BuroHappold Engineering Response to NIC call for evidence

Electricity interconnection and storage

Introduction

With the urgency of both the need for national energy independence and the need to make significant progress on avoiding climate change, several European countries have made commendable progress in terms of balancing supply and demand within an agenda for a low carbon future. Denmark has pioneered wind generation and integrated city energy infrastructure, over many years France has set in place extensive nuclear and hydro infrastructure, Germany has new bold plans for its energy transition or Energiewende. Spain and Italy are making progress too. A number of these countries are now not only addressing their internal energy issues but also are in fact exporting their resilient energy products and experience.

The UK has one of the best national carbon reduction commitments in the form of the 2008 Climate Change Act, which is further strengthened by the outcomes of Paris COP21. This act of law commits the UK to achieving an 80% reduction in CO_2 emissions from 1990 levels by 2050. This is tough, but it is founded on what needs to be done to limit global temperature rise by 2°C. This dictates carbon free power and heat by 2050 if not before.

There have been some quick wins, the 'dash for gas' in the 1990's cleaned up power generation to a certain degree until North sea gas production dwindled and prices rose. The last recession also helped to reduce demand. But the hard yards lie ahead. Renewable incentives in the form of Feed in Tariffs, Renewable Obligation Certificates and Renewable Heat Incentives have driven the implementation of renewables but: bio fuels, carbon capture, nuclear, energy storage and smart grid infrastructure are all technologies that take time to implement. In particular technology such as carbon capture is a pre-requisite in justifying long term investment in shale gas and redeveloping the abstraction of coal, but predicting when this can be successfully deployed is proving difficult and therefore cannot be relied upon in long term planning.

This is the Achilles heel, whereas other countries have strong strategy the UK energy strategy is weak, indecisive and heavily biased towards protecting the incumbent large scale generators rather than encouraging individual and community participation in local renewable power generation, a cornerstone in energy policy within several European countries.

The strategy vacuum forces bodies like the Energy Technologies Institute (ETI), National Grid and DECC to talk in terms of scenarios. For sure demand forecasting is subject to many variables, but one of those variables should not be trying to second guess national energy strategy!

The ETI boils its scenarios down to two; Clockwork, assuming that a strong top down energy strategy will emerge quickly and Patchwork which assumes that central strategy will remain weak and it will be local ground up action that will push us down the carbon reduction curve. The ETI states both are affordable in GDP terms but that patchwork is possibly more costly than clockwork.

If the UK is to hold true to the Climate Change Act there is a growing realisation that it will be local and regional patchwork activity that will get us there.

BuroHappold Engineering is a multi-disciplinary consulting engineering practice whose energy consulting group recently partnered with the Eden project to organise the Energy Island workshop. The goal was simple, to explore whether a collective approach to Cornish energy which makes the most of Cornish natural resources could significantly enhance economic benefit to Cornish people. The workshop involved over 150 experts and stakeholders and we have used this as our basis for evidence, we think that an island within an island would be a key study for further testing, and we are actively seeking partners, including government, to take this further.

Cornwall already generates 20% of its energy by renewable means. But the Energy Island workshop also highlighted the issues of a weak national energy policy. One of many examples that emerged over the two day workshop was that on sunny summer days Cornwall produces over 50% more electrical power than it consumes. To keep the grid stable this must be exported over the grid to meet demand further afield. Grid reinforcement to meet this transient power flow is extremely costly and time consuming (planning applications for new overhead lines can take over ten years). These costs must be met by seeking high connection charges for future solar power generation which in turn provides a degree of regulation of the deployment of solar power. Why can't these costs be used to incentivise an increase in seasonal demand?

It may sound counter intuitive to increase demand to lower emissions but perhaps diverting this investment by making cheap power available for seasonal industry or to increase the use of electric vehicles or to deploy greater storage could solve the infrastructure problem and enhance the performance of the local economy. The problem is right there, our regulated utilities are bound to minimise cost to the consumer, and stitching together sensible local solutions does not compute in the bureaucratic world of utility regulation. It creates a gap between the clockwork and patchwork strategies.

Significant structural and market reform in the energy sector is a necessity and it looks like it may well be the cities and regions, like Cornwall, who will demand and drive this change for the sake of their local economies.

The Cornwall Energy Island project identified the following relevant points:

Vision: Stories are powerful, and this story should be told consistently by Cornwall Council, the LEP, community energy groups, businesses investing in the region, and others, in the media and through publications and public speaking opportunities. This is relevant at a national level particularly when seen as part of a bigger economic regeneration initiative

Coordinated Leadership: There are many people leading the creation of Cornwall's energy future, as is the case across the UK. The involvement of a diversity of stakeholders, and the distributed nature of leadership is a strength, but greater data sharing and coordination is valuable. Coordination activities should be valued and resourced.

Infrastructure planning: Develop a detailed understanding of a future energy system in Cornwall to incorporate demand management, storage, generation and distribution. This study will inform a strategic plan alongside detailed research into the future management of these systems such as funding, legislation and ownership to address the issues of the status quo.

Funding: Ensure availability of development funding, address the cost of capital, interest levels on loans, and support small projects to access larger pots of funding through aggregation.

Policy and regulation: Remove barriers which drive distributors to undertake network reinforcement rather than storage solutions when faced with rapid increases in transient distributed generation and ensure future incentives are flexible and able to adapt in a predictable manner in the face of rapid changes in technology.

This response to the call for evidence is structured in the following way:

For each question, an introductory paragraph summarises our perspective. Below this, a series of paragraphs provide further detail explaining our analysis of the challenges faced by the current system, followed by bullet points outlining our recommendations for how to approach this.

1. What changes may need to be made to the electricity market to ensure that supply and demand are balanced, whilst minimising cost to consumers, over the long-term?

The electricity market needs to achieve all three pillars of the energy trilemma: sustainability, affordability and resilience. This means low carbon, as well as affordable costs to consumers and balancing of supply and demand. Minimising costs to consumers over the long term will include energy efficiency, and the electricity market can contribute to this through tariff structures that incentivise investment in efficiency. This could include time of use tariffs and rising block tariffs. with a focus on sustainability and low carbon, as well as affordability and security. Additionally, the electricity market needs to take into account the long term impacts of other parts of the energy system, including heat and transport, as these become increasingly electrified. Domestic heating and hot water systems can provide an electricity market role through storage of energy as heat in hot water tanks and the fabric of buildings. This can make a substantial impact in peak electricity demand and the ability for demand side management to provide flexibility. Multi-vector energy planning is therefore needed, not isolated electricity market planning. Implementing building and behavioural changes requires action by many individuals and local activity, and devolution provides an opportunity for local authorities and community energy groups to make a substantial contribution. The design and deployment of smart metering should support this, to ensure maximum effectiveness of embedded generation and demand-side management measures.

To what extent can demand-side management measures and embedded generation be used to increase the flexibility of the electricity system?

1. **Multi-vector energy planning is needed for greater flexibility.** Conversion of energy between different forms will be of growing importance to meet the challenges of balancing supply and demand in an efficient manner, including through demand side flexibility. The electricity market should therefore be considered in the context of multi-vector energy planning, including heat, gas (including natural gas, synthetic methane, and hydrogen as a means of storage), chemical energy (in fuels and batteries) and transport fuel. This requires systemic thinking. Heat is on the way to being electrified which will cause significant changes to the electricity market driving up prices. Electrifying heat will lead to substantial seasonal variations in demand, tripling loads on the electricity system which will need to be sized to deal with a few cold days per year - quite the opposite to better balance between supply and demand. Transport is also being electrified, with similar consequences to heat.

- Ensure that regulation of energy markets supports optimisation of use of different energy vectors, through systemic thinking.
- Energy efficiency, electrification of heating and transport, use of gas, heat and other energy vectors and demand response are interrelated with electricity market. The development of the electricity market should therefore support effective uses of the interfaces between these.

2. **Use of more innovative tariff models**[1]**:** Currently tariffs are structured so that domestic customers do not pay for the cost of balancing supply and demand. With the installation of smart meters there is an opportunity to change this. Local and social tariffs could also be used to support the business case for investment in energy efficiency whilst ensuring affordability for vulnerable consumers. Tariffs currently provide cheaper electricity to those who use more, and more expensive electricity to those who use less. This could be changed with rising block tariffs, which are used in many countries around the world. .
    - Explore the potential for tariff structures to incentivise demand reduction (e.g. rising block tariffs) and demand response (time of use tariffs, critical peak pricing), whilst ensuring affordability of basic energy needs e.g. warmth, lighting and cooking.

3. **Demand response and smart meters**: The current capacity market favours emergency generation (diesel generators) over demand response. The roll out of smart meters provides an opportunity for
    - Use capacity market mechanisms to incentivise new and low carbon forms of balancing capacity, through demand response at all scales, and electricity storage, rather than to support diesel and existing fossil fuel generators.
    - Accelerate deployment of smart metering and facilitate market in terms of incentivising intelligent demand management
    - Encourage the demand response aggregator market, learning from the US market.
    - Encourage domestic demand response through domestic aggregators combined with time of use or similar tariffs.

    Maximise the effectiveness of smart meters by designing new buildings to be 'smart-grid ready' - through existing Building Regulations, considering the interfaces between electrical and heating systems, including dual fuel heat, gas and heat networks with heat and electrical storage capacity.

4. **Devolution and electricity market flexibility:** this provides an opportunity for integrated delivery of multiple energy services at a local level, where local energy markets could make use of flexibility in heat, transport, gas and electricity systems to achieve balancing in each. Integration of local energy system delivery can also include demand response, network investment, and community engagement. Local ownership through devolution provides an opportunity to experiment at a local scale, with innovation resulting from diversity of initiatives across the country, particularly if supported by peer to peer knowledge sharing and learning.
    - Local energy markets: provide regulatory space for regional and local experimentation in energy markets, e.g. in Cornwall building on the foundation of the Cornwall Energy Island project. This should be an energy market that includes all energy vectors, and the potential to manage heat, transport, heat networks, electricity generation, storage and demand management within one locality. Local market mechanisms would allow a variety of local stakeholders to participate, including SMEs, social enterprises, national businesses, community energy groups and the local authority.
    - Area based smart meter deployment is needed to provide the technical foundation for local energy market innovation[2].
    - Smart meters should be designed to support third party access to data, and facilitate community energy initiatives. Community projects can substantially increase people's engagement with demand response and energy saving[3].

2. What are the barriers to the deployment of energy storage capacity?

Storage of electricity is essential to enable greater integration of renewable generation, and balancing of the increased electricity demand peaks which would be caused by electrification of heat and transport. Ownership and operation of storage should be considered systemically so as to optimise deployment and viability of renewable generation, grid

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[1] https://www.cse.org.uk/downloads/reports-and-publications/policy/pub1111.pdf

[2] https://www.cse.org.uk/downloads/file/towards-a-smart-energy-city-maping-path-for-bristol.pdf

[3] http://smartcommunities.org.uk/

reinforcement, interconnection and demand response. Storage also needs to be considered in relation to multi-vector energy management: storage of heat in domestic hot water tanks and the fabric of buildings can make a contribution alongside electricity storage technologies. Regulation does not currently support deployment of storage, wrongly classifying it as generation. Storage is required over a number of timescales and geographical scales, leading to potential conflicts between different demands on storage facilities. These need to be better understood in order to make efficient use of storage.

Are there specific market failures/barriers that prevent investment in energy storage that are not faced by other 'balancing' technologies? How might these be overcome?

What is the most appropriate scale for future energy storage technologies in the UK? (i.e. transmission network scale, the distributed network or the domestic scale.)

1. **Classification of storage as generation:** electricity storage does not have a separate regulatory classification, and is classified as a generation asset by default. Additionally, DNOs are required to avoid distortion of competition in generation and supply, which restricts buying and selling of electricity as part of operation of storage, making the business case more complicated as third parties need to be involved[4]. DNOs are well placed to own and operate storage for the purposes of ancillary grid services, and in Cornwall WPD would be very keen to take on storage assets, which could release grid capacity for further connection of renewable generation.
    - Regulation should create a new category of energy storage, so it is not classified as generation
    - DNOs should be allowed to buy and sell electricity to charge/discharge storage, and invest in storage without requiring complex third party commercial and contractual arrangements.

2. **Potential conflict between different services provided by storage:** electricity storage could provide services at multiple timescales and geographical scales, and to multiple parties: to DNOs, to TNOs, to suppliers, to generators. Business models for electricity storage require revenue from multiple services, but there may be conflicts between requirements of different parties at certain times. The extent to which this is an issue is not well understood, and should be tested. Dialogue between parties relying on storage services, and regulation of priority levels may be required to ensure grid reliability is not compromised by conflict between different requirements for storage.
    - Invest in modelling and piloting of use of electricity storage to provide multiple ancillary grid services, to better understand the extent to which there can be conflict.
    - Facilitate dialogue between different parties using storage facilities to support

3. **Multiple geographical scales are required:** including domestic, distribution network and transmission network scale. These need to be operated in such a way that activity at each scale supports the needs of other scales: e.g. domestic operation of storage should be operated to minimise negative impacts of distributed generation and demand peaks on the local distribution network, and local distribution network operation of storage should be operated so as to enable greater deployment of distributed generation, electrification of heat and transport, and support national balancing of supply and demand. The Cornwall Energy Island project considered the potential for nested optimisation of generation, storage and demand at the local, Cornwall and UK levels (see Figure 1).
    - Design tariffs and distributed generation incentives to maximise self-supply and local (domestic or demand side) storage operation to serve distribution and transmission requirements
    - Enable innovation and experimentation at the local level through devolution and geographically specific implementation of storage by local area. This could be supported by allowing local energy market development, including whole-system approaches (storage, smart meter deployment, generation and supply) to be trialled at a local level.
    - Make it easy for commercial customers with generation assets across multiple sites to 'self supply' and benefit from balancing their own supply and demand in real time through some form of licensed supplier status or 'net portfolio metering' e.g. many local councils operating heat networks and CHP / solar have energy consuming assets.

[4] http://poyry.co.uk/sites/www.poyry.co.uk/files/smarter-network-storage-lcnf-interim-report-regulatory-legal-framework.pdf

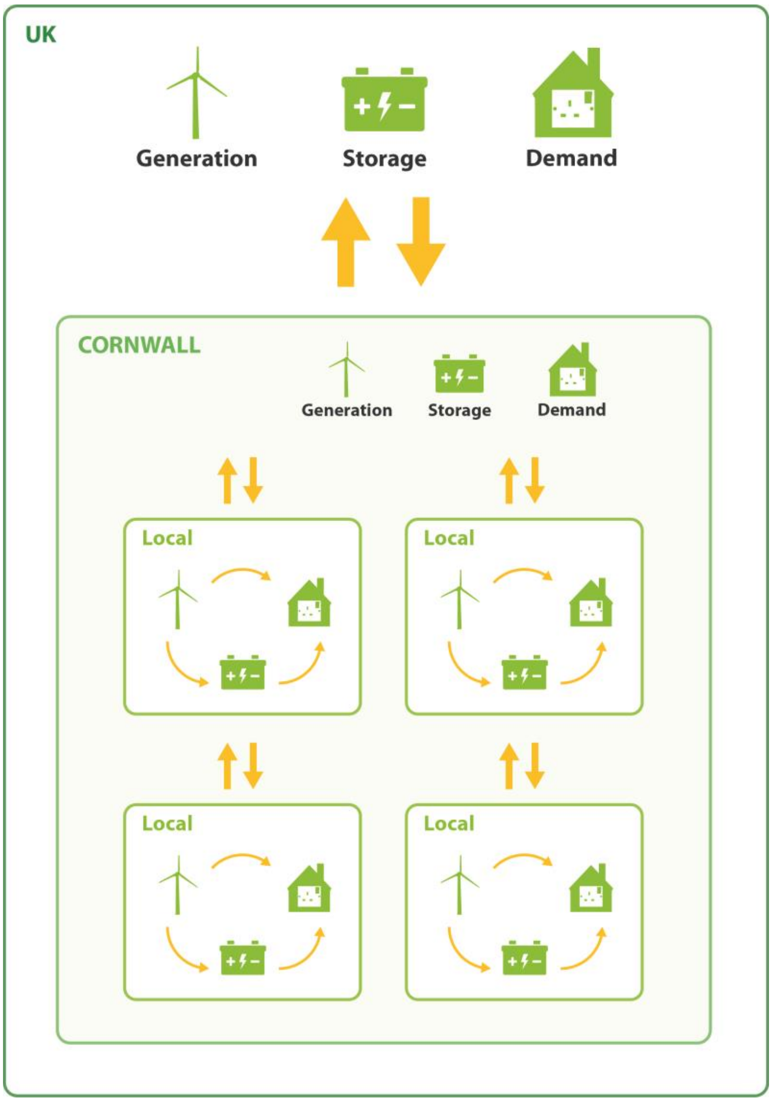

Figure 1: Nested optimisation of generation, storage and demand management at the local, Cornwall and UK levels

3. What level of electricity interconnection is likely to be in the best interests of consumers?

Interconnection can support balancing of supply and demand of electricity in a number of ways: through making use of geographical differences in natural energy resources (e.g. pumped storage, compressed air storage, variable and dispatchable renewable energy generation), differences in weather over larger distances increasing the balancing of wind and solar power, and differences in timings of peak demand between countries. Interconnection also has a role in enabling export of power. The UK is particularly well placed for offshore and onshore wind power, as well as marine energy technologies. Interconnection can ensure that these resources can be exported to benefit the UK economy.

Network development within the UK is also important. The Cornwall Energy Island project imagined the national grid connections from Cornwall to rest of England as 'interconnectors', which need to be reinforced so that the Cornish economy can benefit from export of electricity to the rest of the UK, and contribute to the wider goals of the UK Climate Act and EU renewable energy targets.

Is there a case for building interconnection out to a greater capacity or more rapidly than the current 'cap and floor' regime would allow beyond 2020? If so, why do you think the current arrangements are not sufficient to incentivise this investment?

Are there specific market failures/barriers that prevent investment in electricity interconnection that are not faced by other 'balancing' technologies? How might these be overcome?

1. **Systems thinking:** Interconnection should be understood as part of a whole energy system:
    - Use of interconnection to increase UK electricity resilience, with a focus on export and ability to be independent rather than reliance on other countries for balancing the UK system. Internal energy supply should be prioritised before relying on interconnection.
    - Existing interconnectors are operated according to market signals, and it is therefore difficult to rely on existing usage to model the potential contribution of interconnectors to balancing and energy security[5]. This requires research.

2. **Long term framework:** infrastructure investment should consider the long term:
    - Invest in interconnectors ahead of demand as enabling infrastructure to support long term investment in Atlantic and north sea wind generation

3. **Nested model:** Consider interconnection internationally as analogous to connections between regions within the UK.
    - Regions such as Cornwall can be operated to be as self-sufficient in energy as possible locally, whilst contributing to the wider UK system
    - In particular, electricity infrastructure development should consider the evolving roles of the rural and urban areas, which have changed since the electricity network was initially designed, with the rise of high rural generation of renewable energy, as well as urban distributed generation, increased demand, and potential for demand response.

4. What can the UK learn from international best practice in terms of dealing with changes in energy technology when planning to balance supply and demand?

Planning to balance supply and demand must involve consideration of demand reduction and management. Future sustainable energy scenarios in the UK and internationally rely on ambitious demand reduction to achieve balancing[6], a finding supported by our regional level work in the West of England and Cornwall, which modelled a 50% reduction in demand to achieve an energy island. The UK has the least energy efficient building stock in northern Europe. Energy efficiency should be established as a national infrastructure priority, and the business case for investment in demand reduction should be supported through appropriate pricing and tariff arrangements. The rate at which technology is changing, particularly in the area of decentralised generation is forcing reactive change in both physical infrastructure and incentive programmes, for example the rapid reduction in cost of solar PV since the introduction of the Feed in Tariff. The implementation of relatively mature technology such as thermal insulation, smart metering and demand management should be accelerated. The development of 'game changing' technology such as economically viable bulk storage and carbon capture appears difficult to predict. The use of Shale Gas should only be developed with a strong commitment to renewables and low carbon technologies[7].

1. **Stable and clear energy policy goals:** UK energy policy is currently moving against the global trend to distributed generation as costs for wind, solar and storage continue to fall whilst costs for large power stations, continue to increase well above the rate of inflation, leading to higher costs for consumers. Having a clear and consistent policy direction in Germany, with the Energiewende, has driven innovation and activity. The Climate Change Act 2008 puts the UK in a potentially strong position by setting out very clear goals with respect to CO_2 emissions reductions, but recent policy changes have reduced investor confidence and the ability to respond with agility to changes in technology.
    - Make a clear commitment to a direction of travel that is low carbon, resilient, and affordable.
        i. minimising dependence on fuel imports (including nuclear?)
        ii. Clear statement on nuclear
        iii. Informed long term planning with respect to Climate Change Act

[5] http://erpuk.org/wp-content/uploads/2014/10/52990-ERP-Energy-Storage-Report-v3.pdf

[6] http://www.demandenergyequality.org/2030-energy-scenario.html

[7] https://www.taskforceonshalegas.uk/news-and-events/task-force-on-shale-gas-launches

    iv. Cost/medium term viability of carbon capture and storage as a prerequisite for shale gas development

- Assess long term impacts on bills of infrastructure investment (grid reinforcement) and renewables (long term fuel-prices etc.), taking into account impact of existing tax breaks and subsidies for fossil fuels.
- Prioritise affordability of basic energy access for households, particularly those in fuel poverty
- Address the impacts on energy costs of:
    i. Future fuel price instability
    ii. Decreased load generation load factor arising from increasing proportion of non-dispatchable generation (which may change if storage situation improves)

2. **Demand reduction:** the UK has the least energy efficient building stock in northern Europe. Building space heat demand remains a dominant energy demand with its seasonality adversely affecting energy generation and transmission load factor. If space heating is electrified as part of energy system decarbonisation, this will further exacerbate the impact on plans to balance supply and demand for electricity. Green deal has not been successful, but the goal of improved thermal performance of domestic buildings remains an infrastructure priority, and progress in other countries has demonstrated that significant demand reduction is practical with current technology. More broadly, other countries have taken a strategic approach to encouraging building energy efficiency and demand reduction as a key element of energy systems planning:

    Performance-based incentives - these have been used to encourage technical innovation in the energy efficiency market whilst being flexible about how the target is met. Good examples include the NABERS scheme in Australia or the domestic energy efficiency market in Germany where the availability of low cost loans was linked to the specific targets being achieved.

    Investor confidence - UK investment in energy efficiency and small scale renewables has been undermined by abrupt changes to the policy regime (e.g. FIT, ECO, Zero carbon Homes) resulting in dramatic collapse of the supply industries (e.g. Mark Group, Climate Energy) and undermining of confidence for investing in this sector or the development of new business units within established companies. Other countries have encouraged businesses to invest their own capital in developing new technologies and business models through providing long term investor confidence.

    Low cost finance - other countries have provided financial support mechanisms that are technology-neutral but sufficiently long term and low cost as to stimulate a range of technologies and projects to emerge. Good examples include low interest energy efficiency funds from the German Development Bank KfW and revolving retrofit guarantee funds in Hungary. Whilst the Green Investment Bank has an important role to play in crowding in finance and recycling capital for target sectors (e.g. energy efficiency, waste, offshore wind), state aid limitations have prevented it from achieving the same impact that KfW has managed to achieve.

    - Establish energy efficiency as a national infrastructure priority - Government should invest in energy efficiency as a national infrastructure priority and realise the strong macroeconomic benefits that have been clearly articulated in reports by reputable experts including Cambridge Econometrics. These include tax returns to the exchequer, job creation, regional economic growth, reduced spend on health, improved energy security and cost-effective achievement of carbon targets.
    - Create a demand reduction roadmap - Establish a clear road map for supporting demand reduction and energy efficiency including targets, milestones and support mechanisms.
    - Reform energy pricing within other European countries suggest pricing can be raised through taxation to both incentivise demand reduction and fund demand reduction programmes focussed on those in energy poverty. Tariff structures such as rising block tariffs could further support this.
    - Develop clear policy and structural incentives to stimulate investment in energy efficiency. The UKGBC consultation response on “Reforming the business energy efficiency tax landscape” provides a good reference point for the qualities that need to be achieved, including:

i. Transparency – the final policy mix should make it easier for participants and external stakeholders to understand how their energy performance compares to their peers and to invest accordingly
ii. Visibility – the drivers for action under the new landscape must be clear and visible, so that they attract the attention of senior decision makers
iii. Consistency – as stated above, creating a new regime that is has longevity is absolutely critical. It should be consistent with the UK's long-term climate and energy needs, to avoid the risk of near-term changes disrupting investment.
iv. Ambition – as stated in the consultation document, the final landscape must improve the business case for investment in energy efficiency if we are to deliver a more productive, efficient, low carbon economy. It is extremely unlikely that simplification alone will achieve that aim.

The UKGBC Retrofit Incentives task group evaluated a series of potential mechanisms for the non-domestic sector including variable Stamp Duty, Council Tax and Grants.

3. **Heat supply:** heat networks predominate in many Northern European cities. They are a long term investment, and although the argument can be made that thermal transmission losses negate efficiency benefits in central heat generation, they allow: flexibility to change heat generation to suit: evolving technology; tightening carbon reduction targets; and periods of surplus energy production – e.g. wind energy to heat; as well as access to waste heat sources and reduction in seasonal electrical demand.
    - Increase support for public (through local authority) development and ownership of integrated utility distribution networks (particularly heat)
    - Repurpose bodies such as the Green Investment Bank to provide competitive finance for publicly owned distribution networks

4. **Bulk energy storage vs carbon capture and storage** – the development of these technologies appears slow and is under supported in the UK. Other northern European countries do not predicate the success of their medium term (10-20 year) energy strategy on the success of this technology. This partially due to a desire to limit dependence on fossil fuel importing but nevertheless significantly greater emphasis is being placed on integrated bulk energy storage in other countries.
    - Set required deployment dates for bulk energy storage and carbon capture and storage against Climate Change emission reduction.
    - Set in place decision dates at which point deployment of an alternative approach is necessary if evolution of required carbon capture and storage or bulk energy storage technology appears unable to meet target deployment dates.