DRAFT REPORT

Capturing the full electricity efficiency potential of the U.K.

July 2012

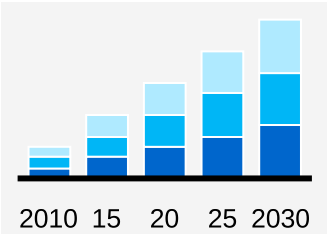
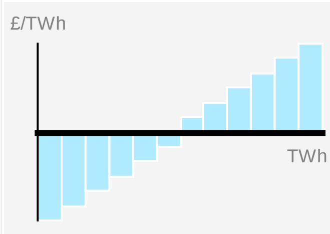
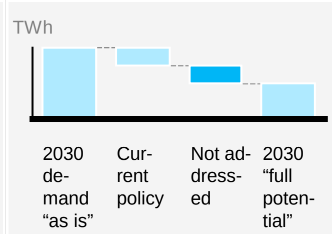
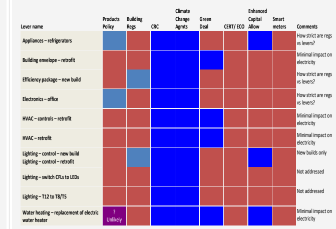
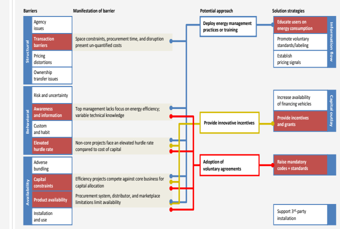
Draft Report on capturing the full electricity efficiency potential of the UK

This is a draft report still undergoing peer review by the Department of Energy and Climate Change.

In order to assist in this peer review process, the Department would welcome comments before publishing a final report.

Any comments should be directed to Tim.Deverell@decc.gsi.gov.uk by 10th August 2012

The project has been structured in 5 phases

	Define baseline electricity demand for the U.K.	Identify key measures and abatement potential	Estimate abatement potential of current policies	Analyse barriers to additional potential being realised	Identify and analyse design options
					
Focus	• Project U.K. electricity demand to 2030 using DECC model • Define and analyse impact of potential “game changing” scenarios	• Identify key measures to reduce energy demand across residential, commercial and industrial sectors • Estimate savings potential and cost of each lever	• Estimate likely portion of total abatement potential addressed by current policy based on impact assessments and interviews	• Identify and prioritise barriers pre-venting the realisation of remaining abatement potential using interviews with users, utilities, finance providers and industry bodies	• Evaluate alternative design options based on existing hypotheses, interviews and inter-national examples
Value to DECC	• Provide a common reference baseline for assessing abatement potential • Assessment of ‘game changing’ scenarios	• Specific electricity efficiency measures across sectors with quantified potential and costs	• Clear identification of current policy impact at measure level and quantification of remaining electricity reduction potential	• Measure-level under-standing of barriers with high-level electricity reduction potential at stake	• Comprehensive list of design options to address barriers • Case studies on four mutually agreed design options

The scope of the project was very focused

Objective of this project

- Review DECC projections and establish baseline of electricity demand projections until 2030 with scenarios on game changers (electric vehicles and electrification of heating)
- Assessment of efficiency measures to decrease electricity use across sectors and end-uses
- High-level estimate of savings potential of current policies and estimate of additional efficiency potential
- Analysis of barriers to implementation and scenario analysis of design options to overcome barriers
- High-level assessment of market development for energy efficiency
- High-level recommendations for a monitoring and verification mechanism based on case-studies of similar mechanisms

Scope

In scope

- **Permanent end-use reduction in electricity demand** in the U.K.
- Residential, industrial and commercial uses of electricity
- Technical and economic considerations in implementing efficiency solutions
- Alternate mechanisms options to achieve full efficiency potential

Out of scope

- Gas and other fuel use in the U.K.
- Demand shifting away from system stress hours (Demand Response projects)
- Improvements in generation efficiency
- Improvements in transmission and distribution efficiency
- Micro-generation and distributed generation
- Improvements in transportation efficiency (e.g., rail system)
- Political and social aspects of implementing efficiency solutions
- Policy recommendations and changes to EMR

Executive summary

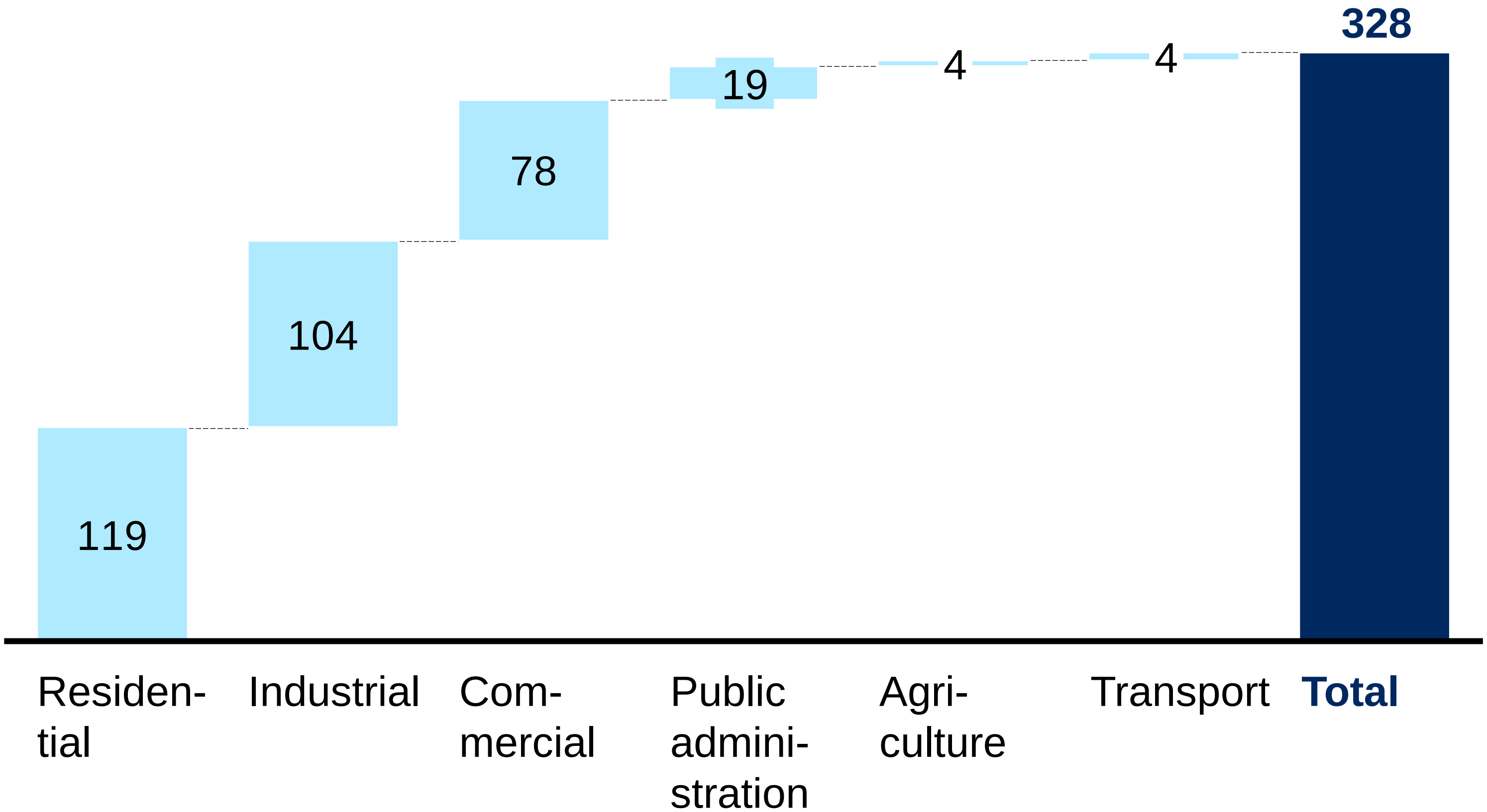
- **Absent any policy intervention, moderate growth in underlying UK electricity demand is projected to 2030, with two electrification scenarios likely to add to that growth**
  – Underlying demand is projected to grow to ~411 TWh in 2030 (CAGR ~0.7%), excluding impact of policy
  – Electrification of vehicles and heating could add an additional ~5-15% to electricity demand in 2030
- **We have identified ~155 TWh (~40% of total demand) of demand reduction potential in 2030 across all three sectors, of which current policy is estimated to capture ~54 TWh (~35% of total potential)**
  – Our analysis has focused on the 3 largest categories of abatement measures per sector which together are estimated to deliver ~127 TWh of savings (~80% of total potential)
  – Residential: top three measures have a potential of ~58 TWh reflecting CFL lighting, appliances and better insulation, of which ~75% is expected to be captured through current / planned policies (primarily Products Policy)
  – Services: top three measures have a potential of ~45 TWh, reflecting better insulation, lighting controls and HVAC, of which ~15% is expected to be captured through current / planned policies
  – Industrial: top three measures have a potential of ~24 TWh, reflecting pump, motor and boiler optimisation, of which ~5% is expected to be captured through current / planned policies
  – Impact of broad policies (e.g. CRC, CCAs) on electricity demand is expected to be incremental to specific policies
  – In 2020, the abatement potential is estimated at ~115 TWh of which ~60% is expected to be captured by current policy
- **Through stakeholder interviews, comparisons with other markets and supporting analysis, we have identified 11 key insights on barriers to capturing the remaining demand reduction potential including:**
  – Insights generated through this process range from policy to market maturity & costs to segment specific barriers in residential, industrial and commercial
- **Design options**
  – Design options can be split into 8 categories, each impacting a number of barriers. These range from market based mechanisms (financing, pricing) to mandate-based mechanisms (taxes, supplier obligations)
  – 4 case examples: ISO New England, Public Utility Commission Texas, Connecticut Energy Saving & EPA Portfolio Manager selected for further analysis given market advancement in the US and mechanism applicability in UK EMR context
  – Key lessons and insights from cases indicate that in order for market based incentives to address barriers, they would need to enhance payback periods, overcome agency issues and mitigate uncertainty

Contents

The U.K.'s 2010 electricity demand was 328 TWh, of which the residential sector was largest

Breakdown of U.K. electricity demand by sector

TWh, 2010



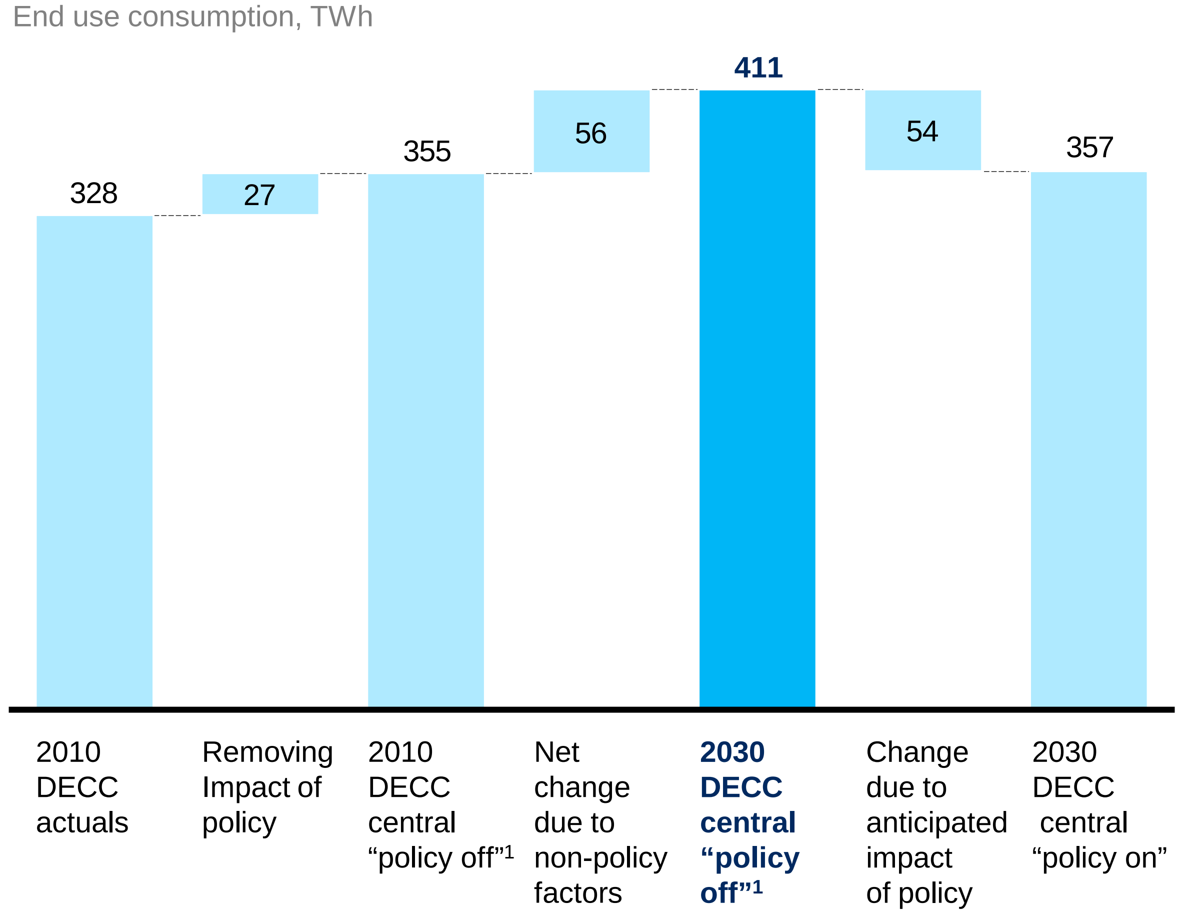
Source: DECC ECUK/DUKES statistics on final consumption of electricity

Underlying U.K. electricity demand is projected to be ~411 TWh in 2030, excluding the impact of current or future policy

Projection methodology

- Historic U.K. electricity use data based on DUKES data published by DECC
- U.K. electricity demand to 2030 based on DECC projections including estimated direct impact of policy due to
  - Increased demand due to demographics and economic growth
  - Reduced demand due to historic trend towards increase in natural energy efficiency
  - Impact of current policy
- Estimated impact of policy on reduction of electricity demand added back to estimate a 2030 'policy off'[1] baseline
- "Policy off" baseline removes the effect of current and future policy impact on consumption projections except for policies which impact the electricity price[1]
- The 2030 policy off baseline allows layering of energy efficiency measures to reduce projected demand and estimate full energy abatement potential

Electricity consumption evolution in U.K., 2010–30



1 "Policy off" includes ETS policies and price impact of policies including the cost of recovery for Supplier Obligation abatement, CRC permits and the bill cost of EU ETS

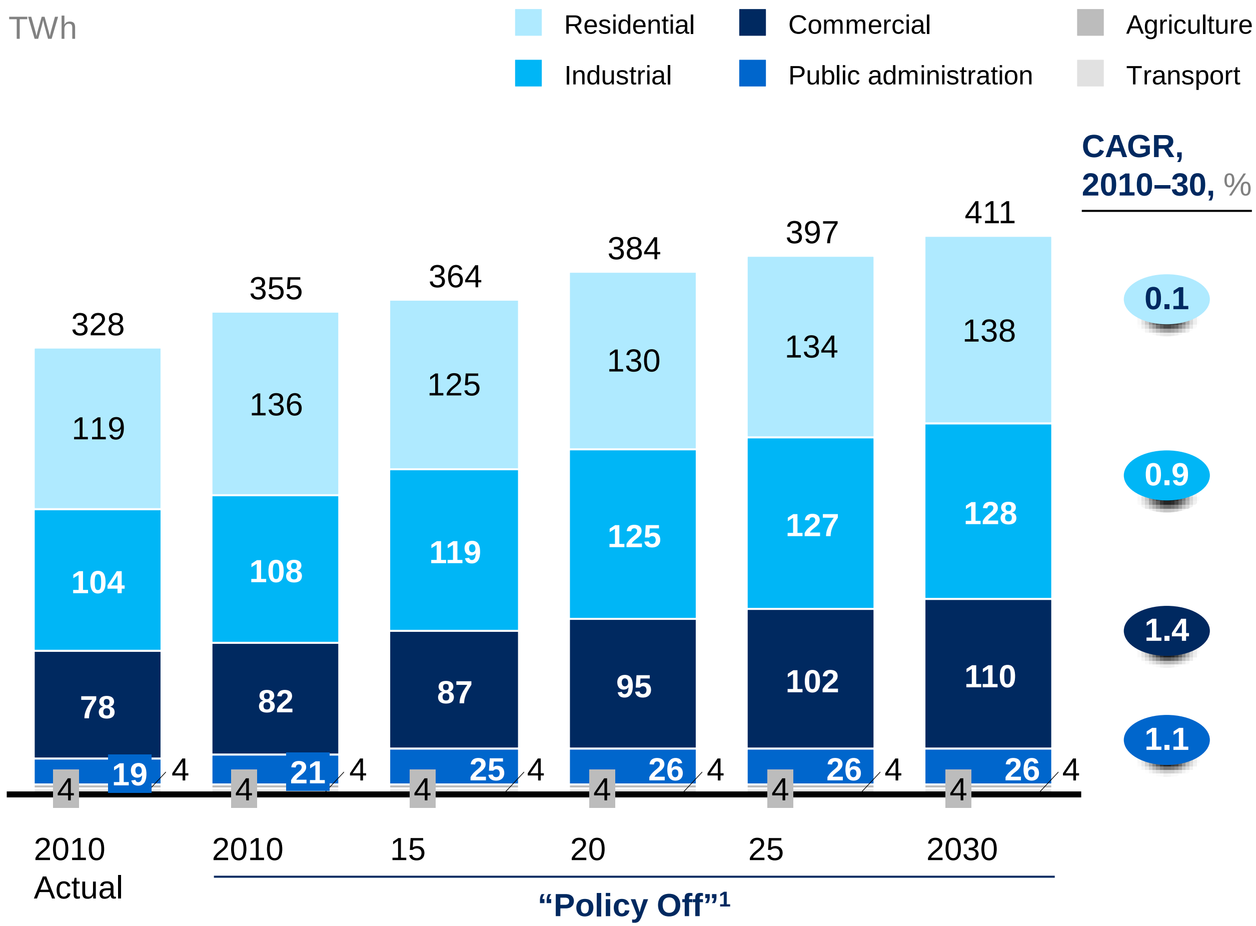
Source: DECC ECUK/DUKES statistics on final and projected consumption of electricity; team analysis

Electricity demand growth is expected to be driven by the commercial and industrial sectors

Methodology and assumptions

- DECC projections based on a historic regression of energy demand against a number of drivers, differentiated by sector and industry
- Key assumptions are in line with IAG guidance and include:
  - GDP growth: 2.3% p.a. from 2010-2030
  - Employment: 0.15% growth p.a. 2010-2030
  - Population growth: 0.52% p.a. 2010-2030
  - Electricity prices: wholesale and retail 3.65% p.a. rise 2010-2030
- DECC projections include expected impact of historic trend towards increased energy efficiency

U.K. end-user electricity demand evolution by sector, 2010–30



1 Includes policy costs, excludes cost of EU ETS allowances

Source: DECC ECUK/DUKES statistics on final and projected consumption of electricity

The combined impact of scenarios on EV and electrification of heating could lead to a ~6-14% increase in total U.K. electricity demand

Low case
Medium case
High case

Scenarios Total electricity demand, 2030 TWh		Potential contribution to total U.K. electricity demand in 2030 % Low	Medium	High	Key assumptions driving medium case
Electric vehicles	17 / 5 / 4 → 26	4	5	6	• Includes plug-in hybrid vehicles (PHEV) and battery vehicles (BEV) • Assumes average carbon emissions per km of new cars of 75 g/km by 2030 • Assumes 2030 penetration of 15% for PHEVs and 13% EVs
+					
Electrification of heating	8 / 8 / 16 → 32	2	4	8	• Includes both air source and ground source heat pumps (primarily domestic) • Assumes ~4 million heat pumps by 2030 (~14% of U.K. households)
=					
Total	25 / 13 / 20 → 58	6	9	14	

Source: ‘Boost! Transforming the powertrain value chain – a portfolio challenge’, McKinsey & Company (2011); team analysis

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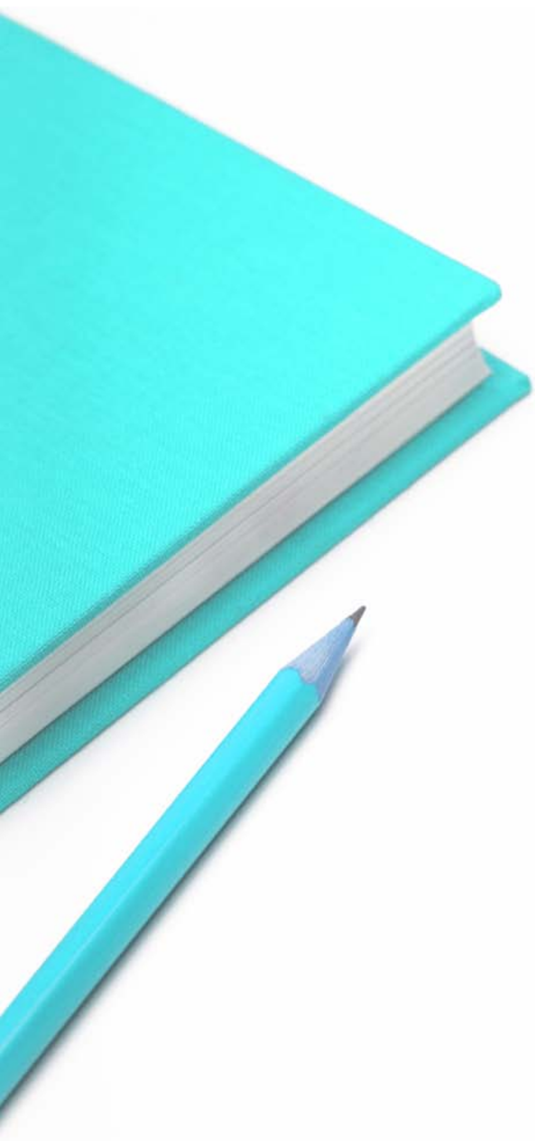


Methodology behind cost curve analysis

Methodology

- **Baseline**
  - Based on DECC baseline
  - Selected analysis to split data as per requirements
- **Abatement**
  - Measures for residential, commercial and public admin sectors based on inputs from
    - Industry experts
    - International research organizations (e.g., IEA, UNEP), academic bodies (e.g., UC Berkeley Program on Housing and Urban Policy)
    - Government bodies (e.g., EPA)
    - Vendor interviews
  - Measures for the industrial sector are based on reports from government bodies (e.g., EPA) and key macro economic inputs
- **Macro inputs**
  - Discount rate (10.5%, 2010-30) from DECC
  - Electricity cost[1] (6-12p/kWh, 2010-30) from IAG
  - Carbon price[2] (£13-74/tCO_2e, 2010-30) from IAG

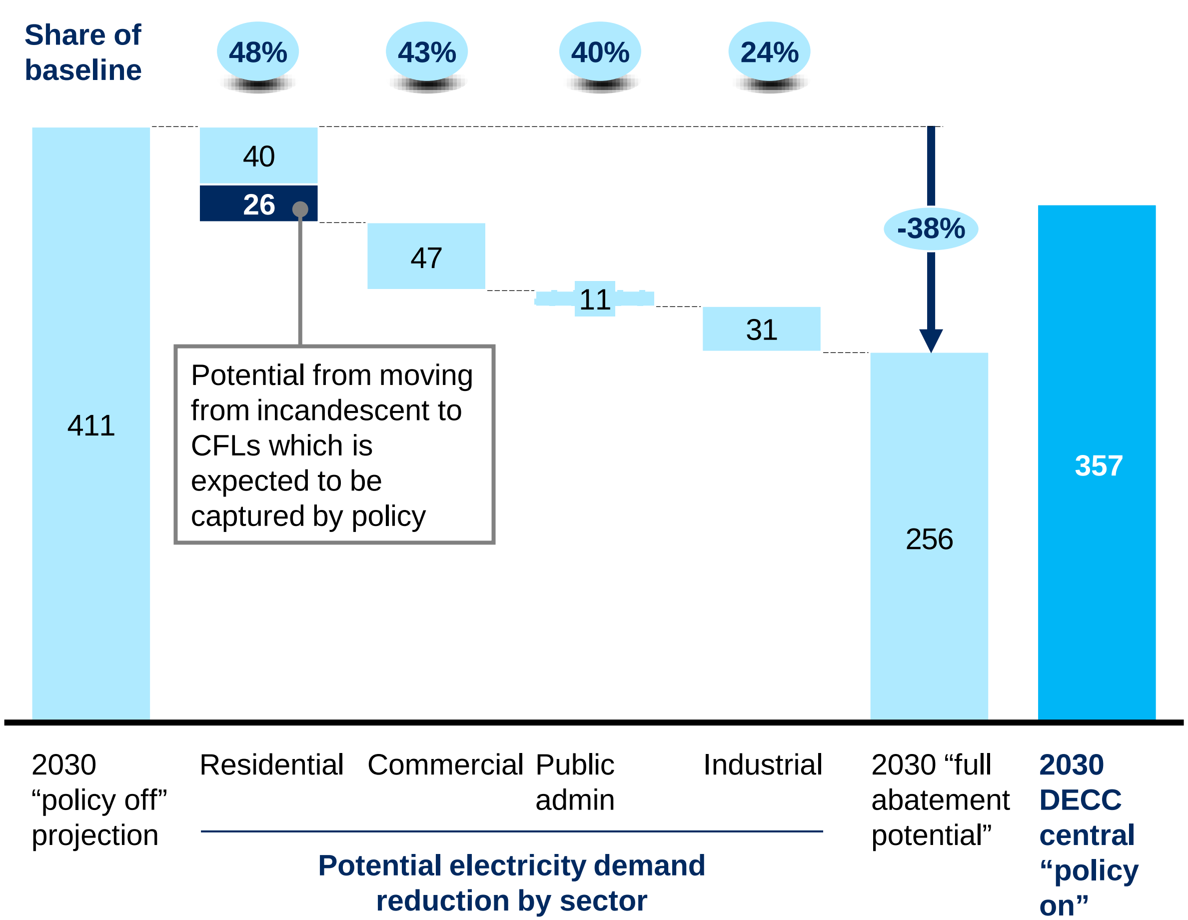
Scope of calculations

- **Abatement calculations include**
  - Reduction in electricity consumption as a direct influence of abatement measures
  - Based on “natural replacement cycle” i.e., replacement by new technology only when old technology retires, however, in the 2030 timeframe, this impacts potential of measures with a lifetime greater than 20 years
  - Comfort taking benefits in residential building shell measures i.e., a minor share of electricity consumption reduction is utilized for other applications, thus reducing abatement potential
- **Abatement calculations do not include**
  - Non-electricity energy reduction which might happen as a side effect of a measure
  - Knock on consequences (indirect effects of measures, e.g., increased electricity consumption of HVAC systems due to switch from incandescent bulbs to CFLs)
  - Purely behavioral measures (e.g., lesser electricity usage through increased public awareness)
- **Cost calculations include**
  - Investment costs calculated with economic amortization period and capital costs
  - Savings from reduced electricity use (for building shell measures also includes savings from reduced gas usage)
  - Savings from reduced carbon costs due to mitigation of electricity and gas use
  - Comfort taking benefits i.e., a minor share of electricity savings is calculated using the retail price of electricity
- **Cost calculations do not include**
  - Subsidies and taxes
  - Communication, information and transaction costs
  - Knock on consequences for other fuels
  - Rebound effect
  - Indirect costs, e.g., disruptive costs

1 Refers to production cost of electricity, not retail price
2 Traded price of CO_2 used for CO_2 saved by reduced electricity consumption and social cost of CO_2 used for CO_2 saved by reduced gas consumption

If implemented in full, electricity efficiency measures have the potential to reduce UK electricity demand by ~155 TWh per annum by 2030

UK electricity demand, 2030, TWh



Key insights

The key drivers for each sector are

- **Residential**: Improved **insulation**, more efficient **appliances** and shifting from **incandescent to CFLs**
- **Commercial:** Improved **insulation** and the use of **lighting controls**
- **Public admin:** Improved **insulation** , the use of **lighting controls** and using **LEDs in street lighting**
- **Industrial:** Technical improvement and usage optimization of **motors**[1],**pump** optimization and **improved boilers**

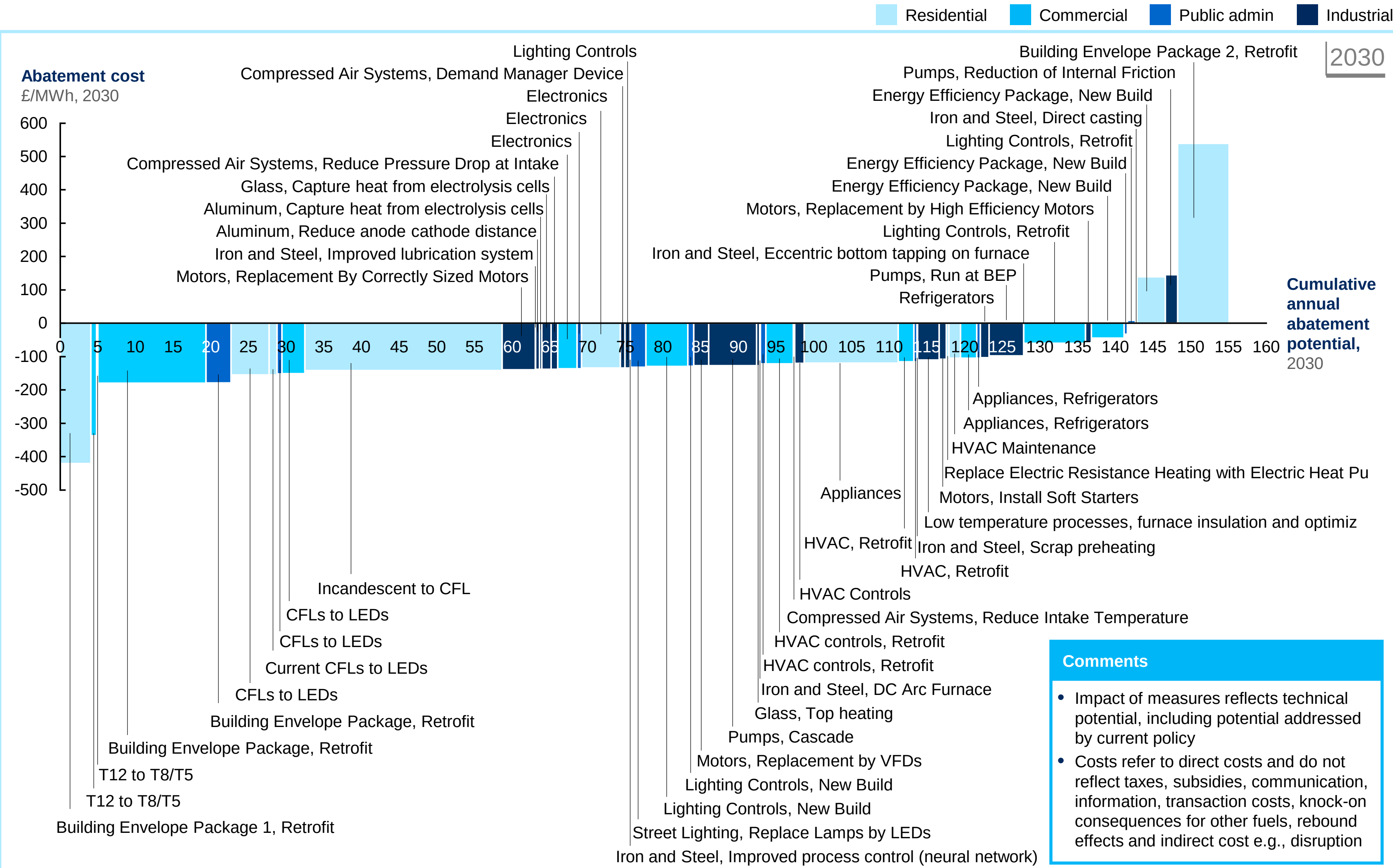
Comments

- Impact of measures reflects technical potential, including potential addressed by current policy
- Costs refer to direct costs and do not reflect taxes, subsidies, communication, information, transaction costs, knock-on consequences for other fuels, rebound effects and indirect cost e.g., disruption

1 Includes measures for optimization of motor operation, replacement of oversized motors by correct size and use of variable speed drives

Source: Team analysis

Achieving full potential will mean implementing a spectrum of solutions with varying savings and costs



Comments

- Impact of measures reflects technical potential, including potential addressed by current policy
- Costs refer to direct costs and do not reflect taxes, subsidies, communication, information, transaction costs, knock-on consequences for other fuels, rebound effects and indirect cost e.g., disruption

Note: Key assumptions for 2030: Discount rate: 10.5%, Electricity price: 12p/kWh, CO2 price: £74/tCO2e

Source: Team analysis

In the residential sector, the greatest potential is in switching from incandescent bulbs to CFLs, followed by building shell improvements

RESIDENTIAL SECTOR

Share of sector potential

Category	Measure	Share of sector potential	Electricity savings TWh, 2030	Abatement cost[1] £/MWh, 2030	Capex Billion £, upto 2030	Abatement measure description
Buildings	Energy Efficiency Package, New Build	22%	3.8	139	29	Improve building design, orientation, insulation and airtightness, improve materials and construction, use high efficiency HVAC and water heating systems
	Building Envelope Package 1, Retrofit		4.1	-421	11	Improve building airtightness, weather strip doors and windows, insulate attic and wall cavities, add basic mechanical ventilation system to ensure air quality
	Building Envelope Package 2, Retrofit		6.8	540	81	Install high efficiency windows, doors; increase outer wall, roof, and basement ceiling insulation; mechanical ventilation with heat recovery
HVAC	Replace Electric Resistance Heating with Electric Heat Pump		0.4	-108	0	Replace electric furnace with high efficiency electric heat pump
	HVAC Maintenance		1.5	-105	0	Improve duct insulation to reduce air leakage and proper channeling of heated and cooled air, correct level of refrigerant and new air filters
Appliances/ electronics	Appliances	27%	12.5	-120	2	Package of certified appliances have a potential to consume ~35% less energy
	Electronics		5.1	-135	0	Use high efficiency consumer electronics that use up to 38% less energy due to reduction in standby losses
Lighting	Incandescent to CFL	38%	26.1	-142	2	Replace incandescent bulbs with CFLs
	CFLs to LEDs		5.1	-155	-1	Replace CFLs with LEDs
	Current CFLs to LEDs		1.1	-155	0	Replace current share of CFLs with LEDs

1 Includes annualized capital expenses, savings from reduced fuel usage and savings from reduced carbon costs

Source: IEA; UNEP; Energy Star; NREL; team analysis

In the commercial sector, owing to the high usage of electricity in HVAC systems, the greatest potential is from building shell improvements

COMMERCIAL SECTOR

Share of sector potential

		Share of sector potential	**Electricity savings** TWh, 2030	**Abatement cost** £/MWh, 2030	**Capex** Billion £, upto 2030	**Abatement measure description**
Buildings	Energy Efficiency Package, New Build	40%	4.4	-45	10.5	Improve building design, orientation, insulation and airtightness, improve materials and construction, use high efficiency HVAC and water heating systems
	Building Envelope Package, Retrofit		14.3	-180	2.0	Improve building airtightness by sealing areas of potential air leakage, weather strip doors and windows
HVAC	HVAC, Retrofit	12%	2.1	-116	0.4	When HVAC system expires, install highest efficiency system
	HVAC controls, Retrofit		3.7	-122	0.5	Improve HVAC control systems to adjust for building occupancy and minimize re-cooling of air
Appliances/ electronics	Appliances, Refrigerators		2.1	-105	0.7	Use improved refrigerators - 17% more energy efficient
	Electronics		2.6	-137	0.1	Use improved electronics - 48% more energy efficient
Lighting	CFLs to LEDs		3.1	-151	-0.3	Replace CFLs with LEDs
	T12 to T8/T5		0.8	-338	-2.0	Replace inefficient T12s / T8s with new super T8s and T5s (linear fluorescent lights)
	Lighting Controls, New Build	29%	5.6	-129	0.5	Install more efficient lighting control systems - dimmable ballasts, photo-sensors to optimize light for occupants in room
	Lighting Controls, Retrofit		8.2	-60	6.1	

1 Includes annualized capital expenses, savings from reduced fuel usage and savings from reduced carbon costs

Source: IEA; UNEP; Energy Star; NREL; team analysis

In the public admin sector, more than 70% of total potential is captured by building shell and lighting improvements

PUBLIC ADMIN SECTOR

Share of sector potential

		Share of sector potential	Electricity savings TWh, 2030	Abatement cost £/MWh, 2030	Capex Billion £, upto 2030	Abatement measure description
Buildings	Energy Efficiency Package, New Build	35%	0.4	-33	1.1	Improve building design, orientation, insulation and airtightness, improve materials and construction, use high efficiency HVAC and water heating systems
Buildings	Building Envelope Package, Retrofit		3.3	-179	0.5	Improve building airtightness by sealing areas of potential air leakage, weather strip doors and windows
HVAC	HVAC, Retrofit	11%	0.4	-116	0.1	When HVAC system expires, install highest efficiency system. e.g., in universities
HVAC	HVAC controls, Retrofit		0.7	-122	0.1	Improve HVAC control systems to adjust for building occupancy and minimize re-cooling of air. e.g., public areas in government offices
Appliances/ electronics	Appliances, Refrigerators		0.5	-105	0.2	Use improved refrigerators - 17% more energy efficient. For e.g., refrigerators in hospitals
Appliances/ electronics	Electronics		0.6	-137	0	Use improved electronics - 48% more energy efficient. For e.g., biomedical devices in hospitals
Lighting	CFLs to LEDs		0.6	-152	-0.1	Replace CFLs with LEDs
Lighting	T12 to T8/T5		0.2	-338	-0.5	Replace inefficient T12s / T8s with new super T8s and T5s (linear fluorescent lights)
Lighting	Lighting Controls, New Build	17%	0.8	-129	0.1	Install more efficient lighting control systems - dimmable ballasts, photo-sensors to optimize light for occupants in room
Lighting	Lighting Controls, Retrofit		1.0	9	1.5	
Lighting	Street Lighting, Replace Lamps by LEDs		2.0	-132	0.5	Replace all street lights with LEDs for residential streets as well as motor ways

1 Includes annualized capital expenses, savings from reduced fuel usage and savings from reduced carbon costs

Source: IEA; UNEP; Energy Star; NREL; The Climate Group; team analysis

As the single largest end user of electricity in the industrial sector, motors (incl. pumps) have the highest potential for electricity reduction

INDUSTRIAL SECTOR

Share of sector potential

Category	Measure	Share of sector potential	Electricity savings TWh, 2030	Abatement cost[1] £/MWh, 2030	Capex Billion £, upto 2030	Abatement measure description
Motors	Motors, Replacement by VFDs	26%	2.0	-128	0.2	Replace fixed drive motors (at constant speed) by Variable Frequency Motors so that they draw power based on load
Motors	Motors, Replacement by High Efficiency Motors		0.8	-59	0.5	Replace with higher efficiency motors – improved impeller share, use of higher quality materials etc
Motors	Motors, Install Soft Starters		0.9	-108	0.2	Reduce energy required for shutdown and startup by installing soft starters
Motors	Motors, Replacement By Correctly Sized Motors		4.4	-140	-0.1	In the majority of cases, installed motors are oversized compared to load anticipating addition of load in the future
Pumps	Pumps, Run at BEP	40%	4.6	-98	1.5	Run pumps at their Best Efficiency Point as pumps have a steep efficiency curve
Pumps	Pumps, Reduction of Internal Friction		1.7	146	3.9	Reduce the accumulation of tuberculate on the interior of the pump's casing which increases energy consumption
Pumps	Pumps, Cascade		6.4	-127	0.5	Running parallel pumps at full speed and constantly creating flow required for peaks only
Compressed air	Compressed Air Systems, Demand Manager Device		0.6	-134	0	Automatically optimize equipment usage based on demand
Compressed air	Compressed Air Systems, Reduce Intake Temperature		0.2	-122	0	By reducing intake temperature, increase gas density to increase compressor volumetric efficiency
Compressed air	Compressed Air Systems, Reduce Pressure Drop at Intake		0.9	-138	0	Reduce pressure drop as compressed air travels through the filter to reduce energy consumption
Other	Lighting Controls		0.7	-134	0	Install more efficient lighting control systems - dimmable ballasts, photo-sensors to optimize light for occupants in room
Other	Refrigerators		1.1	-103	0.4	Use improved refrigerators - 17% more energy efficient
Other	HVAC Controls		1.2	-121	0.2	Improve HVAC control systems to adjust for building occupancy and minimize re-cooling of air

1 Includes annualized capital expenses, savings from reduced fuel usage and savings from reduced carbon costs

Source: IEA; NREL; Energy Star; team analysis

Optimisation of low temperature heating processes suggests sizeable potential in the industrial sector

INDUSTRIAL SECTOR

Share of sector potential

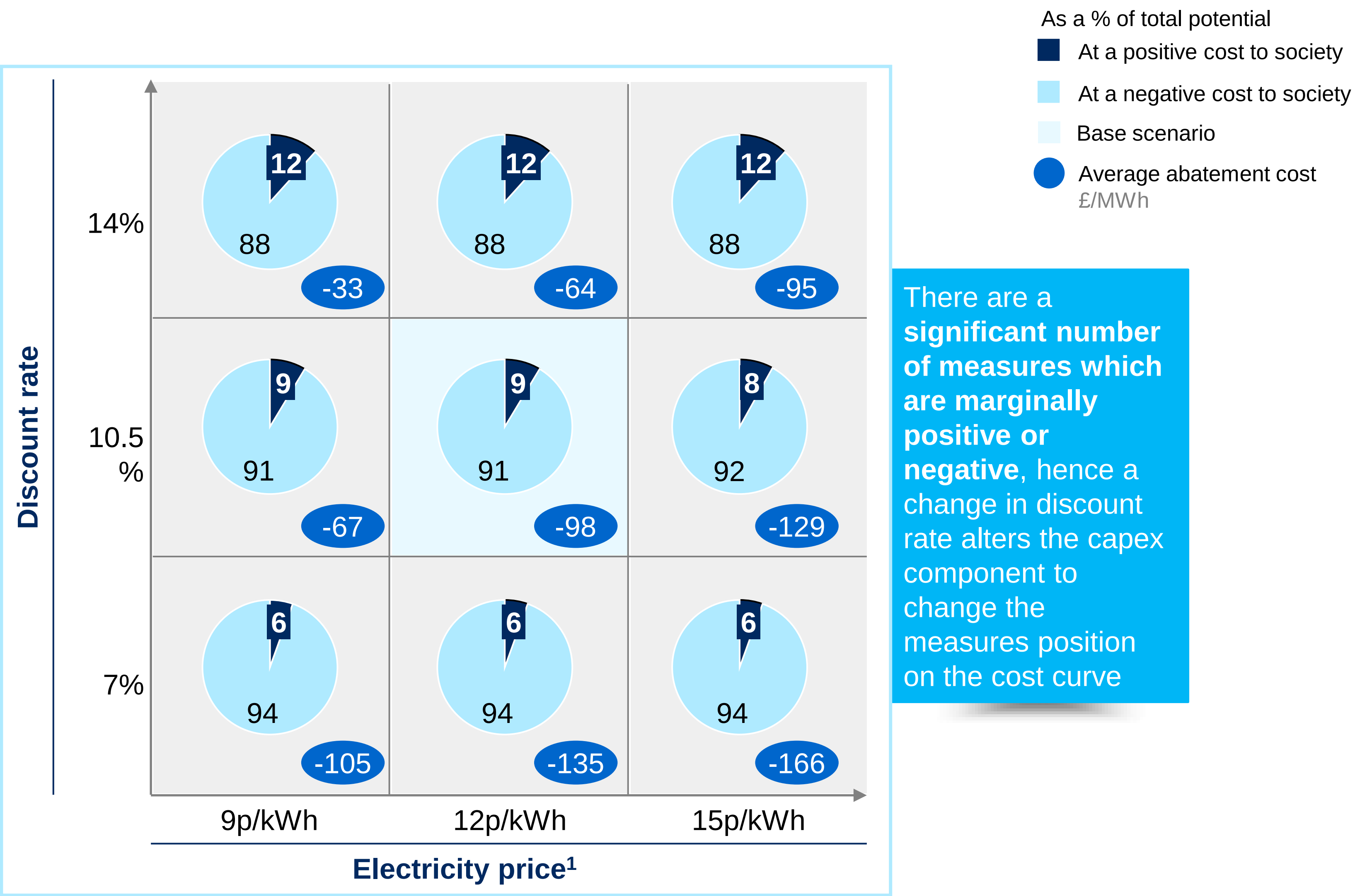
High and low temperature processes

	Electricity savings TWh, 2030	Abatement cost[1] £/MWh, 2030	Capex Billion £, upto 2030	Abatement measure description
Furnace insulation and optimization (9%)	2.88	-110	0.65	Improve furnace insulation, reduce size of furnace entry, install self closing door and use residual heat
Glass, Top heating[2]	0.43	-127	0.04	Top mounted electrodes to improve and provide higher quality
Glass, Capture heat from electrolysis cells[2]	1.24	-138	0	Heat is recovered from top and sides of electrolysis cell
Iron and Steel, DC Arc Furnace	0.09	-127	0.01	Have a similar arrangement, but have electrodes for each shell and one set of electronics
Iron and Steel, Scrap preheating	0.06	-115	0.01	Waste heat used for preheating scrap before passing into the electric arc furnace
Iron and Steel, Eccentric bottom tapping on furnace	0.01	-80	0.01	An alternate hearth shape which reduces electricity consumption
Iron and Steel, Improved process control (neural network)	0.03	-133	0	Employing a neural network, the process control is improved to increase furnace efficiency
Iron and Steel, Improved lubrication system	0.03	-138	0	Installation of pumps, valves and controls to enable increased lubrication
Iron and Steel, Direct casting	0.21	48	0.60	Integrates casting and hot rolling into 1 step, reducing need to reheat
Aluminum, Reduce anode cathode distance[2,3]	0.53	-138	0	The distance between anode and cathode reduced to 3cm
Aluminum, Capture heat from electrolysis cells[2,3]	0.30	-138	0	Heat is recovered from top and sides of electrolysis cell

1 Includes annualized capital expenses, savings from reduced fuel usage and savings from reduced carbon costs. 2 Does not include capex costs
3 Significant electricity consumption from Aluminum production is assumed to continue in DECC baseline, however, with the latest closures of plants in the UK, the realization of this potential is unlikely

Source: EPA: Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Iron and Steel Industry; EPA: Energy Efficiency Improvement and Cost Saving Opportunities for the Glass Industry; team analysis

The share of potential which can be achieved at a negative cost to society is more sensitive to the discount rate than to electricity price



There are a **significant number of measures which are marginally positive or negative**, hence a change in discount rate alters the capex component to change the measures position on the cost curve

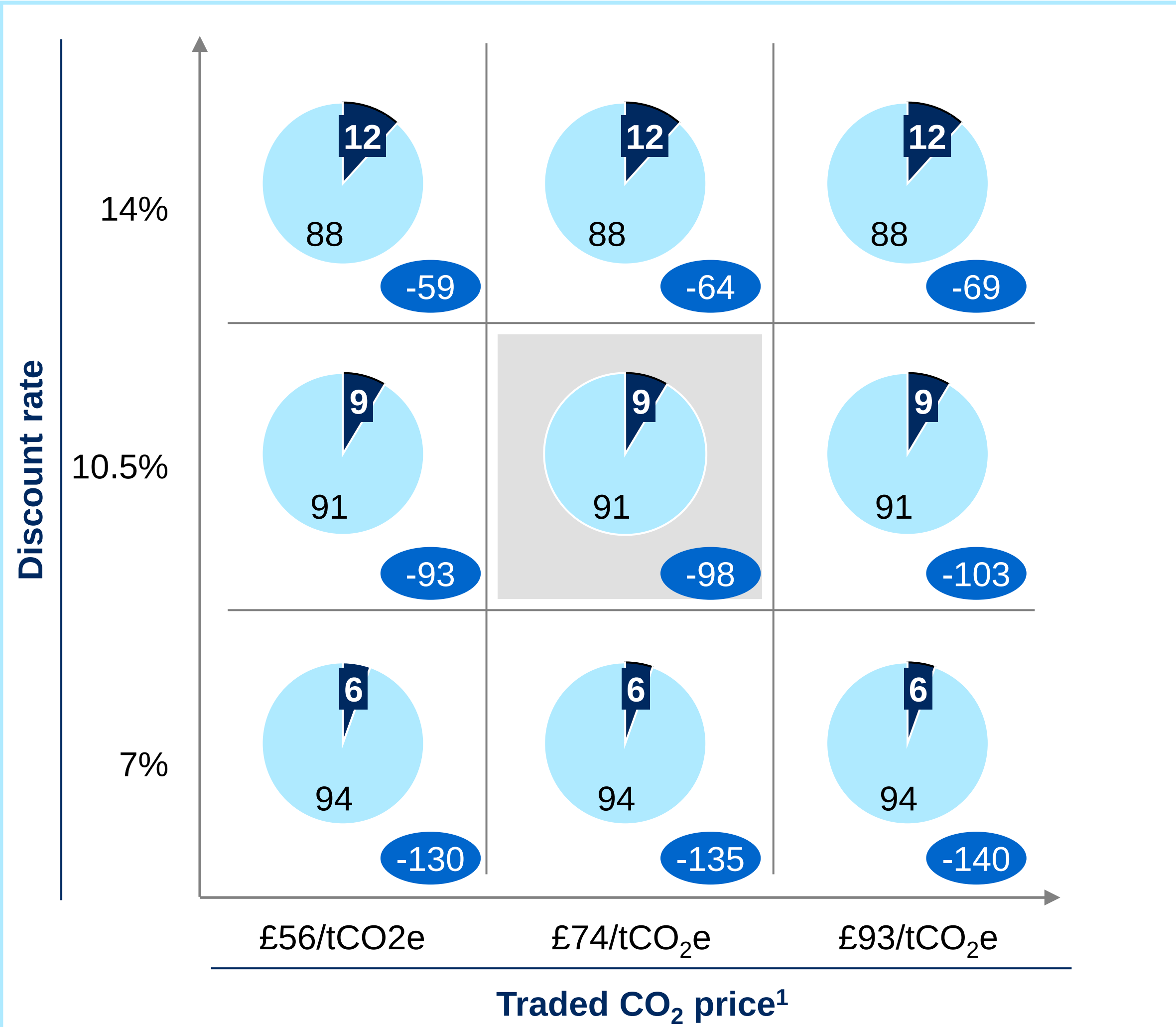
1 Electricity price is the same for residential, commercial and public admin sectors, and 1% lower for industrial sector

Source: Team analysis

Change in discount rate has a greater impact rate on average abatement cost than change in CO_2 price

As a % of total potential

- At a positive cost to society
- At a negative cost to society
- Base scenario
- Average abatement cost (£/MWh)



Given the **large number of capital intensive measures**, discount rate has a large impact on average abatement cost

1 Only the traded CO_2 price is varied i.e., CO_2 price associated with electricity. Non-traded CO_2 price i.e., associated with gas is not varied.

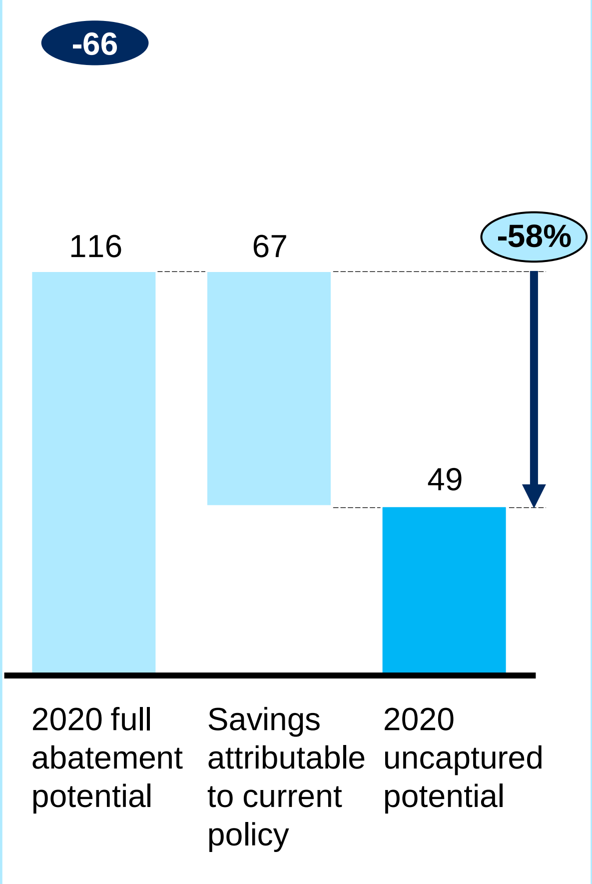
Source: Team analysis

There is significant uncaptured abatement potential both on a 2020 and 2030 view

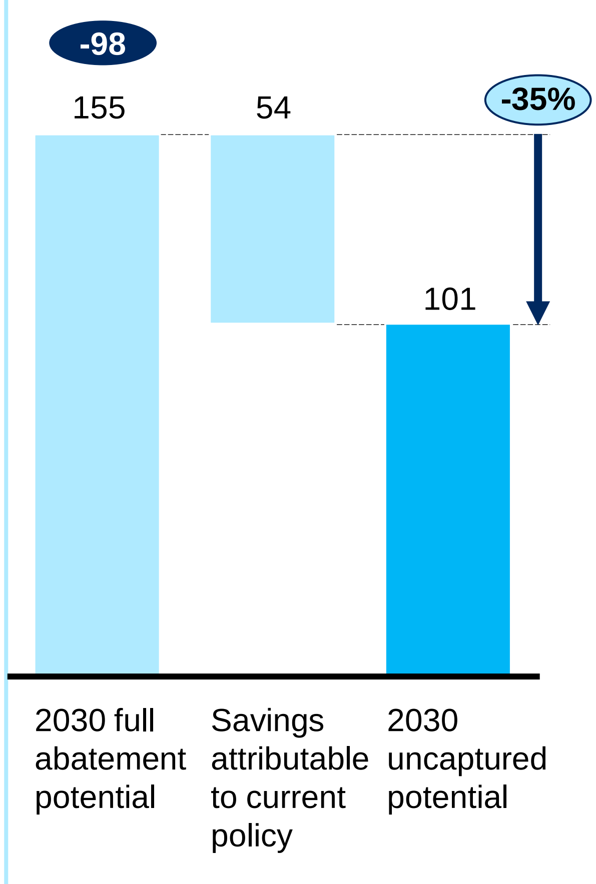
TWh

x Average abatement cost (£/MWh)

Electricity abatement potential, 2020



Electricity abatement potential, 2030



Why does the full abatement potential increase?

- The **baseline electricity demand increases** from 2020 to 2030, hence increasing the base for abatement measures to act upon and is **responsible for ~10 TWh** of increase in abatement potential.
- Majority of technologies (all except appliances, electronics and some lighting) replaced by measures, have a **lifetime greater than 10 years**, hence the amount of such replacements still providing savings in 2030 exceeds that in 2020, **resulting in an increase of ~30 TWh** in abatement potential

Why does the average abatement cost reduce?

This is due to **increase in savings per TWh saved**. Between 2020 and 2030

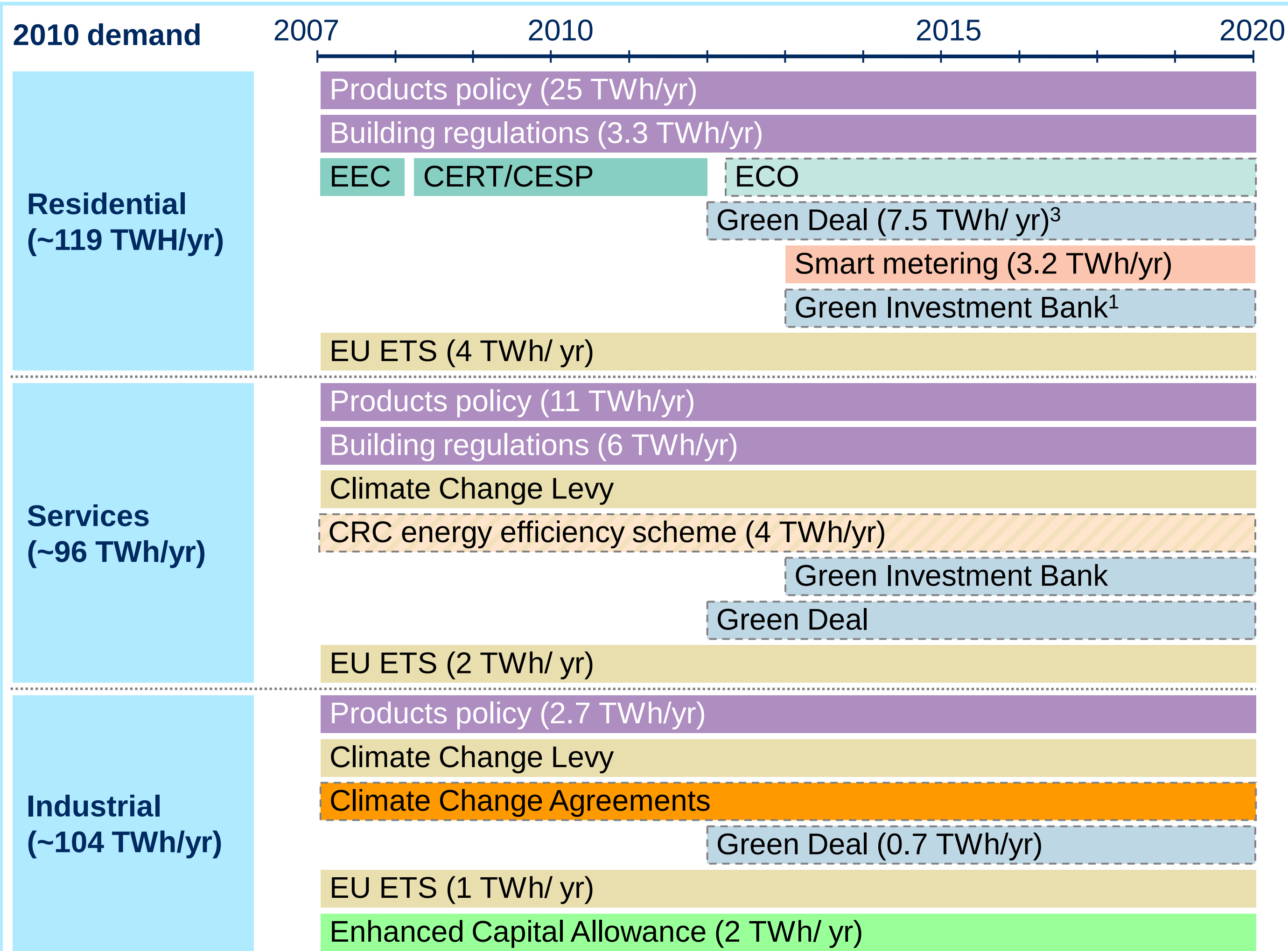
- Electricity price increases by 30%
- CO_2 price increases by 160%

Source: DECC projections; team analysis

Contents

Current and planned policies span all 3 sectors with 7 key mechanisms

- Tax
- Incentives
- Financing
- Information/labelling
- Standards
- Supplier obligations
- Voluntary agreements
- In consultation/under review



- The policy landscape is changing
  - Several key policies are currently being reviewed (e.g., CRC)
  - New policies (e.g., Green Deal, ECO) come into effect
- Products Policy dominates the landscape in terms of impact
- DECC's estimates of the demand reduction impact of current/planned policy[2]
  - 2020 (on this page): ~67 TWh, leaving ~49 TWh of uncaptured potential
  - 2030: ~54 TWh, leaving ~101 TWh of uncaptured potential

1 GIB prioritises non-domestic efficiency, but Green Deal providers are considering seek financing from GIB
2 2020 and 2030 savings estimated by DECC exclude demand reduction resulting from policies that increase the price of electricity (e.g., EU ETS, CRC)
3 Includes impact for CERT/ CESP/ ECO

Source: DECC/DEFRA projections; team analysis

Description of categories of key measures used in remainder of document

The measure categories below represent aggregated potential from largest three groups of measures with similar technology in each sector

	Measure category	Total abatement potential, 2030 TWh	Description
Residential	Incandescent to CFL bulbs	26.1	• Replace incandescent bulbs with CFLs
	Appliances and electronics efficiency	17.6	• Purchase high efficiency consumer electronics (e.g., PC, TV, VCR/DVD, home audio, set-top box, external power, charging supplies) instead of standard items • When refrigerator/freezer, washer/dryer, dishwasher, or fan expires, replace with high efficiency model
	Building efficiency improvements	14.7	• New build: achieve energy consumption levels comparable to "passive" standard – Reduce demand for energy consumption through improved building design and orientation – Improve building insulation and air tightness; improve materials and construction of walls, roof, floor, and windows – Ensure usage of high efficiency HVAC and water heating systems • Level 1 retrofit – "basic retrofit" package – Improve building air tightness by sealing baseboards and other areas of air leakage – Weather strip doors and windows – Insulate attic and wall cavities – Add basic mechanical ventilation system to ensure air quality • Level 2 retrofit – Retrofit to "passive" standard, in conjunction with regular building renovations – Install high efficiency windows and doors; increase outer wall, roof, and basement ceiling insulation; mechanical ventilation with heat recovery, basic passive solar principles
Services	Building efficiency improvements	22.5	• New build: reduce demand for energy consumption through improved building design and orientation • Improve building insulation and air tightness; improve materials and construction of walls, roof, floor, and windows • Ensure usage of high efficiency HVAC and water heating systems • Level 1 retrofit – "basic retrofit" package – Improve building air tightness by sealing areas of potential air leakage – Weather strip doors and windows
	Lighting controls	15.6	• New build – install lighting control systems (dimmable ballasts, photo-sensors to optimize light for occupants in room) • Retrofit – install lighting control systems (dimmable ballasts, photo-sensors to optimize light for occupants in room)
	HVAC and controls	6.9	• When HVAC system expires, install highest efficiency system • Improve HVAC control systems to adjust for building occupancy and minimize re-heating of air
Industrial	Pump efficiency measures	12.6	• Run pumps at Best Efficiency Point • Use pumps with reduced internal friction • Replace large pumps by a cascade of smaller pumps
	Motor efficiency measures	8.1	• When suitable, replace fixed load motors by Variable Frequency Drives • Use higher efficiency motors – improved impeller share, use of higher quality materials etc • Install soft starters • Replace oversized motors
	Boiler insulation and optimisation	2.9	• Improve boiler insulation, reduce size of boiler entry, install self closing door and use residual heat
	Total	127.0	

Source: Team analysis

Products policy dominates key electricity measures

Extent to which policies cover the scope of electricity efficiency measures

- Policy directly addresses all elements of measure
- Policy directly addresses some elements of measure
- Policy encourages measure as part of general electricity efficiency
- Policy does not apply

	Measure category	Total abatement potential, 2030 TWh	Targeted interventions: Products Policy	Targeted interventions: Building Regs	Semi-targeted energy efficiency policies: Green Deal	Semi-targeted energy efficiency policies: ECO	Policies with broad impact: EU ETS, CRC & CCA
Residential	Incandescent to CFL bulbs	26.1	Policy directly addresses all elements of measure	Policy does not apply	Policy does not apply	Policy does not apply	Policy encourages measure as part of general electricity efficiency
	Appliances and electronics efficiency	17.6	Policy directly addresses all elements of measure	Policy does not apply	Policy does not apply	Policy does not apply	Policy encourages measure as part of general electricity efficiency
	Building efficiency improvements	14.7	Policy does not apply	Policy directly addresses some elements of measure	Policy directly addresses some elements of measure	Policy directly addresses some elements of measure	Policy encourages measure as part of general electricity efficiency
Services	Building efficiency improvements	22.5	Policy does not apply	Policy directly addresses some elements of measure	Policy directly addresses some elements of measure	Policy does not apply	Policy encourages measure as part of general electricity efficiency
	Lighting controls	15.6	Policy does not apply	Policy directly addresses some elements of measure	Policy directly addresses some elements of measure	Policy does not apply	Policy encourages measure as part of general electricity efficiency
	HVAC and controls	6.9	Policy directly addresses some elements of measure	Policy directly addresses some elements of measure	Policy directly addresses some elements of measure	Policy does not apply	Policy encourages measure as part of general electricity efficiency
Industrial	Pump efficiency measures	12.6	Policy directly addresses some elements of measure	Policy does not apply	Policy does not apply	Policy does not apply	Policy encourages measure as part of general electricity efficiency
	Motor system optimisation[1]	8.1	Policy directly addresses some elements of measure	Policy does not apply	Policy does not apply	Policy does not apply	Policy encourages measure as part of general electricity efficiency
	Boiler insulation and optimisation	2.9	Policy does not apply	Policy does not apply	Policy does not apply	Policy does not apply	Policy encourages measure as part of general electricity efficiency
	Total	**127.0**					

Key insights

- The residential sector is the most comprehensively covered by policy
- Products Policy is the broadest policy covering key measures across all three sectors
- Whereas Products Policy targets much of the opportunity in specific hardware, there is a gap in policies addressing electricity saving systems and controls, affecting:
  - Lighting controls
  - HVAC controls
  - Pump efficiency
  - Motor optimisation

1 Includes both measures for optimising motor operations and efficiency measures and replacement of oversized motors by correct size and VSDs

Source: DECC projections; team analysis

Current policies capture ~40% of the abatement potential covered by the 9 key measure categories

- Majority of potential captured (>50%)
- Some potential captured (25-50%)
- Little potential captured (<25%)

2030

	Measure category	Abatement potential (TWh)	Abatement potential captured by policies[1] (TWh)	%	Uncaptured abatement potential[1] (TWh)	Average payback period (societal basis)[2] (Years)
Residential	Incandescent to CFL bulbs	26.1	8.6 / 17.5 / 26.1	100	0	0.3
	Appliances and electronics efficiency	17.6	12.8	73	4.8	1.3
	Building efficiency improvements	14.7	5.2	36	9.4	14.7
Services	Building efficiency improvements	22.5	0.6	3	21.9	5.1
	Lighting controls	15.6	1.1	7	14.5	5.6
	HVAC and controls	6.9	4.1	60	2.8	1.9
Industrial	Pump efficiency measures	12.6	0.1	1	12.5	6.9
	Motor efficiency measures	8.1	0.8	10	7.3	1.6
	Boiler insulation and optimisation	2.9	0	0	2.9	3.3
	Total	**127.0**	**50.9**	**40**	**76.1**	**4.5**

Key opportunities

- Top 3 opportunities (ie. Unaddressed measures in TWh) are:
  - Building efficiency improvements in residential and commercial sectors
  - Lighting controls
  - Pump efficiency measures

1 Includes Products policy, Building Regulations and Green Deal/ECO policies

2 Payback period calculated on societal basis and includes transaction costs of ~30%. Payback period reflects average across measure and does not include disruption costs and risk

Source: DECC projections; team analysis

Products policy and related instruments are projected to capture ~40 TWh of electricity savings by 2030

EU mandate
Majority of potential captured (>50%)
Some potential captured (25-50%)
Little potential captured (<25%)

Products policy aims to increase the efficiency of energy using products and covers over 20 household and non-domestic products

	Measure category	Abatement potential TWh	Abatement potential captured by Products Policy TWh	Abatement potential captured by Products Policy %
Residential	Incandescent to CFL bulbs	26.1	8.6 / 17.5 / 26.1	98
Residential	Appliances and electronics efficiency	17.6	12.8	73
Residential	Building efficiency improvements	14.7	Not covered	
Services	Building efficiency improvements	22.5	Not covered	
Services	Lighting controls	15.6	Not covered	
Services	HVAC and controls	6.9	2.6	38
Industrial	Pump efficiency measures	12.6	0.1	1
Industrial	Motor efficiency measures	8.1	0.8	10
Industrial	Boiler insulation and optimisation	2.9	Not covered	
	Total	**127.0**	**41.9**	

Opportunities

- Key questions
  - Products policy covers a wide range of products but is it sufficiently ambitious in terms of percentage reductions?
  - Could it be more effective at targeting the top quartile or median rather than the lowest 20%?
  - How effective is it when the product in question has a long lifetime?

Source: DECC projections; team analysis

Building Regulations is projected to capture ~5 TWh of potential savings mainly through building efficiency improvement measures

- Majority of potential captured (>50%)
- Some potential captured (25-50%)
- Little potential captured (<25%)

Building Regulations set standards for design and construction which apply to most new buildings and many alterations to existing buildings in England

	Measure category	Abatement potential TWh	Abatement potential captured by Building Regulations TWh	Abatement potential captured by Building Regulations %
Residential	Incandescent to CFL bulbs	26.1	0.6	2
Residential	Appliances and electronics efficiency	17.6	Not covered	
Residential	Building efficiency improvements	14.7	2.5	17
Services	Building efficiency improvements	22.5	0.2	1
Services	Lighting controls	15.6	0.8	5
Services	HVAC and controls	6.9	1.2	17
Industrial	Pump efficiency measures	12.6	Not covered	
Industrial	Motor efficiency measures	8.1	Not covered	
Industrial	Boiler insulation and optimisation	2.9	Not covered	
	Total	127.0	5.3	

1 Figures provided for savings in lighting by DECC assumed to be split by relative weighting of lighting control and CFLs to LEDs measure opportunities; CFLs to LEDs measure opportunity, not shown, contributes 0.2 TWh in savings

Source: DECC projections; team analysis

Green Deal and ECO are projected to capture ~4 TWh of potential savings by 2030

- Majority of potential captured (>50%)
- Some potential captured (25-50%)
- Little potential captured (<25%)

- Green Deal and ECO aim to reduce carbon emissions cost effectively by revolutionising the energy efficiency of British properties
- ECO will integrate with the Green Deal, allowing supplier subsidy and Green Deal Finance to come together into one seamless offer to the consumer

	Measure category	Abatement potential TWh	Abatement potential captured by Green Deal and ECO policies TWh	Abatement potential captured by Green Deal and ECO policies %
Residential[1]	Incandescent to CFL bulbs	26.1	Not covered	
	Appliances and electronics efficiency	17.6	Not covered	
	Building efficiency improvements	14.7	2.7	18
Services[1]	Building efficiency improvements	22.5	0.3	1
	Lighting controls	15.6	0.3	2
	HVAC and controls	6.9	0.3	6
Industrial	Pump efficiency measures	12.6	Not covered	
	Motor efficiency measures	8.1	Not covered	
	Boiler insulation and optimisation	2.9	Not covered	
	Total	127.0	3.7	

1 Figures provided for commercial and residential savings by DECC assumed to be split by relative weighting of key measure opportunities and HVAC residential savings, not shown, contributes 0.3 TWh in savings

Source: DECC projections; team analysis

Some policies have broad impact; these capture less abatement potential and are incremental to more specific policies

EU ETS impact on electricity consumption is included in the baseline

	Abatement potential TWh	Total abatement potential captured by policies with broad impact TWh	Abatement potential captured by[1,2] CRC TWh	Abatement potential captured by[1,2] ECA TWh	Abatement potential captured by[1,2] EU ETS TWh
Residential	66	0	0	0	4
Commercial	57	1	1	0	2
Industrial	31	2	0	2	1
Total	155	3	1	2	7

Implications

- EU ETS, CCL and CRC have a broad impact via the price of electricity. All also apply to other fuels.
- These policies have a limited impact on electricity demand once the overlap with other policies is removed:
  - Companies fulfil their carbon obligation via other fuel sources rather than electricity so policy impact is seen on other fuels
  - Gain to users/ providers is small relative to electricity price volatility and cost base
- Impact of EU ETS is included in "policy off" baseline

1 CCA savings not estimated, as targets are in the process of being negotiated with participating industries
2 No estimate available for CCL savings

Source: DECC projections; Saving Energy Through Better Products and Appliances Defra report

Contents

The interviews and international experience suggest 11 key findings on barriers

	Description
1 Policy	A While policy seeks to address a number of barriers in the residential sector, barriers in the service and industrial sectors are less well addressed[1]
	B The complex and ever changing policy landscape results in confusion and delays in EE investment
	C Utility companies and many intensive industrial users largely focus on other energy sources to reach carbon targets
2 Market maturity and costs	A The transaction costs and the effort needed to implement EE measures are often large compared with the benefits associated with EE investments
	B The EE market is not sufficiently developed to deliver on electricity efficiency opportunities
3 Residential	A While agency issues persist in rented accommodation, agency issues in the form of ownership transfer do not appear to be a significant issue in the UK residential sector (unlike the US)
	B Behavioural change is a significant opportunity in the residential sector, with potential as high as ~15% (though this will diminish the remaining opportunity that can be captured by technical measures)
4 Commercial/ industrial	A In the commercial and industrial sectors, stakeholders demand a rapid payback period of ~2 years while EE investments on average have a a payback period of ~5 years
	B Agency issues in the commercial sector appear to be a significant barrier as 61% of commercial space is leased and 75% of the corporate sector outsources its facilities management capabilities, often without incentives for reducing energy costs
	C While capital constraints may be a barrier for SMEs or underperforming companies, large commercial and industrial organisations can secure necessary financing to make an EE investment if attractive
	D Electricity intensive users are focused on realising electricity demand reduction opportunities. However, non-electricity intensive industries represent ~60% of total industrial electricity demand and are less likely to achieve the full scale of opportunities

1 Does not take into account impact of CCAs as it is unclear how CCAs will affect this once they have been finalised

Source: Interviews; team analysis

1 Policy – key insights (1/2)

A Policy gap in commercial/ industrial sectors

- While policy seeks to address a number of barriers in the residential sector, barriers in the commercial and industrial sectors are less well addressed[1]
- Policy captures 76% of the total residential opportunity, but only 13% of the opportunity in the service sector and 4% of the industrial opportunity[2]

B Complex and changing policy landscape is challenge

- The complex and ever changing policy landscape results in confusion and delays in EE investment
- Several existing policies (e.g., CRC, CCAs, Solar FiTs) have changed significantly or are currently under review. Companies who were penalised by the changes in policy are now hesitant to make investments for fear that the policy environment will change again, rendering the investment uneconomic
  - Many new policies have been introduced in the last 2 years and there is a lack of clarity on what the landscape will look like going forward
  - Given the complex policy landscape, not all companies are aware of the existing EE incentives

“ The biggest barrier is the shifting sands that the government has introduced by changing the goal posts (e.g., solar FiTs). This curtails investment. The carbon reduction landscape is extremely complex and I would like to see that simplified.

– Commercial user

“ There’s a mass of different assistance in EE areas. It’s bewildering- what’s on offer. I have never heard of the Enhanced Capital Allowance- maybe that could help some of our business cases

– Electricity intensive user

“ We would appreciate more visibility and stability in terms of policy. CRC has changed significantly and we still don’t know what it will look like tomorrow.

– Utility company

1 Does not take into account impact of CCAs as it is unclear how CCAs will affect this once they have been finalised

2 Based on 9 sets of measures that deliver 80% of value

Source: Based on corporate interviews; team analysis

1 Policy – key insights (2/2)

C Non-electricity measures for reaching carbon targets

- Utility companies and many intensive industrial users largely focus on other fuel sources to reach carbon targets due to relative cost/ carbon impact of coal and gas[1]

"We are investing a lot in biofuels and waste fuels, which reduces our carbon, but increases our electricity usage

– Industrial user

"90% of our current EE programmes are directed towards saving gas (not electricity)

– Utility company

1 Does not take into account impact of CCAs as it is unclear how CCAs will affect this once they have been finalised

Source: Based on corporate interviews; team analysis

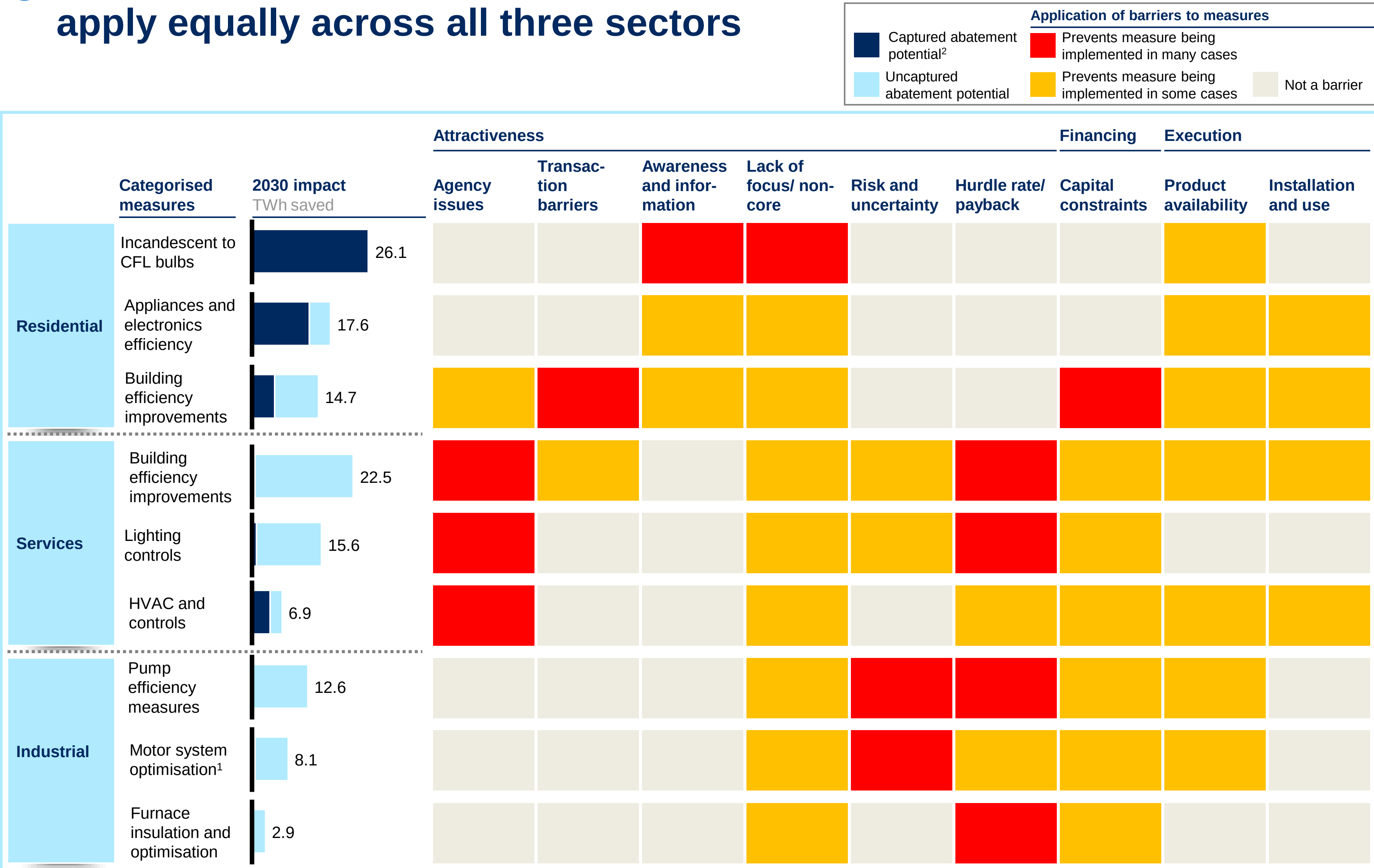
A Barriers can make an investment unattractive or present financing or execution difficulties

		Barrier	Description	Example
Attractive-ness	Awareness and attention	Lack of aware-ness/information	• Users not aware of EE opportunities or impact of own consumption behaviour	• Companies and households are not often aware of the details of what activities drive electricity use • Companies not aware of all available EE options and technologies
		Lack of focus	• Other issues are more central to business or daily life	• Status quo bias leads consumers to hesitate upsetting current situation • Managers have many responsibilities so EE is not high priority
	Financial and non-financial costs	Transaction barriers	• Incidental financial and non-financial costs of deployment	• Hidden "costs" such as the investment of time to research and implement a new measure • Production shutdown to implement measure
		Doesn't meet hurdle rate/ payback period	• Benefits not realised quickly enough	• Businesses typically won't consider investments with payback period longer than 2-3 years • Hyperbolic discounting means people value short term more than long term and attach a higher discount rate
	Capturing benefits	Agency	• Incentives split between parties, impeding capture of potential	• Landlords invest in EE measures but benefits accrue to tenants • In the US, the payback period for a residential EE investment is longer than the period the homeowner intends to own the home
		Risk and uncertainty	• Uncertainty about ability to capture benefit of the investment or possibility of incurring additional costs	• High volatility in electricity prices means that potential savings are hard to estimate • Risk-averse managers do not want to switch to EE equipment because of risks about reliability and compatibility
Financing		Capital constraints	• Inability to finance initial outlay	• Significant capital outlays and low savings rates for consumers
Execution		Product availability	• EE products not widely available to users	• Market for EE service providers is highly fragmented making appropriate vendors hard to find • Some suppliers may not stock EE products
		Installation and use	• Improperly installed and/or operated equipment doesn't realise total potential savings	• Improper use of programmable thermostats can reduce or eliminate savings

Source: US Energy Efficiency report; team analysis

A Excluding impact of policies, barriers apply equally across all three sectors

PRE-POLICY VIEW

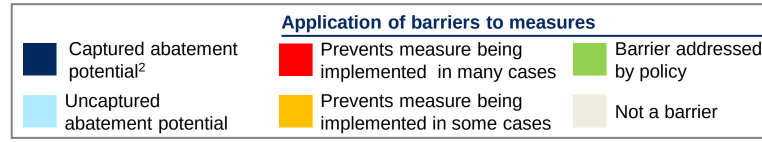


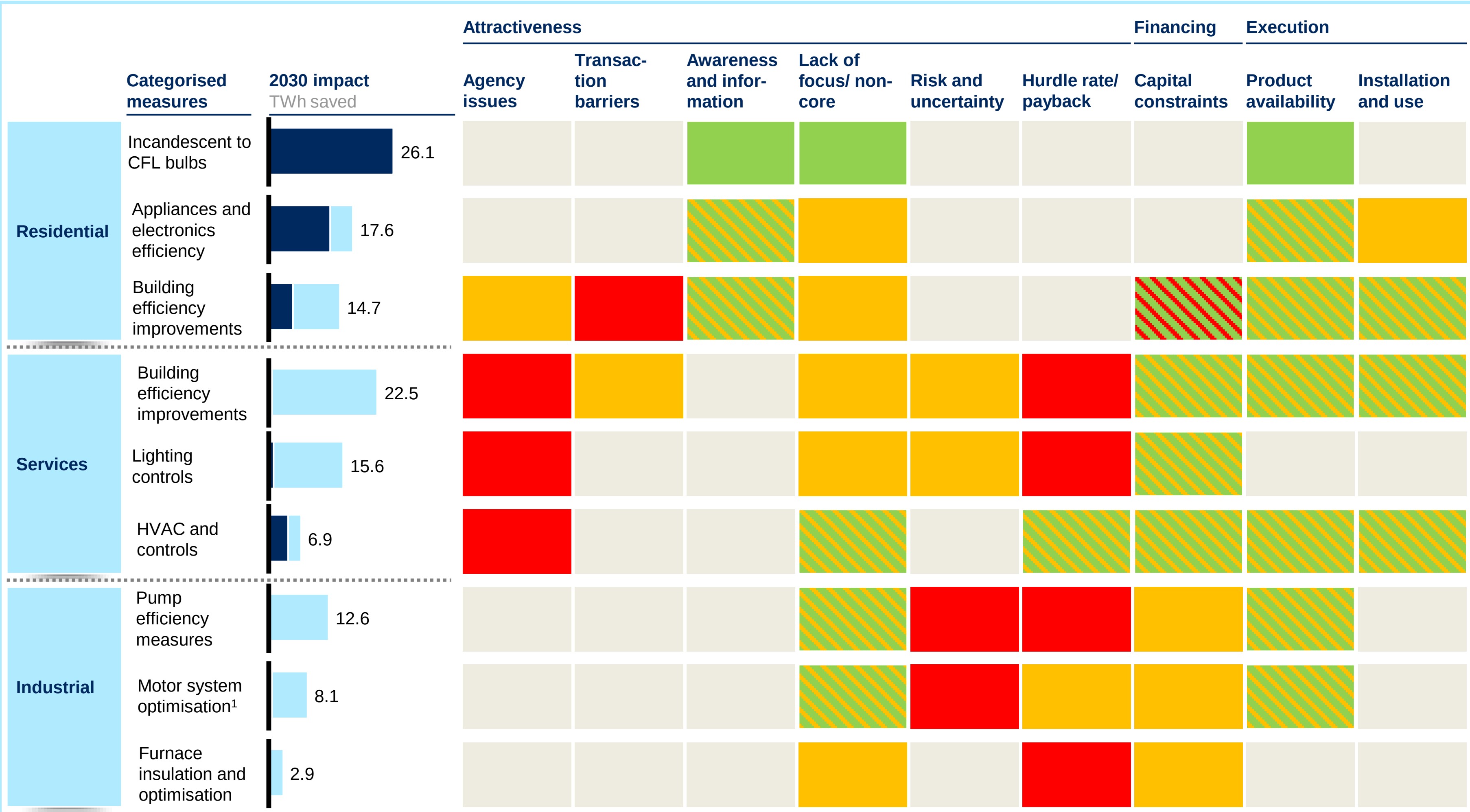
1 Includes both measures for optimising motor operation and efficiency measures and replacement of oversized motors by correct size and variable speed motors

Source: Interviews; team analysis

POST-POLICY VIEW

A Policy addresses many barriers in the residential sector, but challenges remain in the service and industrial sectors





1 Includes both measures for optimising motor operation and efficiency measures and replacement of oversized motors by correct size and variable speed motors

Source: Interviews; team analysis

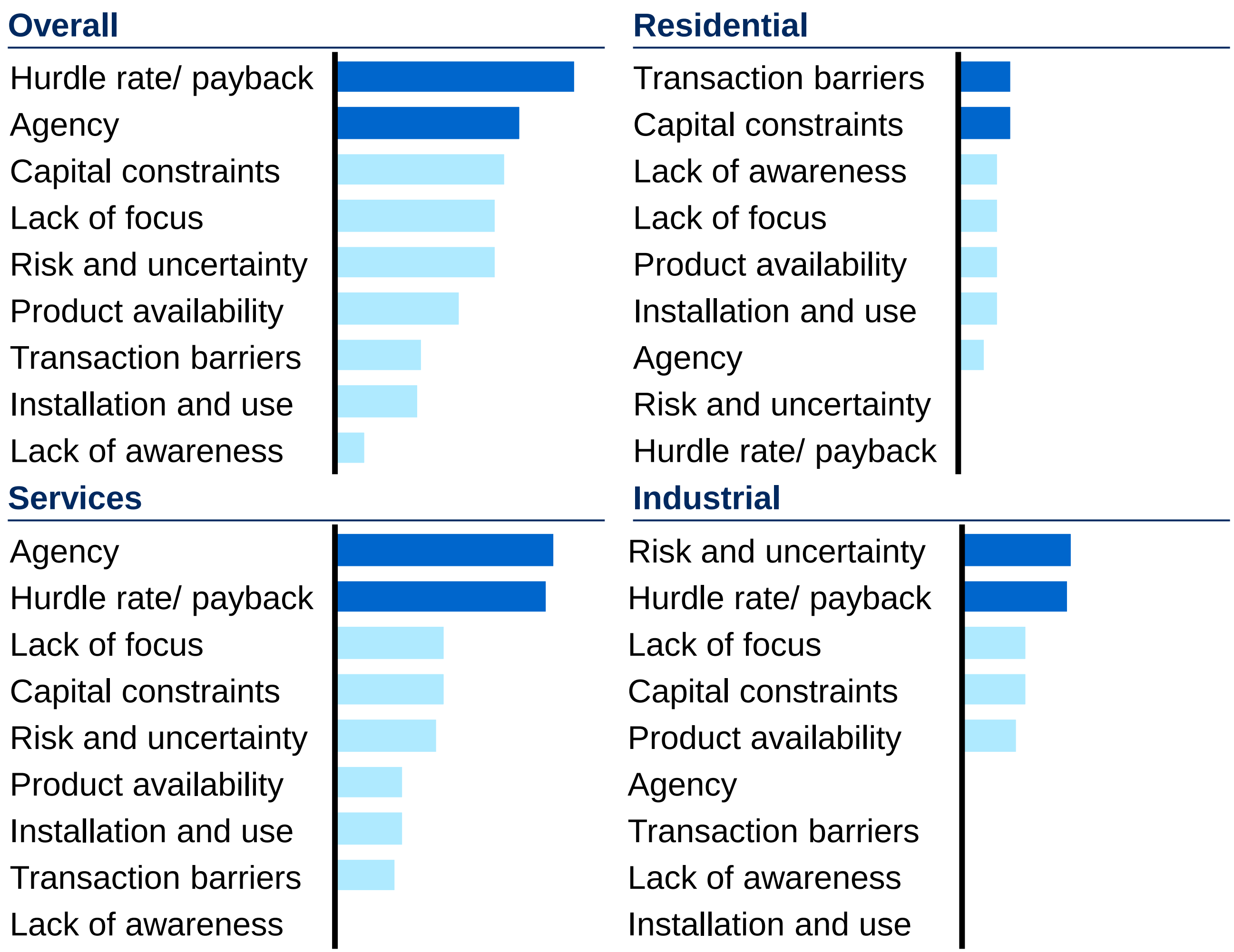
A Assigning a weight based on the level of impact can provide a sense of the scale of the impact of the different barriers

ILLUSTRATIVE

NOT ADDITIVE

Impact of barriers on top measures with largest opportunity

Barrier points



Methodology

- Barriers are assigned a point value based on significance
  - 50 points
  - 25 points
- Using the pre-policy heatmap, barrier points are assigned to each measure
- Barrier points are multiplied by the TWh value of uncaptured potential (Assumes that policy addresses all barriers equally)
- Barrier points are added up to indicate the scale of impact for each barrier

Source: Team analysis

Example: previous experience in the US is one input into the barriers analysis (1/2)

Barrier | Not a barrier

US EXAMPLE

	Cluster	Size of opportunity (2020 potential, quads)	Structural: Agency issues	Structural: Transaction barriers	Structural: Ownership transfer issues	Structural: Risk and uncertainty	Behavioural: Awareness and information	Behavioural: Custom and habit	Behavioural: Elevated hurdle rate	Behavioural: Adverse bundling	Availability: Capital constraints	Availability: Product availability	Availability: Installation and use
Residential	Retrofitting existing non low-income homes	1.30	Barrier	Barrier	Barrier		Barrier		Barrier		Barrier	Barrier	Barrier
Residential	Retrofitting existing low-income homes	0.61	Barrier	Barrier	Barrier		Barrier		Barrier		Barrier	Barrier	Barrier
Residential	Shell and HVAC for new homes	0.32			Barrier		Barrier						Barrier
Residential	Electrical devices and small appliances	0.59	Barrier				Barrier						
Residential	Lighting and large appliances	0.34			Barrier		Barrier	Barrier			Barrier	Barrier	
Commercial	Existing private buildings	0.81	Barrier				Barrier				Barrier		
Commercial	Government buildings	0.36		Barrier			Barrier				Barrier		
Commercial	New private buildings	0.27			Barrier		Barrier						Barrier
Commercial	Office and non-commercial devices	0.57			Barrier		Barrier	Barrier		Barrier		Barrier	
Commercial	Community infrastructure	0.29				Barrier	Barrier				Barrier		
	TOTAL	**5.46**											

Source: Unlocking Energy Efficiency in the U.S. Economy

A Example: previous experience in the US is one input into the barriers analysis (2/2)

Effectiveness of W-M policy measures
- Addressed
- Not addressed
- Partially addressed
- Not a barrier

US EXAMPLE

	Cluster	Size of opportunity (2020 potential, quads)	Structural: Agency issues	Structural: Transaction barriers	Structural: Ownership transfer issues	Structural: Risk and uncertainty	Behavioural: Awareness and information	Behavioural: Custom and habit	Behavioural: Elevated hurdle rate	Behavioural: Adverse bundling	Availability: Capital constraints	Availability: Product availability	Availability: Installation and use
Residential	Retrofitting existing non low-income homes	1.30	Partially addressed	Partially addressed	Partially addressed	Not a barrier	Partially addressed	Not a barrier	Addressed	Not a barrier	Addressed	Partially addressed	Partially addressed
Residential	Retrofitting existing low-income homes	0.61	Partially addressed	Partially addressed	Partially addressed	Not a barrier	Partially addressed	Not a barrier	Addressed	Not a barrier	Addressed	Partially addressed	Partially addressed
Residential	Shell and HVAC for new homes	0.32	Not a barrier	Not a barrier	Addressed	Not a barrier	Addressed	Not a barrier	Not a barrier	Not a barrier	Not a barrier	Not a barrier	Addressed
Residential	Electrical devices and small appliances	0.59	Not addressed	Not a barrier	Not a barrier	Not a barrier	Partially addressed	Not a barrier	Not a barrier	Not a barrier	Not a barrier	Not a barrier	Not a barrier
Residential	Lighting and large appliances	0.34	Not a barrier	Not a barrier	Not addressed	Not a barrier	Partially addressed	Not addressed	Not a barrier	Not a barrier	Addressed	Addressed	Not a barrier
Commercial	Existing private buildings	0.81	Partially addressed	Not a barrier	Not a barrier	Not a barrier	Partially addressed	Not a barrier	Addressed	Not a barrier	Addressed	Not a barrier	Not a barrier
Commercial	Government buildings	0.36	Not a barrier	Not addressed	Not a barrier	Not a barrier	Partially addressed	Not a barrier	Not a barrier	Not a barrier	Addressed	Not a barrier	Not a barrier
Commercial	New private buildings	0.27	Not a barrier	Not a barrier	Addressed	Not a barrier	Addressed	Not a barrier	Not a barrier	Not a barrier	Not a barrier	Not a barrier	Addressed
Commercial	Office and non-commercial devices	0.57	Not a barrier	Not a barrier	Not addressed	Not a barrier	Partially addressed	Not addressed	Not a barrier	Not addressed	Not a barrier	Addressed	Not a barrier
Commercial	Community infrastructure	0.29	Not a barrier	Not a barrier	Not a barrier	Not addressed	Not addressed	Not a barrier	Not a barrier	Not a barrier	Not addressed	Not a barrier	Not a barrier
	TOTAL	**5.46**											

Source: Unlocking Energy Efficiency in the U.S. Economy

2 Market maturity and costs barriers – key insights

A High transactions costs for small projects

- Transaction costs, including the effort needed to implement EE measures are often large compared to the benefits associated with EE investments across all sectors
- Transactions costs include both financial and non-financial costs:
  - Financial costs include legal and accounting services
  - Time and trouble costs include time spent searching for information, project managements time and disruption costs

“It can take anywhere up to 18 months to structure a big efficiency project and the management time involved is significant

– Green finance provider

“There are high transaction costs associated with EE, such as closing the business for 2 days. £2,000 is the average annual bill for an SME customer. If you save £200, it’s not worth it. Even at twice that savings rate it doesn’t make sense.

– Utility company

B EE market not sufficiently developed

- The EE market is not sufficiently developed to deliver on EE opportunities
  - While many companies are keen to be involved, the industry lacks the necessary depth of expertise, which is sometimes imported from the US and Europe
  - Users are sceptical whether the EE benefits realised will meet the level promised by EE suppliers
  - There is a perception that high prices and profit margins by EE providers can make EE products and services uncompetitive

“The EE industry in the UK isn’t sufficiently developed in terms of quality and depth. ESCOs have to bring in people from outside”

– Green finance provider

“I get the impression that people are in the businesses of energy efficiency to get rich quickly. Suppliers start on the basis that they want to make a high profit margin …

– Industrial user

Source: Based on corporate interviews; team analysis

A High transaction costs on small deals act as a significant barrier

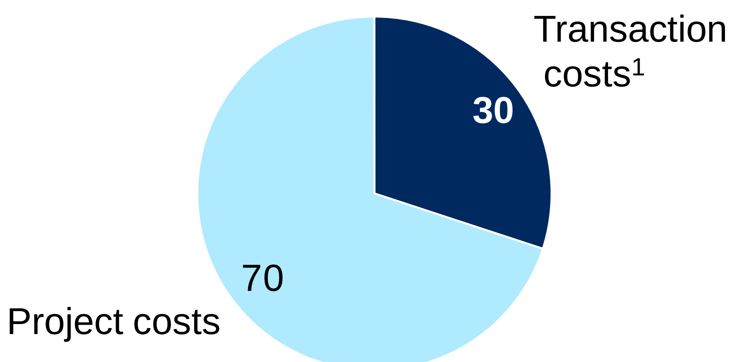
ILLUSTRATIVE

Typical transaction costs include

- Financial costs
  - Investment appraisal and feasibility studies
  - Development of proposal and business case
  - Compliance costs (permits, applications)
  - Measurement and reporting costs
  - Legal and accounting fees
- Time and trouble costs
  - Search for information, project identification
  - Management time in considering and evaluating project
  - Contract negotiations and procurement
  - Production shutdown or disruption of space

Transaction costs as percentage of total EE project costs

Percent



"There are high transaction costs associated with EE, such as potentially closing your business for 2 days. £2,000 is the average annual bill for an SME customer. If you save £200, it's not worth it. Even at twice that savings rate it doesn't make sense.

– Utility company

"Transaction costs for small deals are really high and generally outweigh the benefits

– Green finance provider

"Project costs can include project development time, accounting, audit and legal costs

– Green finance provider

"Retrofit takes 6 months of auditing and appropriately base lining (to illustrate savings), followed by a year of disruption.

– Utility company

1 Experts estimate transaction costs between 20-40% of total project costs depending on project

Source: Expert estimates, Academic studies including, Easton 1999, Valentova 2010, Mundaca 2007

3 Residential – key insights

A Ownership transfer not a key issue

- While agency issues persist in rented accommodation, agency issues in form of ownership transfer do not appear to be a significant issue in the UK residential sector (unlike the US)
- The average payback period for a residential EE measure is 4.2 years, while the average UK owner stays in home for 11 years after purchase

B Opportunities for behavioural change

- Behavioural change appears to be a significant opportunity in the residential sector, with potential as high as 15%
  - Smart metering could provide granular information, breaking the disconnect between electricity use and high bills with a potential impact of 3-5%
  - Audit and advisory services can help consumers realise greater savings by targeting EE measures to those activities with the largest potential
- Implementing domestic efficiency measures may require a strong field force – a new capability that not all utility companies will have

“Drivers of EE in the residential sector might be smart metering and more accurate bills. People need to see the results of actions and get personalised EE advice by data mining

–Utility company

“I don’t know if people in the UK are less knowledgeable about EE. In US, they provide information on bills so you know if your average bill is higher than your neighbour’s

– Utility company

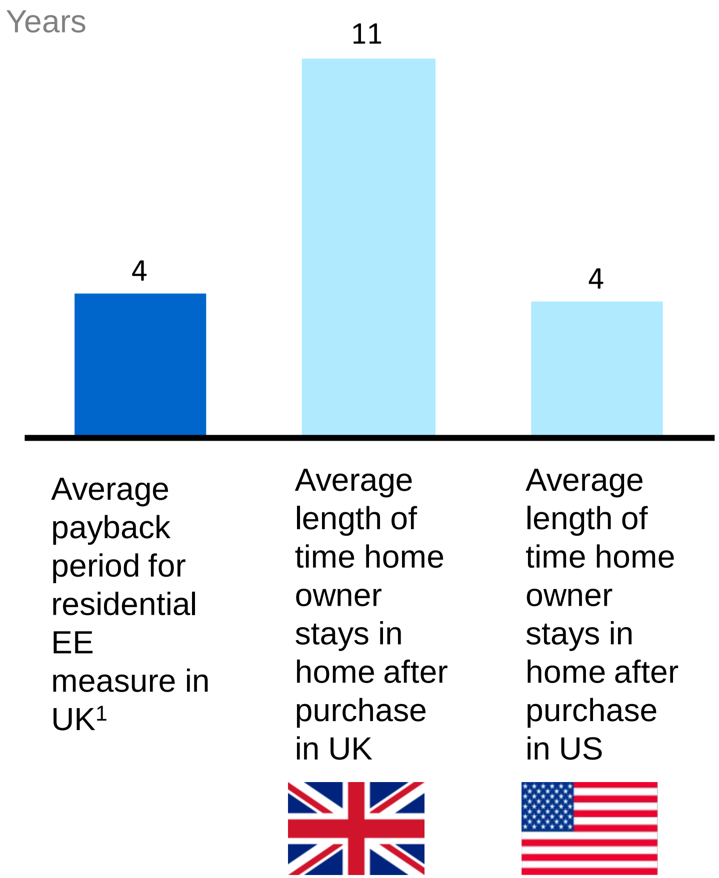
Source: Interviews; team analysis

A Unlike the US, ownership transfer issues in the residential sector do not appear to pose a significant challenge

Context

- The ownership transfer barrier applies to owner-occupied homes when the current owner cannot capture the full duration of the benefits
- To justify the upfront investment, owners facing this barrier would need assurance that they will be able to capture a portion of the future value of the investment upon transfer

Comparison between energy efficiency investments and home ownership



Implications

- While ownership transfer does not appear to be a significant factor, it could be perceived to be a barrier as residents are often uncertain about how long they will remain in the property
- Agency issues between landlord and tenant still affect 32% of residencies in the UK
- While ownership transfer may be less of an issues, other issues remain, including:
  - Costs of gathering information about potential savings and service providers
  - Significant upfront capital costs relative to average UK resident's disposable income
  - Transaction costs in form of disruption, loss of interior space, change to exterior of home

1 Calculated based on team analysis

Source: Unlocking Energy Efficiency in the U.S. Economy; DCLG Survey of English Housing; RICS Economics; team analysis

4 Commercial/industrial – key insights (1/2)

A Expectation of rapid payback period

- In commercial and industrial sectors, many stakeholders expect a rapid payback years of less than 2 years while EE investments on average have a payback period of ~5 years
  - While payback periods ranged from 1-5 years, most companies appear to be seeking a payback period of ~2 years
  - EE projects must compete for limited capex with other opportunities such as revenue creation initiatives or global projects in emerging markets such as China
  - The economic crisis has intensified this pattern as uncertainty keeps business focused on the short run

"Typically if an efficiency project has a payback period of over one year, it is rejected

– Green financier

"We have tens of projects/ year which we constantly evaluate. We are looking for 2-3 year payback period. There are lots of opportunities, but it's about priority of capex. It's hard to compete globally if you look to areas such as China where returns on new investments are high.

– Electricity intensive user

B Agency issues are significant in commercial sector

- Agency issues in the commercial sector appear to be a significant barrier
  - 61% of commercial space is leased so companies are not incentivised to implement EE measures
  - 75% of corporations outsource their facilities management capabilities, often without incentives for reducing energy costs

"We must work with facility management companies, rather than the customer directly. There is an agency problem- getting through to the decision makers.

– Utility company

Source: Interviews; team analysis

4 Commercial/industrial – key insights (2/2)

C Capital constraints not an issue for large companies

- While capital constraints may be a barrier for SMEs or underperforming companies, large commercial and industrial organisations can secure necessary financing to make an EE investment if attractive

"There is no financing issue. Maybe it's a marginal issue. But be it banks, bonds or self-financing, companies can get the financing if the investment makes sense

– Industry association

D Large opportunity with less-intensive industrial users

- Electricity intensive industries have taken significant steps to become more energy efficient as this is key to their competitive advantage. The key opportunity here would be further technological advancement.
- A bigger opportunity may lie with less electricity intensive industrial users, because it is a smaller portion of total costs. However, in the aggregate the less electricity intensive industries use a significant amount of electricity and present a large opportunity for reduction

"Most heavy industries are quite EE except for old kit. There are diminishing returns there. The proportionate scope for EE savings in less intensive industries is much higher

– Industry association

"We have numerous KPIs around EE and we track this every minute. We monitor if any plant gives signs of deviation.

– Electricity intensive user

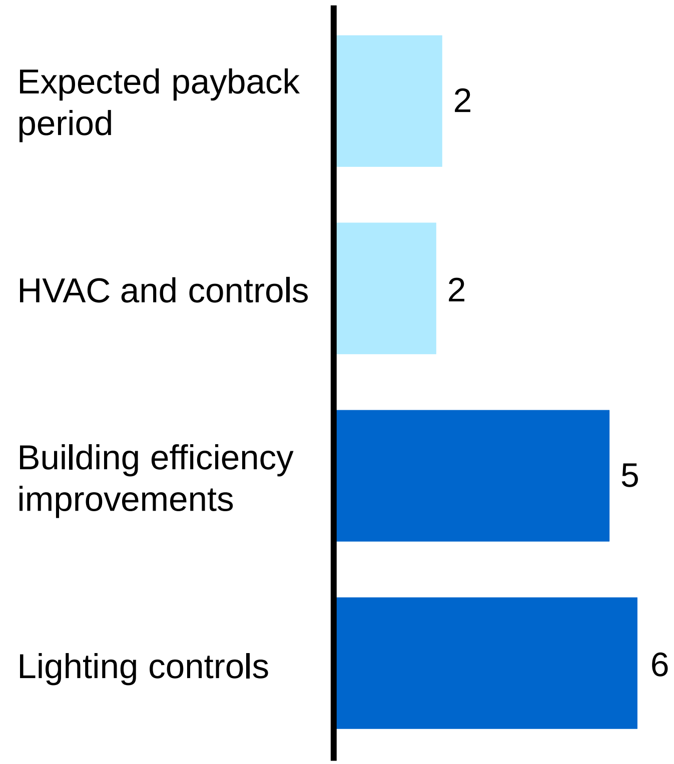
Source: Interviews; team analysis

ILLUSTRATIVE

A Commercial and industrial organisations typically seek a rapid payback period of ~2 years, while payback on many EE investments is significantly longer

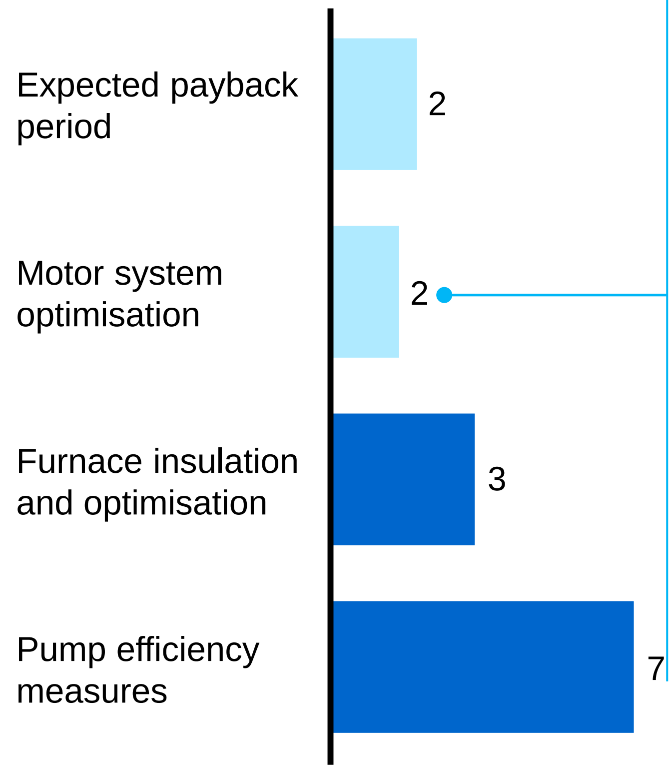
Commercial

Average payback period[1]
Societal payback, Years



Industrial

Average payback period[1]
Societal payback, Years



Motor potential not captured because:

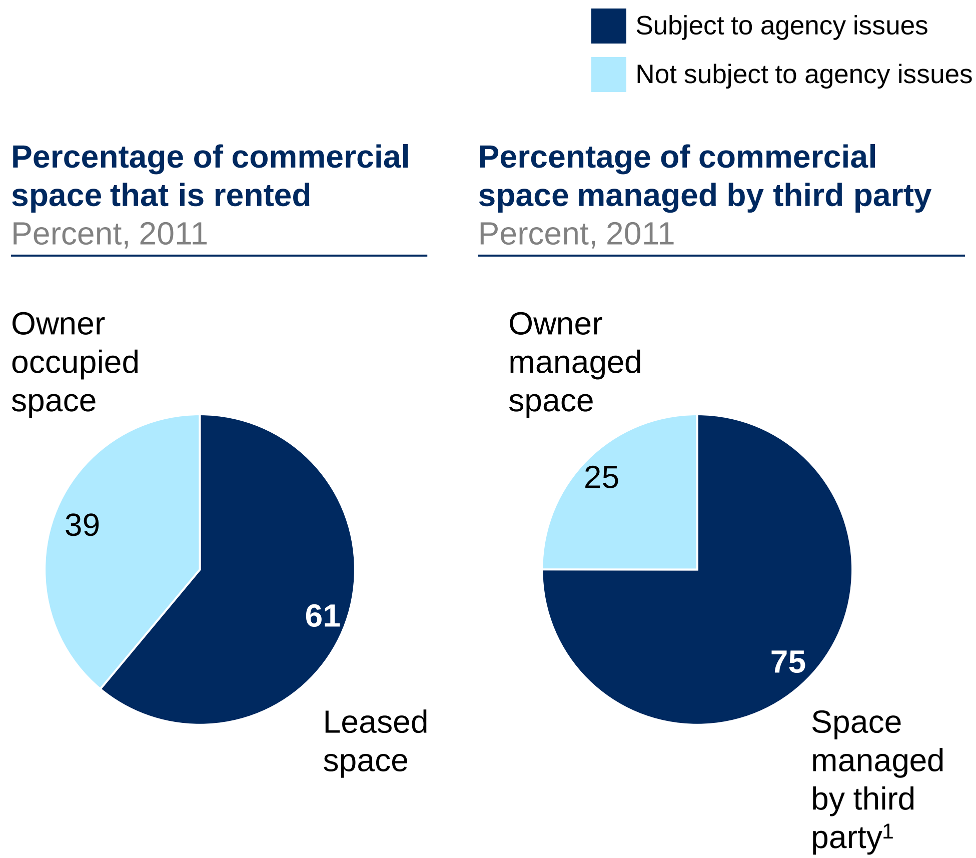
- Payback period reflects average across all motors, but smaller motors may have longer payback period
- Disruption costs and risk not included in payback calculation
- Companies lose optionality due to downsizing of motors

1 Payback period calculated based on team analysis; considers capex and opex at current levels and includes factor of 30% for transaction costs

Source: Interviews; team analysis

B Agency issues appear to be a significant barrier in the commercial sector

More than 60% of UK commercial organisations face an agency issue



Few building management companies have an incentive to reduce electricity use

"Many commercial businesses use facility management companies. There is often an agency problem here because the management company has no incentive to reduce consumption.

– Utility company

"Sometime the facilities management company gets paid on number of light bulbs replaced so that doesn't incentivise them to put in LEDs

– Utility company

"We are starting to focus more on the supplier incentive so that the person incentivised to reduce electricity is the person who can influence it most. We are driving innovation- I don't get the sense that our peers are doing this.

– Commercial user

1 Level of outsourcing for office and retail space ~ 75-80%

Source: British Council for Offices; Interviews

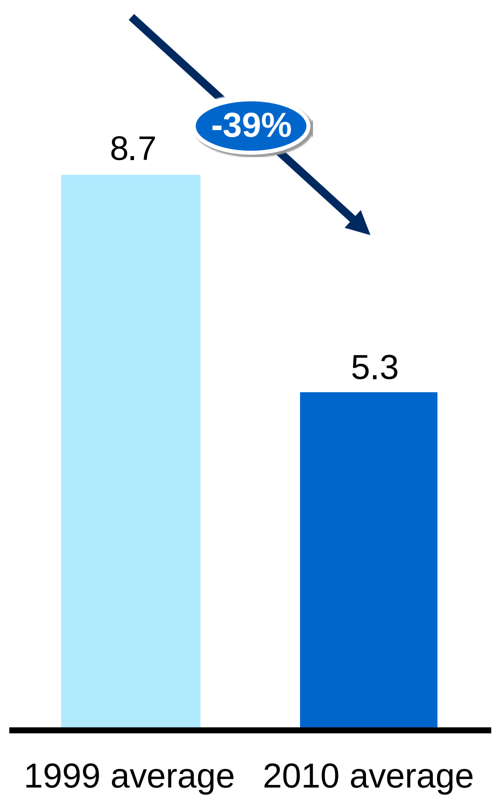
B The length of the average commercial lease has decreased significantly, exacerbating the agency problem

ILLUSTRATIVE

Average length of commercial leases has fallen by more than a third

Duration of average commercial lease in UK

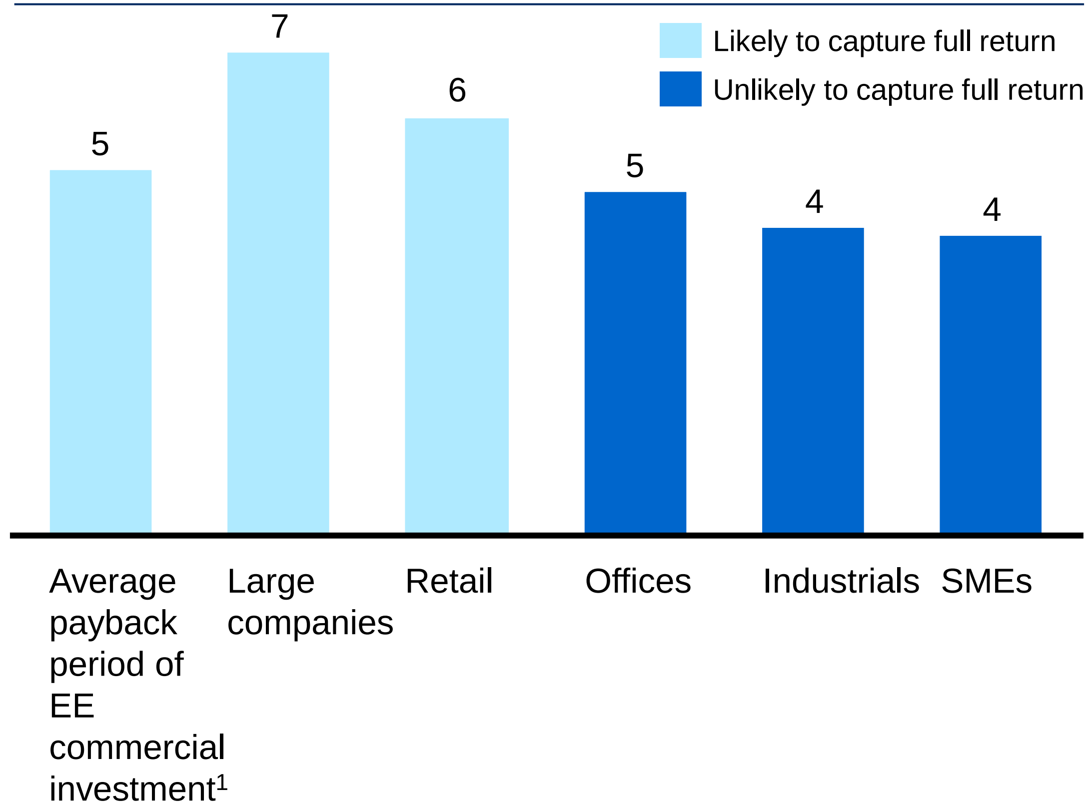
Years



Tenant companies are less likely to remain in the building long enough to earn the full return of an average EE investment

Comparison between energy efficiency investments payback periods and length of commercial leases

Years



1 Payback period calculated on societal basis and includes transaction costs of ~30%

Source: UK property data report 2011; Interviews; Association for the Conservation of Energy

D Interview example: electricity intensive users are actively pursuing efficiency measures and are facing diminishing returns from investment

BASED ON DATA FROM INTERVIEW – NOT VERIFIED

One industrial user undertook multiple initiatives to reduce energy consumption, including:

Lighting

- Installed T5 fittings
- Installed independent sensors that pick up movement and ramp up output
- Daylight detection adjusts light output in closed loop
- Reduced energy by 66%, saving >£10k/ year

Variable speed drives (pumps)

- Identified water pumping system was poorly controlled and not well matched to process requirements
- Replaced pumps with high efficiency units
- Reduced energy by 33%, saving ~£90k/ year

Behavioural measures

- Created 'best practice' standard for equipment, processes and behaviours
- Worked in multi-disciplinary team to create pro-forma checklist
- In one plant, eliminated 3/4 of load during off hours (off hours represent 10-15% total load)

However, the improvement curve is flattening as the limits of current technology are reached

Energy per unit of output

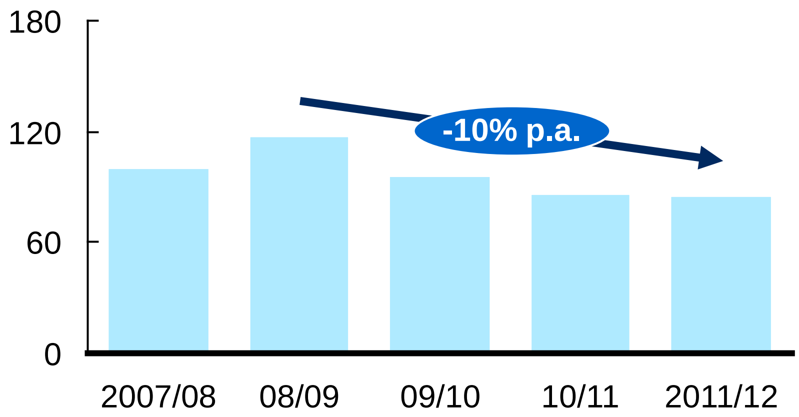
Source: Interviews

D Non-electricity intensive industries may represent a bigger opportunity for electricity demand reduction

Some electricity intensive users have made significant reductions in energy use as this is key to competitiveness

Energy imported per unit at one UK-based plant

Energy, 2007-2012



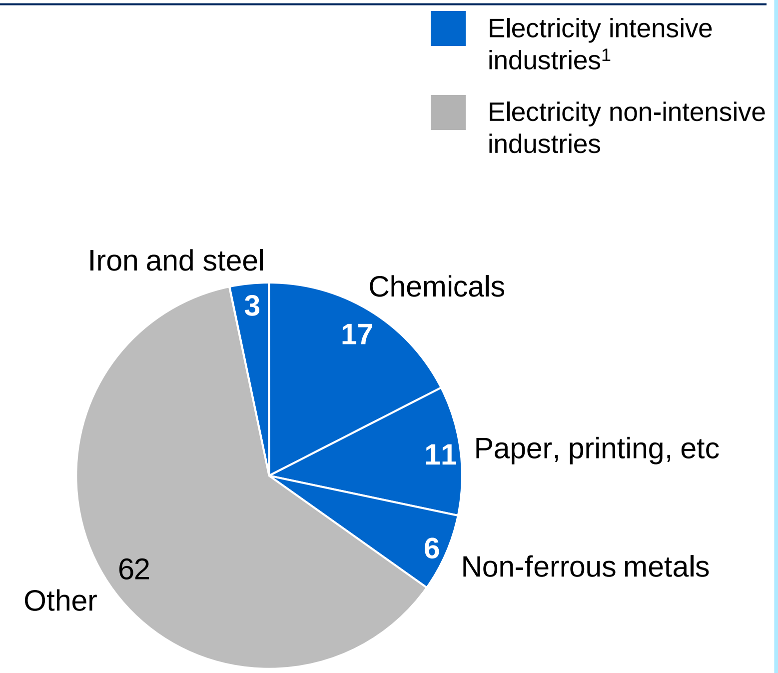
> "We have numerous KPIs around EE and we track this every minute. We monitor if any plant shows signs of deviation from normal use.
> ***– Electricity intensive user***

> In the last 5 years, we reduced electricity by 20-25% for every ton of production, but in absolute terms electricity has gone up wiping out these savings.
> ***– Electricity intensive user***

However, industries that are commonly known as electricity intensive account for only 38% of electricity use

Breakdown of UK industrial consumption by sector

Percent of TWh, 2010



1 Industries commonly cited as electricity intensive include: Iron and steel, chemicals, paper, non-ferrous metals

Source: DECC ECUK/DUKES statistics on final and projected consumption of electricity; Interviewee data, Interviews, team analysis

Contents

Design options can be split into 8 categories, each impacting a number of barriers

Category	Description	Key barriers addressed
1 Mandates[1]	• Rules or regulations compelling EE measures or targets	• Lack of focus/non-core • Lack of awareness/information
2 Financing	• Mechanisms to provide or facilitate the provision of capital, often on non-commercial terms	• Capital constraints • Hurdle rate/payback period • Transaction costs
3 Incentives	• A financial benefit for implementing energy efficiency measures or achieving energy efficiency targets	• Lack of focus/non-core • Hurdle rate/payback period • Capital constraints
4 Tax	• Government imposed levies or charges on electricity users and/or utilities, deterring energy inefficient behavior	• Lack of focus/non-core • Hurdle rate/payback period
5 Information/ labelling	• Measures to increase awareness of energy efficiency opportunities and benefits	• Lack of awareness/information • Agency issues
6 Supplier obligations	• Obligations to carry out EE measures or make EE investments imposed on suppliers of electricity	• Product availability • Agency issues • Lack of awareness/information
7 Voluntary agreements	• Agreements between government and large electricity users to improve electricity efficiency	• Lack of focus/non-core • Lack of awareness/information
8 Pricing	• Measures to invert the relationship between increasing electricity consumption and lower electricity prices	• Lack of focus/non-core • Hurdle rate/payback period

1 Mandates may overcome all barriers if enforcement/penalties are sufficiently strong, but other considerations (e.g. equity) suggest they are not always the preferred design option

Source: Team analysis

We have examined a range of design options used in other countries (1/2)

Case example
Red U.K. example

	Design option	Description	Example
1 Mandate	Product standards	• Policies to increase efficiency of products imposed on the product manufacturer or retailer	• Corporate Average Data-Centre Efficiency (CADE) or Power Usage Effectiveness (PUE) standards – USA • Products policy – EU • Top Runner Programme – Japan
	End user energy efficiency requirements	• Energy efficiency requirements imposed by the state on state agencies and political sub-divisions including counties, public school districts and higher education institutions	• Energy efficiency requirements for local government buildings, operations and schools in Texas, New York and Massachusetts – USA • Energy consumption reduction obligations for state agencies – USA
2 Financing	Financing	• Making finance available potentially on advantageous terms for energy efficiency investment	• Green Investment Bank – U.K. • Salix Finance – U.K. • Green Deal – U.K. • Texas LoanSTAR programme – USA • Pennsylvania Green Energy Loan Fund – USA • KfW – Germany
3 Incentive	Feed in tariffs	• Provides a financial incentive to end users based on the operational performance of their investment in terms of energy savings (a “performance-based subsidy”) • Companies “Saving Sponsors” implement schemes to reduce electricity demand in any eligible sectors, through any eligible measures – working through sub contractors as needed	• Toronto Hydro – Canada • Trondheim Energy – Norway • Public Utility Commission of Texas (PUCT) – USA • Efficiency cheque – Portugal • Pacific Gas and Electric Company (PG&E) – USA • Energy Saving Certificates Trading Scheme in Connecticut – USA and Australia • New York Energy Smart program – USA
	Forward capa-city markets	• Unique market that allows energy efficiency and other demand resources to compete directly with generators • Companies “Saving Sponsors” plan efficiency schemes that will be active during the window of the capacity market • In the Capacity Auction (and/or subsequent re-trading) Saving Sponsor companies bid “on an equivalent basis” to generating companies	• ISO New England’s Forward Capacity Market – USA • PJM’s Reliability Pricing Model (RPM) – USA
	Tax relief	• Tax credits to incentivise industry to invest in more energy efficient technologies • Tax credits, deductions, rebates or accelerated depreciation for commercial buildings • Systems which reward/penalise businesses/end users depending on whether they achieve energy efficiency/buy energy efficiency products e.g., electric vehicles	• The Department of Energy's (DOE) Office of Industrial Programs R&D Tax Credits – USA • US government tax deduction programme for new or renovated commercial buildings • ADEME “Bonus Malus” system – France
	Grants/ subsidies	• Monetary/direct incentives which encourage businesses/individuals to improve energy efficiency of processes along supply chain (including business partners)	• Duke’s Save a Watt programme – USA • New England’s ‘Pay as You Save’ program – USA • Lodi Electric Utility (California) rebate programme for commercial and residential sectors – USA • Vermont’s CFL buy-down programme – USA

Source: Team analysis

We have examined a range of design options used in other countries (2/2)

Case example
Red U.K. example

	Design option	Description	Example
4 Taxes	**Taxes**	• Mechanisms to increase price of electricity and indirectly provide an incentive for greater energy efficiency	• Carbon price floor – U.K. • CCL – U.K. • Emissions trading scheme (ETS) – EU • Agency for Environment and Energy Management's (ADEME) "Bonus malus" system – France
5 Information and labelling	**Benchmarking capability/tools**	• Tools to increase awareness of relative performance of buildings of similar type, age and geography as well as indicating sources of energy loss • Enables users to measure success of energy efficiency investments and decide on future investments • Energy ratings are provided to buildings that meet a specific standard of energy efficiency compared with relevant comparison group	• Environmental Protection Agency's Portfolio Manager – USA • Seattle's Building Energy Benchmarking and Reporting Program – USA
	Awareness campaigns	• Subsector and technology focused awareness campaigns through guidebooks, assessments and forums to boost awareness of energy efficiency improvement options and support available	• The DOE Industrial Technology Program "Save Energy Now" program – USA • EPA's ENERGY STAR Industrial Partnership – USA • Product Labelling – EU
6 Supplier obligation	**Supplier obligation**	• Policies which enforce energy suppliers to comply with mandatory energy savings targets through energy efficiency projects on their clients' or other end–users premises	• CERT – U.K. • CESP – U.K. • EE obligation and tradable certificates – France and Italy • Energy Efficiency Resource Standards – USA
7 Voluntary agreements	**Voluntary agreements**	• Industry covenants, negotiated and long-term agreements, codes of conduct, benchmarking and monitoring schemes which are offered voluntarily to suppliers and end users • In return, participants may receive compensation, potential regulatory exemptions, avoidance of stricter regulations and/or financial rewards	• 2005 five year agreements program – Sweden • Long term agreements ("LTA 1" and "LTA 2") –Netherlands • CCA – U.K. • Energy Performance Certificates (EPCs) – USA
8 Pricing	**Pricing**	• Inverted block rates for residential customers, split into tiers, with the highest consumption tier nearly twice as expensive per kWh as the lowest tier	• California Public Utilities Commission – USA

Source: Team analysis

The four case studies were selected to provide insights into market based incentive mechanisms and options to address services sector potential

Case studies jointly selected with DECC

- **A** ISO New England Forward Capacity Market
- **B** Public Utility Commission of Texas: Energy efficiency programmes (SOPs and MTPs)
- **C** Connecticut Energy Saving Certificates
- **D** US Environmental Protection Agency: Portfolio Manager (commercial and public buildings)

Rationale for selection

- Three of the cases could inform demand side market based incentive mechanisms being considered as part of / linked to EMR:
  - Capacity markets: ISO-NE
  - Feed in tariffs: PUCT and Connecticut ESCs
- Examples from the US were chosen, as these represent the most advanced use of market based incentives
- The EPA's Portfolio Manager was selected as an additional case study to address the uncaptured potential in commercial and public buildings
- An additional filter was applied to avoid cases for which DECC already has a detailed fact base

Source: Team analysis

The case studies suggest a number of implications relevant to the UK context (1/2)

	Key features	Implications for UK market
A ISO-NE forward capacity markets	• Forward capacity markets allowing demand side resources to compete with generation • Demand side resources represented ~10% of capacity bid into the auction in 2010 • Efficiency measures (as opposed to demand response) constituted ~35% of the demand side resourced bid into the auction in 2010 • For one key participant, Efficiency Vermont, ~80% of the portfolio consists of lighting	• Demand side participation in a capacity market could deliver significant efficiency impact, in addition to demand response • Capacity payments could provide sponsors with the incentive and stability to encourage investment in efficiency and compete with generation capacity • The role of National Grid would need to be expanded to be equivalent to ISO-NE (potentially addressed through EMR)
B PUCT: Energy efficiency programmes	• Utilities satisfy obligations to meet 20% of demand growth through two types of incentive programme: – Standard Offer Programmes (SOPs) allowing consumers / aggregators to choose the most cost effective measures – Market Transformation Programmes (MTPs) incentivising specific efficiency measures facing structural barriers • Limited impact to date (~0.15% of total electricity demand in 2010): – Primarily due to targets not being very ambitious (Texas ranked 37th out of 42 states in per capita EE budgets) • Commercial and industrial represent ~63% of total savings	• A FiT-like mechanism could be administered through suppliers, whose incentive to sell more electricity could be somewhat offset • Would require clarification of potential overlaps with current supplier obligations, i.e. ECO • Could be combined with Green Deal as an additional incentive to providers • Due to deregulated pricing in the UK, would require careful setting of incentive rates to ensure manageable cost to customers/taxpayers – In Texas, the PUCT explicitly sets limits on reasonable expenditures by utilities that can be passed on to consumers • MTP like programmes would allow selection of the highest potential opportunities that might otherwise not be adopted

Source: Case studies; Team analysis

The case studies suggest a number of insights and implications relevant to the UK context (2/2)

	Key features	Implications for UK market
C Connecticut: Energy saving certificates	• Tradeable certificates issued by the state regulator representing 1 MWh of savings • Suppliers obliged to meet 4% of electricity supplied through purchase of ESCs – Not all pure energy efficiency – some CHP and micro-generation can participate • Regulator specifies a floor price (~$10) and effectively sets a cap by charging suppliers a penalty of ~$31 for obligations not met – ESCs typically trade just below this price • Allows some degree of prescription as to the efficiency measures incentivised through the eligibility criteria for ESCs	• Tradeable certificates could promote a market in energy efficiency where the most cost effective efficiency measures set the certificate price • Eligibility criteria would need to promote the highest potential opportunities that would otherwise not be adopted • Would require careful setting of supplier obligations / certificate prices to ensure that the cost to customers (passed on by the supplier) is manageable – ~$35 per capita spent in Connecticut
D EPA Portfolio Manager	• Portfolio Manager provides a low cost online benchmarking tool for commercial buildings • Energy Star Rating facilitates communication to prospective tenants and buyers, helping overcome agency barriers • Benchmarking and online resources effectively act as a low cost audit tools, suggesting highest value efficiency opportunities to overcome lack of awareness • Range of variables used in determining performance against benchmarks acts as a dynamic baselining tool, helping to isolate additionality	• Addresses significant uncaptured potential in commercial and public admin buildings • Confidence in benchmarking algorithm is critical in order to generate voluntary participation • Participation could be made compulsory for buildings above a defined size • Publication of building ratings could be made compulsory to further address agency issue • Open question is the extent to which potential tenants and subsequent buyers will consider energy efficiency in decision making • For large commercial users, provides more granular tracking and data than CRC

Source: Case studies; Team analysis

Key insights from the case studies for design of a market-based incentive mechanism

Key insights

Impact

- Forward capacity markets are largely technology neutral whereas a FiT would allow targetting of technological or structural barriers
  - Technologies currently not cost effective would not clear a capacity auction
  - FiT incentives can be targeted at specific abatement measures
- Demand side participation in forward capacity markets facilitates direct offsetting of generation capacity
  - Effectiveness of FiTs is highly dependent on level of incentive and/or demand reduction obligation placed on electricity supplier – risk of over or under-shooting
- Permanent demand reduction measures have proven to compete cost effectively with demand response in either a capacity market or FiT mechanism

M&V

- Almost all mechanisms distinguish between simple / deemed M&V for smaller measures and complex M&V for larger measures
- For forward capacity markets, key consideration is whether the demand reduction is additional to the baseline used by the system operator in projecting capacity required
  - Consequences of failure are potentially an expensive shortfall in capacity
- For FiTs, ensuring genuine additionality is a challenge that has not been comprehensively addressed by any mechanism:
  - Where possible this is a matter of identifying key parameters that allow a dynamic baseline (e.g., per unit of output) perhaps with a natural efficiency gain factor
  - Detailed project evaluation could address this, but creates an administrative burden, requires industry-specific expertise and faces information asymmetry issues

Source: Team analysis

Key characteristics of different archetypes for market-based incentive schemes

Key characteristics	Forward capacity market e.g., ISO New England	Tradeable certificates e.g., Connecticut ESCs	Standardised incentive scheme e.g., PUCT Standard Offer Program	Tailored incentive scheme e.g., PUCT Market Transformation Program
Specificity	• Primary objective of market is to ensure adequate capacity (across supply and demand side) at lowest price: efficiency competes with generation and demand response • Technology neutral: does not incentivise currently uneconomic technologies	• Objective is to incentivise end use energy efficiency • Generally involves standardised eligibility criteria for certificates	• Objective is to incentivise end use energy efficiency • Standardised contracts that are largely technology neutral	• Objective is to incentivise end use energy efficiency for specific measures • Facilitates incentivisation of technologies at early stage of learning curve or facing other financial or structural barriers
Funding capability	• Receives same capacity payments as generators per unit of capacity		• Depends on pre-determined level of incentive or demand reduction obligation placed on supplier	
Source of funding	• Market operator pays demand side participants - costs borne by ratepayer		• Taxpayer (if run by market operator) or ratepayer (if run through suppliers)	
Price discovery	• Market based: only bids below market price clear the auction	• Market based: price set through trading of certificates in open market	• Price discovery done by network operator and/or supplier in setting incentive	
Synchronisation with demand (peak vs baseload)	• Facilitiates direct trade offs with generation capacity • Will favour projects impacting peak consumption		• Trade off against capacity implicitly done by network operator or supplier • Does not distinguish between different load profiles – addresses total energy usage	
Importance of M&V	• Failure to achieve savings could result in insufficient capacity • Additionality to be measured against baseline capacity projection model	• Tends towards simple M&V - additionality considered in setting deemed level of savings		• Additionality ideally measured by identifying key parameters that allow a dynamic baseline (e.g., per unit of output) perhaps with a natural efficiency gain factor

Source: Team analysis

What you would need to believe in order to conclude that market based incentives could address barriers to uncaptured potential being realised

Bold Key barriers for commercial and industrial sectors

Barrier category		Barrier	What you need to believe for a market based incentive to be effective
Attrac-tiveness	Attention to opportunity	• Lack of awareness/info	• Incentives would result in market participants (e.g., aggregators and ESCOs) conducting awareness campaigns
		• Lack of focus	• Increased payoff would elevate efficiency to top of mind for key decision-makers
	Financial and non-financial costs	• Transaction barriers	• Key transaction barriers are capable of being overcome by financial incentives of a reasonable scale
		• **Hurdle rate/ payback period**	• Financial incentives could be large enough to result in significant shortening of payback period to below target period
	Capturing benefits	• **Agency issues**	• Incentives would result in tenants self-funding investments in buildings or a third party aggregator doing so on their behalf
		• **Risk and uncertainty**	• Incentive would outweigh risk of production shutdown / interruption
Financing		• Capital constraints	• Availability of incentives would effectively subsidise financing costs or top-up financing where unavailable
Execution		• Product availability	• Incentives would justify R&D costs of investment in new technologies
		• Installation and use	• M&V associated with incentives requires sponsors to ensure effective installation/use

Source: Team analysis

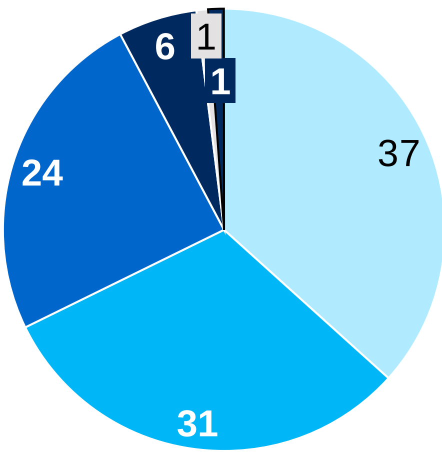
APPENDIX

Appendix contents

Split of UK 2010 end use electricity consumption, split by sector and end use

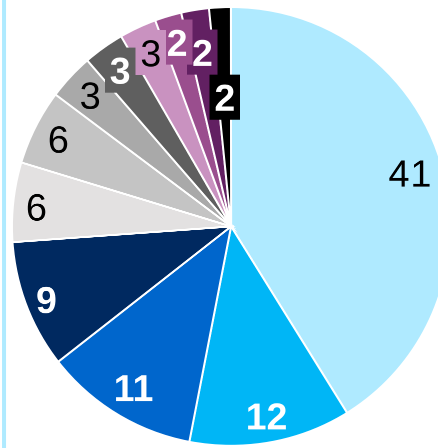
Breakdown of U.K. electricity consumption by sector[1]

Percent of TWh, 2010
100%= 328



Breakdown of U.K. electricity consumption by end use

Percent of TWh, 2010
100%= 328



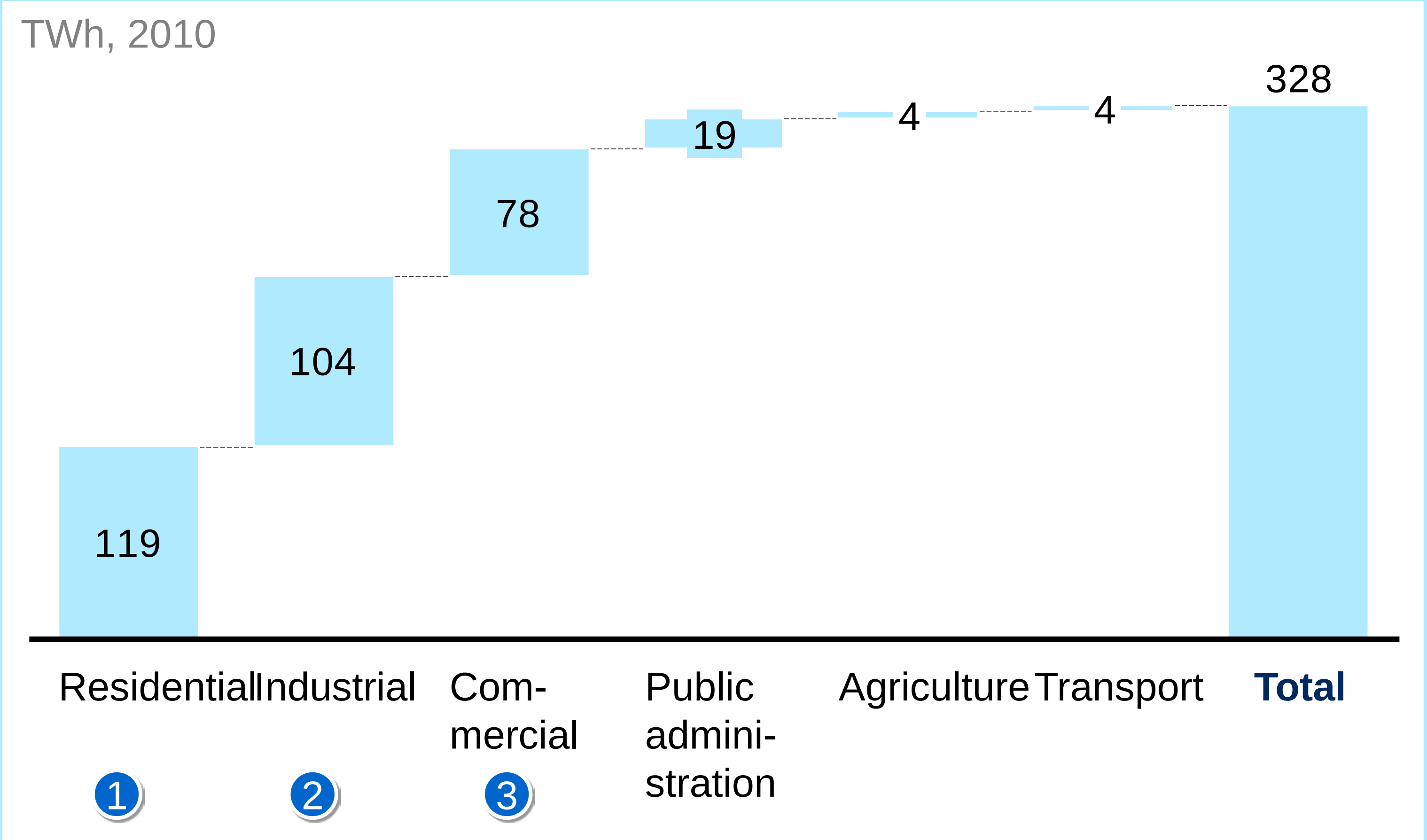
Applied 2009 DECC actuals end usage split to 2010 DECC actuals data

1 Services sector includes commercial, public administration and agriculture sectors

Source: DECC ECUK/ DUKES statistics on final consumption of electricity

The U.K.'s 2010 electricity consumption was 328 TWh

Breakdown of U.K. electricity consumption by sector



Source: DECC ECUK/ DUKES statistics on final consumption of electricity

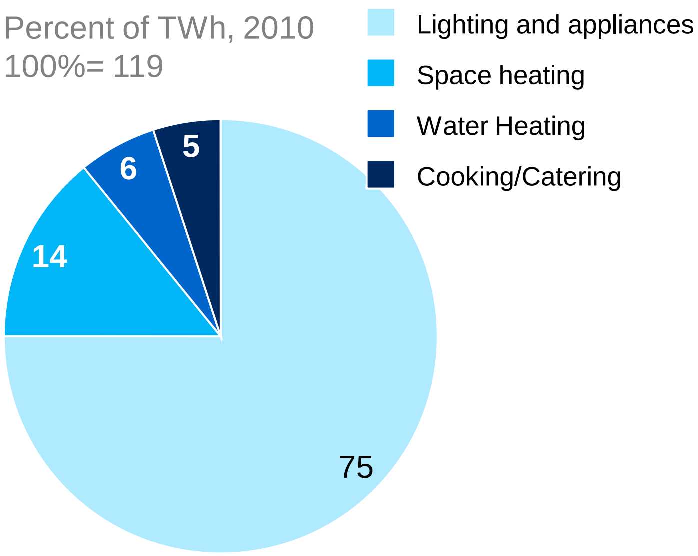
1 + 3 Current domestic and service demand is driven primarily by lighting and appliances

Methodology

Applied DECC 2009 actuals end usage split to 2010 DECC actuals data

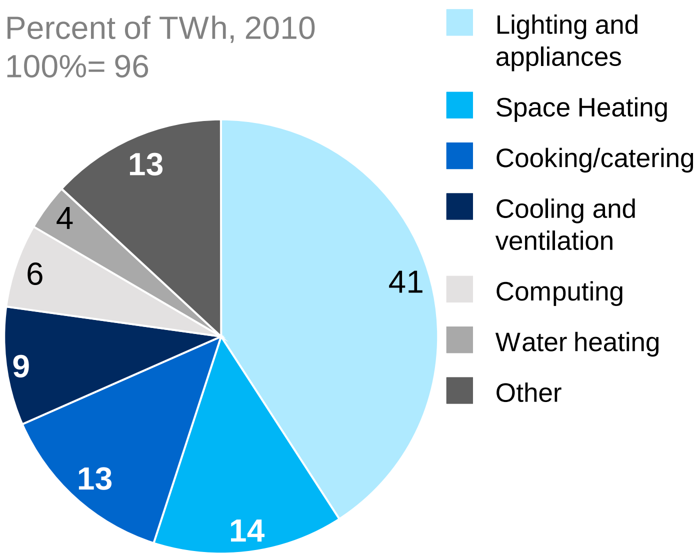
Breakdown of U.K. residential electricity consumption by end use

Percent of TWh, 2010
100%= 119



Breakdown of U.K. services electricity consumption by end use (includes commercial and public admin)

Percent of TWh, 2010
100%= 96



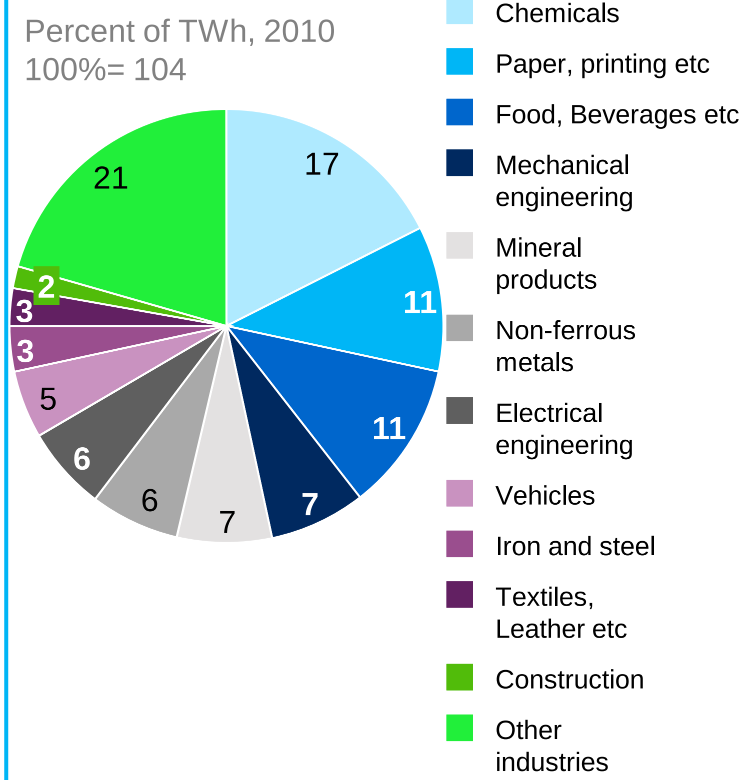
Source: DECC ECUK/DUKES statistics on final consumption of electricity

2 Motors are the largest single industrial use of electricity in the U.K.

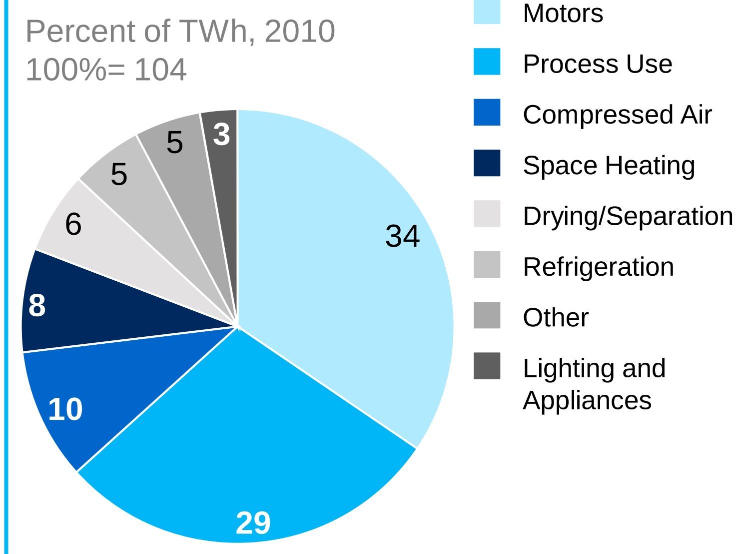
Methodology

Applied DECC 2009 industry actuals end usage split to 2010 DECC actuals data

Breakdown of U.K. industry electricity consumption by sector



Breakdown of U.K. industry electricity consumption by end use



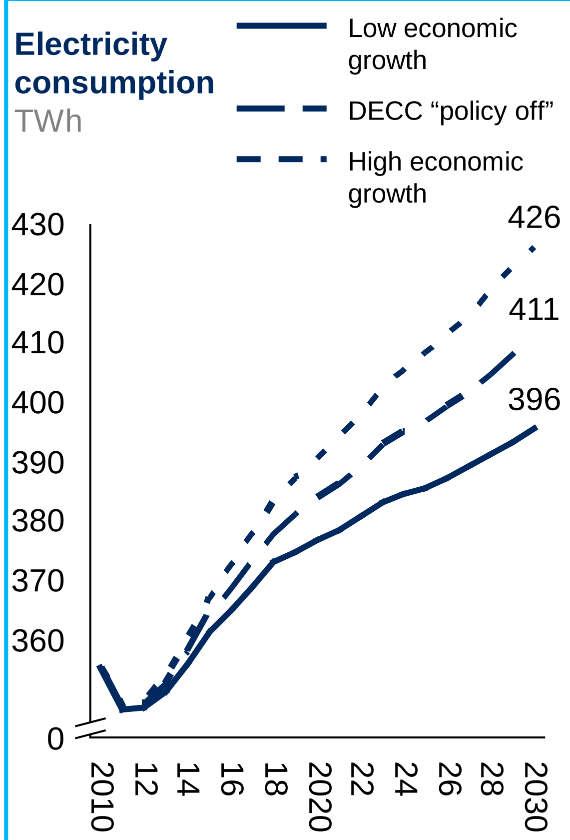
Source: DECC ECUK/DUKES statistics on final consumption of electricity

Economic growth and fossil fuel price sensitivities

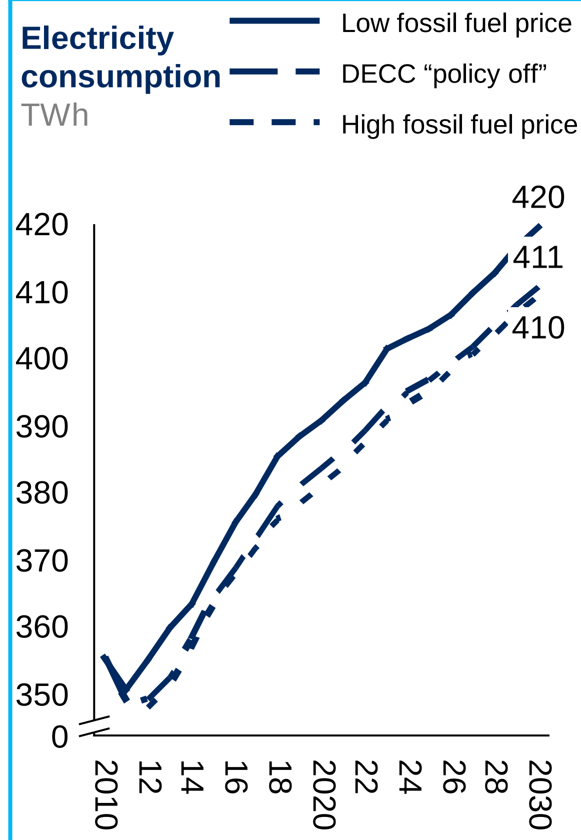
Methodology

- High/low U.K. economic growth and fossil fuel price sensitivities based
  on DECC central projections
- Economic growth sensitivity:
  - High economic growth assumptions:
    - Economic growth of 2.5% p.a.
  - Low economic growth assumptions:
    - Economic growth of 2.0% p.a.
- Fossil fuel price sensitivity:
  - Low fossil fuel price sensitivity assumptions:
    - Wholesale and retail electricity price to increase by 2.4% p.a.
  - High fossil fuel price sensitivity assumptions:
    - Wholesale and retail electricity price to increase by 4.2% p.a.

Economic growth sensitivity



Fossil fuel price sensitivity



Source: DECC central electricity projections; team analysis

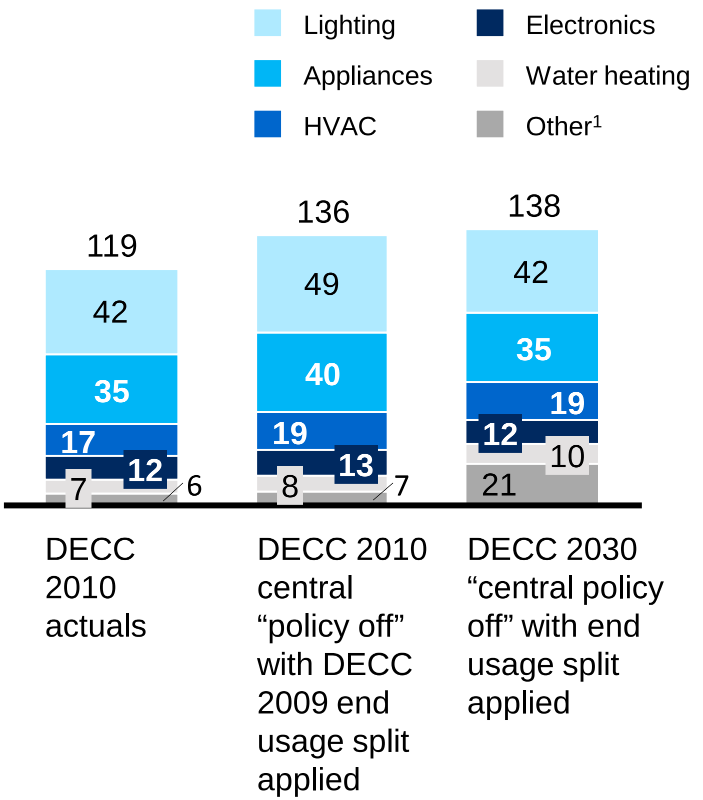
1 RESIDENTIAL: Demand shaped by reduction in lighting consumption

Projected end usage for the residential sector, TWh, 2010 and 2030

Methodology

- Total sector electricity demand estimated using DECC energy demand model
- 2010 split by end use based on DUKES data published by DECC (based on 2009 split as 2010 split not available)
- 2030 split by end use estimated by scaling 2010 split by expected change in relative share of each end use:
  - Based on projections of expected change in end usage share from 2010–30
  - Calculated based on a combination of IEA projections, publicly available reports by industry bodies and internal expert interviews

Electricity consumption, TWh



Key changes and drivers

- Electricity consumption projection 2010-30 remains flat due to two opposing factors:
  - Increase in number of households and household income
  - Electricity retail price increase and switch to more energy efficient appliances
- Key changes include:
  - Decrease in lighting from 36% to 30%
  - Decrease in appliances from 29% to 25%
  - Increase in ‘other’ from 5% to 15% driven by cooking and other factors[1]

1 Other includes cooking and the impact of residual factors not possible to allocate to other end uses

Source: Team analysis

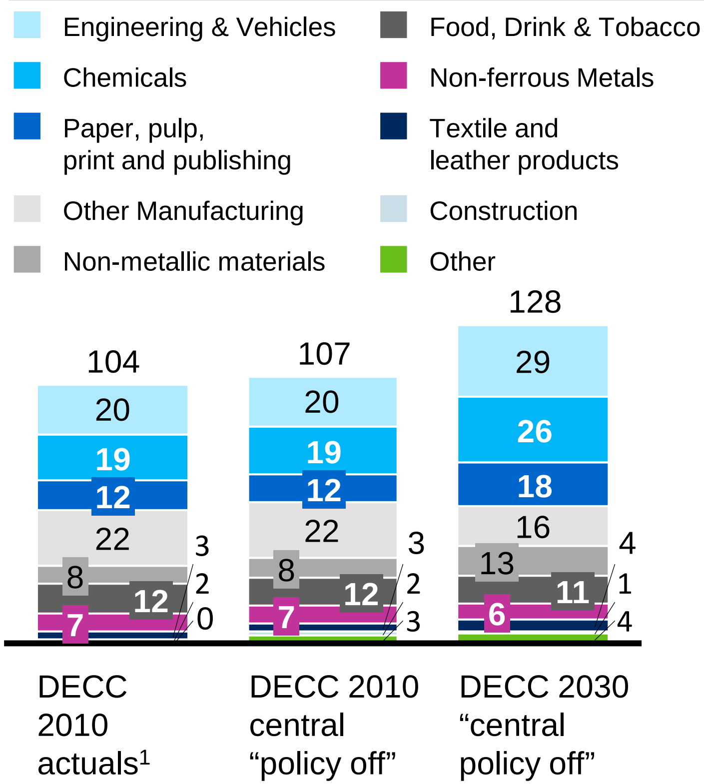
2 INDUSTRIAL: Demand driven by engineering and vehicles and chemicals industries

Projected end usage for industrial sector, TWh, 2010 and 2030

Methodology

- Total sector electricity demand estimated using DECC energy demand model
- 2010 and 2030 splits by sector based on DECC projections

Electricity consumption, TWh



Key changes and drivers

- Electricity consumption increase driven by industry GDP contribution of 1.4% p.a. and increase in electricity share of total fuel usage by industry from 32% to 38%
  - Chemicals and engineering and vehicles contribute the most to total industry GDP
  - Non-metallic minerals, paper, pulp, printing and publishing and chemicals have the biggest increase in electricity share of total fuel usage

1 Central "policy off" sector splits applied due to differences in categorisation in actuals data

Source: Team analysis

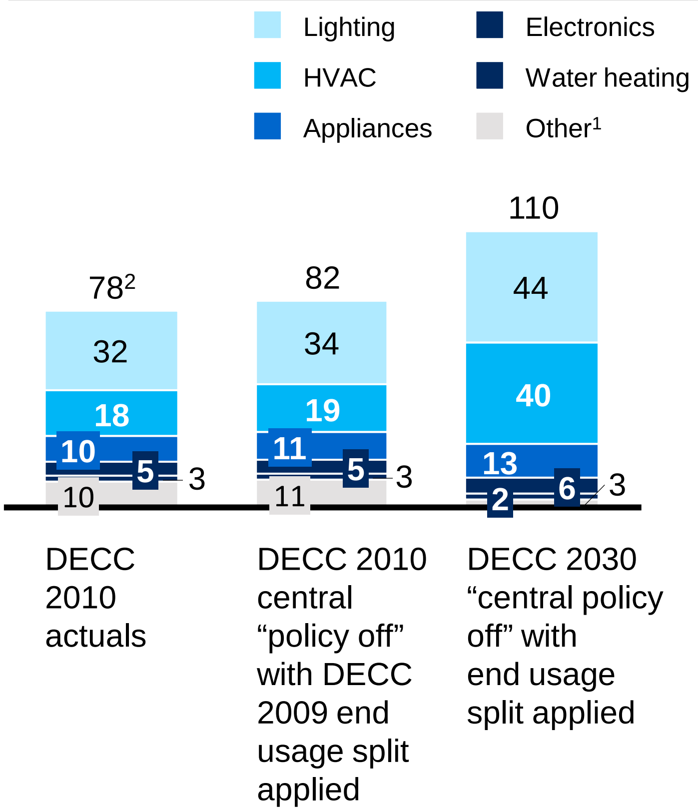
3 COMMERCIAL: Demand driven by increases in HVAC and lighting consumption

Projected end usage for the commercial sector, TWh, 2010 and 2030

Methodology

- Total sector electricity demand estimated using DECC energy demand model
- 2010 split by end use based on DUKES data published by DECC (based on 2009 split as 2010 split not available)
- 2030 split by end use estimated by scaling 2010 split by expected change in relative share of each end use:
  - Based on projections of expected change in end usage share from 2010–30
  - Calculated based on a combination of IEA projections, publicly available reports by industry bodies and internal expert interviews

Electricity consumption, TWh



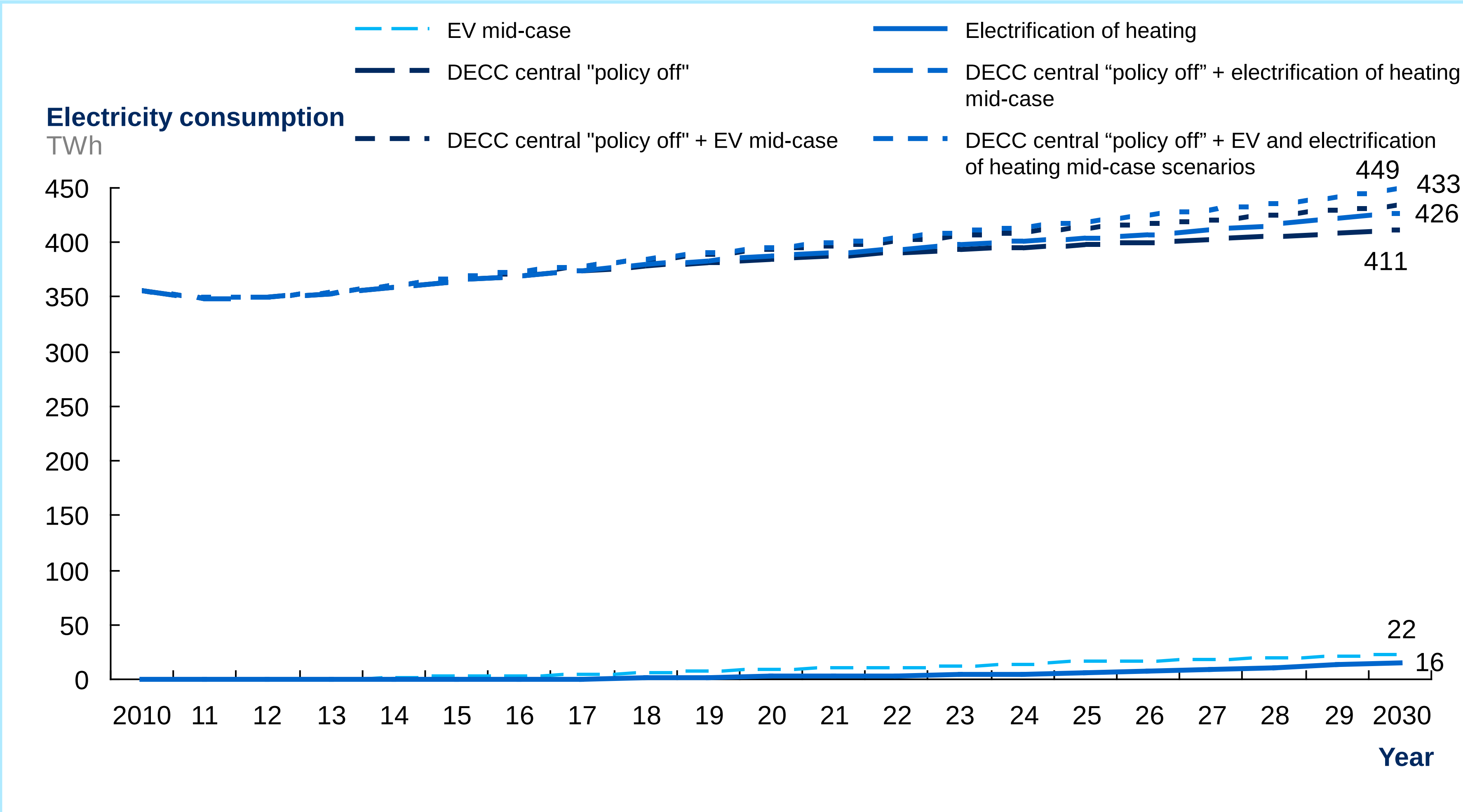
Key changes and drivers

- Electricity consumption increase driven by Gross Value Added (GVA) contribution by the commercial services sector to the U.K. and the increase in electricity as a share of total useful energy for the commercial services sector
- Key changes in relative end usage split include:
  - Increase in HVAC from 23% to 36% due to the electrification of heating
  - Increase in lighting from 42% to 45%

1 Appliances includes catering; 2 Excludes public administration which contributes 18 TWh

Source: Team analysis

Impact of game-changing scenarios on U.K. electricity demand



Source: Team analysis

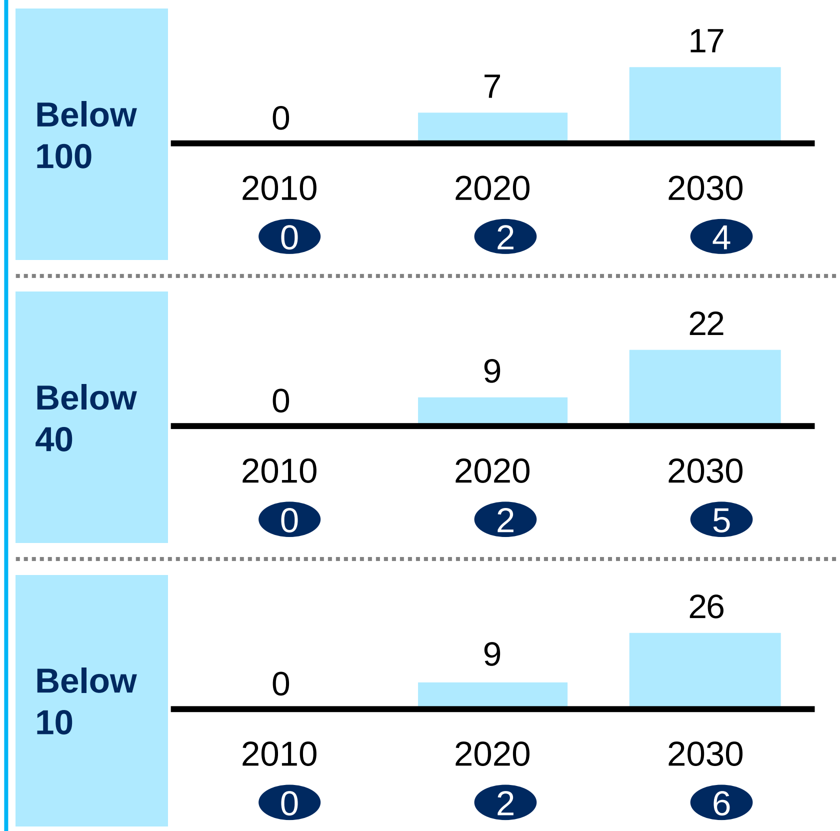
Adoption of electric vehicles can lead to an increase of ~5% in total electricity demand

Percentage of total U.K. electricity demand

Assumptions

- This scenario measures the sensitivity of electricity demand to the widespread **adoption of electric vehicles** in the U.K. – Electric vehicles include both hybrid vehicles (HEV) and battery vehicles (BEV)
- Impact on electricity demand estimated by estimating the **number of electric vehicles** in the fleet over time and the **electricity consumption of each vehicle**
- Three cases have been defined based upon the expected overall **carbon emissions per km of the U.K. sales fleet by 2050** – we have used the intermediate 2030 penetrations:
  - Below 100 – 95 g/km by 2030
  - Below 40 – 75 g/km by 2030
  - Below 10 – 65 g/km by 2030
- Key assumptions include:
  - Electricity usage/km: 0.25 KWh
  - Distance travelled/car/year: 12,000 km
  - Vehicle sales: averaging 2.4 million/year
  - PHEV[1] penetration: 15% by 2030 (mid case)
  - EV[1] penetration: 13% by 2030 (mid case)

Scenario results: Electricity demand, TWh



1 PHEV: Plugin hybrid electric vehicle, EV: Electric vehicle

Source: 'Boost! Transforming the powertrain value chain – a portfolio challenge report', McKinsey & Company (2001); team analysis

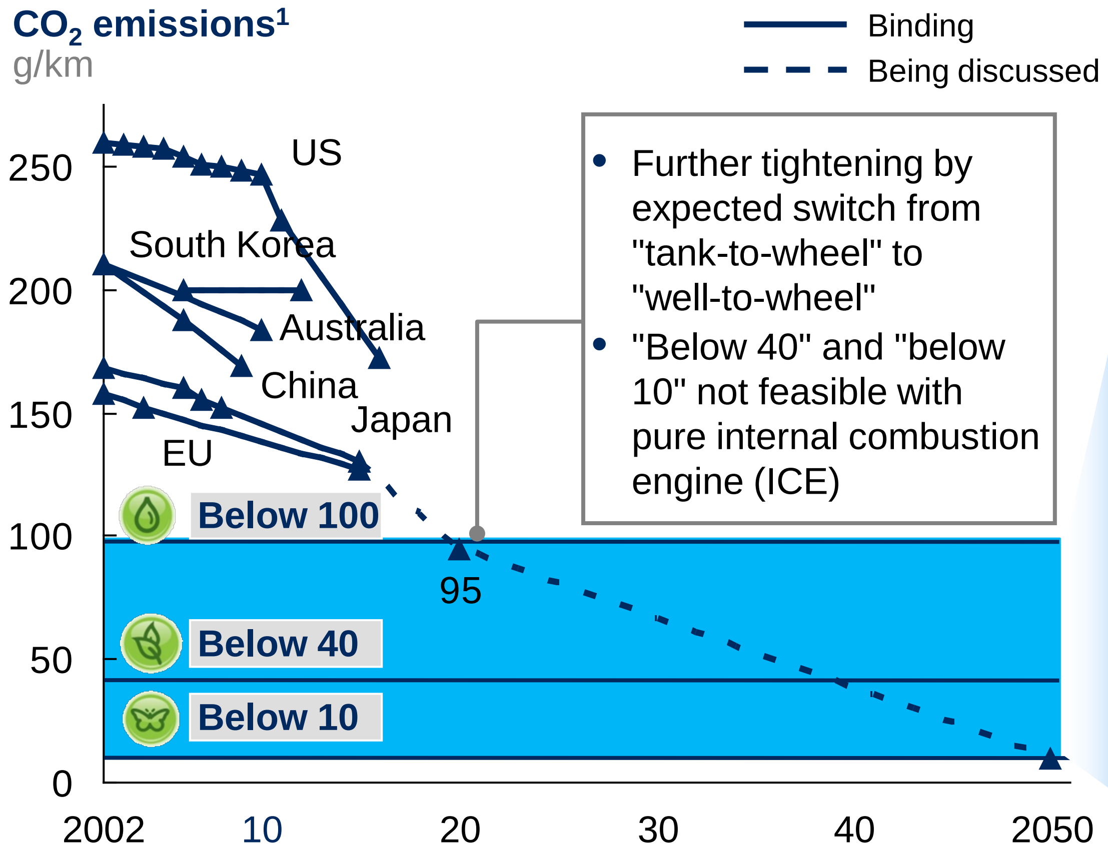
Total share of electricity consumption due to EV in the U.K. is in-line with other leading EV adopting countries

	Total EV electricity consumption, 2030 (TWh)	Total electricity consumption (%)	Key data, 2030
China	277	3	• Vehicle sales: 178.9 million • EV penetration: 18% • Total electricity consumption: 4,680 TWh
US	173	4	• Vehicle sales: 82.6 million • EV penetration: 18% • Total electricity consumption: 8,627 TWh
Germany	33	5	• Vehicle sales: 18.6 million • EV penetration: 25% • Total electricity consumption: 593 TWh
U.K.	22	5	• Vehicle sales: 11.9 million • EV penetration: 18% • Total electricity consumption: 411 TWh

Source: Team analysis; Boost! Transforming the powertrain value chain – a portfolio challenge report

Major driver is tightening CO2 regulation – significant reductions announced until 2020, but uncertainty of future outlook

Converging emission regulations across the globe



- Further tightening by expected switch from "tank-to-wheel" to "well-to-wheel"
- "Below 40" and "below 10" not feasible with pure internal combustion engine (ICE)

3 scenarios to assess development

Moderate CO_2 emission reduction cap of **95 g CO_2/km in 2050[2]** (stop at 2020 regulations)

Strong CO_2 emission reduction to **40 g/km in 2050[2]** (tightening emission standards)

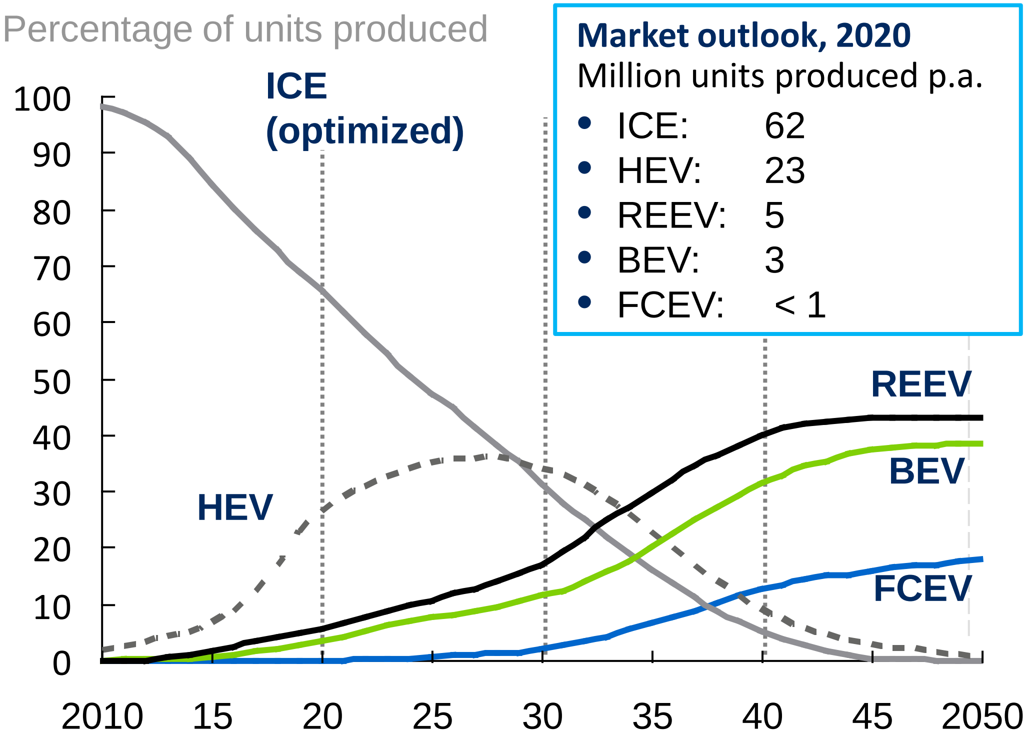
Very strict CO_2 emission reduction to **10 g/km in 2050[2]** ("2°C warming")

1 Regulation under review by the European Parliament: 2015, 2020, 2025 targets will be determined by 2015

Source: European Commission; Boost! Transforming the powertrain value chain – a portfolio challenge report

The "below 40" scenario will favor a fully electric powertrain world dominated by range-extended electric vehicles

Global market shares by powertrain technology



Characterization

- The powertrain **portfolio game started already with a peak in 2030**
- **The electric drivetrain will come**
  - **E-motor in 1 of 3 cars in 2020**
  - **In 2 of 3 cars in 2030**
- **ICE dominant until 2030** – more than **3 of 4 cars** still have an (additional) ICE engine
- As regulation tightens, **REEV/BEV replaces ICE/HEV technology,** in the long run, **BEVs dominate smaller, REEVs medium-sized** and **FCEV larger vehicles**
- **BEV, REEV, and FCEV** existence leads to an **electric-drivetrain-only scenario**

Note: ICE: Internal combustion engine incl. Micro-Hybrids and optimization; HEV: Hybrid electric vehicle (with e-motor and opt. plug-in); REEV: Range extended electric vehicle (opt. plug-in); BEV: Battery electric vehicle; FCEV: Fuel cell electric vehicle

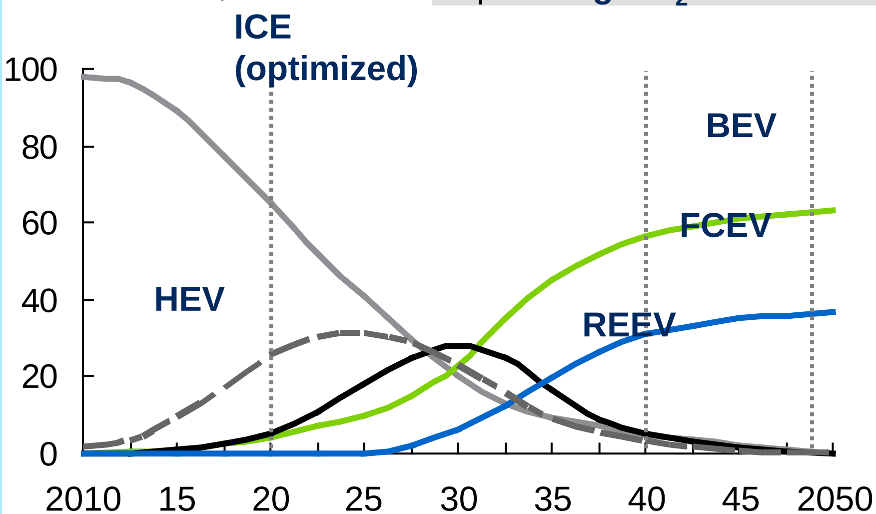
Source: Boost! Transforming the powertrain value chain – a portfolio challenge report

Future of powertrain market highly uncertain – the portfolio challenge is driven by regulation, TCO development and customer needs

"Below 10": Very strict regulation lead to BEV and FCEV world

Market share, %

Cap of **10 g CO_2/km in 2050**

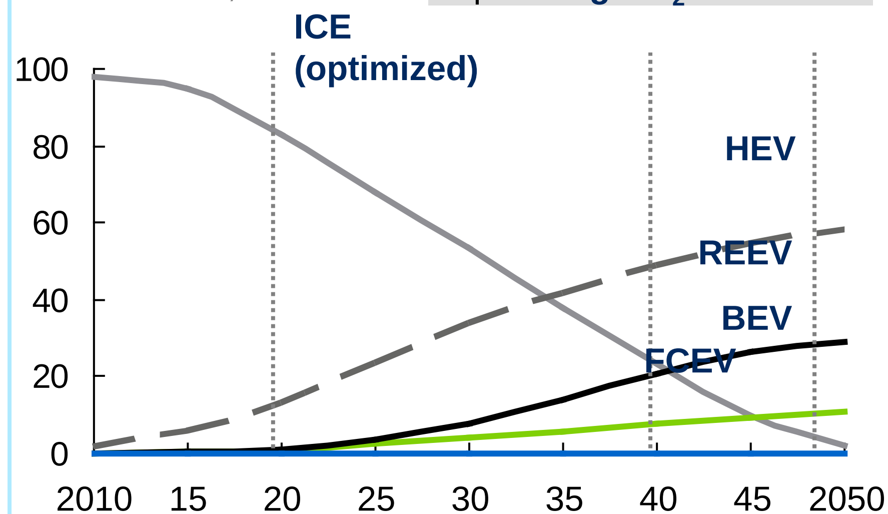


- ICE dominant until 2025, but loses market share to xEVs
- In the long run, BEVs dominant for smaller and FCEV for larger vehicles
- HEV/REEV as bridging technology

"Below 100": Little change in regulation leads to a world of hybrids and BEVs

Market share, %

Cap of **95 g CO_2/km in 2050**



- ICE remains dominant until 2035+
- BEV will only become economically competitive in > 2030, no infrastructure for FCEV is built
- Long-term HEV and REEV/BEV existence leads to a dual powertrain scenario

Note: ICE: Internal combustion engine incl. Micro-Hybrids and optimization; HEV: Hybrid electric vehicle (with e-motor and opt. plug-in); REEV: Range extended electric vehicle (opt. plug-in); BEV: Battery electric vehicle; FCEV: Fuel cell electric vehicle

Source: Boost! Transforming the powertrain value chain – a portfolio challenge report

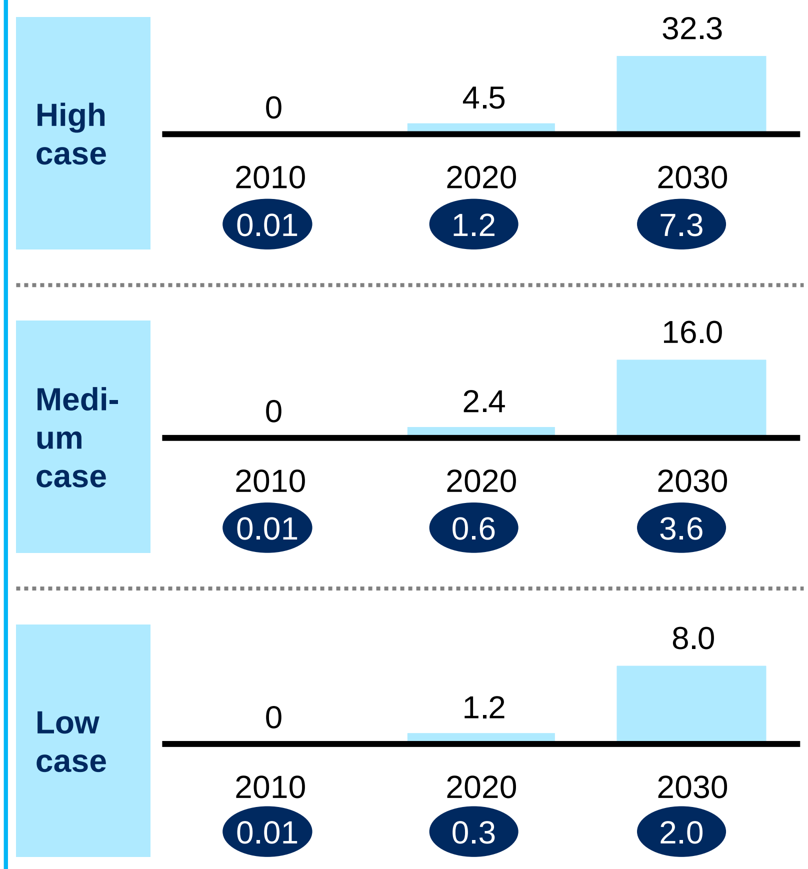
Adoption of heat pumps could lead to an increase of 7% in total electricity demand

Percentage of total U.K. electricity demand

Assumptions

- This scenario measures the sensitivity of electricity demand to the widespread **adoption of heat pumps** in the U.K. – heat pumps include both air source heat pumps and ground source heat pumps
- Impact on electricity demand estimated by estimating the **total number of heat pumps** over time and the **electricity consumption of each heat pump**
- Three cases have been defined based upon the expected **total number of heat pump installations by 2020** – we have projected the penetrations to 2030 based on projections to 2020 in the Environment Agency Heat Pump 2009 report and 2030 estimates based on the Committee on Climate Change Developing Options for Renewable Heat report, government targets and the European Heat Pump Association
  - High case – 8,699,159 heat pumps by 2030 (28% of U.K. households)
  - Medium case – 4,180,972 heat pumps by 2030 (14% of U.K. households)
  - Low case – 2,280,596 heat pumps by 2030 (7% of U.K. households)
- Key assumptions include:
  - Electricity usage per year per pump: 6 MWh
  - Total number of heat pumps in 2010: 12,000
- Assumed that 75% of heat pump energy requirement is provided by the environment and remaining 25% by the national grid

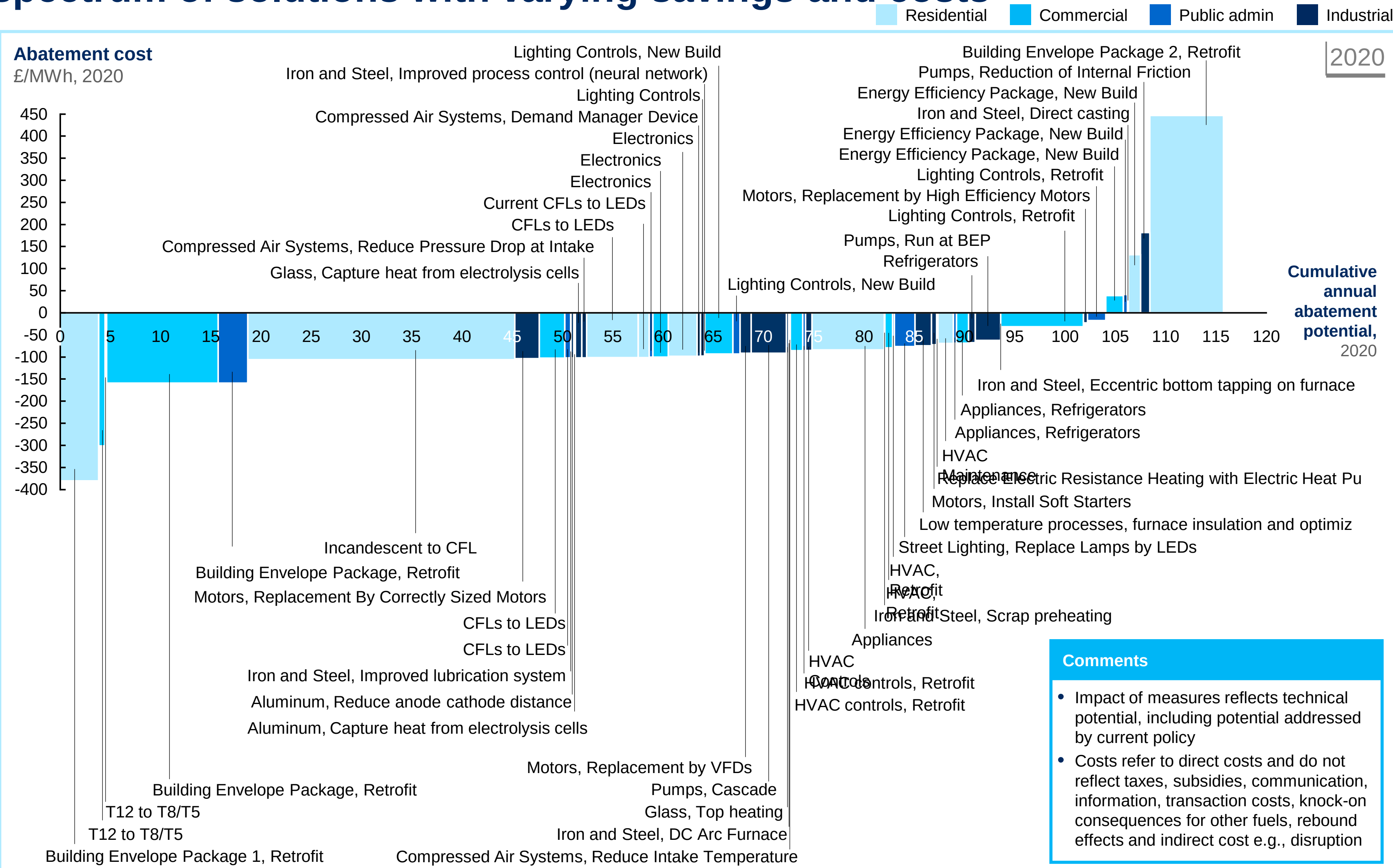
Scenario results: Electricity demand, TWh



Source: Team analysis

Appendix contents

Achieving full potential will mean implementing a spectrum of solutions with varying savings and costs



Comments

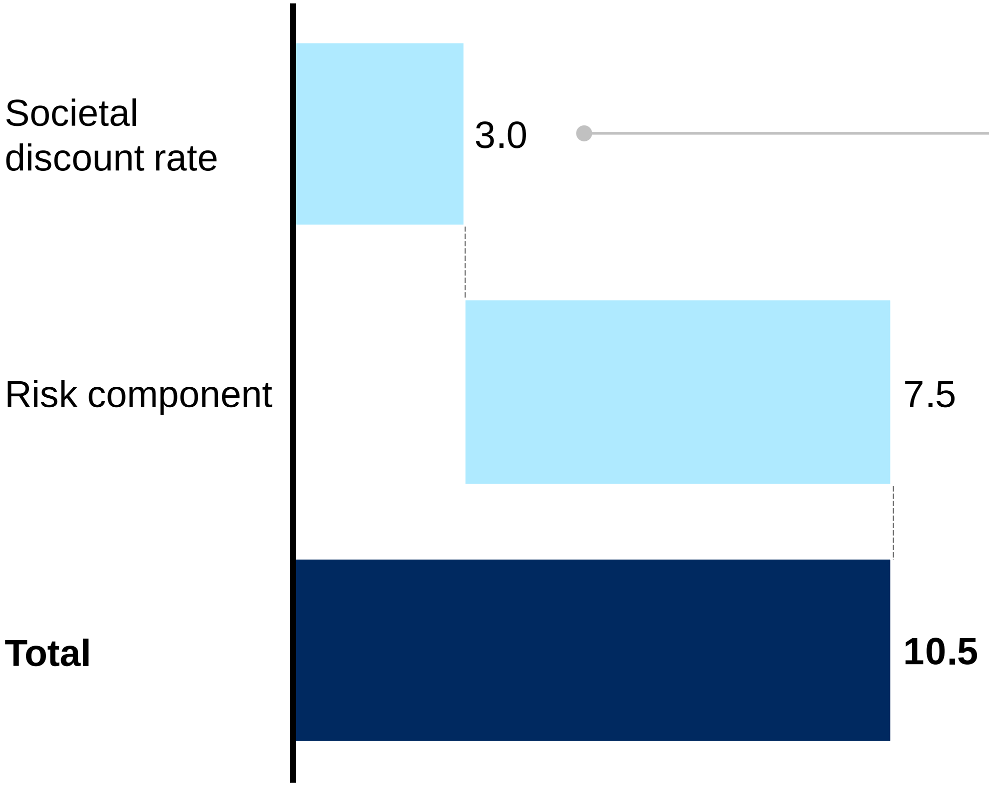
- Impact of measures reflects technical potential, including potential addressed by current policy
- Costs refer to direct costs and do not reflect taxes, subsidies, communication, information, transaction costs, knock-on consequences for other fuels, rebound effects and indirect cost e.g., disruption

Note: Key assumptions for 2020: Discount rate: 10.5%, Electricity price: 9p/kWh, CO_2 price: £29/tCO_2e

Source: Team analysis

Key macro inputs - discount rate

percent



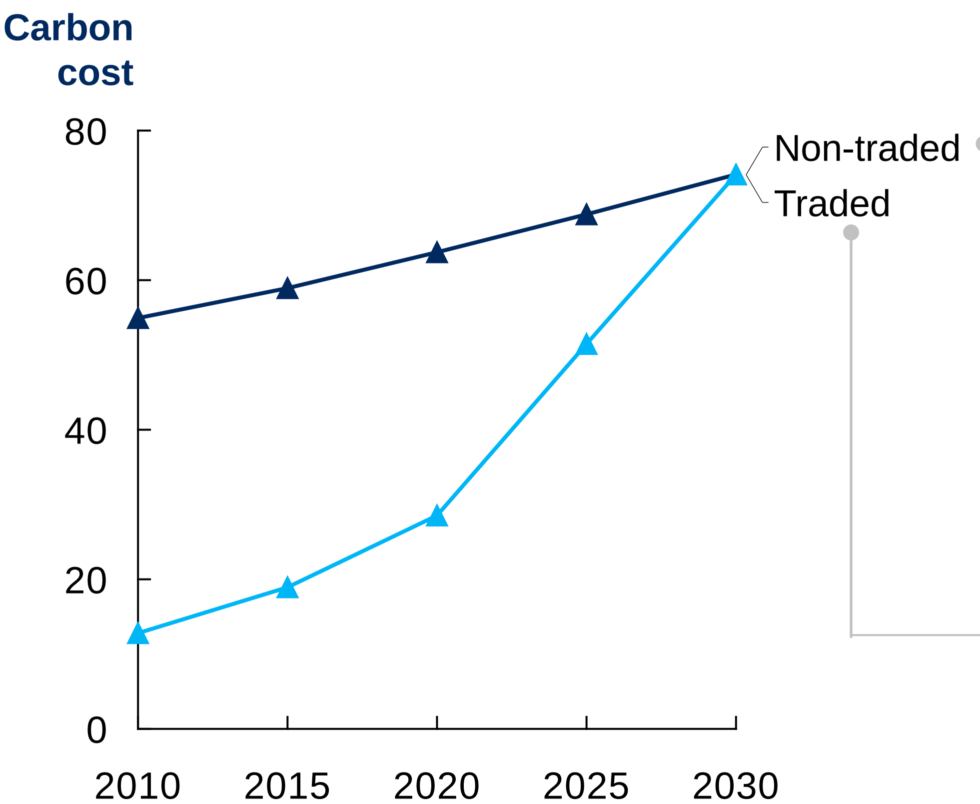
- Accounts for the time value of money

- Accounts for the value of risk in investment
- Currently, the analysis assumes the same rate for all sectors (to be modified later), ideally the industrial sector will have a higher rate than residential , commercial and public admin sectors

Source: DECC

Key macro inputs – carbon costs

£/tCO_2e



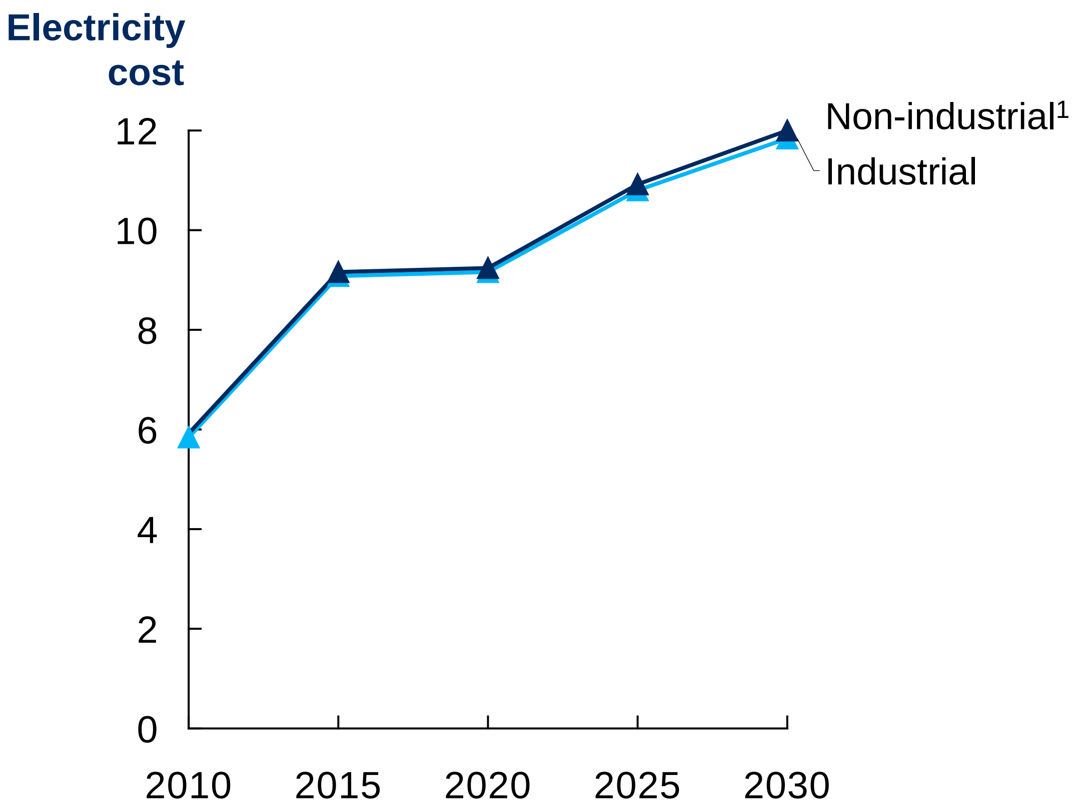
- Corresponds to **social costs** of carbon emissions i.e., environmental impact, health cost etc
- Applied to non electricity related emissions – gas combustion emissions

- Corresponds to **traded price** of carbon
- Expected to merge with the social cost of carbon eventually i.e., 2030
- Applied to emissions from electricity production

Source: Inter-departmental Analysts' Group (IAG)

Key macro inputs – electricity costs

p/kWh



- Corresponds to the production cost of electricity, rather than retail price
- The difference between industrial and non-industrial[1] cost comes from the use of cogeneration plants in industry

1 Residential, commercial and public admin

Source: Inter-departmental Analysts' Group (IAG)

Residential: Abatement measures

	Description
New build efficiency package	• Achieve energy consumption levels comparable to passive housing – Reduce demand for energy consumption through improved building design and orientation – Improve building insulation and airtightness; improve materials and construction of walls, roof, floor, and windows – Ensure usage of high efficiency HVAC and water heating systems
Retrofit building package, level 1 and level 2	• Level 1 retrofit - "basic retrofit" package – Improve building airtightness by sealing baseboards and other areas of air leakage – Weather strip doors and windows – Insulate attic and wall cavities – Add basic mechanical ventilation system to ensure air quality • Level 2 retrofit – Retrofit to "passive" standard, in conjunction with regular building renovations – Install high efficiency windows and doors; increase outer wall, roof, and basement ceiling insulation; mechanical ventilation with heat recovery, basic passive solar principles
Retrofit HVAC, residential	• In appropriate climates, replace electric furnace with high efficiency electric heat pump • Reduce energy consumption from HVAC and AC through improved maintenance – Improve duct insulation to reduce air leakage and proper channelling of heated and cooled air – Ensure HVAC system is properly maintained, with correct level of refrigerant and new air filters
New and retrofit lighting systems	• Replace incandescent bulbs with LEDs • Replace CFLs with LEDs
New and "retrofit" appliances and electronics	• Purchase high efficiency consumer electronics (e.g., PC, TV, VCR / DVD, home audio, set-top box, external power, charging supplies) instead of standard items • When refrigerator/freezer, washer / dryer, dishwasher, and fan expires, replace with high efficiency model

Source: Team analysis

Residential: Key abatement measure assumptions (1/2)

	Key volume assumptions	Key cost assumptions	Sources

New build efficiency package	• Savings potential is ~70%
	  • Assume that maximum site energy consumption for HVAC and water heating in new builds is 115 to 132 kWh / m2 (depending on level of development)
	  • New technology results in 20 kWh / m2 in developing warm countries, 30 kWh / m2 in developing cold countries, and 35 kWh / m2 in developed countries (SITE energy)
		• Incremental cost of energy efficiency new build – 66 USD/m2
		• In 2005, 6-7% cost premium on new builds
		• By 2020:
		  – Developing regions 5% cost premium on new builds with "high efficiency package."
		  – 4% premium in developed regions
		• Assuming a base cost of 1660 USD/m2 from US initial construction costs validated with experts
			• UNEP (1) regulations in Sweden
			• UNEP (1); Passive House Institute US and Germany (3); Expert interview; WBCSD (4)
			• UNEP (1); IPCC Chapter 6 (2); Passive House Institute US and Germany (3); team analysis
			• RS Means construction database (US); Faithful+Gould International Construction Cost Index (Europe and Japan); Expert interviews (ROW)
			• UC Berkley Program on Housing and Urban Policy

Retrofit building package level 1 and level 2	• Level 1 retrofit based on 15-25% heating savings potential • Level 2 retrofit can reach heating/cooling consumption of 20-35 kWh / m2 (SITE energy)	• Level 1 retrofit based on 6.26 EUR / m2 in W. Europe / Japan. • Cost of retrofit 2 is 80 EUR / m2 in 2005 and 50 EUR / m2 in 2030 in Europe, scaled down by geography	• Energy Star Home Sealing Program Assumptions for Estimation of H&C Savings (6); BSC case studies (7) • ORNL (8), (9); Expert interview (10), Levy, et al (11); France MIES: "Facteur 4 et Bâtiment"

1 See following slides for detailed citations. Sources align to volume and cost bullets – left to right, top to bottom

Source: Team analysis

Residential: Key abatement measure assumptions (2/2)

	Key volume assumptions	Key cost assumptions	Sources
Retrofit HVAC, residential	• For electric heat pump, assume up to 50% savings potential compared to electric resistance heating. Savings is slightly lower in extreme climates	• Premium of 2400 EUR for a 20 kW unit – Same size electric resistance heating unit costs EUR 3000 – Same size electric heat pump costs EUR 5400	• Energy Star • Vendor interviews • Penetration estimates from LBNL (12)
	• For HVAC maintenance, assume total 15% savings from proper duct insulation and proper maintenance	• Assume duct insulation / maintenance job costs 635 EUR (aggressive cost estimate) to cover 150 sq. meter house	• DOE / EERE (13); LBNL Home Energy Saver (14); Energy Star (15) • LBNL Home Energy Saver (14); Energy Star (15)
New and retrofit lighting systems	• Lumen / W varies by technology: – Incandescent: 12 – CFL: 60 – LED: 75 in 2010; 264 by 2020 • In abatement case, assume full remaining share of incandescents switch to LEDs, and full remaining share of CFLs switch to LEDs	• Learning rate for LEDs based on prediction to 2020, extrapolated to 2030	• IEA (21); Daiwa (22); IEA presentation (23)
New and "retro-fit" appliances and electronics	• HE consumer electronics use up to 37% less energy • Package of certified appliances in developed countries consume ~35% less energy	• Electronics: 35-40 EUR price premium for bundle of electronics consuming 3 MWh/yr • Appliances: 350 EUR price premium for bundle of electronics consuming 7 MWh/yr	• ACEEE (24); LBNL (12); Data received directly from Energy Star program; UN (25), CEA (26) • Energy Star calculators; industry data 2007 and 2008 • LBNL (12); IEA (27)

1 See following slides for detailed citations. Sources align to volume and cost bullets – left to right, top to bottom

Source: Team analysis

Commercial and public admin: Abatement measures

	Description
New build efficiency package	• Reduce demand for energy consumption through improved building design and orientation • Improve building insulation and airtightness; improve materials and construction of walls, roof, floor, and windows • Ensure usage of high efficiency HVAC and water heating systems
Retrofit building envelope	• Level 1 retrofit - "basic retrofit" package – Improve building airtightness by sealing areas of potential air leakage – Weather strip doors and windows
Retrofit HVAC and HVAC con-trols, residential	• When HVAC system expires, install highest efficiency system • Improve HVAC control systems to adjust for building occupancy and minimize re-heating of air
New and retrofit lighting systems	• Replace incandescent bulbs with LEDs • Replace CFLs with LEDs • Replace inefficient T12s / T8s with new super T8s and T5s • New build – install lighting control systems (dimmable ballasts, photo-sensors to optimize light for occupants in room) • Retrofit – install lighting control systems (dimmable ballasts, photo-sensors to optimize light for occupants in room)
New and "re-trofit" appliances and electronics	• Purchase high efficiency electronics instead of standard items • When refrigerator/freezer, expires, replace with high efficiency model

Source: Team analysis

Commercial and public admin: Key abatement measure assumptions (1/2)

	Key volume assumptions	Key cost assumptions	Sources
New build efficiency package	• 61% savings potential on HVAC and water heating for new builds using "maximum technology"	• In developing regions, 5% cost premium on new builds with "high efficiency package." 4% premium in developed regions • The United States Green Building Council lists a 2.5% cost premium for commercial buildings	• NREL (30); NREL (31); UNEP (1) • RS Means construction database (US); Faithful+Gould International Construction Cost Index (Europe and Japan); Expert interviews (ROW) • The NY Times; Debating the Green Building Premium
Retrofit building package level[1]	• Assume 48% savings potential in cold areas, and 11% savings potential in warm areas	• Retrofit is 4.10 EUR / m2 in W. Europe / Japan. Scaled down to other countries based on GDP • In the U.S. 38% of survey respondents stated a cost premium of 5-10% over conventional retrofit projects, 37% believe the cost premium to be between 1-5%	• NIST (32) • Industry expert interviews • Joint study between Deloitte and Charles Lockwood
Retrofit HVAC, commercial	• HVAC system retrofit: assume similar savings potential compared to residential (~20%) • HVAC controls: 10-20% savings potential	• 1000 EUR premium for every 5 tons (~17000 W) of capacity installed • 5000 EUR cost for retrofit control system in 1700 m2 building in developed countries consuming 116 kWh/m2 of energy for heating	• EIA (33), LBNL (12) • Vendor interviews • Industry and academic expert interview • University of Texas (34); vendor interviews

1 See following slides for detailed citations. Sources align to volume and cost bullets – left to right, top to bottom

Source: Team analysis

Commercial and public admin: Key abatement measure assumptions (2/2)

	Key volume assumptions	Key cost assumptions	Sources
New and retrofit lighting systems	• In abatement case, assume full remaining share of incandescents switch to LEDS, and full remaining share of CFLs switch to LEDs • Assume maximum switch from old T12 and T8s to new T8 / T5s • For lighting control systems – Achieve 50% savings potential in new build – Assume 29% savings potential in retrofit	• Learning rate for LEDs based on prediction to 2020, extrapolated to 2030 • Retrofit is 4.10 EUR / m2 in W. Europe / Japan. Scaled down to other countries based on GDP • In the U.S. 38% of survey respondents stated a cost premium of 5-10% over conventional retrofit projects, 37% believe the cost premium to be between 1-5%	• IEA (21); Daiwa (22); IEA presentation (23) • Rubenstein, et al (35) • Rubenstein, et al (35)
New and “retrofit” appliances and electronics	• 48% savings potential in office electronics • 17% savings potential in commercial refrigerators	• 1.5 EUR price premium per item for high efficiency charging devices and reduction in standby loss • 150 EUR price premium refrigeration units consuming 3 MWh/yr	• LBNL (12) • Energy Star calculator • Energy Star calculator

1 See following slides for detailed citations. Sources align to volume and cost bullets – left to right, top to bottom

Source: Team analysis

Key sources for Buildings sector

- Baseline data sources
  - IEA 2004 and 2007 World Energy Outlook, and associated back-up data directly from IEA
  - Levine, M., D. Ürge-Vorsatz, etc. al. Residential and commercial buildings. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change
  - Rue du Can, S. and Price, L: “Sectoral trends in global energy use and greenhouse gas emissions” Energy Policy 36 (2008) 1386–1403
  - Brockett, D., Fridley, D. et al. “A Tale of 5 Cities; China Residential Energy Consumption Survey” Lawrence Berkeley National Labs
  - Department of Energy “Annual Energy Outlook 2007”
  - EDMC – Handbook of Japanese energy and Economic Statistics, 2007
  - Ghisi, Gosch, and Lamberst: “Electricity End-uses in the residential sector in Brazil” Energy Policy Vol 35, Issue 8 (2007)
  - India Bureau of Energy Efficiency. “High performance buildings and development Project Team Meeting” Beijing, Mar 200
- -------------------
- (1) United Nations Environment Program: “Buildings and Climate Change” 2007
- (2) IPCC Chapter 6 “Residential and Commercial buildings”: 2006
- (3) Passive House Institute: www.passivhaustagung.de, www.passivehouse.org
- (4) World Business Council for Sustainable Development www.wbcsd.org
- (5) RSMeans construction cost data base (US); Faithful and Gould Construction Cost Index (Europe and Japan)
- (6) ENERGY STAR Home Sealing Program Assumptions for Estimation of Heating & Cooling Savings – internal document used to generate Energy Star savings potential
- (7) Building Sciences Corporation: Energy Case Studies www.bsc.com
- (8) ORNL “Progress Report of the National Weatherization Assistance Program” 1997 http://weatherization.ornl.gov/pdf/con450.pdf
- (9) ORNL TEXAS FIELD EXPERIMENT:Performance of the Weatherization Assistance Program in Hot-Climate, Low-Income Homes, 2008 (see page 20) http://weatherization.ornl.gov/pdf/CON%20499.pdf
- (10) Expert Interview with Building Envelope retrofit company
- (11) Levy, et al. “The public health benefits of insulation retrofits in existing housing in the United States” Environmental Health, 2003
- (12) LBNL “Status Report- Estimates for the ENERGY STAR® Voluntary Labeling Program (LBNL 56380)
- (13) DOE / EERE “A Consumer’s Guide to Energy Efficiency and Renewable Energy”: website:http://www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12310
- (14) LBNL Home Energy Saver case example: http://hes3.lbl.gov/hes/input3.taf?f=UpgradeReport&session_id=533065
- (15) Energy Star http://www.energystar.gov/index.cfm?c=heat_cool.pr_properly_sized

Key sources for Buildings sector

- (16) ACCEE: http://www.aceee.org/consumerguide/waterheating.htm#lcc
- (17) Eco-hot water report for European CommissionEco-design of water heaters, Report 2, page 15 http://www.ecohotwater.org/
- (18) Frost and Sullivan: United States Water heating equipment markets” 2003
- (19) National Renewable Energy Lab (NREL) Technical potential to reduce fossil fuel usage through Solar Water heating. Paper 640-41157; 2007
- (20) Fuji Keizai Co Ltd; Water heating report
- (21) IEA Light’s Labour’s Lost, 2006
- (22) Daiwa analyst report “LED Sector: The future’s bright, the future’s green” March 2007
- (23) IEA: Presentation by Paul Waide “Why we‘re here: The potential to lower global lighting energy consumption”
- (24) Source: ACEEE Report E083 The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture, page 14
- (25) UN Economic and Social Affairs: “Trends in consumption and production: household energy consumption” http://www.un.org/esa/sustdev/publications/esa99dp6.pdf
- (26) CEA: www.ce.org
- (27) IEA: “Cool Appliances” 2003
- --------
- (30) National Renewable Energy Laboratory (NREL) / Department of Energy: “Assessment of Technical Potential for Achieving Net Zero-Energy Buildings in Commercial Sector”
- (31) NREL / Department of Energy: “Methodology for Modeling Building Energy Performance Across the Commercial Sector”
- (32) National Institute of Science and Technology “Investigation of the Impact of commercial Building Airtightness on HVAC energy use.” NISTIR7238
- (33) Energy Information Administration, “EIA - Technology Forecast Updates - Residential and Commercial Building Technologies – Reference Case”, Navigant Consulting, Inc., Reference Number 117943, September 2004.
- (34) University of Texas ; Energy Efficient Buildings, chapter on Variable Air Volume systems
- (35) Rubenstein, Neils, and Colak. “Daylight, Dimming, and the California Electricity Crisis” LBNL, 2001
- ----------
- Other sources used:
- Department of Energy LED research program
- IEA “Promoting Energy Efficiency Investments: Case Studies in the Residential Sector” 2008
- Ecofys: “U-values for improving building performance”
- BUTE, under supervision of Zoltan Nagy: “Fuzzy Logic Control of Central Heating Systems” 2003
- Japan “Top Runner” program guide, 2006
- Magyar, Z. “Achieving Energy Savings in Europe through the Energy Performance of Buildings Directive (EPBD)”. University of Pecs, Hungary

Industrial: Abatement measures (1/2)

	Description
Motor systems	• When suitable, replace fixed load motors by Variable Frequency Drives • Use higher efficiency motors - – improved impeller share, use of higher quality materials etc • Install soft starters • Replace oversized motors
Pumping systems	• Run pumps at Best Efficiency Point • Use pumps with reduced internal friction • Replace large pumps by a cascade of smaller pumps
Compressed air systems	• Install a Demand Manager Device • Reduce intake temperature • Reduce pressure drop at intake
Lighting	• Install lighting control systems (dimmable ballasts, photo-sensors to optimize light for occupants in room)
Refrigeration	• When refrigerator/freezer, expires, replace with high efficiency model
HVAC controls	• Improve HVAC control systems to adjust for building occupancy and minimize re-heating of air

Source: Case studies from actual implementation; team analysis

Industrial: Abatement measures (2/2)

	Description
Low temperature heating processes	• Furnace insulation and heating optimization
High temperature heating processes	**Iron and Steel** • Use DC arc furnaces • Preheat scrap • Employ eccentric bottom tapping in furnace • Improve process control using neural networks • Improve lubrication • Use direct casting technique **Glass** • Use top heating in electrolysis cell • Capture heat from electrolysis cells **Aluminum** • Reduce anode cathode distance • Capture heat from electrolysis cells

Source: Case studies from actual implementation; team analysis

Industrial: Key abatement measure assumptions (1/3)

	Key volume assumptions	Key cost assumptions
Motor systems - General	• Variable speed drives have a savings potential of 50%, however can be applied only to 10% of all installed motors (example from chemical industry)	• Capex: 68 EUR/MWh Incremental capex for replacing 2X75kW motors- EUR 50,000
	• Best practice suggests a 30% over sizing, however ~60% of all motors used in industry are oversized to ~50% of requirement i.e., an extra 20%	• Capex: -2.5 EUR/MWh 500kW motor is expected to cost EUR 100,000. Assuming a 15% cost reduction for a 20% capacity reduction
	• High efficiency motors are expected to have 3-5% savings over inefficient ones	• Capex: 31 EUR/MWh Incremental capex for replacing 10X22kW motors- EUR 50,000
	• Installation of soft starters can reduce electricity consumption by 3%	• Capex: 12 EUR/MWh Incremental capex for replacing 5X20kW motors- EUR 7,500
Motor systems - Pumps	• Running pumps at their Best Efficiency Point can reduce electricity consumption by 25%	• Capex: 131 EUR/MWh Incremental capex for replacing 5X50kW motors- EUR 45,000
	• Internal coating to reduce friction has a potential of 11%	• Capex: 411 EUR/MWh Incremental capex for replacing 3X50kW motors- EUR 115,000
	• Cascading multiple pumps instead of using a single large pump can potentially have a savings potential of 28%	• Capex: 39 EUR/MWh Incremental capex for replacing 80kW motor- EUR 15,000

Source: Case studies from actual implementation; team analysis

Industrial: Key abatement measure assumptions (2/3)

	Key volume assumptions	Key cost assumptions
Compressed air systems	• Installation of a Demand Manager Device can potentially lead to a 5% reduction in energy consumption	• Capex: 2.6 EUR/MWh Incremental capex for replacing 360kW motor- EUR 5,000
	• Reducing the temperature of intake air has a potential of 2%	• Capex: 3.1 EUR/MWh Incremental capex for replacing 150kW motor- EUR 3,000
	• Reducing pressure drop at intake has a potential of 7%	• Capex: 0.1 EUR/MWh Incremental capex for replacing 150kW motor- EUR 100
Lighting	• For lighting control systems assume 29% savings potential	• Retrofit is 4.10 EUR / m2 in W. Europe / Japan.
Refrigeration	• 17% savings potential in commercial refrigerators	• 150 EUR price premium refrigeration units consuming 3 MWh/yr
HVAC	• HVAC controls: 10-20% savings potential	• 5000 EUR cost for retrofit control system in 1700 m2 building in developed countries consuming 116 kWh/m2 of energy for heating

Source: Case studies from actual implementation; Energy Star; LBNL; University of Texas; IEA; team analysis

Industrial: Key abatement measure assumptions (3/3)

	Key volume assumptions	Key cost assumptions
Low temperature heating processes	• Improve furnace insulation, reduce size of furnace entry, install self closing door and use residual heat has a potential of 15%	• Capex: 54 EUR/MWh
High temperature heating processes	**Iron and Steel**	
	• Use of DC arc furnaces have a potential of 20%	• Capex: 8 USD/t steel
	• Preheating scrap before introduction into furnace can improve efficiency by 14%	• Capex: 10 USD/t steel
	• Eccentric bottom tapping of the furnace has a potential of 3%	• Capex: 5 USD/t steel
	• Employment of neural networks for process control has a potential of 7%	• Capex: 1 USD/t steel
	• Improved lubrication can reduce energy consumption by 3%	• Capex : Nil
	• Direct casting reduces overall energy consumption by 30%	• Capex: 138 USD/t steel
	Glass	
	• Top heating in the electrolysis cell has a potential of 4%	• Capex: 4 USD/MWh
	• Heat capture from electrolysis cell can reduce electricity consumption by 10%	• Capex: NA[1]
	Aluminum	
	• Reduction of the distance between cathode and anode has a potential of 16%	• Capex: NA[1]
	• Heat capture from electrolysis cell can reduce electricity consumption by 10%	• Capex: NA[1]

1 Not available

Source: EPA: Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Iron and Steel Industry; Case studies from actual implementation; EPA: Energy Efficiency Improvement and Cost Saving Opportunities for the Glass Industry; team analysis

Appendix contents

Methodology for mapping key measures to existing policies

Resource	List of materials/experts	Approach
Public reports	• 'Saving Energy Through Better Products and Appliances' report by DEFRA December 2009 • Impact assessments: Products policy, Building Regulations, Green Deal, EU ETS, CRC, CCA, CERT and CESP • 'What measures does the Green Deal cover' DECC report	• Established coverage and quantification of savings from policies to key measures (mainly Products Policy and Building Regulations) • Established relative importance of policies to coverage of potential of each measure (mainly Products Policy and Building Regulations)
DECC materials	• 'Existing Energy Efficiency Policies' document March 2012 • 'Electricity Demand Reduction – a summary of relevant analysis' document February 2012 • CRC modelling estimates • 'Modelling the Initial Effects of the Climate Change Levy' report	• Provided quantification of savings from policies against key measures not covered in public reports (e.g., Green Deal, CRC and CCA)

SOURCE: Team analysis

The uncaptured potential lies within lighting controls, building efficient improvements and pump efficiency measures

- Majority of potential captured (>50%)
- Some potential captured (25-50%)
- Little potential captured (<25%)
- Policy does not apply

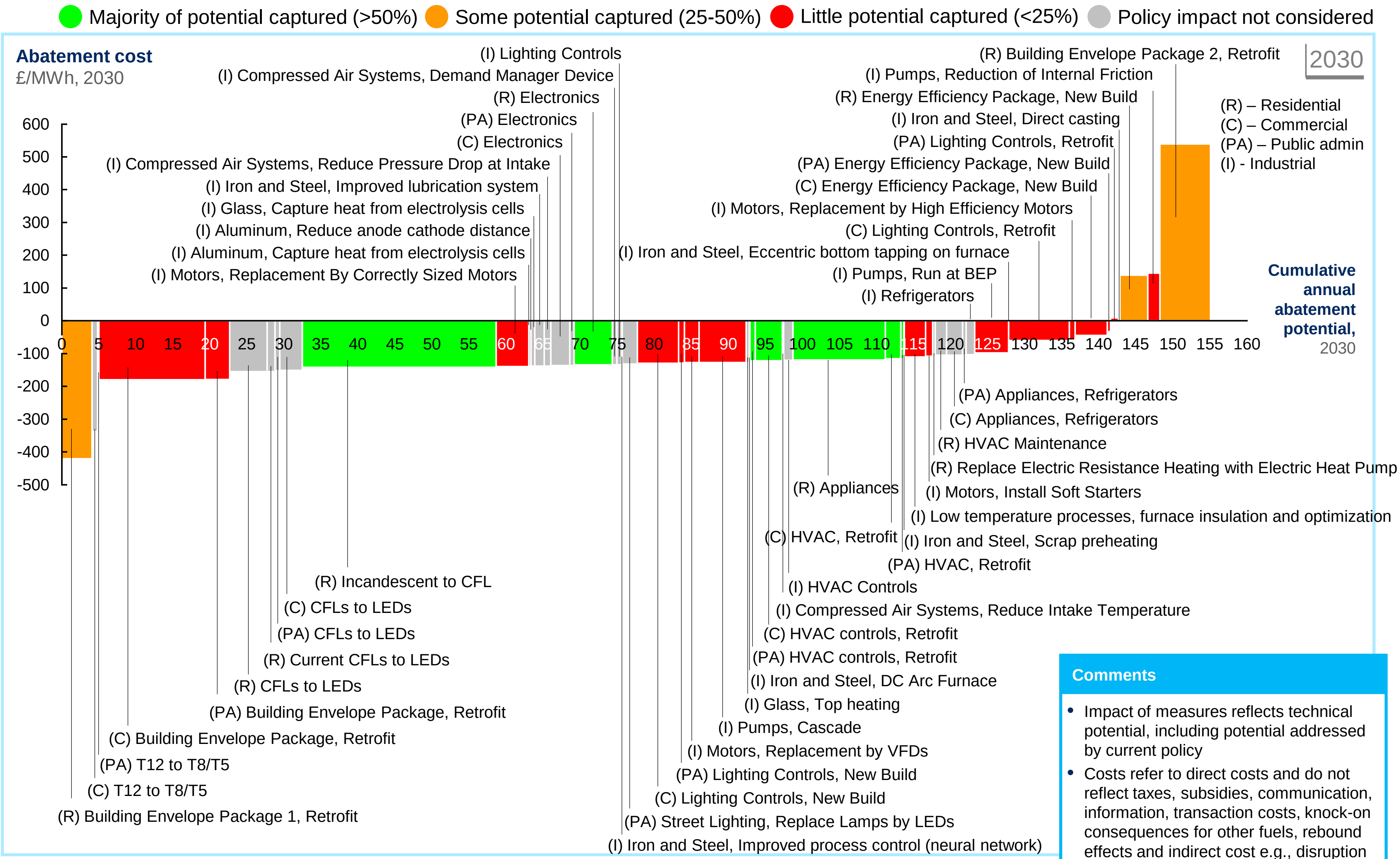
	Measure category	Total abatement potential, 2030 TWh	Abatement potential captured by policies TWh	Uncaptured abatement potential TWh	Targeted interventions: Products Policy	Targeted interventions: Building Regs	Semi-targeted energy efficiency policies: Green Deal	Policies with broad impact: EU ETS, CRC & ECA
Residen-tial	Incandescent to CFL bulbs	26.1	8.6 17.5 26.1	0	25.6	0.6	0.0	4
	Appliances and electronics efficiency	17.6	12.8	4.8	12.8	0.0	0.0	
	Building efficiency improvements	14.7	5.2	9.4	0.0	2.5	2.7	
Services	Building efficiency improvements	22.5	0.6	21.9	0.0	0.2	0.3	3
	Lighting controls	15.6	1.1	14.5	0.0	0.8	0.3	
	HVAC and controls	6.9	4.1	2.8	2.6	1.2	0.3	
Industrial	Pump efficiency measures	12.6	0.1	12.5	0.1	0.0	0.0	3
	Motor system optimisation[1]	8.1	0.8	7.3	0.8	0.0	0.0	
	Boiler insulation and optimisation	2.9	0	2.9	0.0	0.0	0.0	
	Total	127.0	50.9	76.1	41.9	5.3	3.7	10[2]

1 Includes both measures for optimising motor operations and efficiency measures and replacement of oversized motors by correct size and VSDs

2 Impact of EU ETS accounts for 7 TWh of savings is included in the baseline and therefore does not contribute to the abatement potential

SOURCE: DECC projections; team analysis

Current policies capture large potential in residential, but have a low capture rate in services and industry



Comments

- Impact of measures reflects technical potential, including potential addressed by current policy
- Costs refer to direct costs and do not reflect taxes, subsidies, communication, information, transaction costs, knock-on consequences for other fuels, rebound effects and indirect cost e.g., disruption

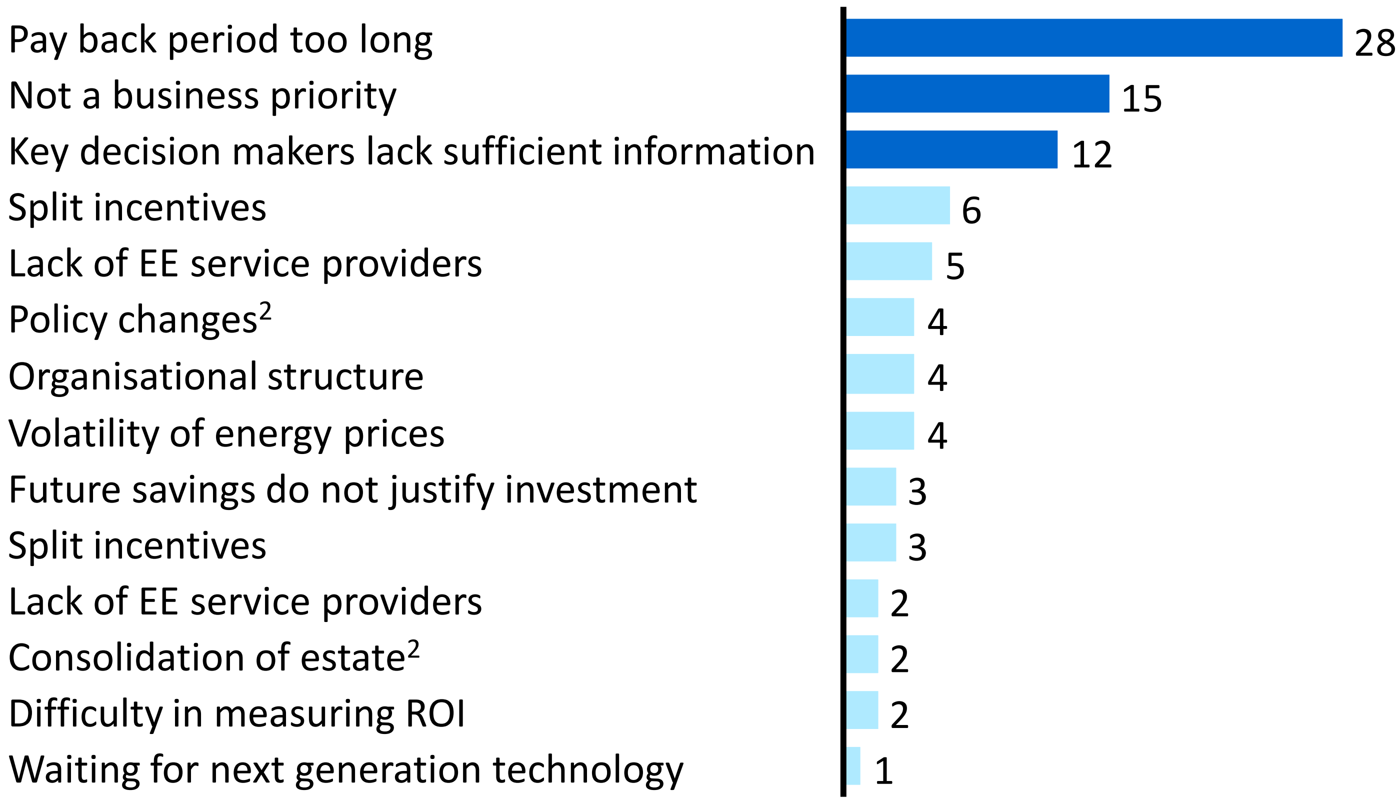
Note: Key assumptions for 2030: Discount rate: 10.5%, Electricity price: 12p/kWh, CO_2 price: £74/tCO_2e
Note: Analysis of capture of current policies has been done at the level of the 9 measure groups identified, not individual measures
Source: Team analysis

Appendix contents

Interviewees identified ‘pay back period too long,’ ‘not a business priority’ and ‘lack of information’ as the most significant barriers

Most significant barriers

Percent, points allocated by interviewees[1], n=11 interviews



1 Interviewees were given 100 points to allocate among 11 selected barriers and were asked to allocate them according to which barriers were most significant
2 Added by interviewees

SOURCE: Interviews

Interview guide 1/2

Preliminary questions

Untapped opportunities

- What are untapped electricity energy efficiency (EE) opportunities in your sector?
- Do you see EE investments in electricity on whole as being cost efficient? Do you see investments in EE as value generating or a cost? How does this differ by type of investment?
- How significant do you see these opportunities being?
- (Tech provider) What types of products/ services are you developing to tap into this market?
- (Utilities) What types of electricity EE services are you providing and what areas are you seeking to grow?
- (Financial institution) Which sectors/ customers do you see as most promising for EE financing? What products does your organisation have/plan to launch?

Organisation/ approach

- (User) Within the organisation, who has responsibility for EE (e.g., compliance, financing, decision-making,etc)? Please provide an organisation chart.
- Which of the following best describes your organisation's current approach to EE?
  - 1 A core compliance and risk management objective
  - 2 Important to reputation in an era of growing focus on climate change/ sustainability
  - 3 A value driver unlocking significant costs saving potential
  - 4 A source of competitive advantage
- In your organisation, what are planning horizons for new equipment purchases (e.g., 5 years out, wait until it breaks, etc) and what criteria are used for selecting what equipment is purchased?

Current policies

- Which energy efficiency policies is your organisation required to comply with (e.g. CRC Energy Efficiency Scheme, Building Regulations)? To what extent has your organisation made changes based on these policies?
- On a scale of 1 to 5, Please describe the familiarity of key decision makers in your organisation with the policies/ initiatives governing energy efficiency (e.g., Green Deal, Enhanced Capital Allowance, etc)?
  - 1 Not familiar with current policies
  - 2 Understand the general aim of current policies, but are not familiar with the details
  - 3 Familiar with current policies, but do not fully understand the implications
  - 4 Understand the details of current policies, but have not been able to leverage or benefit from them
  - 5 Understand the details of current policies, how they affect us, and find them beneficial
- How much of the total electricity EE opportunity is addressed with current policy or policy that has been announced to date?
- (User/ Tech provider) What programmes/ incentives are you aware of that would allow you to realise your organisation's EE potential? Which incentives/ programmes have had the most impact on your business?
- (Facilities management) What are you currently doing to achieve electricity EE in the buildings you manage? What is the attitude of your tenants towards EE?

Interview guide 2/2

Preliminary questions

Barriers

- Please allocate 100 points among the following barriers with the largest barriers receiving more points. Please explain your choices.
  - Financing difficult to obtain -- Key decision makers lack sufficient information
  - Pay back period too long -- Future savings do not justify investment
  - Not a business priority/ non-core -- Difficulty in measuring return on investment
  - Volatility of energy prices -- Waiting for next generation technology to make investment
  - Cost of production shut down -- Lack of EE service providers in marketplace
  - Organisational structure does not allow for elevation of EE issues to decision makers
  - Split incentives (e.g., one party pays, while the other benefits)
- What are key challenges to capturing full efficiency opportunity?
- Do you feel your organisation has the right tools/ information to properly asses the value and risk associated with EE investments?
- Do you feel that the energy efficiency industry is sufficiently developed so that you/ users have access to sufficient funding and diversity of service providers?
- (Utilities) What programmes have you tried to overcome these barriers? What has been successful? Unsuccessful?
- How closely do you measure electricity use (e.g., by end use, production process, etc.)?
- (User) Has your organisation considered any large EE investments? If so, why did you decide to pursue them or not? Please could you walk us step by step through process to determine how significant hurdles were (e.g., awareness of opportunity, navigating available information, securing business support, accessing financing, measuring impact, supporting documentation to receive benefits, etc). For successful projects, what barriers did you have to overcome and what were key success factors?
- How much would it cost you (time, additional investment, etc) to overcome these key barriers?

Policy solutions

- What are key gaps in current policy?
- What will it require to overcome these barriers?
- What policies have you seen in other countries that have helped driver higher electricity EE realisation?

M&V

- How are you currently measuring impact? What challenges have you faced?
- Can you think of any innovative ways to measure and validate the additionality of EE measures?

Appendix contents

Case example – ISO New England FCM mechanism (1/2)

Context

- ISO's FCM compensates for the structural limitations of the electricity market, such as wholesale price increases when demand is greater than system capacity and missing revenues for generators during peak demand due to spot energy market price caps, by reducing market power and increasing reliability
- Provides investors with predictable revenue streams as capacity providers receive an up-front, guaranteed payment for committing capacity to the markets, and a second inducement in the form of dispatch payments when there is there is a shortage of capacity
- Unique market which enables energy efficiency and other demand resources to compete directly with generators

Description of mechanism

- **Demand side inclusion** – Demand resources were included in New England's FCM in 2006 and includes energy efficiency, demand response and distributed generation projects
- **Forecasting** – ISO-NE forecasts peak capacity needs of the power system three years in advance and holds annual auctions to purchase the power resources needed to satisfy future requirements
- **Auction** – Forward auctions are held three years before the delivery year and the generator's 'forward' capacity obligations and amount of capacity put out to bid are established in advance of each auction
- **Payment** – ISO-NE pays participants during the delivery period based on the delivered capacity/demand reduction and the auction clearing price. Shortfalls in available capacity/demand reduction result in loss of payment, as sponsors are only paid for capacity/demand reduction delivered
- **Certification** – Annual certification of compliance with the approved M&V plan is also required, along with participation in any audits and reviews deemed necessary by ISO-NE
- **Participants** - Demand side participants include the state regulatory agencies in New England, Conservation Services Group, Vermont Energy Investment Corporation, Environment Northeast, Regulatory Assistance Project and Conservation Law Foundation

Key facts

Impact

- More than 3,400 MW of demand resources qualified in the first auction in February 2008 (nearly 9% of the total qualified capacity), and 2,554 MW (with 655 MW from energy efficiency) cleared the auction, contributing substantially to eliminating the need for new generating capacity
- Energy efficient resources have increased from 655 MW (26% share of total demand resources) to 1167 MW (35% share) from the first (Dec 2008) to the fourth auction (Aug 2010)
- Participants receive FCA credit for delivering capacity/demand reduction equal to the clearing price ($/kW-mo) x cleared capacity (MW) x 1,000

Cost

- Cost to ISO NE - in 2010 total FCM payments were $856 million
- Demand side participants have to pay financial assurance which consists of a deposit ($2/kW x total qualified kWs) and the cost of an entry (CONE) in the FCM is ($7.50 per kW of demand capacity)
- Demand side participants also pay for the energy efficiency measures which encourage demand reduction with their customers

M&V/ addition-ality

- ISO M&V Standards Manual outlines the minimum requirements
- Baseline conditions are specified by the participant and involve one of the below methods depending on the demand reduction measure:
  - Historical hourly load or output data if demand reduction is actively controlled by the Project Sponsor
  - Rolling average of historical hourly load or output data over some period prior to the demand reduction if demand reduction is controlled by end use personnel/ energy management systems
  - For projects in which operating equipment is replaced with a more efficient equivalent unit, the baseline condition is the MW load of that operating equipment

Source: "Energy efficiency as a resource in the ISO New England forward capacity market" report; ISO NE website; ISO NE "Measurement and Verification of Demand Reduction Value from Demand Resources" manual; annual reports; team analysis

Case example – ISO New England FCM mechanism (2/2)

Potential benefits in U.K. context

- Provide incentives for demand side resources such as energy efficiency to compete effectively with supply resources
- Provide demand resources and new supply providers with long-term stability to encourage investment
- There are potentially significant additional revenues for energy efficiency associated with participating in the FCM
- There is great potential for partnership with energy efficiency focused entities e.g., other participants and schemes

Challenges in U.K. context

- Limited mandate of the UK system operator (National Grid) compared to ISO-NE who are responsible for total system capacity planning and purchase (likely to be addressed by EMR)
- Difficulty in predicting demand and planning capacity requirements up to five years in advance (likely to be addressed by EMR)
- Highly liquid markets (APX UK and ICE) with unregulated pricing
- Dominance of integrated players in generation and retail
- Overlap with current capacity payments such as Renewable Obligations (green certificates) and feed-in tariffs and tax breaks for some renewable projects
- Challenges in measurement and verification of demand resources
- Constructing a mechanism that drivers demand reduction rather than demand response (which shifts rather than reduces demand)

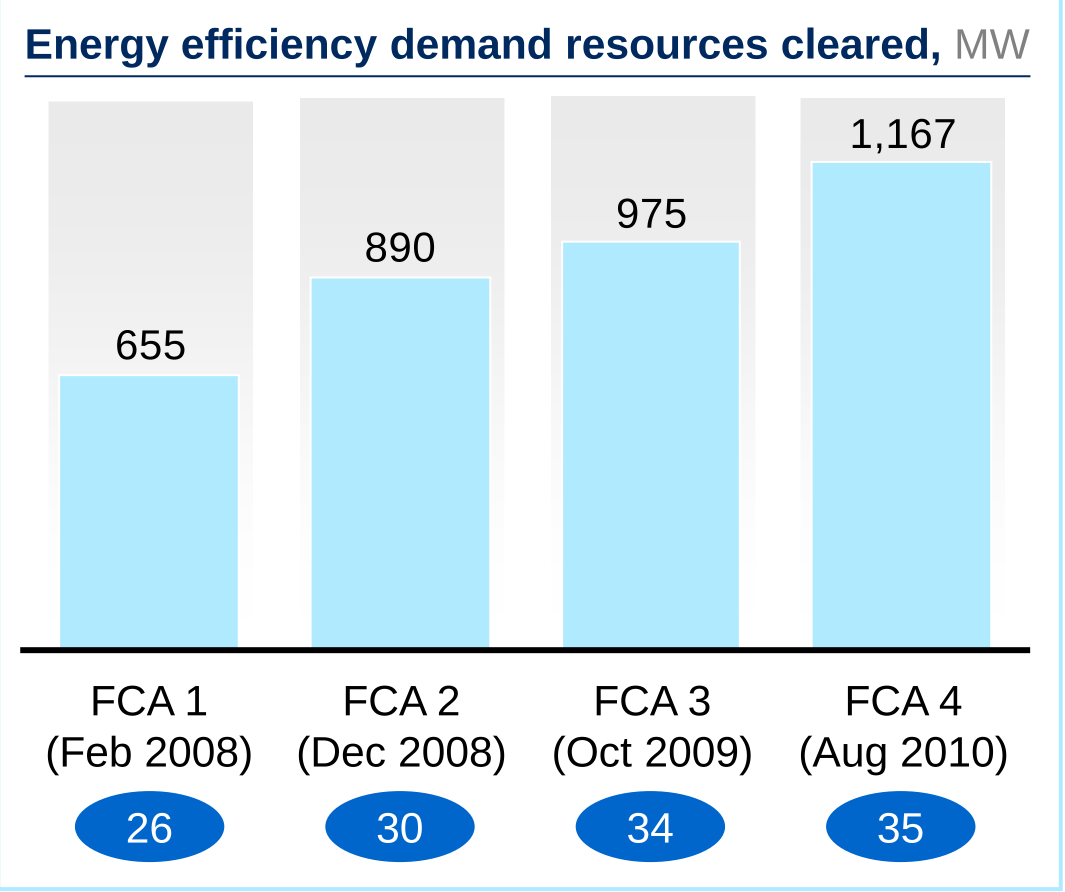
Implications for U.K. market

- The potential from demand resources (especially energy efficiency and demand response) will need to be established accurately and a robust measurement and verification process implemented to ensure system stability
- Multiple horizon auctions may need to be considered based on the payback period of technologies
- Mechanisms will need to be developed to handle inter-connectivity with supply resources in other European markets
- Current capacity payments such as Renewable Obligations and feed-in tariffs will need to be phased out to ensure a fair market
- The auction process should make end-use energy efficiency resources more cost-competitive while providing long-term stability for investment recovery

Source: "Energy efficiency as a resource in the ISO New England forward capacity market" report; ISO NE website and reports; team analysis

Energy efficiency resources as a proportion of total demand resources cleared have increased in successive auctions

Demand-Side Results (ISO-NE)



SOURCE: NEEP; ISO NE auction results; team analysis

Principles of Forward Capacity Market auction

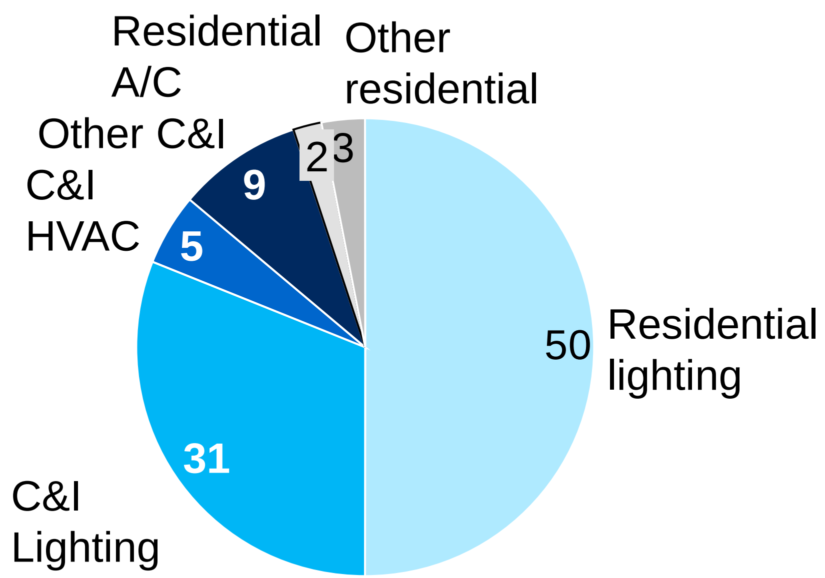
- FCM run by a regional system operator which:
  - Collects supply bids to meet planning targets for regional peak capacity needs
  - Runs a competitive auction to establish capacity prices
  - Procures capacity at the market clearing price to meet the resource adequacy requirements of the region
- The regional system operator is the sole buyer in this market
- Load Serving Entities (LSEs) are individually responsible for meeting their customers' peak loads, and are allocated a pro rata share of the capacity costs incurred by the system operator to meet those loads
- The forward auctions in ISO-NE are held three years before the delivery year and the LSEs' 'forward' capacity obligations and amount of capacity put out to bid are established in advance of each auction
- Three years was selected to roughly match the minimum lead time required for the construction or development of new capacity once demand- and supply-side resources receive a price commitment from the auction
- In particular, it was chosen to reflect a reasonable construction period for new peaking (e.g., gas-fired) power plants, as well as a reasonable "ramp up" period for energy efficiency projects
- The capacity bid into the market (the "supply curve") is comprised of capacity commitments (MW) offered by existing and new resources. These markets and associated auction rules are designed to allow new resources, when needed, to set the clearing price. Existing resources are generally "price-takers" in the sense that they are unlikely to set price unless there is over-supply of existing capacity in the region
- The market clearing price becomes the uniform price for all capacity that clears the auction. That is, the market clearing price is paid to all capacity committed by existing resources and all new resources that have bid into the auction at or below that clearing price
- **Sample calculation of revenue for a successful bidder**
  - Assume a service provider cleared 20 MW of demand-side resources in a capacity auction that had a clearing price of $100/MW-day, and that the provider delivered the 20 MW as contracted during the year. The annual revenue stream for the year would be 20 MW * $100/MW-day * 365 days = $730,000
- Only resources that clear the market receive capacity payments
- ISO-NE allows new resources to lock in a capacity price for up to five years (with a one-year minimum term), regardless of clearing prices in subsequent auctions
- Existing resources, including existing demand-side resources, are eligible only for a one-year price commitment
- ISO-NE impose stiff penalty charges if a unit fails to perform when obligated to run

Source: "Energy efficiency as a resource in the ISO New England forward capacity market" report; ISO NE website; team analysis

Residential lighting is the largest source of energy efficiency savings for Efficiency Vermont, the second largest demand resource participant in ISO-NE's FCM

Saving breakdown of forecasted Efficiency Vermont Savings Portfolio, 2008

Percent of MW, 2010
100%= 624



C&I – commercial and industrial

Source: "Energy Efficiency as a resource in the ISO New England Forward Capacity Markets" report

Advantages and disadvantages of energy markets with forward reserve requirements and centralised capacity markets

Advantages	Disadvantages
• Provides transparent, in-market mechanism for the system operator to acquire necessary resources on behalf of deficient LSEs • Multi-year forward commitment period allows additional supply to compete in market, thereby reducing price volatility • Supports retail competition by facilitating capacity transactions to address load migration and assist small LSEs • Allows incorporation of demand-response in the forward capacity market design, which increases competition and helps reduce system-wide cost of ensuring reliability • Allows for locational forward capacity requirements, which further improve pricing and deliverability of capacity in transmission-constrained areas • Facilitates monitoring and mitigation of market power	• Added complexity of market design imposes high implementation costs for the Regional Transmission Organisation and market participants • Complex market design also carries risks of initial design flaws and inefficiencies • Lengthy forward commitment periods can increase supplier risks. Also increases risk that suppliers default on their forward obligations • Can create political backlash because clearly visible capacity prices draw attention to the high cost of ensuring reliability at current target reserve margins; locked-in forward commitment could appear unnecessarily high cost after change in market conditions reduces resource needs

Source: “Energy Efficiency as a resource in the ISO New England Forward Capacity Markets” report

M&V provisions are communicated and defined across a variety of levels

M&V provision	Description
FCM rule	• Addresses overall rules applicable to all demand resources • References the FCM manual and operating procedures
FCM manual and operating procedures	• Include M&V standards that M&V documents must meet • ISO ensures consistency of the M&V documents with the M&V standards
M&V documents	• Include M&V plans, reports, and other M&V documents that provide detailed documentation of bid and achieved demand reductions

Source: ISO NE reports on M&V; team analysis

Description of M&V documents demand reduction suppliers have to submit to ISO

	Purpose	Schedule for submission to ISO, and ISO review
M&V plan	• Describe the M&V supporting the demand reduction value bid into the FCA • M&V must be consistent with the M&V standards in the FCM manual	• In the qualification phase, prior to the FCA • Reviewed by ISO to ensure consistency with the M&V standards
M&V summary reports	• Report the achieved demand reduction value verified by M&V • Reference the M&V protocols and performance data documented in the M&V plan or the M&V reference report	• Submitted monthly with the monthly FCM settlement report • Reviewed by ISO to ensure consis-tency with the M&V standards
M&V reference report (optional)	• Document and update the verified demand reduction value during the commitment period based on M&V performed during the commitment period • Document major M&V studies	• During the commitment period, according to schedule provided to ISO as part of M&V Plan • Reviewed by ISO to ensure consis-tency with the M&V Standards

Source: ISO NE reports on M&V; team analysis

Step by step process overview of FCM mechanism (1/2)

Description

1 Eligible participants and resources

- Different types of capacity resources are eligible to participate in the FCM on an equal footing, including: traditional power generation; intermittent resources and demand resources
- Demand resources can participate in any of several categories, including real-time demand response, load management, distributed generation, and energy efficiency
- The FCM is the first capacity market in the country to allow energy efficiency assets to participate as a resource in a capacity market – capacity reduction is fully equivalent to capacity supply
- Participants have to meet specified eligibility requirements, payment of dues, and providing financial assurance to back commitments
- Membership is in different “sectors,” with energy efficiency classified as part of a sector labeled “Alternative Resources”

2 FCM time line

- The period of time before each auction is used by resource providers (“project sponsors”) to forecast and plan projects, by ISO-NE to determine the future capacity needs of the region, and by sponsors to work toward qualification of projects to participate in the market
- After successful participation in an auction, project sponsors undertake the implementation of the project in preparation for the delivery of capacity during the delivery period

3 Planning for and qualification of resources

- For the several months before an auction, both project sponsors and ISO-NE undertake forecasting and qualification activities
- Sponsors of new projects must determine the level of capacity that can be made available for the next (starting three-years out) delivery period and the price the project requires from the auction in order to proceed
- For efficiency providers this means that a forecast must be developed for the portfolio of measures to be installed and associated capacity savings that will accumulate by a date three years in the future
- Energy efficiency portfolio must be qualified by ISO-NE to participate in the auction through submission and approval of a formal Qualifications Package, which includes
  - The capacity reduction value, bid price, and bidding strategy to be used in the auction
  - Election of a period of commitment to deliver the capacity reduction at the market, clearing price (1 – 5 years)
  - A plan for customer acquisition to substantiate the project sponsor’s ability to attain the forecast savings,
  - A funding plan for the project to verify financial feasibility
  - A cost analysis to support any proposed bid price below ISO-NE’s threshold for Market
  - Monitor review – required to ensure that low-cost projects are legitimate and are not using low bids to undermine the auction process or to corner the market
  - A plan for the measurement and verification (M&V plan) of the project’s capacity reduction value

4 Project “construction”

- The three-year lead time from auction to delivery period is designed to allow sufficient time for the construction or development of new resources once they receive a price commitment from the auction
- For energy efficiency projects, this is a “ramp-up” period, with capacity reduction capacity growing as measures that make up the project are installed
- In order to assess that sufficient progress is being made toward the final commitment, ISO-NE requires that projects submit as a part of their Qualifications Package a schedule of capacity reduction milestones
- Values of capacity reduction reached as of these interim dates will be reported and the approved M&V plan will be used to verify performance
- Auctions for capacity in subsequent commitment years must include resources that have not been committed in prior auctions

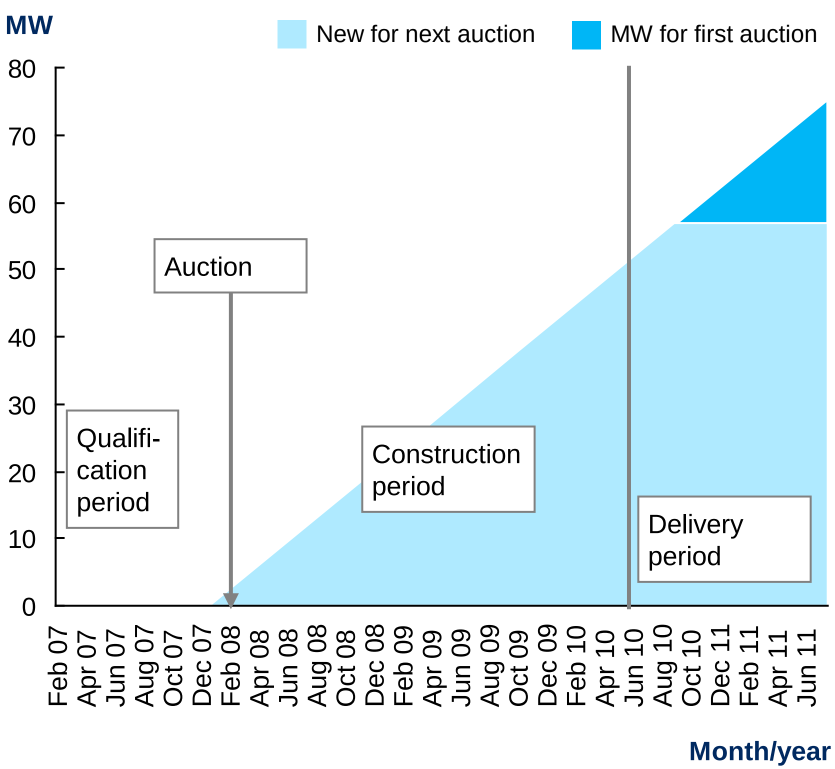
Step by step process overview of FCM mechanism (2/2)

	5 Financial assurance	6 Delivery period	7 Auction mechanics	8 Transition period rules
Description	• As a means of guarantee against the consequences of failure of projects to deliver their capacity obligations, ISO-NE requires sponsors of all new resource projects (supply and demand) to provide financial assurance against non-performance. • Deposits are due at several interim points throughout the construction period, to be released once the project is declared "commercial" and tested or verified for its full capacity rating at the delivery date. If the resource is only capable of delivering less than the amount of its commitment, the project sponsor forfeits the portion of its financial assurance associated with the capacity shortfall	• Monthly reports of delivered capacity are required during the delivery period, and payments are received based on the delivered capacity and the auction clearing price for that delivery period • Shortfalls in available capacity result in loss of payment, as sponsors are only paid for capacity delivered • Annual certification of compliance with the approved M&V plan is also required, along with participation in any audits and reviews deemed necessary by ISO-NE • All existing resources receive a one-year commitment to provide capacity, paid at the clearing price of the auction associated with the delivery period. New resources have elected delivery periods of from one to five years, in annual increments, as a part of their auction bid • For that delivery period, they will receive the guaranteed price determined by the auction clearing price, allowing them to lock in a price regardless of the clearing price in subsequent auctions	• The FCM auctions are live, Internet-based auctions conducted over several days • Prior to each auction, ISO-NE publishes the capacity they seek to procure in the auction (the ICR for the associated delivery period) and, for the first three auctions, administratively determined maximum (starting) and minimum (floor) prices • The bidding begins with all qualified resources in at the starting price, and proceeds in a "descending clock" auction, with resources withdrawing at prices below what they deem acceptable • Prices continue to fall in each subsequent round as long as there is still excess capacity on offer. The auction ends when either there is no longer excess capacity or the price reaches the auction floor price	• Because the delivery period associated with the first FCM auction does not begin until June 2010, the Market Rules define a Transition Period to bridge to the FCM, during which capacity payments are made to all listed and qualified capacity providers • These monthly payments, begun in December 2006 and running through May 2010, include payments to new energy efficiency assets submitted by market participants that qualify and register in the market • Fixed payment levels, equal for all asset types, were set in advance by the Market Rules and increase each year from $3.05 per kW-month in 2006 to $4.10 per kW-month in 2010 • Energy efficiency and other demand resource installations, undertaken as part of merchant, utility, or state-sponsored programs and totaling for any project at least 100 kW of peak capacity reduction aggregated within a single Load Zone, are considered qualified capacity for the transition period, subject to ISO-NE review of their measurement and verification processes • Project sponsors are required to submit M&V plans that meet the requirements of the Market Rule • For efficiency programs, review and approval by the appropriate state regulatory agency with jurisdiction over the utility or state-sponsored program is considered an adequate independent review process for transition period capacity

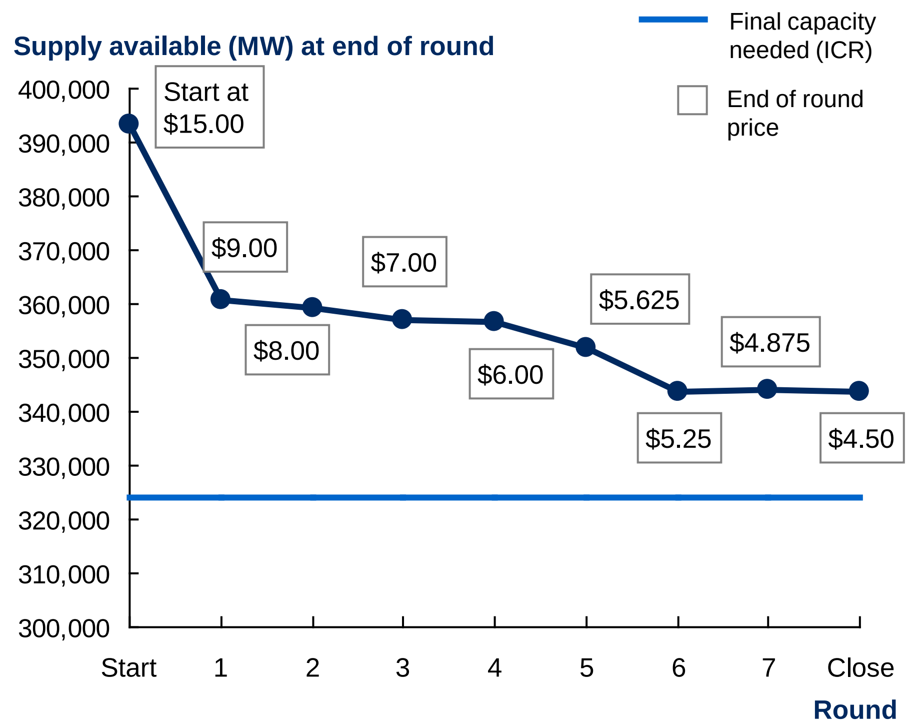
Graphical representation of market time line and auction dynamics

As an example, the results of the first FCM auction are shown in the following charts
The auction began with a set starting price of $15.00 and continued for eight rounds to the administratively set floor price of $4.50, at which excess capacity remained

ISO-NE Forward Capacity Market Time Line Energy Efficiency Resource Example



Final Results of ISO-NE FCM Auction #1



Source: Source

Case example – Texas energy efficiency programmes (1/2)

Context

- State of Texas passed a series of laws requiring utility companies (investor owned utilities- IOUs) to meet energy efficiency goals. Currently they must meet at least 20% of their annual growth in electricity demand through energy efficiency programmes
- All programs are designed to reduce system peak demand, energy consumption, or energy costs through either standard offer programs (SOPs) or targeted market transformation programs (MTPs)

Description of mechanism

- **Energy incentive programmes** - Utilities are required to administer energy savings incentive programmes, which are implemented through energy efficiency service providers (EESPs) and retail electric providers (REPs) through contracts
- **SOPs and MTPs** - Utilities must achieve their energy efficiency goals either through SOPs or MTPs
- **Customers** - Programmes are made available to all customers, which gives each customer a choice of a variety of energy efficiency alternatives
- **Customer targeting** - Both national and local EESPs contact consumers (residential and commercial) about performing work to save energy and reduce their electric bills
- **Selection** - Customers select the EESP, decide what equipment will be installed, and choose what work the contractor does
- **Financial incentives** - Utilities' programs pay project sponsors financial incentives to offset the costs of a variety of energy efficiency improvements. Incentive rates are set for each kW of demand reduction and each kWh of energy savings produced and are based on avoided costs

Key facts

Impact

- Collectively the utilities in 2010 achieved 533 gigawatt hours (GWh) of energy reduction and 301 megawatts (MW) of peak demand reduction, which was 118% above their 138 MW goal
- Between 1999 and 2010, the utilities' programmes implemented after electric industry restructuring in Texas have produced 1,666 MW of peak demand reduction and 4,110 GWh of electricity savings
- A utility that exceeds its demand reduction goal at a cost that does not exceed the limit established is awarded a performance bonus on an annual basis (a utility that exceeds 100% of its demand reduction goal receives a bonus equal to 1% of the net benefits for every 2% that the demand reduction is exceeded, up to a maximum of 20%)

Cost

- All IOUs spent an approximate total of $105 million on energy efficiency programs (including administrative expenses) in 2010

M&V/ addition-ality

- Project sponsors are responsible for planning and conducting all the M&V activities associated with their projects and are required to submit an M&V plan that describes the specific activities, tools, and calculations the sponsor intends to use to determine the projects' actual savings (an industry accepted M&V protocol)
- M&V guidance provided by IOUs to establish baselines depends on the measure involved and is either:
  - Simple M&V - uses stipulated values for data such as operating hours and equipment efficiencies
  - Full M&V - higher level of rigor involving the application of end-use metering, billing regression analysis or computer simulation (project sponsors must use a full M&V approach for measures that do not meet the criteria for a simplified M&V approach)

Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; Utility company reports, team analysis

Case example – Texas energy efficiency programmes (2/2)

Potential benefits in U.K. context

- Puts control in the hand of the end user to determine the most cost effective energy efficiency measures
- Allows for targeted funding for specific efficiency measures that require structural barriers to be overcome or require widespread adoption to become cost effective
- Could lead to the development of a healthy and competitive energy efficiency market of service providers

Challenges in U.K. context

- Due to the deregulated and competitive nature of the UK market, the costs of funding energy efficiency programmes will be passed on directly to the consumer
- Utilities could use their advantage from customer access and understanding of consumption to provide energy efficiency services on their own and capture the value from EE. This could prevent the development of a competitive independent service provision market with customer choice
- Customers could choose high cost EE measures as the costs will be spread across the entire customer base
- Measurement and verification of the promised savings would remain a challenge

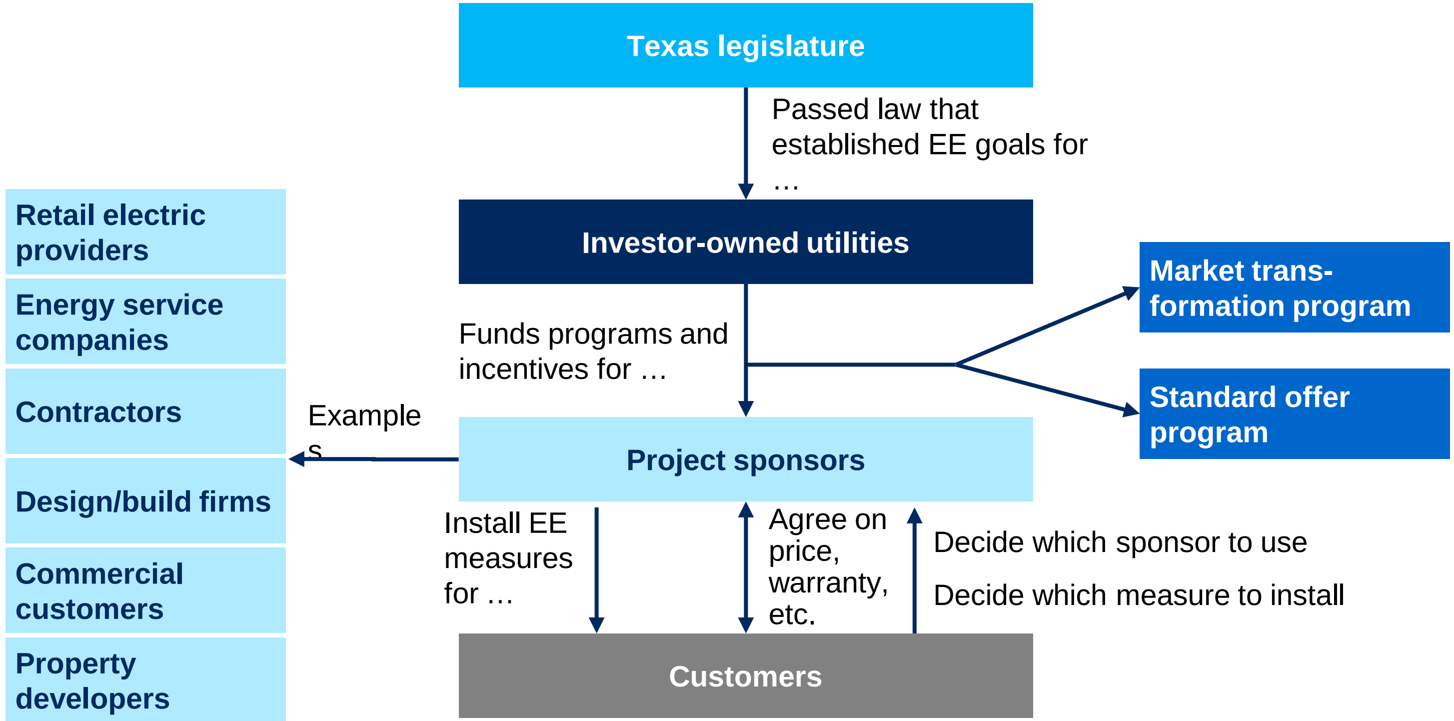
Implications for U.K. market

- Would require clarification of potential overlaps with current supplier obligations
- MTP programmes would require selection to promote the highest potential opportunities that would otherwise not be adopted
- Would require careful setting of incentive rates to ensure that the cost to customers (through the utility) is manageable
- Would require mechanisms to ensure awareness and access of a broad range of energy efficiency service providers
- Will require clear dispute resolution and arbitration mechanisms between utilities, service providers and end customers
- Requires careful setting of baseline with clear focus on proving additionality
- Requires a rigorous M&V process to ensure target EE savings are delivered with clearly identified responsibilities

Source: Team analysis

PUCT – Energy efficiency programmes overview in Texas (1/4)

- Texas passed a series of laws requiring utility companies (investor owned utilities- IOUs) to energy efficiency goals, currently they must meet at least 20% of their annual growth in electricity demand through energy efficiency programmes
- Utilities are required to administer energy savings incentive programs, which are implemented through energy efficiency service providers (EESPs) and retail electric providers (REPs) through contracts
- All programs are designed to reduce system peak demand, energy consumption, or energy costs
- Utilities must achieve their energy efficiency goals through either standard offer programs (SOPs) or limited, targeted market transformation programs (MTPs)
- Programs are made available to all customers, in all customer classes (residential and commercial) which provides each customer a choice of a variety of energy efficiency alternatives
- Customers select the EESP, decide what equipment will be installed, and choose what work the contractor will do (price, warranty, financing, and other purchasing matters are entirely between the contractor and customer)
- The diagram below illustrates the Texas Energy Efficiency Process

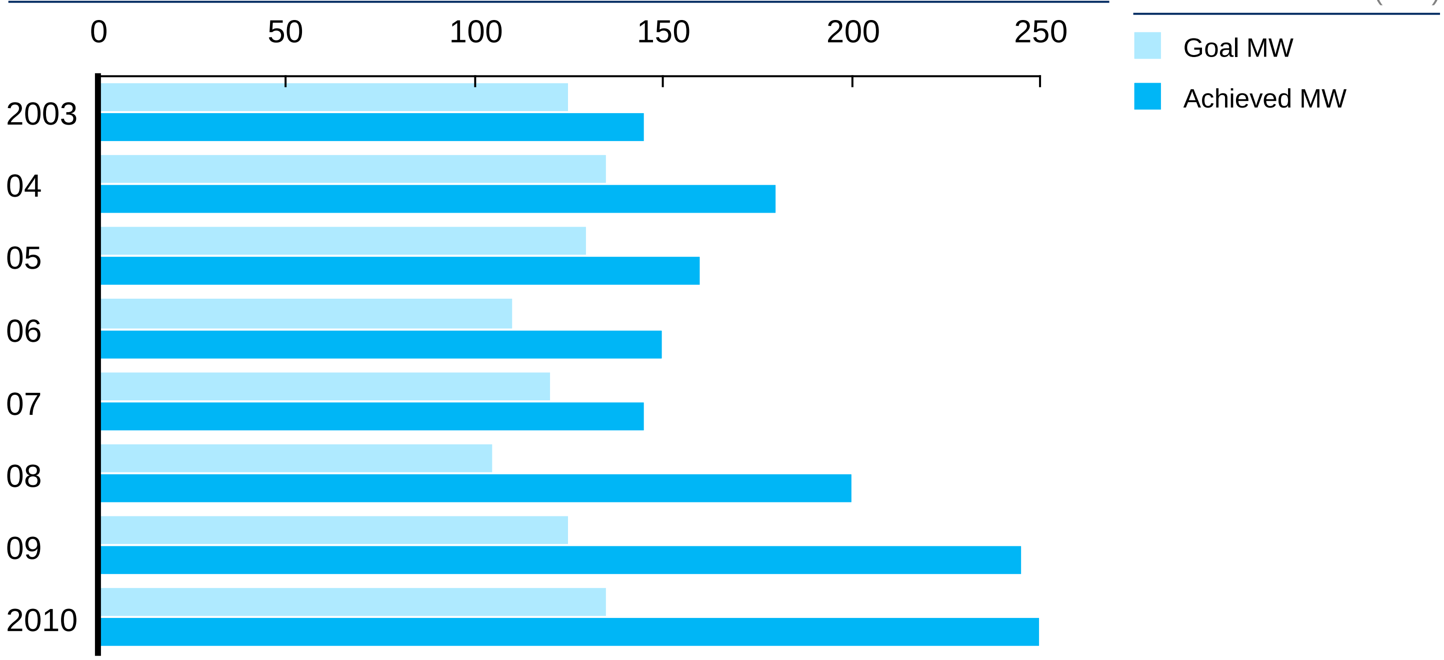


Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; team analysis

PUCT – Energy efficiency programmes overview in Texas (2/4)

- In 2010, the nine Texas investor-owned utilities (IOUs) exceeded their statewide legislative energy efficiency goals for the eighth straight year
- The utilities achieved 533 gigawatt hours (GWh) of energy reduction and 301 megawatts (MW) of peak demand reduction, which was 118% above their 138 MW goal
- Most of the utilities' programs involve financial incentives which are paid to project sponsors to offset the costs of a variety of energy efficiency improvements
- Combined, the IOUs spent approximately $105 million on energy efficiency programs (including administrative expenses) in 2010
- Between 1999 and 2010, the utilities' programs implemented after electric industry restructuring in Texas have produced 1,666 MW of peak demand reduction and 4,110 GWh of electricity savings

Demand reduction by IOUs, 2003 - 10



Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; team analysis

PUCT – Energy efficiency programmes overview in Texas (3/4)

- The table below lists the Texas IOUs and the types of SOPs and MTPs offered by each utility
- Please note that this list does not include every program offered by each utility

Texas investor owned utilities

Utility name	Utility acronym
South Western Electric power company	SWEPCO
American Electric power-Texas central company	AEP-TCC
American Electric power-Texas north company	AEP-TNC
Center point energy houston electric LLC	CNP
El Paso electric company	EPE
Entergy Texas, inc.	ETI
Texas-New Mexico power company	TNMP
Oncor	Oncor
Xcel energy company	Xcel

Programs offered by utility in 2010

Program type	Type	AEP	SWEPCO	CNP	ETI	EPE	TNMP	Oncor	Xcel
Commercial and industrial	SOP	●	●	●		●	●	●	●
Residential and small commercial	SOP	●	●	●	●	●	●	●	●
Hard-to-reach	SOP	●	●	●	●		●	●	●
Load management	SOP	●	●	●	●	●	●	●	
Underserved area	SOP						●		
Low-income weatherization	SOP	●	●	●		●	●	●	●
Energy star new homes	MTP	●		●	●		●	●	
Air conditioning distributor	MTP			●				●	
Air conditioning installer training	MTP							●	
Retro-commissioning	MTP			●					
Large C&I solutions	MTP	●	●		●	●			
Residential solutions	MTP					●			
Small commercial solutions	MTP					●	●		
Hard-to-reach solutions	MTP					●			
Living wise education	MTP					●			
Texas score/city smart	MTP	●	●	●	●	●	●		
A/C tune-up	MTP	●	●					●	
Small distributed renew-able generation (solar PV)	MTP	●	●		●	●	●		
Residential demand response	MTP	●						●	
Premium lighting program	MTP			●	●				

Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; team analysis

PUCT – Energy efficiency programmes overview in Texas (4/4)

Utility's 2010 program savings and expenditures as reported to the PUCT

Utility	Funds expended Dollars	Demand savings MW	Energy savings MWh
SWEPCO	4,282,043	14.8	18,477.9
AEP-TCC	12,898,287	27.0	57,665.0
AEP-TNC	2,238,100	5.1	14,194.4
CNP	28,806,909	121.0	139,664.8
ETI	7,060,072	13.2	28,630.0
EPE	4,166,737	9.9	21,404.0
Oncor	41,107,131	101.1	225,785.4
TNMP	2,754,742	5.2	11,937.0
Xcel	2,004,726	3.7	15,699.0
Total	**105,318,747**	**300.9**	**533,457.5**

Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; team analysis

Overview of SOPs and MTPs

SOPs

- An SOP is a type of energy efficiency program where parties enter into a contract with standard terms and conditions
- Utilities offer standard incentives for a wide range of measures that are bundled together as a project
- Incentive rates are set for each kW of demand reduction and each kWh of energy savings produced and are based on prescribed avoided costs
- Payment is based on the measures installed and deemed savings values for each measure with random inspections to verify proper installation
- The SOPs offered by the Texas IOUs are:
  - **Commercial programs** – target customers that meet minimum demand requirements with incentives for measures that provide verifiable demand and energy savings
  - **Residential and small commercial programs** – provide incentives on a wide range of measures that reduce system peak demand, energy consumption and energy costs
  - **Low income programs** – encourage energy efficiency improvements in households with annual incomes at or below 200% of the federal poverty guideline
  - **Load management programs** – encourage electric load control or shifting of electric loads in facilities from on-peak to off-peak periods

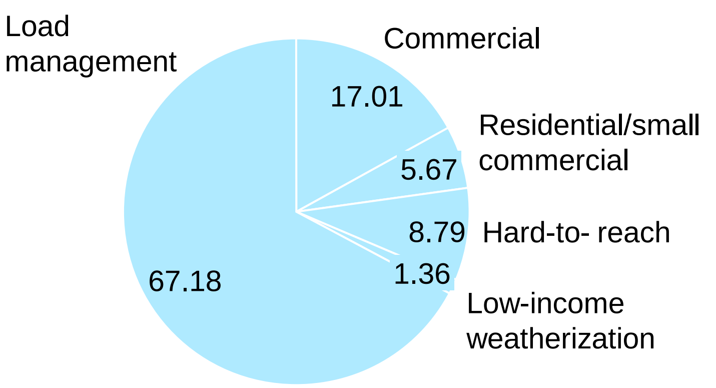
MTP

- An MTP is a strategic effort to make lasting changes in the market that result in increased adoption of energy efficiency technologies, services, and practices
- MTPs are designed to overcome specific market barriers that prevent energy efficient technologies from being accepted
- There are more than fifteen different MTPs offered in Texas, including the following:
  - ENERGY STAR New Home Construction
  - Texas Schools Conserving Our Resources (SCORE) and CitySmart Programs
  - Commercial Retro-commissioning
  - AC Installer and AC Distributor Programs

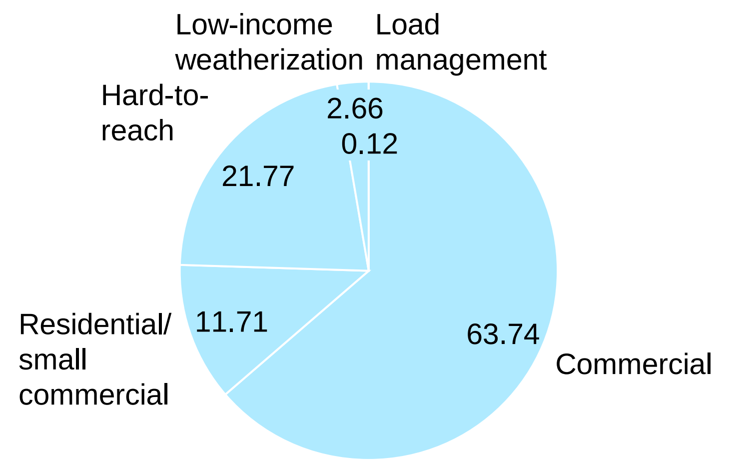
Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; team analysis

Standard offer programme – results

Demand savings, 2010



Energy savings, 2010



Definitions

- The Load Management Program is a group load curtailment program in which commercial customers curtail load when notified
- The Commercial SOP provides incentives for the retrofit installation of a wide range of measures that reduce customer energy costs, and reduce peak demand and/or save energy in non-residential facilities
- The Hard to Reach SOP encourages energy efficiency improvements in households with incomes at or below 200 percent of the federal poverty guideline – PUCT requires that each utility meet at least 5 percent of its savings goal for each year through programs targeted to this customer class
- The Low-Income Weatherization SOP is designed to help improve energy efficiency for residential consumers with an annual household income below 200% of the federal poverty guidelines
- Residential and Small Commercial SOP provides incentives to encourage contractors to install energy efficiency measures in homes and small businesses

Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; utility websites; team analysis

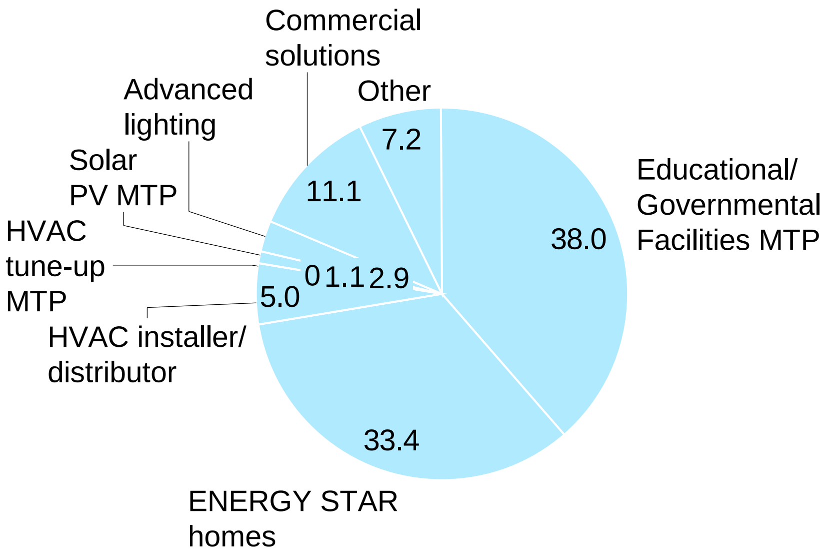
Standard offer programmes – impact on sectors

Sector	
Commercial and qualifying industrial	• The Commercial and Qualifying Industrial (C&I) program targets large commercial and industrial customers with a minimum demand requirement (this varies by utility). Utilities pay incentives to project sponsors for certain measures installed in new or retrofit applications that provide verifiable demand and energy savings. Typical projects include the replacement of existing chillers and lighting equipment with more efficient chillers and lighting, and industrial process retrofits
Residential and small commercial	• The Residential and Small Commercial program targets residential and small commercial customers including multi-family, single-family, and mobile homes. The program provides incentives for the installation of a wide range of measures that reduce system peak demand, energy consumption and energy costs. Retrofits and efficient new construction of low-income housing may also be undertaken • Utilities pay incentives to EESPs. These incentives are based on deemed savings when available. (Deemed savings estimates are predetermined, validated estimates of energy and peak demand savings attributable to an energy efficiency measure.) Otherwise, the EESPs set incentives based off actual peak demand reduction and energy savings as verified using the International Performance Measurement and Verification Protocol • The primary objective of the Residential and Small Commercial SOP is to achieve cost- effective reduction in energy consumption during peak summer demand. There are five additional objectives of the program: (1) to encourage private sector delivery of energy efficiency products and services; (2) to achieve customer energy and cost savings; (3) to significantly reduce barriers to participation by streamlining program procedures and M&V requirements; (4) to encourage participation by a wide range of EESPs; and (5) to produce demand, energy, and bill savings in new single-family affordable housing projects and in new multifamily projects
Hard-to-reach	• The Hard-to-Reach program encourages energy efficiency improvements in households with annual incomes at or below 200% of the federal poverty guideline. It is designed to be a comprehensive program by emphasizing first improving the building shell and then addressing end uses. It is a retrofit program that targets multi-family, single-family, and mobile homes • Incentives are paid to project sponsors for eligible measures that provide verifiable demand and energy savings. Special measures include the replacement of incandescent light bulbs with compact fluorescent lighting and water savers
Load management	• Load Management programs encourage electric load control or shifting of electric loads in C&I facilities. Participating project sponsors provide on-call, voluntary curtailment of electric consumption during peak demand periods in return for incentive payments. The program is designed to assist businesses to reduce their on-peak energy demand and help meet the state's energy efficiency goals. Targeting a mix of industrial, office, and hospital facilities, program requirements differ on a utility-by-utility basis
Low-income weatherization	• Low Income Weatherization programs are designed to cost-effectively reduce the energy consumption and energy costs for low-income residential customers. Program implementer(s) provide eligible weatherization and energy efficiency measures to residential customers who meet the current Department of Energy (DOE) income eligibility guidelines. Implementation of this Senate Bill 712 Weatherization Program also provides targeted eligible residential customers with basic on-site energy education to satisfy the requirements of Substantive Rule 25.181(p)

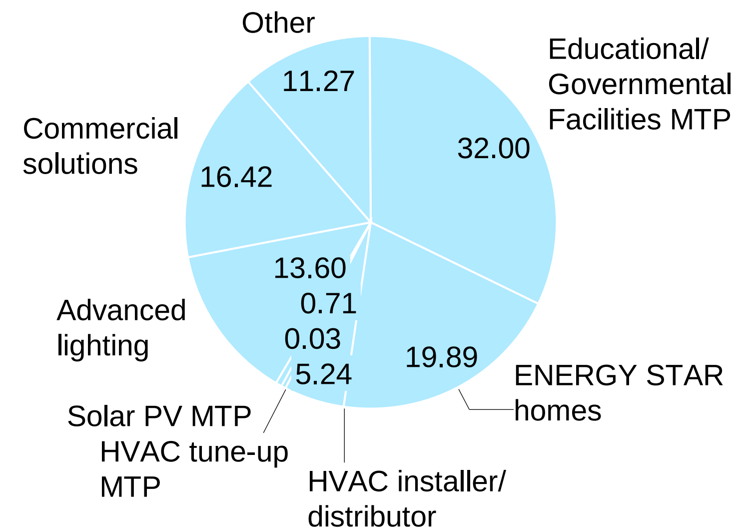
Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; team analysis

Market transformation programme – results

Demand savings, 2010



Energy savings, 2010



Definitions

- The ENERGY STAR New Homes Construction program targets residential new construction and promotes the construction of energy efficient ENERGY STAR® new homes
- The Large C&I Solutions program offers customers both cash and non-cash incentives. The cash incentives are at a lower $/kW than SOPs, with the difference used to provide non-cash incentives that include technical assistance, education on financing energy efficiency projects, and communications services. The Solutions program helps companies that do not have the in-house capacity or expertise to 1) identify, evaluate, and undertake efficiency improvements; 2) properly evaluate energy efficiency proposals from vendors; and/or 3) understand how to leverage their energy savings to finance projects
- Educational/Governmental Facilities MTPs include the Texas Schools Conserving Our Resources (SCORE)/CitySmart programme (promotes a structured process to K-12 school districts to identify opportunities and implement energy efficiency measures) and LivingWise Education (a school-based method that builds student knowledge, provides high efficiency devices to families and serves as an effective community outreach program)

Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; utility websites; team analysis

Market transformation programme– impact on sectors (selected

Sector	
ENERGY STAR New Home Construction	• The ENERGY STAR New Homes Construction program targets residential new construction. It promotes the construction of energy efficient ENERGY STAR® new homes. To qualify, homes must be 15% more efficient than the energy requirements of the locally adopted International Energy Conservation Code. The program provides education and technical assistance to builders and subcontractors. The program is supported by training, education, and advertising components
Air Conditioning Distributor	• The air Conditioning (A/C) Distributor Program promotes the sale of matched, high efficiency air conditioning units. Qualifying equipment must have a capacity of 5 tons or less and be rated at a Seasonal Energy Efficiency Ratio (SEER) of 14 or above. A complete system change-out is required. Single/multi-family and new and existing homes (retrofits) are eligible
Air Conditioning Installer Training	• The Air Conditioning Installer Training Program targets improved installation practices of heating, ventilation, and air conditioning contractors. The program provides training, education, and incentives. It encourages proper sizing, charging, and duct sealing • Local Air Conditioning Contractors Association chapters implement this program
Retro-Commis-sioning	• The Retro-Commissioning program helps energy end users reduce their peak demand and energy usage. The program provides expert analysis and systematic evaluation of building systems. By implementing low-cost and no-cost measures that improve system operation, customers reduce energy and peak demand while maintaining or improving customer comfort
Texas Schools Conserving Our Resources (SCORE)/City Smart	• The Texas SCORE Program promotes a structured process to K-12 school districts to identify opportunities and implement energy efficiency measures. Incentives to school districts encourage these installations. Non-cash incentives promote best business practices. The Texas CitySmart Program promotes a similar program to a targeted audience of local and state government entities and municipalities
Large Commercial & Industrial (C&I) Solutions	• The Large C&I Solutions program offers customers both cash and non-cash incentives. The cash incentives are at a lower $/kW than SOPs, with the difference used to provide non-cash incentives that include technical assistance, education on financing energy efficiency projects, and communications services. The Solutions program helps companies that do not have the in-house capacity or expertise to 1) identify, evaluate, and undertake efficiency improvements; 2) properly evaluate energy efficiency proposals from vendors; and/or 3) understand how to leverage their energy savings to finance projects.

Source: Energy Efficiency Accomplishments of Texas Investor Owned Utilities Calendar Year 2010 report; team analysis

Case example – Energy saving certificates (ESCs) (1/2)

Context

- In the US, many states have established efficiency targets by passing an Energy Efficiency Resource Standard (EERS) or a Renewable Electricity Standard (RES) that require a percentage of MWh growth to be met with efficiency, or that efficiency be used to meet a specified percentage of annual load growth
- Several states (including Connecticut, Nevada, Pennsylvania, and New Jersey) have included provisions in their legislation that would allow third parties, such as commercial and industrial customers, to generate ESCs and sell them to utilities that are seeking to comply with energy efficiency targets

Description of mechanism

- **Tradable certificates** - ESCs are tradable certificates issued by the state regulator, similar to renewable energy certificates (RECs), that typically represent one megawatt-hour (MWh) of energy savings from efficiency projects (also known as energy efficiency certificates or credits (EECs), white certificates or tradable white certificates (TWCs) and “white tags”)
- **Investment in energy efficiency** - ESCs offer utilities a flexible means of achieving energy efficiency targets while rewarding commercial and industrial companies that are successful in reducing energy use with an additional revenue stream that may improve the economics of a project
- **Financing** - Commercial and industrial companies may choose to implement eligible projects independently or seek financing from a third party, such as a utility or a clean energy fund, often in exchange for future ownership of the credits
- **Trading market** - Each ESC represent one MWh of electricity usage avoided and only Connecticut has an active trading market where the minimum floor is set by public utility
- **Project coverage** - guidelines for energy efficiency projects are established by each state’s specific legislation. Examples include commercial and industrial lighting upgrades, cogeneration or combined heat and power (CHP) and increased efficiency of HVAC systems and improved insulation

Key facts

Impact

- In Connecticut the ESC market was estimated to be valued at $8-$10 million in 2007, $16-$20 million in 2008, $26-$30 million in 2009, and $34-$38 million in 2010 (equates to 1.2 TWh of energy savings assuming total ESCs in 2010 were valued at $36 million with an average price of $30/MWh)
- In 2007 there was an excess of supply with 907,891 ESCs exceeding the estimated demand, 640,740 ESCs, for EEPS in 2008

Cost

- In July 2008, the trading price for ESCs in Connecticut was $26.75/MWh
- Since its introduction the indicative prices of ESCs have generally been between $20 and $30/MWh (floor price is $10)
- An alternative compliance payment (ACP) of $31/MWh is charged to utilities that fail to meet their efficiency targets
- Ratepayer support for EE amounted to ~$115m in 2008

M&V/ addition-ality

- The baseline can be established in a number of ways and depends on the specific market design rules
  - “Deemed savings” figures (end-use consumption and then imputing savings based on a projection of baseline energy use, or conducting whole building measurement)
  - Engineering calculations
  - Direct measurement
  - Measured factors
  - System monitoring
  - Modelled savings
- ESCs generally require licensed engineering contractors to conduct the work or independently verify the savings

Source: Energy Savings Certificates report by the World Resources Institute; The Creation of an Energy Efficiency Resource Standard and the Process for Allowing Residential Aggregation report; Energy savings certificates: Toward best practices and standards report; team analysis

Case example – Energy saving certificates (ESCs) (2/2)

Potential benefits in U.K. context

- Provides utilities with a flexible means of achieving energy efficiency targets while rewarding commercial and industrial clients with an additional revenue stream that may enhance project economics
- Enables private actors to identify and access the highest value efficiency opportunities through a market where the most cost effective efficiency measures set the ESC price
- Allows some degree of prescription as to the efficiency measures incentivised through the eligibility criteria for ESCs
- Allows sponsors to use future credits as security for financing
- Prescribes a range of M&V options to set baseline depending on nature of efficiency project

Challenges in U.K. context

- Setting the level of demand reduction required from suppliers and/or the market price for ESCs can be challenging given information asymmetry
- In 2008, number of ESCs generated exceeded total demand, introducing significant price risk for private sector investors
- Developing a sophisticated and robust way of measuring additionality is particularly challenging where a range of actors are able to generate efficiency savings
- ESC regimes also may include demand-response or load-management measures that shift electricity load from peak to off-peak hours
- Carefully tracking ESCs' chain of ownership is necessary to ensure against double-counting

Implications for U.K. market

- Would require clarification of potential overlaps with current supplier obligations
- Selection criteria would need to promote the highest potential opportunities that would otherwise not be adopted
- Would require careful setting of supplier obligations / ESC prices ensure that the cost to customers (through the utility) is manageable
- Requires careful setting of baseline with clear focus on proving additionality
- Requires a rigorous M&V process to ensure target EE savings are delivered with clearly identified responsibilities

Source: Energy Savings Certificates report by the World Resources Institute; The Creation of an Energy Efficiency Resource Standard and the Process for Allowing Residential Aggregation report; Energy savings certificates: Toward best practices and standards report; team analysis

Explanation of ESCs

Example of an ESC created from the earth markets community energy savings project – lighting

Take-out and recycle 20
80W incandescent

Install 20
20W CFL

Electricity savings
1,000 kWh

The market

Class III ESCs are being registered, exchanged, and sold through the NEPOOL generation information system (GIS) – see figure 4

Despite the number of registered ESCs (907, 891) exceeding the estimated demand (640, 740) for the EEPS in 2008, the price appeared to be near the DPUC-established ACP of USD 31. One would expect if the market for ESCs is in surplus (267, 151), then the associated price would approach the floor price of USD 10, but this has not been the case. This market inconsistency presents market price risks for private sector investors interested in using the EEPS to finance EE projects in Connecticut. Due to this over-supply of ESCs in the EEPS in Connecticut, earth markets has recommended to the DPUC through docket number 05-07-19RE02 that there be a cap of 25% on the number of ESCs that can be registered and sold by the CEEF

Source: Team analysis

Case example – Portfolio Manager (1/2)

Context

- Portfolio Manager is an interactive web-accessed energy management tool provided by the EPA that allows individuals to track and assess energy and water consumption across their entire portfolio of buildings in a secure online environment
- Portfolio Manager can help users set investment priorities, identify under-performing buildings, verify efficiency improvements and receive EPA recognition for superior energy performance

Description of mechanism

- **Free registration**– user needs to provide building street address, year built, building gross floor area and key operating characteristics for each major space type in the building
- **Statement of Energy Performance** – After 11 consecutive months of utility bills for all fuel types used in the building a Statement of Energy Performance (SEP) for each building, summarising building characteristics, energy consumption, CO_2 emissions, and energy performance ratings where applicable
- **Identify energy savings opportunities** - Building managers through looking at the performance at the whole building level, can identify opportunities for savings through operational improvements and system optimization as well
- **Evaluate results and potential investments** -Users can prioritise investments, conduct ongoing measurement and verification of improvements- both financial and environmental and benchmark against similar buildings
- **Available to commercial and public buildings** – Wide coverage including banks/financial Institutions, hospitals (acute care and children's) hotels houses of worship, residences, care facilities, supermarkets etc
- **EPA energy performance score** – Can be awarded to users and Indicates how efficiently buildings use energy on a 1-100 scale (accounts for the impact of weather variations as well as changes in key physical and operating characteristics of each building e.g., size, location, number of occupants and number of personal computers)

Key facts

M&V/ addition-ality

- When certifying building performance the following process is used:
  - Verification of the results and impact from implementing the energy strategies and technologies
  - Quantification of energy savings from specific measures
  - Tracking of energy use over the life of the building
  - Validation and documentation of energy performance and determine the carbon impact of the building
- ENERGY STAR Portfolio Manager requires actual billing data to determine and track the energy rating for the facility
- STAR rating or another rating that depends on ENERGY STAR (e.g. LEEDS
- Certification for existing buildings: actual billing data must be used, not adjusted billing data.

Source: EPA Energy Star Portfolio Manager fact sheet; team analysis

Case example – Portfolio Manager (2/2)

Potential benefits in U.K. context

- Energy Star Rating would allow communication to prospective tenants and buyers, helping overcome agency barriers
- Benchmarking and online resources effectively act as a low cost audit tools, suggesting highest value efficiency opportunities to overcome lack of awareness / information
- Range of variables used in determining performance against benchmarks acts as a dynamic baselining tool, helping to isolate additionality

Challenges in U.K. context

- No significant challenges

Implications for U.K. market

- Could be used to address uncaptured potential in commercial and public administration buildings
- Confidence in benchmarking algorithm is critical in order to generate voluntary participation
- Participation could be made compulsory for buildings above a defined size
- Publication of building ratings could be made compulsory to further address agency issue
- Open question is the extent to which potential tenants and subsequent buyers will consider energy efficiency in decision making
- For large commercial users, provides more granular tracking and data than CRC

Source: Team analysis