di-sicurauto/news/auto-a-metano-o-gpl-costi-vantaggi-e-svantaggi.html</td></tr>
<tr><td>Easiness to use</td><td>No difference with traditional fuel</td></tr>
<tr><td>Energy efficiency policies that supports this technology</td><td>Road tax, Guide to fuel saving and decreasing CO_2 emission by cars</td></tr>
</table>

<table>
<tr><td>Sector</td><td>Transport</td></tr>
<tr><td>Sub-Sector</td><td>Vehicle efficiency for passenger and freight transport</td></tr>
<tr><td>Category</td><td>Road transport</td></tr>
<tr><td>Technology</td><td>Car sharing</td></tr>
<tr><td>Number of technology used</td><td>The number of users, vehicle fleets and parking lots of car sharing per year is provided below:
<table>
<tr><td>Car sharing</td><td>2009</td><td>2010</td><td>2011</td></tr>
<tr><td>Users</td><td>17.993</td><td>19.123</td><td>22.693</td></tr>
<tr><td>Vehicle fleet</td><td>573</td><td>567</td><td>618</td></tr>
<tr><td>Parking lots</td><td>383</td><td>382</td><td>422</td></tr>
</table>
Source: ACI-CENSIS, 2012</td></tr>
</table>

Origin of technology	-
Cost of purchase	-
Cost per kWh	-
Energy consumption	-
Advantages / disadvantages of use	Advantages: car sharing involves a drastic reduction in costs arising from the ownership of a car Disadvantages: car sharing is a service provided only in some cities Source: *http://www.6sicuro.it/auto/car-sharing*
Easiness to use	No difference than traditional cars
Energy efficiency policies that supports this technology	National electric car sharing project in cities

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HERON (No: 649690): Deliverable D.1.4

TECHNOLOGICAL TRENDS

PART OF WORK PACKAGE 1: MAPPING OF ENERGY EFFICIENCY POLICY INSTRUMENTS AND AVAILABLE TECHNOLOGIES IN BUILDINGS AND TRANSPORT

NATIONAL REPORT FOR SERBIA

14.09.2015.

Partner: Centre for Energy, University of Belgrade – Faculty of Mining and Geology

Institution: **University of Belgrade – Faculty of Mining and Geology**

Steering Committee member (1): Prof. Dejan Ivezić

Prepared by: Dr. Marija Živković, Prof. Dejan Ivezić, Dimitrije Manić, Assoc. Professor Miloš Tanasijević, Aleksandar Madžarević

(1) The Steering Committee member has the responsibility for ensuring the quality of the report.

HERON: Forward – looking socio-economic research on Energy Efficiency in EU countries

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ACRONYMS

DHW	Domestic Hot Water
EE	Energy Efficiency
HP	Heat Pump
HVAC	Heating Ventilating Air Conditioning
NEEAP	National Energy Efficiency Action Plan
RES	Renewable Energy Sources
RPM	Revolution per minute
U-value	Heat transfer coefficient
VAV	Variable air volume
VAV	Variable Air Volume
VFD	Variable Frequency Drive

EXECUTIVE SUMMARY

Final energy consumption in households in 2013 was 2.930 Mtoe or 34.85% of total final energy consumption (Statistical Office of the Republic of Serbia, 2014). Tertiary sector (public and commercial sector) is responsible for 0.833 Mtoe or 9.91% of total final energy consumption. In other words, energy consumption in the buildings sector accounts almost 45% and represents the largest share of the country's final energy consumption. According to (Econoler, 2012), possible energy savings in buildings sector are expected to be 1.592 Mtoe or 15.8% of final energy consumption, while the costs for achievement of full savings potential are estimated to €8.8 billion.

According to energy balances of the Republic of Serbia for 2013 (Statistical Office of the Republic of Serbia, 2014), final energy consumption in the transport sector was 1.970 Mtoe, or 23.43% of final energy consumption. The only document that has provided quantitative assessment of energy savings that could be achieved by implementation of energy efficiency measures in the transport sector is the Second National Energy Efficiency Action Plan (Government of the Republic of Serbia, 2013). According to this document, energy savings in the transport sector in period 2010-2018 are expected to be 0.2107 Mtoe. Necessary investments in energy efficiency improvement in the transport sector are projected to €1.05 billion, lowering consumption 17% below BAU by 2030 (UNDP, 2013).

High potential for energy saving is identified in both sectors. Still, the World Bank`s report (World Bank, 2014) has assessed energy efficiency market as undeveloped and proposed financing options for all buildings sub-sectors. Although a number of government and donor funded programs have been initiated over the past decade to demonstrate the viability of EE investments in public and residential buildings, implementation has remained fragmented and piecemeal (World Bank, 2014).

The investments in energy efficiency have the potential to create 5,000 to 8,000 jobs by 2030, depending on the specific policies implemented (UNDP, 2013). Of these, 2,000 to 3,000 would be created in the residential, commercial and industrial sectors and the remainder in the transport sector.

In order to increase efficiency of energy use, Serbia promoted several policy instruments. Existing policy instruments for the buildings sector has not been developed to promote some specific technology for energy efficiency improvement, nether concerning to the type nor concerning to their innovatively. Compared to the buildings sector, policy instruments for increasing energy efficiency in the transport sector are less developed. Except instrument fuel economy/vehicle standards, which supports efficiency of vehicles, other policy instruments are not developed to support some specific technology.

For the buildings sector, technologies for more efficient heating, cooling, ventilating, preparation of domestic hot water, cooking and lighting are presented, including available data of costs, energy consumption, advantages and disadvantages.

Available data about promising measures aimed to improve efficiency in transport: car sharing, eco driving, improved vehicle efficiency, start-stop systems and combined road-rail transport are presented, including available data of costs, advantages and disadvantages.

CHAPTER 1: TECHNOLOGICAL TRENDS IN THE BUILDING AND TRANSPORT SECTOR

1.1 ENERGY EFFICIENCY POTENTIAL

Buildings sector

According to energy balances of the Republic of Serbia for 2013 (Statistical Office of the Republic of Serbia, 2014), final energy consumption in households was 2.930 Mtoe or 34.85% of total final energy consumption. Tertiary sector (public and commercial sector) is named as "other users", which are responsible for 0.833 Mtoe or 9.91% of total final energy consumption. In other words, energy consumption in the buildings sector accounts almost 45% and represents the largest share of the country's final energy consumption (Figure 1).

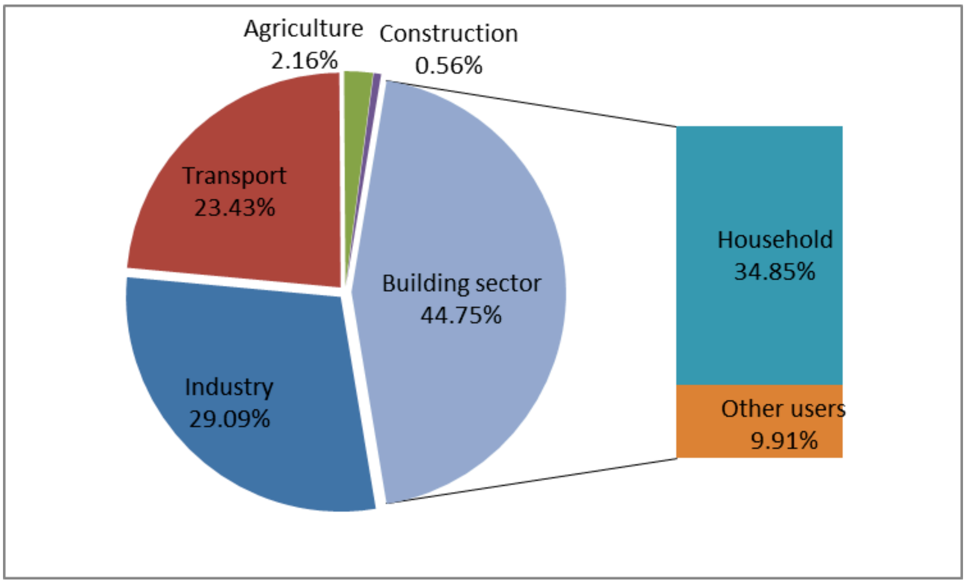

Figure 1: Final energy consumption in the Republic of Serbia in 2013, by sectors (Statistical Office of the Republic of Serbia, 2014)

World Bank has published the National Building Energy Efficiency Study for Serbia (Econoler, 2012). The majority of buildings, about 50%, are single-family houses in both urban and rural environments. Around 90% of building stock is concentrated in cities and towns. The predominant buildings sub sector is residential, followed by the public sub sector, and the commercial sub sector. Estimations of the energy saving potentials in the buildings sector and subsectors are presented in table 1. The biggest potential for savings is found to be in residential sector. The period for achieving proposed savings was not considered in (Econoler, 2012).

Table 1: Average estimated savings per type of building (Econoler, 2012)

Building Sector	Energy Savings Potential [% Building Consumption]	Energy Savings Potential [% Final Energy Consumption]	Total Savings Potential [Mtoe]
I. Residential	39%	10,6%	1.102

Building Sector	Energy Savings Potential [% Building Consumption]	Energy Savings Potential [% Final Energy Consumption]	Total Savings Potential [Mtoe]
II. Public			
Health	47%	0,5%	0.043
Education	44%	0,7%	0.086
Public office buildings	47%	0,8%	0.114
III. Commercial	48%	3,2%	0.247
Total		15,8%	1.592

Estimations about energy consumption by sub sectors (Econoler, 2012), (Statistical Office of the Republic of Serbia, 2014) have shown that residential sector is responsible for 70% to 77% of consumption in the buildings sector, while the rest is for tertiary sector (total consumption of commercial buildings is about 50% bigger than consumption of public buildings). Investments in these sectors have relatively attractive average simple payback period – from 6.4 years for schools and hospitals, to 9.2 years for residential sector (World Bank, 2014).

In (Econoler, 2012) is presented that heating accounts for 61% of energy consumption in buildings. Therefore, most energy saving potential is associated with thermal insulation and heat loss reduction. Current level of averege specific heat consumption in Serbia is estimated to be about 160 kWh/m^2, which is high comparing to Western European countries. (World Bank, 2014) raported different specific heat consumption for subsectors. The highest is in public buildings, folowed by comercial and residential buildings.

If, full energy savings are analized and taken into account, it can be concluded that achieving Serbia's full savings potential would cost a total of €8.8 billion and would result in annual cost savings to investors and end users of about € 1.1 billion. The savings would pay for the measures in about eight years (Econoler, 2012). There are no available, more detailed data about other energy savings (for example, appliences or lighting) in buildings sector.

Transport sector

Transport sector is a significant consumer of energy in the Republic of Serbia. According to energy balances of the Republic of Serbia for 2013 (Statistical Office of the Republic of Serbia, 2014), final energy consumption in the transport sector was 1.970 Mtoe, or 23.43% of final energy consumption (Figure 1).

In terms of oil and oil derivatives consumption, the share of transport is as much as 74%. Approximately, 68% of the final consumption of oil and oil derivatives in the transport sector is related to the consumption in road transport.

The only document that provides quantitative assessment of energy savings that could be achieved by implementation of energy efficiency measures in the transport sector is the Second National Energy Efficiency Action Plan (Government of the Republic of Serbia, 2013). According to this document, energy savings in the transport sector in period 2010-2018 are expected to be 0.2107 Mtoe. The largest number of proposed measures for energy savings in the Second NEEAP, is focused on road transport, due to its dominant share of over 70% in energy consumption of the transport sector, with the expected further increase of consumption.

Necessary investments in energy efficiency improvement in the transport sector are projected to €1.05 billion, lowering consumption 17% below BAU by 2030 (UNDP, 2013). Avoided costs in the transport sector amount to a total of €2.9 billion to a maximum estimated of €5.5 billion, against investments of €1.05 billion. The broad range estimated takes in consideration investments in energy efficiency (low range of avoided costs) and efforts to improve mass transport or non-motor transport (high range of avoided costs). Expected payback of on average, 10 years in the transport sector, is higher compared to investments in building sector (UNDP, 2013). This is due to a variety of factors, including the cost of intervention and energy prices.

1.2 Technologies And Policy Instruments

Existing policy instruments in building sector has not been developed to promote some specific technology for energy efficiency improvement, nether concerning the type nor concerning their innovatively.

Overview of existing policy instruments for the buildings sector

Minimum energy performance requirements for new or reconstructed buildings is the regulatory policy instrument that sets minimal requirements, for newly built buildings to have energy class "C" and for renovated existing buildings to make improvement of at least one energy class. As the energy classes are defined according to annual heat consumption (Ministry of Environment, Mining and Spatial Planning, 2011a-b) it is rationally to assume that technologies for building envelope improvement (walls insulation and low U-value windows) and heating system improvement will have priority. Research into Serbian building stock with respect to its energy performance (Jovanovic Popovic et al. 2012) has shown that the standard measures of improvement (technologies for building envelope) can save from about 25% to as much as almost 90% of the energy currently needed for heating. The advanced level of improvement (technologies for space heating), despite requiring significant investments, often provides savings of about 70%, while in some cases these measures can reduce the annual heat consumption to only 5% of the existing need.

Energy audit (mandatory) is regulatory policy instrument that defines and quantifies possibilities for economy feasible and efficient energy use in buildings. This instrument is used for identification and understanding of energy savings options, and their prioritizing in accordance to conducted economic and financial analysis. Consequently the priority should have technologies that provide maximal energy savings for the same investment. Additional information regarding achieved results and cost efficiency of this instrument are not available yet.

The main objective of **introduction of energy management system** in buildings is the reduction of energy consumption in public and commercial buildings. The designated organizations define targets for energy consumption reduction and prepare the energy efficiency plans and programs for achievement of proposed targets in the most convenient manner - through organizational and investment measures. There is no specific technology promoted by this instrument. This instrument is still not in force, as secondary legislation necessary for its conduction is just partly issued. (Ministry of Mining and Energy, 2015a-b)

The objective of **energy labelling as** policy instrument is to reduce electricity consumption by introducing more energy-efficient household appliances (refrigerators, stoves, washing machines, dishwashers, air conditioners, electrical lamps and luminaries, etc.) (Government of the Republic of Serbia, 2013), (Ministry of Energy, Development and Environment, 2014a-g). Data about cost efficiency and energy savings achieved are not available. Objective is to promote efficient household appliances.

The Law on Efficient Use of Energy (Government of the Republic of Serbia, 2013), provided the framework for establishment of the Budget Fund for energy efficiency, with an aim to provide **subsidies** for financing or co-financing projects, programs and activities directed to increase efficiency of energy use. The Budget Fund was established in 2013 (Government of the Republic of Serbia, 2013c). Financing or co-financing from the Budget Fund is governed in accordance with the annual programs for financing activities and measures for improving energy efficiency. Regulation on establishing the program for financing activities and measures for improving energy efficiency in 2014 (Ministry of Energy, Development and Environment 2014h) was the first Program for financing that was adopted, and in this Program only the public buildings, properties of local self governments were taken into account.

Regulation (Ministry of Energy, Development and Environment 2014h) specifies activities that shall be financially supported: improvement of energy efficiency in buildings (refurbishment, renovation, replacement or installation of new energy efficient equipment in systems for heating and/or cooling, replacement/modernization of interior lighting, introduction of a system for automatic control etc.); connection of new consumers to existing district heating systems; connection of consumers, who use electricity for direct heating or inefficient boilers/stoves for heating to existing gas distribution network; installation of heat pumps with low nominal power and high coefficient of performance; installation of biomass boilers; installation of solar collectors for heating domestic hot water; promotion of energy efficient appliances in households; raising awareness of the importance of energy efficiency.

Rulebook on the conditions for allocation and use of the Budget Fund, defines as the first criteria for ranking the expected energy savings in kWh/RSD. Although, for the first open call, projects that shall be financed are selected (Ministry of Energy, Development and Environment, 2014i), (Ministry of Energy, Development, 2014j), expected energy savings are still not presented.

It should be noted that within the first call for financing there were no funds allocated for funding energy efficiency improvement in the transport sector (Ministry of Energy, Development and Environment 2014h).

Instruments related to **capacity building**, are new, adopted in 2015, and can be classified in two sections: education and training for energy managers (under jurisdiction of the Ministry in charge for energy) and education and training for engineers to be specialized in area of energy efficiency of buildings (under jurisdiction of the Ministry in charge for construction). There is no relevant data about cost efficiency. Within trainings all measures aimed to energy efficiency improvement should be analyzed. This policy instrument is not targeting some specific technology.

Model of **Energy Service Agreement for Public Buildings** is defined by Rulebook on Model Energy Service Contracts for the Implementation of Energy Efficiency when Users are from Public Sector (Ministry of Energy, Development and Environment, 2015c). This document was created to help public entities, as well ESCOs in preparation of the Energy Service Agreement. Two models for contracts are provided, one for the public buildings and another for the public lighting. Since necessary back up legislation is adopted this year, first agreements are expected to be signed. Regarding the buildings sector, this policy instrument is supporting energy efficiency improvement in the public sector.

Strategy of science and technological development of the Republic of Serbia for the period 2010-2015 (Government of the Republic of Serbia, 2010a) identified **Energy and Energy Efficiency** as one of the top priorities in the domain of science and technology in Serbia. This priority is supported partly through the co-funding of integral and interdisciplinary research in “energy efficiency of production, distribution and use of energy, with a special attention to improvement of energy efficiency in buildings” and partly through the funding of projects in Program of technological development (The Ministry of Education, Science and Technological Development, 2010). Data about the outcomes of ongoing and realized projects, and their effects to energy efficiency in buildings are not available. No specific technology is supported.

Overview of policy instruments in the Transport sector

Compared to the buildings sector, policy instruments for increasing energy efficiency in the transport sector are less developed. It should be noticed that in the Program for financing measures for energy efficiency improvement from the Budget fund measures related to the transport sector have not been included (Ministry of Energy, Development and Environment 2014h).

Improvement of bicycle and pedestrian infrastructure is aimed to reduce transport by private own cars in cities. There are no officially available documents about energy savings achieved by this policy instrument or about cost efficiency.

Traffic calming as policy instrument was developed with an aim to reduce and slow intensity of road traffic. Objective of this policy instrument is to ensure an increase of quality of transport intensity and safety, by changes in road geometry and placement of proper traffic equipment, pavement markings and traffic signs. Traffic calming measures are developed to ensure reduction of vehicle speed. Data about cost efficiency and energy savings are not available.

Traffic management system is targeting problem of traffic organization and transport infrastructures in all transport modes. Regarding results related to traffic management system implementation on road transport, it shown that, after implementation of different measures the increase of traffic flow was up to 25% and the travel time reduction was up to 25%. Reduction of energy consumption was almost 30% (Public Enterprise "Roads of Serbia, 2009).

Fuel Quality Standards prescribe technical and other requirements to be met by petroleum based liquid fuels which are used in internal combustion engines, which are as fuels placed on the market of the Republic of Serbia. It also defines method for assessment of compliance (of selected fuel) with standards (Ministry of Energy, Development and Environment, 2013a). There are no official data on increasing energy efficiency related to increased quality of fuels used in the transport sector.

Fuel economy standards/vehicle CO_2 - emission standards is regulatory and mandatory policy instrument. All new imported vehicles need to be equipped with engines that meet at least Euro 5 standard (Government of the Republic of Serbia, 2013b), while for the import of used vehicles minimum Euro 3 standard is required (Government of the Republic of Serbia, 2010b). Official data about energy savings are not available. This policy instrument supports efficiency of vehicles.

1.3 MARKET PERSPECTIVES DUE TO TECHNOLOGICAL TRENDS

According to the World Bank, investments into energy efficiency improvement in essentially social public buildings in Serbia had a catalytic effect on local markets by demonstrating the exemplary role of the Government to the private sector and general public, while at the same time stimulating nascent markets for energy efficiency goods and services.[1] A number of government and donor-funded programs have been initiated over the past decade to demonstrate the viability of EE investments in public and residential buildings. However, implementation has remained fragmented and piecemeal (World Bank, 2014).

Some data about cost-effectiveness for retrofitting public buildings were reported in (Kogalniceanu, 2011). Serbia has introduced a very comprehensive set of measures for schools, hospitals and public welfare buildings. In 27 bildings was invested aprox €40.9 milion. Annual energy consumption was

[1] World Bank http://documents.worldbank.org/curated/en/2013/10/18477181/serbia-energy-efficiency-ee-project

reduced by more than 39 % at investment costs of around 35 €/m^2. In hospitals, the annual energy demand for space heating was reduced by 43.8 % through investments with costs ranging from 21.1 to 58.8 €/ m^2 (Kogalniceanu, 2011).

Analysing effects of investments in energy efficiency (Eric and Babin, 2013) concluded that energy efficiency improvement financed by the public debt increase, would not have positive effects only on trade balance, i.e. decrease of energy imports. Local companies and labour force would increase economic growth and improve budgetary stance by revenue increase. Such investments would especially stimulate the demand for the construction material, which is mostly made locally. Therefore, it can be expected not only energy efficiency improvement, but also increase in GDP and decrease in unemployment.

The investments in energy efficiency has the potential to create 5,000 to 8,000 jobs by 2030, depending on the specific policies implemented (UNDP, 2013). Of these, 2,000 to 3,000 would be created in the residential, commercial and industrial sectors and the remainder in the transport sector. According to the International Trade Union Confederation (ITUC, 2012), more conventional investments could create up to 80 jobs per €1 million invested, leading to the potential creation of 6,000 jobs during the initial years of investment. On the other hand, job creation would be limited if transport energy efficiency improvements would be achieved only through the impor of new passenger vehicles. (UNDP, 2013).

Overwiev of invesments in energy efficiency conducted for 2013 has shown that sorces of financing were as follows: regional loan funds, country loan funds with technical assistants grants, country mixed EE loan, country grant funds (Western Balkan Investing Framework, 2013).

The World Bank`s report Western Balkans: Scaling Up Energy Efficiency in Buildings (World Bank, 2014) has assessed energy efficiency market as undeveloped and proposed financing options for all sub sectors. For the residential sector the four major financing options are as follows: EE funds, commercial bank financing (credit lines), partial credit guarantees for commercial financing, utility EE credit programs (on-bill financing). For the public buildings proposed financial options are: Ministry of Finance financing with budget capture, EE revolving funds or public ESCOs. Generally speaking, it can be concluded that the market perspective for energy efficiency technologies is likely to become more positive, as soon as the Government installs or gives clear support to viable financing options.

By establishing legal framework for operation of ESCO (Government of the Republic of Serbia, 2013a), (Ministry of Mining and Energy, 2015c) additional investments in in energy efficiency improvement are expected. Still, there are no active ESCO projects in Serbia.

Data for the Buildings Sector

Reliable official data about energy consumption are provided by Statistical Office of the Republic of Serbia, which is in charge for the country`s energy statistics. Data about final energy consumption are reported for overall sectors, while additional information regarding consumption in subsectors or more detailed structure are not available. (World Bank, 2014) has reported as one of the key obstacles poor data on baseline energy use.

Available data regarding technologies for energy efficiency improvement in buildings are presented in tables 3-23. Some data about cost effectiveness of proposed technologies are available for building envelope improvements only.

Table 2: Existing building stock by subsector and structure of final energy consumption

<table>
<tr><td>Technology</td><td></td></tr>
<tr><td></td><td>
Residential sector:

Space heating types (Lilić, 2007)

District heating 14%
Local boilers 12%
Electrical resistance heaters 14%
Natural gas 10%
Solid fuels in stoves and furnaces 50%

Air conditioning (how many households use air conditioning?)
Data not available
Water heating (how many households use which water heating systems?)
Data not available

Single family houses (Jovanović Popović M. et al., 2012)
<table>
<tr><td>Total m²</td><td>Stock</td><td>New buildings</td></tr>
<tr><td>176,048,838</td><td></td><td></td></tr>
</table>
Multi-family[2] houses (Jovanović Popović M. et al., 2012)
<table>
<tr><td>Total m²</td><td>Stock</td><td>New building</td></tr>
<tr><td>113,638,882</td><td></td><td></td></tr>
</table>
Commercial/services sector:

Space heating
Data about stucure of the heating sources used for heating in comercial/services sector are not available
Air conditioning
Data about percentage of biuldings that have air conditioning systems are not availabe
Water heating
No available data about water heating systems structure

</td></tr>
</table>

[2] Multi-family houses is a classification of housing where multiple separate housing units for residential inhabitants are contained within one building or several buildings within one complex. A common form is an apartment building. Sometimes units in a multifamily residential building are condominiums, where typically the units are owned individually rather than leased from a single apartment building owner. Source: en.wikipedia.org

<table>
<tr><td></td><td>
Public sector buildings (Encoler, 2012)
<table>
<tr><td>Total [million m²]</td><td>Stock</td><td>New buildings</td></tr>
<tr><td>41</td><td></td><td></td></tr>
</table>
Commercial sector buildings (Encoler, 2012)
<table>
<tr><td>Total [million m²]</td><td>Stock</td><td>New buildings</td></tr>
<tr><td>18</td><td></td><td></td></tr>
</table>
Additional data regarding energy consumption in public and commercial sectors are not available.
</td></tr>
</table>

1.3.1 Building envelope

Available data regarding isolation of building envelope and implementation of low U windows, including anticipated advantages and disadvantages are presented in tables 3 and 4. Aim of proposed measures is decrease of annual energy needed for heating and cooling. Proposed measures are influencing energy performance of building by lowering heat transfer coefficients.

Cost effectiveness of building`s envelope improvement for some types of houses in existing building stock in the residential sector is analysed in (Jovanovic et al. 2013). It was shown that for different retrofit scenarios (depending of quality of walls insulation and/or low U-value windows), and depending of fuel used for heating, payback period is in interval from 6 to over 30 years.

Table 2: Building exterior wall insulation

Sector	Buildings
Sub-Sector	Residential sector, commercial sector, public sector
Category	Space heating / air conditioning
Technology	Walls insulation
Origin of technology	National product (% of imports?) N/A
Cost of purchase	13 €/m^2 (depends on type of isolation)[3]
Cost per kWh	-
Average energy consumption (kWh/a)	-
Advantages / disadvantages of use	Advantages are reduced energy consumption for heating and cooling, prevention of condensation in the walls and on interior surface of walls and improved comfort. Potential problems with specific façade types e.g. the buildings with façade brick cladding,

[3] www.fasade.co.rs (30.07.2015)

	which is technically difficult to re-apply; in this case it is possible to use special market ready systems in which ceramic cladding as the final façade layer has integrated thermal insulation (Popovic, Ignjatovic et al. 2012).
Easiness to use	Generally easy to apply (Popovic, Ignjatovic et al. 2012).

Table 3: Low U-value windows

Sector	Buildings
Sub-Sector	Residential sector, public sector, commercial sector
Category	Space heating/air conditioning
Technology	Low U-value windows
Origin of technology	National product. Percentage of imported materials and prefabricates is unknown.
Cost of purchase	From [4] 95 €/m^2
Cost per kWh	
Average energy consumption (kWh/a)	
Advantages / disadvantages of use	Advantages are reduced energy consumption for heating and cooling and improved comfort since temperatures of radiating surfaces e.i. windows have values closer to optimal. Disadvantages may include condensation on new windows (Carmody, 2000).
Easiness to use	Generally easy to apply.

1.3.2 Heating systems

Available data regarding technologies for heating systems with enhanced efficiencies, including anticipated advantages and disadvantages are presented in tables 5 to 10. Aim of proposed measures is decrease of annual energy needed for heating by increasing efficiency of the heating system.

Table 4: Gasification wood boilers

Sector	Buildings
Sub-Sector	Residential sector
Category	Space heating

[4] www.ibcapital.rs (30.07.2015.)

Technology	Gasification wood boilers
Origin of technology	Imported
Cost of purchase	25 kw ~ 1600 €; 45kw ~ 2000 €[5]
Cost per kWh	Depends on price and quality of firewood
Average energy consumption (kWh/a)	Average energy consumption for heating in households in Serbia is around 160 kWh/m^{2}a (Econoler, 2012)
Advantages / disadvantages of use	The wood log gasification boiler is the most efficient type of wood log boiler available on the market (SEAI, 2015) Purchase price is more than two times higher comparing to conventional solutions[6].
Easiness to use	Easy to use and maintain.

Table 5: Condensing boilers

Sector	Buildings
Sub-Sector	Residential sector
Category	Space heating
Technology	Condensing boilers (gas fuel)
Origin of technology	Imported
Cost of purchase	22 kw ~ 900 €[7];
Cost per kWh	0,036 € (Depends on the cost of natural gas[8]).
Average energy consumption (kWh/a)	Average energy consumption for heating in households in Serbia is around 160 kWh/m^{2}a (Econoler, 2012)
Advantages / disadvantages of use	Maximal possible efficiency for gas heating. At the moment, purchase price is almost equal to conventional – non condensing gas boilers[9].
Easiness to use	Easy to use and maintain.

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[5] www.etazgrejanje.com (30.07.2015)

[6] www.etazgrejanje.com (30.07.2015)

[7] www.vailant.rs, (30.07.2015)

[8] www.srbijagas.co.rs, www.novisadgas.rs (30.07.2015)

[9] www.eponuda.com; www.etazgrejanje.com (30.07.2015)

Table 6: Heat pumps

Sector	Buildings
Sub-Sector	Residential sector
Category	Space heating
Technology	Heat pump
Origin of technology	Imported
Cost of purchase	Source and site dependant. For geothermal heat pumps, price of drilling varies from 15 €/m to more than 100 €/m, depending on the type of soil and total drilling depth.[10] Heat pump prices ranges from 10 €/m^2 of heated space[11].
Cost per kWh	Price of electricity is around 0,08 €/kWh [12]. Heat pump COP depends on type and boundary conditions. Price of kWh of heat from HP = (price of electrical energy)/(heat pump COP)
Average energy consumption (kWh/a)	Average energy consumption for heating in households in Serbia is around 160 kWh/m^2a (Econoler, 2012)
Advantages / disadvantages of use	Renewable energy based system. Geothermal heat pumps require additional investment costs for drilling. Air to water heat pumps have lower COP in wintertime (Sauer and Howell, 1983), (Cengel, Boles et al. 2002). Requires expertize for planning and optimization of heating system in order to operate properly over the span of time. Current prices of electricity and heat pumps make heat pump costs recovery period too long comparing with electrical heating.
Easiness to use	Requires low temperature heating system (e.g. floor heating) for optimized performance

[10] www.srbijabunar.com, www.busenje-bunara.com, geosonda-fundiranje.rs (30.07.2015)

[11] www.etazgrejanje.com; www.vailant.rs; www.artel.rs, (30.07.2015)

[12] www.servisinfo.com/cena-struje (30.07.2015)

	(Hepbasli and Kalinci, 2009).

Table 7: VFD for circulating pumps

Sector	Buildings
Sub-Sector	Residential sector, public and commercial sector
Category	Space heating
Technology	VFD for circulating pumps
Origin of technology	Imported
Cost of purchase	From around 600 € for 5 kW VFD to 7000 € for 130 kW VFD [13].
Cost per kWh	
Average energy consumption (kWh/a)	
Advantages / disadvantages of use	Electricity savings for pumping are around 70% to 90%[14]. Electricity prices in Serbia make payback period too long[15].
Easiness to use	Needs engineering expertise in design phase.

Table 8: Thermostatic valves

Sector	Buildings
Sub-Sector	Residential sector, public and commercial sector
Category	Space heating
Technology	Thermostatic valve
Origin of technology	Imported
Cost of purchase	Around 15 €[16]
Cost per kWh	
Average energy consumption (kWh/a)	
Advantages / disadvantages of use	Can save up to 20% of heating energy (Ristanovic, M., 2015). Very robust appearance comparing to simple

[13] www.indas.rs, (30.07.2015)

[14] www.buildinggreen.com, (30.07.2015)

[15] www.servisinfo.com/cena-struje, (30.07.2015)

[16] www.etazgrejanje.com (30.07.2015)

	valves.
Easiness to use	Easy to use.

Table 9: Room controllers for central heating system

Sector	Buildings
Sub-Sector	Residential sector, public and commercial sector
Category	Space heating
Technology	Room controllers for central heating system
Origin of technology	Imported
Cost of purchase	From 80 to 200 €[17].
Cost per kWh	
Average energy consumption (kWh/a)	
Advantages / disadvantages of use	Can achieve high energy savings, but requires knowledge for proper device selection (if it has or does not have weather compensating control). (Ristanovic, M., 2015).
Easiness to use	Moderate ease of use.

1.3.3 Cooling

Available data regarding technologies for cooling systems with enhanced efficiencies, including anticipated advantages and disadvantages are presented in table 11. Aim of a proposed measure is decrease of annual energy needed for cooling by increasing efficiency of the applied system.

Table 10: Split systems with inverter technology

Sector	Buildings
Sub-Sector	Residential sector, public and commercial sector
Category	Cooling
Technology	Split systems with inverter technology
Origin of technology	Imported
Cost of purchase	From 400 €[18].
Cost per kWh	Depends on price of electricity and device COP
Average energy consumption (kWh/a)	No data on average energy consumption for

[17] www.grejanje.com, (30.07.2015)

[18] www.eponuda.com, (30.07.2015)

	cooling in residential or tertiary sector in Serbia
Advantages / disadvantages of use	At least 30% to 50% cheaper run, as it consumes less power[19]. It is several times more expensive than split system without inverter. Therefore payback period is reasonable only for excessive use and not for very small units[20].
Easiness to use	Easy to use.

1.3.4 Mechanical Ventilation Systems

Available data regarding technologies for ventilating systems with enhanced efficiencies, including anticipated advantages and disadvantages are presented in tables 12 to 14. Aim of proposed measures is decrease of annual energy needed for ventilating by increasing efficiency of the applied system.

Table 11: VAV systems

Sector	Buildings
Sub-Sector	Public and commercial sector
Category	Mechanical Ventilation Systems
Technology	VAV systems
Origin of technology	Imported (% of national production of system devices is unknown)
Cost of purchase	Depends on the system (includes devices like VFD, bypass boxes, VAV boxes etc.)
Cost per kWh	
Average energy consumption (kWh/a)	
Advantages / disadvantages of use	Can achieve high energy savings (Sekhar, 1997).
Easiness to use	Demands expertise un HVAC and control systems design.

Table 12: Economizer systems

Sector	Buildings
Sub-Sector	Public and commercial sector
Category	Mechanical Ventilation Systems

[19] www.airconditioner.me.uk, (30.07.2015)

[20] www.eponuda.com, (30.07.2015)

Technology	Economizer systems
Origin of technology	
Cost of purchase	Depends on the system
Cost per kWh	
Average energy consumption (kWh/a)	
Advantages / disadvantages of use	Using outside air for free cooling when conditions are favourable (Brandemuehl and Braun, 1999). Increased investment costs for ventilation systems.
Easiness to use	Demands expertise un HVAC and control design.

Table 13: Heat recovery from exhaust air (heat exchanger)

Sector	Buildings
Sub-Sector	Public and commercial sector
Category	Ventilation
Technology	Heat recovery from exhaust air (heat exchanger)
Origin of technology	National
Cost of purchase	Recuperator price depends on the size and efficiency[21].
Cost per kWh	0 €
Average energy consumption (kWh/a)	
Advantages / disadvantages of use	Reduces energy consumption for heating and cooling.
Easiness to use	Easy to use.

1.3.5 DHW preparation

Available data regarding technologies for domestic hot water preparation with enhanced efficiencies, including anticipated advantages and disadvantages are presented in tables 15 to 19. Aim is decrease of annual energy needed for domestic hot water preparation.

Table 14: DHW preparation with district heating (Centralized supply)

Sector	Buildings
Sub-Sector	Residential & tertiary sector
Category	domestic hot water preparation

[21] www.jakkagroup.com, (30.07.2015)

Technology	DHW preparation with district heating
Origin of technology	
Cost of purchase	
Cost per kWh	About 0,06 €/kWh[22]
Average energy consumption (kWh/a)	For DHW preparation in households - 966 kWh/a (Stojiljkovic and Todorovic, 2015)
Advantages / disadvantages of use	Using lower grade energy (than electricity) for DHW heating leads to reduced conversion losses in the energy system. Unreliable operation of DH companies. Higher possibility of contamination of water in storage tanks (Engineers, 2015) ,(CeSID 2011).
Easiness to use	Easy to use.

Table 15: Gas water heaters with storage tank

Sector	Buildings
Sub-Sector	Residential, public and commercial sector
Category	domestic hot water preparation
Technology	Gas water heaters with storage tank
Origin of technology	
Cost of purchase	From 300 € (www.etazgrejanje.com)
Cost per kWh	0,036 € (Depends on the cost of natural gas[23])
Average energy consumption (kWh/a)	For DHW preparation in households - 966 kWh/a (Stojiljkovic and Todorovic 2015)
Advantages / disadvantages of use	Lower conversion losses in the energy system (compared to electrical water heaters). Requires connection to gas network or gas storage tank.
Easiness to use	Easy to use.

Table 16: Combined water heaters (kombi boilers)

Sector	Buildings
Sub-Sector	Residential, public and commercial sector

[22] www.beoelektrane.rs, (30.07.2015)

[23] www.srbijagas.co.rs, www.novisadgas.rs (30.07.2015)

Category	domestic hot water preparation
Technology	Combined water heaters (or kombi boilers)
Origin of technology	
Cost of purchase	From 400 €[24]
Cost per kWh	
Average energy consumption (kWh/a)	For DHW preparation in households - 966 kWh/a (Stojiljkovic and Todorovic 2015)
Advantages / disadvantages of use	Using hot water from central heating network for domestic hot water preparation during heating season. Needs additional plumbing.
Easiness to use	Easy to use.

Table 17: Solar DHW preparation system

Sector	Buildings
Sub-Sector	Residential & tertiary sector
Category	DHW preparation
Technology	Solar DHW preparation system
Origin of technology	
Cost of purchase	1300 € for 200 l system; 2020 € for 300 l system etc.[25]
Cost per kWh	0 €
Average energy consumption (kWh/a)	For DHW preparation in households - 966 kWh/a (Stojiljkovic and Todorovic 2015)
Advantages / disadvantages of use	Enables using of solar energy source for DHW preparation. Solar energy is intermittent heat source, hence system needs backup energy source (e.g. gas or electricity). With current electricity prices, for average household, payback period is not reasonable.
Easiness to use	Moderate – can cause lack of hot water in the morning hours if not properly backed up with gas or electrical water heating.

[24] www.itim.rs, www.eponuda.rs, (30.07.2015)

[25] www.solarni-kolektori.net, www.solarnisistemi.rs, (30.07.2015)

Table 18: Air to water heat pump

Sector	Buildings
Sub-Sector	Residential, public and commercial sector
Category	domestic hot water preparation
Technology	Air to water heat pump
Origin of technology	
Cost of purchase	400 € for 200 l system; 2020 € for 300 l system etc.[26]
Cost per kWh	Depends on COP (which depends on device and operating conditions)
Average energy consumption (kWh/a)	For DHW preparation in households - 966 kWh/a (Stojiljkovic and Todorovic 2015)
Advantages / disadvantages of use	Enables usage of non-intermittent RES for DHW preparation. Electricity prices in Serbia cause too long payback period.
Easiness to use	Easy to use.

1.3.5.1 Lightning

Available data regarding technologies for efficient lighting with anticipated advantages and disadvantages are presented in tables 20 and 21. Aim of proposed measures is decrease of annual energy needed by applying efficient light bulbs and introduction of occupancy sensors.

Table 19: Energy efficient light bulbs

Sector	Buildings
Sub-Sector	Residential, public and commercial sector
Category	Lightning
Technology	Energy efficient light bulbs
Origin of technology	Imported
Cost of purchase	2 to 10 €[27]
Cost per kWh	
Average energy consumption (kWh/a)	Residential average: 294 kWh/a
Advantages / disadvantages of use	Produces 60 lm/W or more, compared to 16 lm/W from incandescent bulbs[28].

[26] www.protem.co.rs, (30.07.2015)

[27] www.winwin.rs, (30.07.2015)

	Several times more expensive than incandescent bulbs.
Easiness to use	Easy to use.

Table 20: Occupancy sensors

Sector	Buildings
Sub-Sector	Public and commercial sector
Category	Lightning
Technology	Occupancy sensors
Origin of technology	Imported
Cost of purchase	7 €[29].
Cost per kWh	
Average energy consumption (kWh/a)	
Advantages / disadvantages of use	Enables lightning control based on occupancy (lights are off if space is vacant).
Easiness to use	Easy to use.

1.3.6 Cooking

Available data regarding technologies for cooking with enhanced efficiencies, including anticipated advantages and disadvantages are presented in tables 22 to 23. Aim of proposed measures is decrease of annual energy needed for cooking by introducing efficient appliances and avoiding conversion losses.

Table 21: Microwave oven

Sector	Buildings
Sub-Sector	Residential and public and commercial sector
Category	Cooking
Technology	Microwave oven
Origin of technology	Imported
Cost of purchase	From 50 € [30]
Cost per kWh	

[28] eartheasy.com, (30.07.2015)

[29] www.eponuda.com, (30.07.2015)

[30] www.tehnomanija.com (30.07.2015)

Average energy consumption (kWh/a)	Residential average: 1260 kWh/a (Stojiljkovic and Todorovic 2015)
Advantages / disadvantages of use	Uses less electricity for cooking than any other electrical cooking device[31]. Suitable only for specific purposes[32].
Easiness to use	Moderate ease of use.

Table 22: Gas cookers

Sector	Buildings
Sub-Sector	Residential and tertiary sector
Category	Cooking
Technology	Gas cookers
Origin of technology	Imported
Cost of purchase	Similar to electric cookers
Cost per kWh	0,04 to 0,05 €/kWh[33]
Average energy consumption (kWh/a)	
Advantages / disadvantages of use	Decreased conversion losses compared to electrical cookers. Requires gas storage or connection to gas network.
Easiness to use	Easy to use.

[31] www.uswitch.com, (30.07.2015)

[32] World Health Organization (www.who.it), (30.07.2015)

[33] www.srbijagas.co.rs, (30.07.2015)

1.4 Data for the Transport Sector

Available data about measures aimed to improve efficiency in transport sector are presented in tables 24-28 and include: car sharing, eco driving, improved vehicle efficiency, start-stop systems and combined road-rail transport. There are no available data about cost effectiveness of proposed technologies.

Table 23: Car sharing

Sector	Transport
Sub-Sector	Passenger transport - System efficiency
Category	Road transport: • passenger transport: ○ short distance,
Technology	Car sharing is a model of car rental where persons rent cars for short periods of time, often by the hour. It is acceptable to customers who only occasionally use a vehicle, as well as others who need different type of vehicle compared to their own. Car sharing systems may be organized at the level of a company, community, or by commercial rentiers.
Origin of technology	It is based at experience from EU countries with some adaptation to local conditions[34]. Car sharing systems in Serbia[35] don't have significant place yet.
Cost of purchase	n/a
Cost per kWh	n/a
Average energy consumption (kWh/a)	n/a
Advantages / disadvantages of use	Advantages are: no vehicle maintenance, no registration or insurance costs, road assistance, a wide selection of vehicles depending on the needs, initial costs are lower. Disadvantages are: responsibility, consequences of potential damage, needs for reservations, long-term profitability[36].

[34] www.invers.com/en-eu/carsharing (30.07.2015)

[35] www.car4use.com (30.07.2015)

[36] www.spendingprofile.com/blog/2011/08/car-sharing-is-this-worth-it (30.07.2015)

Easiness to use	It is needed to make reservation before usage.

Table 24: Eco driving

Sector	Transport
Sub-Sector	Passenger transport - Travel efficiency
Category	Road transport: • passenger transport: ○ short distance,
Technology	**Eco driving**, driving techniques which can provide significant fuel savings. There are five basic rules to follow: Anticipate traffic flow, Maintain a steady speed at low RPM, Shift up early, Check tire, and Consider any extra energy consumer (air conditioner). Eco driving is similar with self-control fuel consumption.
Origin of technology	Experience from EU countries is applied with little adaptation to local conditions[37].
Cost of purchase	n/a
Cost per kWh	n/a
Average energy consumption (kWh/a)	n/a
Advantages / disadvantages of use	Advantages are related to decrease of fuel cost, reductions of GHG emissions, increased safety and comfort. Disadvantages of driving with low RPM causes possibility of engine failure.
Easiness to use	Eco driving represents a driving culture, not technical solution and is connected to the motivation and patience of drivers.

Table 25: New generation engines with increased efficiency

Sector	Transport
Sub-Sector	Passenger transport - Vehicle efficiency
Category	Road transport: • passenger transport: ○ car short distance, ○ car long distance, ○ bus,

[37] www.ecodrive.org (30.07.2015)

	○ coach,
Technology	Usage of vehicles with new generation engines.
Origin of technology	Limited imports of vehicles in accordance with the EU standards[38].
Cost of purchase	n/a
Cost per kWh	n/a
Average energy consumption (kWh/a)	n/a
Advantages / disadvantages of use	Imports of euro 6 for new and euro 4 for old vehicles, would have a positive impact on increasing the number of energy-efficient vehicles. Expected costs of purchase will increase. Renewing of vehicles require large initial investments. Long payback period.
Easiness to use	New vehicles provide higher level of comfort

Table 26: Start stop systems

Sector	Transport
Sub-Sector	Passenger transport - Vehicle efficiency
Category	Road transport: • passenger transport: ○ car short distance, ○ bus, ○ coach,
Technology	Usage of vehicles with start-stop system.
Origin of technology	Experience from EU is applied.
Cost of purchase	n/a
Cost per kWh	n/a
Average energy consumption (kWh/a)	n/a
Advantages / disadvantages of use	Benefit is the reduction of fuel consumption up to 10% in urban areas. The adverse impact on engine[39].
Easiness to use	Does not affect the reduction in driving comfort. Potentially increases maintenance costs.

[38] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:l28186 (30.07.2015)

[39] www.autocar.co.uk/car-news/new-cars/stop-start-long-term-impact-your-car-s-engine (30.07.2015)

Table 27: Combined road-railway freight transport

Sector	Transport
Sub-Sector	Freight transport - System efficiency
Category	Road transport: • freight service: ○ truck Rail transport • freight service: ○ short distance, ○ long distance,
Technology	Combined road-railway freight transport
Origin of technology	Both transport systems are developed and optimized based on past experience[40].
Cost of purchase	n/a
Cost per kWh	n/a
Average energy consumption (kWh/a)	n/a
Advantages / disadvantages of use	Advantages are related to achieving advantages of rail and road transport simultaneously. Disadvantages are related to potential problems with waiting time and breakdowns and the necessity of container packing.
Easiness to use	Good organization is needed

40 http://www.zeleznicesrbije.com/system/en/home/newsplus/viewsingle/_params/newsplus_news_id/26178.html (30.07.2015)

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TECHNOLOGICAL TRENDS

– NATIONAL REPORT FOR UK

DATE 07 AUGUST 2015

Partner: “*Oxford Brookes University*”

Institution: Oxford Brookes University, UK

Steering Committee member [(1)]: Prof Rajat Gupta

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[(1)] The Steering Committee member has the responsibility for ensuring the quality of the report.

HERON: Forward – looking socio-economic research on Energy Efficiency in EU countries

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ACRONYMS

AFV	Alternative Fuel Vehicles
BAT	Best available technologies
BEMS	Building Energy Management System
BIS	Department for Business Innovation and Skills
CARES	Community Renewable Energy Scheme
CCA	Climate Change Agreements
CCL	Climate Change Levy
CCS	Carbon Capture and Storage
CERT	Carbon Emission Reduction Target
CESP	Community Energy Saving Programme
CFLs	Compact Fluorescent Lighting
CHP	Combined Heat and Power
CO2	Carbon Dioxide
CO2e	Carbon Dioxide equivalent
CP	Control Period
CSH	Code for Sustainable Homes
DCLG	Department for Communities and Local Government
DEC	Display Energy Certificates
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
DH	Department of Health
DNO	District network operators
ECO	Energy Company Obligation
ECML	East Coast Main Line
ECUK	Energy Consumption in the UK
EE	Energy Efficiency
EEC 1 & 2	Energy Efficiency Commitment (Strands 1 and 2)
EED	Energy Efficiency Directive
EE-MACC	Energy Efficiency Marginal Abatement Cost Curve
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate

ERTMS	European Railway Traffic Management
ESCO	Energy service company
ESOS	Energy Savings Opportunity Scheme
ETCS	European Train Control System
ETI	Energy Technology Institute
EU	European Union
EV	Electric Vehicles
FiT	Feed-in Tariff
GDP	Gross Domestic Product
GGC	Greening Government Commitments
GHG	Green House Gas
HGV	Heavy Goods Vehicles
HNDU	Heat Networks Delivery Unit
ICE	Incentive on Connections Engagement
IMO	International Maritime Organisation
LCVIP	Low Carbon Vehicles Innovation Platform
LCVPP	Low Carbon Vehicle Public Procurement Programme
LED	Light Emitting Diode
LGV	Light Goods Vehicles
MFP	Multi-functional printer
Ofgem	Office of Gas and Electricity Markets
OLEV	Office for Low Emission Vehicles
R&D	Research and Development
RCEP	Research Councils Energy Programme
RTFO	Renewable Transport Fuel Obligation
RTFCs	Renewable Transport Fuel Certificates
SFN	Strategic Freight Network
SME	Small Medium Enterprises
SMMT	Society of Motor Manufacturers and Traders
TINAs	Technology Innovation Needs Assessments
TSB	Technology Strategy Board
TWh	Terawatt-hours
UCO	Used cooking oils
UK	United Kingdom

ULEV	Ultra-Low Emissions Vehicles
UNFCCC	United Nations Framework Convention on Climate Change
VED	Vehicle Excise Duty
VCA	Vehicle Certification Agency
WML	Western Main Line
ZCH	Zero Carbon Hub

EXECUTIVE SUMMARY

This paper presents the economic and technical energy efficiency potential in the United Kingdom in terms of the building and transport sectors, as well as the existing and innovative technological trends within these sectors.

The first chapter outlines the overall energy efficiency potential in the building and transport sectors. This is followed by chapter two which outlines the existing technologies in the building and transport sectors, and highlights the policy instruments used in the UK to support and promote their use and uptake. This section also discusses which policy instruments support innovative technologies and the economic and technical role they have.

Data in tabular form for individual technologies within the subsectors of the building and transport sectors are then presented.

CHAPTER 1: TECHNOLOGICAL TRENDS IN THE BUILDING AND TRANSPORT SECTOR

In this task, for each country relevant technologies that are already used and promoted by corresponding energy efficiency policy instruments will be presented.

1.1 ENERGY EFFICIENCY POTENTIAL

The UK's indicative national energy efficiency target for 2020 (under Article 3 of the Energy Efficiency Directive Summary) has been set at a final energy consumption of 129.2 mtoe (1,503 TWh) on a net calorific value basis (DECC, 2014d). In 2013, the total energy consumed in the UK was 142.5 mtoe (1,657 TWh). The energy used by buildings accounted for approximately 43% of the UK's total energy use; with the residential sector accounting for 29% of this. The energy used by the transport sector accounted for 36%.

Annex E of the UK's Energy Efficiency Strategy (DECC, 2012)outlined total potential energy savings of up to 268 TWh based on a UK wide Energy Efficiency Marginal Abatement Cost Curve (EE-MACC)[1]; 66 TWh of which could be attributed to the transport sector, 93 TWh to the domestic sector, 28 TWh to the commercial sector and 38 TWh to products. The Energy Efficiency Strategy (DECC, 2012) also provided cost-effective potential for energy efficiency of up to 196 TWh (equivalent to 41 $MtCO_2e$) savings in final energy consumption; of which 121 TWh could be attributed to the building-related sectors (27 TWh to the commercial sector, 56 TWh to the domestic sector, and 38 TWh to the products sector) and 33 TWh were attributed to the transport sector.

In terms of economic potential, in 2012, the UK automotive industry had a £40bn turnover with £8.5bn value added, and with over 700,000 jobs, it accounted for 10% of the UK's total exports. It also invests around £1.5bn per year in Research and Development (SMMT, 2012). On an individual level, users of energy efficient vehicles will benefit from higher fuel economies; with 100 miles in an ultra low emission vehicle expected to cost under £3 (OLEV, 2014). A key area in terms of improving efficiency in the transport sector is through improvements in the efficiency of fuel. According to the UK's Energy Efficiency Strategy (DECC, 2012), a European Commission Impact Assessment indicated that, through improvements in the efficiency of fuel, the average motorist could save about €500/year by 2020. Furthermore, research undertaken through the Technology Innovation Needs Assessment indicates that hydrogen technologies for transport could contribute an economic value of £10-26bn (to 2050) from global export of goods and services, and a further £9-23bn economic benefit to the UK (to 2050) via a shift in energy sources for the production of transport fuel. As such, the economic energy efficiency potential in the transport sector is significant but total overall figures are unknown.

Carbon Trust research (Low Carbon Innovation Coordination Group, 2012) suggests that existing energy efficiency measures within the commercial (building) sector could provide a 35% carbon saving alone, with a minimum net benefit of £4bn by 2020. However, DECC analysis (DECC, 2012)suggests that around 14% of the total energy use in the business and public sector are not

[1] The EE-MACC estimates the energy savings, measured in terms of final energy consumption that could be achieved in a given year through implementing energy efficiency measures between now (2012) and that year (2020) DECC (2012). The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK. Department of Energy and Climate.Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65602/6927-energy-efficiency-strategy--the-energy-efficiency.pdf

addressed by any of the UK's existing policies. Furthermore, as identified in the Energy Efficiency Strategy (DECC, 2012), National Energy Efficiency Action Plan (DECC, 2014d) and supported by the findings of the collaborative Technology Innovation Needs Assessments (TINAs), the building sector also offers further economic energy efficiency potential. Innovation in the non-domestic buildings sector is estimated to be able to contribute savings of 18MtCO_2e by 2020, with a potential net value of c. £13bn (by 2050). The additional global market value of innovative products in this sector is estimated to reach around £488bn (cumulatively from 2010-2050), with £200bn expected to be accessible to the UK; innovative products in this sector could provide a further £1.7bn to the UK's GDP in export opportunities (Low Carbon Innovation Coordination Group, 2012). Innovation in the domestic buildings sector is estimated to be able contribute savings of 11MtCO_2e by 2020, with a potential net value of around £16bn (by 2050). The additional global market value of innovative products are estimated to reach around £620bn (cumulatively from 2010-2050), with £220bn expected to be accessible to the UK; innovative products in this sector could provide a further £1.7bn to the UK's GDP in export opportunities. As the Energy Efficiency Strategy (DECC, 2012) states, the development of a stronger understanding of the energy efficiency potential, alongside the evaluation of the impact of existing policies is a priority.

1.2 Technologies And Policy Instruments

1.5.1 Buildings

Existing technologies and supportive policy instruments (DECC, 2013a)

Space and water heating: There are several existing technologies that aim to increase the efficiency of buildings in terms of the space heating and air conditioning requirements. These include combined heat and power (CHP) systems, heat pumps and high efficiency condensing boilers, biomass boilers, solar thermal, building fabric measures (wall and loft insulation, improved glazing) as well as improved heating controls and management systems (such as building energy management systems (BEMS), domestic smart meters and app-based smart controls). In terms of supportive policy instruments, there are several regulatory policy instruments that seek to increase the energy efficiency of new and existing (domestic and/or non-domestic) buildings in terms of their space and water heating technologies, including the Energy Company Obligation (ECO), the Renewable Heat Incentive (RHI) and its predecessor, the Renewable Heat Premium Payment, the Heat Network Delivery Unit (HNDU), the Community Energy Saving Programme (CESP, 2009-2012) and the Carbon Emissions Reduction Target (CERT, 2008-2012)and its predecessors, the Energy Efficiency Commitment Scheme (EEC, 2002-2008), and the Energy Efficiency Standards of Performance (EESoP, 1994-2002).

Appliances and lighting: The uptake of, and improvements to the efficiency and performance of lighting (specifically the uptake of CFLs and LEDs) and appliances relating to cooking, laundry washing and drying, dish washing, refrigeration and televisions has been supported by national policy instruments that embed EU directives into the legal and regulatory framework of UK policy, such as, the Climate Change Agreements, the EU-Emissions Trading Scheme, the Ecodesign for energy related Products Directives 2009/125/EC and the Energy Labelling Directive (2010/30/EU).

Renewable energy generation: There are several existing technologies relating to renewable energy generation in the UK, including solar photovoltaic panels, wind turbines (on and off-shore), tidal, hydro, energy from waste, sewage and landfill as well as anaerobic, animal and plant biomass. There a several supporting policy instruments for renewable energy generation including the Renewables Obligation Certificate (ROC), Renewable Energy Strategy, Feed-in Tariffs (FiTs), the Renewable Energy Investment Fund and LicenseLite.

There are also several policy instruments that do not encourage specific energy efficiency measures, but rather aim to enable all types of existing and cost-effective energy efficiency technologies in the building sector. Such policy instruments (mainly regulatory and economic) include measures such as the updated Building Regulations (Part L) – for new and existing buildings (non-domestic and domestic), the national roll-out of Smart Meters, the Code for Sustainable Homes and Zero Carbon Homes Standard, the Green Deal, SME Loans, the Carbon Reduction Commitment Energy Efficiency Scheme (CRC) and the Energy Savings Opportunity Scheme (ESOS).

Penetration of existing technologies due to policy instruments

Through policy instruments and measures running from 2008 to 2012, such as EEC 1 and 2, CERT, CESP:

- 139,000 solid (or hard-to-treat cavity) wall dwellings had solid wall insulation installed (total number of dwellings in UK with solid wall is 7.99 million; as of December 2014, 4% have insulation) (DECC, 2014a).
- 2.6million cavity wall dwellings had cavity wall insulation installed (total number of dwellings in UK with cavity wall is 19.39million; as of December 2014, 73% have insulation) (DECC, 2014a).
- 5.45 million dwellings had improved levels of loft insulation installed (total number of dwellings in UK with suitable lofts is 23.91 million; as of December 2014, 70% have insulation) (DECC, 2014a).

Due to ECO and the Green Deal, a total of 1,541,290 measures have been installed in dwellings in the UK between January 2013 and May 2015 (DECC, 2014a). Table 1 outlines the penetration of some of the main technologies within the building sector, due to Green Deal schemes and ECO.

Table 1. Energy efficiency measures delivered through UK Government policy measures

Measure Type	Delivery mechanism			
	ECO	Green Deal Cashback	Green Deal Home Improvement Fund	Green Deal Finance
Boiler	311,269	12,379	2,980	4,846
Cavity wall insulation	563,936	300	137	366
Lighting	0	0	0	158
Loft Insulation	403,694	773	60	1,069
Micro-generation	0	0	0	4,737
Other Heating	101,456	12	2,661	1,313
Other Insulation	12,061	60	302	1,017
Solid Wall Insulation	89,064	2,108	20,876	2,325
Window Glazing	3,117	64	124	35
Total number of measures	**1,484,597**	**15,696**	**27,140**	**15,866**

In relation to renewable energy generation, of the total capacity of solar photovoltaics installed up to the end of May 2015 (7,265MW capacity over 709,550 systems), 42% (3,075MW over 694,961 systems) is accredited to Feed-in Tariff (FiTs) installations and 45% (3,300MW over 11,774 systems) is accredited to the Renewables Obligation (DECC, 2014c).

Innovative technologies and supportive policy instruments

Innovative technologies within the building sector cover the technology areas of: pre-construction and design (e.g. advanced modelling), the build process (e.g. automated surveying and inspection tools, off-site construction), building operation (e.g. predictive controls, targeted real time energy usage information), and materials and components (e.g. 'switchable' glazing, dynamic insulation) (Low Carbon Innovation Coordination Group, 2012). There are several research and development (R&D) policy instruments in place to encourage innovative technologies, particularly in terms of ensuring cost-effectiveness, including:

- The Energy Technologies Institute's (ETI) £100million, five year Smart Systems and Heat Programme; aiming to investigate heat demand drivers and potential for this to be met more efficiently (DECC, 2012);
- The Energy Entrepreneurs Fund (EEF); aimed at supporting the development and demonstration of innovative building technologies, processes, generation and storage as well as helping bring innovative technologies to market (DECC, 2012).
- The Technology Strategy Board's (TSB) £10 million Invest in Innovative Refurb competition in 2012, through its Small Business Research Initiative programme; aimed at tackling the barriers to entering the market with developing and innovative technologies and processes (DECC, 2012).

Cost-effective technologies

As the UK's Carbon Plan (2011) states, the cost-effectiveness of measures is affected by the scale and timing of their deployments; as such "achieving a cost-optimal transition overall often necessitates deploying technologies in the medium term that may not yet be statically cost effective against the carbon price" (HM Government, 2011). This means that the most cost-effective technologies will vary over time. The EE-MACC analysis undertaken for the UK's Energy Efficiency Strategy (DECC, 2012) in terms of energy efficiency potential, cost-effective energy savings and projected savings from current UK policy, indicates that currently, overall, existing best available technologies, particularly relating to lighting and appliance products are most cost-effective, such as switching from halogens to LEDs. Heat pumps and district heating technologies are also cost-effective technologies but recent research suggests that technologies relating to thermal insulation are not as effective as previously expected, particularly solid wall insulation (CCC, 2013a).

In terms of innovative technologies, and the value of their abatement potential, the Technology Innovation Needs Assessments suggest that innovations in building operations could be of most value in the domestic sector, and save the most carbon, most quickly. In the non-domestic sector, whilst innovations in integrated design and build process would be of most value, innovations in management and operation would provide the quickest carbon savings (Low Carbon Innovation Coordination Group, 2012). In both the domestic and non-domestic sector, research suggests that innovations in materials and components will not provide significant value; unless costs reduce quicker than expected.

1.5.2 Transport

Existing technologies and supportive policy instruments

In terms of the transport sector, the main existing energy efficiency technologies include (DECC, 2012):

- For *road transport (freight and passenger)*: low rolling resistance tyres, improved engine efficiency, improved vehicle dynamics, improved infrastructure for electric vehicles, alternative fuels (e.g. hydrogen, electric, hybrid engines, biofuels), automated vehicles, intelligent systems (e.g. improved routing and scheduling, training and performance monitoring through telematics)

- For *rail transport (freight and passenger)*: transport rail electrification, enhanced braking systems, automated train operation
- For *shipping/marine (freight)*: improved auxiliary power (efficient pumps, high efficiency lighting, solar PV panels), improved hydro- and aerodynamics, improved operational systems (weather routing, autopilot upgrades, speed reduction), improved thrust efficiency (propeller and rudder upgrades), improved energy efficiency (waste heat recovery systems, engine controls) (Sekimizu, 2015);
- For *aviation (freight and passenger)*: engines with increased fuel efficiency, use of alternative fuels, improved dynamics.

The majority of the main existing energy efficiency technologies in the road and rail sectors are supported by policy instruments in the UK; and are mainly based on policies set at EU level. They include a mix of instrument types including regulatory (EU new car CO2 emissions targets: 130 gCO2/km by 2015 and 95 gCO2/km by 2020; and complementary measures), economic (Plug-in car and van grants (including Electric Vehicle Homecharge Scheme) and planning ((Ultra-)Low Carbon Emissions Zones at local authority/regional level e.g. London). In addition, there are a number of voluntary approach policy instruments such as the Freight Transport Association Logistics Carbon Reduction Scheme. In terms of existing technologies in the shipping/marine and aviation sectors, these are mainly being driven by international markets and standards; such as measures put in place by the International Maritime Organization (IMO).

Penetration of existing technologies due to policy instruments

The majority of the main existing energy efficiency technologies supported by policy instruments in the UK are showing signs of significant penetration in their relevant domestic markets. However, total figures relating to the direct effect of the policy instruments upon the penetration of the technologies were not available at the time of writing.

Despite this, a Society of Motor Manufacturers & Traders (SMMT) report (SMMT, 2014) indicates significant shifts in the UK's new car market; in 2013, 63% of new car registrations met the EU's 2015 CO2 target (130gkm or below), with an increase in the purchase of cars with 95g/km and below, and fewer cars emitting CO2 over 200g/km being purchased. Furthermore, sales of VED top-band (Band M – over 255g/km) cars fell from over 100,000 units in 2000 to less than 10,000 in 2013 (0.4% of the market). SMMT research also indicates that there was a definite step-change in the uptake of low emission cars after 2007. In addition, it is not just petrol and diesel cars, with improved fuel efficiency that are experiencing increased uptake; comparative annual figures also indicate that there is a significant increase in the uptake of vehicles with alternative fuel sources; with 'pure electric plug-in' vehicles experiencing an annual percentage change increase of 83%, and 'other electric plug-in' vehicles experiencing a 520% increase in uptake, from June 2014 to June 2015. However, currently (mid-2015) alternative fuelled vehicles (AFVs) account for only 2.1% of the market (SMMT, 2015)

In terms of the rail sector, significant rail electrification along three key routes began in 2014 by Network Rail[2], alongside capacity improvements and the implementation of the European Rail Traffic

[2] Network Rail is the company responsible for owning, operating and managing Britain's railway network, operating under a licence enforced by the Office for Rail Regulation. On 1st September 2014, Network Rail Limited with all of its subsidiaries was reclassified as a central government body, and is a public-sector arms-length body of the Department for Transport HM Treasury (2014). National Infrastructure Plan 2014.

Management System to improve line capacity, as part of the UK Government's National Infrastructure Plan (HM Treasury, 2014).

Innovative technologies and supportive policy instruments

Innovative technologies in the transport sector are supported through policy instruments aimed at encouraging research and development at all three levels of energy efficiency; system efficiency, travel efficiency and vehicle efficiency, including infrastructural innovations, innovations in ultra-low emission vehicles and alternative fuels. In response to the regulatory EU policy instruments relating to alternative fuels and improved vehicle fuel efficiency, the UK Government set up the Office for Low Emission Vehicles (OLEV) in 2009. The OLEV helps support and develop the market for ultra-low emissions vehicles (ULEV) and provides over £900million to "position the UK at the global forefront of ULEV development, manufacture and use" (OLEV, 2014). Alongside the Technology Strategy Board/InnovateUK, the OLEV has helped, and continues to help fund innovative technologies in the transport sector. Some of the research and development that the OLEV has helped fund include:

- The Low Carbon Vehicles Innovation Platform (LCVIP)
- The Low Carbon Vehicle Public Procurement Programme (LCVPP)
- The Low Carbon Truck trial
- Advanced biofuel demonstration competition

In addition to providing funds directly, the OLEV is also working collaboratively with the UK's Automotive Council to provide innovation roadmaps, focusing on key areas for innovation; internal combustion engines, power electronics and electric machines, energy storage, lightweight vehicle and power train, and intelligent mobility (HM Government, 2013).

In order to identify and promote low emission road freight technologies specifically, a Low Carbon HGV Technology Taskforce was set up in 2011; it includes Freight Transport Association, Road Haulage Association, Chartered Institute of Logistics and Transport, the Society of Motor Manufacturers and Traders, Low Carbon Vehicle Partnership and Transport Knowledge Transfer Network and is supported by the Department for Transport, the Office of Low Emission Vehicles and Defra (DfT, 2014).

UKH2Mobility is also a collaborative research and development project that involves industry, public/private partners and UK Government departments, amongst others, and which seeks to evaluate the potential for hydrogen fuel cell technology within the transport sector.

Cost-effective technologies

The EE-MACC analysis undertaken for the UK's Energy Efficiency Strategy (DECC, 2012) indicates that the cost-effective energy savings within the transport sector from existing technologies is much less than the total energy efficiency potential (33TWh cost-effective to 66TWh total energy efficiency potential). Whilst most of the UK's existing energy efficiency policy covers the cost effective potential (CCC, 2013b), this highlights the need for significant improvements and further investment in the industrialisation of manufacture through process innovation as well as reliable and affordable technologies being available through the reduction in capital costs to ensure continued uptake of existing technologies and future uptake of innovative technologies. The most cost-effective existing technologies relating to transport are electric vehicles and battery leasing (CCC, 2013a). Cost-

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London.Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/381884/2902895_NationalInfrastructurePlan2014_acc.pdf effective measures are those that cost less than the projected carbon price across their lifetimes (CCC, 2013a).

1.3 Market Perspectives due to Technological Trends

The UK's energy efficiency sector accounted for approximately 136,000 jobs and had sales of over £18 billion in 2011-2012 (DECC, 2014d). As stated in the Energy Efficiency Strategy (2012);

"The energy efficiency investment market is growing but, given that the technology is available to make cost effective low carbon investments, it is small relative to the size of the potential opportunity. With the notable exception of the domestic insulation market following CERT, the market has not grown sufficiently over the years and there are no well-developed financial products for investing in energy efficiency."

The transport sector offers the greatest potential; the SMMT's 2015 Automotive Sustainability Report (16th edition - 2014 data) states that the overall UK automotive market is growing, supported by economic growth and strong exports; with a record £69.5billion turnover and signatories reporting a 4% rise in turnover in 2014. UK vehicle production increased by 0.1% in 2014 (1.6million units), with car output rising by 1.2% (1.53million units). Whilst growth followed increased output for the domestic market, exports represented four out of every five cars produced in the UK in 2014. The EU remained the UK's key trading partner, and car exports to the EU rose by over 10% in 2014 (53% of all car exports). Exports to China rose by 14.5% (137,000 units) and is a key market for higher-value products (SMMT, 2015).

Further industry investment was announced in 2014, with the total of around £8billion being invested over the past three years; including Jaguar Land Rover investment in new products and supporting supply chain development, a new R&D facility by Bentley, and new low carbon engines by Ford. The net effect of this investment is an increase in UK car production of up to 1.95million units in 2017.

The SMMT report (SMMT, 2015) also stated that the new car market rose by 9.3% in 2014; more than the EU's 5.6% growth and enabled the UK to retain its position as the second largest car market in Europe (behind Germany). Whilst all fuel types grew in 2014 (the share of diesel over 50%), registrations of alternatively fuelled vehicles (AFVs) rose by 58.1% in 2014 (51,739 units) and accounted for a 2.1% share of the market. Models using electric power rose from 36 in 2012 to 58 in 2014; including both pure electric and plug-in vehicles. In addition, a small number of hydrogen vehicles were also registered (ahead of full commercial sales in 2015). An example of the positive impact of transport-related technologies on the UK's energy efficiency market is the production of electric vehicles (EVs) by Nissan; output for Nissan's 100% electric LEAF model doubled to more than 17,000 units, and helped Nissan's Sunderland plant remain the UK's largest vehicle producer (manufacturing over 500,000 units in 2014). The UK battery plant facility also increased production due to it starting to supply units to Nissan's Barcelona plant to use in the 100% electric e-NV200 van.

1.4 Data for the Buildings Sector

1.5.1 Residential Sector

Table 2. Buildings-residential-space heating

Sector	**Buildings**
Sub-Sector	**Residential sector**

<table>
<tr><th>Category</th><th>Space Heating</th></tr>
<tr><td>Technology</td><td>Condensing combi boiler (gas, oil or solid fuel)</td></tr>
<tr><td>Number of technology used</td><td>
<table>
<tr><td>Type of boiler</td><td>Standard/ Back boiler</td><td>Combination boiler</td><td>Condensing boiler</td><td>Condensing - combination boiler</td><td>No boiler</td></tr>
<tr><td>Number of households</td><td>7,896</td><td>4,669</td><td>3,298</td><td>8,787</td><td>3,118</td></tr>
</table>
(DECC, 2014b)
Data for single family houses (urban/rural) and multi-family houses are unknown as UK statistics do not use these definitions.
</td></tr>
<tr><td>Origin of technology</td><td>There are over 20 manufacturers that supply gas boilers to the UK market. A large proportion of these sales are made by four companies: Baxi, Worcester Bosch, Vaillant and Ideal. It is estimated that at least 70% of UK gas boilers sold were manufactured in the UK (DECC, 2013b).</td></tr>
<tr><td>Cost of purchase</td><td>For a gas condensing combi boiler: €1000-€1720 with additional installation costs from €775-€2060. Costs generally more if it is an oil boiler (DECC, 2014b).</td></tr>
<tr><td>Cost per kWh</td><td>Dependent on gas/oil/solid fuel tariffs (different depending on supplier)</td></tr>
<tr><td>Energy consumption</td><td>On average 130kWh/annum (based on SAP calculations) and on average, 62% of the average households energy use (DECC, 2013c)
<table>
<tr><td></td><td>Flat</td><td>Terrace</td><td>Semi-detached</td><td>Detached</td></tr>
<tr><td>Space heating (kWh/annum)</td><td>103</td><td>133</td><td>144</td><td>144</td></tr>
</table>
</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>Advantages: A combi (combination) boiler provides hot water directly, and does not need a hot water cylinder/tank (uses less space). A regular boiler (with hot water tank) is more efficient at producing hot water but some heat is inevitably lost from the hot water tank, so the combi may be more efficient overall (EST, 2015).
Disadvantages: Combi boilers, if there is not a hot water tank present, are generally not compatible with solar thermal systems. If the cold water supply is not adequate then there can be issues with hot water flow.</td></tr>
<tr><td>Easiness to use</td><td>Combi boilers generally relatively easy to use but ease of use will be dependent on the type of heating controls available.</td></tr>
</table>

Table 3. Buildings-Residential sector-Air conditioning

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Air Conditioning**
Technology	Air conditioning unit (multisplit)
Number of technology used	Total numbers of air conditioning units installed in the UK unknown, but a report commissioned by DECC (BRE, 2013) indicates that less than 3% of households use fixed or portable air conditioning units.
Origin of technology	-
Cost of purchase	Costs per unit range from €510-€1780 alone; whilst costs including

	installation can be more than €3000 (based on average costs taken from : (ACC, 2015).
Cost per kWh	Dependent on household electricity tariff (UK 2014 average was €0.20/kWh (DECC, 2013c)
Average energy consumption	201-446kWh/annum (Taken from: http://www.topten.eu/english/building_components/air_conditioners/Multi-split.html [accessed 16/07/15])
Advantages / disadvantages of use	Advantages: • Ideal if you have one room that gets very hot • A secure way of air conditioning your home – no need to leave windows open • Quieter and more efficient than single units • Usually more powerful than single units Disadvantages: • Tend to be more expensive than single units • Need to be permanently mounted on an outside wall – installation can be tricky and you may need to hire a professional (Taken from: which.co.uk [accessed 16/07/15])
Easiness to use	Dependent on controls available and user

Table 4. Buildings-Residential sector-Water heating

Sector	**Buildings**
Sub-Sector	**Residential sector**
Category	**Water Heating**
Technology	**Condensing combi boiler**
Origin of technology	See heating system
Cost of purchase	See heating system
Cost per kWh	See heating system
Average energy consumption	On average 40kWh/annum (based on SAP calculations) and on average, 18% of the average households energy use (DECC, 2013c) <table><tr><td></td><td>Flat</td><td>Terrace</td><td>Semi-detached</td><td>Detached</td></tr><tr><td>Water heating (kWh/annum)</td><td>47</td><td>43</td><td>41</td><td>30</td></tr></table>
Advantages / disadvantages of use	See heating system
Easiness to use	See heating system

Table 5. Buildings-Residential sector-Cooking

Sector	**Buildings**

<table>
<tr><td>Sub-Sector</td><td>Residential sector</td></tr>
<tr><td>Category</td><td>Cooking</td></tr>
<tr><td>Technology</td><td>Electric cooker with electric cooktop (hob)</td></tr>
<tr><td>Origin of technology</td><td>-</td></tr>
<tr><td>Cost of purchase</td><td>Approximately €215-€1430 (Taken from: http://www.which.co.uk/home-and-garden/home-appliances/guides/how-to-choose-a-cooker/freestanding-cookers/ [accessed 16/07/15])</td></tr>
<tr><td>Cost per kWh</td><td>Dependent on household electricity tariff
(UK 2014 average was €0.20/kWh (DECC, Average variable unit costs and fixed costs for electricity for UK regions: Table 2.2.4)</td></tr>
<tr><td>Average energy consumption (kWh/a)</td><td>Cooking accounts for 3% of the average households total energy use and the average household uses 460kWh/annum (DECC, 2013c).
On average, an electric cooker with electric hob uses 317kWh/annum (DECC, 2013c).
<table>
<tr><td>No. of occupants</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>Approx. electricity used for electric cooker & hob (kWh/annum)</td><td>320</td><td>150</td><td>100</td><td>70</td><td>70</td><td>100</td></tr>
</table>
source: (Intertek, 2012)</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>Advantages:
• Generally cheaper than range cookers and built-in ovens.
• Generally space-saving.
• Even oven temperature.
• Ovens generally offer multi-functions (heat from top, bottom of oven, grill and fan) ovens.
• Easy-to-clean hobs (electric cooker's ceramic hobs are easier to wipe clean than the hobs and metal risers on a gas cooker).
Disadvantages:
• Built-in ovens are better for fitted kitchens. Freestanding cookers don't offer as much cooking flexibility as range cookers, which have more burners.
• Use fewer units of energy than gas cookers, but are more expensive per unit to run than a gas equivalent.
• Takes hob rings longer to heat up with electricity than with gas.
(Taken from: (Which, 2015))</td></tr>
<tr><td>Easiness to use</td><td>Generally easy to use.</td></tr>
</table>

Table 6. Buildings-Residential sector-Lighting

Sector	**Buildings**
Sub-Sector	**Residential sector**

Category	**Lighting**
Technology	LEDs (bayonet)
Origin of technology	*National figures are unavailable for origins due to relative low numbers of LEDs installed in households in the UK (on average in 2010-2011, less than 1 LED lights are installed per average household (Intertek, 2012)*
Cost of purchase	Range from €12-€34 (Taken from: http://www.top10energyefficiency.org.uk/products/led_lamps/b22_(bayonet) [accessed 16/07/15])
Cost per kWh	Dependent on household electricity tariff (UK 2014 average was €0.20/kWh)
Average energy consumption	Lighting accounts for 3% of the average households total energy use (UK Housing Energy Factfile 2013) and the average household uses 537kWh/annum (Powering the Nation, EST, 2012). Range from 4kWh-16.5kWh/annum (Taken from: http://www.top10energyefficiency.org.uk/products/led_lamps/b22_(bayonet) [accessed 16/07/15])
Advantages / disadvantages of use	Advantages: • LEDs are the most energy-efficient bulbs. They use 90% less energy than traditional incandescents and can sometimes pay for themselves through energy savings in just a couple of months. • LEDs claim to be ultra long lasting - lasting for 25-30 years. • LEDs give out their light almost instantly when the light switch is flicked. Disadvantages: • The LED market is currently a self-regulated market, so quality of LED bulbs can vary. • Until recently, LED light bulbs were generally only been available in lower wattages and lumen levels than other types of light bulb. • To be able to dim LED lights, a dimmer that recognises low electrical loads is required. (Taken from: (Which, 2015))
Easiness to use	Very easy to use; same fittings as halogen/CFL lighting

Table 7. Buildings-Residential sector-Refrigeration

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Refrigeration**
Technology	Fridge-freezer A+++
Origin of	The most energy-efficient A+++ models currently make up only 0.5% of all the fridge models available on the UK market. The largest number of models (1,291

technology	or 56%) currently available are A+ rated. The picture for freezers is similar with 0.6% of available models being A+++ rated and the vast majority (365 or 53.5%) qualifying for an A+ label. (Taken from: (EEG, 2015))
Cost of purchase	€895-€1775 (Taken from: (EEG, 2015))
Cost per kWh	Dependent on household electricity tariff (UK 2014 average was €0.20/kWh)
Average energy consumption	130kWh/annum – 175kWh/annum (Taken from: (Taken from: (EEG, 2015))
Advantages / disadvantages of use	Advantages: • Cheaper than integrated or American-style fridge freezers. • Lower electricity costs than integrated or American-style fridge freezers. • You can opt for a larger fridge or freezer compartment depending on whether you need space for more fresh or frozen food. • Easy to fit into a kitchen. • You can take it with you if you move house. Disadvantages: • Cheaper models tend to be basic. Useful features such as a frost-free freezer, fast-chill functions and chiller cabinets will quickly add to the price. • Freestanding models typically store less fresh and frozen food than American-style fridge freezers. • Less discreet than an integrated model and can dominate the space in a small kitchen. (Taken from: (Which, 2015))
Easiness to use	Generally easy to use and maintain.

Table 8. Buildings-Residential sector-Washing machines

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Washing machines**
Technology	8kg washing machine (A+++) - freestanding
Origin of technology	About 14% of washing machine models currently on the UK market are within the most efficient A+++ efficiency class. A++ and A+ dishwashers account for 9% and 22%, respectively. With 43% (equivalent to 456 models), A-rated models currently dominate the market. (Taken from: (EEG, 2015))
Cost of purchase	€440-€1845 (Taken from: (Taken from: (EEG, 2015))
Cost per kWh	Dependent on household electricity tariff (UK 2014 average was €0.20/kWh)

Average energy consumption	118kWh/annum – 196kWh/annum (Taken from: (Taken from: (EEG, 2015))
Advantages / disadvantages of use	Advantages: Wider range of drum capacities, features and colours than integrated models. Disadvantages: Do not blend into homes like integrated models do. (Taken from: (Which, 2015))
Easiness to use	Generally easy to use and maintain.

Table 9. Buildings-Residential sector-Laundry dryer

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Laundry Dryer**
Technology	8kg tumbledryer (A++) - freestanding
Origin of technology	Tumble dryers are one of the most energy-hungry appliances now common in our homes, with almost half of all UK households owning one. In May 2013, a new labelling criteria for tumble dryers came into effect. The top category for tumble dryers is now A+++, bringing tumble dryers into line with washing machines and dishwashers. Previously, the top category for tumble dryers had been A. Currently, no tumble dryers on the market are efficient enough to qualify for the A+++ label. The most efficient models available (A++ label) make up 1% of the current market. 67% of models are in the C class. (Taken from: (Taken from: (EEG, 2015))
Cost of purchase	€740-€2140 (Taken from: (EEG, 2015))
Cost per kWh	Dependent on household electricity tariff (UK 2014 average was €0.20/kWh)
Average energy consumption	212kWh/annum – 235kWh/annum (Taken from: (EEG, 2015))
Advantages / disadvantages of use	-
Easiness to use	Generally easy to use and maintain

Table 10. Buildings-Residential sector-Dishwasher

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Dishwasher**
Technology	Freestanding dishwasher (A+++)

Origin of technology	The most energy-efficient A+++ models currently make up only 2% of all the dishwasher models available in the UK. A++ and A+ dishwashers account for 10% and 17%, respectively. The largest number of models (480 or 68%) currently available have an A label. (Taken from: (Taken from: (EEG, 2015))
Cost of purchase	€570-€1460 (Taken from: (EEG, 2015))
Cost per kWh	Dependent on household electricity tariff (UK 2014 average was €0.20/kWh)
Average energy consumption	214kWh/annum – 239kWh/annum (Taken from: (EEG, 2015))
Advantages / disadvantages of use	-
Easiness to use	Generally easy to use and maintain

Table 11. Buildings-Residential sector-Other electrics

Sector	**Buildings**
Sub-sector	**Residential sector**
Category	**Other electrics**
Technology	40”-44” LED Television (A+)
Origin of technology	*A+ rated TV sets account for 14.6% of the UK market* (Taken from: (EEG, 2015))
Cost of purchase	€570-€1175 (Taken from: (EEG, 2015))
Cost per kWh	Dependent on household electricity tariff (UK 2014 average was €0.20/kWh)
Average energy consumption	54kWh/annum – 67kWh/annum (Taken from: (EEG, 2015))
Advantages / disadvantages of use	Advantages: • LED TVs able to be slimmer than LCD TVs • Against comparably sized LCD and plasma TVs, LEDs will generally be most efficient Disadvantages: • Qualitative feedback suggests plasma TVs have better picture quality • Picture and sound quality on LED TVs vary hugely between brands and models (Taken from: (Which, 2015))
Easiness to use	Generally easy to use and maintain

1.5.2 COMMERCIAL / SERVICES SECTOR

Table 12. Buildings-Commercial/services sector-Space heating

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Space Heating**
Technology	Combined Heat and Power 60kWe to 1.5MWe
Number of technology used	In 2012, there were around 1200 CHP schemes supplying over 2.5TWh of heat per year heat to non-domestic buildings (DECC, 2013b).
Origin of technology	-
Cost of purchase	Costs including installation: €1070 per kW for large scales schemes to around £15730 per kW for small systems
Cost per kWh	Dependent on energy and energy tariff
Average energy consumption	Dependent on demand (size and population of building)
Advantages / disadvantages of use	Advantages: • CHP can cut costs by typically 20% compared to the use of grid electricity and on-site boilers • It can reduce greenhouse gas emissions cost-effectively because the technology can be applied to existing energy installations • High efficiency of fuel conversion; it is thought that they can achieve overall efficiencies in excess of 70% at the point of use. This compares to a typical figure of 40% for electricity provided via the grid from conventional power stations. • More reliable and secure energy supply. Disadvantages: • Correct sizing of the CHP unit, based on an accurate understanding of likely heat and electricity loads, is essential and so requires an in-depth feasibility study • Planning permission will be required for the majority of large scale CHP applications. • Very high upfront costs. • Infrastructure requiring long-term investment with long payback periods. • The exhaust gases from a CHP plant can cause nuisance within the local environment if the installation is not correctly designed and operated. Adequate pollutant dispersion can be achieved by ensuring that flues are sufficiently high. • Some CHP technologies are noisy – internal combustion engines in particular. • Operation of CHP does not generate large quantities of liquid effluent. However, some effluents (for example, oils, cleaning fluids or washing effluent) can cause environmental damage if not controlled. • Large scale CHP can have landscape and visual impacts given that plants

	are large structures, particularly the flue
Easiness to use	Dependent on controls systems in place, and if a Building Energy Management System (BEMS) is installed, how knowledgeable the building manager is in terms of the system

Table 13. Buildings-Commercial/services sector-Air conditioning

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Air conditioning**
Technology	Combined Heat and Power 60kWe to 1.5MWe
Number of technology used	See heating system
Origin of technology	See heating system
Cost of purchase	See heating system
Cost per kWh	See heating system
Average energy consumption	See heating system
Advantages / disadvantages of use	See heating system
Easiness to use	See heating system

Table 14. Buildings-Commercial/services sector-Water heating

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Water heating**
Technology	Combined Heat and Power 60kWe to 1.5MWe
Number of technology used	See heating system
Origin of technology	See heating system
Cost of purchase	See heating system
Cost per kWh	See heating system
Average energy consumption	See heating system
Advantages /	See heating system

disadvantages of use	
Easiness to use	See heating system

Table 15. Buildings-Commercial/services sector-Cooking

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Cooking**
Technology	Range cooker
Origin of technology	-
Cost of purchase	€1,400 or more (taken from: http://www.nisbets.co.uk/)
Cost per kWh	- UK April 2015 average was €0.79/kWh for electricity and €0.207/kWh for gas
Average energy consumption	- Cooking/catering accounts for 10% of the average commercial/services total energy use. On average, the cheapest gas range cooker uses 74kWh/annum and the most expensive a dual-fuel range cooker uses 204kWh/annum (Taken from: (Which, 2015)])
Advantages / disadvantages of use	Advantages: • Generally bigger than freestanding cookers • Generally has an assortment of ovens, grills and hobs – between five to eight hobs, two ovens, a grill and a heated warming/storage drawer • Many range cookers have multifunction ovens – e.g. conventional, fan assisted, browning, defrost • Most popular types are dual-fuel cookers with a gas hob and electric oven • Helps to reduce cooking odours • Can be a more cost effective choice Disadvantages • - Taken from: (Which, 2015)
Easiness to use	- Generally easy to use

Table 16. Buildings-Commercial/services sector-Refrigeration

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Refrigeration**
Technology	Storage refrigeration (A)

Origin of technology	-
Cost of purchase	€3045-€3245 (Taken from: http://porkka-inventus.com/docs/Pricelist_INVENTUS.pdf [accessed 17/07/15] and based on results from http://www.topten.eu/english/professional-refrigerators/storage-refrigerators/storage-refrigerators-1-door.html [accessed 17/07/15])
Cost per kWh	Dependent on energy tariff
Average energy consumption	288-342kWh/annum
Advantages / disadvantages of use	-
Easiness to use	Easy to use and maintain

Table 17. Buildings-Commercial/services sector-Lighting

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Lighting**
Technology	LED ceiling lights
Origin of technology	-
Cost of purchase	€70-€290 (based on internet search of LED ceiling lights available in UK)
Cost per kWh	Dependent on energy tariff
Average energy consumption	20-63W (based on: http://www.topten.eu/english/lamps/office-luminaires/ceiling-mounted.html [accessed 17/07/15])
Advantages / disadvantages of use	Advantages: • LEDs are the most energy-efficient bulbs. They use 90% less energy than traditional incandescents and can sometimes pay for themselves through energy savings in just a couple of months. • LEDs claim to be ultra long lasting - lasting for 25-30 years. • LEDs give out their light almost instantly when the light switch is flicked. Disadvantages: • The LED market is currently a self-regulated market, so quality of LED bulbs can vary. • Until recently, LED light bulbs were generally only been available in lower wattages and lumen levels than other types of light bulb. • To be able to dim LED lights, a dimmer that recognises low electrical loads is required. (Taken from: (Which, 2015))
Easiness to use	Very easy to use; same fittings as halogen/CFL lighting

Table 18. Buildings-Commercial/services sector-Public street lighting

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Public street lighting**
Technology	LED
Origin of technology	-
Cost of purchase	€140-€700 (excluding installation) (based on internet search for LED street lights available in UK)
Cost per kWh	Dependent on energy tariff
Average energy consumption	60-500W (based on internet search for LED street lights available in UK)
Advantages / disadvantages of use	Advantages: • LEDs are the most energy-efficient bulbs. They use 90% less energy than traditional incandescents and can sometimes pay for themselves through energy savings in just a couple of months. • LEDs claim to be ultra long lasting - lasting for 25-30 years. Disadvantages: • The LED market is currently a self-regulated market, so quality of LED bulbs can vary. • Until recently, LED light bulbs were generally only been available in lower wattages and lumen levels than other types of light bulb. (Taken from: (Which, 2015))
Easiness to use	Very easy to use; same fittings as halogen/CFL lighting

Table 19. Buildings-Commercial/services sector-Office equipment

Sector	**Buildings**
Sub-Sector	**Commercial / services sector**
Category	**Office equipment**
Technology	Laser Multifunctional printer (colour 41-80 ipm) (MFP)
Origin of technology	-
Cost of purchase	€140-€700 (excluding installation) (based on internet search for LED street lights available in UK)
Cost per kWh	Dependent on energy tariff
Average energy consumption	1.9kWh/week (TEC) – 5.7kWh/week (TEC)
Advantages /	Advantages:

disadvantages of use	Convenience and space saving: includes fax, printer, scanner and copier, and only has one power cord so saves on wires. Cost Effective: initial cost higher, but do not have to maintain and buy several separate pieces of office equipment. Energy Savings: reduces need for several machines one all at once. Speed: MFPs often perform faster than standalone printers Disadvantages: Expensive repair and downtime costs Lack of features: whilst it offers more than one office device in one, features often only offer basic functionality Multiple functions can’t be used all at once Lack of Colour Printing Options and high cost of colour ink
Easiness to use	Easy to use and maintain but will require some specialist maintenance

1.5 Data for the Transport Sector

1.5.1 Passenger transport sector

Table 20. Transport-Passenger transport-system efficiency

Sector	**Transport**
Sub-sector	**Passenger transport**
Category	**System efficiency**
Technology	Electric vehicle charging points network
Number of technology used	Approximately 8500 charge points (OLEC, 2011)
Origin of technology	-
Cost of purchase	-
Cost per kWh	-
Energy consumption	-
Advantages / disadvantages of use	Advantages: • Charging networks provide additional EV charging support and the opportunity to extend journey distances in EV mode • New charging points are being added daily • Approximately 3400 locations have charging points (public charging points) • Number of fast charging points have increased by 1680 since July 2014 Disadvantages: • One of the main issues is the presence of several government schemes and lots of private companies installing points • A high number of different maps all competing to present charging point location • A full charge takes six to eight hours at a slow charge point • UK public charging net (taken from: http://www.thechargingpoint.com/knowledge-hub/charging-points.html and zap-map.com [accessed 06/08/15])
Easiness to use	Might not be easy having access to charger points, some companies require a membership to have access to.

Table 21. Transport-Passenger transport-Travel efficiency

Sector	**Transport**

Sub-sector	Passenger transport
Category	**Travel efficiency**
Technology	Public bicycle hire scheme – London Cycle Hire Scheme
Number of technology used	London's public bike sharing scheme, Santander Cycles, is available 24/7, 365 days a year. There are more than 10,000 bikes and over 700 bike docking stations across London to help you get around quickly and easily. The scheme includes South West London so now you can saddle up anywhere from Shepherds Bush to Canary Wharf and Wandsworth Town to Camden Town. (Taken From: http://www.visitlondon.com/traveller-information/getting-around-london/london-cycle-hire-scheme [accessed 06/07/2015])
Origin of technology	The scheme's bicycles are popularly known as Boris Bikes, after Boris Johnson, who was the Mayor of London when the scheme was launched. The scheme is sponsored, with Santander UK being the main sponsor from April 2015, Barclays Bank was the first sponsor from 2010 to March 2015, when the service was branded as Barclays Cycle Hire. (Taken from: https://tfl.gov.uk/info-for/media/press-releases/2015/february/mayor-announces-santander-as-new-cycle-hire-sponsor and http://www.corpcommsmagazine.co.uk/features/1114-boris-barclays-and-the-big-blue-branding [accessed 06/07/2015])
Cost of purchase	It costs £2 (€ 2.84) to access the bikes for 24 hour bike access, and the first 30 minutes of each journey is free. Longer journeys cost £2 (€ 2.84) for each extra 30 minutes.
Cost per kWh	-
Energy consumption	-
Advantages / disadvantages of use	Advantages: • the cycle hire scheme contributes to a city's 'healthy' status by creating more opportunities for active travel (Taken from: http://www.c3health.org/uncategorized/benefits-of-boris-bikes/ [accessed 06/07/2015]) • Easily accessible – simply hire a bike, ride it where you like, then return it to any of the hundreds of docking stations across the city • Online system & Mobile APPs which give you an update status of availability bikes around the city Disadvantages: • Increased the number of serious and fatal injury rates of cyclists in the Capital (Taken from: http://www.c3health.org/uncategorized/benefits-of-boris-bikes/ [accessed 06/07/2015]) • Over/under estimation of demand • Theft and vandalism • Conflict with pedestrians and other road users (Taken from: (DfT, 2008))

Easiness to use	Generally easy to use

Table 22. Transport-Passenger transport-Vehicle efficiency

Sector	**Transport**
Sub-sector	**Passenger transport**
Category	**Vehicle efficiency**
Technology	ZOE Renault
Number of technology used	The last two years have seen a remarkable surge in demand for electric vehicles in the UK with new registrations of plug-in cars increasing four-fold from over 3,500 in 2013 to almost 15,500 in 2014. There has also been a huge increase in the number of electric models available in the UK, Renault ZOE is one of the 10 best-selling EV. (taken from: http://www.nextgreencar.com/electric-cars/[accessed 06/08/2015])
Origin of technology	-
Cost of purchase	RENAULT Zoe has an OTR price of €19,090, annual Car Tax of €0 (Tax Band A).
Cost per kWh	Electricity cost of €0.54/mile and is congestion charge exempt. A charge costs around €4 and takes between 30 minutes and nine hours to complete.
Energy consumption	Engine/motor: 65kW Synchronous with rotor coil MPG/CO2: 169 MPG equivalent / 0 g/Km EV Range/charging: 130 miles/ Slow (3kW), Fast (22kW) and Rapid AC (43kW) (Taken from: http://www.nextgreencar.com/review/7123/ngc-electric-drive-renault-zoe/ [accessed 06/08/2015])
Advantages / disadvantages of use	Advantages: • Battery performance guaranteed to at least 75% of its original charge capacity Disadvantages: • The range in the ZOE is limited to about 100 miles of mixed driving. • The car has zero emissions, but if you take into account the carbon dioxide produced by making the electricity in the first place, the ZOE's CO2 rating is around 54g/km. • A full charge from the direct plug is upwards of 15 hours, so it's only of use for occasionally topping it it up away from home. (Taken from: http://www.autoexpress.co.uk/renault/zoe [accessed 06/07/2015])
Easiness to use	Generally easy to use and maintain

Table 23. Transport-Passenger transport-Road transport: car

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport: car short/long distance
Technology	Electric car (EV)
Number of technology used	16,497 (0.1% of the total of cars in the UK) electric cars were registered in the UK in 2014 (DfT vehicle licensing statistics, TableVEH0203, 2015).
Origin of technology	Twenty-nine models are available in the UK; the top five in 2014 were the Nissan Leaf, Mitsubishi Outlander P-HEV, Renault Zoe, Toyota Prius PHV, Vauxhall Ampera and BMW i3. The Nissan Leaf is manufactured in the UK (alongside three other countries), and in early 2015 was estimated to be the world's all time best selling highway-capable all-electric car. (Taken from: https://en.wikipedia.org/wiki/Plug-in_electric_vehicles_in_the_United_Kingdom#cite_note-UKsales092014-86 [accessed 17/07/15])
Cost of purchase	€31000-€43000 (based on internet searches of top five electric cars sold in UK)
Cost per kWh	Charging an electric car from flat to full will cost from as little as €1.50-€6 (for a typical pure-electric car with 24kWh battery, offering a 100 mile range); the average cost of 'fuel' will be approximately €0.04 per mile. (Taken from: http://www.smmt.co.uk/wp-content/uploads/sites/2/Electric-Car-Guide-2011.pdf [accessed 17/07/15])
Energy consumption	150Wh/km (Based on Nissan Leaf specification; http://www.nissan.co.uk/content/dam/services/gb/brochure/Nissan_Leaf.pdf [accessed 17/07/15]) *Passenger vehicles accounted for 2.83ktoe of the UK's total energy consumption in 2013 (DECC, 2014b).*
Advantages / disadvantages of use	Advantages: • No emissions at the point of use • A quiet driving experience • Easy to use infrastructure • Practical and easy to drive, particularly in urban stop-start traffic • Home charging is convenient and avoids queuing at petrol stations Disadvantages: • Travel distances between charges lower than in regular/hybrid car • High upfront costs in relation to similar regular/hybrid cars (Taken from: http://www.smmt.co.uk/wp-content/uploads/sites/2/Electric-Car-Guide-2011.pdf [accessed 17/07/15])
Easiness to use	Generally easy to use and maintain

Table 24. Transport-Passenger transport-Road transport: bus

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport: bus
Technology	Double deck hybrid bus
Number of technology used	1,355 operating across UK (out of a total 42,200 buses operating in the UK in 2013-2014). (Low Carbon Bus Market in the UK and Barriers to Technology Take-Up Gloria Esposito Head of Projects Low Carbon Vehicle Partnership – UK Hybrid User Forum, 12 May 2014)
Origin of technology	Four manufacturers of the diesel hybrid bus; Alexander Dennis Ltd, Wrightbus, Volvo, Optare (Low Carbon Bus Market in the UK and Barriers to Technology Take-Up Gloria Esposito Head of Projects Low Carbon Vehicle Partnership – UK Hybrid User Forum, 12 May 2014). Alexander Dennis is in the top 5 UK commercial vehicle manufacturers. Wrightbus and Optare are also British manufacturing companies (http://www.smmt.co.uk/wp-content/uploads/sites/2/SMMT-2013-Motor-Industry-Facts-guide.pdf?9b6f83 [accessed 17/07/15]).
Cost of purchase	€115000 or more Nylund, N. and Koponen, K. (2012) Fuel and Technology Alternatives for Buses Overall Energy Efficiency and Emission Performance (http://www.vtt.fi/inf/pdf/technology/2012/T46.pdf [accessed 17/07/15]).
Cost per kWh	Dependent on fuel prices
Energy consumption	3.0-3.2kWh/km (Lajunen, 2014) *Buses accounted for 1.42mtoe of the UK's total energy consumption in 2013 (DECC, 2015)*
Advantages / disadvantages of use	Expected to produce over 30% fewer CO_2 emissions than standard diesel bus; better fuel economy over standard diesel; and batteries enable greater passenger capacity. (Taken from: http://www.alexander-dennis.com/products/enviro400h/ [accessed 17/07/15])
Easiness to use	Generally easy to use and maintain

Table 25. Transport-Passenger transport-Road transport: coach

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport: coach
Technology	Standard diesel coach
Number of	In total, there were 8,300 coaches in the UK in 2013-2014 (DfT Statistics,

technology used	Table BUS0601, 2015)
Origin of technology	There are approximately 10 bus and coach manufacturers based in the UK (http://www.smmt.co.uk/wp-content/uploads/sites/2/SMMT-2013-Motor-Industry-Facts-guide.pdf?9b6f83 [accessed 17/07/15])
Cost of purchase	-
Cost per kWh	-
Energy consumption	Unknown; believed to be included in passenger vehicle energy consumption figures (DECC, ECUK,2014)
Advantages / disadvantages of use	-
Easiness to use	Generally easy to use and maintain

Table 26. Transport-Passenger transport-Road transport: motorbike

Sector	**Transport**
Sub-sector	Passenger transport
Category	Road transport: motorbike
Technology	1000cc+ motorbike
Number of technology used	196946 (16% of total) in Great Britain in 2014 (DfT vehicle licensing statistics, Table VEH0306, 2015)
Origin of technology	The top five major brands (according to the motorcycle industry association; http://www.mcia.co.uk/Press-and-Statistics/NewReg_Statistics.aspx [accessed 17/07/15]) in the UK at the end of 2014 were Honda, Yamaha, BMW, Piaggio and Triumph. Triumph is a British motorbike company (manufacturing in UK (39% of total output) and Thailand (61% of total output)). The company sold more than 52,000 bikes in 2013 and held a 20% share of the UK market for 500cc+ motorcycles as well as increasing its global market share to 6.2% in 2013. Approximately 86% of Triumph motorcycles were exported to more than 50 countries across Europe, North and South America, Australasia, Africa and Asia in 2013. ICF Consulting services (2015) Economic Benefits of the UK Motor Cycle Industry 2014 (http://www.mcia.co.uk/Press-and-Statistics/Resources/Category/Research.aspx [accessed 17/07/15])
Cost of purchase	€5000-€169600 (based on internet search of available motorbikes)
Cost per kWh	Dependent on fuel prices
Energy consumption	*Motorbikes accounted for 0.16mtoe of the UK's total energy consumption in 2013 (DECC, 2015)*
Advantages / disadvantages of use	-

Easiness to use	Generally easy to use and maintain

Table 27. Transport-Passenger transport-Rail transport

<table>
<tr><th>Sector</th><th>Transport</th></tr>
<tr><td>Sub-sector</td><td>Passenger transport</td></tr>
<tr><td>Category</td><td>Rail transport: short/long distance</td></tr>
<tr><td>Technology</td><td>Super voyager trains (Class 221)</td></tr>
<tr><td>Number of technology used</td><td>There are 44 sets of super voyager trains in the UK (Virgin Trains have 21, and CrossCountry have 23).
(Taken from: https://en.wikipedia.org/wiki/British_Rail_Class_221 [accessed 17/07/15])</td></tr>
<tr><td>Origin of technology</td><td>Manufactured in Belgium.</td></tr>
<tr><td>Cost of purchase</td><td>Unknown (leased to rail operators)</td></tr>
<tr><td>Cost per kWh</td><td>Dependent on fuel prices</td></tr>
<tr><td>Energy consumption</td><td>Power output 560kW per car
(Taken from: https://en.wikipedia.org/wiki/British_Rail_Class_221 [accessed 17/07/15])
Rail Transport Energy Consumption
<table>
<tr><th>Fuel Type</th><th>Coal[4]</th><th>Coke & breeze</th><th>Electricity[4,5]</th><th>Petroleum products</th><th>Total</th></tr>
<tr><td>Energy consumed (ktoe)</td><td>10</td><td>-</td><td>350</td><td>700</td><td>1,060</td></tr>
</table>
Notes: Table believed to include both passenger and freight rail.
Table taken from: (DECC, 2015)</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>-</td></tr>
<tr><td>Easiness to use</td><td>Generally easy to use and maintain</td></tr>
</table>

Table 28. Transport-Passenger transport-Navigation

Sector	**Transport**
Sub-sector	**Passenger transport**
Category	**Navigation: short/long distance**
Technology	**Passenger ferry**
Number of technology used	In 2014 the number of international short sea(ferry) passengers travelling increased to 21.3 million, a 4 per cent rise from 2013.

	Since opening in 1994, the trends in the number of passengers travelling via the Channel Tunnel and by sea have steadily converged. Channel Tunnel passengers exceeded those on international short sea journeys for the first time in 2012. Dover - Calais remained the busiest route carrying 10.8 million passengers in 2014, this was an increase of 3 per cent compared to the previous year. This route accounted for 51 per cent of all short sea journeys (DfT, 2015a)
Origin of technology	-
Cost of purchase	-
Cost per kWh	-
Energy consumption	*Water transport accounted for 2013Mtoe of the UK's total energy consumption in 2013 (DECC, 2015)*
Advantages / disadvantages of use	-
Easiness to use	-

Table 29. Transport-Passenger transport-Aviation

Sector	**Transport**
Sub-sector	**Passenger transport**
Category	**Aviation: short distance**
Technology	**Boeing 737**
Number of technology used	Worldwide: 8,350 produced in total (http://www.b737.org.uk/sales.htm) and 1,159 active in 2014 (http://www.airfleets.net/exploit/production-b737-0.htm [accessed 06/07/2015]) 98 active and 24 stored Boeing 737's are registered to operational airlines in the UK (http://www.airfleets.net/recherche/country.htm [accessed 06/07/2015]).
Origin of technology	All Boeing 737's are manufactured in America, but Boeing has a strong presence in the UK; their induced employment impact was estimated to have equalled approximately 5750 jobs throughout the UK, in 2012. (http://www.boeing.co.uk/resources/en_UK/media/Boeing-in-the-UK/About-Boeing-in-the-UK/Boeing_in_the_UK_brochure_FINAL.pdf [accessed 06/07/2015]).
Cost of purchase	$61.5 million to $69.5 million (http://www.b737.org.uk/sales.htm [accessed 06/07/2015])
Cost per kWh	-

Energy consumption	*Air travel accounted for 12,258ktoe of the UK's total energy consumption in 2013 (DECC, 2015)*
Advantages / disadvantages of use	-
Easiness to use	-

1.5.2 Freight Transport Sector

Table 30. Transport-Freight-System efficiency

Sector	**Transport**
Sub-sector	Freight transport
Category	System efficiency
Technology	Strategic Freight Network (SFN) - European Rail Freight Corridor
Number of technology used	Using funding committed in Control Period 4 (2009-2014), Network Rail has coordinated the development of the SFN on behalf of the industry and the DfT. The SFN can be viewed as a network of core trunk routes with sufficient capacity and appropriate gauge to carry the expected major flows of freight. The resulting SFN forms an extensive network. The SFN is intended to provide sufficient flexibility to enable increased availability of the network for freight against the background of growth in both the passenger and freight markets. With appropriate investment to increase capacity and gauge, it should be able to accommodate growth (mostly anticipated from the main ports and domestic containers), enable routeing of more freight traffic away from London and reduce conflicts with passenger services, where possible. It should also enable the development along a number of major internal axis of freight market flows. (Taken from: *NetworkRail, Aug. 2012, European Rail Freight Corridor Linking UK and Continental Europe*)
Origin of technology	The concept for the Strategic Freight Network ("SFN") in England and Wales was established in 2007 as part of the government's high level strategy to address the growing demands on the network for moving passengers and freight. (Taken from: *NetworkRail, Aug. 2012, European Rail Freight Corridor Linking UK and Continental Europe*)
Cost of purchase	-
Cost per kWh	-
Energy consumption	-
Advantages /	Advantages:

disadvantages of use	• High volume movements compare with land-based modes • Good fuel efficiency • Relatively high speed and good penetration of urban city centres Disadvantages: • Delays and restrictions, due to mixed use passenger-freight transport on the same rail network (Taken from: http://www.theitc.org.uk/itc-debates-freight-efficiency-in-the-uk/ [accessed 06/07/2015])
Easiness to use	-

Table 31. Transport-Freight-Travel efficiency

Sector	**Transport**
Sub-sector	Freight transport
Category	Travel efficiency
Technology	European Railway Traffic Management System (ERTMS) Infrastructure
Number of technology used	ERTMS is one of the projects funding under CP5 (2014-2019) Enhancements Delivery Plan of the Network Rail. Output - ETCS (European Train Control Systems) level 2 systems will: • reduce the cost of signalling renewals (when installed with no lineside signals); • reduce the cost of signalling maintenance (when installed with no lineside signals); • improve safety through continuous automatic train protection; • provide the opportunity for enhanced operational capability and increased capacity (when installed with no lineside signals); and • afford regulatory compliance to Railway Interoperability Regulations (2011). (Taken from: *NetworkRail, March 2015, CP5 Enhancements Delivery Plan*)
Origin of technology	*"Only 17 % of freight are carried by rail in the EU, whereas the figure for the US - the land of highways - stands at about 38%. Given the current variety of national systems, it will be impossible to strongly increase this percentage unless we overcome segmentation along national borders. It is therefore indispensable to make a clear commitment to investing in ERTMS as a matter of priority."* (Taken from: Micheal Cramer's speech, Copenhagen, 16/04/2012, *ERTMS Conference in Copenhagen; http://www.michael-cramer.eu/en/transport-policy/single-view/article/rede-von-michael-crame/* [accessed 06/07/2015]) The scope is to synchronise projects in order to commission Level 2 ETCS European Train Control Systems on the East Coast Main Line (ECML) and Western Main Line (WML) whilst ensuring the optimum industry efficiency. It is also planned to implement ERTMS as an overlay on the remainder of the WML, Paddington-Bristol South including spurs to Oxford and Newbury by

	July 2019. (Taken from: *NetworkRail, March 2015, CP5 Enhancements Delivery Plan*)
Cost of purchase	ETCS is one of the projects funding under CP5 (2014-2019) Enhancements Delivery Plan of the Network Rail. The Programme is covering a period of five years that includes some 5,000 projects. (Taken from: http://www.networkrail.co.uk/publications/delivery-plans/control-period-5/cp5-delivery-plan/ [accessed 06/07/2015])
Cost per kWh	-
Energy consumption	ERTMS include an electrification programme which intends to increase regional and national connectivity and support economic development by creating a high capability 25kV electrified passenger and freight routes. (Taken from: *NetworkRail, March 2015, CP5 Enhancements Delivery Plan*)
Advantages / disadvantages of use	Advantages: • Increased capacity on existing lines and greater ability to respond to growing transport demands • Higher speeds, ERTMS allows for maximum speed up to 500 Km/h • Reduced maintenance costs • An opened supply market, customers will be able to purchase equipment for installation anywhere in Europe and all suppliers will be able to bid for any opportunity. Trackside and onboard equipment may be made by any of the six ERTMS suppliers, which makes the supply market more competitive Disadvantages: • Necessity to standardize railway system to allow locomotive run on all 20 countries part of the ERTMS programme (Taken form: http://www.ertms.net/?page_id=44 and http://www.michael-cramer.eu/en/transport-policy/single-view/article/rede-von-michael-crame/ [accessed 06/07/2015])
Easiness to use	-

Table 32. Transport-Freight-Vehicle efficiency

Sector	**Transport**
Sub-sector	Freight transport
Category	Vehicle efficiency
Technology	C2G Ultra Biofuel
Number of technology used	C2G Ultra Biofuel is the premium advanced biofuel solution from Convert2Green. Fully proven on Euro 6 engines, Ultra Biofuel is a dual fuel technology and Ultra Biofuel, processed from used cooking oils (UCO) and animal fats, this solution gives commercial fleet operators the opportunity to achieve a real competitive advantage through lower fleet running costs, whilst lowering greenhouse gases (EBTP, 2015).

	In 2014-15: • 1,356 million litres of renewable fuel have been supplied, which is 3.54% of total road and non-road mobile machinery fuel. 1,013 million litres (75%) of this renewable fuel has so far been demonstrated to meet the sustainability requirements of the RTFO. • 1,529 million RTFCs have been issued to fuel meeting the sustainability requirements, of which 1,032 million were issued to double counting feedstocks. • Of the 1,013 million litres so far meeting the sustainability requirements, biodiesel (FAME) comprised 50% of supply, bioethanol 49% and biomethanol 1%. There were also small volumes of biogas and off road biodiesel (DfT, 2015b).
Origin of technology	Characteristics of the biofuels to which Renewable Transport Fuel Certificates (RTFCs) have been issued: • The most widely reported source for biodiesel (by feedstock and country of origin) was used cooking oil from the UK (85 million litres, 8% of total fuel, 17% of biodiesel). • The most widely reported source for bioethanol (by feedstock and country of origin) was corn from the Ukraine (82 million litres, 8% of total fuel, 16% of bioethanol). • 51% of fuel was made from a waste/non-agricultural residue (double counting) feedstock. • 29% of the fuel was sourced from UK feedstocks. (DfT, 2015b)
Cost of purchase	-
Cost per kWh	-
Energy consumption	-
Advantages / disadvantages of use	Advantages: • Offer a massive 97% greenhouse gas emission saving against the use of mineral diesel in road transport. • Energy from waste – producing biofuel from the used cooking Oil (UCO)
Easiness to use	United Biscuits (UB) is a leading manufacturer of biscuits and snacks, producing some of Europe's best loved brands, such as McVities, KP and Jacobs. This partnership has played a key role in the Department for Transport's Low Carbon Truck Demonstration, which commenced in 2012 with £11m of Government funding to assess the performance of various alternative low carbon fuels in the 'real world' and their potential to reduce carbon emissions in LGVs. Early results show that the Ultra Biofuel solution is fully compatible with the latest engine technology (EURO6); matches the fuel efficiency of mineral diesel; and has proven carbon savings in real world conditions (EBTP,

	2015).

Table 33. Transport-Freight-Road transport: truck

Sector	**Transport**
Sub-sector	Freight transport
Category	Road transport: truck
Technology	Rigid HGV
Number of technology used	264300 registered in 2014 (DfT, 2015, vehicle licensing statistics, Table VEH0524)
Origin of technology	There are approximately 80 truck manufacturers based in the UK (https://en.wikipedia.org/wiki/List_of_truck_manufacturers#Europe [accessed 06/07/2015]). Market share of manufacturers is unknown.
Cost of purchase	-
Cost per kWh	-
Energy consumption	*Rigid HGVs accounted for 3.38mtoe of the UK's total energy consumption in 2013; HGVs (rigid and articulated accounted for 7.8mtoe (DECC, ECUK, 2014, Table 2.02: Road transport energy use[1] by vehicle type2, split by DERV and petrol 1970 to 2013)*
Advantages / disadvantages of use	-
Easiness to use	-

Table 34. Transport-Freight-Rail transport

Sector	**Transport**
Sub-sector	Freight transport
Category	Rail transport: short/long distance
Technology	
Number of technology used	Freight rail accounted for 21000million freight tonnes/km in 2011 ((DECC, 2015). • The rail freight industry directly contributes £870 million to the nation's economy every year, but supports an economic output of £5.9 billion, six times its direct turnover. • In 2011/12 rail freight transported 101.7 million tonnes of goods worth over £30 billion. • Each freight train takes about 60 HGVs off the roads (Taken from: http://www.networkrail.co.uk/aspx/10439.aspx [accessed 06/08/2015])

<table>
<tr><td>Origin of technology</td><td>-</td></tr>
<tr><td>Cost of purchase</td><td>-</td></tr>
<tr><td>Cost per kWh</td><td>-</td></tr>
<tr><td>Energy consumption</td><td>
Rail Transport Energy Consumption
<table>
<tr><th>Fuel Type</th><th>Coal[4]</th><th>Coke & breeze</th><th>Electricity[4,5]</th><th>Petroleum products</th><th>Total</th></tr>
<tr><td>Energy consumed (ktoe)</td><td>10</td><td>-</td><td>350</td><td>700</td><td>1,060</td></tr>
</table>
Note: totals believed to include both passenger and freight.
Table taken from: (DECC, 2015)
</td></tr>
<tr><td>Advantages / disadvantages of use</td><td>
Advantages:

Moving goods by rail is increasingly the most cost-effective way of transporting freight.
Saving both money and greenhouse gas emissions (less fuel is needed to transport a tonne of goods by rail than by road)

(taken from: NetworkRail, April 2013, Value and importance of rail freight)
</td></tr>
<tr><td>Easiness to use</td><td>-</td></tr>
</table>

Table 35. Transport-Freight-Navigation

<table>
<tr><th>Sector</th><th>Transport</th></tr>
<tr><td>Sub-sector</td><td>Freight transport</td></tr>
<tr><td>Category</td><td>Navigation: short/long distance</td></tr>
<tr><td>Technology</td><td>Container vessels</td></tr>
<tr><td>Number of technology used</td><td>
The world's merchant fleet as of 1st Jan 2014 was around 50,000, some 16,800 ships were bulk carriers; 10,300 Cargo ships and 5,100 Container ship.
(Taken from: http://www.statista.com/statistics/264024/number-of-merchant-ships-worldwide-by-type/ [accessed 06/07/2015])
(Taken from: DfT, Feb 2015, Shipping Fleet Statistics 2014, "UK type of Vessels.
<table>
<tr><td>UK registered vessels 2014</td><td>60%</td></tr>
<tr><td>UK direct owned vessels 2014</td><td>35%</td></tr>
</table>
Container ship")
</td></tr>
<tr><td>Origin of technology</td><td>-</td></tr>
<tr><td>Cost of purchase</td><td>The oversupply of container ship capacity has caused prices for new and used ships to fall.
(Taken from: UNCTAD 2010 P.53, P57)</td></tr>
<tr><td>Cost per kWh</td><td>-</td></tr>
</table>

Energy consumption	*Water transport accounted for 0.8Mtoe of the UK's total energy consumption in 2013 (DECC, 2015)*
Advantages / disadvantages of use	-
Easiness to use	-

Table 36. Transport-Freight-Aviation

Sector	**Transport**
Sub-sector	Freight transport
Category	Aviation
Technology	Air cargo
Number of technology used	In 2013 2,304 Thousand Tonnes of Freight handled (set down and picked up) is registered in the UK's Airports. (Taken from: *CAA, July 2015, table AVI01010 – Air traffic UK airports 1950-2014*)
Origin of technology	-
Cost of purchase	-
Cost per kWh	-
Energy consumption	*Air transport accounted for 12.4Mtoe of the UK's total energy consumption in 2013 (DECC, 2015)*
Advantages / disadvantages of use	-
Easiness to use	-

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