Department of Energy & Climate Change

UK National Comprehensive Assessment of the Potential for CHP and District Heating and Cooling

15th April 2016

Helena Crow, Heat Infrastructure Team, DECC

Department of Energy & Climate Change

Energy Efficiency Directive (EED)

- Directive 2012/27/EU on energy efficiency (EED)
- Directive established a common framework for promotion of energy efficiency measures taking account of the EU's 2020 target on energy consumption (1,474 Mtoe of primary energy)
- **Efficiency in Energy Use** (building renovation, public buildings, energy audits and energy management systems, metering and billing information)
- **Efficiency in Energy Supply** (heating and cooling, transmission and distribution)

Department of Energy & Climate Change

Article 14. Promotion of efficiency in heating and cooling

- **Article 14(1).** '*By 31st December 2015, Member States shall carry out and notify to the Commission a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling*'.
- **Article 14(5-8).** *'Member States to ensure that a cost-benefit analysis ... is carried out after 5 June 2014 for new or substantially refurbished thermal electricity generation installations and district heating and cooling networks with a total thermal input exceeding 20 MW'.*

UK NCA Outcomes

- An assessment of national **heating and cooling demand** and how this may change over the next 10 years
- An assessment of the **technical and socially cost effective potential** of different heating and cooling technologies and district heating solutions
- **Heating and cooling maps** showing heating and cooling demand and supply
- A summary of the **existing UK policies** supporting high-efficiency CHP and efficient district heating and cooling
- The results should be taken as purely indicative and cannot be used to judge the viability of specific schemes. The definitions and methodology specified in the Directive are not always consistent with DECC's.

Department of Energy & Climate Change

UK NCA Project Governance

DECC carried out the NCA on behalf of the UK, with input from the Devolved Administrations as heat is a devolved issue

Department of Energy & Climate Change

The Scottish Government
Riaghaltas na h-Alba

Department of Enterprise, Trade and Investment
www.detini.gov.uk

Llywodraeth Cymru
Welsh Government

Ricardo undertook the modelling and wrote the report.

RICARDO
Ricardo Energy & Environment

Department of Energy & Climate Change

Helena.Crow@decc.gsi.gov.uk

Department of Energy & Climate Change

NCA methodology, Input Data and Assumptions

UK National Comprehensive Assessment

London, 15th April 2016

Mahmoud Abu-Ebid, CHPQA Programme Director
Ricardo Energy & Environment

Department of Energy & Climate Change

Agenda:

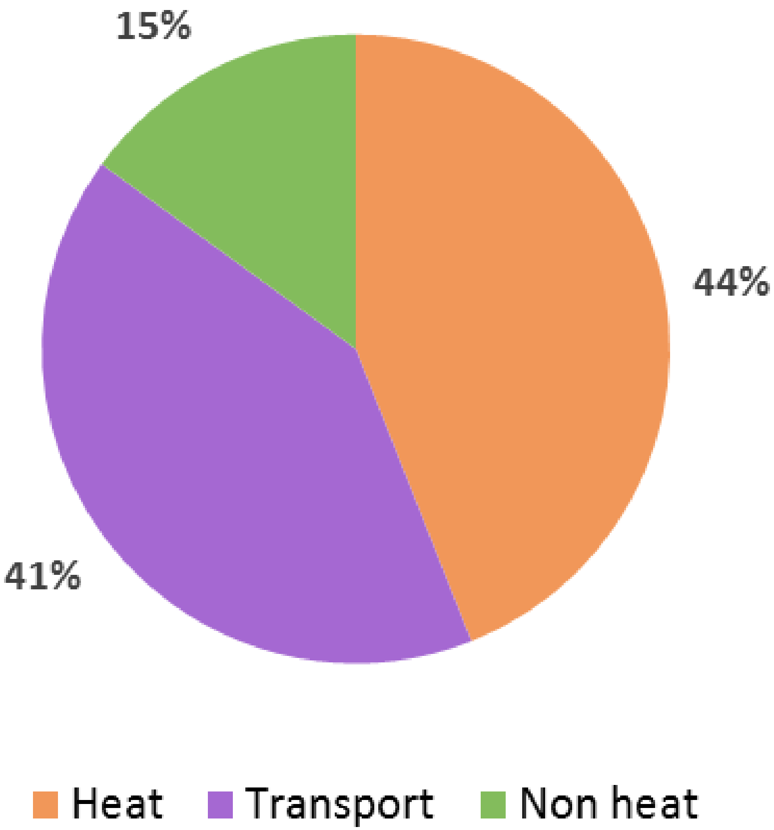
1. Context
2. Methodology: Overview
3. Methodology: Heat and cooling consumptions
4. Methodology: Technical potentials
5. Methodology: Socially cost-effective potentials
6. Questions
7. BREAK

Department of Energy & Climate Change

Context

Nearly half the energy we use in the UK is used for heating of one sort or another.

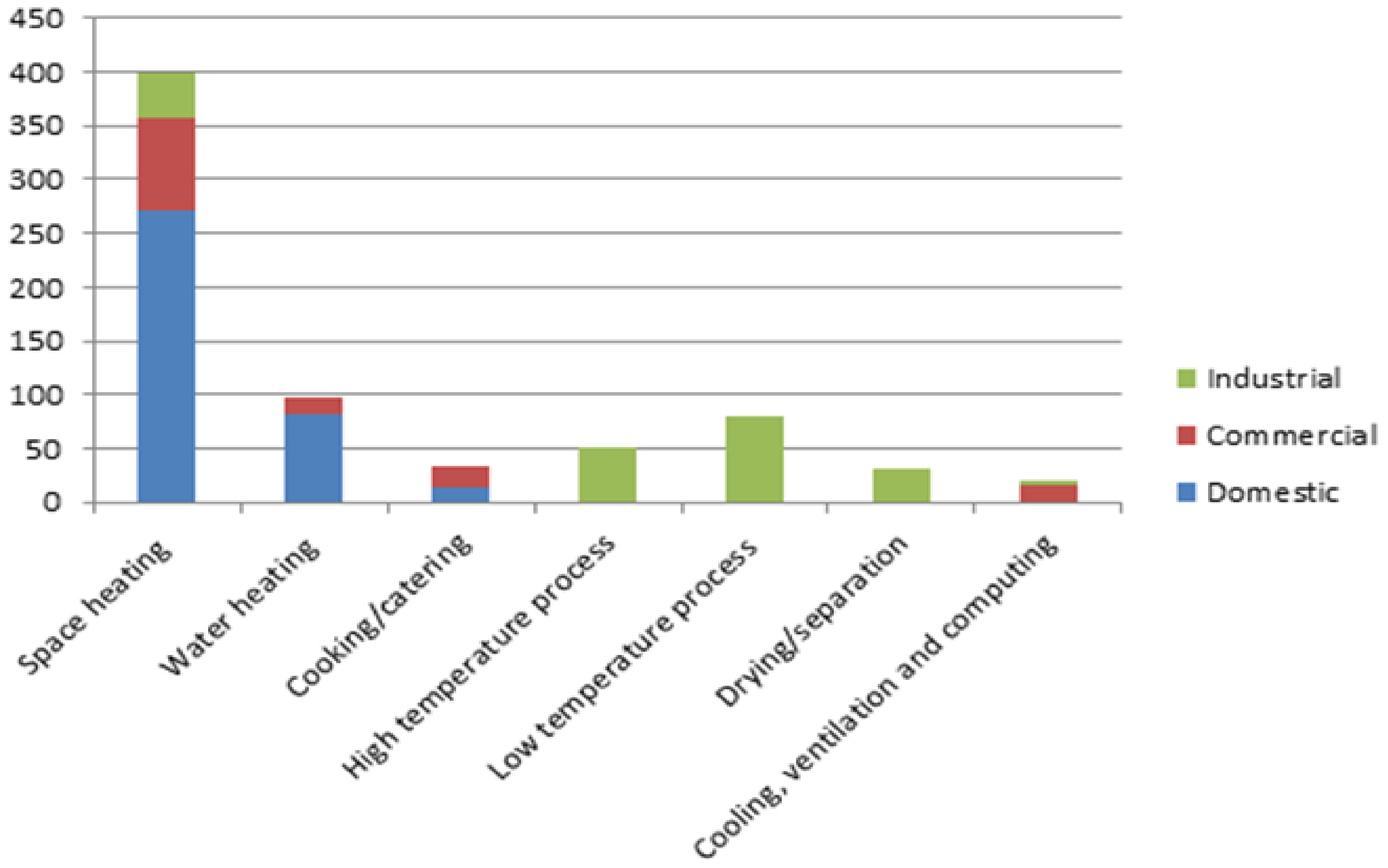
Energy Usage for Heat, Non Heat and Transport, 2011



Department
of Energy &
Climate Change

Context

Energy consumption for heating by sub-sector and end-use in TWh



Department of Energy & Climate Change

Energy Efficiency Directive requires

Article 14 of EED (2012/27/EU) - Promotion of efficiency in heating and cooling

Article 14 (1) – Potential

By 31 December 2015, Member States shall carry out and notify to the Commission a comprehensive **assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling**, containing the information **set out in Annex VIII**. If they have already carried out an equivalent assessment, they shall notify it to the Commission.

Article 14 (2)

Member States shall **adopt policies** which encourage the due taking into account at local and regional levels of the potential of using efficient heating and cooling systems, in particular those using high-efficiency cogeneration. Account shall be taken of the potential for developing local and regional heat markets.

Article 14 (3) - CBA

For the purpose of the assessment referred to in paragraph 1, Member States shall carry out a **cost-benefit analysis** covering their territory based on climate conditions, economic feasibility and technical suitability in **accordance with Part 1 of Annex IX**. The cost-benefit analysis shall be capable of facilitating the identification of the most resource-and cost-efficient solutions to meeting heating and cooling needs.

Department of Energy & Climate Change

What the EED requires (Annex VIII)

a) a description of heating and cooling demand;

b) a forecast of how this demand will change in the next 10 years;

c) a heat map of the national territory;

d) identification of the heating and cooling demand that could be satisfied by high-efficiency cogeneration, including residential micro-cogeneration, and by district heating and cooling;

e) identification of the potential for additional high-efficiency cogeneration, including from the refurbishment of existing and the construction of new generation and industrial installations or other facilities generating waste heat;

f) identification of the potentials for efficient district heating and cooling infrastructure;

g) Identification of strategies, policies and measures that may be adopted up to 2020 and up to 2030 to realise the potentials.

Department of Energy & Climate Change

Methodology overview

Department of Energy & Climate Change

Key principles and definitions (1)

1- Social cost-benefit analysis

"Cost-benefit analyses for the purposes of Article 14(3) shall include an economic analysis covering socio-economic and environmental factors."

The analysis has sought to reflect the true **socio-economic costs** and benefits rather than being **a commercial analysis**. It has therefore:

- Employed the HM Treasury Green Book social time preference rate of 3.5% to discount cash flows to present values.
- Included factors such as air quality damage and carbon costs.
- No impact of existing or future policies included.
- Cost of Finance (15% for industry and 10% for non-industrial applications)

Other technologies

As well as 'conventional' CHP and district heating, the assessment has included various other heating technologies such as **biomass**, **heat pumps** and **solar thermal** serving both individual demand points and district heating.

Department of Energy & Climate Change

Key principles and definitions (2)

2- The cost-benefit analysis to include the following steps and considerations:

(a) Establishing a system boundary and geographical boundary

(b) Integrated approach to demand and supply options

(c) Constructing a baseline

(d) Identifying alternative scenarios

(e) Method for the calculation of cost-benefit surplus

(f) Calculation and forecast of prices and other assumptions for the economic analysis

(g) Economic analysis to include:

- Value of output to the consumer (heat and electricity)
- External benefits such as environmental and health benefits, to the extent possible
- Capital costs of plant, equipment and the associated energy networks
- Energy and other operating costs

(h) Sensitivity analysis: different energy prices, discount rates and other variable factors can have a significant impact on the outcome of the calculations.

Department of Energy & Climate Change

Key principles and definitions (3)

3- High-efficiency cogeneration

means cogeneration meeting the following criteria:

- providing primary energy savings of at least 10% compared with EU efficiency reference values for the separate production of heat and electricity,
- or for small-scale and micro-cogeneration units, providing any primary energy savings

4- District heating and cooling

means the provision of heating and/or cooling to **multiple buildings** from centralised plant via a network of pipes.

Communal systems (one building) have not been modelled in this work.

5- Efficient district heating and cooling

means a district heating or cooling system using at least 50% renewable energy, 50% waste heat, 75% cogenerated heat or 50% of a combination of such energy and heat. (Article 2 (41))

Department of Energy & Climate Change

Key principles and definitions (4)

6- Statistical geographies employed

Increasing aggregation

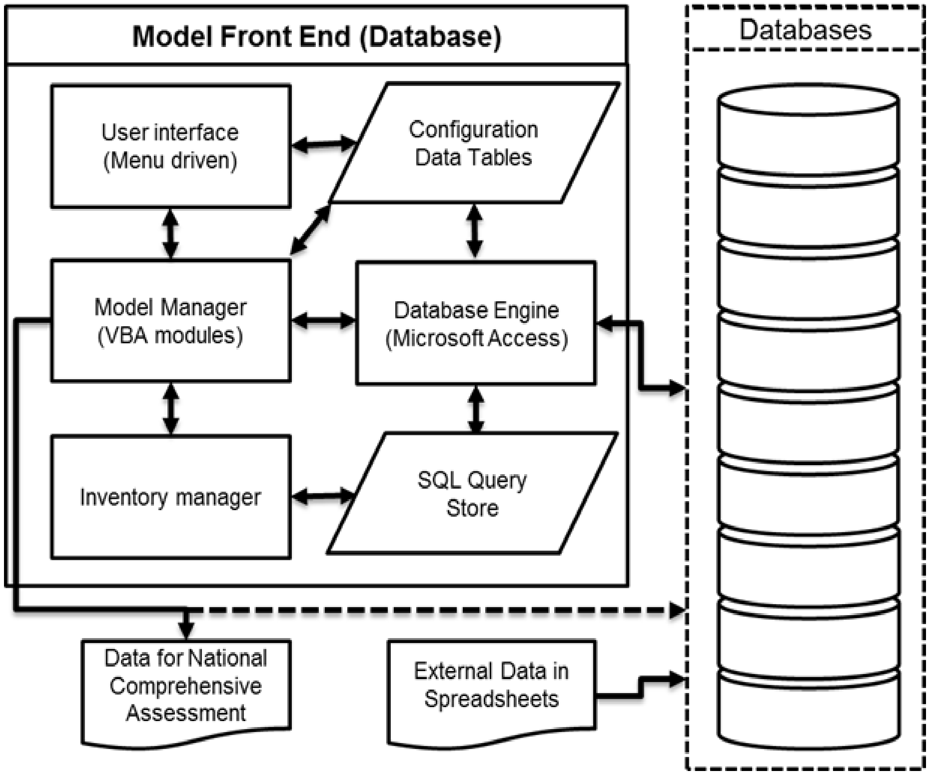
accuracy

Statistical geography type	Territory	UK total
Census 2011 Output Areas (OAs)	Great Britain	232,296
Small Areas (SAs)	Northern Ireland	
Lower Super Output Areas (LSOAs)	England & Wales	42,625
Data Zones (DZs)	Scotland	
Super Output Areas (SOAs)	Northern Ireland	
Medium Super Output Areas (MSOAs)	England & Wales	9,602
Intermediate Zones (IZs)	Scotland	
Wards	Northern Ireland	
Built-up Areas (BUAs)	England & Wales	6,458
Scottish Settlements (SSs)	Scotland	
Northern Ireland Settlements	Northern Ireland	

Department of Energy & Climate Change

Methodology - the approach taken (1)

- Developed a **dedicated** model
- Due to the large volume of data (covering about 30 million properties).
- the modelling has been implemented in **MS Access** rather than Excel.
- Pre-processing of data has been undertaken as appropriate in Excel, GIS software, and as part of the Access model.
- c. 1000 steps (SQL queries) in the model



Department of Energy & Climate Change

Methodology - the approach taken (2)

- Input assumptions agreed with DECC and Devolved Administrations:
  - Specific input parameters such as **discount rate**, **energy prices**, **CAPEX** and **OPEX** of each technical solution, **cost of capital**, etc.
  - Simplifying assumptions to make the modelling achievable.
- Modelling of ~ 30 million properties in the UK:
  - Each identified by a "Unique Property Reference Number" (UPRN), most currently served by individual heating (or cooling plant); a small proportion by district heating/cooling.
- About 4 million segments where modelled.
- Results aggregated to standard geographies:
  - OS areas (LSOA, MSOA)
  - Local authority areas
  - UK regions

***Published results, particularly maps, need to respect confidentiality*.**

Department of Energy & Climate Change

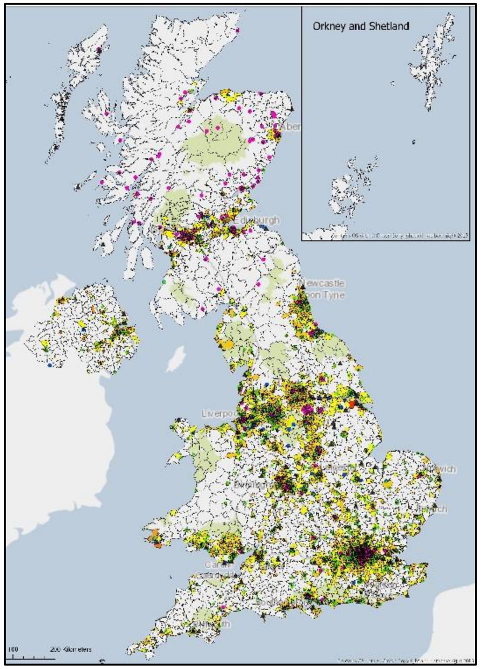
Methodology - the approach taken (3)

Heat and cooling consumption 2012 & 2025

Heat Maps

Determine technical potentials

Determine socially cost effective potentials



Department of Energy & Climate Change

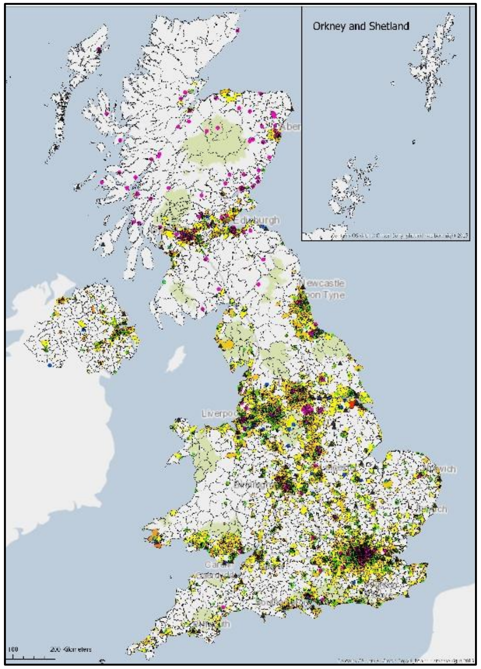
Heating and cooling consumption

Heat and cooling consumption 2012 & 2025

Heat Maps

Determine technical potentials

Determine socially cost effective potentials



Department of Energy & Climate Change

Heating consumption

- The analysis provides an estimate of the annual heat consumption in 2012 of each of the 30 million properties in the UK, categorised into five sectors:
  - Agriculture
  - Industry
  - Commercial services
  - Public services
  - Residential
- To derive this has involved following data sources:
  - Fuel consumption at various spatial resolutions from individual sites to national level (EC UK, sub-national fuel statistics, NAEI, CHPQA, national housing model, etc)
  - Employment statistics
  - Building co-ordinates (OS address base), footprints and heights (OS master map)

Department of Energy & Climate Change

Principal data sources (1)

To obtain the complete picture of spatial consumption various data sources had to be employed, the key ones are:

Energy data – national and sub-national statistics

- Energy consumption in the UK (ECUK) data (2012)
  Data on overall energy consumption in UK, Sector specific breakdown (incl. domestic, industrial and services sectors) and energy trends.
- Sub-national gas and electricity data
  Electricity consumption data for the UK and gas consumption data for GB is compiled by DECC at MSOA and LSOA levels. We compile gas data for NI at LA level.

Energy data – site specific

- NAEI Point Source data (2012)
  Data on fuel consumption for larger individual sites at specific locations
- CHPQA data (2012)
  Data on the generation of heat from CHP installations at their specific locations
- DECC District Heating and Cooling survey
  Data on the generation of heat from district heating systems at their specific locations

Department of Energy & Climate Change

Principal data sources (2)

Energy data – commercial buildings

- Inter Departmental Business Register (IDBR)
  Employment data used as a proxy for relative heat consumption of commercial buildings

Energy data – residential

- 2011 Census data
  Central heating by accommodation type
- DECC National Housing model
  Regional energy consumption estimates per household by house type by fuel type

Energy data – Scotland

- Scottish Heat Map data
  Spatial heat demands

Department of Energy & Climate Change

Principal data sources (3)

Geographic (mapping) data

- OS Master Map (GB only) / LPS(NI) Property Database
  Data on building floor areas
- OS Address Base / OSNI Pointer
  Coordinates of individual UPRNs

Problems encountered and overcome in using the various datasets have included:

- Gaps in available data, e.g. building height mapping is incomplete
- Inconsistencies and inaccuracies in the spatial and sectoral classification information in different datasets
- Incompatibility between datasets

Department of Energy & Climate Change

Cooling consumption

- In NCA context, demands for cooling are those that can be provided by district cooling (e.g. via absorption chilling plant driven by a supply of heat) via chilled water flow temperature in the region of 4°C.
- There are no existing national or regional data on the demands for cooling in the UK.
- To estimate cooling demand, a ratio of cooling to heating consumption has established for activities (defined at the 5 digit SIC code level) where space cooling is typically used.
- However, in any particular building air conditioning, unlike heating, is not necessarily a given.
- Industrial survey (limited responses).

Department of Energy & Climate Change

Projecting annual consumptions to 2025

DECC's 2014 Updated Energy & Emissions Projections (UEP) were used to inflate/deflate the 2012 consumptions to 2015 and 2025

Final Energy Consumption (TWh pa) by sector: Based on UEP 2014 Annex F

Sector	2012 TWh pa	2015 TWh pa	2025 TWh pa
Agriculture	10	13	19
Commercial services	160	153	130
Residential	508	480	447
Iron & steel	14	16	13
Other industry sectors	269	274	250
Public services	73	70	56
Total final energy consumption	**1,034**	**1,005**	**915**

Department of Energy & Climate Change

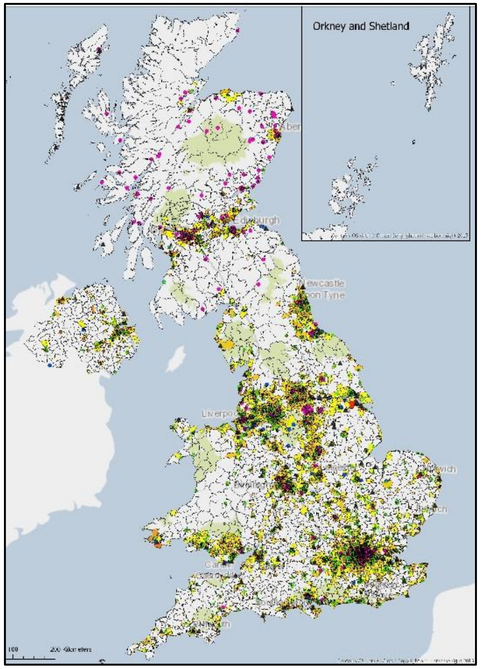
Determining the technical potentials

Heat and cooling consumption 2012 & 2025

Heat Maps

Determine technical potentials

Determine socially cost effective potentials



Department of Energy & Climate Change

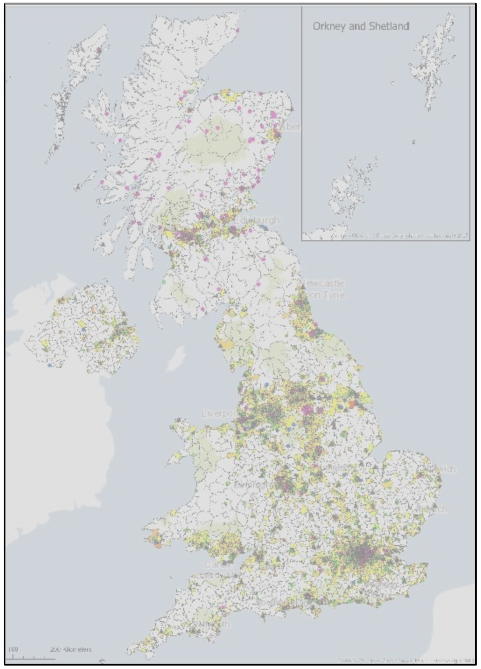
Determining the technical potentials

Heat and cooling consumption 2012 & 2025

Heat Maps

Determine technical potentials

Determine socially cost effective potentials



Department of Energy & Climate Change

High efficiency and baseline heating solutions

- For any particular circumstance there will be a **number of ways** in which the requirement for heat can be satisfied.
- For this work a number of solutions have been defined within **three categories:**
    - Baseline solutions – representing “business as usual”
    - High-efficiency (HE) individual heat demand point solutions
    - Efficient district heating solutions
- Multi story buildings (Communal heating) been considered as high density heat load.
- Available data on cooling was insufficient to allow the modelling of the potential for district cooling

Department of Energy & Climate Change

Baseline

The baseline is the **anticipated replacement heating technology** that would be employed between 2015 and 2025 under a ‘business as usual’ scenario:

- Replacement of existing heat only boilers with high efficiency gas boilers (or oil where gas is not available).
- Like for like replacement of existing electric heating
- Like for like replacement of existing CHP systems.
- New dwellings fitted with high efficiency gas boilers (or oil where gas is not available) or electric heating (on a pro-rata basis using current ratios).

The baseline has no impact on the technical potential – it is used as the reference for determining cost-effectiveness.

Department
of Energy &
Climate Change

Individual heat demand point HE solutions

- Gas CHP:
    - 1 kWe (electrical capacity) micro gas CHP with no backup boiler
    - >1-50 kWe micro gas CHP with gas backup boiler
    - 0.05-4 MWe gas engine with gas backup boilers
    - 4-40 MWe OCGT with gas backup boilers
    - >40 MWe CCGT CHP with gas backup boilers
- Biomass CHP:
    - ORC up to 1.5 MWe (7.5 MWt) with gas backup boilers
    - steam turbines from 2.5 MWe (7.5 MWt) upwards with gas backup boilers
- Biomass boilers
- Air source heat pumps
- Ground source heat pumps
- Solar thermal panels with gas/oil boiler top up
- Solar thermal panels with biomass boiler top up

Selected individual solutions technical characteristics

Technology	Size range	Heat to power ratio	Minimum thermal capacity MWt	Maximum thermal capacity MWt	Gross electrical efficiency in condensing mode percent GCV	Gross electrical efficiency in CHP mode percent GCV	Heat efficiency GCV	Load Factor
Stirling engine micro gas CHP	1 kWe	11.83	0.012	0.012	6.00%	6.00%	71.00%	11%
Small OCGT	7 to 25 MWe	1.20	8.400	30.000	30.00%	30.00%	36.00%	72%
Biomass organic rankine cycle CHP	0.2 to 2.5 MWe	5.67	1.133	14.000	12.00%	12.00%	68.00%	60%
Industrial biomass steam turbine CHP	10 to 25 MWe	3.00	30.000	75.000	31.00%	18.60%	55.80%	72%
CCGT	40 to 200 MWe	0.76	30.400	152.000	45.07%	38.56	29.30%	72%
Domestic gas boilers	20 kWt	0.00	0.000	0.020	0.00%	0.00%	84.60%	6.50%
Industrial gas boilers	3.6 to 100 MWt	0.00	3.600	100.000	0.00%	0.00%	81.00%	20%
Solar Thermal	5 to 10 kWt	0.00	0.005	0.010	0.00%	0.00%	-	7%
Industrial Electric Air/Radiative Heaters	>3.6 MWt	0.00	3.600	N/A	0.00%	0.00%	100.00%	20%
Domestic Air Source Heat Pumps	10 to 20 kWt	0.00	0.010	0.020	0.00%	0.00%	320.00%	13%
Domestic Ground Source Heat Pumps	10 to 20 kWt	0.00	0.010	0.020	0.00%	0.00%	400.00%	18.50%

Department of Energy & Climate Change

Efficient district heating solutions

- Gas-fired CHP DH with thermal storage
- Biomass CHP DH with thermal storage
- Biomass boiler DH with thermal storage
- Gas boiler DH with thermal storage
- Ground Source Heat Pump DH with thermal storage

- Heat recovery options with DH:
    - Heat from power stations (extraction)
    - Energy from Waste (EfW) (extraction)
    - Industrial waste heat (Sources identified in DECC's study)
    - Water source heat pumps (WSHPs)

Department of Energy & Climate Change

District heating geographies overview

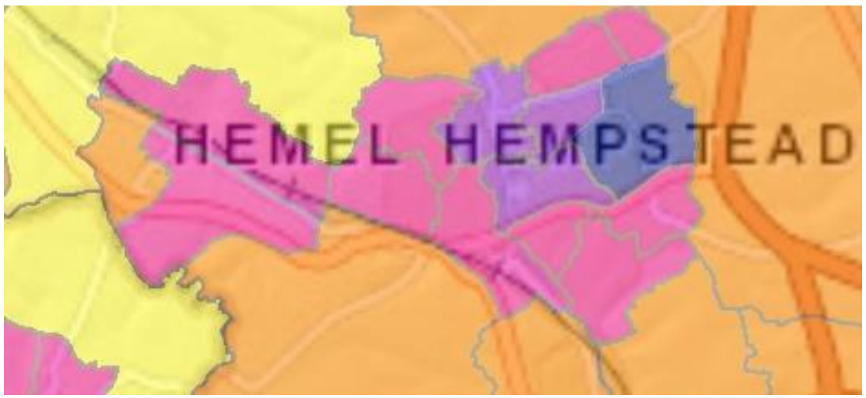
In order to account for the range of possible solutions, DH schemes have been modelled at three scales:

- Separate networks in each MSOA within Built-up Areas with a plot ratio ≥0.3
- Separate networks in each LSOA within Built-up Areas with a plot ratio ≥0.3
- Individual networks for groups of contiguous LSOAs within MSOAs within Built-up Areas with plot ratios ≥0.3

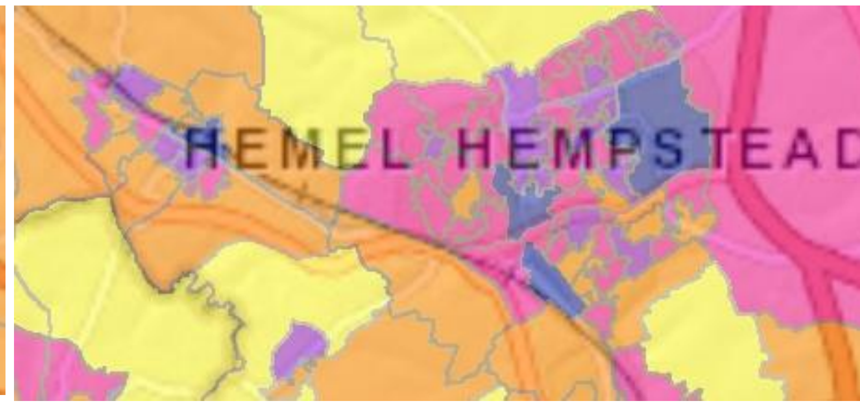
For each option the plot ratio calculations were undertaken following the removal of open spaces such as parks.

Plot Ratio - Example

MSOA Level



LSOA Level



- Calculating Plot ratio at LSOA level gives greater resolution
- Results in smaller schemes which may have lower economies of scale than larger MSOA schemes
- So both geographies tested

Department of Energy & Climate Change

District heating key assumptions

- New DH schemes only serve Built-up Areas with a plot ratio ≥0.3
- New DH is low temperature hot water and does not serve industry
- Primary DH pipes installed in every street to serve every non-industrial property
- Branch connections, heat interfaces and meters are sized for each property
- High density houses (communal heating included)
- Current DH schemes retained not replaced or refurbished

For waste heat recovery:

- Supply heat to the nearest demands first
- Limited to 15km radius
- Possible competition between sources for heat loads

Department of Energy & Climate Change

Technical potentials – calculation

- Each solution, individual and district heating (all 5 options of DH), is considered independently by the model.
- For each solution, the heat demand points (annual kWh heat consumption) that the solution in question could satisfy are summed for each MSOA and aggregated up to regional and national levels.
- A number of solutions could satisfy a particular demand for heat so the technical potential results for the solutions are **not** additive.
- Whether a particular solution can satisfy a demand point depends on a number of restrictions applied in the model.

Department of Energy & Climate Change

Technical potentials – restrictions applied

The model assumes that:

- For dwellings where there is no gas supply within the postcode, individual gas CHP is ruled out.
- This restriction is not applied to non-residential buildings.
- Where dwellings or non-residential buildings are currently heated with electricity they will continue to be heated with electricity, potentially by heat pumps. This does not extend to DH systems.
- No individual domestic biomass boilers can be installed in smoke control zones. Larger plant is assumed to include sufficient emissions abatement.
- No individual CHP, biomass boilers, GSHPs or solar thermal can be installed for individual flats in multi storey buildings.
- No heat pumps, solar thermal systems or district heating schemes will serve industrial sites (these require steam).
- A number of technology lower size thresholds (e.g. 1 kWe CHP, 3 kWth) apply.

Department of Energy & Climate Change

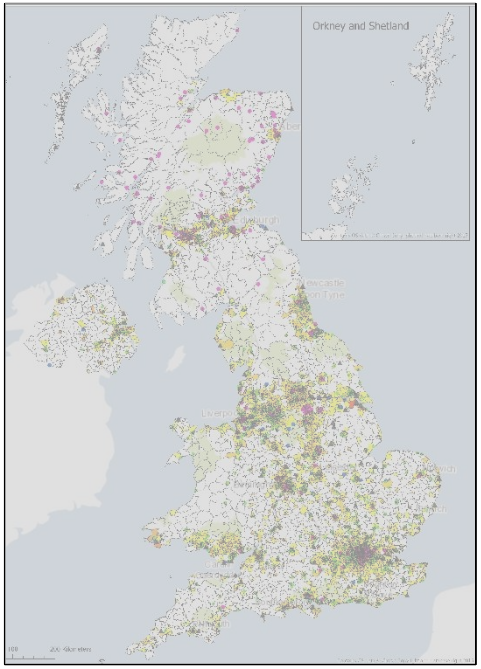
Determining the socially cost effective potentials

Heat and cooling consumption 2012 & 2025

Heat Maps

Determine technical potentials

Determine socially cost effective potentials



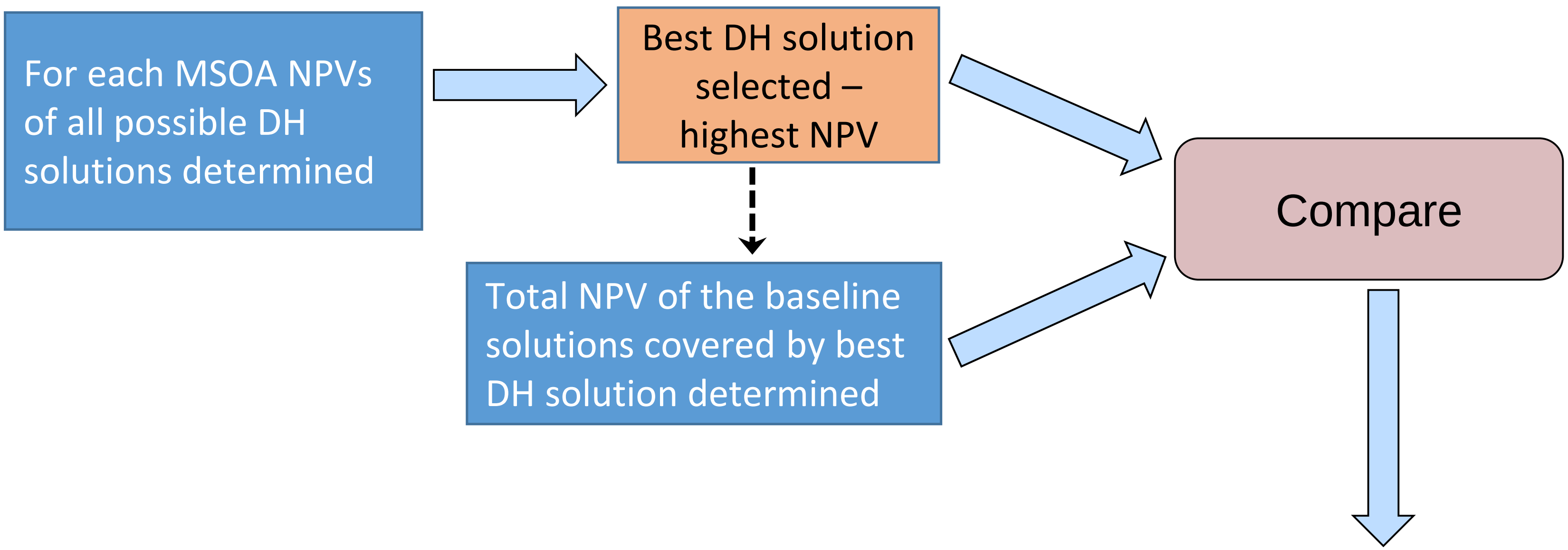
Department of Energy & Climate Change

Socially cost-effective potentials

- The analysis has employed a <u>discounted cash-flow</u> approach to determine a <u>net present value (NPV),</u> with cash-flow lines for:
  - capital costs;
  - fixed and variable operating costs;
  - energy costs (long-run variable costs of energy supply) – IAG 2014;
  - air quality damage costs – IAG 2014;
  - the costs of carbon – IAG 2014; and
  - the cost of finance (central scenario, 15% for industrial and 10% for others)
- The DCF has used the HM Treasury Green Book social time preference rate of 3.5% to discount cash flows to present values.
- Inter-departmental Analysts' Group on Energy and Climate Change (IAG 2014) values used where relevant, including exchange rate assumptions and GDP deflators.
- Impact of current or future policies to support specific technologies or fuels <u>**not included.**</u>

Department
of Energy &
Climate Change

Cost-effective solution selection – **DH stage**



Result is:

- DH solution selected covering all or some properties in the MSOA; or
- No solution is selected for the remaining properties in the MSOA if there is only partial or no coverage by DH.

Department
of Energy &
Climate Change

Cost-effective solution selection – **CHP stage**

For each property in the MSOA not already selected for DH, NPVs of all possible CHP solutions determined

Best CHP solution selected for each property
– highest NPV

NPV of the baseline solution corresponding to each CHP solution is determined

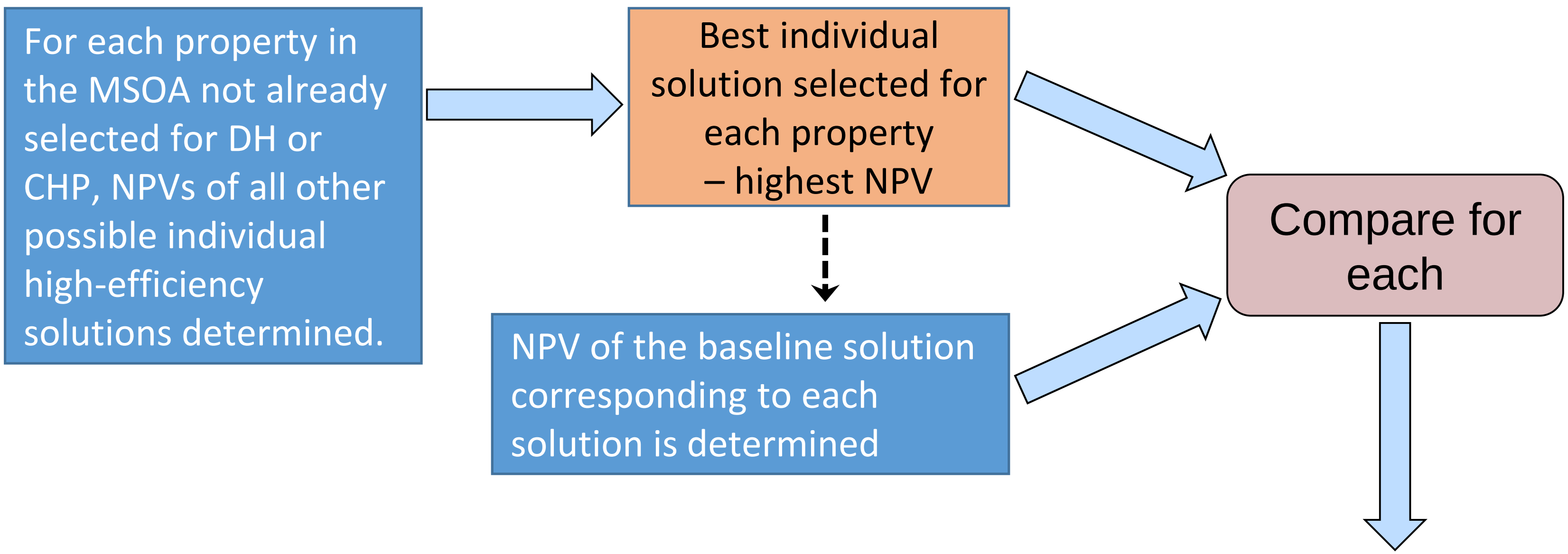
Compare for each

Result is:

- A number of CHP schemes selected; and
- No solution is selected for the remaining properties.

Department
of Energy &
Climate Change

Cost-effective solution selection – individual stage



Result is:

- Various individual high efficiency solutions are selected; and
- The appropriate baseline solution is selected for each of the remaining properties.

Department of Energy & Climate Change

Socially cost-effective potentials

- The results by solution for each of the 9,602 MSOAs (E & W), IZs (S) and Wards (NI) can be simply summed to provide aggregate figures for;
  - the UK as a whole,
  - the individual devolved administrations, English regions, local authorities, etc.

Department of Energy & Climate Change

Assumptions and sensitivities

- Modelling and analysis of this nature relies on various assumptions.
- Sensitivity tests of the results to the following parameters were undertaken *(reference values shown)*:
    - Capital and operational costs *(UK best evidence values)*
    - Energy prices *(IAG 2014 LRVC central values)*
    - Cost of carbon *(IAG 2014 central values, traded and non-traded)*
    - Cost of finance *(15% industry, 10% non-industry)*
- Sensitivity values:
    - Capital and operational costs: ± 20%
    - Energy prices: *IAG 2014 LRVC low and high values*
    - Cost of carbon: *IAG 2014 low and high values, traded and non-traded*
    - Cost of finance: *0% industry & non-industry; 20% industry & 15% non-industry*

Department of Energy & Climate Change

Capex and opex assumptions

- Capital and operating costs were derived from various sources, both published and unpublished.
- For district heating:
  - Primary DH Pipework capex assumed to be same as capex for a network where **all pipes sized to supply 50% of peak demand**.
  - Branch connections, heat interfaces and meters **costed for each property**
  - Cost of pipes **for communal schemes** also included.
  - **Annual inspection/maintenance** costs assumed for heat interfaces
  - Cost of new networks in areas with existing DH equated with cost of rebuilding a network to serve whole area less cost of rebuilding existing network.
- Limited cost data for particular technologies, for example water source heat pumps connected to DH (based on discussion with suppliers)

Department of Energy & Climate Change

Scenarios presented

Variable \ Scenario	Full financing costs	Zero financing costs	Extreme carbon price
Cost of finance	15% for industry, 10% for non-industrial sectors	0% all sectors	15% for industry, 10% for non-industrial sectors
Energy prices	IAG 2014 long-run variable cost (LRVC) of energy supply, central values	IAG 2014 long-run variable cost (LRVC) of energy supply, central values	IAG 2014 long-run variable cost (LRVC) of energy supply, central values
Carbon prices	IAG 2014 carbon prices traded and non-traded, central values	IAG 2014 carbon prices traded and non-traded, central values	£500 per tonne of CO_2
Capex and opex	UK best evidence values for each technology	UK best evidence values for each technology	UK best evidence values for each technology

Department of Energy & Climate Change

Questions?

Department of Energy & Climate Change

BREAK

Department of Energy & Climate Change

Results

UK National Comprehensive Assessment

London, 15th April 2016

Mahmoud Abu-Ebid, CHPQA Programme Director
Ricardo Energy & Environment

Department of Energy & Climate Change

Agenda:

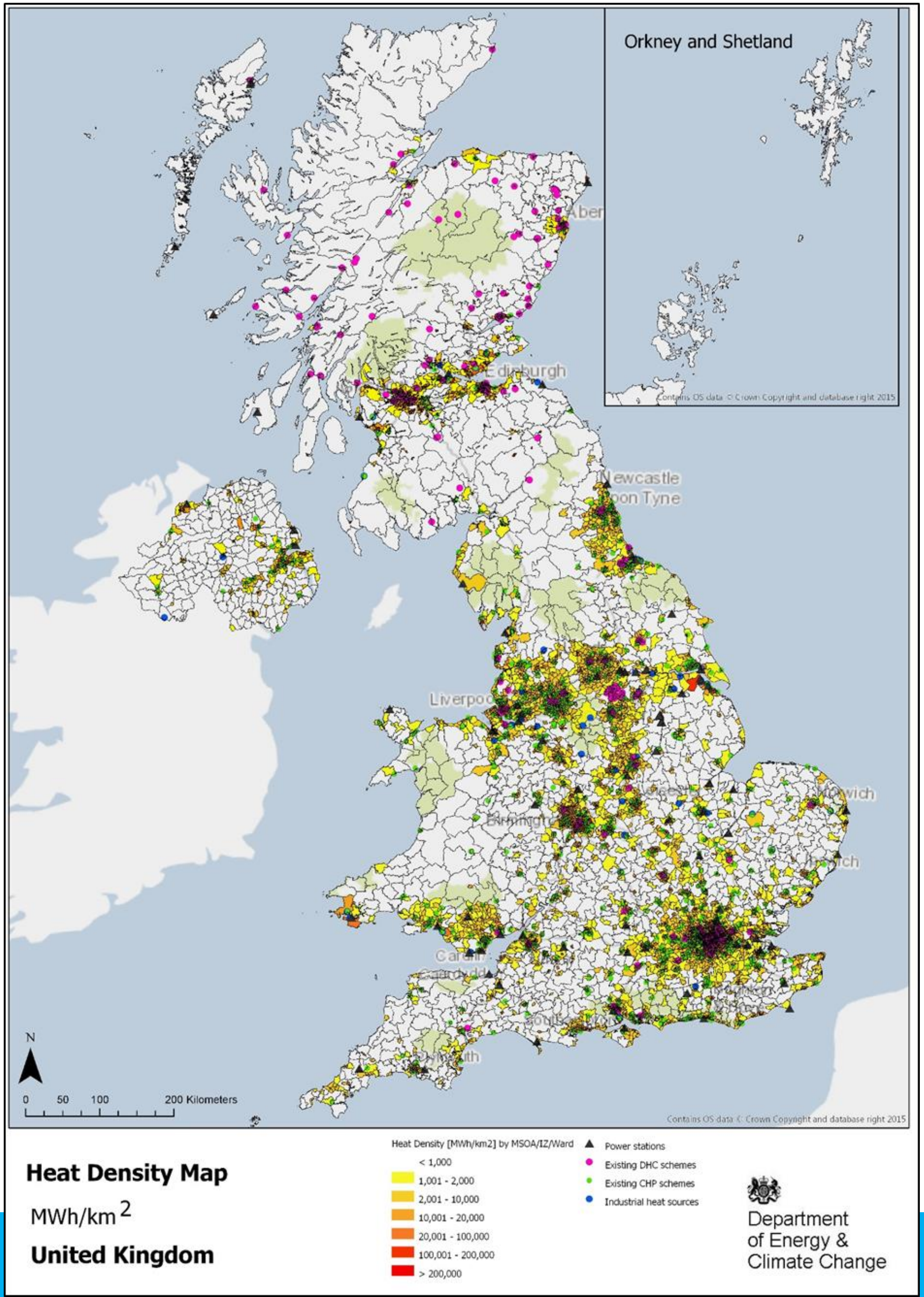
1. Results: Heat and cooling consumptions, and maps
2. Results: Technical potentials
3. Results: Socially cost-effective potentials
4. Questions

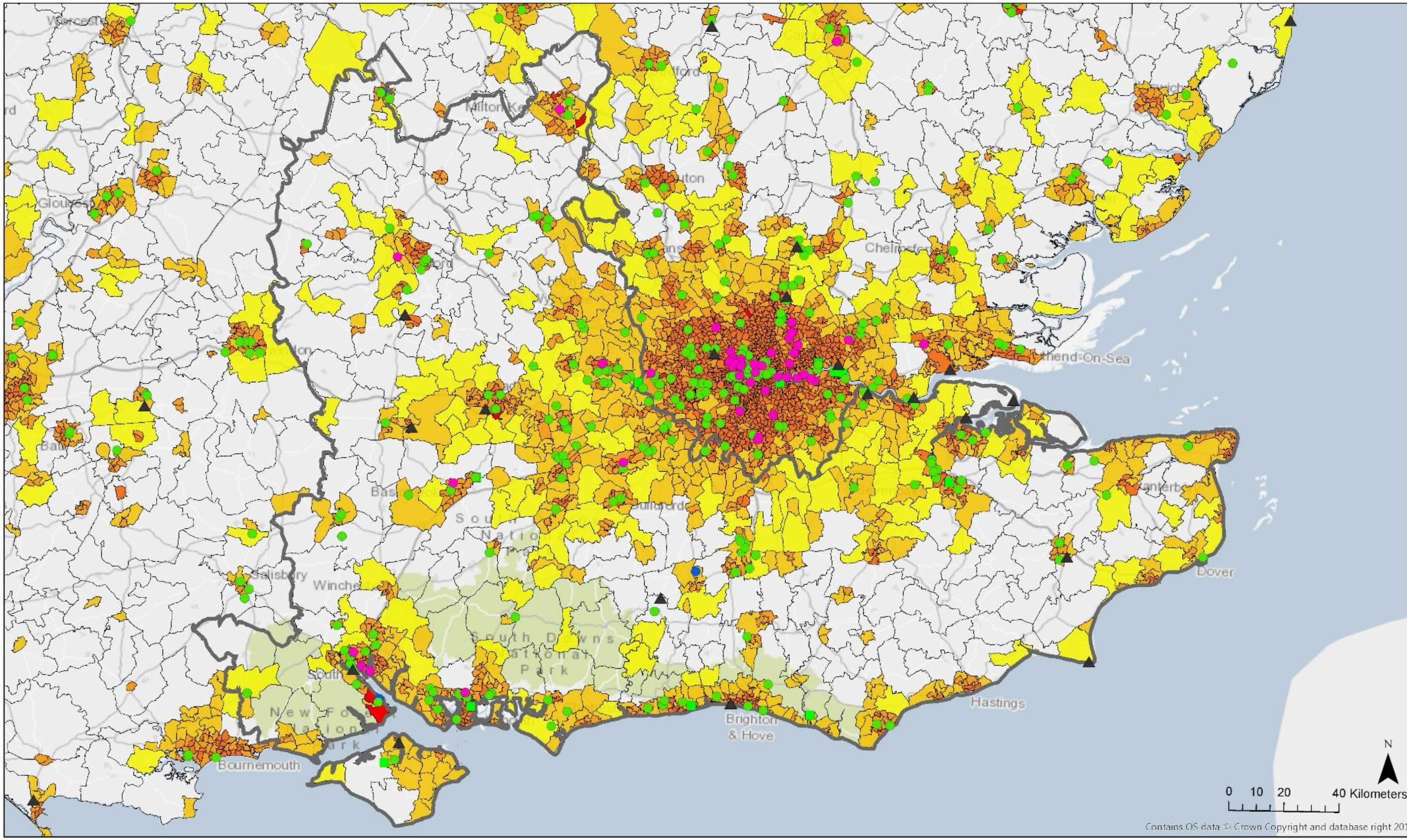
Department of Energy & Climate Change

UK 2012 heat consumption, TWh pa

NUTS112 Code	Devolved administration / English region	Total	Industry (incl. agriculture)	Commercial services	Public sector	Residential
		TWh pa	TWh pa	TWh pa	TWh pa	TWh pa
UKC	North East	**25**	11	1	1	13
UKD	North West	**63**	21	4	4	33
UKE	Yorkshire & the Humber	**56**	25	2	3	26
UKF	East Midlands	**29**	5	1	1	22
UKG	West Midlands	**33**	3	2	2	26
UKH	East of England	**39**	7	1	2	28
UKI	London	**42**	2	3	3	34
UKJ	South East	**60**	13	3	2	41
UKK	South West	**29**	2	1	2	24
UKL	Wales	**30**	10	1	2	17
UKM	Scotland	**65**	22	5	3	35
UKN	Northern Ireland	**15**	2	0	0	12
	UK totals	**484**	**123**	**23**	**25**	**312**

Department of Energy & Climate Change





Heat Density Map

MWh/km ^{2}

South East England

Heat Density [MWh/km2] by MSOA
- < 1,000
- 1,001 - 2,000
- 2,001 - 10,000
- 10,001 - 20,000
- 20,001 - 100,000
- 100,001 - 200,000
- > 200,000

- Power stations
- Existing DHC schemes
- Existing CHP schemes
- Industrial heat sources
- Waste to energy plants

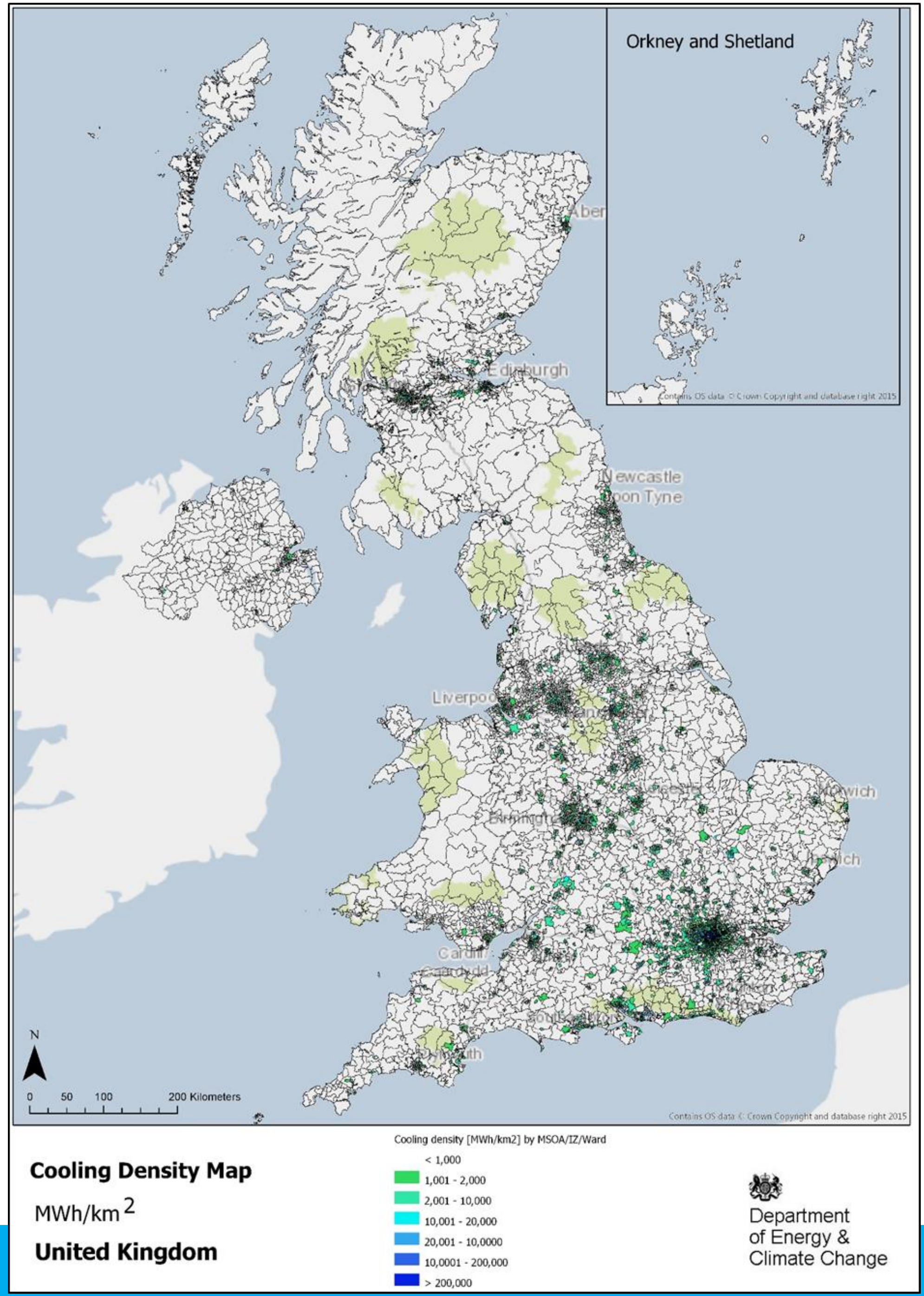
Department of Energy & Climate Change

Department of Energy & Climate Change

UK 2012 cooling consumption, TWh pa

NUTS112 Code	Devolved administration / English region	Total TWh pa	Industry (incl. agriculture) TWh pa	Commercial services TWh pa	Public sector TWh pa
UKC	North East	**1**	0	0	0
UKD	North West	**3**	1	1	0
UKE	Yorkshire and The Humber	**3**	1	1	1
UKF	East Midlands	**3**	2	1	0
UKG	West Midlands	**3**	2	1	0
UKH	East of England	**6**	4	1	0
UKI	London	**18**	3	13	1
UKJ	South East	**15**	10	3	1
UKK	South West	**5**	3	1	0
UKL	Wales	**1**	1	0	0
UKM	Scotland	**2**	1	1	0
UKN	Northern Ireland	**1**	0	0	0
	Total	**59**	**30**	**24**	**5**

Department of Energy & Climate Change



Department of Energy & Climate Change

Results: Technical potentials

Department of Energy & Climate Change

UK, high-efficiency solutions technical potential, TWh pa heat supplied

<table>
<tr><th colspan="2">High-efficiency heating solutions</th><th>Total
TWh pa</th><th>Industry (incl. agriculture
TWh pa</th><th>Commercial Services
TWh pa</th><th>Public Services
TWh pa</th><th>Residential
TWh pa</th></tr>
<tr><td rowspan="7">Individual</td><td>Gas CHP + gas boilers</td><td>401</td><td>112</td><td>20</td><td>25</td><td>244</td></tr>
<tr><td>Biomass CHP + gas boilers</td><td>46</td><td>38</td><td>2</td><td>6</td><td></td></tr>
<tr><td>Biomass boilers</td><td>167</td><td>39</td><td>7</td><td>9</td><td>112</td></tr>
<tr><td>Air to water heat pumps</td><td>334</td><td></td><td>19</td><td>23</td><td>291</td></tr>
<tr><td>Ground source heat pumps</td><td>267</td><td></td><td>19</td><td>23</td><td>225</td></tr>
<tr><td>Solar thermal + gas boilers</td><td>322</td><td></td><td>19</td><td>23</td><td>280</td></tr>
<tr><td>Solar thermal + biomass boilers</td><td>160</td><td></td><td>7</td><td>9</td><td>144</td></tr>
<tr><td rowspan="8">District heating</td><td>Gas CHP + gas boilers</td><td>276</td><td></td><td colspan="3">276</td></tr>
<tr><td>Biomass CHP + gas boilers</td><td>276</td><td></td><td colspan="3">276</td></tr>
<tr><td>Biomass boiler</td><td>276</td><td></td><td colspan="3">276</td></tr>
<tr><td>Ground source heat pumps</td><td>276</td><td></td><td colspan="3">276</td></tr>
<tr><td>Water source heat pumps</td><td>114</td><td></td><td colspan="3">114</td></tr>
<tr><td>Power station heat</td><td>46</td><td></td><td colspan="3">46</td></tr>
<tr><td>Waste incinerator heat</td><td>3</td><td></td><td colspan="3">3</td></tr>
<tr><td>Industrial waste heat</td><td>3</td><td></td><td colspan="3">3</td></tr>
</table>

Department of Energy & Climate Change

Results: Socially cost-effective potentials

Department of Energy & Climate Change

Recap of scenarios

Scenario / Variable	Full financing costs	Zero financing costs	Extreme carbon price
Cost of finance	15% for industry, 10% for non-industrial sectors	0% all sectors	15% for industry, 10% for non-industrial sectors
Energy prices	IAG 2014 long-run variable cost (LRVC) of energy supply, central values	IAG 2014 long-run variable cost (LRVC) of energy supply, central values	IAG 2014 long-run variable cost (LRVC) of energy supply, central values
Carbon prices	IAG 2014 carbon prices traded and non-traded, central values	IAG 2014 carbon prices traded and non-traded, central values	£500 per tonne of CO_2
Capex and opex	UK best evidence values for each technology	UK best evidence values for each technology	UK best evidence values for each technology

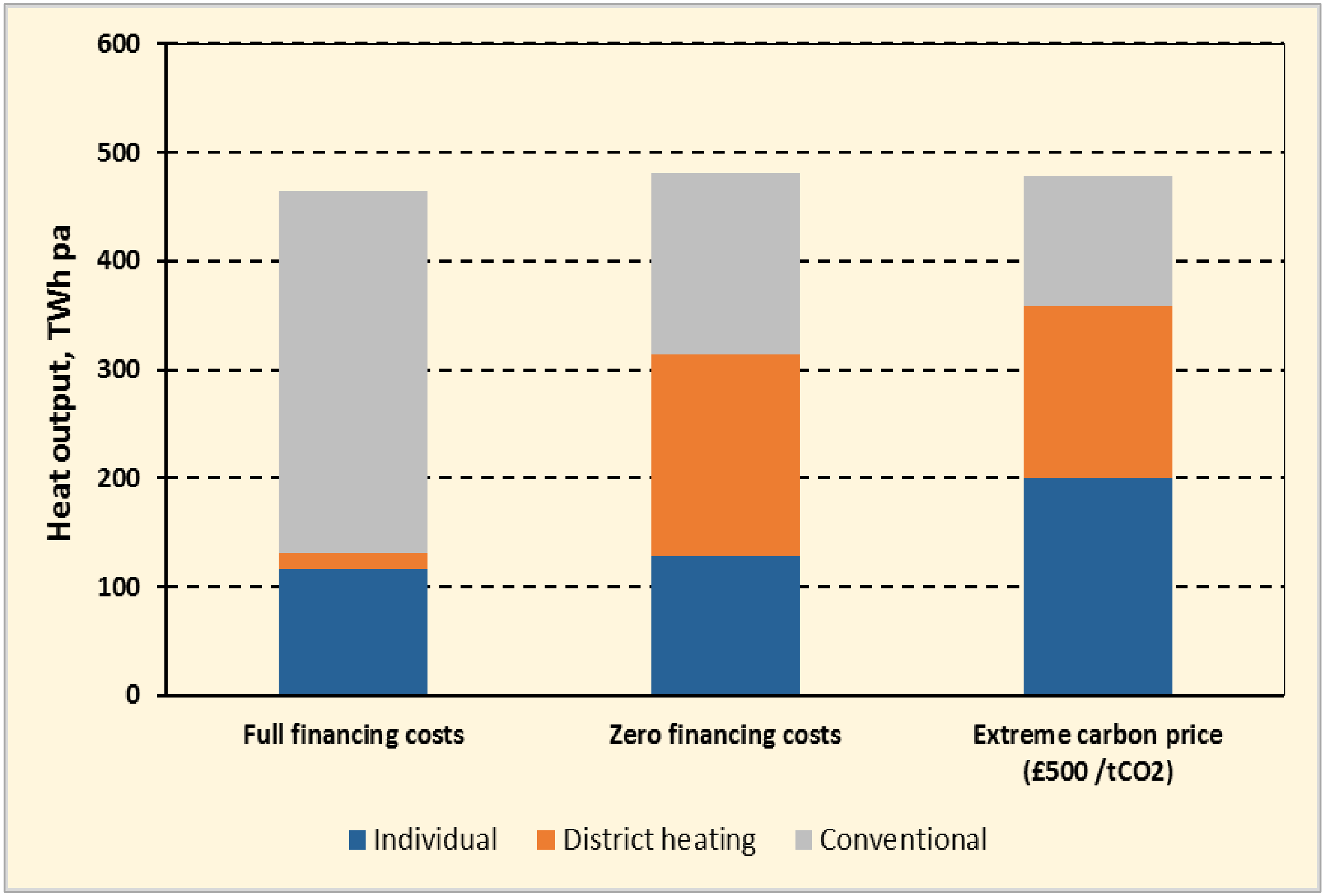
Department of Energy & Climate Change

UK, socially cost-effective potentials, TWh/year

Heating solutions	Total TWh pa	Industry (incl. agriculture) TWh pa	Commercial Services TWh pa	Public Services TWh pa	Residential TWh pa
Full financing costs scenario					
Individual	116	101	4	9	2
District heating	15		15		
Conventional	334	22	13	11	289
Total heat output	**465**	**123**	**342**		
Zero financing costs scenario					
Individual	128	109	2	3	13
District heating	186		186		
Conventional	168	14	5	3	145
Total heat output	**481**	**123**	**358**		
Extreme carbon price (£500/tCO_2) scenario					
Individual	200	103	4	6	87
District heating	158		158		
Conventional	120	21	4	1	94
Total heat output	**477**	**123**	**354**		

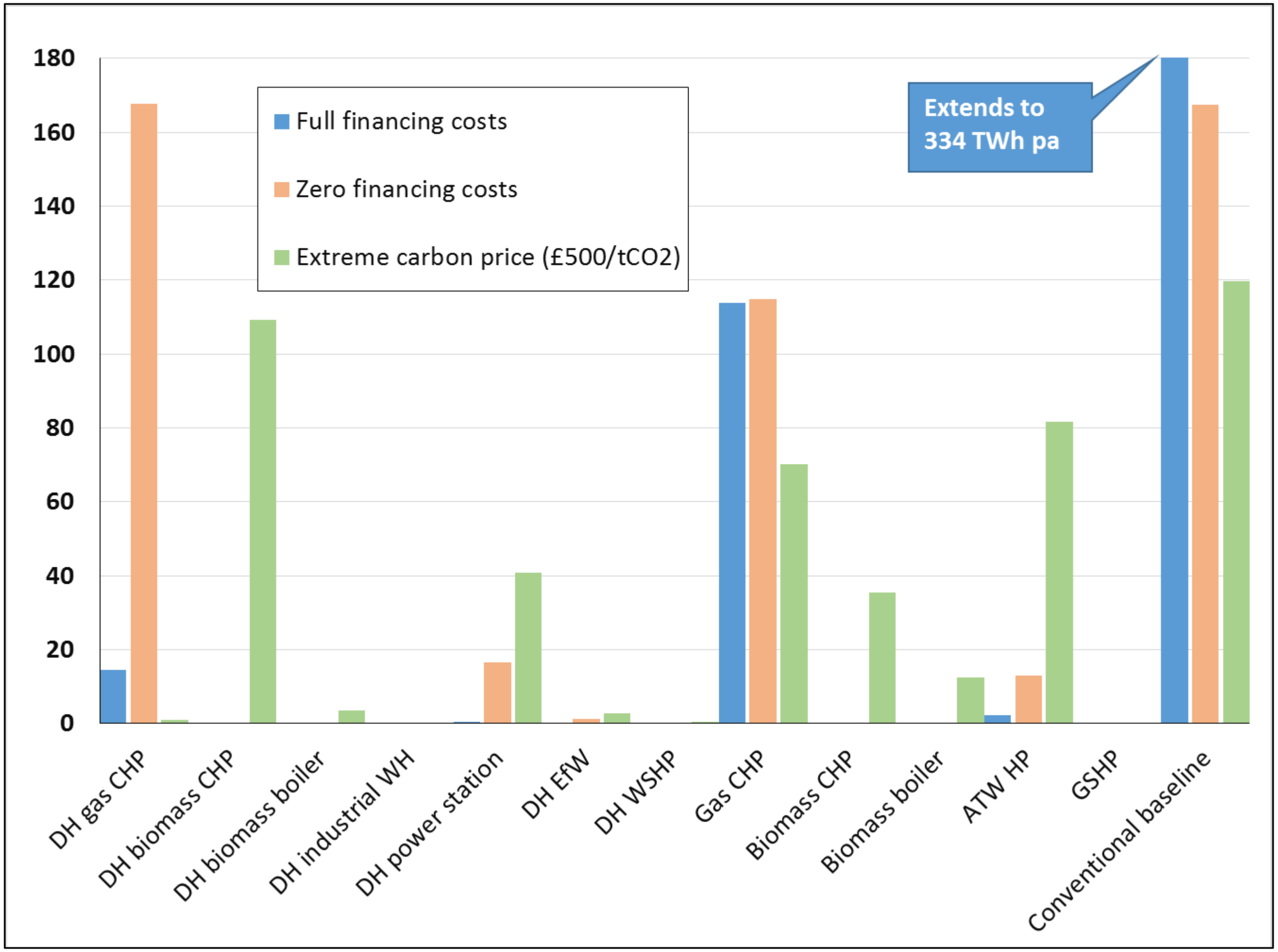
Department of Energy & Climate Change

UK, summary of socially cost-effective potentials, TWh/year



Department of Energy & Climate Change

UK, socially cost-effective potentials, TWh/year



Department
of Energy &
Climate Change

Questions???