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Latest Built Environment Innovations

Lori McElroy – BRE
Director Building Energy Performance and Research

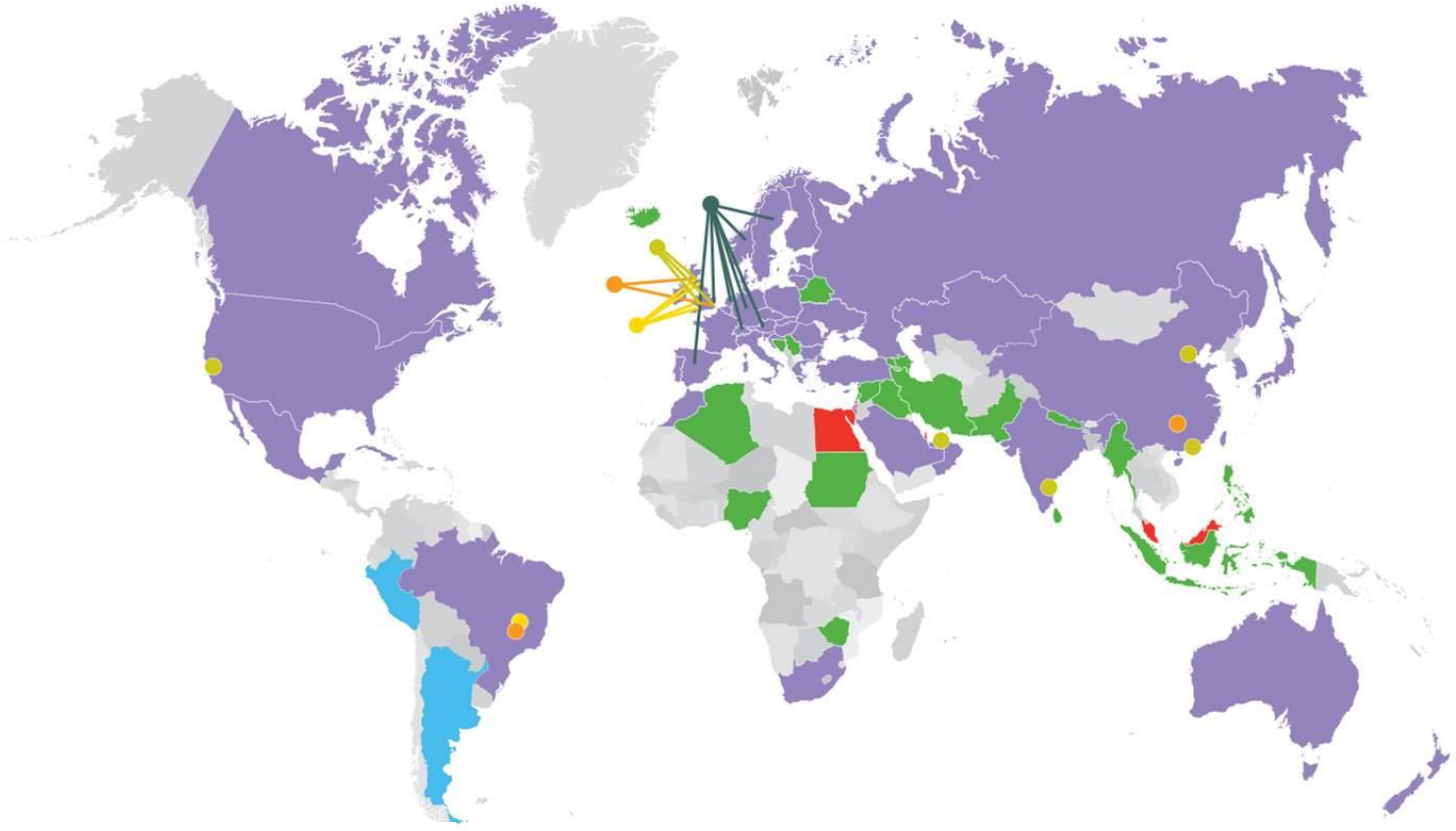
Building a better world together

Our History

- Est 1921, investigate building materials for new homes post WW1.
- British Standard for Bricks – UK's first for construction materials.
- 1997 – privatised, BRE Trust.
- Registered charity, aims to achieve:
  - A higher quality built environment
  - Built facilities that offer improved functionality and value
  - A more efficient and sustainable construction sector with a higher level of innovative practice.
- Significant investment in education, research and partnerships

BRE TRUST 20 YEARS OF POSITIVE IMPACT

Where we are in the world



Actively working in

80 countries

14,500

3rd party fire/security products/services certified

35,000

people upskilled through training

2,270,000

sustainable certification registrations

BRE's University Centres: world class research

BRE Trust funds 6 University Centres of Excellence

- University of Bath
- University of Cardiff (2)
- University of Strathclyde

"*Energy Utilisation*"

- University of Edinburgh
- University of Brasilia

University of Strathclyde Engineering

UN – Sustainable Development Goals

Energy a National Infrastructure Priority

In response to the EPBD Scottish Government has set new targets –

Near zero carbon for all new buildings by 2032 and all buildings by 2045.

And emissions reduced by 75% and 98%, respectively, by 2032 on 2014 levels.

Energy Efficient Scotland (EES) – being rolled out from 2018.

EES will improve the energy efficiency of buildings and will decarbonise heat supply.

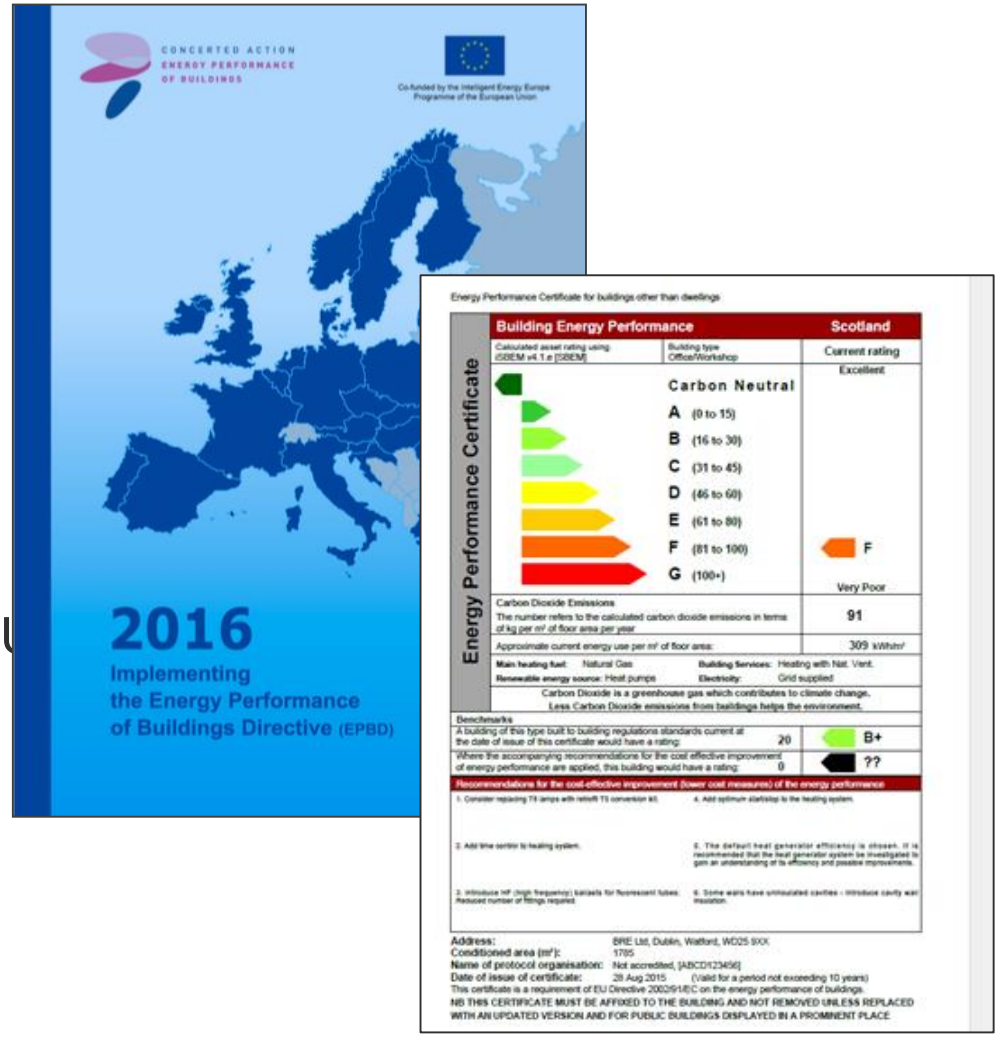
Minimum energy efficiency standards play a key role: EESSH, Regulation of Energy Efficiency in the Private Sector (REEPS) and Local Heat and Energy Efficiency Strategies (LHEES)

The initial estimated overall investment in excess of £10 billion

Energy Performance of Buildings Targets

European Energy Performance of Buildings Directive sets a clear path towards ‘near zero energy’ for new buildings by 2020.

However there is no clear EU definition of ‘Near Zero Energy’.



Scottish Government's 2045 Vision

Scottish Government's 2045 Vision

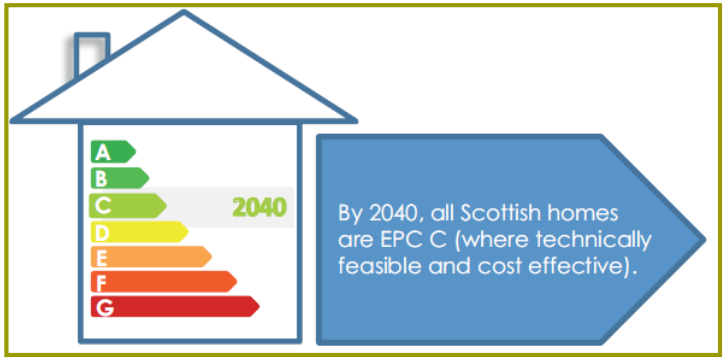
Scotland's buildings are near zero carbon by 2045 and this is achieved in a way that is socially and economically sustainable.

- by 2032 - 94% of non-domestic buildings' and 80% of domestic buildings' heat is supplied using low carbon heat technologies;

- new EPC targets for all housing as part of the Energy Efficient Scotland programme – EPC Band C by 2040 for all homes and EPC Band B for Social Housing by 2032; and

- improvements to the fabric of non-domestic buildings results in a 20% reduction, and domestic buildings results in a 15% reduction, in their heat demand by 2032.

Image – Helen Lucas Architects



Scotland's Existing Buildings

We cannot neglect refurbishment as 99% of buildings already exist

- 80% of the buildings in use in 2050 are already standing today

Currently around 600,000 households in Scotland remain in fuel poverty. The current objective is reduce this to 5% by 2040

There are a number of organisations lobbying to address this sooner – including Shelter, Citizens Advice Scotland, the Existing Homes Alliance and Energy Action Scotland.

Meeting the standard - assessment

What Scottish Government said in the EES Route Map:

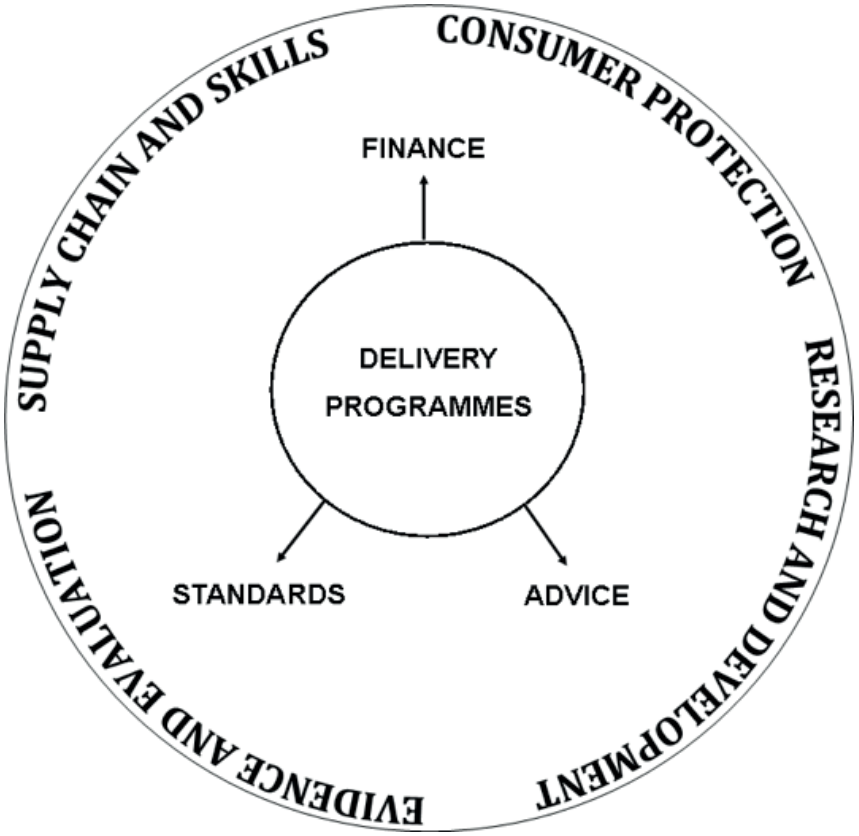
‘In setting the long term standard using the Energy Efficiency Rating of EPCs we are committing to using and building on the current EPC assessment process. With the setting of the standard we will need an appropriate and proportionate assessment process. Owners need to know how energy efficient their buildings are (which is based on the EPC), what they have to do to meet the standard, the best way to do that and once the work is done, to be able to demonstrate that the standard has been reached.’

Delivery includes

- the regulation of private rented sector housing to increase efficiency standards;

- heat regulations commensurate with the scale of the heat market;

- phased regulation of other existing buildings to bring them up to higher energy efficiency standards as well as an exploration of financial incentives.



Renewable Heat

22% of Scotland's energy is used to provide heat to domestic building

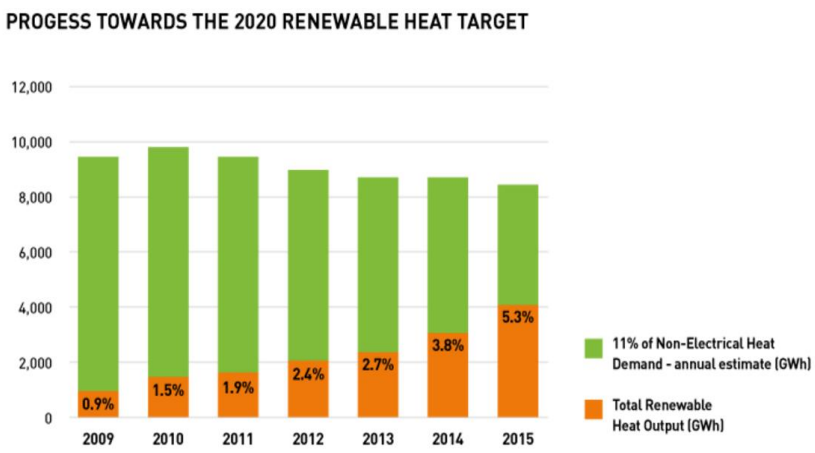
Scottish Government has set a target of 11% of Scotland's non-electrical heat demand by 2020.

By 2032, the **target** is to have 35% of **heat** for domestic buildings and 70% of **heat** and cooling for non-domestic buildings supplied using low carbon **heat** technologies.

By 2030 the aim is to generate 50% of Scotland's overall energy needs from renewables, and

By 2050 to have decarbonised our energy system almost completely.

Chart 11: Progress Towards the 2020 Heat Target



Source: Energy Saving Trust – Renewable Heat in Scotland 2015

Flexible Electrical Networks for a low Carbon future

bre

IP 1/17

Information Paper

Flexible electrical networks for a low carbon future

Network and built environment opportunities for enabling smarter networks

Colin Sinclair, BRE Scotland, and Watson Peat and Kevin Smith, SP Energy Networks

This Information Paper provides an introduction to the concept of flexible electrical networks. It provides an overview of technical solutions that can be applied (by network and building designers, owners and operators), at either the network or built environment level, to increase flexibility in the energy system and assist the UK's transition to a low carbon future.

It will be of particular interest to network and building designers, owners and operators. The techniques presented include recently trialled Distribution Network Operator (DNO)-led smart grid solutions that focus on increasing and enhancing the capability of existing network infrastructure in constrained areas.

The Information Paper also highlights built environment energy-efficiency opportunities that building designers, owners and operators can consider in order to save energy and reduce peak demand, while supporting wider network flexibility and efficiency.

Opportunities for flexibility exist across the energy system

1 Introduction

The Department of Energy and Climate Change (DECC) report *Towards a smart energy system*[1] highlighted a number of challenges facing the UK's energy system. It states: 'most trajectories of energy demand and supply to 2050 anticipate significant new system challenges as we incorporate more low carbon generation, and meet increases in peak demand (typically 16:00 to 20:00 on winter weekdays), driven largely by the extent to which transport and heating become increasingly electrified'[1]. The report highlights that under a range of future scenarios, peak demand is forecast to increase, and in some scenarios these increases could be very significant. In order to meet the increases in demand, DECC suggests that a large increase in low carbon generation is needed as well as a smart energy system that incorporates new forms of flexibility, smarter networks, energy storage, demand side response and increased interconnectivity. The report also highlighted that it may also involve a focus on energy-efficiency improvements which target peak demand.

It is anticipated that distribution networks will be required to connect and manage increasing levels of demand from electric vehicles, heat pumps and general load increases. The distribution networks will also need to manage increased distributed generation (eg large scale renewables) and other embedded generation (eg microgeneration at the built environment level). This growth of low carbon technology on the electrical network is widely expected to be rapid, in order to achieve ambitious climate change mitigation objectives. It is also expected to be localised, eg focussed on major centres of population or by geographical areas offering significant potential for distributed generation. As a result, DNOs are expected to have limited forward visibility to enable them to plan and implement network upgrades. This introduces a risk that the rate of change within some parts of the network may exceed the capability of DNOs to respond with traditional solutions. In addition, complexities associated with demand and generation profiles for low carbon technology have the potential

SP ENERGY NETWORKS

IHS

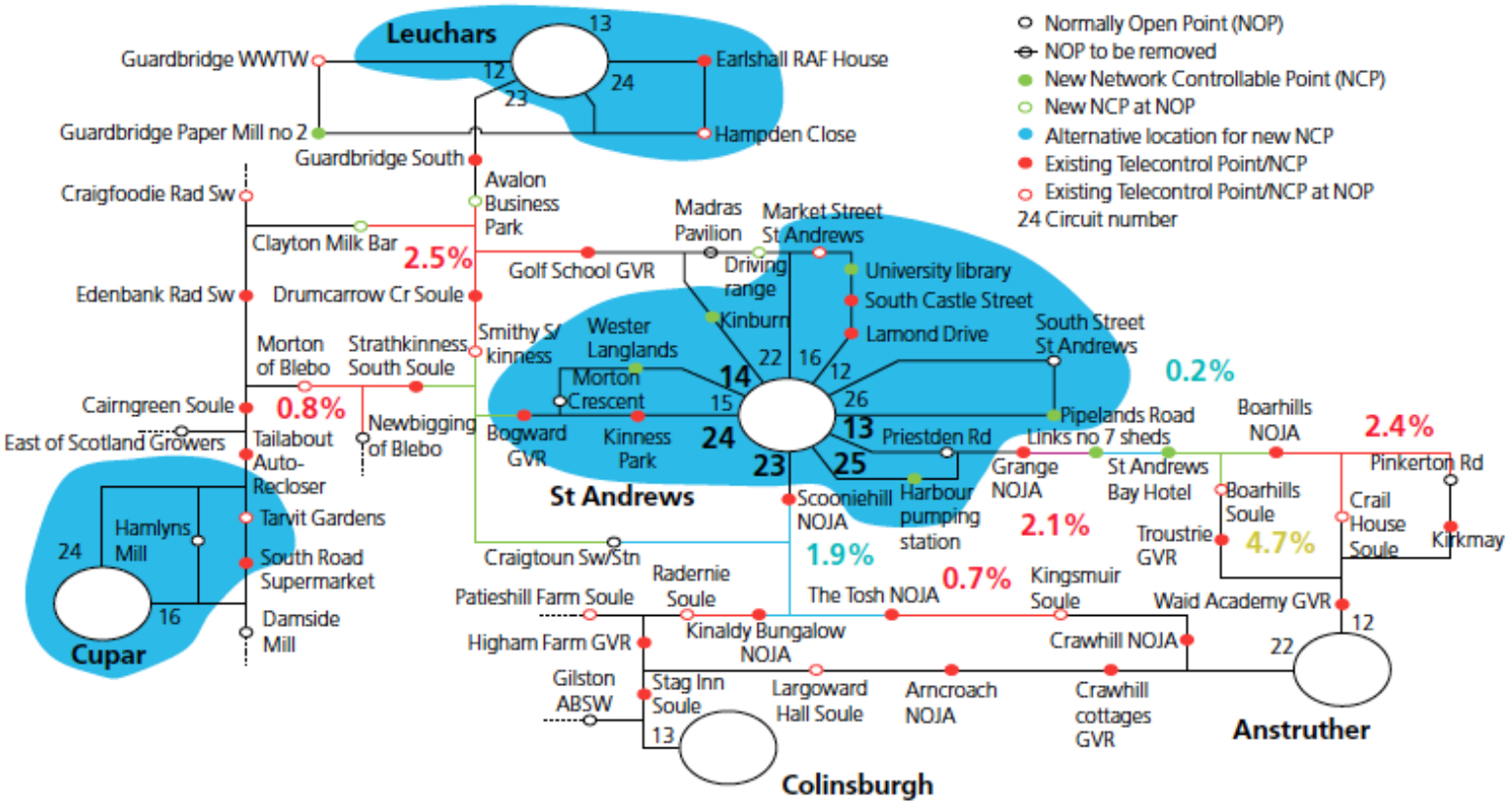


Figure A: Flexible network analysis output (image courtesy of University of Strathclyde)

Landscaping study for Scottish Government

climate change

Scotland's centre of expertise connecting climate change research and policy

Heat Generation Technology Landscaping Study, Scotland's Energy Efficiency Programme (SEEP)

Smart Energy – Technology Landscaping Study, Scotland's Energy Efficiency Programme

Energy efficient retrofit – Technology Landscaping Study, Scotland's Energy Efficiency Programme

Technology Readiness Levels

TRL 0: **Idea**. Unproven concept, no testing has been performed.

TRL 1: **Basic research.** Principles postulated and observed but no experimental proof available.

TRL 2: **Technology formulation**. Concept and application have been formulated.

TRL 3: **Applied research**. First laboratory tests completed; proof of concept.

TRL 4: **Small scale prototype** built in a laboratory environment ("ugly" prototype).

TRL 5: **Large scale prototype** tested in intended environment.

TRL 6: **Prototype system** tested in intended environment close to expected performance.

TRL 7: **Demonstration system** operating in operational environment at pre-commercial scale.

TRL 8: **First of a kind commercial system**. Manufacturing issues solved.

TRL 9: **Full commercial application**, technology available for consumers.

Fabric - Landscaping Research

– ClimateXChange, 2017 (R&D workstream)

climateXchange
Scotland's centre of expertise connecting climate change research and policy

– **1 – energy efficiency retrofit technologies**:
  – 55 technologies (44 dom, 45-50 public and commercial, 21 industrial)

  – Draught proofing and insulation most effective
  – Incremental improvements rather than step/game changing.
  – Innovation:
    - Material enhancement (e.g. moisture, resistance to fire and decay)
    - Novel system (e.g. offsite manuf. / systems approach to thermal bridging /air tightness)
    - Surveying techniques
    - Performance risk management
  – Importance of proper design, specification, installation and verification.

Fabric – emerging opportunity areas

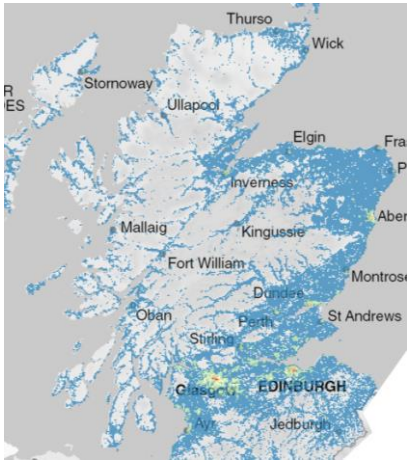
Thermal elements (fabric)	Components
External walls	cavity wall insulation
	internal wall insulation
	external wall insulation
	frame
Roof	ceiling
	sarking
	flat
Floor (ground)	suspended timber
	suspended (other)
	solid concrete
Floor (upper)	timber
	concrete
Party walls	masonry
	framed
Windows/doors	
Glazing	triple glazing
	suspended film glazing
	secondary glazing
Associated fabric issues	
Thermal bridging detailing	
Air tightness / draughtproofing	

Fabric – emerging technologies/solutions

- Factory manufactured / off-site construction
  - new surveying tools =accurate measurement of existing dwellings =easier to produce insulation products/panelling that can be manufactured off-site, to high levels of tolerance, for rapid installation on site as either an external or internal wall insulation product.
- New, high-performing, insulation products
  - emerging insulation technologies e.g. Aerogel blankets/boards and Vacuum Insulated Panels could provide significant improvements.
  - thin solutions and less disruptive to install
- New/improved insulation retrofit techniques
  - technologies and solutions that reduce impact on occupants, improve quality/consistency, reduce time and cost, etc.
  - possible opportunity to return to previously upgraded properties to carry out further thermal improvements previously disregarded.
- Circular economy / embodied energy of building fabric components
  - growing focus on products offering future re-use/recycle-ability

Heat - Landscaping Research

- **2 – heat generation technologies**:
  - Heat: 53% of energy use by Scotland's homes & businesses
  - Scottish (and UK) heating market dominated by gas boiler
  - 21 groups of technologies (various applications)
    - Dom: heat pumps, PV-T, fuel cell/cogeneration, electric heating, WWHR
  - Barriers to large scale heat pump uptake
  - Role of District Heating (especially 3rd and 4th generation)
  - Longer term, biogas, hydrogen, ???



Heat Generation Technology Landscaping study

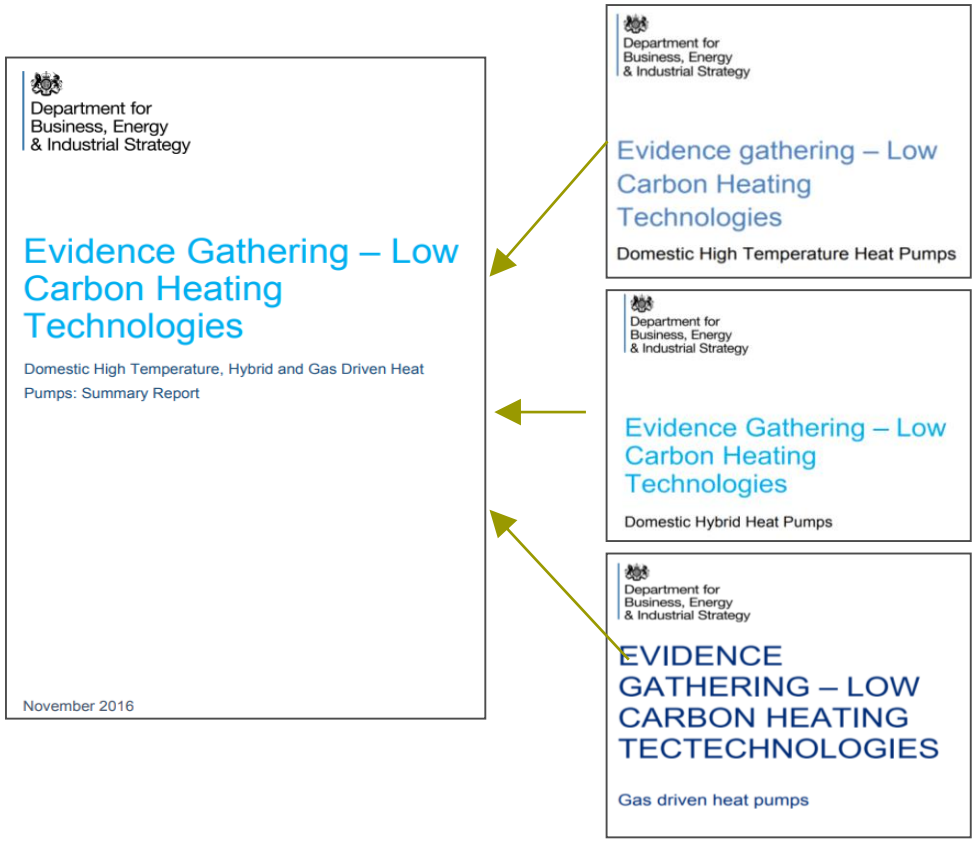
Findings:

heat pump technologies such as:

– high temperature heat pumps,

– hybrid heat pumps, and

– gas-fired heat pumps look most promising



Heat – emerging opportunity areas

Technology	Category	Sub-category	Comments
Space heat generation technology	boilers	gas	
		oil	
		electric	smart/storage enabled
		biomass	
		biogas	in longer term
		hydrogen	in longer term
	heat pumps	traditional heat pump (air, ground, water source)	
		exhaust air heat pump	
		high temperature heat pump	
		gas driven heat pump	in longer term
		solar-assisted heat pump	
		hybrid heat pumps	
	cogeneration (CHP / mCHP)	gas / oil fired	
		biomass	
		biogas	in longer term
		hydrogen	in longer term
		fuel cell (hydrocarbon)	
		fuel cell (hydrogen)	in longer term
	solar	solar thermal	
		PV-thermal	
		solar assisted ventilation	

Heat – emerging opportunity areas

Technology	Category	Comments
Water heating	hot water cylinders (any type and fuel) and related components	
	point of use water heaters (any fuel)	
	hydrocarbon fired standalone heaters	
	'renewable' derived water heater	especially heat pump driven
	DHW secondary return technologies / innovative control	
Heat storage (including thermal stores)	electric storage heater / emitter (with storage)	especially high heat retention and/or smart enabled
	other electric / battery storage	
	thermal stores	
	phase change material	
	fabric integrated storage	
heat emitters (non-storage)	radiators, convectors, radiant panels, etc. (wet)	
	radiators, convectors, radiant panels, etc. (direct electric, non-storage)	
	underfloor heating	
	warm air	

Heat – emerging opportunity areas

Technology	Category	Comments
heat recovery	ventilation heat recovery	
	flue gas heat recovery	
	waste water heat recovery	
heat distribution / circulation	pipework insulation	
	circulating pumps and controls	
	heat exchangers	
	low temperature distribution technologies	
heat controls / metering / monitoring / user platforms	home energy monitoring products	
	heat metering	
	heating controls (traditional) (e.g. thermostat, TRVs, programmers, valves)	
	heating controls (smart) (e.g. smart thermostats, home energy management systems)	
	electricity to heat diverters	

‘Future Energy Scenarios’ (Heat Pumps)

National Grid’s ‘Future Energy Scenarios 2018’

– for the UK to be on a pathway to 2050 compliance in terms of carbon reductions heat pump installations will need to rise from the 2017 level of circa 0.04m to at least 2.72m by 2030

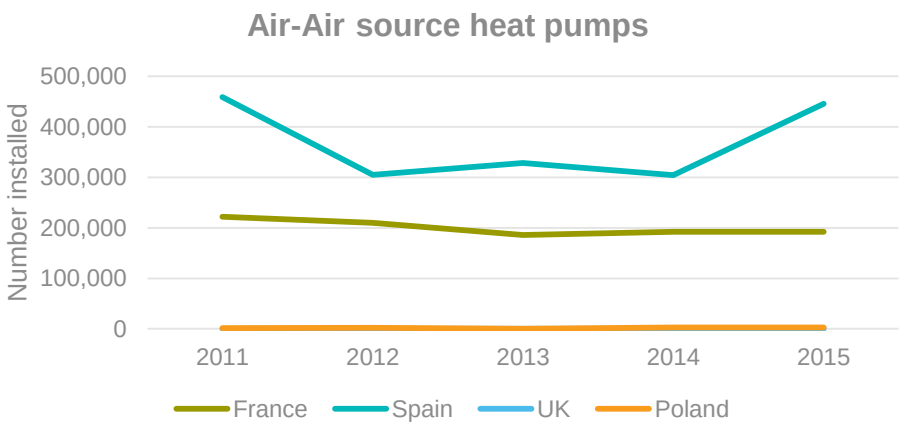
(equates to approx 612 heat pump installs per day, for next 12 years!)

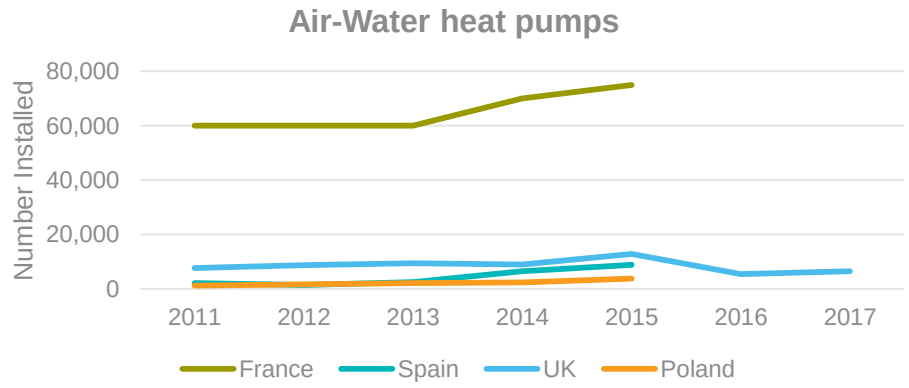
– (non 2050 compliant) ‘Steady Progression’ pathway would require a 12-fold increase to 0.48m units by 2030.

http://fes.nationalgrid.com

Domestic Heat Pump Trends

- The domestic scale air-air heat pump market [1] is well established in France and Spain. In both they can provide cooling as well as heating and is a reasonable solution for rural properties.
- Both the UK & Poland have negligible numbers of heat pumps partly due to the lower cooling requirement but also due to lower heating efficiencies and cheaper alternatives (gas in the UK & coal in Poland).
- Air-Water heat pumps have some market share in France but negligible in other countries.
- France provides subsidies for air to water (as does the UK) but has better success due to the lack of gas networks in many French rural areas. Spain is less successful due to lack of subsidies and its inability to provide cooling.





[1] Chiffres clés des énergies renouvelables, EurObserver & OFGEM

Smart Energy - Landscaping Research

- **3 – Smart energy technologies**:
  - technologies that “enable flexibility in parts of the energy system that have previously been inflexible”

  - Network companies moving towards a Distribution System Operator (DSO) model where they will play a key role in facilitating local energy balancing markets. Central to this is increased visibility of network behaviour
- 26 technologies (21 with applications in buildings. 6 broad categories:
  - Monitoring and sensors - Monitoring, data collection and in-built data analysis / controls
  - Platforms / data analytics - analysis of data on a digital platform
  - Communications – New technologies for transporting data
  - Control - Technologies with a primary control function
  - Storage - Electrochemical, heat and cold storage
  - Response – signal driven generation/consumption alteration.

Smart Energy Technology Landscaping study

Main findings:

Most promising technologies:

- Smart meters
- Consumer-facing devices, apps and platforms
- Supervisory buildings control
- Response – domestic / commercial
- Storage
- Network-facing technologies

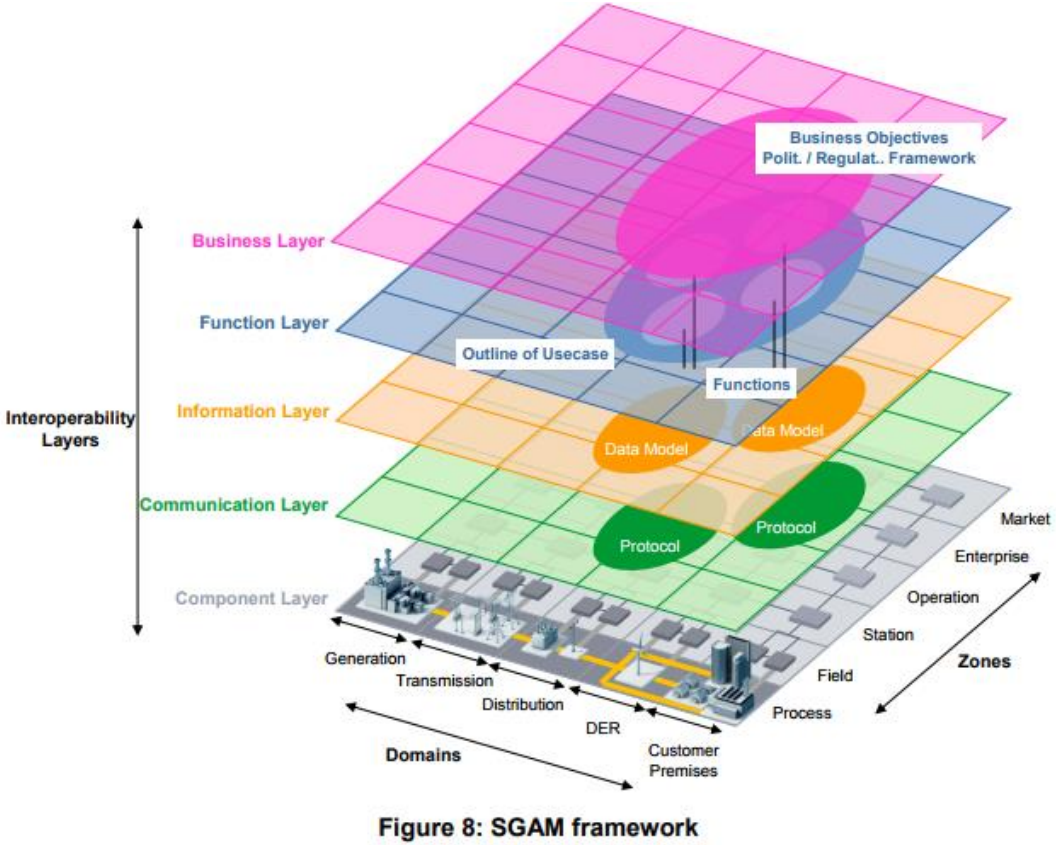


Figure 8: SGAM framework

Smart Grids Architecture Model (SGAM)

Aggregated energy efficiency - emerging

Smart Power sub-sector: 'Customer Side of Meter'		
Category	**Sub-category**	**Comments**
Smart meters	n/a	
Home energy management systems	In-home displays	
Demand Side Response	Monitoring and controls	
	Heating and hot water systems	e.g. flexible heating, hybrid systems, thermal storage.
	Electrical energy systems	e.g. smart storage heaters, smart appliances, energy diverters.
	Energy Storage	e.g. Electrical storage (batteries), thermal stores, phase change material.
	Electric vehicles to/from grid	consider impact on substations and emerging technologies
Distributed generation	on-site generation	

Examples / Case Studies

- **FREEDOM project** – 75x domestic hybrid heating system switching between gas and electric to provide fuel arbitrage and highly flexible DSR (Western Power Distribution, Wales & West Utilities, PassivSystems. £5.2m.
- **FLATLINE** – Fixed Level Affordable Tariffs Led by Intelligently Networked Energy. Sero Homes, combined control of domestic appliances, heating, photovoltaic generations and battery storage.
- **Smart storage heating** – Vcharge (Ovo energy) smart storage solution trialled in social housing to control electric storage heating to manage resident comfort, address fuel poverty and providing valuable grid balancing services.
- **Peer-to-peer energy marketplace** - Open Utility's Piclo® peer-to-peer energy marketplace to buy direct from local generators.

Case Studies

Closer to Home

- Trials of new natural gas mixes in **Argyll and Fife**
- **South and East Ayrshire and Dumfries and Galloway** initiative involving the impact of warmer homes on health in association with **NHS (Ayrshire and Arran)** and the **Energy Agency**
- **St Andrews University** – Biomass District Heating extended to the wider community.
- **Glasgow City Council - RUGGEDISED** – an EU Horizon 2020 funded project, brings together six cities: Rotterdam, Glasgow, Umeå, Brno, Gdansk and Parma to test, implement and accelerate the smart city model across Europe. Working with businesses and research centres the project will demonstrate how to combine ICT, e-mobility and energy solutions to design smart, resilient cities for all.
- **Renfrewshire and Cornwall Councils** have just won funding from **BEIS** for a Whole House Retrofit initiative – exploring potential for extreme, ‘deep’ retrofit solutions for hard to treat housing.

Funding sources

Many funding sources will require matched funding

- Construction Scotland Innovation Centre
- The Construction Innovation HUB
- Scottish Enterprise
- Scottish Government
- Energy Companies Obligation
- UK Government
- BEIS
- Innovate UK
- International Energy Agency
- Horizon 2020

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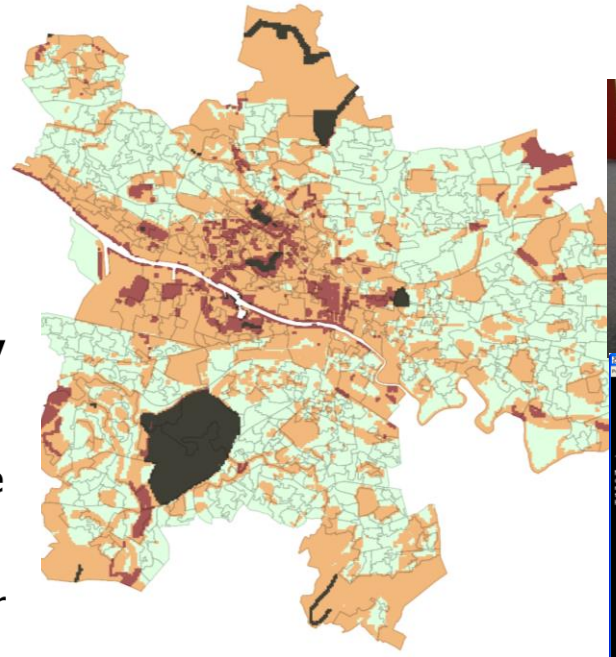
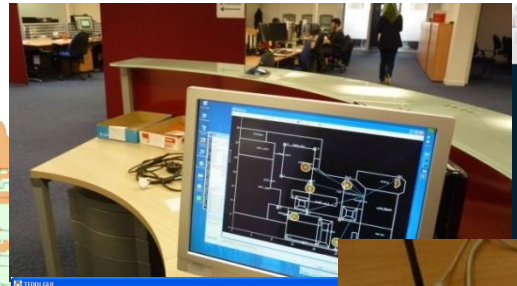
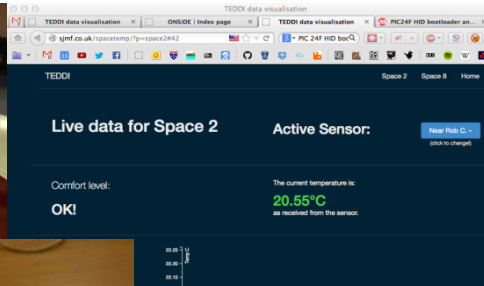


Legend

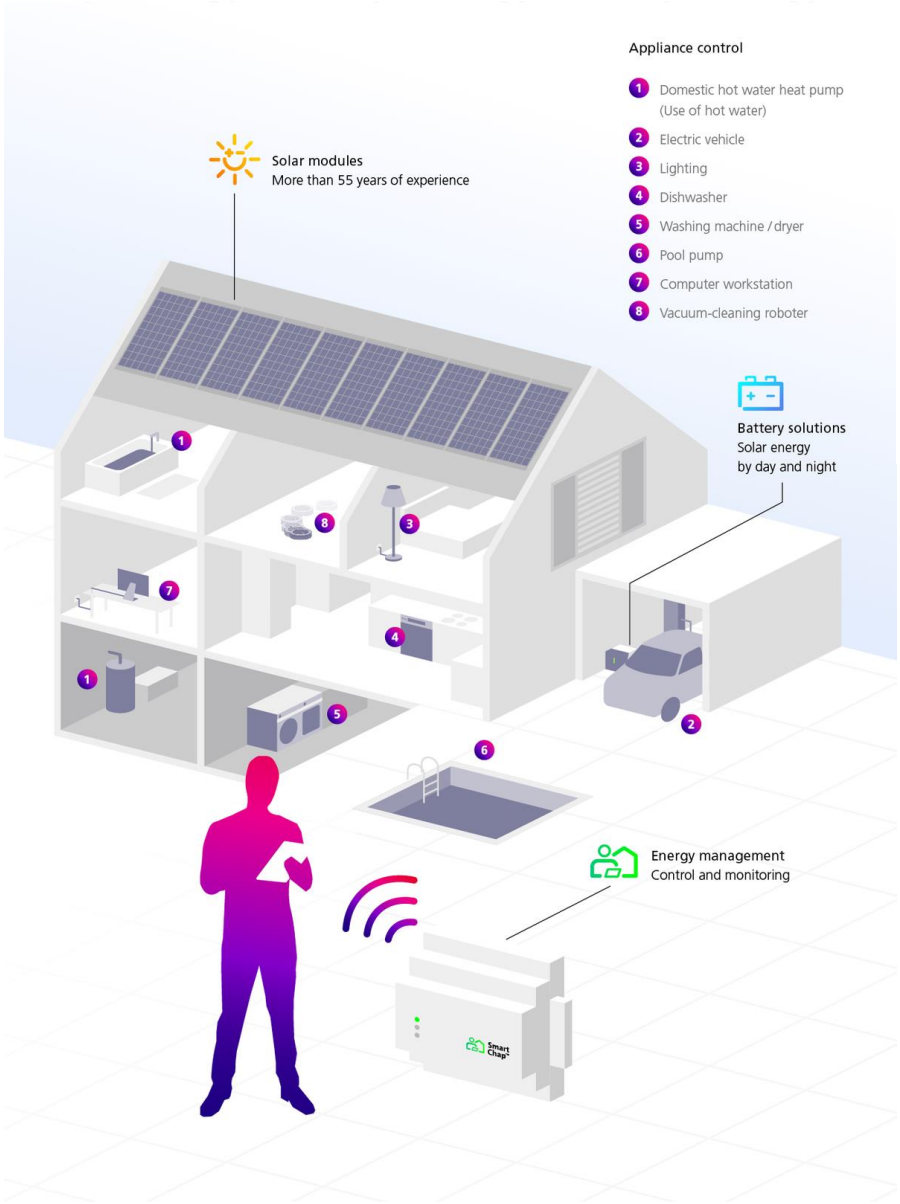
Combined policy

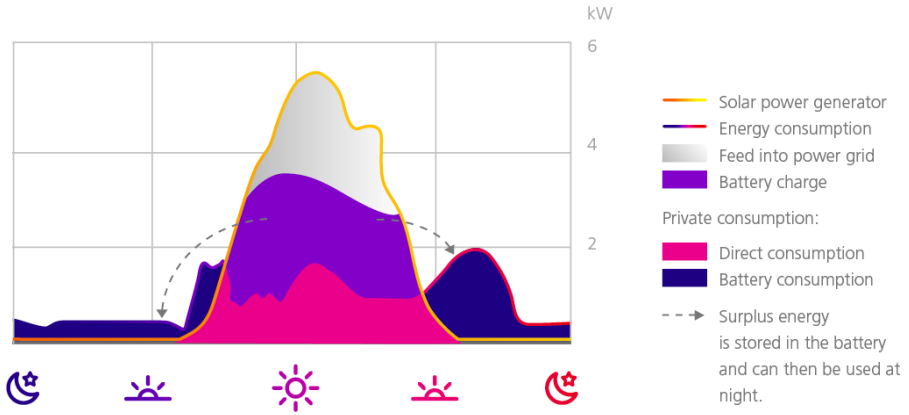
- Possible
- Intermediate
- Sensitive
- Showstopper

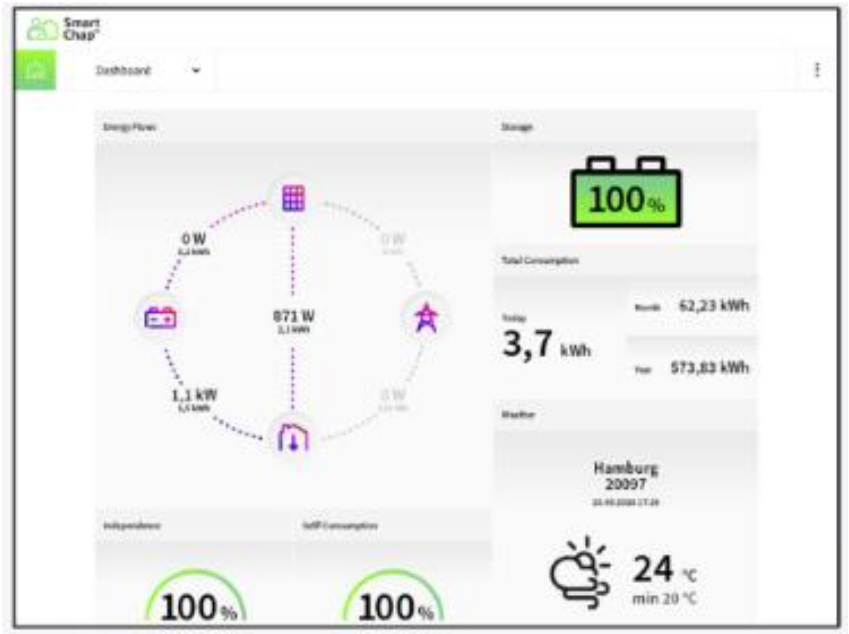




University of Strathclyde Engineering







Source: SHARP
http://www.sharp.co.uk/cps/rde/xchg/gb/hs.xsl/-/html/energy-management.htm

Conclusions

- A range of technologies are likely to present specific opportunities
- No magic bullet / no ‘one-size fits all’
- The promotion of district heating has a significant role to play
  - 3rd and 4th generation systems due to the lower heating requirements of modern and retrofitted buildings.
- Longer term? watch the development of low carbon heating fuel markets e.g. biogas, hydrogen.
- Heat technology selection is complex mix of efficient design, control and use.
- Consumer inertia barriers. customer awareness needed.
- Demonstrators and pilots are key
- Use trusted and experienced professionals to advise.

Research Outputs

Technologies to support Scotland's Energy Efficiency Programme

Innovation will be a key part of reducing heat demand through the delivery of Scotland's Energy Efficiency Programme (SEEP).

ClimateXChange commissioned research on the status of near-to-market energy efficiency, heat generation and smart technologies. The research will inform the Scottish Government on these technologies' potential suitability in SEEP. The three technology landscaping studies will feed into the Research and Development (R&D) workstream of SEEP. Ultimately, the application of emerging technologies will help steer the direction of SEEP as a long-term programme of investment.

Key findings:

- In collaboration with consumer organisations, SEEP can support energy and carbon savings from smart

Downloads

SEEP synthesis report
199kb pdf
Released: September 2017

Technology landscaping report
y
578kb pdf
Released: August 2017

Heat tech_scorecard summary
1mb pdf
Released: August 2017

Technology landscaping Repor
ncy Technologies
1mb pdf
Authors: Luke Smith, Thomas Whiffen
Released: July 2017

Technology landscaping report
821kb pdf

https://www.climatexchange.org.uk/research/projects/technologies-to-support-scotlands-energy-efficiency-programme/