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TECHNOLOGICAL TRENDS – NATIONAL REPORT FOR UK

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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-

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><td>Category</td><td>Space Heating</td></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])

Origin of technology	-
Cost of purchase	-
Cost per kWh	-
Energy consumption	Rail Transport Energy Consumption Fuel Type | Coal[4] | Coke & breeze | Electricity[4,5] | Petroleum products | Total Energy consumed (ktoe) | 10 | - | 350 | 700 | 1,060 Note: totals believed to include both passenger and freight. *Table taken from: (DECC, 2015)*
Advantages / disadvantages of use	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)
Easiness to use	-

Table 35. Transport-Freight-Navigation

Sector	**Transport**
Sub-sector	Freight transport
Category	Navigation: short/long distance
Technology	Container vessels
Number of technology used	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.* UK registered vessels 2014 | 60% UK direct owned vessels 2014 | 35% *Container ship")*
Origin of technology	-
Cost of purchase	The oversupply of container ship capacity has caused prices for new and used ships to fall. (Taken from: *UNCTAD 2010 P.53, P57)*
Cost per kWh	-

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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