


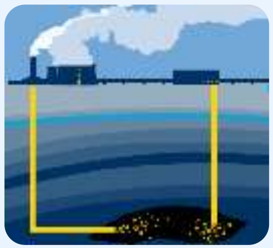



Across Scales in Energy Decision-making (ASCEND)

EPSRC and Energy Systems Catapult

5th December 2017

Element Energy Ltd

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Element Energy is a consultancy focused on the low carbon energy sector

- Element Energy is a **specialist energy consultancy**, with an excellent reputation for rigorous and insightful analysis in the area of low carbon energy
- We consult on both **technical and strategic issues** – our technical and engineering understanding of the real-world challenges support our strategic work and vice versa
- Element Energy covers all major low carbon energy sectors:

Smart Electricity and Gas Networks

Energy Storage

Carbon Capture and Storage

Hydrogen

Low Carbon Transport

Built Environment

Our clients span the public and private sector in the UK and across Europe

- Our work with public sector clients, from local authorities to national government departments and international NGOs, has influenced policy decision making at all levels
- Private sector clients encompass both start-ups looking to commercialise and large multi-national corporations

Selected clients:

Public sector

Department for Transport
Department of Energy & Climate Change
Department for Communities and Local Government
Committee on Climate Change
Transport Scotland
Transport for London
Greater London Authority
scottishcitiesalliance
Birmingham City Council
Roinn Cumarsáide, Fuinnimh & Acmhainní Nádúrtha / Department of Communications, Energy & Natural Resources
seai Sustainable Energy Authority of Ireland
European Commission

NGOs

iea International Energy Agency
European Climate Foundation
Transport & Environment
icct
World Bank Group
UNDP

Public-Private Partnerships

energy technologies institute
UK H_2 Mobility
LowCVP low carbon vehicle partnership
FCH

Private Sector

British Gas
nationalgrid
EDF Energy
Scottish and Southern Energy
UK Power Networks
Intelligent Energy
ESB Energy for generations
Air Products
bp
BOC
Shell
Nissan
Rolls-Royce
Toyota
Daimler
zipcar

Key features of the energy transition

Centralised
Segregated
Fossil-fuel driven

- Embedded and distributed generation
- Electrification of heat and mobility
- Transition to other energy vectors (bio-energy, H_2)
- Deeper energy efficiency
- Increasing participation of consumers
- Increasing flexibility of the demand-side (DSR, storage)

Decentralised
Integrated
Renewable

Heat decarbonisation is currently receiving a lot of attention from policy-makers

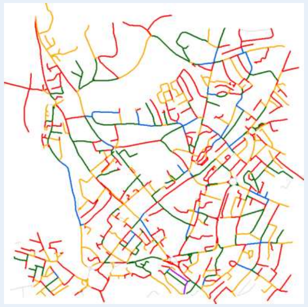
LOW CARBON HEATING

Key questions for policy-makers:

- What is the most **cost-effective pathway** – should policy pick technology winners?
- On what **timescales** are key policy decisions required – how do we **avoid lock-in**?
- Are there **low or no regrets actions** that should be taken immediately?
- What's the **future for the gas grid** and to what extent is **electricity system reinforcement** required?

1) Consumers and building-level

2) Spatial planning



3) National strategy and infrastructure

Agenda

- Consumer and building-level
- Spatial planning
- National strategy and infrastructure

We have built models to simulate consumer behaviour across building archetypes and consumer segments

BUILDING STOCK SEGMENTATION (Building archetypes)

- Building type
- Building age
- Main heating fuel
- Thermal efficiency level
- …

≈10s-100s combinations

CONSUMER SEGMENTATION (Consumer archetypes)

- Ownership/tenancy group
- Private/social housing
- Employment status
- Early adopter/Majority/Laggard
- …

≈10s-100s combinations

Energy efficiency and renewable energy technologies

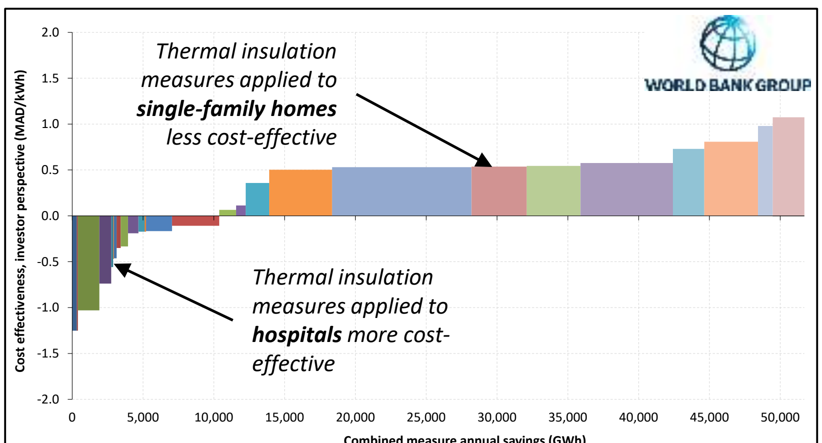
Energy consumption in building
Technology cost
Energy and carbon savings
Fuel bill savings
Technology payback time etc.

CONSUMER UPTAKE MODELLING

Segmentation is important to capture variation in measure impact, cost-effectiveness and uptake across different building types and consumers

Importance of segmenting by building type

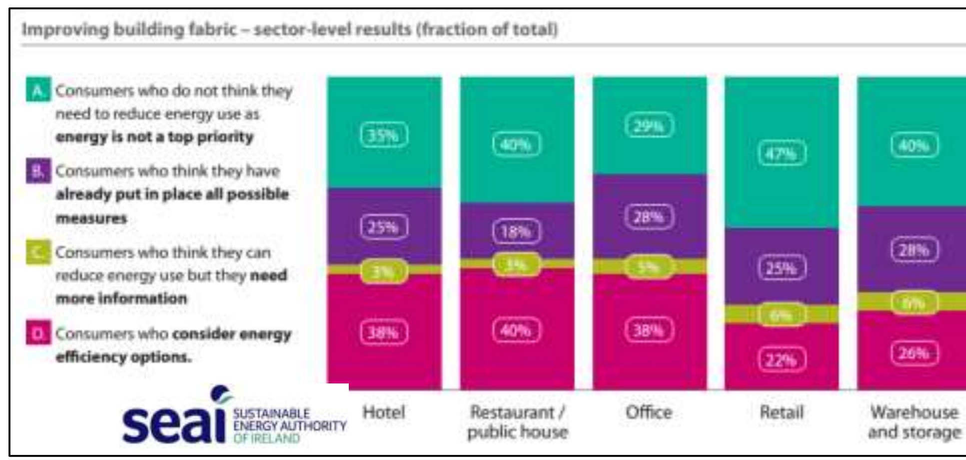
- **Differences in the physical building stock** and appliance stock lead to a wide **variation in the impact and cost-effectiveness** of energy efficiency and renewable energy technologies
- Factors such as the heating fuel, the building geometry, the construction method and insulation level of the building all impact strongly on the technology cost-effectiveness
- This variation leads to a '**supply curve**' of opportunities for energy and/or carbon savings



Cost curve for energy saving measures in Morocco: Differences in building characteristics lead to variation in cost

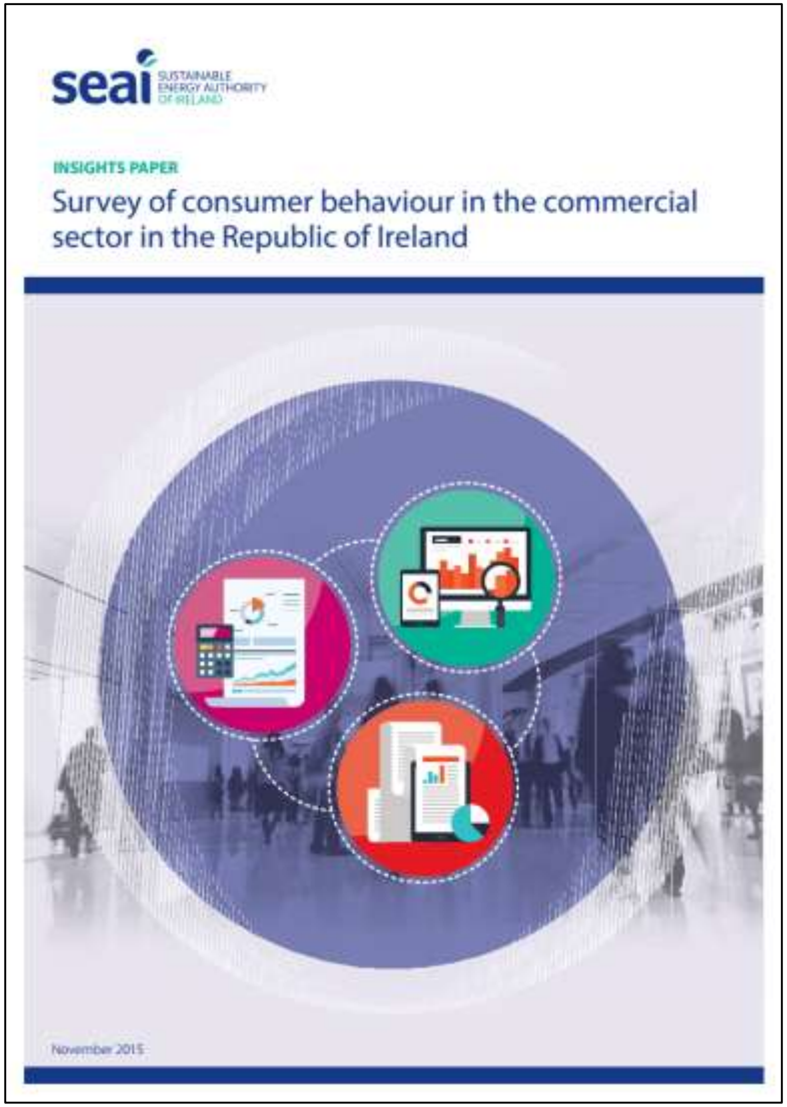
Importance of segmenting by consumer group

- On top of this 'supply curve' due to physical factors, **differences in consumer behaviour** lead to a **wide variation in the uptake** of those opportunities
- Factors such as the ownership/tenancy status, the household budget, the level of engagement with energy supply and fuel bills, the propensity to adopt new technologies and many other factors impact whether the consumer is likely to deploy low carbon technology



Results from a survey of commercial building occupants in Ireland: Fraction of consumers engaged in energy efficiency strongly varies by sector

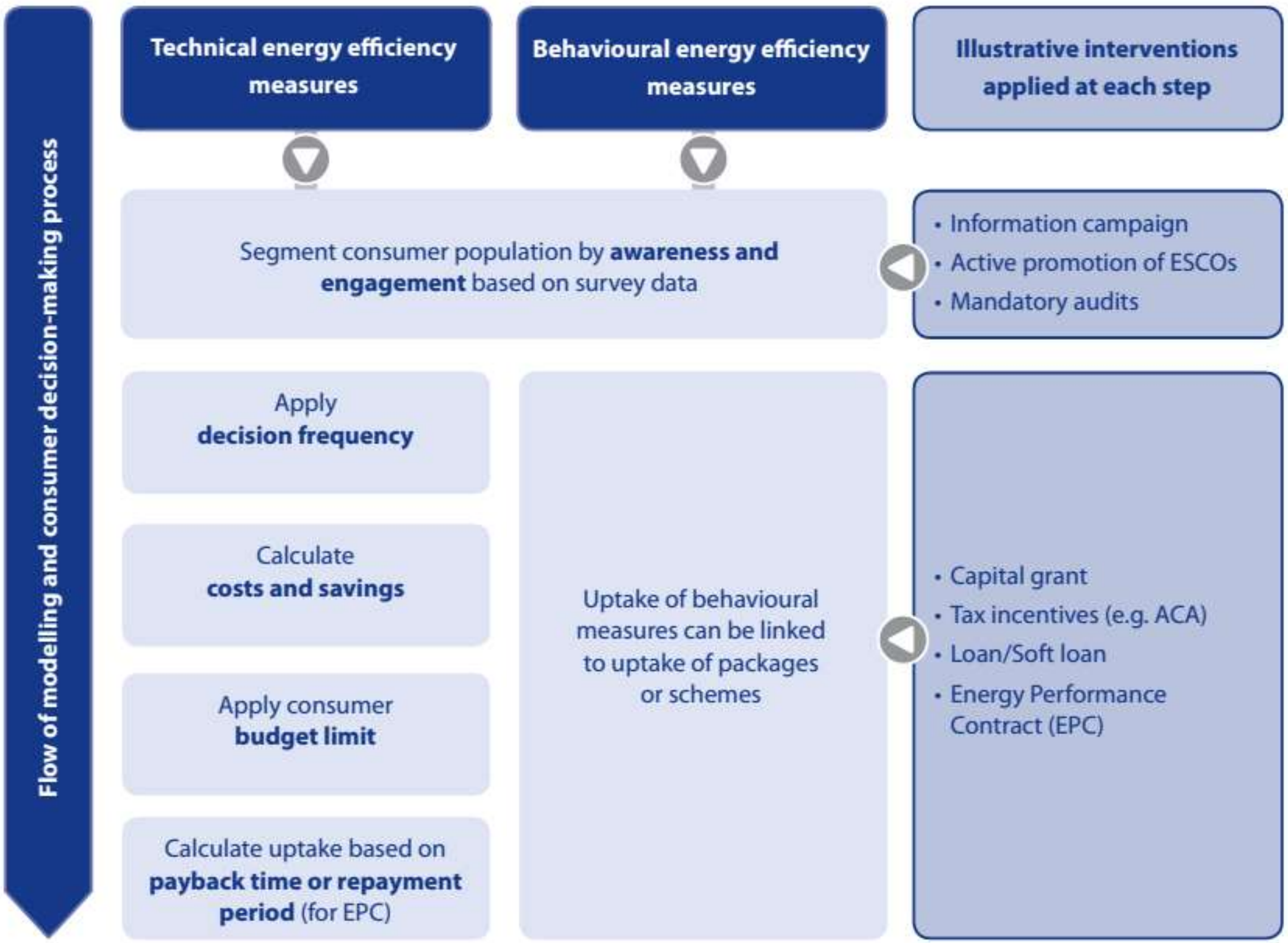
Our conceptual model of consumer behaviour is informed by primary surveys of consumers in the commercial and residential sector



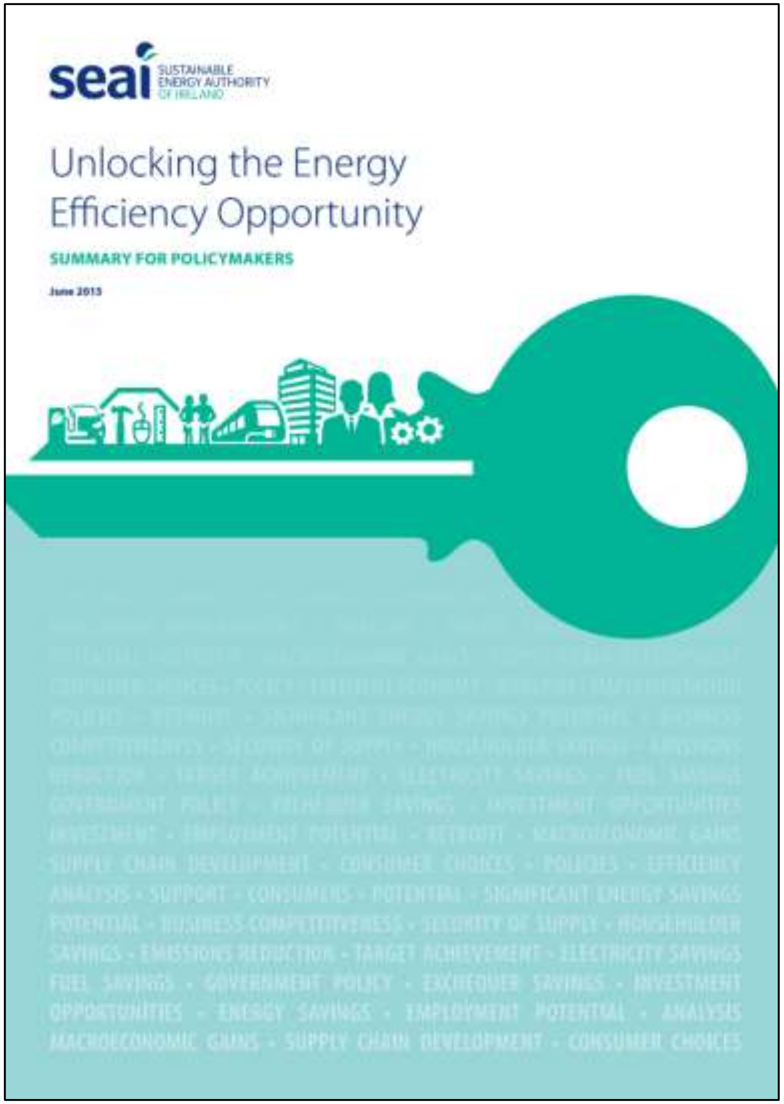
- **Element Energy designed and carried out a survey of consumer behaviour** in the commercial building sector for the Sustainable Energy Authority of Ireland (SEAI)
- 1,500 organisations surveyed
- The survey included a range of questions designed to inform a **quantitative model** of consumer behaviour:
  - Segment the population by building type, size and other physical building characteristics
  - Segment the population by **awareness and engagement** in energy issues
  - Understand consumers' financial constraints including **payback requirements** and **budget limits**
  - Understand the frequency with which potential '**trigger points**' for energy efficiency occur, including regular maintenance work and major building renovation

Conceptual model of consumer behaviour includes a description of how policy interventions might impact each decision point

Model of the consumer decision-making process



Example study: Unlocking the Energy Efficiency Opportunity in Ireland



Element Energy-led study for SEAI:

- Assessment of the energy efficiency opportunity across all energy-consuming sectors in Ireland
- Design of concrete and actionable policy interventions to unlock those energy savings
- The study informed the development of Ireland's 3rd National Energy Efficiency Action Plan to achieve a 20% reduction in primary energy demand to 2020

Key findings:

- 2020 target is very challenging
- However, a range of policies including regulation, low-interest loans and targeted grants could allow the target to be met
- Likely to require a total investment of just over €3 billion…
- …but lead to lifetime savings of over €11 billion, and provide a net benefit to the Exchequer of more than €1 billion

The model was used to estimate the potential contribution of individual policy interventions to Ireland 2020 energy efficiency target

Policy intervention	Primary energy savings 2007-2020 (% savings)		
	Central scenario	**High** scenario	**Very high** scenario
Savings already achieved 2007-2012	5.0%	As for Central	As for High
Existing interventions (including ACA and Energy Performance Contracting)	3.9%	As for Central	As for High
Information campaign for energy efficiency	0.0%	As for Central	As for High
Active promotion of ESCOs	1.6%	As for Central	As for High
Behavioural change	0.6%	As for Central	As for High
Regulation for minimum boiler and lighting efficiency	2.6%	As for Central	As for High
Mandatory energy audit for large companies	2.8%	As for Central	As for High
Direct support of up to 30% of capex (for Deep retrofits)	Not included	1.6%	As for High
Direct support of up to 60% of capex (for Deep retrofits)	Not included	Not included	2.2%
Total	**16.5%**	**18.1%**	**20.3%**

Agenda

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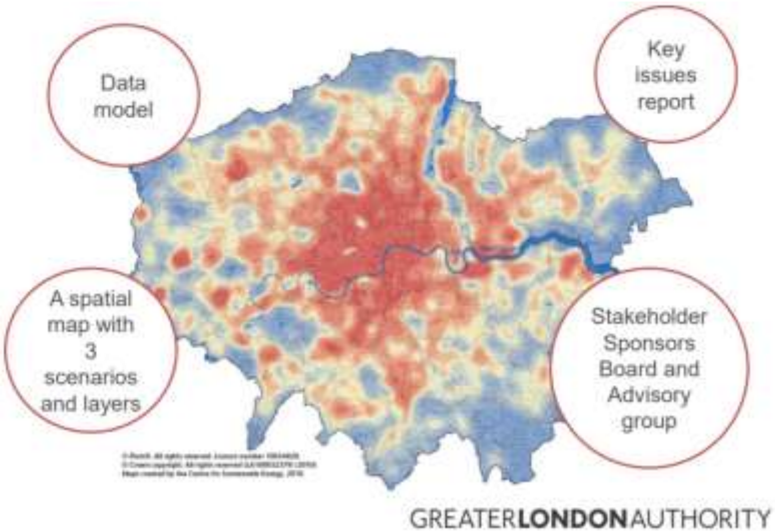
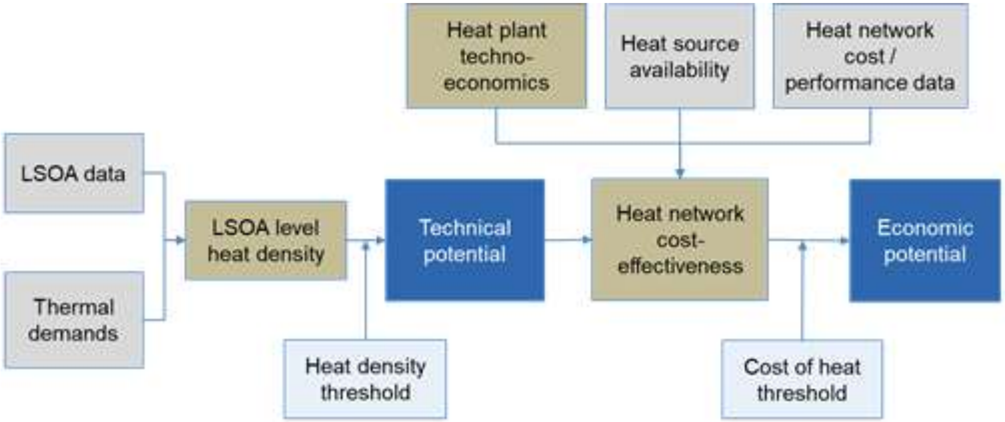
- Spatial planning
- National strategy and infrastructure

Project example: The GLA developed the London Energy Plan to understand the infrastructure implications of energy scenarios



- Coordinated London approach
- Interaction of demand, supply and infrastructure
- Looking out to 2050
- Considering availability of local resources, e.g. secondary heat sources
- Impact on the electricity grid

London heat model

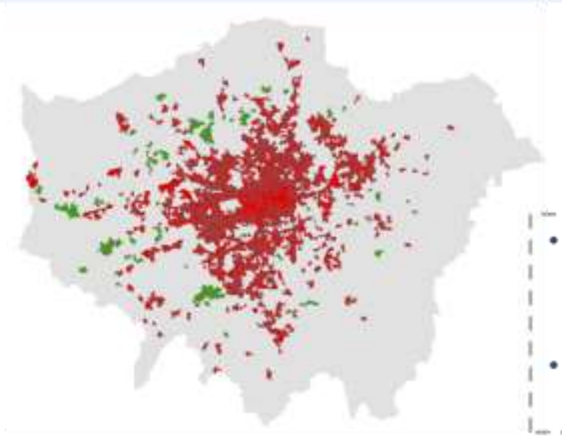


The model considers:

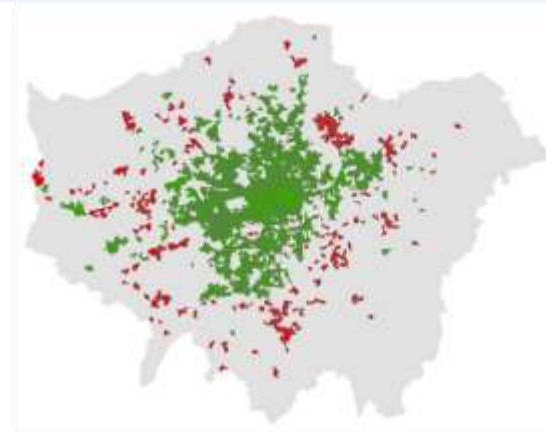
- LSOA level heat density
- Availability of secondary heat sources and proximity to demand centres
- Costs of network and heat supply infrastructure
- Cost of heat from competing techs.

Heat network opportunity areas identified based on demand density and cost-effectiveness of heat sources

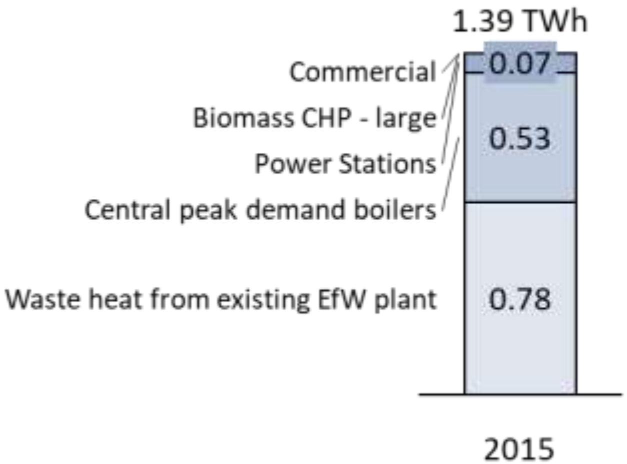
2015	2025



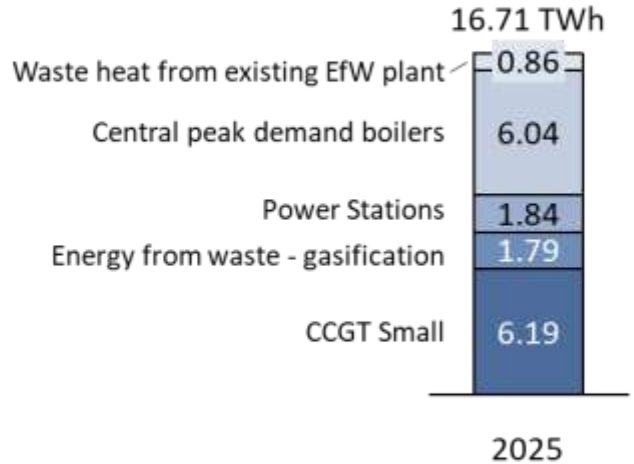
- Green areas have economic potential for heat networks
- Red areas are not viable



Heat delivered by source (TWh)



Heat delivered by source (TWh)

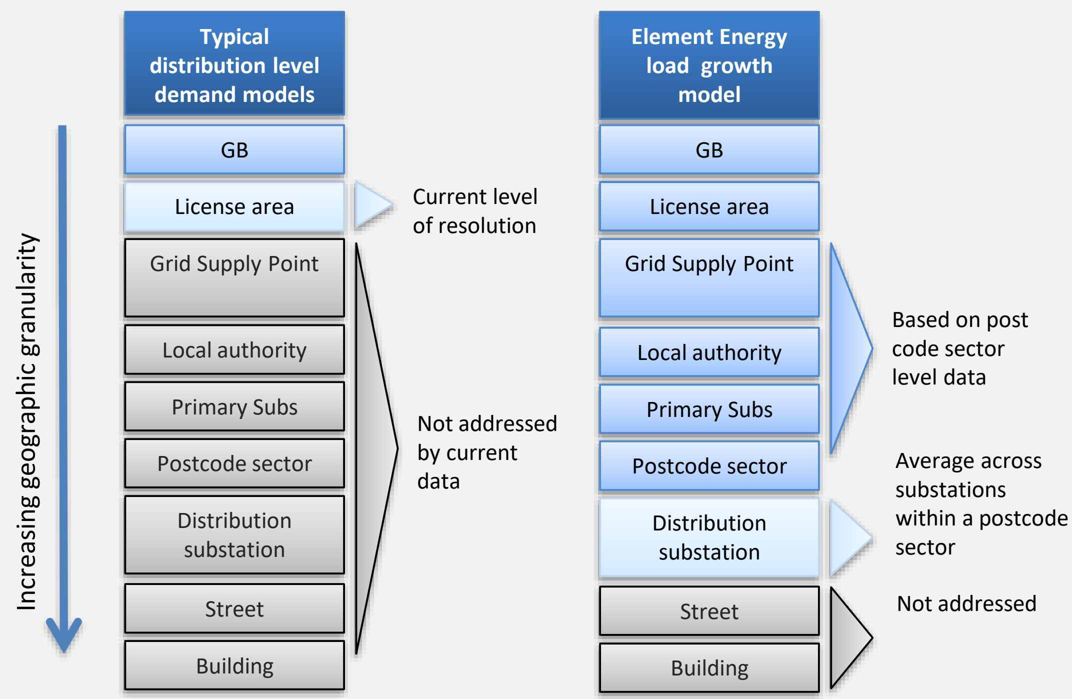


Network infrastructure: Modelling of impact of low carbon technologies at high spatial granularity to identify clustering and peak load impacts

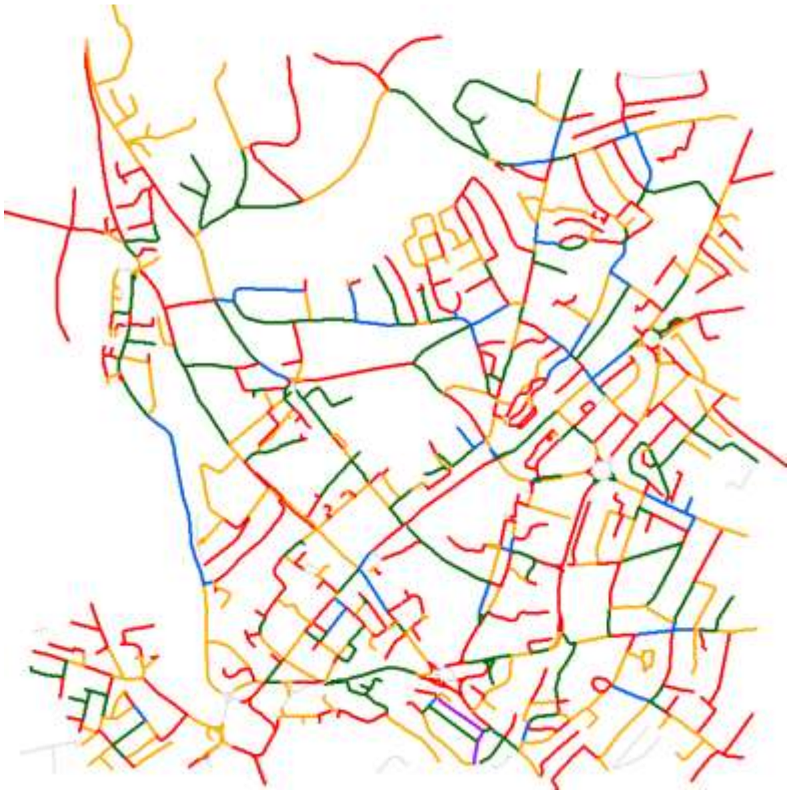
- The Element Energy network load model provides forecasts of load growth at each substation (GSP to distribution level) within a licence area.
- Load forecasts include the impact of uptake of low carbon technologies, energy efficiency, population and economic growth
- Postcode sector level data on the building stock and demographics are used to inform a bottom-up model of electricity demand
- DNO data on LV connections and substation locations are used to map load growth forecast onto specific network assets

- The model incorporates building stock and demographic data at postcode sector level
- Load growth forecasts at distribution substations, based on the building stock / demographics of the postcode sector

The Element Energy load model provides forecasts at far higher geographic resolution than existing DNO tools



Example study: EnergyPath Networks software tool (Energy Technologies Institute)



An electricity distribution network synthesised using an automated GIS technique, developed by Element Energy, on the basis of road layout, supply locations and demand connections. Roads are colour coded to represent spatially contiguous low voltage (LV) feeders. (Image taken from the EnergyPath project).

EnergyPath Networks

- Element Energy in a consortium led by Baringa, also working with UCL
- EnergyPath is a software tool which can be used to study a range of **energy pathways for local authority areas** based on a broad range of local data
- Based on input of various building stock and spatial datasets, enables detailed analysis of network infrastructure reinforcement costs (electricity and gas networks) and district heating viability
- The initial software version has been released and is being **trialled by a number of local authorities**

Agenda

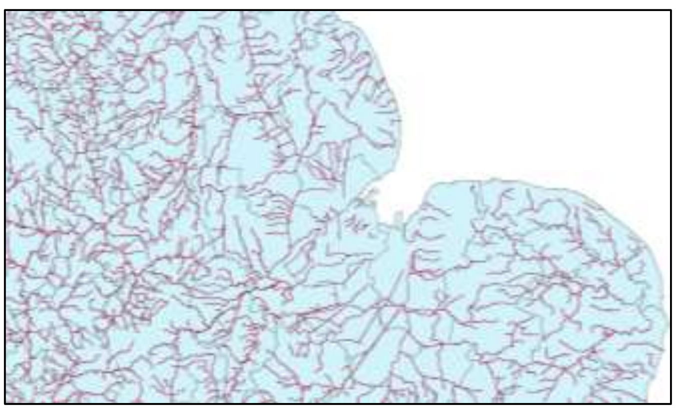
- Consumer and building-level
- Spatial planning
- National strategy and infrastructure

Project example: Heat network scenarios to 2050 for the 5th Carbon Budget

- Element Energy worked with Imperial College and Frontier Economics for the Committee on Climate Change to develop scenarios for heat network deployment
- Inherently a spatial / geographically-resolved challenge

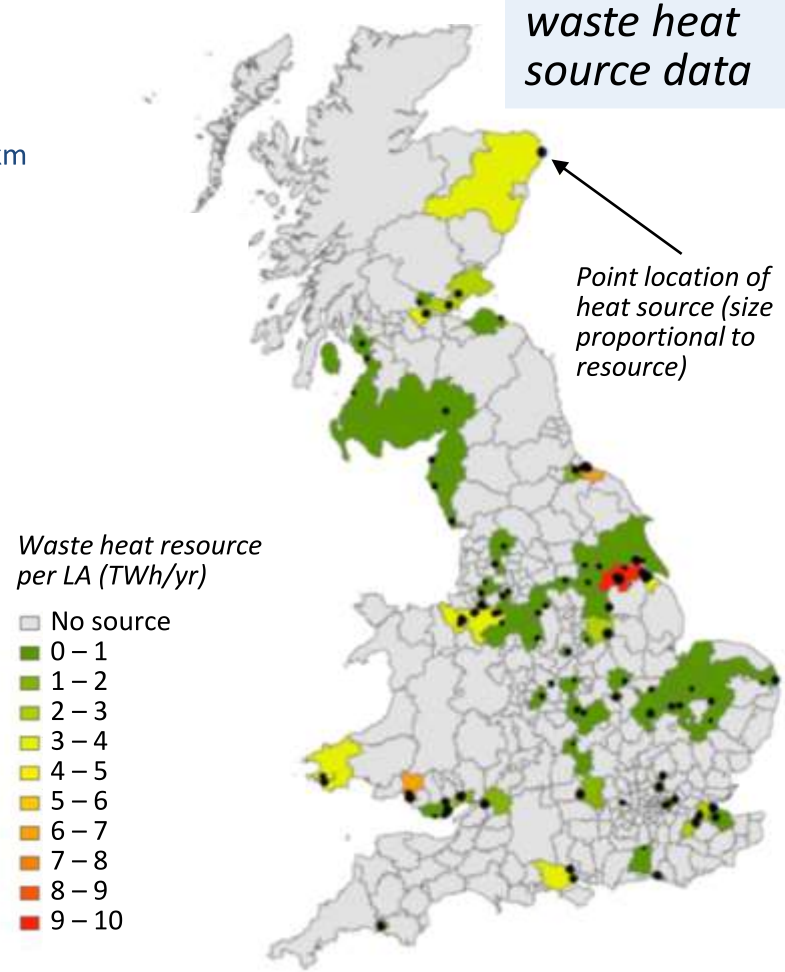
Geographical-resolved datasets on heat demand and potential heat sources were used

DECC heat map data



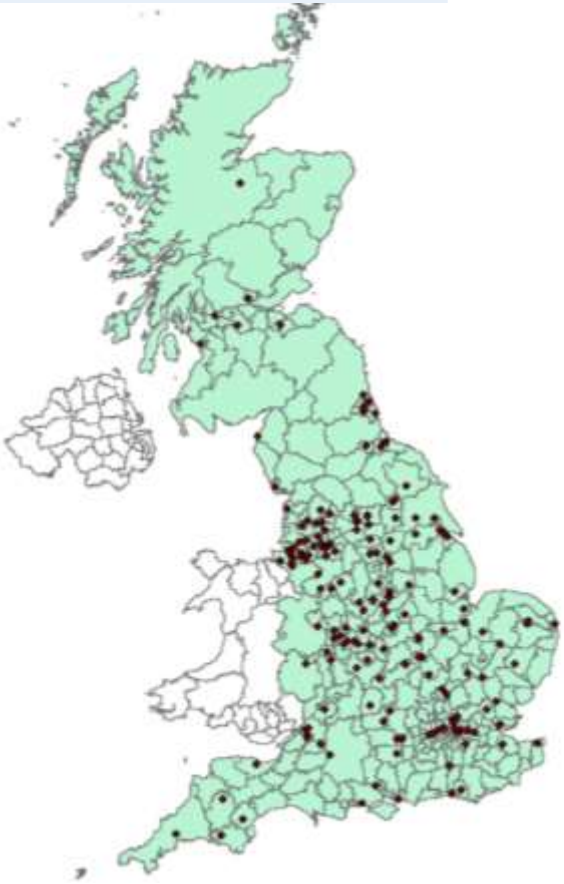
DECC water source data

Element Energy waste heat source data

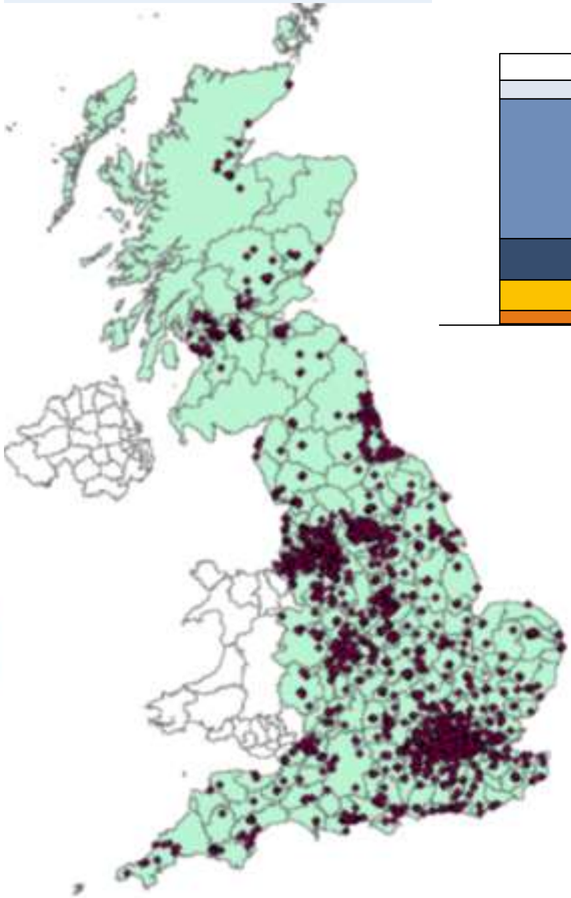


This allowed scenarios to be developed for the deployment of heat networks based on cost-effectiveness

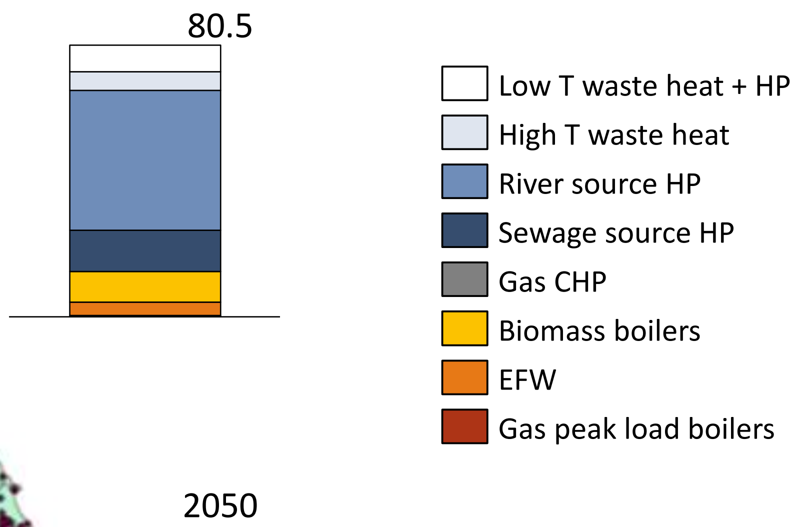
2020: 171 schemes in England and Scotland



2050: 2,722 schemes in England and Scotland



Heat delivered by DH, by technology (TWh)

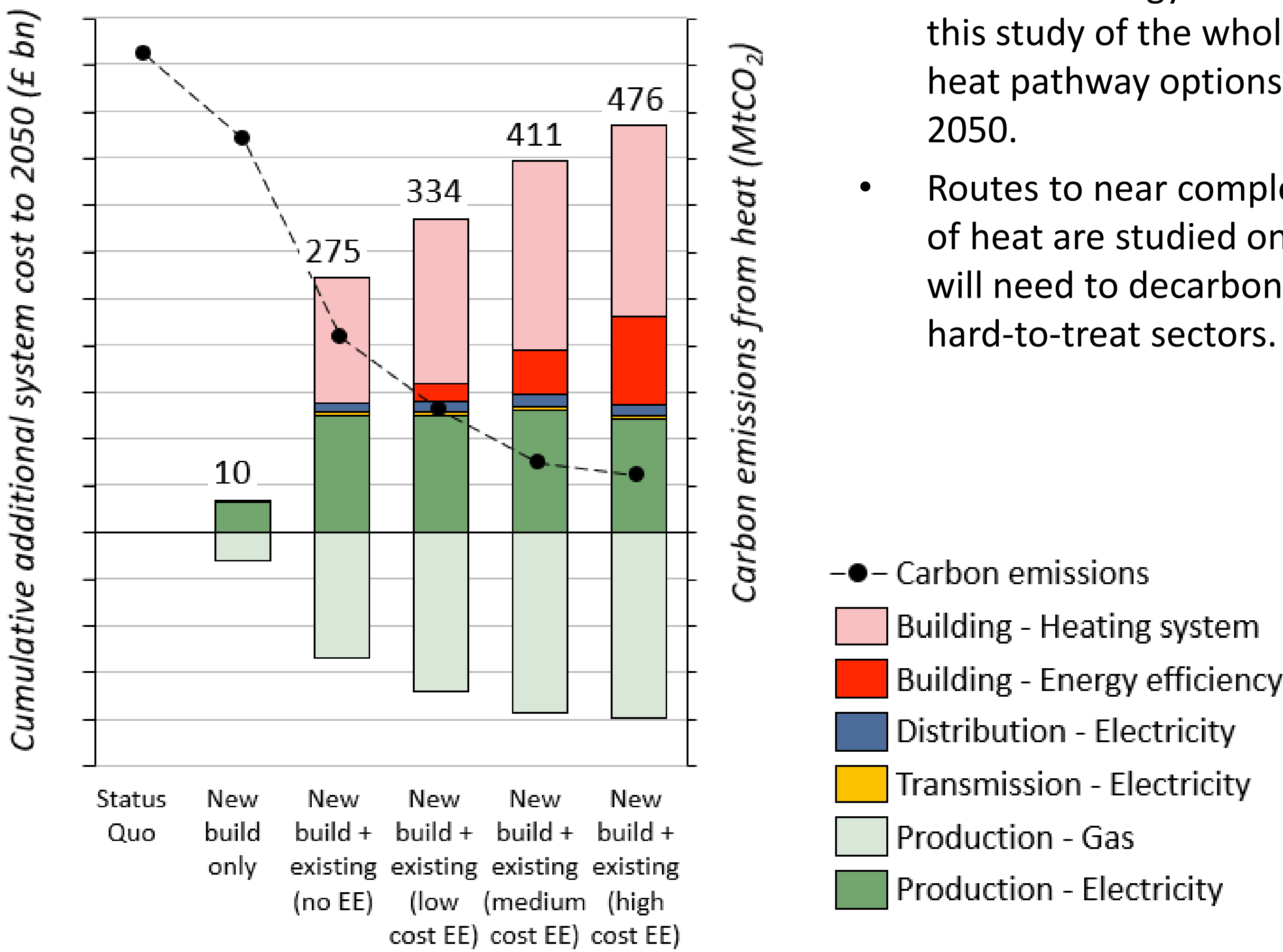


Project example: Assessment of the cost-effectiveness of heat pathway options for the National Infrastructure Commission

High-level model schematic specifying the cost components included in the modelling

Level	Building level	Distribution level	Transmission level	Generation level
Inputs	• **Deployment** of heating options across stock • **Cost per building** of building-level technologies • **kWh/yr** and **kW peak** demand per building for each fuel	• **kW peak** per fuel type (aggregated across stock) • **Cost per kW** of distribution level new build, reinforcement, and maintenance	• **kW peak** per fuel type (**aggregated** across stock) • **Cost per kW** of transmission level new build, reinforcement and maintenance	• **kW peak** per fuel type (**aggregated** across stock) • **kWh/yr** per fuel type (aggregated across stock)
Cost outputs	• **Energy efficiency** retrofit • **Building-level heating system** (boilers, HPs) • **Heat transfer unit + heat meter** (DH) • **Fuel storage** (Biomass) • Building-level **thermal storage**	• **Distribution networks** for electricity, gas, hydrogen and heat • **Network-level heating plant for DH** (e.g. large HPs, CHP)	• **Transmission networks** for electricity, gas, hydrogen • No transmission network assumed for heat	• **Production cost** of gas, electricity, H_2 production, bioenergy

Whole system cost analysis of pathway options to 2050 and associated carbon reduction



- Element Energy is working with E4Tech on this study of the whole system costs of heat pathway options over the period to 2050.
- Routes to near complete decarbonization of heat are studied on the basis that heat will need to decarbonize >80% to offset hard-to-treat sectors.

Final remarks

- The above examples are highlight how energy modelling is being applied to inform policy development at different scales:
  - **Consumers and building level**
  - **Local authority / regional spatial planning**
  - **National strategic and infrastructure level**

- Energy models assist policy-makers to:
  - Understand the implications for **infrastructure** and the wider system
  - Understand **localised impacts**
  - Design **effective policy**

- Despite the sophistication of energy models, there are **large uncertainties**. For example, in the case of low carbon heat there are uncertainties around consumer acceptance, practicality and safety of particular pathways

- R&D, field trials, early commercialization etc. are needed to reduce uncertainties and increase confidence in model inputs