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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

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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/m²y 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 m² 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

	39 MW_{th} in the residential sector by 2020 (CODE2, 2014).
Origin of technology	National and imported products.
Cost of purchase	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)
Cost per kWh	The cost depends on the gas/biomass/electricity prices. Indicatively, for household/tertiary sector the prices for 2009-2012 were (in €/MWh) (CODE2, 2014): (see table below) 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).

Year	**Natural gas**	**Electricity**
2009	38	105
2010	45	97
2011	59	102
2012	68	106

[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.

[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]

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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

	Measurement and Control devices.
Number of technology used	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.
Origin of technology	National and imported products.
Cost of purchase	N/A
Cost per kWh	This depends on the fuel prices.
Energy savings	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):

Device	**Savings (reduction in propulsion fuel consumption)**	**Cost (depending on the device)**
Wake Equalizing and Flow Separation Alleviating Devices	0-5%	Low to medium-low
Pre-swirl Devices	2-6%	Medium-low
Post-swirl Devices	2-6%	Medium-low
High-efficiency Propellers	3-10%	Medium-low

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

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