Local Energy Masterplan

- *a combined and developed approach*

Summary

Multiple community, data and policy methodologies were combined and further developed as a single approach to local energy master-planning. This built on existing publically accessible data approaches. The approach was developed with a practical settlement and its community. Validation and lessons are included to support further development.

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Burntisland Local Energy Masterplan – Methodology Paper

1. Report overview

This report presents the methodology used to develop the Burntisland Local energy masterplan.

The findings of this project are presented under the following headings:

1. **Report overview**;
2. **Context**;
3. **Methodology**;
4. **Community engagement**;
5. **Data collection and modelling**,
6. **Baseline;** including geographic scope and calculating energy demand;
7. **Energy demand results** summary of energy results
8. **Energy efficiency measures;** (including economic assessment of each and comparative assessment of whole town scenarios;
9. **Moving and storing energy;** (including economic assessment of each and comparative assessment of whole town scenarios;
10. **Low carbon energy generation;** (including economic assessment of each and comparative assessment of whole town scenarios;
11. **Policy**; policy implications and weighted spatial analysis
12. **Property archetype data validation exercise**
13. **Transport energy;**
14. **Evaluation and lessons learned**; and
15. **Project reporting**;

Appendix

With grateful thanks to our funders and supporting organisations for the development of the methodology and Burntisland Local Energy Masterplan.

Introduction

The way we generate and use energy has constantly changed. In recent decades it has become the role of the National Grid, gas network, and multinational energy companies to deliver nearly all the energy: heat, electricity and transport fuels. We interact with energy via familiar light switches, gas boilers and petrol stations. In the future, delivery of and demand for energy in Scotland will be transformed. The Scottish Government's ambition is to see an increasing number of new sustainable energy and district heating networks developed across the country to make the best use of natural energy sources including unused and renewable heat. This can help cut carbon emissions, reduce fuel bills and combat fuel poverty. Energy Masterplanning can assist developers and local authorities plan this process better, provide for 'future proofing' for communities and assist in using energy more efficiently.

Many of the choices that impact on this wider energy transition are made locally. These energy choices are made by local people, local business, and collectively through local communities and by local government. It is recognised that we all need to start planning today for the coming decarbonisation of our energy systems, and to ensure that communities can transition away from fossil fuels and toward sustainable energy systems, in a managed approach and in a manner which maximises the benefits to local communities. Councils are central to this mission and are now increasingly involved in planning local energy systems and ensuring that local decision making and ownership is at the centre of the new energy paradigm that is emerging in Scotland. It is recognised that future energy systems have to be based within a community instead of outside of it. This is a whole new world of working, thinking and delivery for everyone; from national Government, Local Authorities, Community Councils, infrastructure providers, to utility companies and local communities.

There are a lot of questions facing stakeholders when they consider this topic:

- What does a local energy system look like? One local system may be different from another. What do they have in common? What factors will necessitate differentiation in different locations?
- All may have different finance and ownership models. How can they all work together? How can we ensure that community benefits and ownership is maximised under different finance and ownership models?
- What type of energy systems do we need to future-proof us against the twin challenges of climate change and energy security?
- How can we plan now for the energy transition that Scottish Government believes that the whole country needs to undergo?

Fife Council believes that many of these questions can best be answered by trialling the Community Energy Masterplanning process in partnership with a local community. Successful energy Masterplanning requires a lead organisation with a commitment to bring stakeholders together, promote, develop and subsequently adopt and help deliver the energy masterplan. Fife Council is keen to maximise the opportunities that can arise from the process, for the benefit of communities across Fife.

One of the key objectives within the Fife Community Plan is the need to reduce carbon emissions and create a healthier fairer Fife for all. Fundamental to this will be engagement with communities around their energy consumption and supply. To facilitate this Fife Council are developing a Sustainable Energy Climate Action Plan (SECAP) for Fife. This will potentially include local energy masterplans as a tool for integrating energy and climate solutions into local community planning. This trial was designed to help us to do that. It is anticipated that the lessons learned within this project will be able to be replicated with local communities across Fife.

The purpose of this project is to develop a Local energy masterplan for Burntisland for the local community and council to better understand local energy needs and how it could be supplied locally in a low carbon manner. It aims to reflect the community's priorities and support its transition to becoming a low carbon, high resilience settlement. The document will then be reviewed as part of the local planning process to help guide proposals and policies influencing Burntisland.

This pilot project worked in partnership with the local community in Burntisland, Fife, with the aim of reducing fuel and mobility poverty and reducing carbon emissions. Through a series of consultation meetings and workshops we mapped the 'whole energy system' for Burntisland looking at heat, electricity and transport options including storage opportunities. The project brought in external expertise to enable the community to understand their energy demands (using the heat map and other developed tools) and to work collaboratively to map agreed low carbon solutions

The priorities and ideas contained within the Local energy masterplan were developed by the local community. The main output from this project is the creation of a local Energy Masterplan for Burntisland to support the development of a locally-planned sustainable energy system. As part of this, the following topics have been considered:

- Demand side management options for Burntisland;
- Delivering renewable heat and electricity to customers in Burntisland;
- Linking local energy demand with local renewable energy generation; and the potential for co-location / combining technologies for example wind and solar
- Energy storage potential in Burntisland; and
- Sustainable travel options for Burntisland.

The transition to a low carbon economy and energy system will have multiple benefits beyond just reducing carbon emissions. We aim to enable the following outcomes following the development of a Local energy masterplan for Burntisland:

1. The local community will benefit (once projects within the Energy Masterplan are implemented) from secure, affordable, low carbon heat, electricity and transport options.
2. Locally owned energy systems can strengthen local communities by providing an income from local renewable energy generation, improving community empowerment, resilience and cohesion;
3. Reduced fuel poverty by reducing energy demand and providing affordable energy, locally;
4. Improved local air quality leading to health and wellbeing benefits within Burntisland;
5. Improved local understanding of energy and climate change and inspiring others about what can be achieved when communities work together;
6. Reducing carbon emissions – showing that communities can take ownership of, and develop local solutions to this global problem;
7. Experiential and learning benefits - the process of developing a Local energy masterplan for Burntisland has taught all involved, valuable lessons on how best to deliver Energy masterplans which emphasise community decision-making and ownership options..
8. This knowledge and learning will enable us to bring benefits to other local communities and it is hoped that this will inspire other communities to follow Burntisland's lead.

2. Context

The Scottish Government recognises that the twin challenges of climate change and energy security in an increasingly uncertain world, will force Scotland to look at energy in a different way. As the natural gas reserves in the North Sea and fossil fuels in general become more difficult and expensive to exploit, and as carbon emissions regulations have become more stringent, there is increasing focus on changing how heat and power is provided to homes and businesses. To this end, the Scottish Government's new draft Energy Strategy and new draft Climate Change Plan were launched in January 2017 and represent the basis by which the Scottish government is moving beyond old energy paradigms and is seeking to replace them with something more fit for the future. Furthermore the Community Empowerment Act and the Land Reform Act, mean that there is also increasing legislative focus on communities having more say and ownership around local energy issues.

Other supporting guidance and legislative instruments in this area include: The Climate Change (Scotland) Act, 2009; the Electricity Generation Policy Statement, 2013; and the 'Heat Policy Statement – Towards Decarbonising Heat: Maximising the Opportunities for Scotland', 2015; all of which outline the ambition to move towards a fully integrated energy approach in Scotland. In these policy documents the Scottish Government has published targets for decarbonising the heat and electricity sector including:

- 80% reduction in greenhouse gas emissions by 2050;
- Total final energy consumption in Scotland reduced by 12% by 2020;
- Meeting at least 30% of overall energy demand from renewables by 2020;
- A largely decarbonised heat system by 2050, with significant progress made by 2030;
- Source 11% of heat demand from renewables by 2020;
- Providing 80% of domestic heat by low-carbon technologies by 2032;
- Decarbonising all buildings in Scotland by 2050;
- Delivering an equivalent of at least 100% of gross electricity consumption from renewables by 2020;
- Electricity generation will be almost entirely decarbonised by 2025 through a mix of energy generation technologies, with negative emissions i.e. carbon capture and storage and gas from plant material and biomass waste from the late 2020s onwards;
- An increased reliance on electricity to heat homes and power vehicles; and
- An overall target of 1.5 TWh of heat to be delivered by district heating by 2020; and 40,000 homes to be supplied with low cost, low carbon heat through heat networks and communal heating by 2020.

These are an ambitious set of targets and will require investment in both energy demand reduction and in energy infrastructure.

In recent years, Scotland has moved progressively away from traditional models of centralised energy provision and passive consumption. Scottish companies and communities have pioneered the development of innovative local energy systems. In particular, the desire for renewable generation in areas of constrained grid capacity, thereby limiting export potential, has driven remarkable innovation in technology, systems, business and engineering models for local provision[1]. With the creation of local solutions to meet local needs –decentralised or distributed energy systems – there is the potential to create vibrant local energy economies. Heat, electricity

[1] Draft Energy Strategy, 2017 http://www.gov.scot/Resource/0051/00513466.pdf

and storage technologies combined with demand management and energy efficiency measures on an area-by-area basis, could realise substantial local economic, environmental and social benefits.

Through the Scottish Energy Strategy, the Scottish Government is committed to supporting the development of local energy economies as part of a varied and proportionate response to the challenges brought by the transformation of Scotland's energy system. The Scottish Government is also committed to making significant investment and employing targeted regulation to make Scotland's buildings near zero carbon by 2050.

Decarbonisation will not just reduce overall energy demand, there will also be a change in the types of energy used to perform various tasks. Increasingly there will be a greater use of electricity for tasks that are today carried out by other fuels (i.e. gas, diesel, petrol). The draft Climate Change Plan pathway shows that electricity demand could increase by approximately 30% in Scotland as a result of further electrification (as heating and transportation needs are increasingly met by electricity). To accommodate this increase, the flexibility and efficiency of the electricity system will be of increasing importance as well as the resilient supply of electricity throughout Scotland. Scotland has been at the forefront in experiencing and meeting network challenges that are a result of decarbonisation and decentralisation.

The Scottish Energy Strategy sets out a whole-system view of energy policy, examining where our energy comes from and how we use it – for power (electricity), heat and transport. This integrated approach recognises the interactions and effects that the elements of the energy system have on each other. A new 2030 'all-energy' target for the equivalent of 50% of Scotland's heat, transport and electricity consumption to be supplied from renewable sources, demonstrates the ambition of this system-wide approach.

While we have a proud legacy of community energy projects in Scotland, what we think of as community energy is now shifting towards new models designed to be viable in a more difficult market (as the UK government strips away the support mechanisms for renewable energy). Not only does this mean a shift towards shared ownership (of commercial schemes), but also a broadening of policy scope towards smart local energy systems using non-traditional business models - and innovation in energy tariffs to offer different kinds of value to consumers of locally generated energy. With a focus on local energy, Fife Council agrees with the Scottish Government's view that we can help tackle some of our most pressing issues, from security of supply, to demand reduction, making energy supplies more affordable for households and businesses, and to stimulate regeneration and local economic renewal.

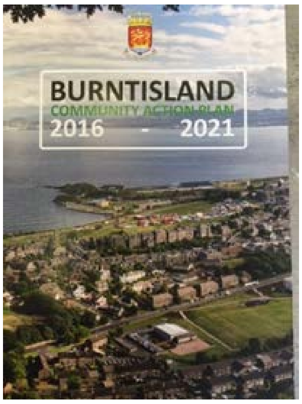
We sought to investigate the feasibility of employing a whole system energy approach to one settlement, and seeing how we could meet the 2030, and 2050 targets for decarbonisation, with a real world example. This project investigates the development of one such local energy economy, that of Burntisland in Fife.

Why Burntisland?

Burntisland was chosen as the pilot location for the project for the following reasons:

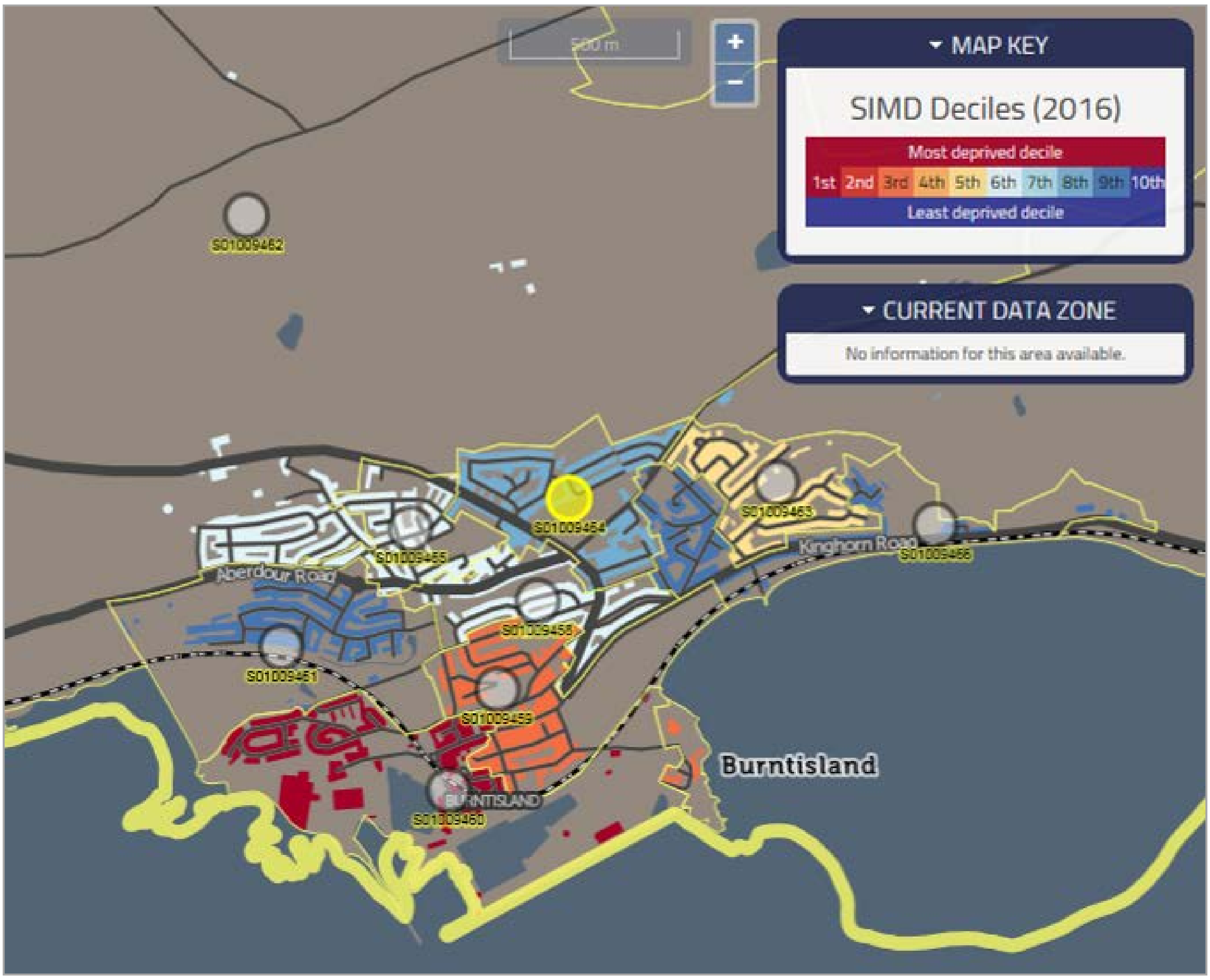
1. A previous invite to Resource Efficient Solutions to participate in the launch of the Burntisland Community Action Plan demonstrated that the community were keen to be involved and were enthusiastic about local energy;
2. Burntisland, in many ways represents a typical Scottish community and experiences problems typical to many settlements around the country (an aging population, wide demographic mix, de-industrialisation, rise of internet shopping threatening the local High Street);
3. Local energy is not a new concept for the town, historically Burntisland was an important coal port, and produced shale oil at the works at Binnend.
4. The town is sited in such a way that there are a wide range of renewable energy opportunities (i.e. coastal, south facing etc.). Burntisland is also small enough to turnaround an engagement project within a short timeframe unlike the larger Fife towns of Kirkcaldy or Glenrothes.

The initial idea for the energy masterplan project was made through the Burntisland Community Council who invited REFSOL to the launch of their Community Action Plan in May 2016. Their Action Plan included sustainable travel and renewable energy aspirations and there was real enthusiasm to develop these ideas further through the creation of an energy masterplan. REFSOL officers then met with the newly established Burntisland Community Development Trust (BCDT). It was this group that committed to a collaborative project to develop an energy masterplan for the Burntisland community, and which has been an active partner throughout. The BCDT hopes to work alongside other partners to help guide community energy projects from the drawing board, to implementation when the pilot phase of the energy masterplan project concludes at the end of March 2017.



Burntisland is a small seaside town located on the Firth of Forth, in mid-Fife, 6 miles west of Kirkcaldy between Aberdour and Kinghorn. The settlement is located on a south facing slope that runs between the Binn hill, and the Forth coast, with open views across the Firth of Forth to Edinburgh and the Forth road and rail bridges. Burntisland has a picturesque setting and much of the appeal of the town comes from its proximity to beautiful natural features. Historically Burntisland was an important transport link within eastern Scotland. The town used to be the ferry port for crossing the river Forth over to Granton prior to the Rail and Road Bridges being built. A ferry point and crossing was resurrected in the 1990's as a trial, but failed to become financially viable. While the town is no longer a major transport node, Burntisland is serviced by train and bus transport links today. The town's train station is on the main East Coast rail network and benefits from regular services to and from Edinburgh and around the Fife circle (although there are limitations on its use because of a lack of stair-free northbound access at Burntisland station). Buses also link the town to Kirkcaldy and Dunfermline. Key road transport routes include relatively easy connection to the trunk-road network (the A92) and the A921 which runs through Burntisland from Kirkcaldy and onto Aberdour.

The population of Burntisland is around 6,600 and has grown significantly over the last 15 years. There are around 3,200 households in Burntisland, compared to just over 2,500 in 2001. This growth has largely been due to significant new-build development, particularly on the site of the former Alcan Aluminium factory in the west of Burntisland, which has brought many new families to the town. There is further housing development planned on several sites in the town including on the site of the old primary school. The latest figures available for 2013 show a population growth of 16.74% since 2001, compared to a growth of 5% for Fife over the same period, and 4.6% for Scotland up till 2011. The greatest growth has been in the population of children, and the over 60 age groups. Burntisland is, in many ways a typical Scottish community. The settlement contains a mixture of demographic groups, and while there are affluent parts of the town there are also pockets of serious deprivation. The map below illustrates the demographic makeup of the town as defined by the Scottish Index of Multiple Deprivation 2016.



Source: SIMD (Scottish Index of Multiple Deprivation, 2016)[2]

It reveals the broad demographic mix seen in the town, and highlights that the south-west of the town (primarily the Castle Estate) is ranked as being in the most deprived decile of communities within Scotland (i.e. the top 10% in terms of deprivation rankings). Initial investigations lead us to believe there may be as many as 1,300 homes in fuel poverty in the town, many of which are located in the most deprived parts of the settlement.

Burntisland has a strong industrial heritage but the major industries on which the town was based, historically, have witnessed serious decline in the last half century. Major industries which were formerly located in the town include:

- From 1918 to 1969 Burntisland was known as a ship building port, however, local industry has declined and ships are no longer built here,
- the Grange distillery started as a brewery in 1767 and was still used as a warehouse until 1987,
- a ‘Coal Port’, unfortunately this has demised alongside the once prosperous Fife coal industry.
- the shale oil works at Binnend,
- the vitriol works and the limekiln at Lammerlaws, and
- The British Alcan plant (previously British Aluminium, which closed in 2002 after 85 years of operation in Burntisland).

[2] http://simd.scot/2016/#/simd2016/BTTTTTT/14/-3.2424/56.0629/

Today Burntisland's economy is characterised by a retail and service centre (centred on the High Street) which features a good selection of independent shops, cafes, fast food outlets, pubs and other service businesses; there are a small number of industrial SME industrial units within Burntisland but none are major employers, and there are a small number of larger industrial employers. The biggest employers within Burntisland today are:

- BiFAB - Burntisland Fabrications Ltd which produces fabrications for the oil and gas industries, and for the renewables sector.
- Briggs Marine – marine and environmental services.
- Scott Pallets – timber pallet manufacturing.

Burntisland is also heavily dependent upon tourism. The following facilities cater for tourism in the wider area and represent important assets for local employment and the local economy:

- Burntisland is home to the world's second oldest Highland Games, the Games are still held on the Links in Burntisland and attract thousands of visitors to the town each year.
- 3 Caravan Parks in neighbouring Kinghorn,
- Blue Flag Beach – Burntisland,
- Certificated Rural Beach – Kinghorn,
- Summer fair ground – Burntisland (8 weeks),
- The Ecology Centre,
- 2 Leisure Centres (1 in Burntisland, 1 in nearby Kinghorn).
- Burntisland retains 4 hotels and has numerous bed and breakfast facilities.

The area is surrounded by farmland but very few people are employed in this industry locally. Today a significant proportion of the town's residents commute out of the town for employment. Burntisland's transport links mean that the town is a popular dormitory settlement for Edinburgh.

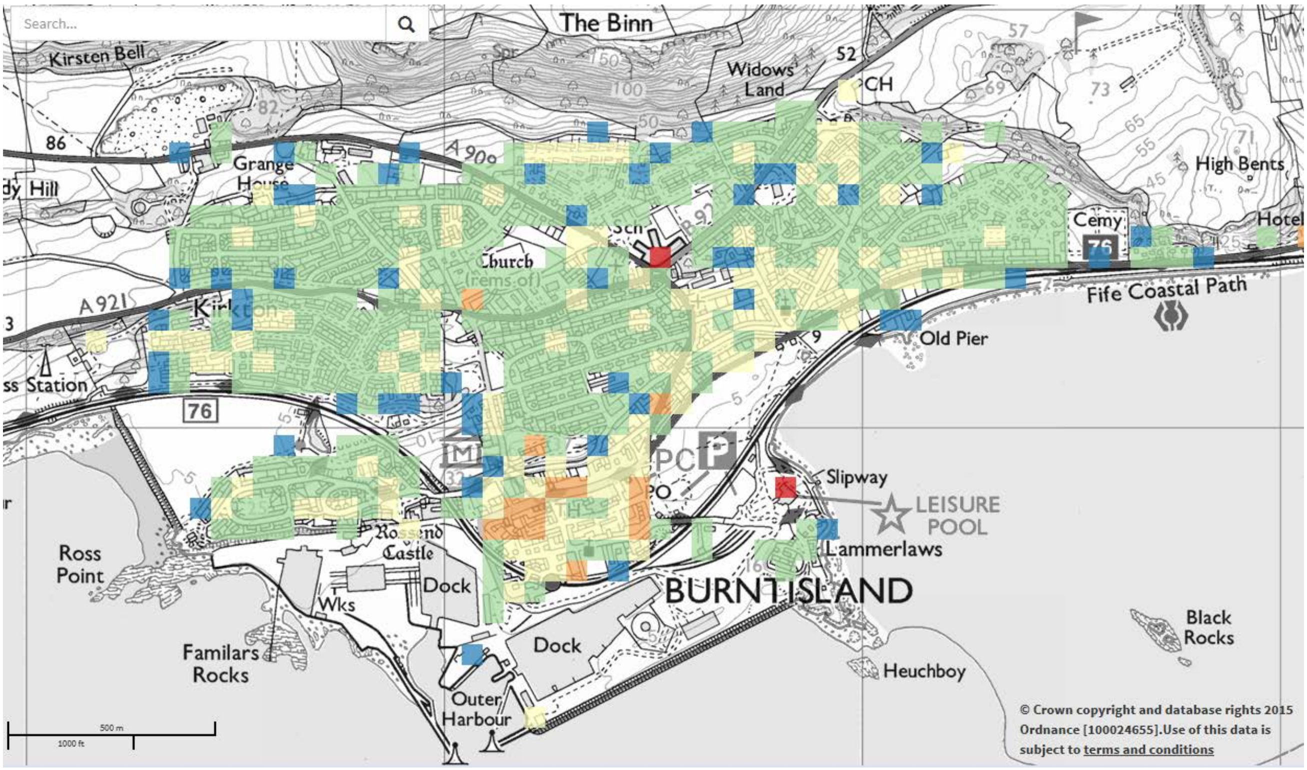
Overview of energy in Burntisland

The project established the following statistics about energy consumption and supply within Burntisland today:

There are 3,391 properties within Burntisland. 3,198 of these are domestic. The property stock within the town was classified into building archetypes, the breakdown of this was as follows:

- 1,256 flats,
- 869 semi-detached houses, and
- 677 detached properties.

Burntisland is connected to the mains gas grid, and all bar a few rural outlying properties and multi-story flats utilise gas for cooking, and in most instances heating. The project team calculated that the current total heat demand within the town is 49 GWh per year, of which 2 GWh is demand from public sector buildings (i.e. the school, leisure centre etc.)



Source: http://heatmap.scotland.gov.uk/

There are estimated to be 2,855 light vehicles in Burntisland.

- 30.5% of Burntisland households have no access to a car.
- 42.2% have access to 1 car or van.
- 21.6% have access to 2 cars or vans.
- 5.6% of Burntisland households have access to 3 or more cars / vans.

It was estimated that the total light vehicle fleet in Burntisland, drives 25,384,947 miles per year. Today it costs Burntisland residents £3,439,660 to run their hydrocarbon vehicles. Today the car and van fleet in Burntisland, cumulatively emits approximately 7,632 tCO_2e every year. Which works out at an average 2.67 tCO_2e per vehicle per year.

What is a local energy masterplan?

Energy Masterplanning is defined as the assessment of the supply and demand of energy on a regional or sub-regional level, the overall aim of which is to ensure that energy projects are developed in a planned and structured fashion that ensures energy resources are used to their full potential and possible key opportunities are not lost.

Energy Masterplanning is best used to identify opportunities to connect energy (including heat) resources with demands in the most cost effective, sustainable and low carbon manner. This can be developed strategically at a regional scale, city scale or at a local level to identify a vision for the future energy system and will identify a number of cluster opportunities that can be developed collectively and/or individually. Energy Masterplans are best focussed on specific spatial geographic areas that may have been identified as a result of an assessment of multiple opportunities or because a decentralised energy system is identified as providing a strong benefit to a specific project.

Benefits of local energy master-planning

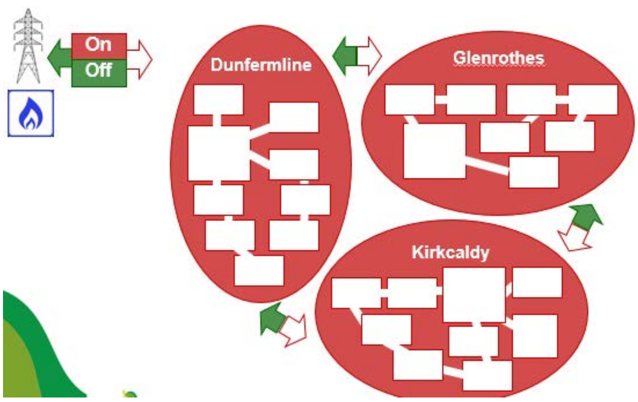
Creating local energy masterplans will have multiple benefits for a wide range of stakeholders. The move toward whole energy system design, has the potential to deliver a healthier, fairer, more sustainable and prosperous Fife. Local sustainable energy supplies could have multiple benefits, including:

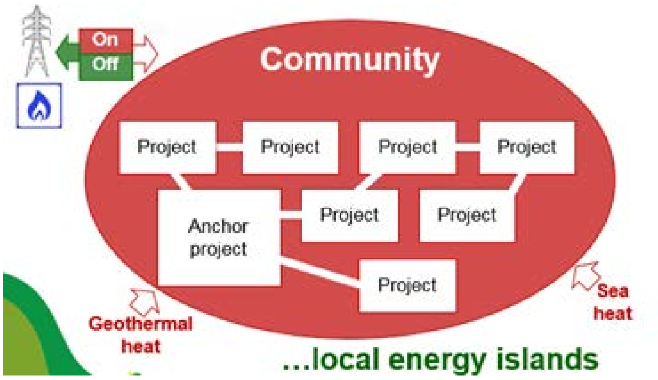
- Providing economic opportunities, employment and apprenticeships and training opportunities up and down the supply chain;
- Keeping more money in the local economy (rather than seeing money spent on energy leave local communities to go to large multinational companies);
- Making use of heat and energy which otherwise may go to waste;
- Providing regeneration and rural diversification opportunities;
- Reducing air pollution and carbon emissions;
- Reducing fuel poverty and reducing the health impacts (including early deaths) associated with damp and under-heated homes;
- Reducing transport emissions (shipping and road transport) by maximising the use of local resources;
- Application of technology to provide the most efficient use of the fuel content from primary fuels;
- Targeting district heat in an area that includes higher numbers of hard to treat properties and property archetypes that may be difficult to retrofit with other sustainable energy technologies could provide a low carbon low cost energy supply. ;
- Provide the flexibility to manage the evolution of power and heat generation sources within a network and to replace with more sustainable energy generation sources over time;
- Network balancing effects can potentially reduce the overall capacity required for distribution network infrastructure;
- Enabling multiple generators' input creates diversity and spreads risk rather than the current system which concentrates generation into a small number of large generators, creating a major potential risk to the whole system;
- Increased energy security in the face of geopolitical uncertainty and the impacts of climate change;
- Increasing the resilience of local communities;
- Helping to mainstream innovative new technologies;
- Improving the sense of community cohesion and wellbeing; and reducing inequality by creating shared goals and shared benefits;
- Improving the national balance of trade.

Strategic objectives

The different project partners all had their own different objectives that they hoped would be achieved by the Burntisland community energy masterplan project. Many of these aims are shared between different partners, and all were harmonious and mutually-reinforcing.

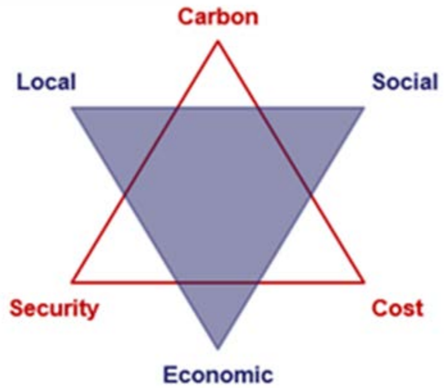
The Burntisland community, through their Community Action Plan, aspired to increase the sustainability of local transport and travel and harness the benefits of local renewable energy generation. Detailed objectives in these areas were not yet cemented. There was an enthusiasm to develop firm project ideas and commitments in this area to improve quality of life, health and well-being, the local environment and local economy within Burntisland. The engagement programme has built capacity and understanding around energy helping to formulate those energy objectives more precisely.





The Fife Council team members working on the Burntisland energy masterplan project are also working to develop a Sustainable Energy Climate Action Plan (SECAP) for Fife. Central to the Fife SECAP was the idea of encouraging the creation of local energy 'islands' i.e. smart local grids and energy supply systems designed to meet local needs and maximise local generation to meet the carbon emission reduction targets.

We were interested to work with local communities to see if the idea of a local embedded, co-owned sustainable energy system could work in reality. We wanted to explore what options would be most feasible in decarbonising a settlement, and the associated cost-benefits. We also wanted to understand how these new energy systems had the potential to deliver non-energy benefits to local communities, potentially, helping to create a healthier, fairer Fife for all. The project's shared strategic objectives included:



- Carbon reduction;
- Increased energy security and energy affordability;
- Improving social inclusion;
- Economic regeneration;
- Identifying barriers and developing solutions, to allow the creation of local energy systems;
- Increased capacity for community-decision making;
- Increase in local empowerment and resilience.

This pilot project sought to explore a processes that could enable Fife Council to work with community groups to deliver energy locally in the most effective manner. It is envisaged that Energy Masterplans will fit within the community's own action plan (embodied within the desires and needs of neighbourhood plans) and will link directly into the local planning process and the Council's Sustainable Energy Climate Action Plan (SECAP). It is hoped that in the future the roll-out of all Neighbourhood and Local Plans will be connected to Local energy masterplans to address needs and priorities locally. This pilot project has identified lessons and opportunities that could be replicated both locally and nationally.

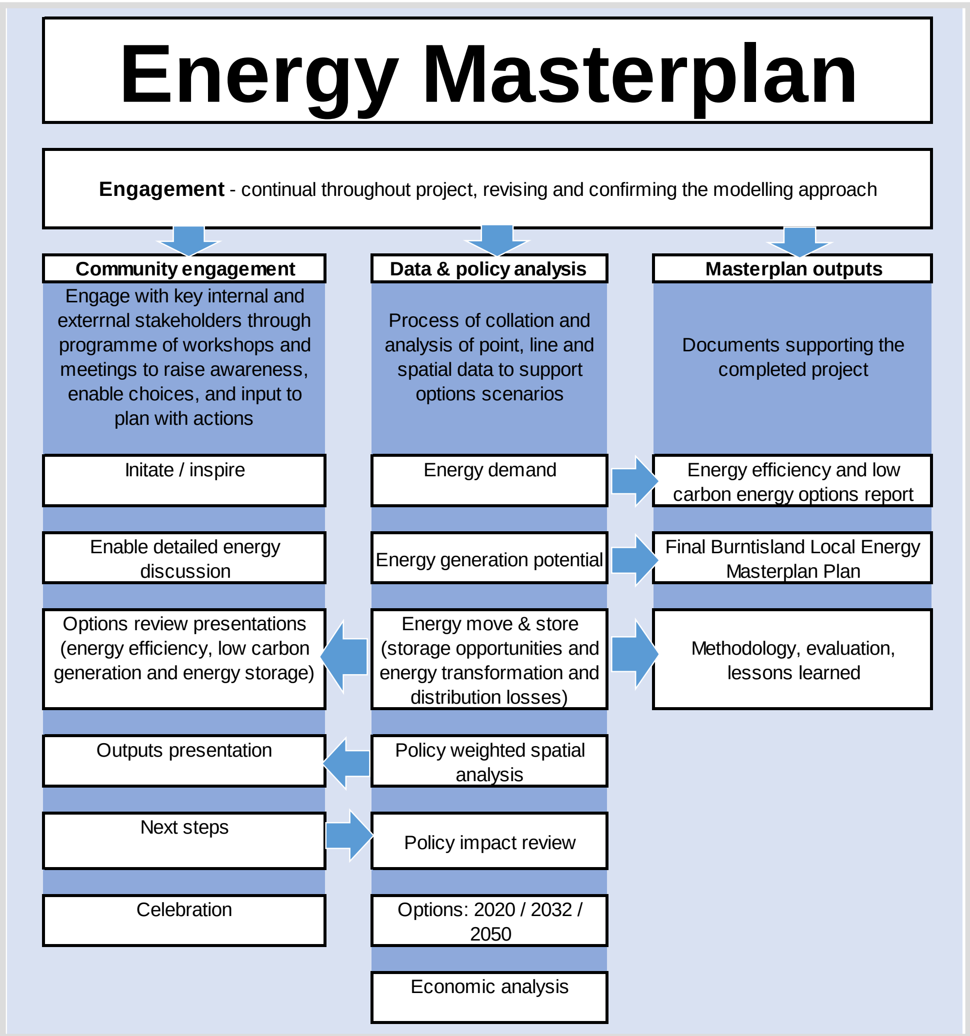
3. Methodology

Activities Undertaken

The Burntisland Energy Masterplan project was led by Fife Council to pilot an energy masterplan with community agreed solutions and planning buy-in. It is made up of two funded elements: A local energy masterplan (funded through the CARES IIF fund through Local Energy Scotland), and a Travel Hub (funded through Transport Scotland).

This pilot project worked in partnership with one community, Burntisland, within Fife to focus on local actions to reduce fuel and mobility poverty and reduce carbon emissions. Through a series of consultation meetings and workshops, technical experts, local government officers and the local community worked together to map the ‘whole energy system’ looking at heat, electricity and transport options including energy storage opportunities. Technical expertise was brought in to build local capacity and understanding of energy issues. This, alongside local skills and experience, enabled the community to understand their energy demand (using the heat map and other energy modelling tools) and work collaboratively to map jointly-agreed low carbon solutions.

The project activities were designed to establish an effective process for Fife Council to combine close partnership working and engagement with community groups together with detailed policy and technical data analysis to deliver energy locally and to facilitate local decision making with regard to energy. Essentially there were three distinct work streams which ran throughout the projects: community engagement; data / policy modelling and creation of the masterplan outputs. An overview of the activities and work-streams that were undertaken during the Burntisland energy masterplan project is illustrated in the diagram below:



Community engagement

Community engagement activities were undertaken throughout the duration of the project. This was to ensure that the community defined the direction taken by the project, generated the local energy project ideas that they wished to see being explored locally and ensure local people were happy with the technical outputs produced by the project team. Further information on this work stream is provided in Section 4 of this report.

Data / policy modelling

The second strand of the project was the data modelling work stream. This was a process of collating and analysing line, point and other spatial data to support the development of local sustainable energy project options for Burntisland covering energy efficiency, low carbon energy and heat generation and distribution, and energy storage. This process required the data team to be able to analyse energy demand in Burntisland, energy generation potential (for a range of different technology options), energy storage opportunities and assumptions made about energy losses from distributing energy and transforming energy into different energy types. These energy datasets were analysed for Burntisland to test and cost different technology options.

As well as the creation of an energy model for Burntisland, weighted spatial analysis was also undertaken to assess the impact of planning policies and inform the feasibility of the proposed technology options. To facilitate this a spatial policy review was undertaken. Further information on this work stream is provided in *Sections 6-9* of this report.

Masterplan output development

Finally the outputs of the two primary work streams were brought together into the masterplan deliverables produced to facilitate knowledge transfer to other parties looking to create their own energy masterplans, and to document the evidence required by our project funders. The final project outputs are

- The final Burntisland local energy masterplan with community-agreed solutions and Planning Services buy-in. The pilot report will record the communities' understanding and appetite for local ownership of energy systems, and detail the list of sustainable energy project that the community would like to progress. This pilot Energy masterplan is the first of what we hope will be many to cover all of Fife;
- This methodology paper (detailing the process undertaken and the lessons learned).The learning outcomes will enable us to roll this approach out across Fife, and build in appropriate capacity-building;

Next steps

The next steps of the project could, potentially involve a 3 year process subject to agreement from local communities and project partners.

To develop further the lessons learnt on this energy plan would be to create energy masterplans for other settlements in Fife i.e. Glenrothes, Kirkcaldy and Leven for example, and link to the Burntisland masterplan. This would enable us to learn about the realities of sustainable local energy systems in different geographic and social situations and how community Energy Masterplans can link together through a smart grid system. We need to understand how these local energy island settlements could link together to share a surplus of energy created by local wind turbines or solar panels, and how this energy can be moved and stored. A phased approach over a longer time period would give time to link Energy Masterplans into the Neighbourhood and Local plans currently being developed by Fife Council's Planning Services.

For more details on next steps projects for Burntisland see table at end of document p183.

Project Partners

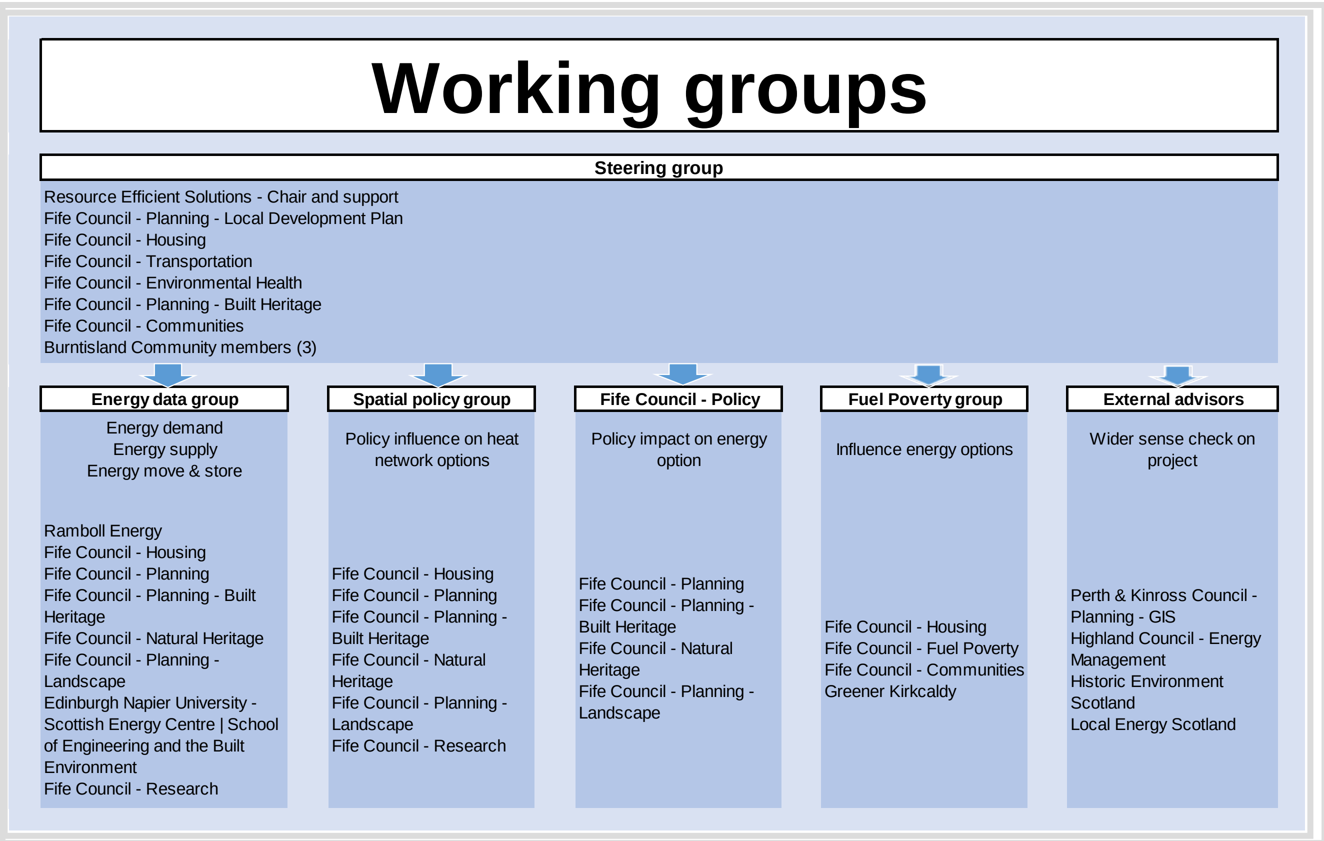
This Local energy masterplan was a collaborative effort between the local community, Fife Council and other stakeholders. The process is essentially community led but has been supported, where necessary by technical expertise from Fife Council and external consultancies such as Ramboll Energy (who have provided the technical tools to furnish the evidence base for community decision making).

The following parties were involved in this project:

- The Burntisland community (including individual residents and representatives from community groups);
- The Burntisland Community Council;
- The Burntisland Community Development Trust;
- Fife Council's Planning, Housing, Landscape, Built Heritage, Natural Heritage and Local Community Development officers;
- Local sustainability charities and champions (i.e. community engagement and fuel poverty agents: Greener Kirkcaldy);
- Community renewable energy ownership experts;
- Heat engineers;
- Heat Mapping specialists;
- Researchers from Edinburgh Napier University and
- GIS specialists (Fife Council).

The project contained a wide range of project partners, with team members coming from a range of different technical backgrounds.

To organise the project team, the following working group structure was adopted:



The project was managed by the Climate Change and Zero Waste team from Resource Efficient Solutions (Refsol). Refsol is an arms-length (ALEO) company wholly owned by Fife Council, tasked with delivering waste and climate change services across Fife (and Scotland) for Fife Council.

Local energy opportunities

Decentralised energy generation can come from a wide range of sources including well known technologies such as micro-renewables, hydroelectric, wind turbines, marine energy, combined heat and power, heat only boilers (including biomass), heat pumps, solar PV and solar thermal but also less well known opportunities, including, but not limited to:

- Un-utilised and under-utilised heat loads from existing and proposed plant including: biomass plants; Energy from waste (EfW) plants; Anaerobic digestion (AD) plants;
- Low grade heat opportunities: sea/Forth estuary, sewers, Geothermal and mine-water,
- Utilisation of any surplus biogas derived from existing waste water treatment works and waste heat from the sewer network;
- Where there are clusters of energy intensive businesses, their manufacturing processes may also present an opportunity to develop different forms of energy networks.

Combining these solutions with smart network infrastructure as well as heat and electricity storage solutions allows the potential for balancing of the heat and power networks. A further step in balancing the network is the adoption of a smart energy system that integrates hardware and system controls across a network. Smart grid technology can aid the:

- Transference of energy between gas, electricity, heating and cooling grids;
- Storage of energy over long and short timescales;
- Controlling demand by managing the energy supply to non-critical appliances; and
- Aggregation and switching between a wide range of fuel sources, including intermittent renewables, low carbon waste to energy plants and low grade industrial waste heat.

Project learning points

The project was hoped to provide more understanding on:

- How best Councils and communities can work together to deliver local energy systems;
- What energy opportunities can be realised at a local level;
- Possibilities for joint and locally owned energy solutions;
- The community benefits which can arise from low carbon local energy systems, and how to maximise the realisation of these benefits for local residents and businesses;
- How a whole energy system can deliver a healthier, fairer Fife with increased opportunities for economic development, training, jobs and fuel poverty reduction; and
- How local energy systems can meet Scotland's energy and carbon targets for 2050.
- The real world challenges of local energy systems and how they can best be tackled by communities, local and national governments and other stakeholders.

This masterplan document contains community-agreed solutions and has achieved significant buy-in from the Fife Council Planning Service. The pilot report records the local communities' understanding and appetite for local energy generation and / or community ownership. This methodology report documents the process undertaken to produce the Burntisland Local energy masterplan. It is hoped that the learning outcomes from this project will enable us to roll this approach out across Fife, and build in appropriate capacity building where it is needed.

Burntisland Local energy masterplan

It is anticipated that Energy Masterplans will fit within a community's own action plan, will record local peoples' own desires and energy needs and will link directly into the local planning process and the Council's Sustainable Energy Climate Action Plan (SECAP). The document structure is based on the Scottish Enterprise guidance document on Energy Masterplanning.

Burntisland Local energy masterplan - Methodology Paper

This document provides further detail on the process used to develop Fife's first local energy masterplan. It documents data sources, assumptions, modelling outputs, methodological limitations and lessons learned as well as the overall process followed. It contains technical appendices which provide useful information for communities and Local Authorities seeking to produce their own energy masterplans. The document structure is based on the Scottish Enterprise guidance document on energy masterplanning https://www.scottish-enterprise.com/knowledge-hub/articles/publication/guide-to-energy-masterplanning

Knowledge sharing

Another key tenet of this project is knowledge sharing. This pilot project was devised with the express intention to build a model for creating local energy masterplans that work for local communities and the Council that can be adopted for different areas across Fife. Key knowledge-sharing aspects of this project include:

- Our partners Fife Communities Climate Action Network (FCCAN) who sit within the Fife Environment Partnership (FEP) can help distribute that model amongst communities.
- Our proposed partners academia carrying out research on the process and effects locally.
- Refsol will monitor and evaluate the pilot and deliver a report on the process with contributions from all partners, including the community.
- Lessons learnt will be shared through the other networks via Sustainable Scotland Network (SSN), Local Energy Scotland, Fife Environmental Partnership (FEP), Fife Communities Climate Change Action Network (FCCAN), Green Business Fife and with Highland and Perth Councils with whom we partner on the development of our Energy Map plans.

4. Community Engagement

Stakeholder engagement and community consultation was a key element of the project right from the outset, and consultation continued throughout the work plan. Community engagement is a process which provids the foundation for:

1. Shared decision-making: where communities influence options, outcomes and the decisions that are taken;

2. Shared action: where communities contribute to any action taken as a result of the engagement process; and

3. Support for community-led action: where those communities that are best placed to deal with an issue that they personally experience, are supported to take the lead in providing a response.

A discussion of the community engagement activities undertaken is presented in this section, under the following headings:

- Stakeholder identification;
- Guidance;
- Our approach;
- What we did;
- Outcomes;
- Barriers; and
- Next steps.

Members of the youth action group are introduced to how energy storage works (in the guise of an interactive Shetland pony)

Stakeholder identification

A stakeholder analysis exercise was undertaken during November 2016 to identify a comprehensive list of stakeholders that were felt likely to be important to the projects from both within the community and from within Fife Council.

The initial stakeholder workshop also identified the most appropriate methods for communicating with different stakeholder groups. The output from this workshop was a baseline of contacts and the most appropriate methods for communicating what the BCEM was trying to achieve, to each stakeholder group. (See community engagement plan in appendix).

As this was a community driven project, the project team recognised that organic growth would inevitably help to take the project forwards and that this would mean that new stakeholders would emerge throughout the project timeline. It was established early on that we needed to create an engagement structure that facilitated organic growth and which was welcoming to all. Key to this was the need to have a forum whereby new, interested parties could contact the project.

The pop-up-shop[3] established by the project team on the High Street in Burntisland proved to be an ideal vehicle for this, and became instrumental in building contacts, relationships and local trust.

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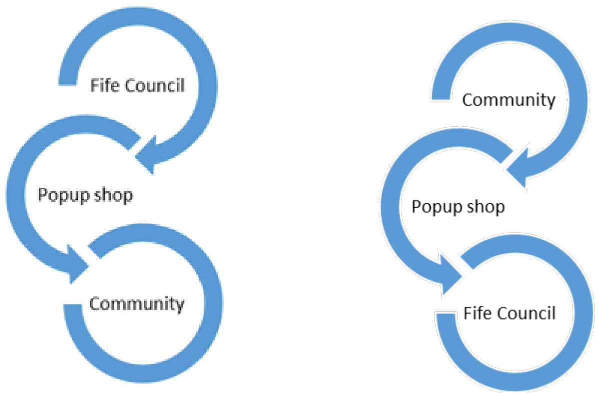
[3] A temporary project office / drop in centre established in the now-vacant Burntisland Fife Council offices, located on Burntisland High Street.



The pop-up-shop became a gateway for information and created a snowball effect in terms of engagement: local people were able to come in, learn more about the project and suggest other stakeholders to the project team. In turn, the more people we engaged with, the more information, help and contacts they gave back to the project team and the wider our communication network became. A symbiotic relationship was quickly established, and enabled a very useful flow of information from the project team to the community and from the community to the project team. The pop-up-shop acted as a two-way conduit and has proved to be an invaluable part of the project.

'It's all starting to make sense now. I'm beginning to understand'

Guidance

We used the National Standards for Community Engagement[4] as the framework to define our approach to stakeholder engagement. A summary of the 7 key principles enshrined by these standards is illustrated below:

The National Standards for Community Engagement are good-practice principles designed to support and inform the process of community engagement, and improve what happens as a result. They were originally launched in 2005 and since then they have been used to support community engagement, and user involvement, in Scotland in areas such as community planning and health and social care. They have been widely accepted by a range of practitioners as key principles for effective practice. Our approach to community engagement was based on these principles.

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[4] http://www.scdc.org.uk/what/national-standards/

Our approach

Further detail on our approach to stakeholder engagement within the project is covered in the following sections of this document, using the themes from the National Standard presented in the diagram above i.e.:

1. Inclusion,
2. Support,
3. Planning,
4. Working together,
5. Methods,
6. Communication, and
7. Impact

> ***'Thank you everyone for giving so much time especially evenings and weekends to make the project consultation really effective and meet residents in their own space and time'***

Inclusion

A central aim of the project was to include as much of, and as broad a cross-section of the community of Burntisland as possible. The project team recognised that using pre-existing local groups was the most efficient way to maximise community inclusion in the short time frames of the project.

Active local groups were identified through:

1. Web searches;
2. Liaison with different Council departments or agencies;
3. Interviews with key community contacts such as Fife Council Elected Members or members of the Community Council in Burntisland.

It was identified that some of the most useful people to engage with to deliver the aims of project, were those with young children, the elderly, those on low or fixed incomes, people involved with civic activities and / or charitable local works (such as the church food parcel group), stakeholders with high heating or electricity demand, people interested in technology, and those who are interested in the wider regeneration of Burntisland. We were in the fortunate position that some of these groups already had existing networks and community groups established to cater to their needs. One of the first tasks of the project was to identify and then make use of the networks of these pre-existing local groups to maximise local participation. Categories of groups that were identified during the stakeholder identification process include:

- Community groups;
- Faith and ethnicity groups;
- Political interests (Fife Council Members; Members of Scottish Parliament; Members of the UK Parliament);
- Charitable and environmental groups;
- Social, interest and leisure groups;
- Primary and Nursery schools;
- Groups focussing on specific age groups including: youth groups and senior citizen groups;
- Employers, business groups and local job clubs;
- Existing transport groups; and
- Council departments including those teams looking at housing provision (both social housing and private sector), roads / transportation and teams considering issues such as fuel poverty and social inclusion.

To gain local support and commitment for the project key groups were engaged early on in the process: i.e. Ward 10 (local Members meeting); the Burntisland Community Council; and the local Burntisland Community Development Trust. The Burntisland Community Development Trust was identified by the Burntisland Community Council to work closely with the project.

Not every community member belongs to a local group therefore different engagement methods were developed to enable those that don't, to participate in the project.

Burntisland Community Development Trust members

The project had to be agile and fast paced in its approach (given the short timescales of the project), and the pop-up-shop facilitated a rapid turnaround of ideas, so that what had been a conversation last week, became a community event the following week and enabled quick and productive generation of ideas and an increase in shared understanding and community momentum behind the project.

The shop enabled those, not able to come to events in person, to take part so became an important space where local voices could be heard and captured. The Development trust (BCDT) used the space for meetings and the EMP project held a number of workshops. We wanted the project to grow from the grass roots up and be owned locally rather than be delivered from a top down approach.

Support

'Another stimulating night of education. Pleased to learn I can catch up on missed sessions at the pop up shop'

Timing of stakeholder events was varied and held during the day and early evening to increase the scope of those who could attend. Events were also held on a mixture of weekend and midweek days to further facilitate broad community participation. Hot food and drinks were served to enable residents to come without having to worry about cooking, being hungry or affording to eat on a cold winters night.

'Interest is … building in the town

It was recognised, early on, that for most people energy is not a topic that they naturally find engaging and that for large sections of the community, information would need to be provided to open up this topic for them. The travel project which ran alongside the energy masterplan project was a good ice-breaker for discussing ideas about energy with the local community, as everyone had an opinion on how to improve travel in Burntisland. Once chatting about travel and recording stakeholders' suggestions for how it could be improved, it was then easy to move onto discussing sustainable power and heat, which are often less tangible to grasp on a local level.

Our approach to how we talked about energy was influenced by a number of sources including:

- The Scottish Government's draft Energy Strategy (which includes the UK government's energy trilemma (the need to provide affordable, secure and low carbon energy; alongside the Scottish Government priorities of a stable managed transition to a whole energy system, with local benefits;

- Fife Council's Energy Strategy;
- SECAP principles; and
- The Energy Hierarchy).

The priority for us was taking the discussion of energy back to basic principles, improving the literacy of stakeholders in terms of understanding energy principles and terminology, and avoiding the use of jargon (where possible) so as to maximise the inclusivity and interest for a wide range of stakeholders. Where possible, discussions were framed around the following basic energy equation:

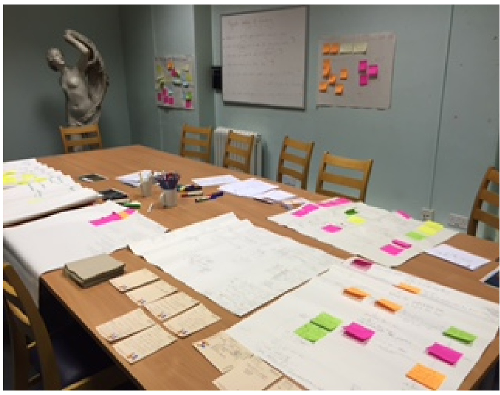
I.e. in short the amount of low carbon energy generated needs to be at least equal to energy demand, plus energy storage capacity and the energy losses that arise from moving energy / converting it into different forms. The lower the energy demand, the lower the transmission losses, and the larger the storage potential then the smaller the amount of low carbon energy that will need to be generated.

Working together

The Community Empowerment (Scotland) Act 2015, Land Reform (Scotland) act 2015 and the new draft Scottish Energy Strategy 2017 seek to maximise community involvement in local decision making. This project sought to test these noble ideals in a real, on the ground project and to deliver useful lessons in how best to maximise grass-roots involvement and how best to make participatory decision-making a reality.

In a world of reduced public sector staff, budgets and funding, it was understood right from the outset of the project that partnership working would be essential to delivering large energy projects locally. We had, within the timeframe of the project, to understand the community we were working with; their interests, concerns, issues, knowledge around energy and their capacity and appetite to be partners for local sustainable energy planning. We were incredibly fortunate that the interest in the project from the residents of Burntisland was a real asset to the whole project. The degree of engagement and willingness from the local population, to work in partnership on this project cannot be underestimated.

Joint decision making was an essential part of the entire project. A project steering group guided the overall project work. Membership of the steering group included Fife Council (including representatives from Fife Council's Planning; Community Planning; Transportation Services; Housing Services and Climate Change and Zero Waste teams) and the Burntisland Community Development Trust (BCDT). Although the trust is newly-formed group they are passionate, skilled, civically minded, motivated and active residents that have been involved in many other community groups, including:



- The Parent Council (linked to the local school),
- The Castle development group, and
- The Burntisland Community council.

Project staff attended monthly BCDT meetings and were available for regular drop in meetings in the pop-up-shop for community updates and to further the development of ideas. Project progress was discussed regularly on the agenda of Burntisland Community Development Trust's monthly meeting, where project officers provided an update on the teams' work in responding to issues or suggestions that were raised by the local community. Members of the Burntisland Community Development Trust also dropped into the shop 2 or 3 times a week to provide a response to any issues or suggestions that arose. These drop in meetings were very valuable in moving the project forward.

'Whole idea of discussing energy is very encouraging for improving energy consumption and conservation'

The timeframe for the project was 6 months. Once contracts were awarded and legal terms agreed it only gave 5 months for the engagement programme. To deliver a meaningful programme in such a short time meant that we needed get to know people, be trusted, discover local history / politics and what was important to the people of Burntisland, very quickly. Our partnership with the Burntisland Community Development Trust (BCDT) and relationship with the community council and primary school was key in enabling us to do this.

From past experience of community engagement work, we knew that when a new project begins it takes time for people to hear about it, and to come to events so to cut the time that it took to build momentum around the project initially we piggy-backed, on other local events to share information faster and to raise the profile of the project as quickly as possible.

Methods and communication

A wide range of marketing and awareness-raising methods were used to communicate with local residents about the project and to maximise community participation. These included:

- Paper publicity materials;
- A Pop-up-Shop;
- Social media;
- Email communications;
- The local media;

Posters, leaflets and other publicity materials were distributed through door to door leaflet drops. 4 separate leaflet drops were delivered to all homes during the project and via the school (i.e. putting leaflets in school bags for children to take home).

The 'Pop-up-shop' used to be the Local Council office so was well known locally. It was a space for inspiration and offloading, for meeting, making friends, for planning, for engaging. It was a perfect space for partnership working. We opened it 3-4 days a week, and had visits from local folks interested in the project as well as those looking to get their bus pass or sort out their council tax. After resolving their initial enquiries we were able to introduce them to the projects and offer them information on insulation and free energy efficiency services in preparation for the winter months.

Burntisland already has an active presence on social media. Social media and online Burntisland Facebook pages that were approached to participate in the project include:

- Burntisland Community Council;
- Burntisland (Facebook group);
- Burntisland.net;
- Burntisland Community Development Group;
- Burntisland Mums,
- Burntisland Primary school; and
- Greener Kirkcaldy.

Events were also advertised through the Fife Direct website and Fife Council's intranet 'FISH'

Emails were sent to those identified through the stakeholder identification exercise. As the engagement programme developed we collected email addresses from interested parties, groups and residents and updated our mailing list to enable updates and event invitations to these contacts.

The Local press was also used for more generic communication. The local community newspaper in Burntisland is called the 'The Burgh Buzz', articles on the project featured in October 2016 and January 2017 editions of the Buzz.

BURGH BUZZ

Published in association with
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Burntisland Community Award Winner 2017
Mary Brownlee

On 31st December 2016, Mary Brownlee was absolutely stunned when informed by Alex MacDonald, Chairman of the Community Council that she had been selected as Burntisland Citizen of the Year for 2017.

Mary and her husband Renwick moved to Burntisland almost 40 years ago and from the start she became actively involved as a volunteer in community activities. Having two young daughters, her initial participation was with toddlers and parents playgroups and with the Brownies at the Erskine Church. As her daughters grew up, Mary took the opportunity to obtain a formal qualification in pre-school education and was employed as an Early Years Officer with Fife Council. Despite holding down a full time job, Mary continued to offer her services as a volunteer. She completed a First Aid course and having a mini bus licence, she occasionally drove the local ambulance on non-emergency duties, on one occasion inadvertently using the ambulance emergency lights but arriving at her destination in record time!

For over 20 years, Mary has been the driving force on the organising committee of the Wednesday Club at the Toll Centre, a self-funded organisation which provides entertainment, relaxation, fun and companionship for the over fifties in the town. She still maintains contact with pre-schoolers through "Light Bite" at the Erskine Church and "Rhyme Time" Parent and Toddler Group at the Toll Centre. Mary currently chairs the organising committee of the Burntisland Branch of Cancer Research UK which in recent years has raised thousands of pounds through its varied fund raising programme. She is also an enthusiastic member of the Langtoun Singers and just before Christmas could be seen amongst a group of carol singers in the High Street, singing for charity.

Mary said that she was extremely proud and honoured to receive this award but took pains to emphasise that she could not serve the community as she does without the support of her family and of the many other dedicated volunteers who give of their time and effort, and whom she feels are equally deserving of such an honour.

Neil MacNicol – Winter Champ of the West Highland Way

Local endurance athlete Neil MacNicol recently set a target that will be extremely difficult to beat – he completed a winter traverse of the 96 mile West Highland Way in an unbelievable 20 hours and 33 minutes. This feat is normally attempted by athletes who have participated in the annual West Highland Way Race which takes place over the weekend nearest the summer solstice. The winter version is attempted by a dedicated few as near to the shortest day of the year as possible.

Neil's achievement is even more commendable as he completed the run alone and without any logistical support other than a pal to drop him off at Fort William and to pick him up at Milngavie on completion. He carried all his essential equipment and sustenance in a back pack, quenching his thirst en route from rivers and streams. Most of the run took place in total darkness, the only light being provided by the moon and a head torch. Neil was not entirely out touch however, as his progress was carefully monitored by friends and relatives through a GPS tracking device which he wore throughout.

Although he experienced strong winds and heavy rain when crossing exposed sections of the Rannoch Moor, Neil felt that the temperature was unseasonally mild as he encountered no snow or ice. This was a major contributing factor in being able to record such a competitive time. Nevertheless Neil was extremely relieved, satisfied and tired at the end – and really chuffed with his time.

Photo by Patricia Carvalho

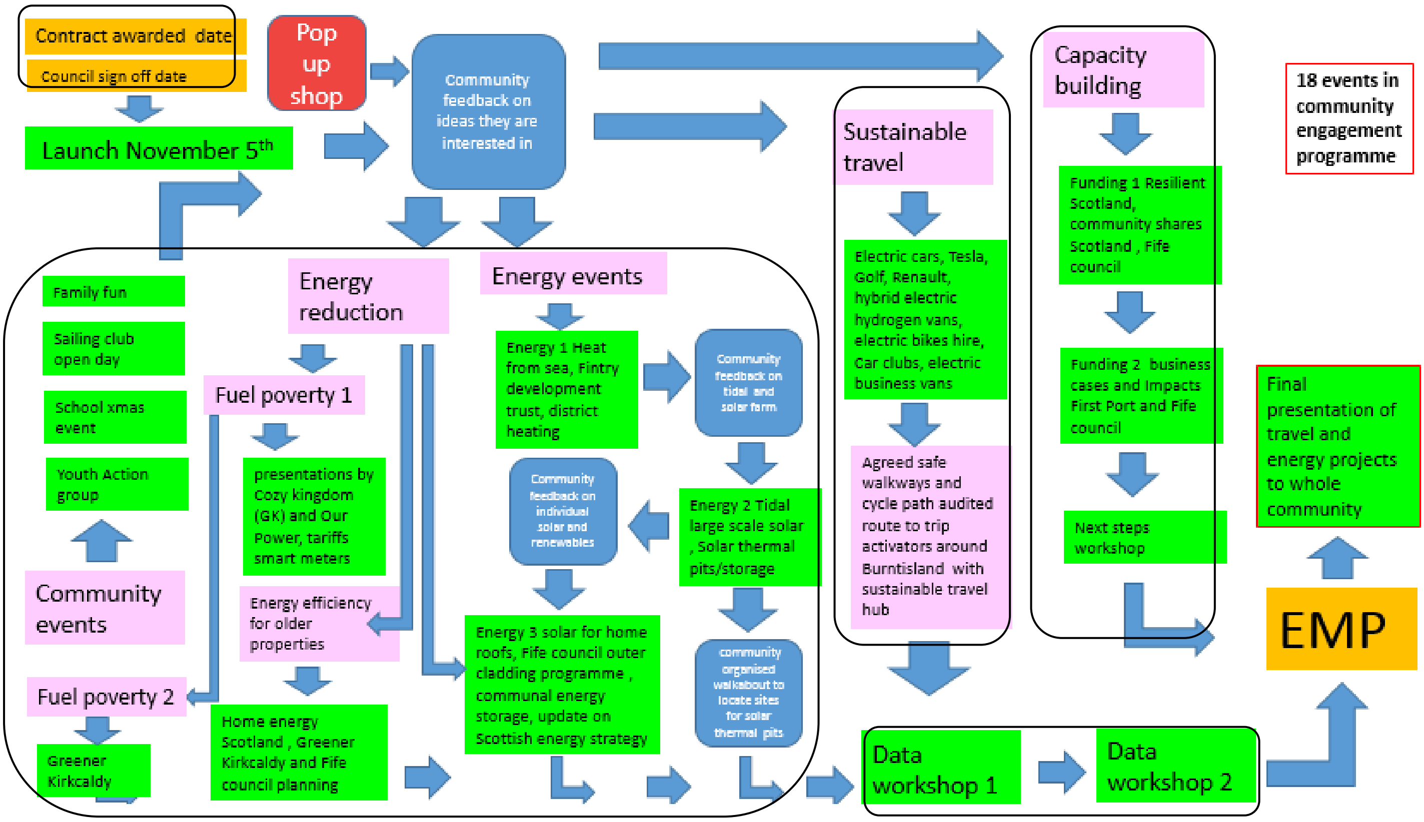
Neil is a massage therapist and running coach who works from his purpose built treatment room at home. He is a member of the coaching staff of the Beacon Runners and conducts his own beginner group sessions at the Toll Park. He can be contacted at Tel: 07930396022 email: neil@macnicol.co.uk website: www.runrecover.co.uk or follow him on Twitter or Facebook.

What we did

In addition to the contact methods described above, 18 formal events were undertaken as part of the community engagement process between November 2016 and March 2017. A summary of the numbers involved in the community engagement process is illustrated in the diagram below:

At the heart of the community engagement process are two simple principles: to ask questions and to listen to the local community's answers. The whole events programme was based upon feedback and input from local people. Our approach was flexible and agile to both maximise what we could achieve in a short time span, but also so that we could accommodate the evolving wishes of the local residents. Each event held, in turn created new opportunities which were followed up, and delivered (along with unanswered questions from previous events) for the next event.

The diagram below illustrates the events flow chart for the stakeholder engagement undertaken as part of the Burntisland Energy Masterplan:



Source: Carolyn Bell, REFSOL, 2017

The events held were broadly thematic and included technical presentations and the opportunity for local residents to workshop solutions and ideas. Experts in technical areas and top speakers from academia and industry were keen to share their knowledge, debate and answer questions with the local community. The following topics were covered by these formal events:

- Reducing the need for energy including addressing fuel poverty, and where possible reducing the demand for energy down to the levels targeted in the Scottish Energy Strategy[5];
- Low carbon energy generation (both building-scale and community-scale) opportunities within Burntisland including tidal energy, wind, heat from the sea, large scale solar generation, and building-integrated PV and solar thermal. These sessions also looked at renewable energy storage potential including communal heat storage;
- Sustainable travel including active travel and ULEV;
- Capacity building amongst local residents about energy generally, how and who to apply for funding, business case writing, understanding impacts of projects; and
- Next steps how and what projects were the community happy to take forward.

[5] http://www.gov.scot/Publications/2017/01/3414

Events were held in different venues throughout the town including the Salvation Army Hall, the local community centre the Toll Centre, the pop up shop , the local Primary School and popular local venues such as the Potter About café and the Sands Hotel. A full list of the events held during the public engagement element of the project is provided in the Appendix.

Reducing the need for energy

Three events (following the principles of the energy hierarchy) looked at reducing energy demand within Burntisland. Only once demand for energy is dramatically reduced will it become realistic to meet consumption needs from zero carbon sources. The ultimate long term aim for this work stream was to get buildings within Burntisland as close to net zero operating carbon (and for as many as possible to be carbon negative) as possible. What a zero carbon home looks like in reality, varies widely with some designers opting for a fabric first, thermally massive approach and others looking at lightweight structures with high levels of renewable energy generation incorporated.

The low heating demand of Passivhaus buildings of less than 15kWh per square metre per year means that annual fuel costs are reduced by a factor of 5-10 compared to conventional buildings. For example a household living in a 70m2 Passivhaus with gas heating could spend as little as £25 on space heating each year

One popular standard for highly energy efficient homes is the Passivhaus standard[6]. Passivhaus is a rigorous, voluntary standard for energy efficiency in a building, reducing its ecological footprint which results in ultra-low energy buildings that require little energy for space heating or cooling. Generally Passivhaus homes feature high levels of insulation and low air-change rates and fabric permeability.

Developed in Germany in the 1990s, 30,000 properties around the world are now accredited to Passivhaus or 'Passive House' standard. The Passivhaus standard's strengths lie in the simplicity of its approach; build a house that has an excellent thermal performance, exceptional airtightness with mechanical ventilation. So that the need for a heating system is designed out. The Passivhaus standard can be applied not only to residential dwellings but also to commercial, industrial and public buildings. As well as being an energy performance standard Passivhaus also provides excellent indoor air quality, this is achieved by reducing the air infiltration rates and supplying fresh air which is filtered and post heated by the MVHR unit. Passivhaus is a standard designed for new build properties.

The Scottish Government's draft Energy Strategy aspires that every building in Scotland will be decarbonised by 2050. Essentially will mean that all buildings will need to either have the thermal performance of a Passivhaus and / or will need to be connected to zero carbon power and heating networks. While it may not be physically possible or economically practicable to retrofit every building within Burntisland to the Passivhaus standard, ultimately to make decarbonisation practicable as many buildings as possible need to be brought up to a comparable standard in terms of their energy performance. We wanted to explore the feasibility of achieving this with a real world example – Burntisland.

[6] http://www.passivhaus.org.uk/standard.jsp?id=122

Tackling Fuel Poverty

Addressing fuel poverty was one of the key motivations behind the project. The Community Planning team were keen to explore with local stakeholders, what local benefits and additionality could be provided by the creation of a local energy masterplan. We wanted to realise additional social benefits from decarbonisation.

One of the barriers to reducing fuel poverty is simply knowing where households in fuel poverty are. Although there are many agencies working together they aren't able to share information on addresses (due to data protection issues) so we couldn't target particular homes. We looked instead at the areas of deprivation and targeted those areas with leaflets for energy efficiency events with leaflets entitled 'Do you have high heating bills or a hard to heat home?

Our partner for this part of the project was Greener Kirkcaldy. Greener Kirkcaldy (GK) is a community-led charity who work on a local scale to benefit the community and the environment. They give advice and support to reduce fuel bills through the Cosy Kingdom energy efficiency advice programme across Fife. GK were present at 4 events promoting energy reduction and delivered 2 workshops within the programme on energy efficiency - one targeting homes in conservation areas, and the other looking at fuel poverty. Energy efficiency information was provided at the events and covered the following:

- Internal wall insulation;
- External wall insulation;
- Energy tariffs and smart meters;
- Solutions and help for hard to heat homes and tackling high energy bills;
- Energy efficiency measures suitable for heritage buildings and homes in conservation areas;
- Behaviour change;

'Invaluable is the word I'd use to describe this evenings event. Thank you'

Presentations at the events were given by the following organisations:

- Scottish Welfare fund
- Greener Kirkcaldy
- Our Power;
- Home Energy Scotland; and
- Fife Council staff.

'Having all the help together at the same meeting was really useful'

It was recognised that the issue of fuel poverty in Burntisland requires both short term and long term solutions.

Short term approach

We set up a fuel poverty group to look at what services were being delivered in the area to address the issue, and how best we could dovetail with existing services to help those in fuel poverty locally. As winter was approaching, the first priority was to offer help in the short term to vulnerable residents.

- We promoted Greener Kirkcaldy's Cosy Kingdom energy efficiency advice service through the pop-up-shop and at project events to ensure those at risk of fuel poverty had access to help. It is well-known that the most vulnerable groups are often the hardest to reach.
- Through speaking with local church groups and charities offering food bank services we learned that local people were sometimes having to make the difficult decision as to whether

they could afford to eat OR to heat their homes. These agencies advised us that for some households' could not afford to cook food, therefore foods which could be eaten cold were prioritised. Cosy Kingdom leaflets and information on help available were placed in the food parcels and information and leaflets were given to the charities and local groups to hand out.

- We also partnered up with other internal council services working with vulnerable groups to highlight the help that was available to their customers in reducing their energy spend and making their homes more comfortable.
- Other avenues used to connect with those experiencing fuel poverty in Burntisland included working with the local primary school in advertising fuel poverty support services to families (via leaflet drops in school bags, posters, the school's Facebook page and information on notice boards). Briggs Marine, a large local employer sponsor a staff member to work with vulnerable families at the school and we worked with her to advertise events and services which could help those in fuel poverty.

'So much help I was unaware of right on my doorstep. Very friendly. Had to come with a toddler and people were very accommodating'

The two events aimed at low income families were organised in parts of the town we knew from SIMD and GIS data had high levels of fuel poverty. These events included advice on the most affordable tariffs for prepaid meters from Our Power, how to increase money coming into the home, what help and benefits were available, including grants from the Scottish Welfare Fund and Home Energy Scotland; plus how to access free insulation and energy audits from the Cosy Kingdom service.

Both fuel poverty events enabled local people to get direct help. After the first efficiency event people came into the pop-up-shop requesting application forms and contact details for Cosy Kingdom. At the second event the Scottish Welfare Fund and Home Energy Scotland were able to offer residents actual grants for heating, hot water and energy efficiency measures. These events reached a range of residents including private landlords, tenants from the private rented sector, home owners in fuel poverty as well as social housing tenants on low incomes.

'What was really useful was the help and advice available to landlords and tenants alike and grants and loans to help with heating and warmth'

Our Power, a community benefit society acts as an independent gas and electricity supplier who deliver low-cost utilities to homes all across Scotland, specialising in affordable prepaid (key) meter tariffs. Our Power already works with Fife Council but the Council has no powers to switch tenants utility supply contracts for them, so tenants need to sign up themselves. Our power were able to present at 2 events which gave those on prepaid meters the opportunity to ask questions directly and be supported in their decision making around energy costs.

Long term solutions

Moving energy supplier and ensuring that those on low incomes are in receipt of all of the benefits to which they are entitled is a short term fix for fuel poverty. Changing the building fabric of people's homes to increase energy efficiency will provide a long term solution to fuel poverty. People on benefits or low incomes are likely to remain in fuel poverty if the fabric of their homes is poor and / or their incomes do not materially increase. This situation is particularly problematic when people live in private rented accommodation as tenants have few rights and limited agency in improving the energy efficiency of their home. Many landlords are not motivated to improve the energy efficiency of their property portfolios because they do not pay the energy bills, and as such do not receive the savings from any energy efficiency measures installed.

There are two key avenues to explore when looking for long term solutions to fuel poverty:

1. Addressing the fabric of the building to reduce the need for heat in the first place.
2. Delivery of cheaper heat, for example, via a district heating system or switching supplier.

When considering longer term solutions to reducing the energy demand from the settlement, we looked at external and internal wall insulation options that could be suitable for the homes in Burntisland. The main data modelling element of the project looked at assessing what percentage of the Burntisland building stock could be suitable for retrofitting of internal, external and cavity wall insulation and the potential carbon savings arising. The engagement programme wanted to look at a smaller scale real-world example and focused on an area already known to experience high levels of fuel poverty.

Creating a small case study enabled us to explore how much it could cost to reduce fuel poverty in an area of Burntisland with the highest proportion of residents living in fuel poverty, today. Working with Fife Council's Local Housing Officers we mapped a small area of 6 streets and highlighted which properties were known to be suffering from damp, or were otherwise hard to heat. We further subdivided this sample by tenure type (owner occupier, private rented, social rented etc.) and then cross referenced this with records of housing benefit recipients. Fife Council's Housing Service then checked what was known about the building fabric and if any works had previously been undertaken with regards to insulation and otherwise improving the energy performance of these properties.

Policy and funding barriers

This exercise then looked at what measures could be installed using today's suite of incentives to improve energy performance so that fuel poverty could be prevented, and, if possible to assist in reducing energy performance to the levels required by 2050 in the Scottish Energy Strategy. It was discovered that the current incentive framework is not sufficient to achieve these performance standards in a real life setting, and indeed acts as a barrier in some instances. For example, it was found that for traditional properties with cavities, the ECO policy rules mean that funding is only available for cavity and loft insulation. Installing cavity wall insulation and loft insulation (whether to a virgin loft, or via a loft insulation top-up) is not sufficient to bring these properties up to a zero carbon demand. Indeed in some instances where glazing is poor and where poor quality flooring is a source of considerable draughts, these measures may not be sufficient to prevent fuel poverty. Therefore fuel poverty can remain even after these measures are installed.

Within the small sample we looked at in Burntisland the only way to ensure that residents no longer suffered from fuel poverty would be to clad the buildings with external wall insulation (EWI) or deliver cheaper sources of heat. Both EWI and connection to a low cost and low carbon district heating network would be needed to bring these buildings to the energy performance standards required by the Energy Strategy. At present ECO funding rules won't allow further funding for EWI for these properties. Councils can't afford to deliver this service without external funding. Fuel poverty looks to be unavoidable for some households, even with support, unless affordable heat can be provided to these homes and funding rules for energy efficiency measures changed.

Low carbon energy generation

In theory, once the total energy demand from a settlement has been dramatically reduced, the next step in decarbonisation (as recommended in the Energy Strategy) is to provide the heat and electricity consumed from local low-carbon resources. We wanted to explore the renewable energy and heat generation potential offered in Burntisland, and also any opportunities for energy storage, so that generation could best fit with consumption patterns.

A suite of low carbon energy events were held to inspire the community to think what they would like to see in terms of future energy generation within the town. The events were well attended, and discussed a wide range of topics and included:

'The standard of the speakers was really impressive'

- Inspirational talks from other community groups, development trusts and successful community renewable energy projects around Scotland;
- The type/ s of low carbon energy generation and energy storage systems that may be suitable for Burntisland including solar PV farms, individual solar PV / solar thermal for homes, biomass district heating, heat pump systems (including heat from the sea, heat from sewers etc.), solar thermal storage pits and tidal power
- Communal electricity buying power (i.e. half hour generation purchase agreements); and
- Communal energy storage options (including battery banks, solar thermal pits and the use of battery powered vehicles as storage).

'Starting to look at the scale of the problem and what's possible was very useful'

While good knowledge of low carbon generation technologies was held by some in the community, understanding of energy storage options was less. Thermal storage in particular proved to be an area of considerable interest to the Burntisland community. After the event some of the residents organised a walkabout to explore potential locations for solar thermal pits and met with Fife council to map these areas to include in the Energy Masterplan

Data workshops

Once all the energy events had been delivered the community could bring their own energy experience to the data workshops. These events were an opportunity to discuss, debate and decide with Fife Council departments and external energy consultants what sustainable energy generation and storage technologies would be suitable for Burntisland. Ideas that the community wanted to explore in more detail were then passed onto the energy modelling team so that costs, barriers and opportunities could be understood in more detail.

'Good round table discussions. Very good presentations'

The outcomes data meeting reflected the impact these community decisions had on energy security, affordability and local greenhouse gas emissions. It gave opportunity for further community input into the final project list and the draft Burntisland Energy Masterplan.   Local residents have enthusiasm for sustainability generally and sustainable local energy generation in particular. Their detailed knowledge around energy and their ability to think creatively and problem-solve was impressive. Burntisland residents have a real passion for where they live and appreciate that the natural qualities which make it such a great place to live, also offer real potential for decarbonising their lives in the future.

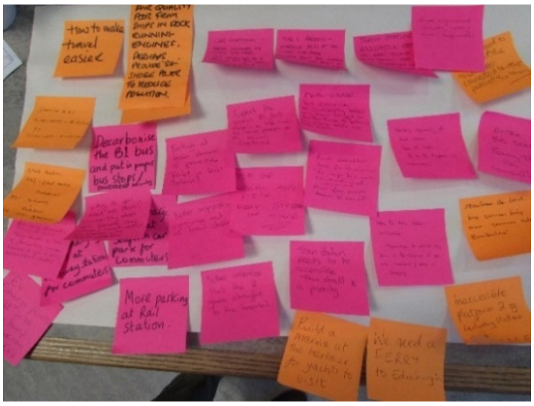
The Energy Masterplan (see travel, heat and electric stories) shows the list of projects requested by the community and the next steps section show how the community is looking to work alongside other actors, to develop these projects.

> ***'After the data workshop I came away understanding the thrust of this initiative and how it fits with National policy'***

Sustainable travel

As well as considering the energy consumed within the built environment in Burntisland, the project sought to help the local community reimagine how they could travel in more sustainable ways in their day to day lives. The initial focus being on how people travelled around the town itself.

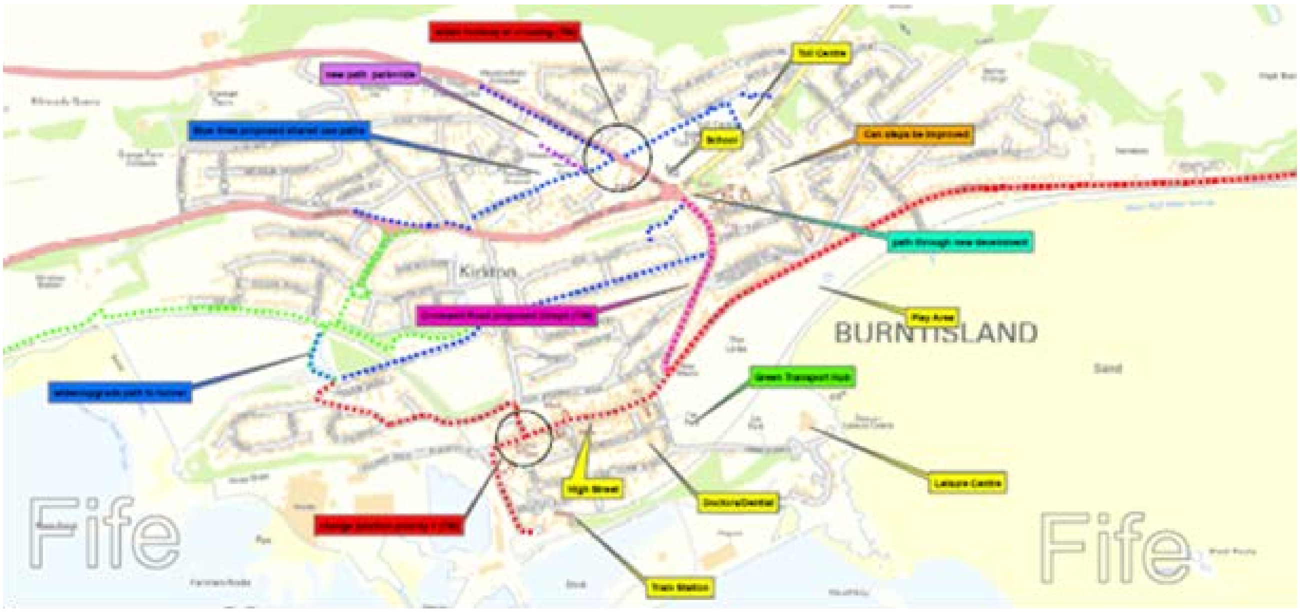
Measurable objectives for the transport element of the project were to expand and develop safe active travel pathways, and create a sustainable travel hub to enable low carbon travel in and around the community. The project team and the local community worked in partnership to explore key questions around delivering sustainable transport needs within Burntisland's existing infrastructure. We sought to develop and test ideas in collaboration with the community to deliver low carbon travel and transport activities locally.



During the first 3 months of the project we collected information at every event on what the community felt were the barriers to increasing levels of walking and cycling in the town. Working with the project team, the community mapped these barriers and opportunities to increase active travel from housing developments, school, play areas in the links, the beach, the main shopping area, medical facilities, the train station, main bus stops and the popular coastal path.

Suggestions were sought for the best place to site a sustainable travel hub with electric vehicle charging points. The Links carpark was the most popular suggestion. All travel feedback was then included within an active travel route design. The output from this phase of the project was an improved safe active travel route map for the town with costings. The draft active travel map produced by the project is reproduced below: p31

A walkabout of the routes took place with Fife Council departments, members of BCDT and the parent council from Burntisland Primary School. Decisions on route design were collaborative and it was a successful example of joint local decision making. The route map includes 20 proposed improvements. Designs were tailored to community needs and include safe walkways, green corridors, cycling initiatives and electric car charging points. Suggested cycling initiatives include, bike hire, safe and secure facilities for cycle parking, bicycle repair / maintenance facilities and improved links to public transport for cyclists. Community sustainable travel improvement suggestions have all been individually priced by Fife Council's Transportation Service, which will enable flexibility around when and how the project is funded and delivered. Decisions on which routes / elements are prioritised will take place locally. Funding and delivery of the project will be a partnership between Fife Council, local councillors, the BCDT and Burntisland Community Council.



In addition to active travel options, there was considerable interest in alternative fuelled vehicles such as electric and hydrogen cars. Feedback garnered at project events showed there was little direct experience of, but a real interest in electric cars amongst Burntisland residents. To capitalise on this and to provide residents with the direct experience of these vehicles, we delivered a sustainable travel event where we showcased the following;

- A Tesla EV car;
- An electric VW Golf from Fife Council's car pool;
- A new electric EVE from Renault;
- A hydrogen / electric hybrid Renault Kangoo van from the hydrogen project at nearby Methil;
- 2 electric vans already in use by a Burntisland business;
- Car clubs;
- Stirling Council's electric bike hire scheme.

'Great to try out electric bikes- would be great for the hills round here'

'Electric vehicles are fantastic! Smooth quick and very easy to drive. It's the future.'

'The Tesla was amazing'

The project also looked at how local businesses can benefit from the opportunities afforded by sustainable travel. Project meetings were held with local businesses to explore how they could be part of the development and funding for local hybrid fuels and electric vehicle charging points.

During the energy events community members suggested a number of local energy project ideas to take forward as part of the Community Energy Masterplan for Burntisland. These are summarised below:

Energy Event 1 created a lot of interest in the prospect of a **district heat system** using heat pump technology to utilise heat from the sea. To supply heat to the whole town would require a very large-scale district heating scheme (by UK standards), although a scheme of this scale would not be unusual in Scandinavia. There was apprehension from the community about around whether everyone in the town would be able to benefit from such a scheme (or whether it would only be targeted at social housing), and a degree of concern that it was not a project the community felt they could deliver and / or be appropriately represented in the decision making processes needed.

Energy Event 2 Burntisland faces south so the location offers considerable opportunities for solar energy generation, these were discussed in depth at this meeting.

Solar thermal pits were a popular idea for storing sustainable heat for the town, and members of the community were so enthused by the idea that they joined together to do a walkabout around Burntisland to find suitable sites. They then arranged a meeting with Fife Council to map these locations and discuss their outline feasibility. This could be a project the community take further with a detailed feasibility study and costing.

The idea of a **solar PV farm** (whether locally owned or delivered by a commercial solar farm operator) also created a lot of interest amongst the local community.

A presentation on Tidal power showed this energy was not appropriate for the town.

Energy Event 3 focussed on **energy efficiency improvements** such as **external wall insulation (EWI)** and the potential for **individual solar PV** for homes with **communal energy storage**.

The current ability of Fife Council to deliver external and internal wall insulation cladding is at full capacity and is presently focussed (due to funding constraints) to deliver in areas within Fife that experience higher levels of fuel poverty than those witnessed in Burntisland. Within the current EWI timetable, Burntisland despite having 1300 homes currently in fuel poverty, may not be addressed for another 3-5 yrs.

The community was keen to explore a partnership between Fife Council, BCDT, Home Energy Scotland and various different funding bodies for delivering energy efficiency improvements. BCDT are keen to look at improving the energy performance of all properties within the town. At the moment the main funding for energy efficiency improvements (SEEP funding) is targeted at Local Authority applicants, rather than community groups. If community groups could work in partnership with Fife Council and receive this funding then the capacity to deliver **external and internal wall insulation cladding** projects would increase dramatically, with associated benefits in terms of carbon reduction and fuel poverty.

Individual solar for homes was discussed at length, and the consensus was that bulk purchasing could be considered, so as to bring down the individual unit costs and make PV a more affordable option.

There was acknowledgment that **individual electrical storage** would be expensive whereas **communal electrical storage** would be a cheaper and preferable option.

Attendees were interested in having an **energy hub** in the town so there would be a place to come to sign up for projects and to enable information exchange.

Capacity building events

It was recognised by all parties that if the local community are to be partners in the design, delivery and management of sustainable energy projects they will need a number of skills. Particularly the ability to apply for funding and deliver strong business cases within those funding bids. Feedback from the community around the issue included the following points:

- a lack of knowledge of where to apply for funding;
- a lack of understanding of what funding was available for different project types;
- a lack of experience in quantifying the impact assessments needed by funders and quantifying the impacts delivered by local projects;
- a lack of confidence in putting together strong business cases.

To combat this, we ran two funding events to build capacity / skillsets in writing funding applications, project impact assessment and building strong business cases. Presentations and workshop activities were provided by:

- Resilient Scotland;
- Community Shares Scotland;
- Fife Council's community funding team; and
- First Port (an organisation dedicated to providing business support, funding and resources to groups wishing to start a social enterprise in Scotland).

Next steps workshop

Feedback from the BCDT shaped the agenda for the workshop. The priority was to get clarification on what the Energy Masterplan was suggesting so they could then look to develop their next step plans. Topics included

- Discussion around masterplan scenarios with timeframes, carbon savings and costs associated with different policies and measures;
- Measuring the BCDT's appetite and confidence in taking forward the suggested energy projects;
- Mapping what future energy solutions the community could be involved in and what roles and responsibilities they saw themselves taking;
- Devising a community energy strategy to map out on paper what the community's local energy priorities, are.

'The next steps workshop was a great discussion. For the next session can we break down the whole de-carbonisation journey into its strategic elements?'

Outcomes

The engagement programme has delivered a range of tangible and intangible benefits. In terms of 'soft benefits' i.e. intangible outputs: all parties have a greater understanding of how to boost capacity and technical understanding of energy issues and the type of themes which can be used as 'carrots' to raise interest and bring people into the process. The community's natural enthusiasm for the topic has been focused into real practical ideas they are keen to see being implemented locally. Their confidence in discussing energy, standing up for local priorities, understanding technical data and applying for funding has increased.

In spite of enthusiasm and increased knowledge there is a real apprehension that some of these projects are too big for a small local Development Trust to lead on i.e. the development of multi-million pound district heating systems. Most of the community members work or have caring responsibilities for their families. Participants are worried about the stress this would place on their time capacity outside of families and jobs. Community members are wary of taking on too much and then letting others down. There is genuine concern about lack of support structures. As confidence grows and support and financial structures are put in place to drive the process, then the community's appetite may grow for greater involvement.

Barriers

The barriers to greater community / Local Authority collaboration are becoming increasingly apparent in the present time of constrained Council budgets. These barriers to engagement are further emphasised when economies of scale force a one size fits all approach to Local Government policy making and community engagement.

'*With ever increasing statutory obligations, particularly for social care, and diminishing budgets, Scottish Local Authorities have necessarily become focussed on 'efficient' delivery of public services rather than on being forums for engaging communities in public debate and deliberation. Citizens have become customers -as recipients of public services, which are increasingly outsourced and privatised. This focus on economies of scale, cost-cutting and efficiency-savings in the delivery of services has led to a standardized approach which takes no account of the wide diversity of Scottish communities and the need for locally appropriate solutions. A sense of local knowledge and ideas being ignored or undervalued risks undermining local autonomy, empowerment and resilience. Officials may be reluctant to engage with a local initiative that could potentially be disruptive or a threat to their normal 'one-size fits all' way of doing things. When they do seek engagement, there is frequently a 'culture gap' between council officials and community groups that creates a challenge for both sides, exacerbated again by the lack of any representative, local, democratic forums'*[7].

This project has highlighted the reality of these barriers to greater community engagement. The need for funded 'gateway staff' to facilitate information flows and engagement between local government and communities was recognised early on in the Burntisland pilot project, however where the gateway staff should sit (in terms of organisational structures) is more complicated. Should the gateway staff sit on the Community Council or local Development Trusts or should these roles sit within Local Authorities, and if so, the question is - in which department? While Community Planning and / or Housing Services teams tend to have excellent engagement skills, presently these services primarily engage with social housing tenants or particular areas of deprivation i.e. welfare, employment and skills, substance abuse etc. and as such their skills can be specialised. These professionals are not familiar with energy and sustainability. Equally these officers are assigned to small areas of deprivation within a settlement / settlements and they do not take a settlement-wide view. Equally there is not sufficient budget for these officers, nor capacity of human resource available for them to cover entire towns.

Another key barrier that was identified by this project is that within Council planning local low carbon energy and heat generation is not, seen, as a way to deliver services and realise a broad range of socio-economic and environmental benefits for communities. Climate change mitigation is viewed, instead, by many Services as an expensive 'extra' that has to be seen to be delivered alongside the frontline public services that the electorate "really care about" i.e. education, transportation, street lighting, waste management and social care. Renewable energy generation was seen time and again to be something that can be valued engineered out of asset designs and project delivery, to meet budget constraints.

However this view is short sighted and fails to recognise the multiplicity of benefits that can be realised by capitalising on local sustainable energy and heat generation, storage and energy networks. Creating local sustainable energy / heat projects can help Fife Council to achieve a wide-range of Council objectives. Some examples of which are given below:

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[7] Revell, Philip. 2016, Community Resilience and the New Narrative of Community Empowerment in Scotland http://www.tess-transition.eu/

Housing Services	Reduction of fuel poverty, improved health and wellbeing, improved tenant satisfaction and quality of life. Increased energy security and resilience for all, but most especially for vulnerable residents.
Economic Development	Local ownership of energy solutions, job opportunities, and increased economic prosperity for local economies. Reduced risk of energy supply disruption and price spikes.
Transportation Services	Reduced congestion, improved air quality, use of low carbon transport fuels and market development for these technologies, meeting active travel, mobility poverty, and health and wellbeing targets. Reducing Fife-wide carbon emissions. Greater uptake of Fife Council EV charging networks.

Next steps

In terms of next steps, the community and Fife Council are keen to investigate moving this project from a pilot energy masterplan to implementation of the energy project ideas conceived by the community. In particular, to not lose the momentum and enthusiasm that the pilot project generated.

Burntisland could be used to illustrate the reality of translating community energy masterplans from paper to real community energy projects, as the enthusiasm, skills and collaborative partnerships are now in place. However this can only become a reality if further external funding was made available. It is important to the residents of Burntisland that the energy projects realised as a result of this project are inclusive and target as wide a range of social groups within the town, as possible.

Should further funding be available the following actions have been identified during the community engagement phase, as the logical next steps for the project:

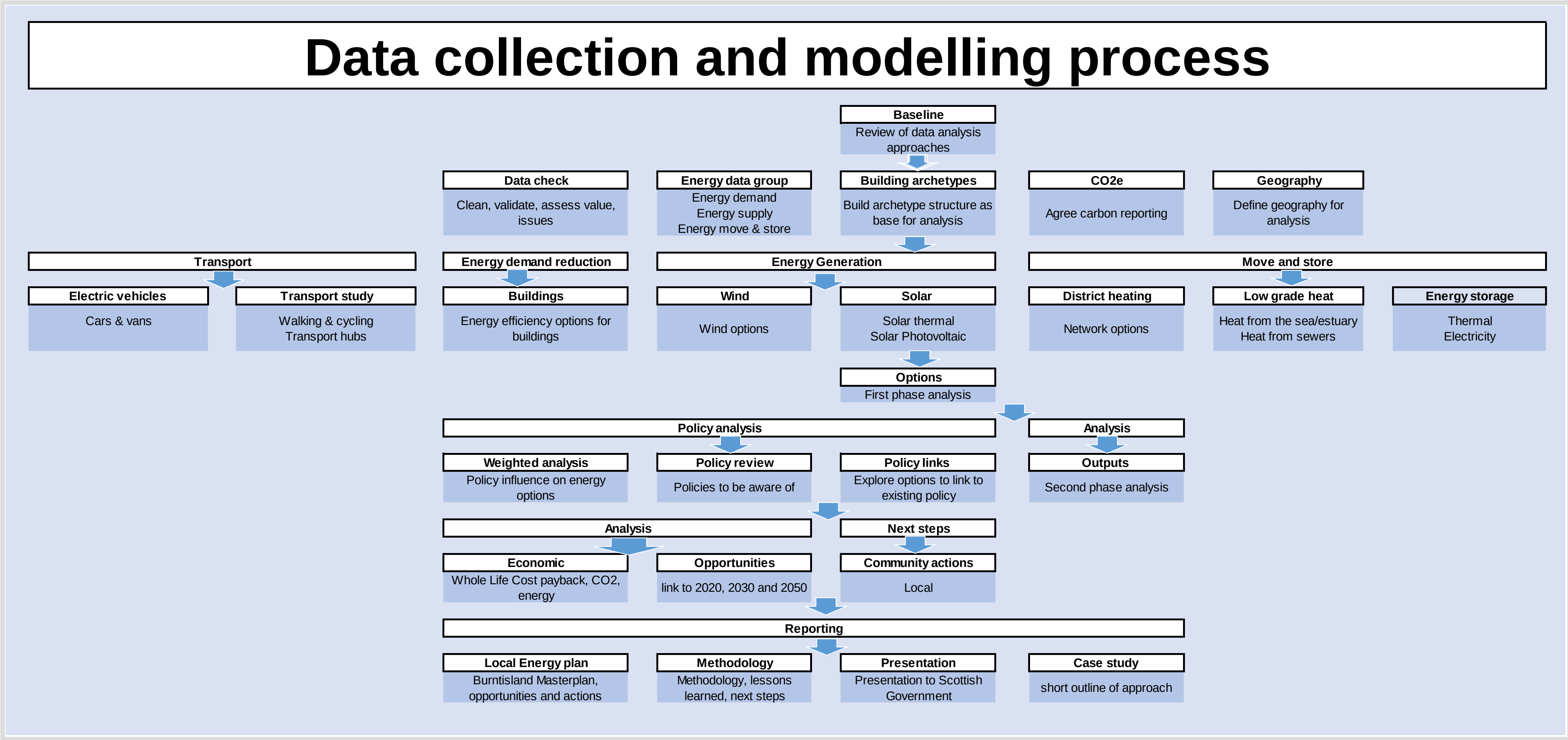
- A detailed feasibility study to gauge the technical suitability of the proposed locations for solar thermal pits, and whether or not the landowners of these sites are interested in progressing the idea;
- A solar fly-over over the town to photograph the available roof area, suitability of roof types and orientation of roofs to more accurately measure the potential opportunity for building mounted solar PV / solar thermal, within Burntisland. IIF funding rules precluded the inclusion of this activity within this phase of the project.
- Funding for an infra-red survey of all buildings in the town to allow prioritisation of energy efficiency works and to check that the energy efficiency measures installed historically, are not defective.
- A joint campaign to promote EWI cladding and solar PV to Burntisland homes and businesses, including (if feasible) a bulk purchase of the measures to reduce the unit price and increase affordability. This campaign would be undertaken in partnership with Home Energy Scotland, Fife Council and the BCDT.
- Development and operation of a staffed, local energy hub (to build on the momentum established by the pop-up-shop) and create a solid hub for community collaboration.
- And numerous travel projects.

See next steps table for further details p187.

5. Data collection and modelling

Introduction

The data collection and modelling work stream contained a large number of tasks. These are summarised in the diagram below and will be discussed in more detail in *Sections 6* to *11* of this report.


Data collection and modelling process
Baseline
Review of data analysis approaches
Data check
Clean, validate, assess value, issues
Energy data group
Energy demand
Energy supply
Energy move & store
Building archetypes
Build archetype structure as base for analysis
CO2e
Agree carbon reporting
Geography
Define geography for analysis
Transport
Electric vehicles
Cars & vans
Transport study
Walking & cycling
Transport hubs
Energy demand reduction
Buildings
Energy efficiency options for buildings
Energy Generation
Wind
Wind options
Solar
Solar thermal
Solar Photovoltaic
Move and store
District heating
Network options
Low grade heat
Heat from the sea/estuary
Heat from sewers
Energy storage
Thermal
Electricity
Options
First phase analysis
Policy analysis
Weighted analysis
Policy influence on energy options
Policy review
Policies to be aware of
Policy links
Explore options to link to existing policy
Analysis
Outputs
Second phase analysis
Analysis
Economic
Whole Life Cost payback, CO2, energy
Opportunities
link to 2020, 2030 and 2050
Next steps
Community actions
Local
Reporting
Local Energy plan
Burntisland Masterplan, opportunities and actions
Methodology
Methodology, lessons learned, next steps
Presentation
Presentation to Scottish Government
Case study
short outline of approach

Overview

To assess energy options we need a way to map energy at a local level. A working group of local authorities (Highland Council, Perth & Kinross Council and Fife Council) have been working together over several years, supporting each other toward this goal. In particular this work draws on work of Highland in their HERO (Heat Energy Renewable Opportunity mapping) and the Perth & Kinross spatial analysis work.

The Scotland heat map provides a solid data structure and approach to build local energy maps. To date the key outputs layers include heat demand, larger energy generation and heat networks. There have been a number of tools and approaches that have evolved from the Scotland heat map data. In addition, the project team felt that there are a number of other national datasets that looked as though they had potential to be drawn together, alongside the heat map data into a broader energy framework.

The core aims of the data analysis has been to develop a pilot for local energy Masterplanning that:

1. builds on existing work and extant datasets;
2. could be used by any pilot local authority;
3. could be expanded up to a Scotland-wide level; and which
4. uses data which is readily and affordably (preferably free to access) available to public bodies (in particular local authorities and the Scottish Government).

In any smart local energy system, the aim is to reduce energy demand. Energy efficiency was made a national infrastructure priority for the Scottish Government (2014). Reducing demand means lower fuel bills for energy users. Additionally, reducing energy demand in turn reduces the total requirement for low carbon energy generation and lowers the potential temperatures at which district heating systems need to operate. Both these have significant cost benefits over the longer term.

The local cost and benefit of proposals was seen to be key to getting buy-in from local people. Most existing analysis is not provided at the level where people can make a personal connection – such as at the settlement level. The statistics for the costs of providing heat or electricity or vehicle fuels to Scotland, are eye-catching but more usually expressed at the national level. The project partnership felt that providing figures at the settlement level could provide useful data for understanding the cost of the energy transition, and the cost benefits for local communities.

The overall, long term impacts of policy (particularly transformational policies) are often lost in short term cost benefit analysis. A common theme in discussions about prioritising district energy references the Danish approach of socio-economic analysis. The project partnership felt that different approaches could provide a standardised weighted approach for assessing policy and promoting local priorities, more effectively than the current policy framework. This approach could test out ideas for socio economic analysis. In this way information could be provided in a better way which would maximise engagement with the local community and provide them with a baseline with which they could take ownership of planning future energy choices.

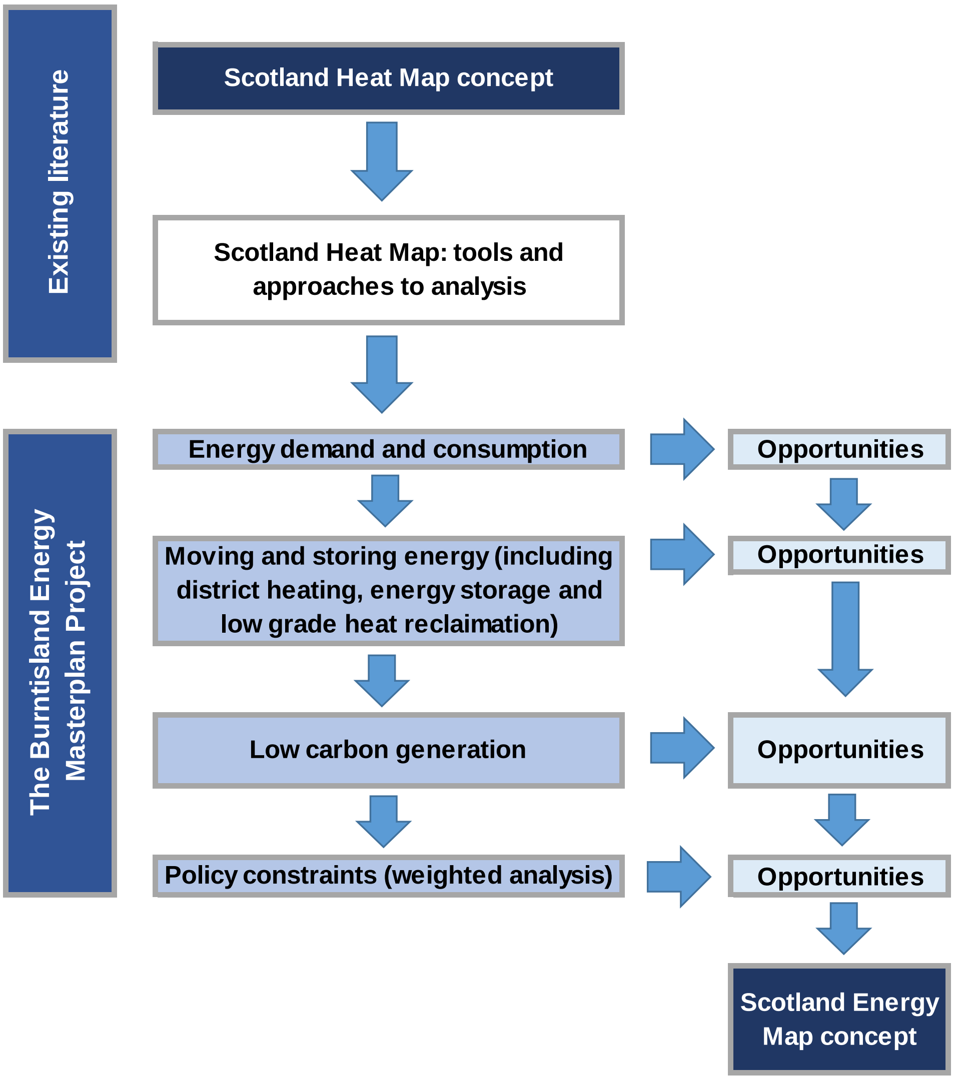
We recognised the need to improve the energy literacy of the community to enable them to engage and effectively challenge and interrogate with the often technical ideas being put forward, and to be able to put forward their own ideas from a well-informed position. The data modelling team worked very closely with the officers leading the community engagement work package to guide the type of presentations provided to the community. In turn the community was constantly feeding back to the data process, influencing the choices for technology which were to be modelled, in line with the community's own preferences, and also influencing the subsequent analysis undertaken.

The data process does not include all sources. Transport emissions only includes cars and light vans, and does not include any other vehicle or form of public transport. Agriculture is not considered in this model. Food and goods produced outwith the settlement are not included.

Community feedback was fed back into the data modelling process through the following activities:

- Through engagement, consultation and workshops November 2016 – January 2017;
- Through the options workshop (February 2017)
- Through the outcomes workshop (March 2017)
- Through the next steps process (March 2017)

Overview of the data collection and modelling process



Key modelling work streams

The modelling component of this project was divided into the following sub work streams:

1. Baseline modelling (see Chapter 6);
2. Calculating energy demand / consumption (Chapter 7);
3. Modelling the impacts of energy efficiency measures on demand (Chapter 8);
4. Modelling how energy could be moved and stored in Burntisland (including district heating options) (Chapter 9);
5. Modelling the low carbon generation potential within Burntisland (Chapter 10);
6. Modelling transport energy demand and demand reduction options (Chapter 13);
7. Opportunity and constraints: Review and policy consideration of proposals, and further analysis

8. Economic and opportunities appraisal: consider lifecycle economic benefits leading to next steps are built into sections

Key data sets

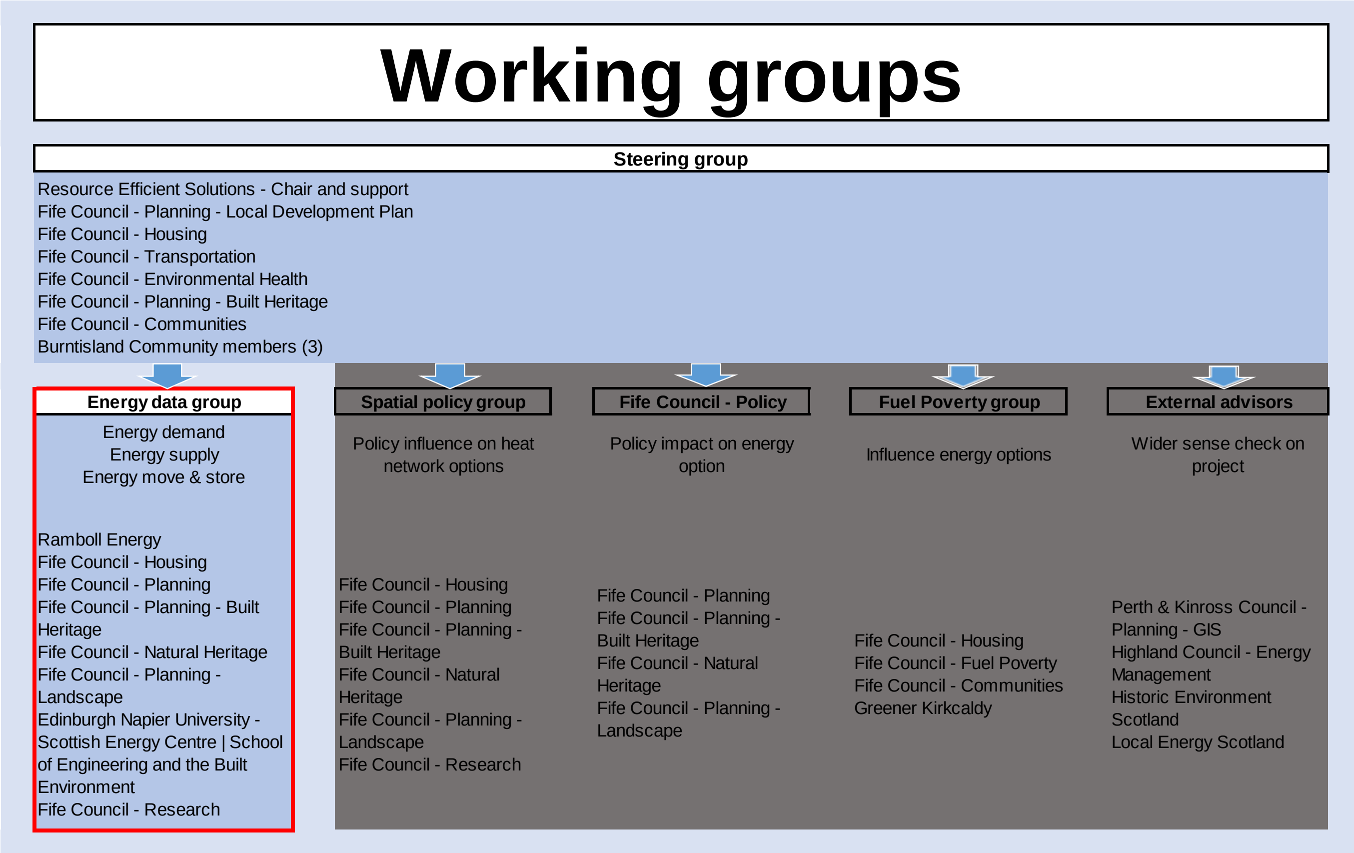
The modelling side of the project involved a considerable degree of data manipulation and analysis and was reliant on a large number of external datasets. The first stage of this process involved the collection of key data sets including:

- Characterisation of the properties within the study area in terms of their building type, tenure and heat demand which was initially estimated from the Scotland Heat Map (www.scotland.gov.uk/heatmap) and then enhanced with supplementary national and local data;
- Identification of initial groups of properties by ownership or property type that could be aggregated together under one company or community group to facilitate future stakeholder consultation activity;
- Understanding of grid infrastructure and network capacity constraints;
- Information on proposed new developments in the area, through consultation with local planners and developers, including information on proposed floor areas / number of dwellings and planned energy supply plant;
- The location, capacity and ownership of existing or potential heat generation sources including a review of potential energy resources;
- Collection of the above data into summary tables and production of a locally detailed Geographical Information System (GIS) showing heat demand and heat supply layers for the area of interest; and
- Additional GIS information sought in order to assist with the development of the database including: information on proposed infrastructure works, information on utilities where available, and areas of proposed development.

Further information on the data sources used is provided in more detail in the following chapters.

Energy data group

Because of the complexity of the modelling process, an energy data group was set up. The role of the Energy Data Group was to bring together expertise, to guide the work, and provide a forum for discussion and decision making with particular focus on the technical details of the modelling and assessing the value of the different data sets available. Membership of this group is shown in the diagram below, alongside the other working groups created for the project:



Our approach

The data and policy analysis was undertaken in stages:

- Baseline: project initiation and developing the baseline;
- Examining the three energy choices: Initial analysis across the three key energy choices identified by the project partners: i.e. final energy consumption, moving / storing energy and low carbon generation;

- Opportunity and constraints: Review and policy consideration of proposals, and further analysis
- Economic and opportunities appraisal: consider lifecycle economic benefits leading to next steps

Different technology solutions were considered for each stage of the process. We considered the range of options available using different energy consumption scenarios for Burntisland (high, medium and low consumption), these different energy demand scenarios would implicitly require differing levels of low carbon energy generation and energy storage options. In short the more energy demand reduction undertaken, the lower the levels of low carbon generation that would be needed. An example of this iterative process is given below, considering how building energy consumption would reflect the different consumption scenarios and the types of technical and behavioural change that would be associated with each scenario.

	End consumption	+	Move & Store	=	Low Carbon Generation
The energy choices	To use less (or more) energy	+	To use the energy we have more efficiently or less efficiently	=	To generate enough energy
What is it?	Insulating buildings Using more efficient technology i.e. boilers Driving cars more efficiently More energy efficient behaviours (i.e. demand management)		District heating Shared energy storage Shared electricity storage Using available low grade energy stores (i.e. heat from the sea)		Wind Solar photovoltaic Solar thermal Geothermal
Building energy					
High consumption choice	Few significant improvements to existing building fabric and insulation levels, continued use of individual energy heating systems.	+	Less integrated energy systems such as district heating and energy storage options.	=	Significantly high levels of low carbon generation from renewables.
Medium consumption choice	Moderate levels of building insulation with some external wall cladding, and some individual energy heating systems.	+	Integrated energy where building / energy density allows, with moderate energy storage.	=	High levels of low carbon generation from renewables.
Low consumption choice	Very high levels of building insulation with high levels of EWI, loft insulation, and other improvements to building fabric, and very few individual energy heating systems	+	Energy supply within the town is mostly integrated energy into a smart local system, with substantial energy storage.	=	Moderate levels of low carbon generation from renewables.

This process was repeated for different energy demand sectors i.e. transport, heat, electricity etc.

6. Baseline

The core of this work was to bring together the expertise and information to tell a more coherent energy story at a local level that could be used to initiate and start the process toward a stable managed energy transition. This required establishing a baseline for Burntisland in terms of the scope of the work, the study boundary and a baseline for existing heat and electricity consumption in the town.

Note that the transport baseline (i.e. the number of existing vehicles is determined in the transport section of this report).

Overview of the modelling process for establishing the baseline

Modelling overview

1. Establishing the baseline (building energy consumption)

Key questions	Data sources	Modelling decisions made	Results
a) What are the boundaries of the study area?	Burntisland Community Council Boundary (Fife Council GIS) National Address Gazetteer Unique Property Reference Number (UPRN)	The settlement boundary was used for building related modelling. For modelling renewable energy / energy storage options to counteract transmission losses we prioritised proximity to the settlement and considered some of the rural hinterland within the Community Council area.	a) The study area is 2.4 km2. The study area boundary was taken as the settlement boundary, and hinterland within x km of the settlement.
b) How many buildings are there in this area?	Burntisland settlement boundary (National Records Centre)	We excluded the immediate rural hinterland of other settlements such as Kinghorn and Kirkcaldy (where it was located within Burntisland CC area). As these hinterland areas would more appropriately be used to generate sustainable energy for the settlements that they are closest to.	b) There are 3,391 properties within Burntisland. 3,198 of these are domestic. 33 properties are of an unknown type according to assessor data but the majority of these are assumed to be non-domestic.
c) What type of properties are there in Burntisland (i.e. tenure and use)?	Datazone boundaries and Census output areas (CENSUS> 2011> output area> Locality 2010> Burntisland> household)	Where possible data was used and analysed at the UPRN level. The National Gazette UPRN was used as the link for all building level data sources.	c) Property characteristics described as archetypes. Flats = 1,256; semi-detached = 869; and detached = 677 properties.
d) Can we categorise the different construction types / building styles within Burntisland into building archetypes?	Rasterised spatial data (e.g. 25m and 50m raster files, including the Scotland Heat map 50m raster)	Even though building level data was available license agreements precluded us from showing some datasets at any granularity finer than datazone.	d) x kWh consumption per year for x archetype etc.
e) What assumptions can be made about the typical energy demand of different building archetypes?	Fife Council asset data (asset boundaries, social housing, conservation areas, listed buildings)	Scotland heat map core archetypes used as a basis for analysis, attributes were considered which would lead to a greater understanding of energy demand reduction potential and energy generation potential.	e) Outputs in kgCO2e per gross calorific value kWh, for exact factors see:
f) What GHG emissions are associated with this energy consumption?	Fuel poverty spatial data (Changeworks)	Census data was collated so that results could be linked at datazone or settlement level.	https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2014
	Home Analytics combined housing data (Fife Council under license from the EST) i.e. loft and wall insulation, glazing and PV figures for the datazone level.	Fuel poverty datasets were used to target areas for intervention priority. Heritage designations were considered for potential to constrain demand reduction and energy generation options.	f) Total Burntisland heat demand = 49 GWh; Public sector heat demand = 2 GWh
	Scottish House Condition Survey data	The heat demand data from the heat map was combined with EPC assessor data and EPC records for all properties. The dataset was then filtered using pivot tables to analyse the characteristics of Burntisland housing stock.	
	BEIS sub-national gas and electricity consumption data	Scotland heat map demand point and heat demand 50m raster used for heat demand and heat density calculations.	
	Building surveys	Identify streets where common property types exist and undertake surveys.	
		Identify large individual heat demands in Burntisland and undertake surveys of these buildings.	
	2016 UK Greenhouse Gas Reporting Emission Conversion Factors (BEIS)	Fife Council property EPCs were used as a cross-check against existing data.	

Geographic scope

Defining the geographic scope involved selecting a boundary for the area of study in the GIS layers available. This boundary would ideally be coincident with a collection of datazones or intermediate geographies to assist in the data processing and validation stage. The geography of the study was an important early consideration which needed to be established before data collection could begin in earnest. There were a number of ways that the study area could have been defined using existing boundaries, and a number of benefits and disadvantages to using these boundaries with the existing datasets.

Political boundary

Politically the Burntisland area is often joined with the larger, nearby settlement of Kirkcaldy, but Kirkcaldy and Burntisland are very different places with different needs and distinct local identities. The sense of community is definitely defined as around the settlement of Burntisland to the exclusion of Kirkcaldy (which is a separate community). It was realised very rapidly that the political boundary of Burntisland and Kirkcaldy was not an appropriate study area because if we chose this boundary, the vast majority of population and buildings would be in areas other than Burntisland itself.

Community Council boundary

The Community Council boundary is smaller than the political boundary that extends behind and to the boundary of a number of other neighbouring communities. The Community Council boundary includes a lot of rural areas which are more accurately, the hinterland of neighbouring settlements (for example it extends right behind neighbouring Kinghorn) and these areas may be better suited for providing renewable energy generation for these adjacent communities instead.

Settlement boundary

The third potential geographic scope was the formal settlement boundary of Burntisland as defined by the National Records Centre.

The geographic scope selected

The scale of the study boundary, as a proportion of the land area and energy demand within Fife, is illustrated below.

Burntisland Settlement boundary		Fife Council boundary	
Total Heat Demand (GWh)	49	Total Heat Demand (GWh)	3,558
Public Heat Demand (GWh)	2	Public Heat Demand (GWh)	67
Area (km^2)	2.4	Area (km^2)	1,373.9

The following modelling decisions were made when it came to the geographical scope of the study:

- Building data analysis within the study was defined by the settlement boundary of Burntisland as this area contained the high density of buildings appropriate for energy analysis purposes, and enabled links to be made to other relevant spatial data and datasets.
- It was recognised that renewable energy generation needed to look at both rural and urban areas. One solution to this could have been to use the Community Council boundary as a de facto study boundary. However, political boundaries, such as the Community Council boundary would artificially benefit some communities and constrain others; for example the Burntisland Community Council boundary includes all the hinterland more closely linked to the adjacent community of Kinghorn. Therefore the question was how best to define the rural hinterland of Burntisland without reducing the ability of other neighbouring settlements to develop their own Energy Masterplans and low carbon energy generation in the future?
- Proximity to settlement was considered a core factor when considering low carbon energy generation and available energy sources. Some low grade heat sources were very close to the settlement but outwith the Community Council boundary (such as heat from the Forth Estuary / sea), and these were considered as part of the study area as these were not zero sum energy sources and would not impact on the ability of other local settlements to meet their own energy needs.
- Transmission losses (i.e. the energy lost when moving energy away from where it is generated and to where it will be consumed or stored) can have a major impact on the viability of local energy systems and the degree of transmission losses encountered correlates directly with the distance that energy is moved. Therefore we considered low carbon energy generation sources and potential energy stores located within the Community Council boundary but within close proximity to the settlement boundary of Burntisland itself.

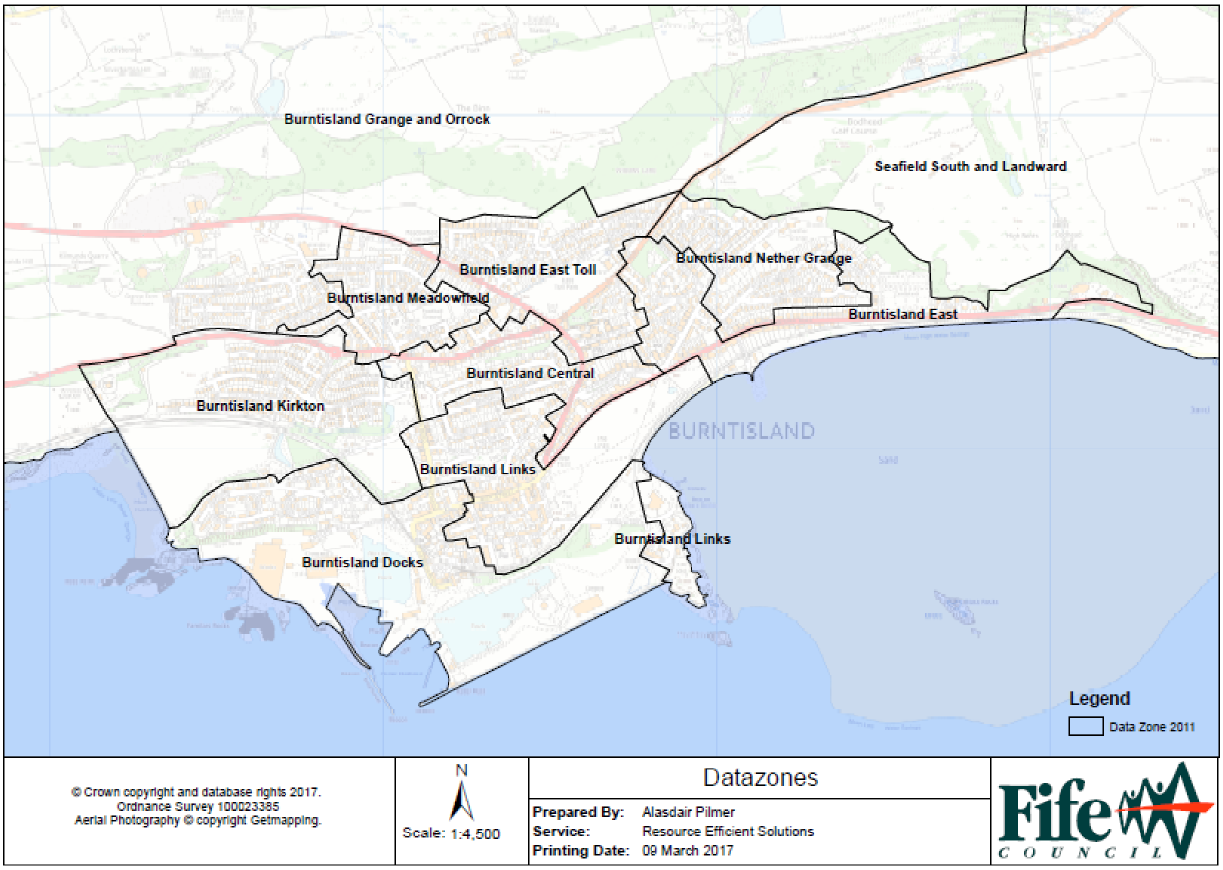
A judgement was made around proximity to the settlement based on the technical and economic implications associated with private wire connections and moving heat. In practice this meant that low carbon energy generation and storage opportunities were constrained to locations within around 1-2km of the settlement boundary.

- For some data sources, data was only available in limited spatial areas for example datazones and could not be broken down to smaller areas or to the individual property level. Datazones were therefore chosen as an important analysis level as this was the most common data output area available (below settlement level data) for spatial data.
- Some data was available at a more detailed level. Where possible data was used at a building level using the National Address Gazetteer Unique Property Reference Number (URPN) identifier to link the data to individual buildings.

The following datazones were used within the study:

Datazone number	Name
S01009458	Burntisland Central
S01009459	Burntisland Links
S01009460	Burntisland Docks
S01009461	Burntisland Kirkton
S01009462	Burntisland Grange and Orrock
S01009463	Burntisland Nether Grange
S01009464	Burntisland East Toll
S01009465	Burntisland Meadowfield
S01009466	Burntisland East
S01009476	Seafield South and Landward

These datazones are presented in map form, below:



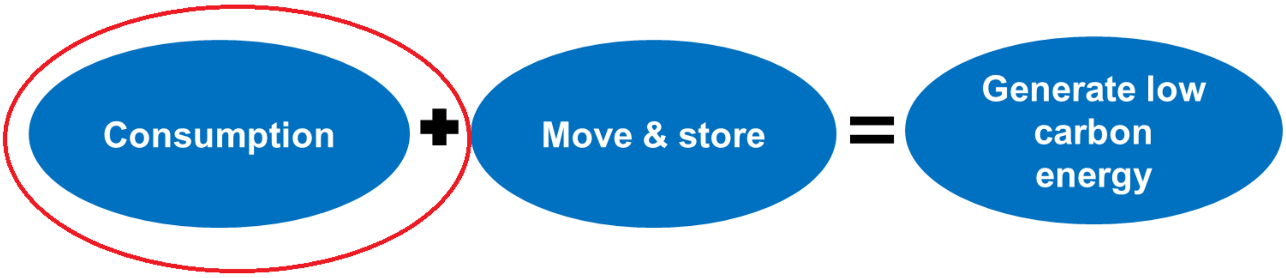
Zoning

Once the study boundary had been defined, the next step in the baseline process was to establish appropriate zones for detailed data analysis within the boundary. This process divided the town into smaller sub-areas depending on the property type / class of buildings present and then adding a qualitative description of each zone to provide further information that would assist with analysis. The process involved site visits in order to suitably classify each zone appropriately. The zoning of the area enabled project partners to evaluate the feasibility of a range of renewable technologies within certain parts of the study area and to take advantage of local scale (sub-settlement) opportunities and needs. The principle purpose of the zoning exercise was to qualitatively assess certain key parameters that distinguished areas within the town from one another, these included:

- The heat demand density of each zone;
- The land use of each zone; and
- The age of properties within each zone (as an indicator of the baseline energy efficiency of properties).

The zones were drawn as shapefiles in GIS to facilitate more simple extraction of data.

Calculating energy demand / consumption



Once the geographic scope of the study was defined the next step was to establish the baseline of energy demand (i.e. existing gas and electricity consumption levels) within Burntisland. To model this, the following steps were undertaken:

Overview of the modelling process

Modelling overview

3. Energy efficiency measures (buildings)

Key questions

a) What energy efficiency measures would be feasible for the different building archetypes within Burntisland?

b) What percentage of buildings in Burntisland are already fitted with energy efficiency measures, and which type?

c) What would the installation of different building energy efficiency measures cost?

d) What would the financial benefits be of installing different building energy efficiency measures?

e) What would be the carbon savings arising from installing different building energy effiency measures?

Data sources

Home Analytics data (EST)

Energy Performance Certificate data (Fife Council)

National Address Gazetteer Unique Property Reference Number (UPRN)

Burntisland settlement boundary (National Records Centre)

Green Deal emission reduction assumptions for energy demand reduction measures (CWI, EWI, loft insulation, underfloor insulation)

Property and street surveyings

Standard Assessment Procedure calculations (SAP)

EST energy demand reduction assumptions (CWI, EWI, loft insulation, underfloor insulation).

Modelling decisions made

This modelling phase sought to test an approach for rolling-out building energy efficiency measures to reduce Burntisland's energy spend and carbon emissions, and fuel poverty within the town.

Scotland Heat Map 50m raster squares were numbered and properties totalled per square. The raster squares were coded for analysis.

A small trial area was selected for detailed examination to test the methodology. The area around Rossend Terrace was selected as it had a good representation of the building archetypes, included some social housing and was within an area predicted to be experiencing high fuel poverty. EPCs were examined for owned properties. A site survey was undertaken using SAP. This included a survey of property types, photos of properties and an internal survey of some properties. The SAP calculations were compared with the heat map data.

Only 1/3 of the buildings in Burntisland had an EPC. There were some errors / lack of clarity on the EPC coding meaning that EPCs could only evidence the presence or absence of insulation, and not the type or depth of the insulation present. The Home Analytics data was preferred because it covered all of the buildings within Burntisland.

The EST gave the project team, approval to use Home Analytics data for existing energy efficiency measures (in the form of probability rates per measure, per data zone). Careful data manipulation was needed to avoid double counting. Home Analytics data is a combined dataset, with sources not identified so it is not appropriate to use it in combination with other data sources).

Combining Home Analytics data was used at different data levels, and by the use of pivot tables we were able to collate energy demand reduction data for the 10 datazones within Burntisland.

The following energy efficiency measures were considered: solid wall insulation (internal and external), virgin loft insulation (0-270mm), Loft insulation top-up (120-270mm), cavity wall insulation, floor insulation).

The final approach created a datazone model, we linked in the building archetypes, demonstrated the impact of each measure separately and then the cumulative impact of measures per property. Finally we illustrated the cumulative impacts for Burntisland using a phased approach for 2020, 2032 and 2050.

Results

a) Fuel space heating requirements (kWh/year) for each property archetype

b) Number of existing measures (by archetype and datazone)

c) Number of potential measures (by archetype and datazone)

d) Cost of options (by archetype and datazone)

d) Energy impact of choices in terms of kWh and MWh savings.

e) Carbon saving impact of energy efficiency options (tCO_2e), by property and cumulatively for the settlement.

f) Cumulative settlement carbon impacts by dates 2020, 2032 and 2050

Data Collection

When considering energy demand within Burntisland, the initial heat mapping phase involved collecting and analysing data from the following sources:

- Scotland Heat Map (SHM)
- Billing data for public buildings (Fife Council-owned)

Further billing and energy performance data may be available from other public and commercial properties through additional stakeholder engagement but this was not able to be provided at this stage due to the time constraints of the project timeline.

Data validation

In order to ensure a high quality outcome the data used by the project needed to be validated to ensure that it was as robust and error-free as reasonably possible. Data cleaning was undertaken as was validation to remove sources of double counting.

Scotland Heat Map data

Some of the underlying datasets were known to have issues regarding data validity for example the Scotland Heat Map (SHM) because of the complexity, scale and organic growth of these data sources.

The following issues and potential mitigation options were identified as being potential sources of error within the existing heat map datasets:

Issue	Details	Effect	Mitigation
Under- or overestimation of heat demands and duplication of records	Particularly for private non-domestic loads where the confidence in the heat map data is low.	May influence the economic KPIs of a project opportunity	Manual review of data including visual check of large and small heat demands, particularly large loads.
Point Data location for some demands does not match their physical location	Heat demand points may not be in the actual location of the building or point of connection.	Potential Network incorrect – over/under estimate cost associated with project	None included at this stage – to be reviewed at feasibility study stage.
Building Use Classification does not match the known building use.	In some cases property records do not accurately reflect the actual use. This could be the result of changes to building use or incorrect classification.	Incorrect assessment of opportunity and assignment of type-specific parameters	None included at this stage – to be reviewed at feasibility study stage.

However it should be noted that, although extensive work has been undertaken on data validation by Fife Council on the heat map data that was then fed back to the Scottish Government for inclusion in future heat map updates; the updated data represents only a fraction of the total records associated within Burntisland. As such the project outcomes remain subject to the accuracy of the records within the SHM datasets that were not able to have been updated as part of the project.

Billing Data Correction

Billing datasets were provided by Fife Council for a limited number of public buildings in Burntisland. These provided yearly metered primary fuel consumption data for gas and electricity. This information was replaced in the SHM database since the actual billing data was known to provide more accurate data. Billing data shows primary energy usage and it has therefore been necessary to apply an efficiency factor in order to estimate the net heat demand associated. The efficiency factors for converting different energy vectors into net heat demand used in the project are shown in the table below.

Heating System Type	Main Heating fuel	Gross Efficiency
Biomass boiler	Biomass	80%
Natural Gas boiler	Natural Gas	85%
Oil fired boiler	Oil	75%
District Heating	District Heating	100%
Electric	Grid Supplied Electricity	100%
Coal boiler	Coal	75%
LPG	LPG	80%
CHP	Natural Gas	50%

Benchmarking

The SHM was created in 2014 and since been updated annually by Scottish Government. Many buildings' heat demand figures within the SHM are not based on actual energy consumption or EPC data and have been derived by benchmarking. This may not reflect the actual energy demand or energy efficiency of the buildings but provides a best estimate in the absence of other data.

Benchmarking[8] was carried out in the original SHM database according to CIBSE document *TM 46 (non-domestic properties)* and based on *Scottish House Condition Survey (SHCS)* for domestic properties. To achieve this, each building's BLPU (Basic Land and Property Unit code from the heat map) class has been assigned a corresponding use class from *TM46* based on the guidance contained within that document. This has enabled the creation of an overall benchmarking database that could be cross referenced against each data record to assign energy demand where no other information was available.

Data cleaning

Visual inspection of the data and checking of very large and small heat demands (which could represent anomalies or data errors) was undertaken. It was also necessary to identify duplicate properties with different UPRNs but corresponding to the same load.

Data formatting

Data imported into the model needed to be organized in columns and in the following order:

1. Zone,
2. Use Class,
3. Heat Demand (in kWh),
4. Number of Users per Record,
5. Average Consumption per Record (in kWh); and
6. UPRNs (Unique Property Reference Numbers).

[8] http://www.gov.scot/Topics/Business-Industry/Energy/Energy-sources/19185/Heat/HeatMap/HMManualApril14

The average consumption figure produced was simply the aggregated heat demand for each record divided by the number of consumers for that record. Others following our approach should note that additional columns may be imported into the model for record purposes, but this it is not recommended as the computational time and the size of the model may increase significantly.

Limitations

The analysis undertaken was inherently based on information provided to the study from a series of external data sources. This posed some limitations to the study for example with regard to quality control, limitations of data access and data metrics. These limitations are discussed in more detail below:

All of these data sources contain assumptions and may include errors. Although some basic validation and checking of data has been undertaken by the project partners, the data quality and control for these data sources is outwith our control. Datasets were only considered where they provide a reasonable level of accuracy for the purposes of the analysis needed within this study.

Limitations to data use meant that the data analysis had to be split. While there were no limitations regarding data access by Fife Council internal teams and using internal data. Some datasets, such as the Scotland heat map could only be shared under licence to other project partners. Furthermore some data sets, such as Home Analytics data could only be shared at a defined geographic scale – in this case datazone, and use of this data at a finer granularity was not possible.

Where data was aggregated and could not be separated into datazone or at the building level, it was used as is and was therefore not able to be subject to further combination with other data before analysis. This constrained some of detailed analysis which the team were able to undertake.

Property archetypes

The current demand for space and water heating in the town was calculated based on the make-up of the building stock in Burntisland, this necessitated understanding the most common building archetypes within the town in terms of use, size, construction type and age.

Assign building use and profile class

A suitable use and profile class was assigned to each property using their individual Basic Land and Property Unit (BLPU) code from the heat map. A lookup function was used in the Excel modelling to assign each code to a use and a profile class. This approach was developed through the data analysis work.

The initial phase of work mapped the town and identified key property characteristics. On the basis of a set of principal characteristics of properties within the town a more detailed analysis of energy efficiency and energy supply to the most common property types could be undertaken. By considering a series of indicators for property characteristics this allows the total aggregated annual demand for space heating and hot water to be estimated. The heat demand data from the heat map was combined with Energy Performance Certificate (EPC) assessor data and EPC records for all properties, where it was available.

The available property data was characterised by a series of indicators to produce a series of property archetypes seen in Burntisland:

Floor area was grouped by ranges:

- 0 – 50 m²
- 50-100 m²
- 100-150 m²
- 150-200 m²
- 200-300 m²
- 300-500 m²
- 500+ m²

Property type properties were defined as either**:**

- Flat
- Mid-terraced
- Semi-detached
- Maisonette
- Detached
- Non-domestic

Age properties were grouped by age ranges:

- <-1870
- 1870-1900
- 1900-1914
- 1918-1939
- 1925-1930
- 1945-1953
- 1945-1960
- 1953-1964
- 1960+
- 1964-1971
- 1971+
- 1990+

Archetype analysis process

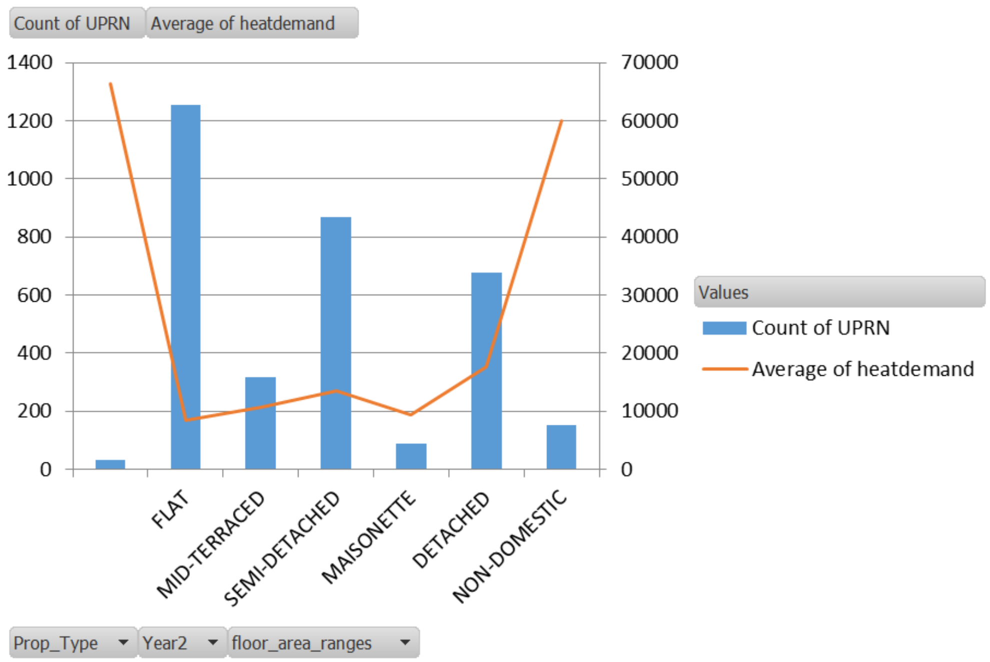
The Scotland Heat Map dataset of 3,391 properties identified within Burntisland was then filtered using pivot tables in excel to analyse the characteristics of the Burntisland housing stock, by property type and by age. It was recognised that the best way to assess the energy demand of different buildings within Burntisland in a short time period was to break down the building stock into different property archetypes based on commonalities of property type, age and floor area; and to make energy demand assumptions at the archetype level.

When considering property type, the data indicates that of the 3,391 properties 3,198 were identified as domestic. The largest proportion of domestic properties was: flats (1,256), semi-detached (869) and detached properties (677). The average heat demand of these properties increases according to type which is not surprising as the area is expected to increase according to the same sequence: flats, maisonettes, mid-terrace, semi-detached and detached.

The average heat demand across all domestic properties only (excluding non-domestic) for Burntisland, today was calculated to be 11,981 kWh / pa.

33 properties were of unknown type according to the assessor data but the majority of these are assumed to be non-domestic. The results are presented in tabular and graphical format below to illustrate the frequency distribution of properties by relevant characteristics and the average heat demand per property.

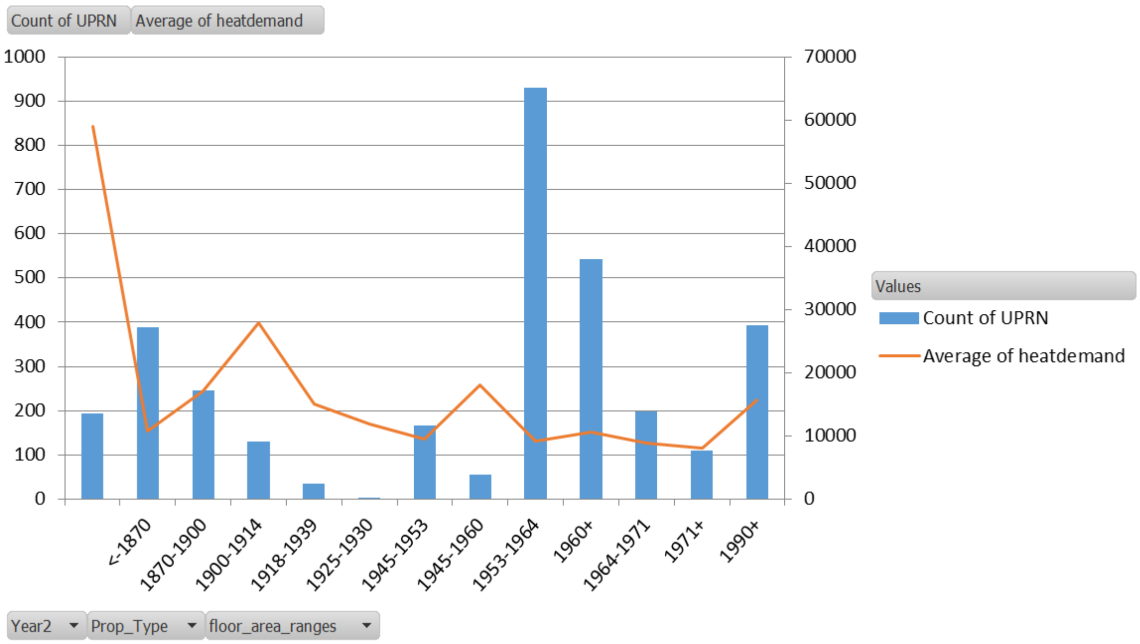
Property type	Number of properties (UPRN count)	Average heat demand per property (kWh / year)
Unknown	33	66,379379
Flat	1,256256	8,408408
Mid-terraced	317	10,692692
Semi-detached	869	13,518518
Maisonette	87	9,353353
Detached	677	17,581581
Non-domestic	152	60,029029
	3,391391 (Total UPRN count)	14,611611 (Average heat demand)



Source: Ramboll Energy

When considering property age, the age of properties was sorted into a series of ranges. The width of each range varies and so this is a relatively crude indicator. It is, however informative when considering the average heat demand of properties. The results are presented in tabular and graphical format below to illustrate the frequency distribution of properties by age range and the average heat demand per property.

Property age range	Number of properties (UPRN count)	Average heat demand (kWh / year)
UNKNOWN	193[9]	58,999999
<-1870	389	10,740740
1870-1900	245	17,151151
1900-1914	131	27,882882
1918-1939	34	14,986986
1925-1930	1	11,928928
1945-1953	166	9,413413
1945-1960	56	18,086086
1953-1964	930	9,245245
1960+	543	10,645645
1964-1971	199	8,928928
1971+	110	8,060060
1990+	394	15,651651
Grand Total	3391	14611



Source: Ramboll Energy

The results indicate a general trend of reducing average heat demand over time as construction methods and energy efficiency performance standards for newbuilds have improved. The results were further filtered to show only domestic properties. The filtered data more clearly emphasises the

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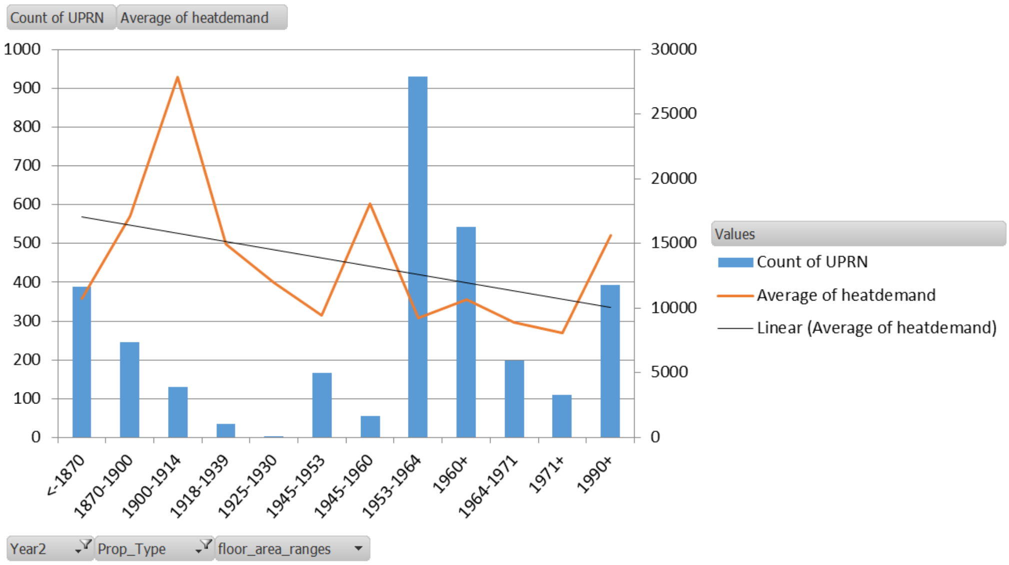
[9] 152 of these properties are recorded in the data as non-domestic and 33 are of an unknown property type and therefore likely to be non-domestic.

reduction in heat demand observed with time as the energy performance requirements of Building Standards have tightened.

The figure below illustrates the frequency distribution of properties by age, for domestic properties only (3,198 properties), and the average heat demand associated with each property age range



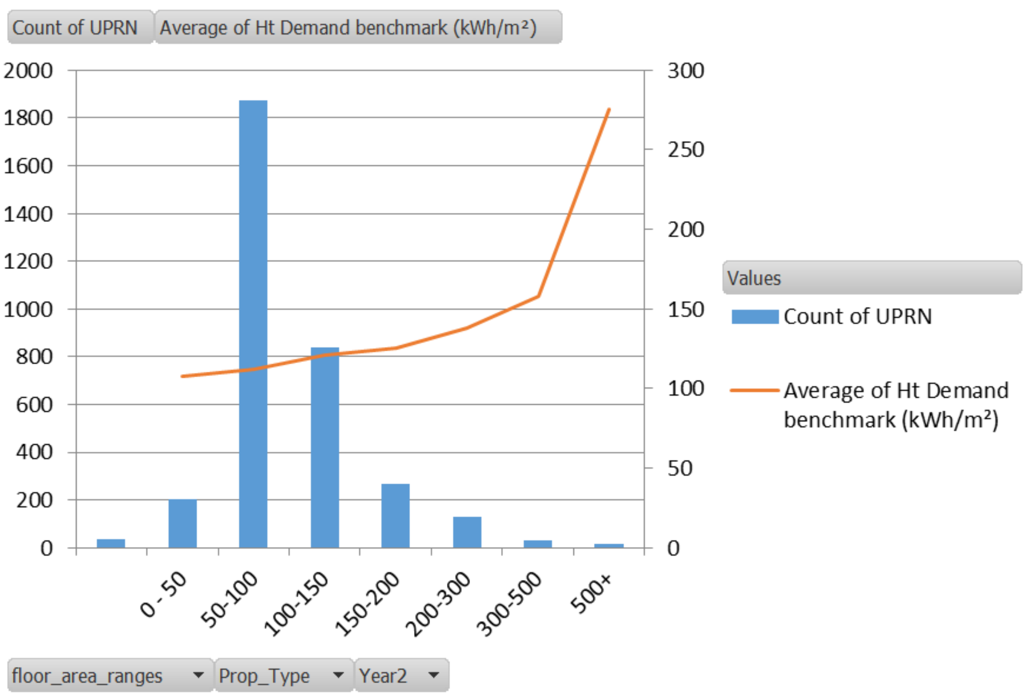
Source: Ramboll Energy

Some points which can be noted include:

- The high demand associated with buildings built between 1900 -1914 is likely to be due to the high proportion of larger detached and semi-detached properties built at the time which may have been solid wall insulated.
- The high energy demand seen in properties constructed between 1945 -1953 is likely to be due to the high proportion of larger detached properties built at the time, and post-war non-traditional construction types, which often had poor levels of energy efficiency.
- The high demand associated with properties built post-1990 is likely to be due to the high proportion of larger detached properties built recently and is not necessarily indicative of poorer energy efficiency performance.

Property floor area was another useful metric used to benchmark average heat demand. The table below illustrates the frequency distribution of property by floor area range, and the average heat demand associated with each range.

Property floor area (m^2)	Number of properties (UPRN count)	Average heat demand benchmark (kWh / m^2)
UNKNOWN	34	N/A
0 - 50	202	107.658995
50-100	1876	112.4093337
100-150	837	120.9893411
150-200	266	125.6248609
200-300	131	138.1764353
300-500	30	157.8111181
500+	15	275.8210238
Grand Total	3391	117.4513197



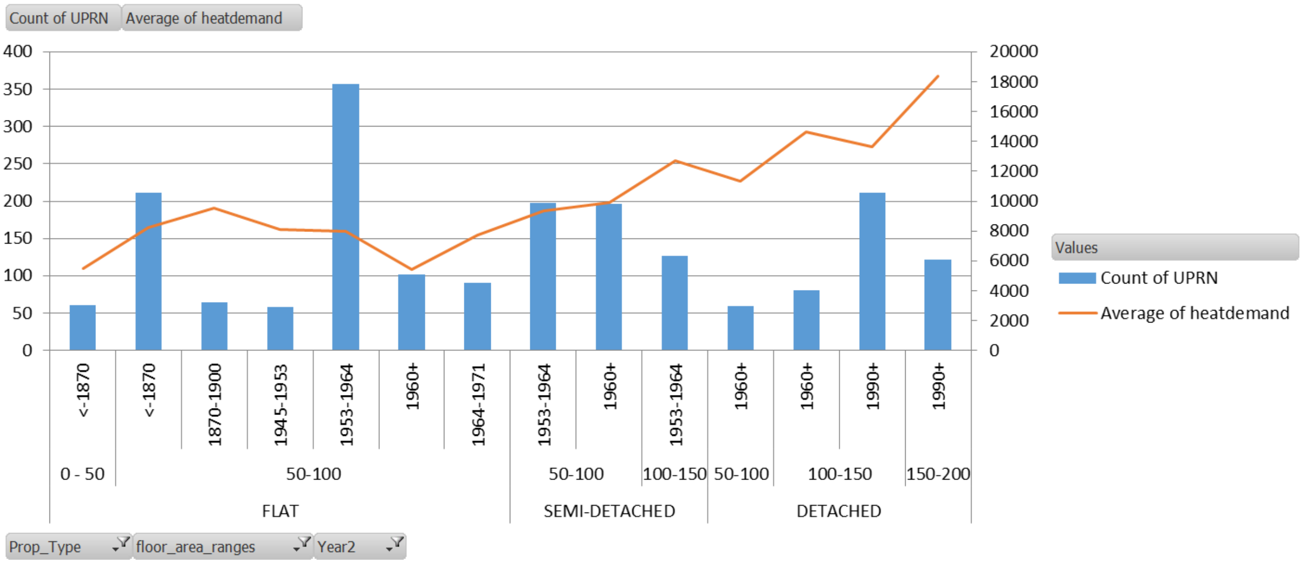
Source: Ramboll Energy

Identification of the most common property characteristics

Based on the above analysis the most common property types identified in Burntisland were grouped by common characteristics into property type characteristics. The 14 property type groups defined in this manner, included 1,935 properties and represented over 60% of the number of domestic properties in Burntisland and approximately 40% of the total heat demand. However it was noted that 8 of these 14 property type groups contained approximately half of all domestic properties within Burntisland. This selection is highlighted in blue in the table below. This selection illustrates property groups which have more than 100 properties within the group. In total this smaller selection represents a total of 1,522 properties and over 47% of the total number of domestic properties in Burntisland. These 8 property type groups can be said to represent the most common building types within Burntisland.

Row Labels	Count of UPRN	Average heat demand (kWh / year)
FLAT	944	7,706706
0 - 50	61	5,510510
<-1870	61	5,510510
50-100	883	7,858858
<-1870	211	8,244244
1870-1900	64	9,515515
1945-1953	58	8,122122
1953-1964	357	8,005005
1960+	102	5,442442
1964-1971	91	7,757757
SEMI-DETACHED	519	10,371371
50-100	393	9,617617
1953-1964	197	9,342342
1960+	196	9,894894
100-150	126	12,724724
1953-1964	126	12,724724
DETACHED	472	14752
50-100	59	11346
1960+	59	11,346346
100-150	291	13,932932
1960+	80	14,630630
1990+	211	13,667667
150-200	122	18,357357
1990+	122	18,357357
Grand Total	1935	10,140140

This data was graphed to illustrate the frequency distribution of property floor area and average heat demand for each range (including type and age):

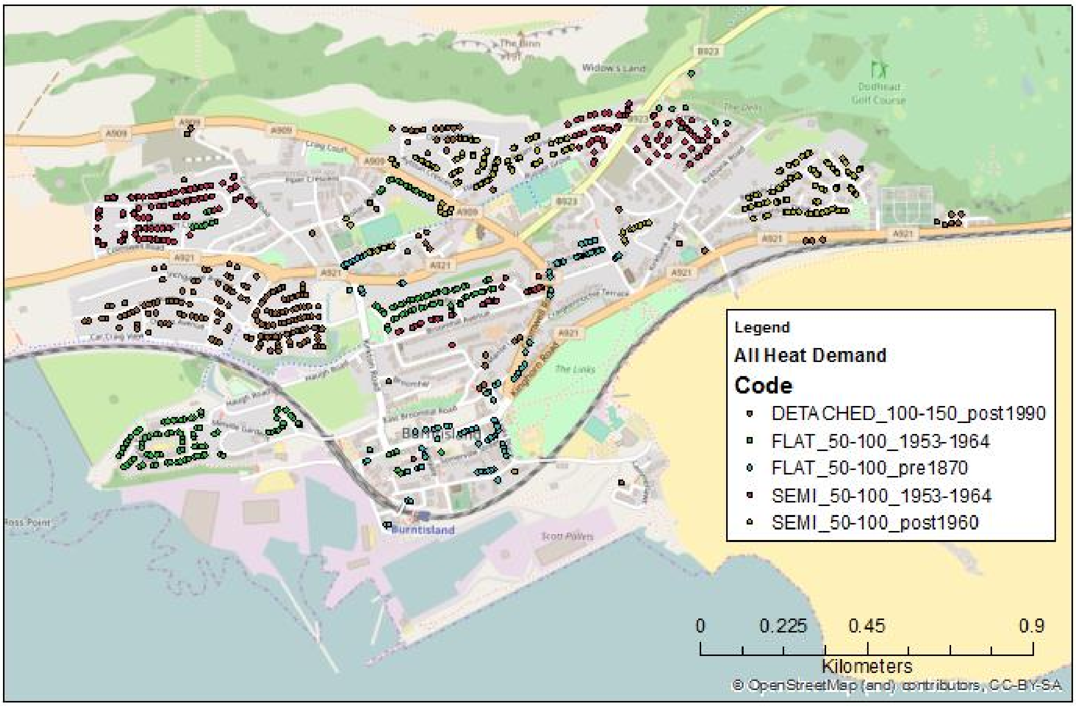


Source: Ramboll Energy

The graph above clearly identifies the frequency distribution of the more common property types in the area. This can be used with filters to sub-select the properties and identify target properties to further investigate for energy efficiency improvements, low carbon energy generation and suitability for connection to district heating networks; as being "representative" of the town. After this sub-selection process, a more refined list of the 5 most common property types found in Burntisland was identified as:

- Detached house; 100-150m^2; constructed post-1990;
- Flat; 50-100m^2; constructed 1953-1963;
- Flat; 50-100m^2; constructed pre-1870;
- Semi-detached house; 50-100m^2; constructed 1953-1963;
- Semi-detached house; 50-100m^2; constructed post-1990;

The spatial distribution of these 5 most common property types is illustrated in the following map:



The photographs below illustrate what the 5 most common property types found in Burntisland, typically look like.

These are the property archetypes that have been used within the data modelling element of this project. Underneath each archetype are a series of sub-archetypes containing different permutations of the different archetypes (i.e. ground floor flat, mid floor flat, top floor flat etc.).

Example of Flat_50-100_1953-1964, Dick Crescent

Example of Flat_50-100_pre1870, Links Place

Example of Semi_50-100_1953-1964, Kilmundy Drive

Example of Semi_50-100_post1960, Duncanston Drive

Example of Detached_100-150_post1990, Kirkton Drive

Source: images Googlemaps / streetview

The next step within the project was to undertake physical surveys of some of these streets or individual properties to determine the feasibility of retrofitting typical energy conservation measures and the associated costs and benefits which could be accrued. Surveys were undertaken as an important step in validating the property archetype modelling exercise.

7. Energy demand results

More detail on how heat demand was calculated is presented in the District Heating section of this report in *Chapter 9 Moving and Storing Energy*. The following figures, from BEIS MSOA gas and electricity consumption datasets were used as the baseline for heat and electricity demand in Burntisland.

	Heat (Gas / 85%[10]) Demand (kWh / year)	Total Heat (Gas + Electric switch)[11] (kWh / year)	Electricity demand (kWh / year)
Domestic	41,123,184	43,037,943	8,416,796
Non_Domestic	4,337,798	6,101,778	1,983,334
TOTAL	45,460,982	49,139,721	10,400,131

In terms of cost of energy, a simple assessment of the current cost of energy for the whole Burntisland community, based on the MSOA data from BEIS and assumed energy tariffs including standing charges, is provided below:

	Tariff (including standing charges) (p / kWh)	Consumption (kWh / year)	Cost (£ / year)
Gas	6.5	42,525,691	£ 2,764,170
Electricity[12]	14	14,078,870	£ 1,971,042
TOTAL COST OF ENERGY (GAS & ELECTRICITY)			£ 4,097,326

Using this MSOA data from BEIS[13] [14], we can summarise heat demand in Burntisland today, thus:

- There are 3,391 buildings requiring space and water heating in Burntisland, 3,198 of which are domestic properties;
- These buildings, cumulatively use 49,139,721 kWh of heat every year;
- Supplying heat to these buildings cumulatively emits 10,018 tCO2e per year. This equates to 1,653 tCO2e from electric heating (including transmission and distribution losses for electric heating demand), and 8,365 tCO2e from gas heating;
- As an average this works out at 2.95 tCO2e per building in Burntisland.
- Heating and powering all of the buildings in Burntisland today (whether by gas or electric heating), costs residents, businesses and public bodies £4,097,326 per year.
- As an average this works out at £1,208 per building in Burntisland.

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[10] 10% of gas consumption assumed to be used for cooking in domestic properties. 85% assumed gross efficiency of gas boilers

[11] Assumes that 148 domestic properties are electrically heated and applies average heat consumption of a domestic property to these buildings. For non-domestic assumes that 50% of electrical consumption (of non-gas supplied customers) is for heating.

[12] Includes electric heating

[13] https://www.gov.uk/government/statistics/lower-and-middle-super-output-areas-electricity-consumption

[14] https://www.gov.uk/government/statistics/lower-and-middle-super-output-areas-gas-consumption

Electricity demand

Building electricity demand was calculated using electricity MSOA data from BEIS. This data includes electricity used by street infrastructure (i.e. streetlighting and street sign furnishings) but this data is aggregated into the total figures. To separate the electricity consumed by infrastructure in Burntisland (i.e. streetlighting, automated bollards and electronic road signs) from that used by buildings we calculated road infrastructure electricity demand, using Fife Council's streetlighting energy management data base. This allowed us to extrapolate that the infrastructure electricity consumption in Burntisland is estimated at 269,804 kWh per year. Assuming the current grid generation mix, using 2016 emissions factors[15] for electricity generation and transmission and distribution losses, we can summarise total electricity consumption today in Burntisland as follows:

- There are 3,391 buildings (of which 3,198 are domestic) connected to the electricity grid in Burntisland;
- These buildings cumulatively use 10,400,131 kWh of electricity every year (excluding electric heating which is included above in the heat totals above);
- Of this total town-wide electricity consumption, kWh is used by streetlighting and related lighting (signs, bollards, traffic signals etc.);
- Generating and supplying this electricity for every building in the town, results in 4,672 tCO2e being emitted to the atmosphere every year (excluding the electricity used for heating which is included in the heat figures above).
- As an average, this works out at 1.37 tCO2e being released annually, per Burntisland building for electric consumption (excluding electric heating).
- This electricity consumption (excluding electric heating) costs the town an estimated £1,456,018 every year.
- Which equates to an average of £429 per building in the town (excluding electric heating).

Transport energy demand

Transport energy demand is calculated in *Chapter 11 Transport Energy*. For completeness the results are presented here. It was calculated that, today in Burntisland:

- There are 2,855 cars and light vans.
- Cumulatively these vehicles drive 25,384,947 miles per year.
- These vehicles cumulatively emit approximately 7,632 tCO2e every year.
- Which works out at an average 2.67 tCO2e per vehicle per year.
- It costs residents £3,439,660 to run their light hydrocarbon vehicles using petrol and diesel.
- As an average this works out at £1,204 per vehicle, per year in Burntisland.

[15] Gross Calorific value factors used. Available from BEIS, at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2016

Total Burntisland energy demand

Current energy consumption statistics (town-wide)

	Heat		Heat (total)	Electricity[16]	Transport (cars and light vans)	TOTAL
	Gas heating	Electric heating				
Consumption (kWh)	45,460,982	3,678,739	49,139,721	10,400,131	6,092,387	65,632,239
Associated emissions (tCO2e)	8,365	1,653	10,018	4,672	7,632	22,322
Cost of consumption (£)	£2,764,170	£515,024	£3,279,194	£1,456,018	£3,439,660	£8,174,872

Current energy consumption statistics (average per household)

	Heat		Heat (total)	Electricity[17]	Transport (cars and light vans)	TOTAL
	Gas heating	Electric heating				
Consumption (kWh)	n/a	n/a	15,366	3,252	1,905	20,523
Associated emissions (tCO2e)	n/a	n/a	3.13	1.46	2.39	6.98
Cost of consumption (£)	n/a	n/a	£1,025	£455	£1,076	£2,556

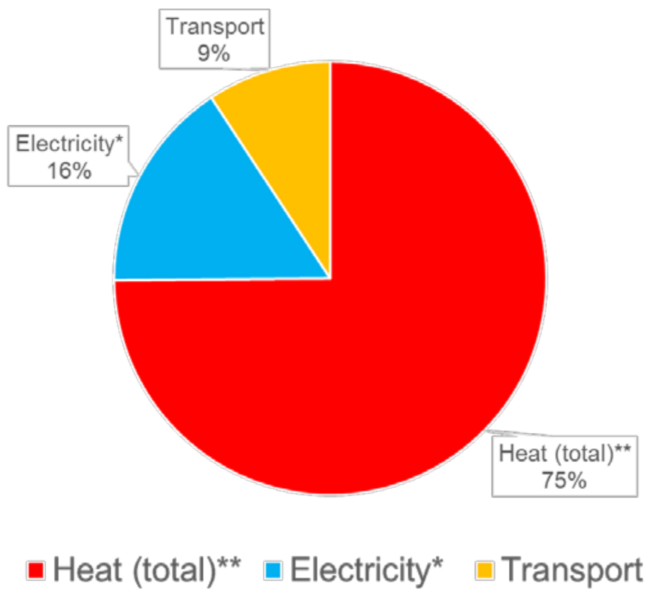
Putting all of this baseline data together we can see that today the community of Burntisland:

- Emits 22,322 tCO2e per year from energy and fuel consumption;
- Uses the equivalent of 65,632,239 kWh of energy every year for running their buildings, infrastructure and vehicles;
- Spends £8,174,872 per year on energy.

The following graph illustrates the total consumption of energy and fuel in Burntisland by kWh (primary fuel source).

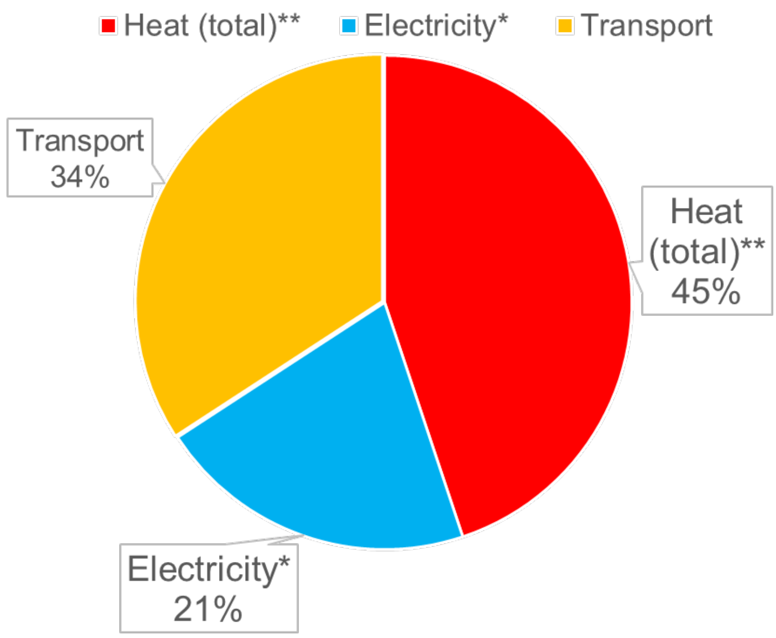
[16] Excludes electric heating

[17] Excludes electric heating



Cumulative Energy Consumption kWh

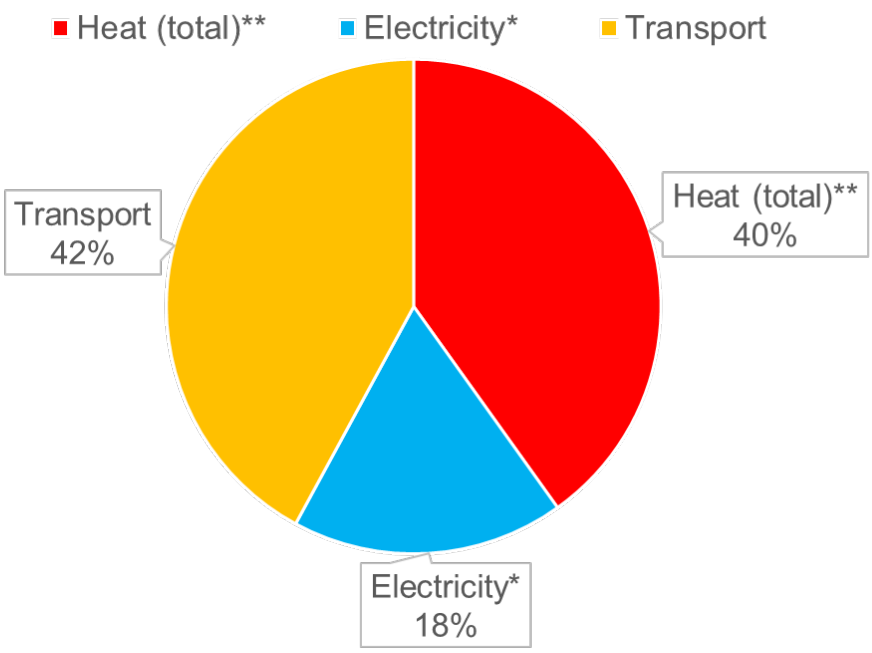
Note in these pie charts *Heat** includes electrical heat and Electricity* does not include electrical heat.* The following graph illustrates the breakdown of settlement-wide carbon emissions from Burntisland by energy end use (tCO2e).



Cumulative GHG emissions (tC02e)

*electricity figures exclude electric heating (which is included in the heat total)

The final graph illustrates the breakdown of settlement-wide energy spend from Burntisland by energy end use (£).



*Cumulative Energy Consumption costs (£))

On a household level, considering that there are 3,198 domestic properties within Burntisland, this equates to an average of:

- Annual greenhouse gas emissions of 6.98 tCO2e per year from their building and vehicle energy consumption;
- Annual energy and fuel consumption equivalent to 20,522 kWh per typical Burntisland household for running buildings and vehicles;
- An average household in Burntisland spends £2,556 on energy and fuel, annually. This equates to more than 10% of the average Scottish household income[18] being spent on energy.

Decarbonising Burntisland – required carbon cuts

The carbon cuts already delivered, and the future carbon emission reduction trajectory needed to ensure that Burntisland achieves its share of national emission reduction targets is illustrated in the table below:

Data type	Estimated	Actual	Projected	Projected
Year	1990	2014	2032	2050
Percentage of emissions (% compared to 1990)	100%	54%	34%	20%
Emission reductions achieved (% cut over 1990)	0%	-46%	-66%	-80%
Settlement-wide footprint (tCO2e)	41,337	22,322	14,054	8,267
Annual emission reduction needed (tCO2e)	n/a	n/a	459	321
Emission reduction period			14 years	18 years

To meet the targets of the Scottish Government[19] the greenhouse gas emissions from daily life in Burntisland need to be cut by 66% by 2032 and 80% by 2050 (compared to 1990 levels). Burntisland's current carbon footprint from running buildings and vehicles equates to 22,322 tCO2e per year. Assuming Burntisland is in line with the rest of Scotland in terms of its emissions reduction

[18] Given that average household incomes in Scotland are estimated to be £23,000, Resolution Foundation, 2014

[19] draft Energy Strategy: http://www.gov.scot/Publications/2017/01/3414

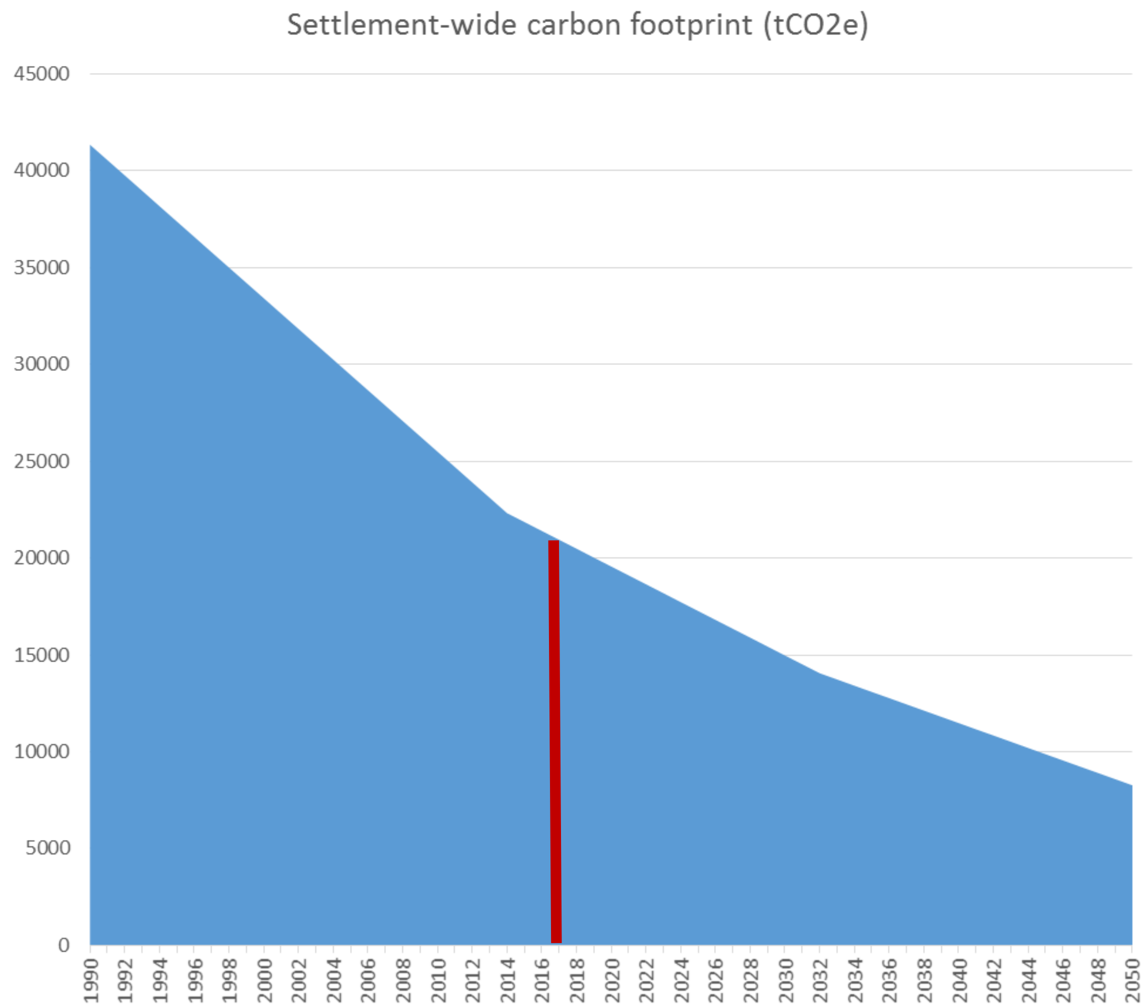
trajectory between 1990 and today, then it is likely that emissions have already fallen by 46% between 1990 and 2014[20]. This would mean that Burntisland had an estimated settlement carbon footprint of approximately 41,337 tCO2e circa 1990. Therefore, in order to meet national decarbonisation targets and to avoid the worst consequences of climate change, Burntisland's annual emissions will need to fall to a settlement-wide carbon footprint of:

- 14,054 tCO2e by 2032; and
- 8,267 tCO2e by 2050.

Because the emission reductions required in national decarbonisation targets are front-loaded, the majority of future carbon emission cuts have to actually occur before 2032. This will require higher annual emission reduction rates in the period to 2032, than in the period from 2032 – 2050.

- Therefore for the period from 2018[21] – 2032 the annual emission reductions achieved need to be 459 tCO2e per year, every year over the 14 year period.
- For the period from 2032 – 2050 the annual emission reductions achieved need to be 321 tCO2e per year, every year, over the 18 year period.

The emissions trajectory for Burntisland to meet national targets, is illustrated in the chart below:



[20] The latest year for which data is available.

[21] Assuming that material action on the ground will commence next year, 2018.

To meet national targets Burntisland's settlement-wide carbon footprint needs to fall from 22,322 tCO2e (2014), to:

- **14,054 by 2032; and**
- **8,267 tCO2e by 2050**

The community masterplan, therefore needs to deliver annual emission reduction proposals of approximately:

- 459 tCO2e a year, for the settlement, every year from 2018 to 2032.
- And annual emission reduction proposals of approximately 321 tCO2e per year, every year from 2032 to 2050.

If, in line with some members of the community's aspirations, outlined during developing this plan, we move to a near zero carbon target[22] for the settlement for 2050, then this would require annual carbon emission cuts in the order of 697 tCO2e a year, every year to be achieved in Burntisland from 2018 to 2050. The draft Climate Change Plan[23] includes the following targets:

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

For Burntisland this will necessitate 80% (or 2,558) of the town's homes being connected to a low carbon district heating network or fitted with a domestic low carbon heating system by 2032. In the intervening years from 2018 to 2032 this will require 183 homes per year having their heating systems decarbonised, or being connected to a low carbon district heating system.

For the non-domestic sector this will require 98% (or 189) of the town's non-domestic buildings being connected to / or fitted with a low carbon heating system by 2032. This will necessitate 14 non-domestic properties per year having their heating systems decarbonised (or being connected to a low carbon district heating system), in the intervening years from 2018 to 2032.

It should be noted that to reduce the cost of a decarbonised heat system that demand reduction measures (e.g. fabric improvement to buildings or process improvements to equipment) and heat decarbonisation measures need to be undertaken together.

To meet the transport sector emission reduction targets in the draft Energy Strategy, 67 cars / light vans a year in Burntisland need to be replaced with an EV equivalent. That's 67 vehicles a year, EVERY year between 2018 and 2032

In terms of the transport sector, in the Draft Energy Strategy, the Scottish Government has targeted emissions from transportation to fall by one third (33%) by 2032, compared to 2014 levels. For Burntisland (assuming that car ownership levels remain static) this will require 942 of the 2,855 existing car and light van vehicles in the town to be replaced by EV by 2032, this would equate to 67 cars a year for the next 14 years, being replaced.

The final scenario for energy efficiency measures and the first phase of district heating (zone 7) are calculated to meet the Scottish Government 2032 Carbon emissions reduction target. See below figure:

Heat demand options

Three choices

There are three choices: to reduce heat demand such as through improved building insulation; to supply low carbon heat considering priorities like system affordability and efficiency; and thinking

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[22] Excluding emissions from consumption (i.e. food, material goods, international travel etc.).

[23] Draft Climate Change Plan: the draft Third Report on Policies and Proposals 2017-2032: http://www.gov.scot/Publications/2017/01/2768

about how much low carbon generation will be needed to provide heat after the other choices have been made.

What is known about Burntisland's buildings?

Different measures provide different opportunities to different building types: Burntisland is made up of 1256 flats and 87 maisonettes, 317 mid-terraced, 869 semi-detached, 677 detached and 152 non-domestic.

Age guides the energy choices for a building. There are 765 buildings older than 1914. The peaks in building are between 1870 and 1900, between 1953 and 1964, then again after 1990.

The average heat demand for different domestic buildings in Burntisland is: Flat 8,408kWh/year; semi-detached 13,518kWh/year; and detached 17,581kWh/year. As you would expect bigger buildings need more energy. The average heat demand benchmark (kWh / m²) also increases with property floor area – meaning bigger buildings also come out as less efficient per square meter.

> **The average heat demand for domestic buildings in Burntisland:**
>
> - **Flat 8,408kWh/year**
> - **detached 17,581kWh/year**

The high demand associated with buildings built between 1900 -1914 is likely to be due to the high proportion of larger detached and semi-detached properties built at the time which may have been solid wall insulated. The high energy demand seen in properties constructed between 1945 -1953 is likely to be due to the high proportion of larger detached properties built at the time, and post-war non-traditional construction types, which often had poor levels of energy efficiency. The high demand associated with properties built post-1990 is likely to be due to the high proportion of larger detached properties built recently and is not necessarily indicative of poorer energy efficiency performance.

Options to reduce heat demand

Reducing energy demand is accepted as the first place to start. The Energy Saving Trust notes that a quarter on heat can be lost through a roof and a third through the walls.

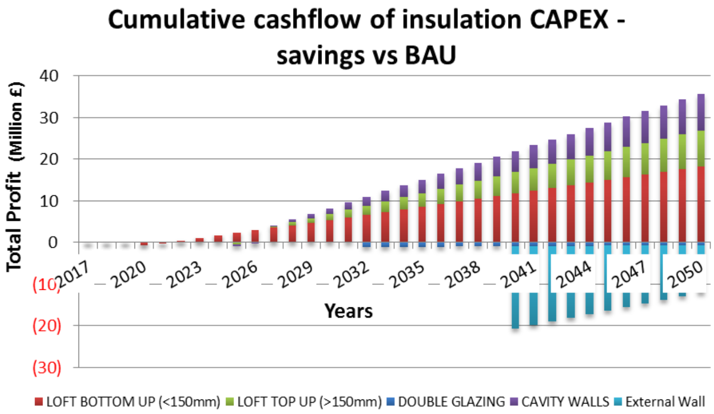
The main choices for insulating a building are in the roof, the wall cavity, under the floors, the windows and cladding the outside of a building. The cost for these will vary, for example insulating a cavity wall where there is one on average costs for a: flat £330; semi-detached £475; detached £720.

Taking into account data about which insulation measures have already been completed in Burntisland, the remaining opportunity is summarised below.

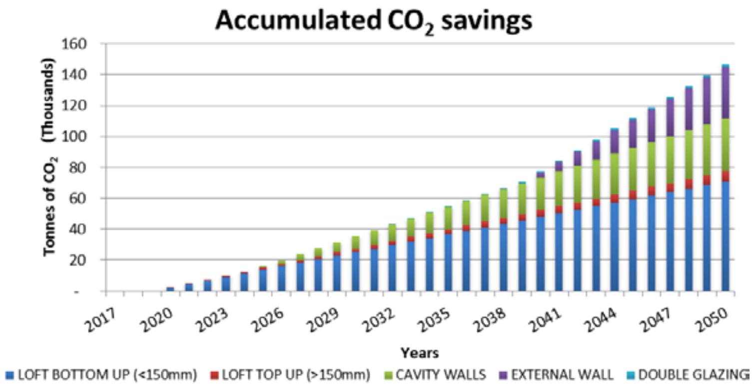
Insulation Technology	Installation Year	CAPEX (£)	1st Year annual saving vs BAU (kWh)	Simple payback (years)	Number of insulated buildings
LOFT INS (<150MM)	2020	451,925	3,627,097	2	1374
LOFT INS (>150MM)	2020	169,429	218,882	12	674
CAVITY WALLS	2025	346,798	2,644,838	2	698
EXTERNAL WALL	2040	20,937,000	13,479,200	24	1990
DOUBLE GLAZING	2032	971,827	433,042	35	194

How much could this save Burntisland?

Over time investing in insulation measures would release a lot of money that could then be spent on other things, like the local economy.



In turn these insulation measures would also help to meet our climate change targets to reduce carbon dioxide equivalent emissions.



Potential actions:

- Investigate the option for a scheme to target the quick payback insulation measures in Burntisland
- Investigate for a test pilot to target the longer term payback insulation measures in Burntisland, particularly external cavity wall insulation
- Thermal camera study _ CAROLYN
- Work with Fife Council, Greener Kirkcaldy and the Energy Efficiency Advice Centre to develop a model for large scale delivery of insulation measures based on the approach used for the Home Energy Efficiency Programme for Scotland (HEEPS).

Heat demand example

What would this mean for a typical flat: toping up loft insulation where it is less than 150mm to 270mm would cost £285 and save 283 kWh a year; Cavity wall insulation would cost £330 and save 1,800kWh a year; external wall insulation would cost £6,000 and save 3,300 kWh a year; and double glazing would cost £4,000 and save 1,121 kWh a year.

Insulating options: a flat

- **150mm to 270mm would cost £285 and save 283 kWh a year**
- **Cavity wall insulation would cost £330 and**

Heating options for Burntisland

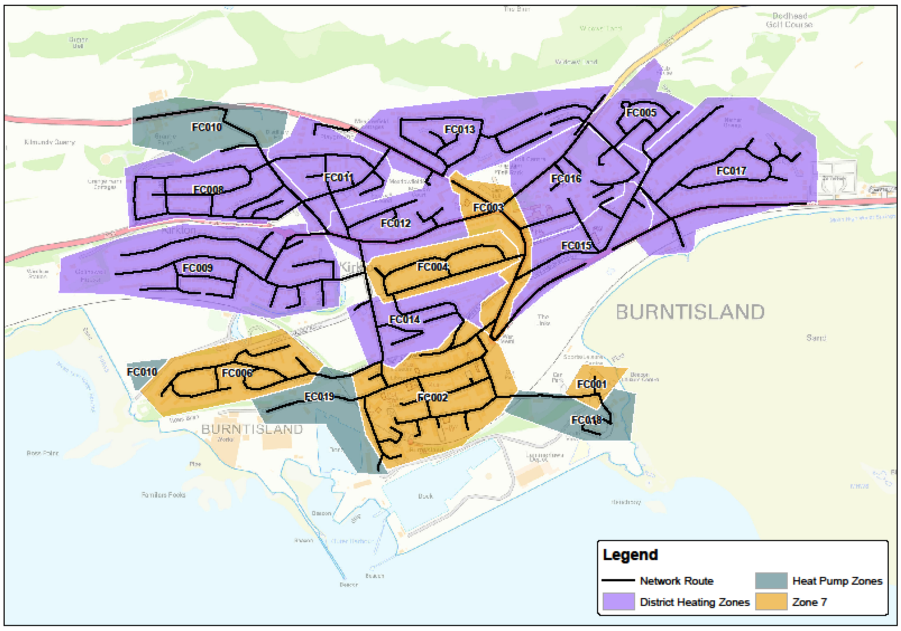
A number of low carbon heating options were assessed for Burntisland. The analysis looked at individual heating solutions and area wide heating solutions. Individual solutions were assessed using heat pumps and the area wide solution was district heating.

Heat pumps use a refrigerant and pressure to raise the temperature of water more efficiently than directly heating water with electricity.

District heating networks are used to distribute heat, in the form of hot water, from centralised generation through insulated pipe networks with connection to customers.

The best heating choice for cost and carbon emission reduction

Burntisland was split into zones that could be assessed. District heating was the best choice for most of Burntisland with heat pumps the best option in four areas. Five zones were grouped together to make the best option for an initial phase of a district heating scheme.



Source: Ramboll Energy

Zone 7 would cost around £13M, based on using a water source heat pump from the sea. The sea provides an unlimited source of slightly heated water that improves the efficiency of the heat pump and reduces the running cost. The scheme would deliver to 574 buildings – the largest heat demand in Burntisland. An 8MW thermal heat pump would deliver 17,400,000kWh/yr of heat, but only need 5,800,000kWh/yr electricity. That is three times more efficient. This would cut the total existing heat demand for Burntisland of 49,139,721kWh/yr by 23.6% to 37,539,721kWh/yr. It would transfer some of the kWh provided by gas to electricity, meaning an increase of 42% to 19,878,870kWh.

The district heating option for Burntisland uses an 8MW thermal heat pump. The sea could provide an unlimited source of slightly heated water, improving the efficiency and reduces the

Are there better sources of heat?

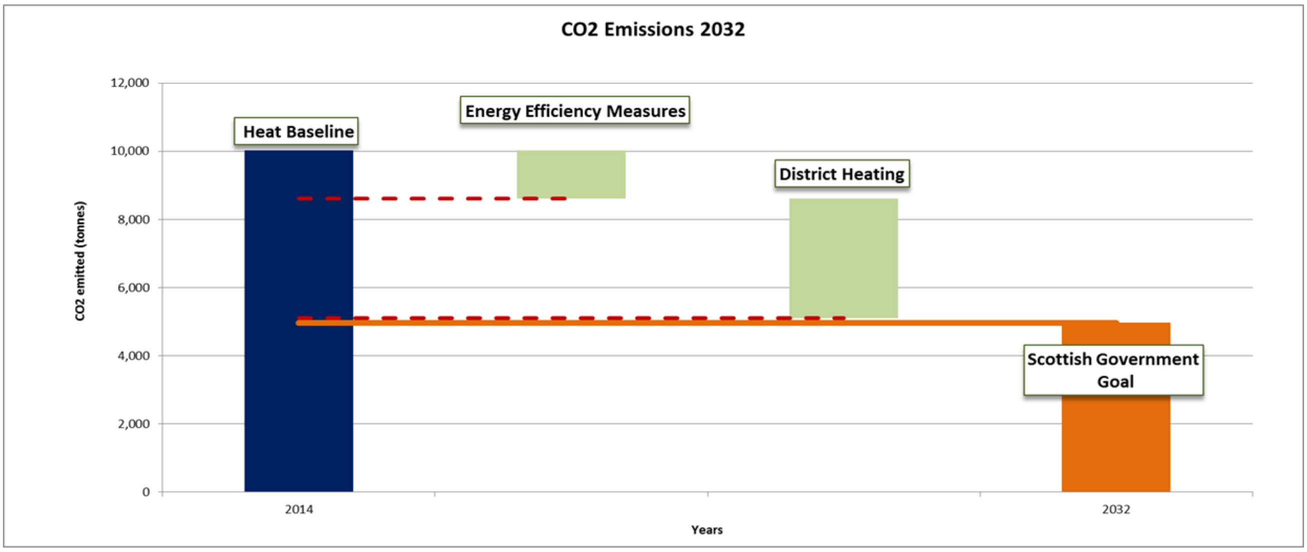
A large array of solar thermal panels and a large inter-seasonal heat store were costed as an alternative heat supply for a district network. For comparison: the solar park with thermal store generated 8.2 GWh/yr with a CAPEX of £6.5 million; the Water Source Heat pump from the sea generated 17.5 GWh/year with CAPEX £2.2 million. Proportionately the sea heat pump is a sixth of the cost of the solar park with thermal store per GWh/yr generated. The sea heat pump is the recommended approach for a district heat network in Burntisland.

Phased roll out of district heating

Zone 7 would be complete by 2032. This would be split into the five separate phases in sequence. Each requires a pre-construction phase (minimum 2 years) including feasibly, full design, planning and finance. The construction phase would be approximately 18 months. The next scheme in the sequence would start approximately 1-2 years after the first.

How does this help with carbon emission targets?

The Scottish Government is consulting on draft targets for 2032. Below is a chart that shows how the suggested energy efficiency measures and sea heat pump powered district heating would meet Burntisland's heat demand proportion of the proposed Carbon Emission reduction target.



Source: Ramboll Energy

Potential actions:

- initiate discussions between the Council and Burntisland on interest to seek funding for a feasibility study for the first phase of a proposed district heating scheme for Burntisland
- Open discussions with Scottish Government regarding terms for support funding that could be widened to enable fuel poor areas of the town to be included
- Develop a more detailed time line for roll out of area wide heating

Transport options

The Scottish Government target for transport in the draft Climate Plan is a 32% reduction by 2032.

Public transport is a good option for those that can use it, reducing the number of separate vehicle trips and thereby energy per person. Public transport change to alternative fuels not included in this plan. It is anticipated that changes to low carbon energy sources will continue, such as electrification of railways and alternative fuels for buses.

Potential actions:

- Encourage use of public transport
- Explore option of a shared use of vehicles (car club)
- Continue request for all abilities access to the train station

Electric vehicles looks to provide an opportunity in the short to medium term. The focus of the study was cars and light vans as these were most likely to be controlled by residents of Burntisland. The Census (2011) records 2,855 cars and light vans in Burntisland. If all these cars and light vans in Burntisland were electric this would reduce the cost from £3,439,660 to £792,574 per year. They would need 6,092,387kWh per year, or 2,134kWh per vehicle. This is a massive saving of £2,647,085 every year. Or £927 a year per vehicle. This is based on the 2017 average fuel costs (petrol/diesel £0.14p and electricity £0.03p). To meet the 32% carbon reduction target by 2032 for cars and light vans could be achieved by 952 being electric at 2,031,507 kWh/yr. This would mean 67 additional electric vehicles per year from 2018-2032, at 142,973 kWh/yr. To change the remaining 1941 would mean 108 additional electric vehicles per year from 2033-2050. The collective saving for 67 vehicles would be £70,452 annually.

Potential actions:

- Fife Council to look for funding for semi rapid electric vehicle charging options in Burntisland in the short term
- Undertake a local survey of homes that could have space for an electric car.

- A series of promotion events could be run to encourage electric car use. Existing charging technology requires private space to charge the vehicle. Initial promotions would benefit from focussing promotions on buildings with private spaces such as a garage or driveway. This might focus first on the 869 Semi-detached and 677 Detached properties.
- An electric vehicle social club could be set up to share experience and have competitions on how far a vehicle could go on a charge?!
- Look at generation options (ie panels to match ev demand)

Low carbon generation options

The low carbon generation is needed to deliver on the Scottish Government Energy Strategy vision of an integrated reliable clean energy system that brings benefits across our communities. Renewable energy comes from natural resources including sunlight, rain, wind, tides and waves. For Burntisland the low carbon generation opportunities are from wind and solar.

The wind resource

The Met Office's Virtual Met Mast estimate wind speed for Burntisland is 5.53m/s at 20m and has been extrapolated. An example turbine, the ETW 900Kw / hub height 69m / wind speed 6.1 could produce 2, 000, 000 kWh/yr.

Wind constraints

The numerous existing wind turbine developments in the hinterland inland behind the town demonstrate this technology. However, the number of wind turbines is a consideration for planning putting constraints on the landscape capacity. Connection to the electricity grid has also been cited as an issue in previous nearby studies.

The solar resource

Burntisland has some of the best opportunity for solar radiation in Scotland.

A good majority of buildings are south facing, no doubt making the best of the views across the Forth. The Energy Saving Trust dataset Home Analytics data indicates that roof mounted solar energy could be placed on 1107 buildings in Burntisland. This would produce an estimated 894,294kWh / year.

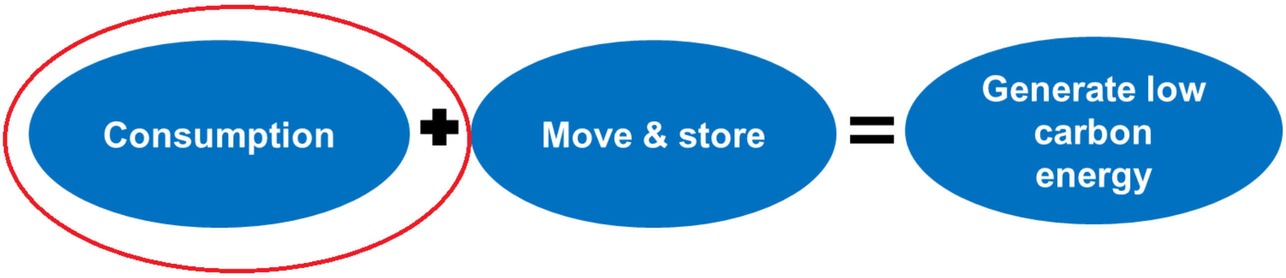
A large scale solar installation could be placed within the Burntisland hinterland. A desk based study from a supplier costs an 8 hectare, 4MW solar park, producing 3,500MWh/yr. This would supply approximately a quarter of the existing energy demand for Burntisland. If all the vehicles in Burntisland were electric then 14 hectares of solar park would be needed to supply the electricity.

An 8 hectare, 4MW solar park, by Burntisland could produce an estimated 3,500MWh/yr. This would supply approximately a quarter of the existing energy demand for Burntisland.

Potential actions:

- Investigate funding for a drone based spatial study of Burntisland to assess in detail the solar thermal potential
- Investigate the potential for a community owned solar park on land near Burntisland

8. Energy Efficiency Measures



RESULTS - Energy demand reduction

- Phase 1: loft insulation offers a quick opportunity with 674 that could benefit from significant loft insulation, and 1,374 who would still benefit. There are still a reasonable number of cavity walls to be filled, though some look to be limited to part of a building such as an extension. A programme targeting opportunities for loft insulation and cavity wall, linked to an at scale delivery programme should be considered as an early action. Loft and cavity wall insulation would make significant progress to the 2030 and 2032 targets. External wall insulation offers the next best return. A total of 332 external wall measures are estimated to be needed to meet the energy reduction targets by 2032. Phase 1 would has the potential to reduce demand of buildings by around 8,672,000kWh.
- Phase 2 energy efficiency measures would involve a roll out of external wall insulation across a substantial part of the building stock. Exceptions would include unsuitable buildings and those where external insulation would impact on the building status, for example in conservation areas.

	Year	Energy saving kWh	CAPEX	Simple payback	Number buildings	Measures
Loft insulation (<150MM)	2020	3,627,097	451,925	2	1374	1374
Loft insulation (>150MM)	2020	218,882	169,429	12	674	674
CAVITY WALLS	2025	2,644,838	346,798	2	698	698
EXTERNAL WALL	2040	13,479,200	20,937,000	24	1990	332 by 2032/ 1658 by 2050
DOUBLE GLAZING	2032	433,042	971,827	35	194	194

Introduction

Once the settlement's estimated energy demand was calculated, the next step was to assess a range of energy efficiency measures that could be suitable for retrofitting to the properties present in Burntisland, to identify their cost-effectiveness.

The aims of this exercise were to:

- bring together data about buildings to allow better energy planning choices to be made;
- do this with existing data that was available to public sector bodies;
- make data more widely available (where permitted); and
- build on the data approach in the Scotland heat map.

Input data

There were a wide range of activities undertaken during this stage ranging from obtaining the heat demand data from the Scottish Heat map to obtaining the CAPEX and energy saving figures for each potential insulation measure. These activities can be broken down into 3 main categories as it is shown in figure below:

Heat demand data (from the previous exercise)

Existing insulation data

Impact of insulation measures and costs

For the heat demand data, the Scotland Heat map was used to obtain data for the properties present in the area.

Information about the existing insulation in the properties considered was essential to evaluate the possible future potential for retrofitting each insulation measure. A range of data sources were considered. Although there exists good data for many individual buildings, this does not exist in any one data set for all the buildings in Burntisland. Home analytics provides a collated set of data for each data-zone in the area. Installation cost and potential energy savings data for each insulation measure were obtained from three sources: Energy saving trust (EST); Fife Council and data from the former Department of Energy & Climate Change (DECC).

The information was then assessed and a final master table was constructed.

The table below illustrates the installation cost and potential energy savings data that we collated for three of the potential insulation measures considered in this phase of the study.

Dwelling Type	Cavity wall insulation		Double glazing		Loft insulation Top Up (150-270mm)	
	Installation Cost (£)	Energy Saving (kWh/year)	Installation Cost (£)	Energy Saving (kWh/year)	Installation Cost (£)	Energy Saving (kWh/year)
Flat	330	1,800	4,000	1,121	240	283
Semi-Detached	475	3,500	5,000	2,529	240	250
Detached	720	6,500	6,000	2,481	290	490
Mid-Terrace	370	2,300	4,000	2,181	230	290
Bungalow	430	2,700	5,000	1,742	290	517

The excerpts from the master table produced below illustrates the sum of existing properties within the datazones that were estimated, from Home Analytics data to have a range of insulation measures already in situ.

Estimated energy efficiency measures already in situ

Loft insulation

Datazone Code	No. of Houses	0-50mm	51-100mm	101-150mm	151-200mm	>201mm	No loft	A room in loft
S01009458	353	28	1	14	9	144	141	16
S01009459	514	26	58	12	13	131	252	22
S01009460	433	32	8	17	26	62	279	9
S01009461	276	64	1	0	11	197	0	3
S01009462	270	21	40	24	31	106	28	20
S01009463	328	16	18	31	17	152	62	32
S01009464	392	47	30	29	34	168	77	7
S01009465	275	1	41	19	26	117	40	31
S01009466	262	16	12	2	2	106	48	76
S01009476	1	0	0	0	0	0	0	1
Totals	3104	251	209	148	169	1183	927	217

Wall insulation

Datazone Codes	No. of Houses	Wall Insulated	Wall Uninsulated
S01009458	353	189	164
S01009460	433	293	140
S01009466	262	65	197
S01009464	392	217	175
S01009462	270	167	103
S01009461	276	276	0
S01009459	514	252	262
S01009465	275	107	168
S01009463	328	208	120
S01009476	1	0	1
Totals	3104	1774	1330

Insulation technologies assessed as part of the study

This section outlines the range of insulation technologies that were considered in this report. It is useful at this juncture to provide more explanation of the nature of the technologies, and to furnish an evaluation of the capital costs for a community-wide roll-out and for individual installations at a building level. The building types that were considered are:

- Flat
- Semi Detached
- Detached
- Mid-terraced
- Maisonette

Loft insulation

Insulating a loft or roof (as illustrated below) involves laying a layer of insulation material or blowing insulation material into the roof void, so that a cold roof space is created and the heat rising through the house is unable to penetrate beyond the level of insulation, and is returned back to the usable space.

The payback for loft insulation is estimated at 2 years for bottom-up insulation (in lofts with <150mm of insulation already present); and 12 years for top-up insulation of lofts (which already have 150mm in

Loft insulation can save a great amount of heat from being lost from a building to the atmosphere. According to Energy Saving Trust (EST), a quarter of a building's heat is lost through the roof in an uninsulated roof. Insulating loft spaces usually has a very short payback period and is generally expected to provide a rapid return on investment.

There are a range of different materials which are used today, to insulate lofts and roof spaces. This is an energy efficiency measure which can be very simple to install, and which can be installed by a homeowner. However in in this report, the effect of a blown insulation consisting of a cellulose-fibre or wool is studied, as these materials are expected to yield the greatest energy savings. Loft insulation can be installed in different thicknesses, providing different levels of insulation. For this study, the various thicknesses of existing loft insulation seen already in situ in properties in Burntisland were categorised into two groups: those with a thickness of insulation less than 150mm and those where insulations levels were deeper than 150mm. To differentiate the two, the first one was named light insulation / bottom-up insulation and the second top-up insulation. The effect of fully insulating a loft is different for each of these categories in terms of the associated cost and attributable energy savings as it is shown in the tables below. To be considered as fully insulated, a loft must have a total insulation thickness of at least 270mm[24].

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[24] Energy Saving Trust 2017

In the case of lofts where little to no insulation (<150mm) is present today, and bottom-up insulation would be installed, the effects in energy, carbon and financial savings are expected to be high.

The payback for loft insulation is estimated at 2 years for bottom-up insulation (in lofts with <150mm of insulation already present); and 12 years for top-up insulation of lofts (which already have 150mm in place).

The analysis of the uptake of loft insulation measures was calculated at datazone level. Information on the probability of installed energy efficiency measures, already being in situ was derived from Home Analytics data which is presented at datazone level. The results of installing bottom-up and top-up insulation at the settlement level (by datazone) is illustrated in the first graph below:

Datazone		CAPEX		Energy Savings (kWh/year)	
		Bottom-up (0-270mm)	Top-up (150-270mm)	Bottom-up (0-270mm)	Top-up (150-270mm)
Burntisland Central	S01009458	164,739	85,388	108,189	1,410,694
Burntisland Links	S01009459	407,119	287,779	369,716	3,425,634
Burntisland Docks	S01009460	193,314	144,430	178,765	1,691,584
Burntisland Kirkton	S01009461	77,306	18,291	30,906	587,130
Burntisland Grange and Orrock	S01009462	27,226	15,832	18,627	232,069
Burntisland Nether Grange	S01009463	77,060	36,735	47,205	634,273
Burntisland East Toll	S01009464	91,801	48,314	62,197	766,517
Burntisland Meadowfiel d	S01009465	46,298	23,021	27,408	394,302
Burntisland East	S01009466	95,992	50,250	66,122	795,900
Seafield South and Landward	S01009476	285	240	283	2,691
	Total	£ 1,181,140	£ 710,280	909,419	9,940,795

Indicative figures for the potential cost and energy savings available to individual stakeholders for installing these measures at the individual household level is presented, by dwelling type in the proceeding table:

Dwelling Type	Loft insulation Bottom-up (0-270mm)		Loft insulation Top Up (150-270mm)	
	CAPEX (£)	Energy Saving (kWh/year)	CAPEX (£)	Energy Saving (kWh/year)
Flat[25]	285	2,691	240	283
Semi-Detached	300	2,500	240	250
Detached	395	3,000	290	490
Mid Terrace	285	2,200	230	290
Maisonette	395	3,000	290	517

Cavity wall insulation

Cavity wall insulation inhibits heat escaping through the walls of a house. A typical cavity wall construction is illustrated below:

Cavity walls consist of two 'skins' separated by a hollow space. The skins are commonly masonry such as brick or concrete block. Cavity wall insulation (CWI) is the installation of air blown insulation material into the cavity between the two skins, to improve the u-values of the structure and to prevent drafts from the weep holes typically present in the outer skin of cavity wall constructions, from detracting from the thermal comfort inside the house. In general, houses built before the 1990's tended to be solid wall constructions, with no cavity present (according to the EST). Solid wall properties cannot be fitted with CWI. Common types of non-traditional construction style properties (so-called 'non-trads'), seen in Fife also do not tend to have a cavity (according to information from Fife Council's Housing Services), and would also not be able to have CWI retrofitted. The results of the estimated CAPEX and associated energy savings for rolling out this energy efficiency measure across the applicable properties within Burntisland (figures are given at the datazone level) is presented in the proceeding table:

Datazone		CAPEX (£)	Energy Savings (kWh / year)
Burntisland Docks	S01009460	644,097	96,885
Burntisland Links	S01009459	2,429,895	337,213
Burntisland East Toll	S01009464	519,805	69,538
Burntisland East	S01009466	458,341	60,492
Burntisland Central	S01009458	879,049	124,171
Burntisland Kirkton	S01009461	-	-
Seafield South and Landward	S01009476	1,800	330
Burntisland Nether Grange	S01009463	410,085	54,134
Burntisland Meadowfield	S01009465	219,585	31,346
Burntisland Grange and Orrock	S01009462	197,978	28,769
Total		5,760,636	802,877

The next table breaks down these results to the individual household level and illustrates the costs and benefits for individual stakeholders, from installing CWI:

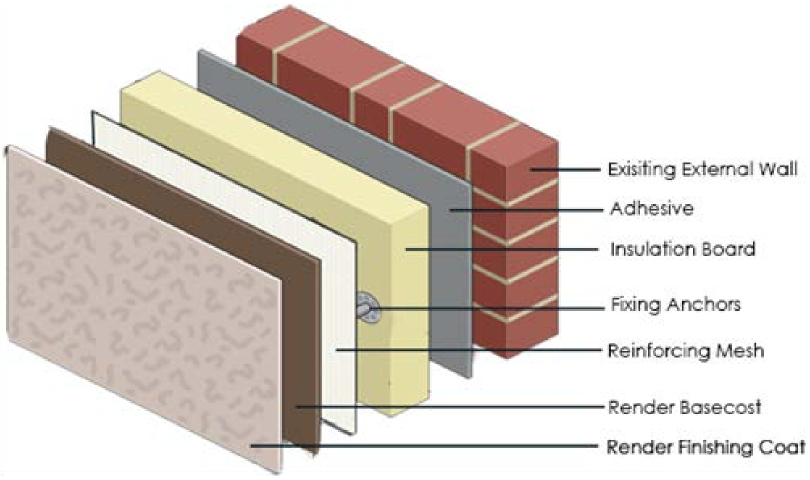
[25] Only applicable for top-floor flats

Dwelling Type	Cavity wall insulation (CWI)	
	CAPEX (£)	Energy Saving (kWh / year)
Flat	330	1,800
Semi-Detached	475	3,500
Detached	720	6,500
Mid Terrace	370	2,300
Maisonette	430	2,700

External Wall Insulation

Solid wall construction styles are more difficult to treat from an energy efficiency perspective. Techniques existing for applying insulation to solid walls internally and externally. For this study external wall insulation was considered because it does not necessitate internal redecoration and the shrinkage of internal room dimensions, and is generally easier to retrofit than internal wall insulation. That said, EWI is still an expensive undertaking. External wall insulation (EWI) describes methods of insulating buildings with single external solid walls and no cavity. EWI can consist of retrofitting a range of insulation layers made out of different materials as cladding to the outside of the existing external wall. A typical example is illustrated below:

The payback period for installing external wall insulation (EWI) is calculated to be 24 years for properties in Burntisland.



Solid wall construction styles without cavities were standard in buildings built before 1919, and continued to be a common construction style from 1919 to 1990, when changes to the Building Standards prohibited solid wall construction because of the lower levels of energy efficiency inherent to this style. Because EWI requires the application of a new facia material to all of the external walls of a property this can mean that architectural features are hidden and potentially permanently lost, external wall insulation is unlikely, therefore to be acceptable on listed buildings.

The results for the capex and energy savings from this technology’s implementation to the community and an individual dwelling are illustrated in the tables below. The first table illustrates the cost and estimated energy savings for applying external wall insulation to all applicable properties in Burntisland (excluding listed and conservation areas) at the datazone level. In practice it is likely that either cavity wall insulation or external wall insulation (i.e. not both) would be applied, therefore the project team have had to be careful to avoid double-counting.

Datazone		CAPEX (£)	Energy Savings (kWh / year)
Burntisland Docks	S01009460	1,186,300	2,093,000
Burntisland Links	S01009459	945,600	1,459,000
Burntisland East Toll	S01009464	2,308,700	3,659,000
Burntisland East	S01009466	1,292,800	2,005,000
Burntisland Central	S01009458	1,240,100	2,007,000
Burntisland Kirkton	S01009461	2,560,000	3,840,000
Seafield South and Landward	S01009476	3,300	6,000
Burntisland Nether Grange	S01009463	1,860,900	2,934,000
Burntisland Meadowfield	S01009465	1,001,700	1,615,000
Burntisland Grange and Orrock	S01009462	617,500	1,005,000
	Total	13,016,900	20,623,000

The next table breaks down these results to the individual household level and illustrates the costs and benefits for individual stakeholders, from installing EWI:

Dwelling Type	External wall insulation	
	Installation Cost (£)	Energy Saving (kWh / year)
Flat	6,000	3,300
Semi-Detached	9,000	6,000
Detached	15,000	10,000
Mid Terrace	8,000	4,200
Maisonette	10,000	5,000

Double Glazing

Insulated glazing, more commonly known as double glazing, consists of two glass window panes separated by a vacuum or gas filled space to reduce heat transfer across the glazed part of the building envelope.

The analysis undertaken for this project assumed that double glazed windows cannot be retrofitted to listed buildings and properties within the conservation area, although it is understood that this is an oversimplification and that actually double and tripled glazed options are available for heritage buildings but that they are considerably more costly. An example illustration of a typical double glazed window can be seen below.

The payback period for installing double glazing is calculated to be 40 years for properties in Burntisland.

The results of the estimated CAPEX costs and energy savings from this implementing double glazing to applicable properties at the community, and individual level are illustrated in the tables below:

Datazones		CAPEX (£)	Energy Savings (kWh / year)
Burntisland Docks	S01009460	106,111	322,471
Burntisland Links	S01009459	41,336	89,510
Burntisland East Toll	S01009464	-	-
Burntisland East	S01009466	25,441	58,725
Burntisland Central	S01009458	109,878	290,595
Burntisland Kirkton	S01009461	67,774	163,902
Seafield South and Landward	S01009476	1,121	4,000
Burntisland Nether Grange	S01009463	72,588	163,485
Burntisland Meadowfield	S01009465	18,159	41,931
Burntisland Grange and Orrock	S01009462	8,190	18,667
	Total	450,598	1,153,286

The next table breaks down these results to the individual household level and illustrates the costs and benefits for individual stakeholders, from installing double glazing:

Dwelling Type	Double glazing	
	Installation Cost (£)	Energy Saving (kWh / year)
Flat	4,000	1,121
Semi-Detached	5,000	2,529
Detached	6,000	2,481
Mid Terrace	4,000	2,181
Maisonette	5,000	1,742

Analysis

The aim of this stage was to test an approach to add building energy demand reduction measures to assess the potential impact and costs and to facilitate the creation of a heat demand map for a future district heating network for Burntisland.

The steps taken to manipulate the heat demand data and compose an integrated heat demand map are outlined below:

1. ArcGIS was used to identify and export heat demand data for properties in the vicinity of Burntisland. A master excel document was composed which included the Unique Property Reference Number (UPRN) and categorised each property using a series of characteristics outlined in the subsequent tasks. Initially, properties were categorised as Domestic or Non Domestic.
2. The data were then sorted in terms of their class. Using the class code from the address data each property was assigned a use class and profile class.
3. The tenure type of each dwelling was identified and added to the master document.
4. A council housing field was added to classify which properties are council owned and which are private, using information from the Fife Council.
5. The data were classified as traditional or non-traditional. This dictates which energy saving technologies can be implemented in each building.
6. The tenure type of each dwelling was updated after new data was received from the Fife Council. The dwellings were classified as public or privately owned, and subcategorised as one of the following:
   - RSL (registered social landlord) domestic;
   - Domestic private;
   - Non-domestic private;
   - Domestic Council;
   - Non-domestic Council;
   - Non-domestic public
7. Demand density was visualised by buffering each property by a distance proportional to the demand at that location. First heat demand was aggregated where multiple properties exist at a single location (e.g. flats). The buffer distance was calculated as being aggregated heat demand / 4000.
8. Based on the demand density and using ArcGIS, the potential network was digitised and the total area split into different zones. This action makes data manipulation more efficient and helps communicate information better.
9. The heat demand and dwelling class type data for all the different data-zones were joined to form a master attribute table.
10. Master property type field added and created by combining. Description or Use class with non-traditional or conservation.
11. The MSOA (Middle Layer Super Output Area for gas and electricity demand) for each property was identified using ArcGIS and added to the master excel sheet.

Economic modelling

To create an economic model of the project, providing information such as the simple payback time for each of the measures along with the respective potential cumulative cash flow for an individual customer and the whole community was a complicated process. To assemble the economic model the following steps were undertaken:

1. A cost database for different insulation technologies was created. Each technology was also assigned a yearly energy saving (kWh). Three sources were used to obtain the final figures: Energy saving trust (EST), Fife council, Department of Energy & Climate Change (DECC). Assumptions were made when choosing the final benchmark.
2. The probabilities of a type of flat having an insulation technology were found using Home Analytics data for the different data-zones in Burntisland. This included flats with no roof available for insulation.
3. The implementation of cavity to traditional buildings and of double glazing and external wall to listed buildings was excluded due to current regulations and structural limitations. It was assumed that no dwelling already had external wall insulation.
4. The CAPEX and Energy saving per insulation and dwelling type were calculated for privately owned properties using the cost database.
5. The projected gas price for the years 2017-2030 was obtained from the Department for Business, Energy & Industrial Strategy (BEIS). All calculations including heat prices are made using these figures. No price data was present from this source, after year 2030 so the gas price for the final year of available data, was used for all remaining future years.
6. The CAPEX and energy saving for individual consumers of different dwelling types was found along with the simple payback for each insulation technology. The dwellings considered are the most common ones, namely: Flat; Semi Detached; Detached.
7. A cumulative cashflow of insulation measures for all of the suitable dwellings in Burntisland and for individual dwellings was calculated. This calculation included the CAPEX cost and the energy savings profit. This graph was used to illustrate the amount of years that an investment would break even.
8. A graph illustrating the Business as usual (BAU) vs Insulation costs was produced for the whole community and for a single consumer.
9. The year that the installations are assumed to be implemented was set based on information from the project team, as follows:
   - Loft bottom up insulation to virgin loft (<150MM) and top-up (>150MM) = 2020;
   - Cavity walls = 2025;
   - External walls = 2040;
   - Double glazing = 2032;
10. The CO_2 savings associated with the implementation of these insulating technologies was calculated using data from the Department for Environment, Food & Rural Affairs.

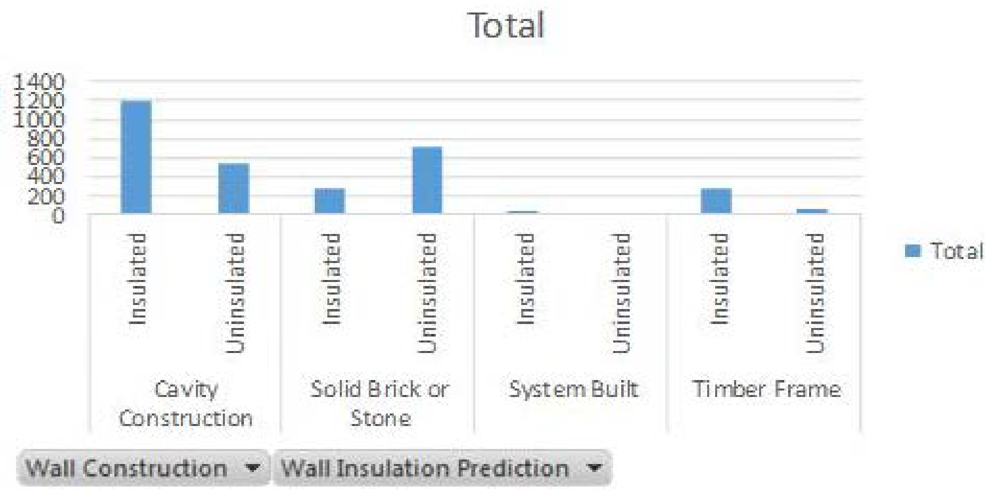
Energy Efficiency Measure Outputs

The outputs from the analysis section can be found in this section. These outcomes were processed and expressed through maps and graphs to better communicate the results. It is important to note that the results found in this section assume the installation years mentioned previously which are summarised in the table below:

Insulation Measure	Installation Year
LOFT BOTTOM UP (<150 mm)	2020
LOFT TOP UP (>150mm)	2020
CAVITY WALLS	2025
DOUBLE GLAZING	2032
EXTERNAL WALL	2040

Some of the outputs from this phase of the modelling were used in a presentation given to representatives of the community's residents on the 3rd March 2017 to actively engage them in the decision-making process. The positive feedback received, indicated a good approach in illustrating the key results in an easy-to-understand and informal manner.

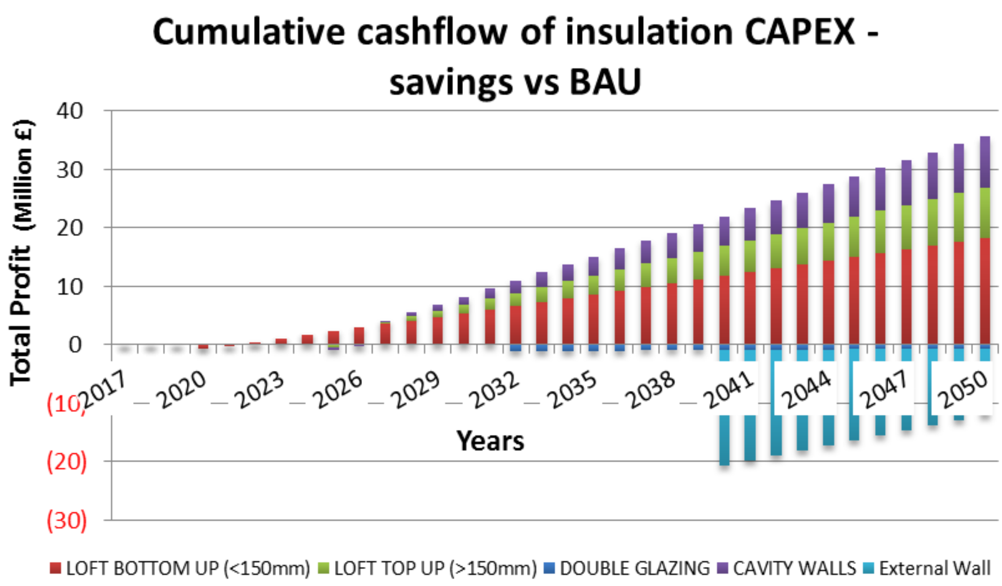
Modelling results suggested that 69% of the domestic properties within Burntisland already had one or more of insulation measures recommended for reducing the settlement's energy demand, and that the remaining 31% were uninsulated. The total proportion of insulated versus uninsulated properties within Burntisland, by construction type, is graphed below:



Source Extract from Home Analytics data

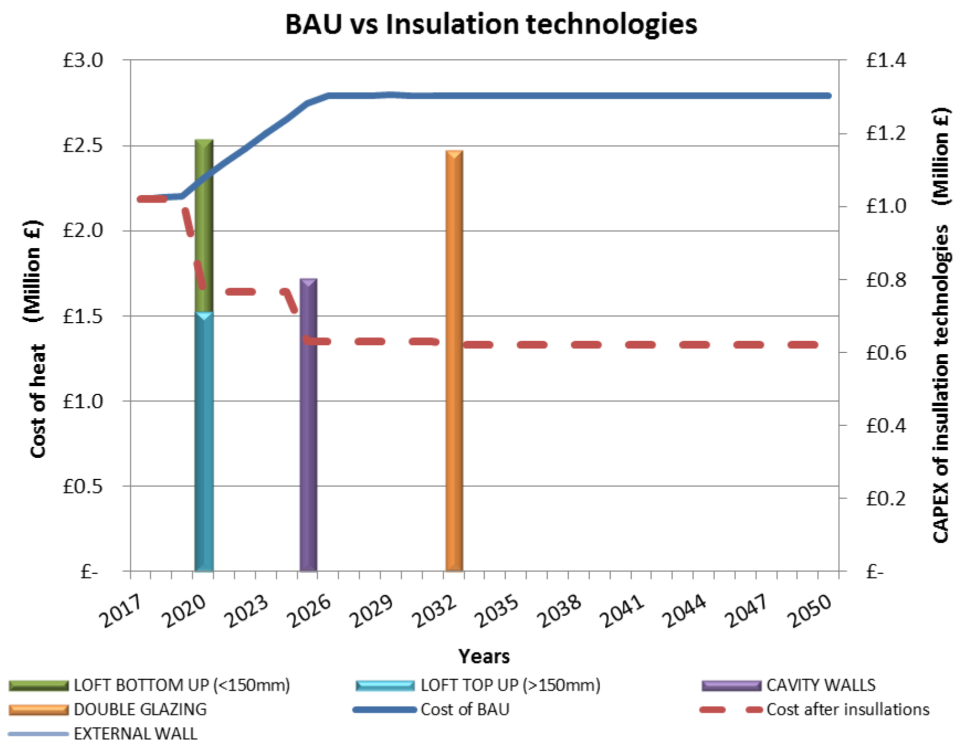
Economic analysis results

This section provides more information on the results of the associated economic analysis, illustrating the CAPEX and savings associated with the modelled energy efficiency scenarios for the whole community of Burntisland. The first graph shows the cumulative effect of the investment across the settlement, and aims to indicate the simple payback period and the potential cashflow (profit or loss) for each measure.



Source: Ramboll Energy

The next graph illustrates the cost of providing heat for space heating to the town, before and after the insulation installations while showing the CAPEX expected for each measure as bars. Business as usual costs can be seen in the solid blue line, whereas the community-wide reduction in energy spend which could be realised in Burntisland is shown in the dashed red line.



Source: Ramboll Energy

Payback periods

The estimated payback for each of these measures was determined as seen in the table below:

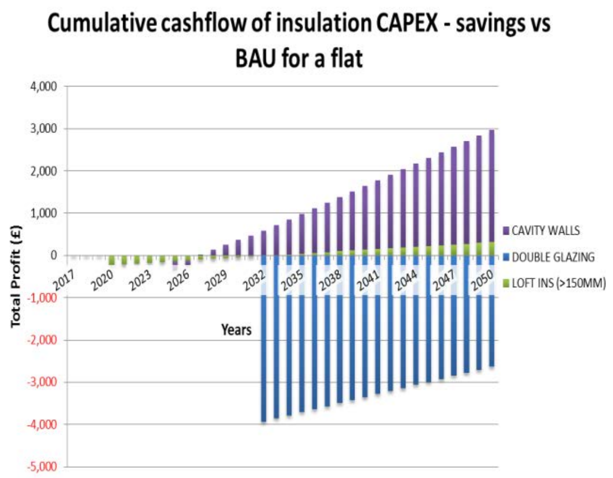
Insulation Measure	Simple Payback Period (years)
LOFT BOTTOM UP (<150 mm)	2
LOFT TOP UP (>150mm)	12
CAVITY WALL INSULATION	2
EXTERNAL WALL INSULATION	24
DOUBLE GLAZING	40

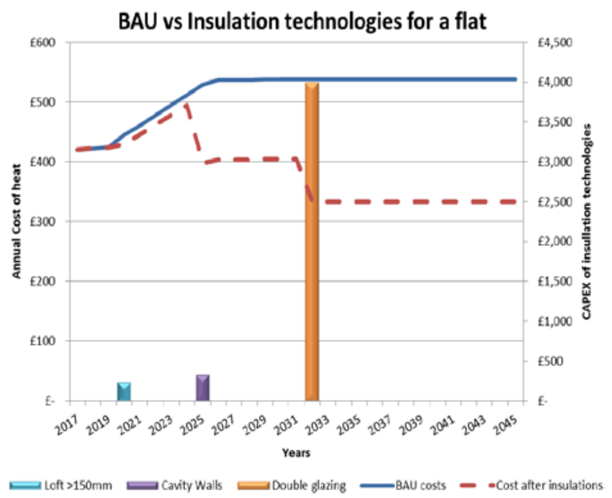
Source Energy Saving Trust

The data suggests that double glazing is a highly unattractive option from a cost benefit perspective, while loft insulation and cavity wall insulation look much more promising. It is clear from these graphs that the most profitable measure that could be installed is loft insulation, especially the retrofitting of bottom-up loft insulation to homes where there is little or no existing loft insulation (<150mm). This insulation measure can only be applied to flats on the top floor, semi-detached and fully detached houses. Double glazing seems to have a very high capital cost and a relatively small effect on energy savings. It should be noted that windows are on average replaced every 20 years.

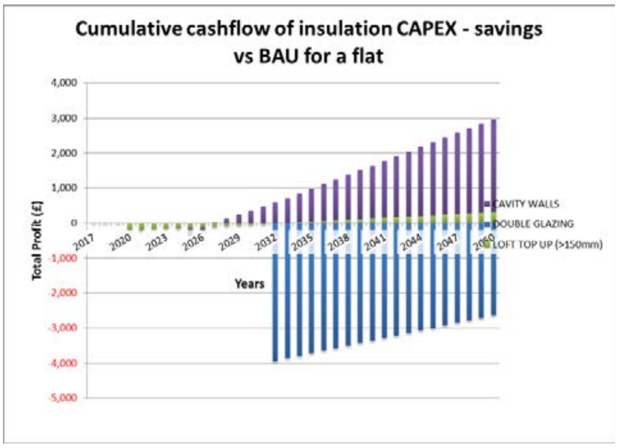
It was deemed useful to produce the same graphs for individual dwellings to schematically explain to the individual consumer the effect that retrofitting such measures may have in her / his property. These graphs were produced for the most common dwelling types in the study area, namely flats, semi and fully detached houses.

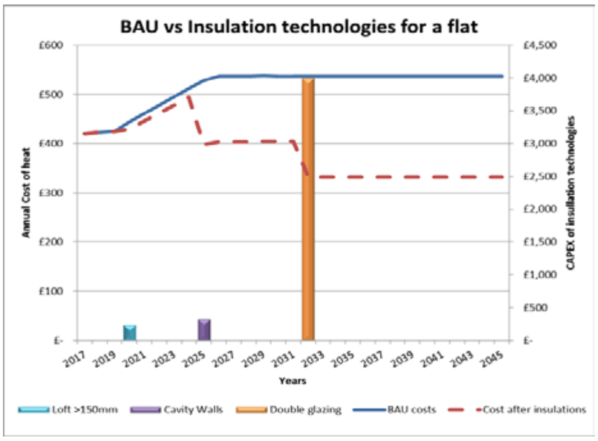
An example of these graphs for a flat can be seen in the figures below, which illustrate cumulative cashflow to the left, and CAPEX and the cost of heat, to the right:



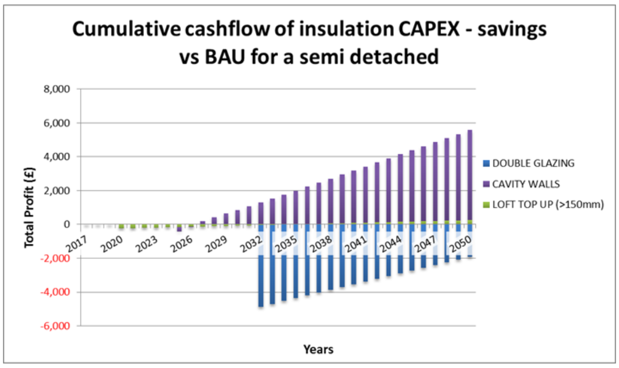


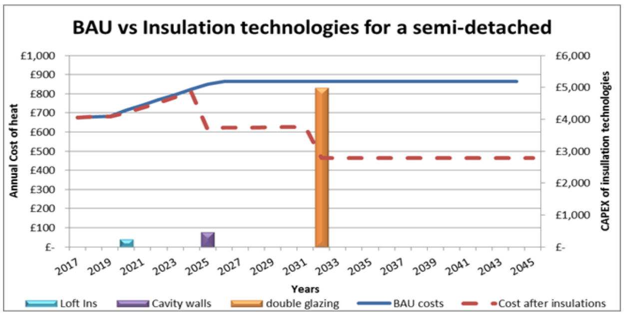
Cashflow and BAU - Flat



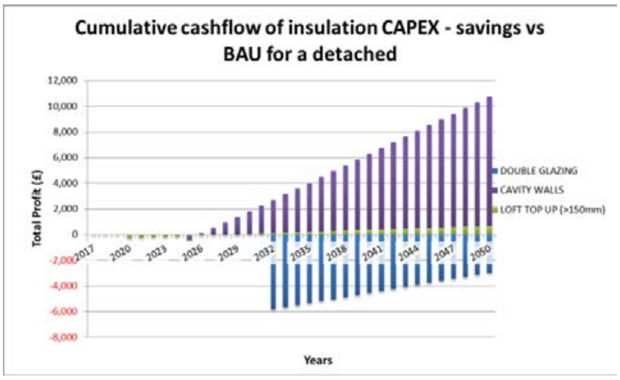


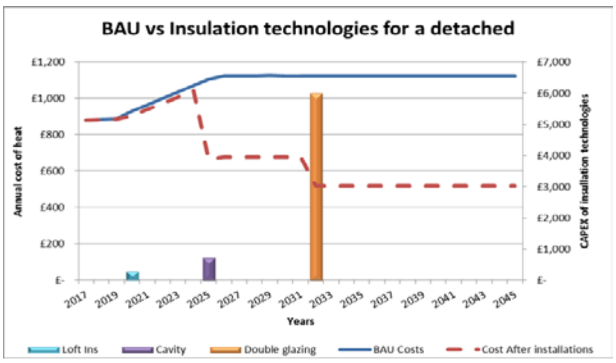
Cashflow and BAU – Semi-detached





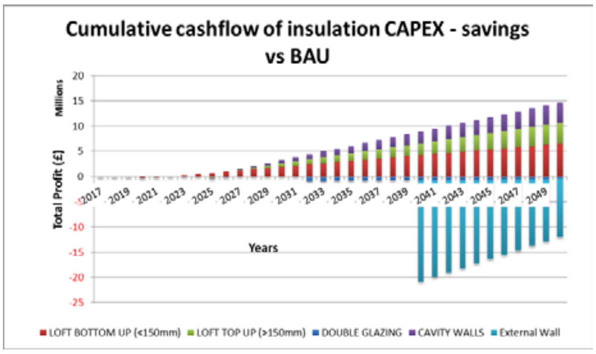
Cashflow and BAU - detached

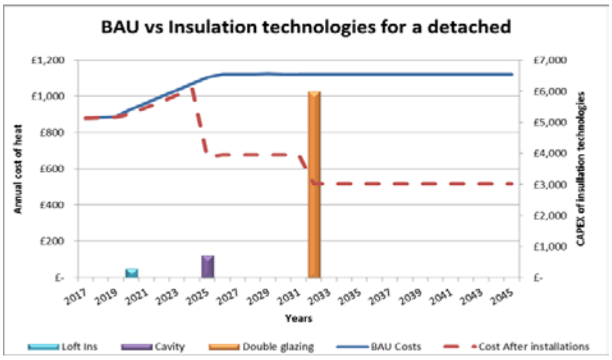




Source: Ramboll Energy

Comparision of all insulation technologies:

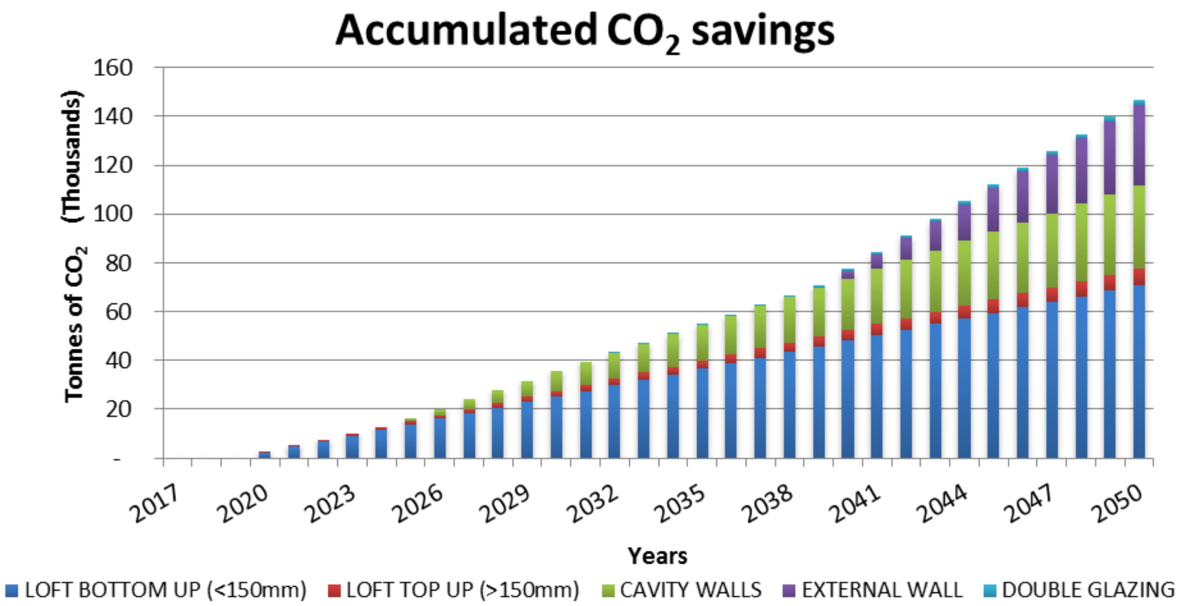




Source: Ramboll Energy

In these graphs, it is assumed that the dwellings have some loft insulation, so the top-up loft insulation measure was applied. The external wall was also omitted as an option for the dwellings since it was associated with an extremely large capital cost making the illustrations very hard to read.

Finally, the accumulated CO_2 savings realisable across Burntisland, from the implementation of these technologies is shown in the graph below:



Source: Ramboll Energy

As it can be seen, the biggest effect is again associated with insulating cavity walls and the installation of bottom-up loft insulation to lofts with little or no existing insulation present. Interestingly, installing top-up loft insulation to lofts which already have a modest amount of insulation (which is a very popular measure at present) has relatively low energy savings associated and leads to a comparatively small contribution to overall CO_2 reductions from the Burntisland building stock.

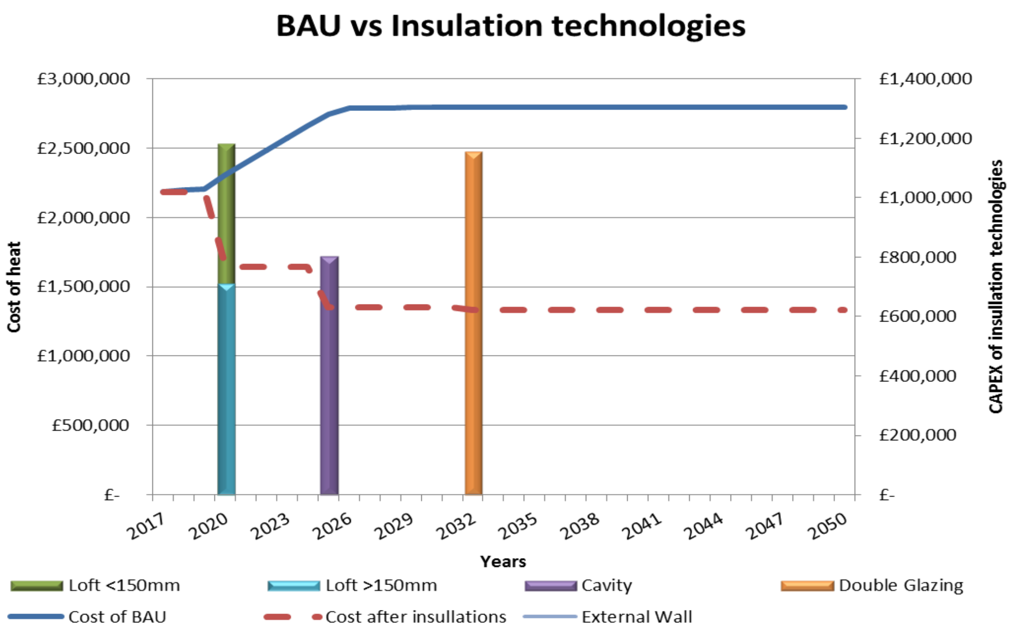
The payback period for installing loft insulation to a previously uninsulated loft, or for retrofitting cavity wall insulation was calculated as just 2 years for a typical Burntisland home

Summary

The following table summarizes all the key findings from this section of the modelling, including the CAPEX, energy savings and simple payback for rolling out these measures across the whole community. The approach to investment and installation of these measures requires further development to ensure that it can be delivered in the most cost-effective manner and to prioritise properties experiencing fuel poverty and those households experiencing health impacts from poor standards of thermal comfort. For the purposes of the masterplan the phasing of investment is also highlighted in the table below (see column 2). The data in the table could be used as key performance indicators (KPIs) for the practical roll-out of any community wide insulation programme within Burntisland.

Insulation technology	Installation year	CAPEX (£)	Annual saving vs BAU (kWh)[26]	Payback (years)	Number of buildings
Loft light insulation	2020	451,925	3,627,097	2	1374
Loft top up	2020	169,429	218,882	12	674
Cavity Walls	2025	346,798	2,644,838	2	698
External Wall	2040	20,937,000	13,479,200	24	1990
Double Glazing	2032	971,827	433,042	35	194

Source Ramboll



Source: Ramboll Energy

The BAU annual cost of heating the town is shown in the figure to above along with the estimated capital costs for each phase of investment and the potential cost of energy after installation of these measures.

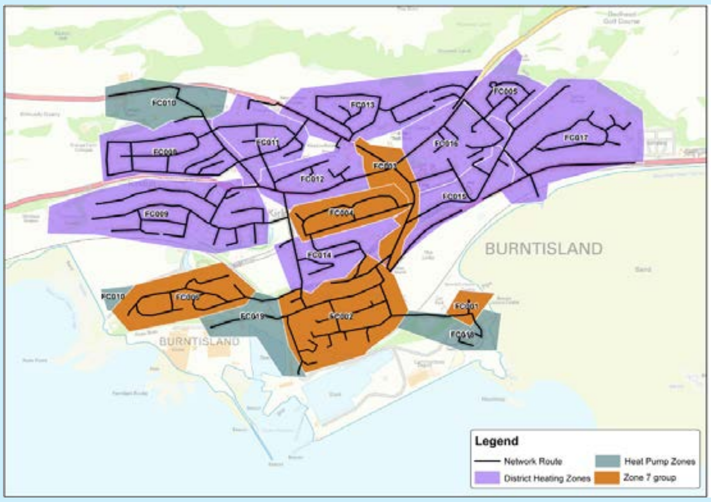
[26] Saving is the first year annual saving, and BAU assumes that properties remain as is, with no additional energy efficiency measures retrofitted.

9. Moving and storing energy

RESULTS - Heat and energy moving & storing

Communal heating solutions were considered against individual low carbon heating solutions. The vast majority of Burntisland returned district heating as the most cost effective solution. The financial return was not commercial and would need to be taken forward as a community or government driven project. Two heat sources were considered for the district heating scheme. Heat from the Forth Estuary using a large scale heat pump was six times more cost effective than a solar thermal park and large scale thermal store. The inter-seasonal thermal store cost makes it something to reconsider in future years. The estuary heat pump delivers 15,800,000 kWt for 5,266,000kWh electric.

- Phase 1: involves initiating work that could lead to a phased roll out of 5 district heating zones collectively called Zone 7. This would supply 574 buildings. The first step would be to seek feasibility funding for the first zones. This would lead toa period of planning and pre development works. In total these first steps would take at least 3 years. Construction of each zone in the first phase would take around 18 months. This could be planned as a rolling programme of planning and construction with each zone following the previous one.
- Phase two would be the remaining zones for the district heat network, following the same approach as above. Reassessment of the inter-seasonal store should be considered at this at stage. Alongside the district heating roll out a feasibly should be carried out for individual heat pump zones to confirm these are still the best technology for the outlying low density areas. If this individual heat pump feasibility proves cost effective then a roll out should be planned alongside the district heating works.



Introduction

Moving and storing energy describes the section of the energy system which provides the vital link between energy generation and the end use of energy, whether that be charging a battery or heating a home.

The draft Energy Strategy sets out the Scottish Government's vision for the future energy system in Scotland, for the period to 2050. It articulates the priorities for an integrated system-wide approach that considers both the use and the supply of energy for heat, power and transport. Our current energy system is not very efficient when one considers the losses that arise from converting energy from one form to another (thermal power station efficiencies are typically less than 40%); and when we consider the losses that arise from moving energy over large distances via the National Grid, distribution network and the mains gas network. Current energy supply systems will not be fit for purpose in the future, and many are already antiquated and operating under stress today.

The overall efficiency of an energy system can be improved by integrating the way we move, store and ultimately use energy but this will require a major change in how we organise our energy systems. It can be more efficient to generate energy close to where it will be consumed because this minimises transmission losses. Shared energy systems also increase overall system efficiencies (meaning that less energy needs to be produced to meet consumption) and the adoption of collective solutions for using and storing energy, at a community level look set to become commonplace between now and 2050.

When we speak about moving and storing energy it is often difficult to visualise this, beyond the obvious examples of pylons and gas pipes. Examples of moving and storing energy that are likely to become commonplace in Scotland's low carbon energy system this century include:

- District heating: where heat is provided to a number of buildings from a central point / energy centre, as is already commonplace in Scandinavia;
- Individual heat solutions at scale: where a change is made from the existing heating system to a lower carbon alternative (such as a heat pump) and applied at a large scale;
- Solar thermal: where large scale solar heat is captured
- Energy storage: where storage is combined with intermittent low carbon generation to manage peaks in demand, including inter-seasonal demand patterns (i.e. capturing natural summer heat to use for space and / or water heating during the winter heating season);
- Using low grade heat sources; including heat from the sea and waste heat reclaimed from industrial processes and from the wastewater network.

When considering how we could change the way that energy is moved and stored in Burntisland we considered all of the options listed above. An overview of the modelling undertaken is presented in the flow chart below, and the modelling activities undertaken for each movement / storage technology option are summarised in the following sections:

Note that reclaiming low grade heat is considered in this moving and storing energy chapter; as reclaiming low grade heat requires primary energy (such as electricity if using a heat pump) to recover the low grade heat and enable it to become useful heat.

Storing heat in particular is considered an important element in transitioning to low carbon local energy systems. Thermal storage provides a way of managing the peaks and troughs of heat demand over a period of time. Heat stores may store heat in the form of hot water, for example in large insulated tanks, above or below ground or in phase change materials, often taking up less space than hot water. However technologies can range significantly in scale: from hot water tanks and electric storage heaters in homes providing hours of storage to large-scale underground tanks (or old mines) holding hundreds of thousands of cubic metres of water providing inter-seasonal storage for a district heating network. Thermal storage can be used alongside heat recovery, solar thermal panels, heat pumps, biomass boilers, and combined heat and power (CHP). It can be part of a wider approach to managing our energy system, including the electricity network. Thermal storage can utilise intermittent energy sources such as wind and wave generation, and potentially bringing down the cost of decarbonisation through greater efficiency. Thermal storage can enable CHP plant to run at maximum capacity, reducing the number of hours run at part load which enhances overall efficiency. It can provide ‘grid balancing services’ by enabling electricity generation equipment such as CHP to be switched on and off at short notice without negatively affecting the heat supply that user’s need.

District heating

District heating (DH) networks are used to distribute heat, in the form of hot water, from centralised generation through insulated pipe networks with connection to customers. The customer interface comprises a direct connection to the heating or hydraulic separation using a heat exchanger. DH networks are common in Northern Europe and are supported by Scottish Government policy.

DH systems offer benefits deriving from economies of scale. This may result in heat production efficiencies and reduced operating costs to customers. They are also ‘technology agnostic’, meaning they are able to take heat from a wide range of fuels and technologies which means they can be used as part of Burntisland’s vision to decarbonise their overall energy supply. District heating networks, especially as networks grow, offer opportunities to use renewable and/or low carbon sources of heat (for example biomass, heat pumps, heat from water and sewage, geothermal, solar thermal and heat storage technologies) that may otherwise not be viable.

A valuable economy may be the ‘economy of integration’ that derives from the ability to balance different heat loads which have peak requirements at different times. Maximum heating and cooling loads are typically very peaky, with maximum demand occurring for short periods of time. When loads with different peak demand times are served by the same network, the total heat capacity required can be significantly less than the sum of each individual heat capacity requirement. The more diverse the heat loads on a system (mixing commercial buildings with homes, and with civic buildings, for example), the greater the benefit. A diversification benefit of 15%-25% has been demonstrated in many district heating systems. This is illustrated in the example in the box below.

In addition to the ability to connect and balance heat demands, interconnected networks offer the possibility of using large scale thermal storage to further balance heat loads and further improve system efficiencies.

District heating systems are very reliable. The International District Energy Association (IDEA[27]) states that “*Most district energy systems operate at a reliability of "five nines" (99.999 percent). To IDEA's knowledge, there have been no rolling "heat-outs" related to district energy systems.”*

District heating systems have the potential to help to address fuel poverty by providing secure heat at prices lower than alternatives. Whilst the development of a district heating system may be capital intensive, district heating systems have the potential to offer stable financial returns to investors, which may then allow access to finance at low rates. This, together with the ability to use efficient heat generation, and to feed in low cost heat (for example waste heat from industrial processes), can result in the ability to supply heat at a relatively low cost, with the security of long-term contracts and the security of a local energy supply giving some protection from the volatility of energy markets. To date in the UK, however, access to suitable finance has remained a barrier to developing some district heating projects.

A report[28] on heating upgrade options in multi-storey flats for Edinburgh City Council noted that district heating could significantly reduce the number of households at risk of fuel poverty: “*Investing in fabric and electric heating improvements can reduce these figures substantially but even with this investment seven in ten tenants risk poverty with electric heating and four in ten [with] district heating*.” However the report also noted that “considerable cost savings are needed before district heating can be classed as a cost effective means of reducing fuel poverty.”

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[27] http://www.districtenergy.org

[28] “Heating upgrade options for multi-storey flats in Edinburgh”, Changeworks, June 2014, based on work by Craighall Energy.

As described above, through economies of scale and for other reasons district heating systems deliver carbon savings when compared to conventional heating systems. Quantifying these savings does require some degree of specification, so that a specific existing heat supply can be compared with a specific district heating based supply.

The technical and economic assessment of District Heating opportunities for Burntisland was undertaken using two modelling tools. The analysis described in this methodology is intended to provide a high level assessment of the potential economics of the project to allow the Burntisland community to make decisions regarding which areas to consider zoning for district heating and to inform the priority and sequence of development of these zones.

Technical and economic modelling

The modelling for the district heating (DH) assessment was undertaken in two technical and economic models. The first is a tool developed by Ramboll for rapid analysis of DH opportunities using SHM data. The second tool was developed for a previous project in Fife, and was reengineered for use in Burntisland. The results of analysis described in the masterplan show the potential economics to be considered on a comparative basis. The models are based on high–level estimates and detailed feasibility studies to design and price the potential networks, energy centre and customer connections. This should take account of the project risks that influence the final business case for any project.

It is important to note that district heating is not the only solution to decarbonise heat to the town and in areas of lower heat density the cost of DH infrastructure may not be economically feasible. In these areas individual building solutions, such as heat pumps, may be more appropriate.

This report is intended to provide information that allows the community to make decisions regarding which areas to consider zoning for district heating and to inform the priority and sequence of development of these zones.

Modelling the cost of district heating compared with alternative heat supply options

The following section of the report presents the methodology that was followed to evaluate the opportunity for a district heating network development in Burntisland.

The reporting of the project and the process involved was broken down into two phases:

- the methodology phase; and
- the masterplan phase.

In this report the methodology phase is thoroughly analysed and broken down into its constituent parts. To assist this analysis the process was further subdivided into input, analysis and output phases as shown in the table below. Note that the final masterplan methodology paper includes the outputs from all sections, whereas the final masterplan paper will only present the results of this analysis:

The technical and economic assessment of district heating opportunities for Burntisland was undertaken using two modelling tools. It is based on heat demand and property information obtained from Fife Council combined with technical and cost information that Ramboll Energy hold and based on their considerable real-world experience in the district heating market.

In order to ensure a high quality outcome for the project, the project team validated the data used for the project to ensure that it was robust and as error free as reasonably possible. Considerable data validation and data cleaning was undertaken (as discussed in the Chapter 8 subsection on *Data validationData validation* which starts on pp 49).

The district heating modelling process involved the following steps (which are discussed in more detail below):

1. Select the maximum potential boundary for the district heating network (i.e. supply asset mapping);
2. Zone the area;
3. Input data:
4. Aggregate heat demand;
5. Assign use and profile classes to the buildings;
6. Format the data;
7. Calculate heat demand;
8. Initial opportunity mapping to establish Phase 1 of the network;
9. Modelling the cost of district heating with alternative heat supply options; and
10. Consultation with the local community.

Select Boundary of Town

This involves selecting a boundary for the area of study in the GIS. This boundary would ideally be coincident with a collection of datazones or intermediate geographies to assist in the data processing and validation stage. We used the settlement boundary of Burntisland for this because of the density of buildings within this boundary.

Zoning

This process divides the town into smaller areas depending on the property type / class of the buildings present and then adding a qualitative description of each zone to provide further information if necessary. The process involved site visits in order to suitably classify each zone appropriately. The zoning of the area enables the user to evaluate the feasibility of a range of renewable technologies within certain parts of the study area. The principle purpose of the zoning is to qualitatively assess certain key parameters that distinguish areas within the town from one another, these include:

- The heat demand density of each zone;
- The land use of each zone; and
- The age of properties within each zone (as an indicator of the baseline energy efficiency of properties).

The zones were then drawn as shapefiles in GIS to facilitate simple extraction of data.

Input data

This section sets out the key assumptions that have been made in the course of developing the district heating assessment for the development of the Burntisland energy masterplan.

The following input data was used:

Dataset	Responsible Party	Description	Used for	Format
Scotland Heat Map (SHM)	Fife Council (data centrally controlled and supplied by Scottish Government)	Heat Map created in 2013 covering all of Scotland and defining heat demand at individual property level. All data tied to UPRN. Heat demand assessed by a range of metered energy data, EPCs, and benchmarking.	Main property and heat demand dataset, defining use classes of each property and property archetypes (age, use, floor area).	ArcGIS geodatabase, point data raster data and shapefiles

		- Metadata, limitations and data management - Data dictionary - Data agreement LINK - Public data Inspire ATOM feed LINK		
Gas and electricity demand data at middle super output area29	Data held by BEIS an updated in January 2017	Middle Layer Super Output Area (MSOA) domestic and non-domestic gas and electricity consumption based on data from licensed energy retailers	Validation of heat map data	Microsoft Excel
Domestic and Non-Domestic Assessor Data – in Scotland heat map	Scottish Assessors and Fife Council	Record of all addresses in the study area	Updating addresses, location, tenure, and status of NHM records	Microsoft Excel
Energy Performance Certificate (EPC) – in Scotland heat map	Scottish Government – produced by approved assessors	Produced by law for all buildings bought, sold or rented in Scotland. This gives a predicted Performance Rating for each building. (Data held in Heat Map	Floor Area information (used to benchmark heat demand for buildings) and heating plant type in NHM dataset	Microsoft Excel
Billing Data	Various	Metered/Billing data for either heat demand or fuel consumed for public sector buildings, collected by Fife Council.	Updating heat demand information and heating plant type in SHM dataset	Microsoft Excel
Strategic Planning Layers	Local Authorities	GIS polygons containing development quantums for planned strategic residential and non-residential developments.	Assessing Future Heat demand in LCR	ArcGIS .shp files
Constraints and Opportunities Layers	Local Authorities	GIS layers showing public transport planned and future infrastructure, conservation areas, listed buildings etc.	Barrier / opportunity identification	Mapinfo TAB files or ArcGIS .shp files
Home Analytics	Energy Saving Trust	Combination dataset, funded by The Scottish Government, managed by the Energy Saving Trust (Scotland) and licensed to local authorities.	Composite of building data including: Energy Performance Certificate, Home Energy Efficiency Database and other	Excel files

Aggregate heat demand

When multiple heat demands (addresses) shared x and y coordinates then they were assumed to represent multiple occupancies within the same building. The heat demand data for the building was

29 https://data.gov.uk/dataset/electricity_and_gas_consumption_at_middle_layer_super_output_area_mlsoa_and_intermediate_geography_z

therefore aggregated to a single data point for subsequent analysis. This involved summing all heat demand sharing coordinates to create a new point. This new point takes the property details (address, use / profile class etc.) of the point that has the highest annual demand.

Assign use and profile class

A suitable use and profile class is assigned to each property using their individual Basic Land and Property Unit (BLPU) code from the heat map. A lookup was used to assign each code to a use and a profile class.

Format Data

Data imported into the model was then organized in columns and in the following order: Zone, Use Class, Heat Demand (in kWh), Number of Users per Record, Average Consumption per Record (in kWh) and UPRNs. The average consumption mentioned was simply the aggregated heat demand for each record divided by the number of consumers for that record.

Calculate heat demand data to assess different heat supply solutions

The heat demand data for Burntisland that was used in modelling was based on the Scottish heat map data. This was validated, cleaned and heat demands aggregated by building. The analysis relies on information and assumptions that were made during the development of the SHM. It is therefore useful to validate the heat map information with other publically available datasets including data held by the UK Department of Business Energy and Industrial Strategy (BEIS).

The Scotland Heat Map Data for Burntisland is summarised below by property use class and in total.

Use Class	No. of Connections	Total Heat Demand (MWh)	Proportion of DHW[30] (%)	Profiles
Education	3	1,095	20%	Education
Health	1	4	30%	Health
Hotel	5	129	50%	Hotel
Industrial	21	788	50%	Industrial
Office	101	2,109	22%	Office
Recreational	19	3,367	50%	Recreational
Restaurant / pub / bar	1	140	30%	Restaurant / pub / bar
Retail	5	161	10%	Retail
Non-Domestic Total	156	7,793	Varies	
Residential	3,210	38,983	30%	Residential
Domestic Total	3,210	38,983	30%	
Total	3,366	46,776	Varies	

[30] Domestic hot water

The assumed heat demand can be compared to the data included from energy consumption by middle super output area (MSOA[31]) and reported by BEIS, published in January 2017. The data included in the MSOA data is presented in the following table:

	No. Gas Meters	No. Electricity Meters	MSOA Electricity Demand (MWh / year)	MSOA Gas Demand (MWh / year)
Domestic	3002	3150	10,332	38,839
Non_Domestic	12	205	3,747	3,687
TOTAL	3014	3355	14,079	42,526

The figures presented are fuel consumption and require conversion to heat consumption in order to account for the efficiency of boilers and for gas consumption for gas cooking and other electrical systems. Analysis of heat and electricity demand based on BEIS MSOA data is presented below:

	Heat (Gas / 85%[32]) Demand (kWh)	Total Heat (Gas + Electric switch)[33] (kWh)	Electricity demand (kWh)
Domestic	41,123,184	43,037,943	8,416,796
Non_Domestic	4,337,798	6,101,778	1,983,334
TOTAL	45,460,982	49,139,721	10,400,131

These results indicate that the SHM is broadly in agreement with the MSOA data but underestimates the heat demand by approximately 2.5 GWh/year.

A simple assessment of the current cost of energy for the whole Burntisland community, based on the MSOA data from BEIS and assumed energy tariffs including standing charges, is provided below:

	Tariff (including standing charges) (p / kWh)	Consumption (kWh / year)	Cost (£ / year)
Gas	6.5	42,525,691	£ 2,764,170
Electricity[34]	14	14,078,870	£ 1,971,042
		TOTAL COST OF ENERGY	£ 4,097,326

The district heating system offers benefits due to the ability to diversify[35] heat demand. Under the business as usual scenario each property has a boiler that can deliver the individual peak demand for that property, and for most of the time, these systems are operating at far from peak efficiency.

[31] Middle Layer Super Output Area (MSOA) domestic and non-domestic gas and electricity consumption https://data.gov.uk/dataset/electricity_and_gas_consumption_at_middle_layer_super_output_area_mlsoa_and_intermediate_geography_z

[32] 10% of gas consumption assumed to be used for cooking in domestic properties. 85% assumed gross efficiency of gas boilers

[33] Assumes that 148 domestic properties are electrically heated and applies average heat consumption of a domestic property to these buildings. For non-domestic assumes that 50% of electrical consumption (of non-gas supplied customers) is for heating.

[34] Includes electric heating.

[35] Since not all customers will require peak heat demand concurrently the expected peak can be reduced based on industry standard probability factors.

Using a DH network and benefitting from diversity of demand, the installed capacity of heat generation in the town could be reduced from approximately 100 MW to just 16 MW. This is simply because not everyone wants hot water at the same time, so the heat plant only needs to meet the diversified peak – which is a much demand. The expected total heat capacity in the town including diversification is illustrated below:

	Heat Demand (MWh)	Weighted proportion of DHW (%)	DHW Demand (kWh)	Sum of Individual Peak Demands (kW)	Diversified Peak Demand (kW)
Office	1,645	22.0%	464	4,121	2,967
Education	876	20.0%	219	6,749	528
Residential	27,288	30.0%	11,695	91,458	11,711
Industrial	394	50.0%	394	646	421
Recreational	1,683	50.0%	1,683	1,373	1,013
Retail	145	10.0%	16	165	129
Restaurant / pub / bar	98	30.0%	42	66	66
Hotel	64	50.0%	64	78	66
Health	3	30.0%	1	36	36
Total	32,197 (MW)		14,579 (kWh)	104,691 kWh)	15,759 kWh)

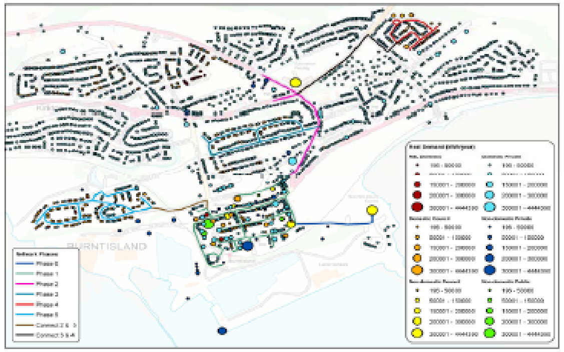
Initial opportunity mapping to establish Phase 1 network

This model takes individual heat demand for individual zones of a settlement and calculates associated network pipeline lengths to assess the associated capital costs, operating costs and revenues. It completes a simple lifecycle assessment of the opportunity and provides a dashboard result. This presents a series of economic indicators for comparison against other scenarios. These results are not intended to provide inputs to an outline or detailed business case and should be fully validated through a feasibility study. An example output from the opportunity model is illustrated in the figure below:

OPPORTUNITY FC007 - CONNECTED TOWN NETWORK

New WSHP (3.0 MW)

Connections between Leisure Centre, Town Centre, School, Dick Crescent and Rosslee Avenue.



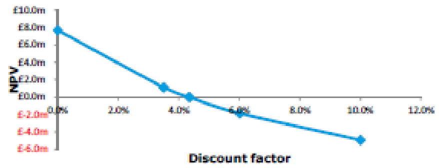
Contains Ordnance Survey data © Crown copyright and database right [2014]

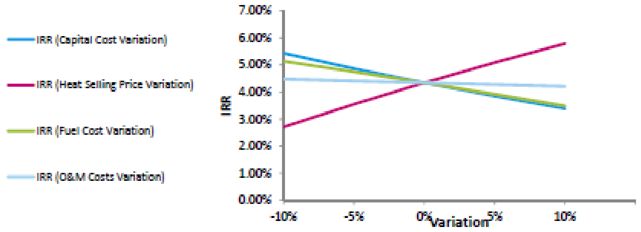
Summary Economic Indicators	
Total Capital Cost of the Project:	£12.7M
No Capital Injection	£0M
Annual Income:	£1.5M
Annual operating margin:	£0.77M
Return on Investment:	6%
Simple Payback Period:	16 years

Key Performance Indicators	
Economic Saving Potential:	£7.5k (per GWh supplied basis)
Annual CO_2 Savings:	1900 tCO2
Development Risk Factor:	0.92 (1=high,0=Low)

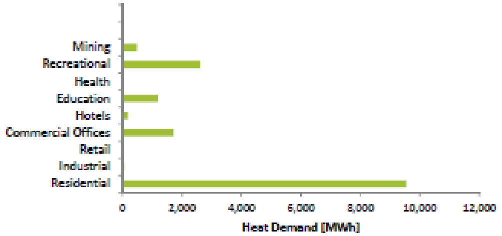
Summary Technical Parameters	
Generating station technology:	WSHP
Generation asset heat offtake capacity:	3 MWth
Annual heat demand:	15.8 GWh
Diversified peak heat demand:	4.5 MWth
Length of network:	11.8 km
Linear heat density:	1.3 MWh/m
Number of connections:	574
Main generation asset contribution:	95%
Network construction type:	New development greenfield or brownfield in surburban
Accumulator modelled?:	yes

Key Economic Indicators			
Energy Centre CAPEX:	£2.2M		
Heat Network CAPEX:	£8.2M		
Connection CAPEX:	£2M		
Development CAPEX:	£0.3M		
Land acquisition CAPEX:	£0M		
No Capital Injection	£0M	£0M	£0M
Value of Electricity:	n/a		
IRR over 25 years:	4.34%		
NPV over 25 Years @ 6% DF:	£-1.9M		
Overall heat generation cost*:	£41.9/MWh		
Heat generation cost main generation asset. **:	£33.2/MWh		
Annual electricity generated:	n/a		
Annual heat generated:	17.4GWh		
Average heat selling price:	£67.7/MWh		
Annual revenue from electricity sales:	n/a		
Annual revenue from heat sales:	£1072k		
RHI support modelled as:	shared benefit, 1		
Annual RHI income:	£466k		
Annual fuel costs:	£31k		
Annual O&M costs:	£60k		





Scheme Quality	
Are municipally owned buildings involved as anchor loads ?:	significant contribution to total scheme demand
Demand Diversity:	Medium
Expected impact of development timescale on viability:	Low
Development status of main generation asset:	not applicable
Number of public sector heat loads:	5
Number of private sector heat loads:	569
of these, number of non residential:	80
% of total heat to the public sector:	8%
% of total heat to the private sector:	92%



Additional Information and Notes:
Economic and carbon KPIs exclude impact of development phasing.

Economic KPI's reflect EBITDA and exclude project financing.
* excludes RHI where relevant but including all overheads.

** excludes RHI (where relevant).

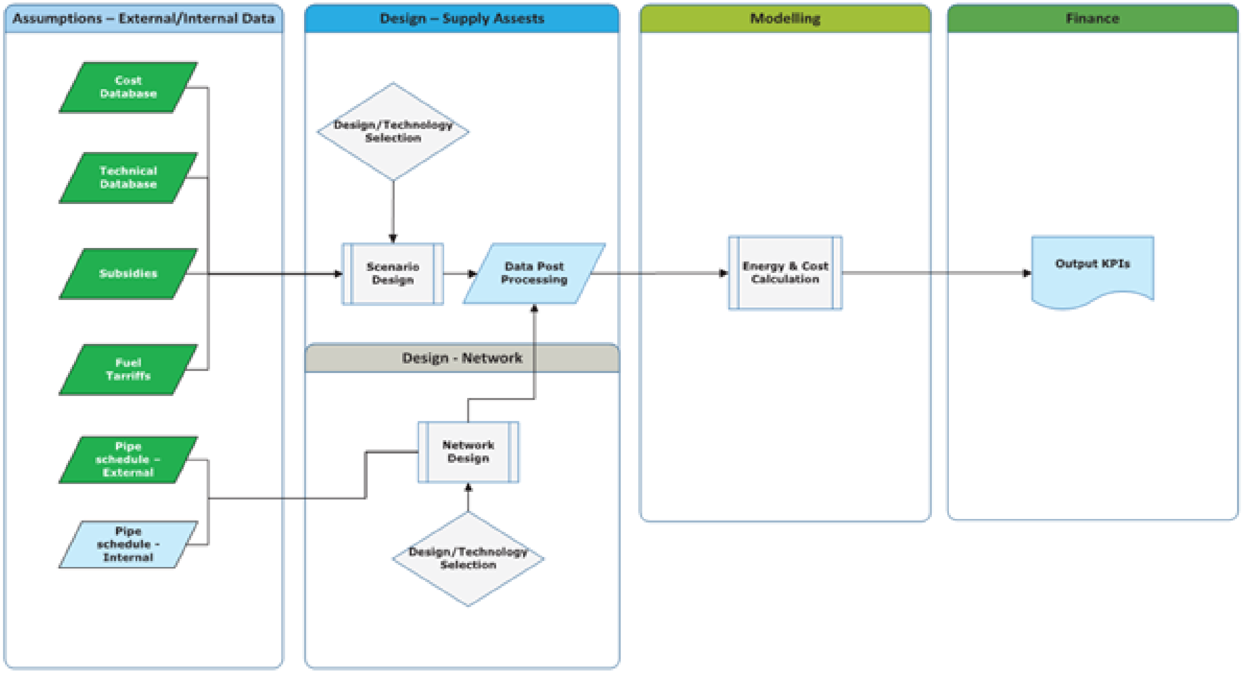
RAMBOLL

Source: Ramboll Energy

A full set of opportunity analysis outputs are in Appendix

Modelling the cost of district heating compared with alternative heat supply options

The structure of this model is presented below and it reports a series of economic indicators – notably the net present cost (NPC) of each of the options for comparison. It also makes a simple estimate of the NPC for each zone within the town.



Source Ramboll

Ramboll developed this model on behalf of BEIS and it was initially applied to Cowdenbeath in Fife to estimate the whole system lifecycle cost of a town-wide DH network, individual electric heat pumps, and individual hybrid heat pumps.

Consultation with the community

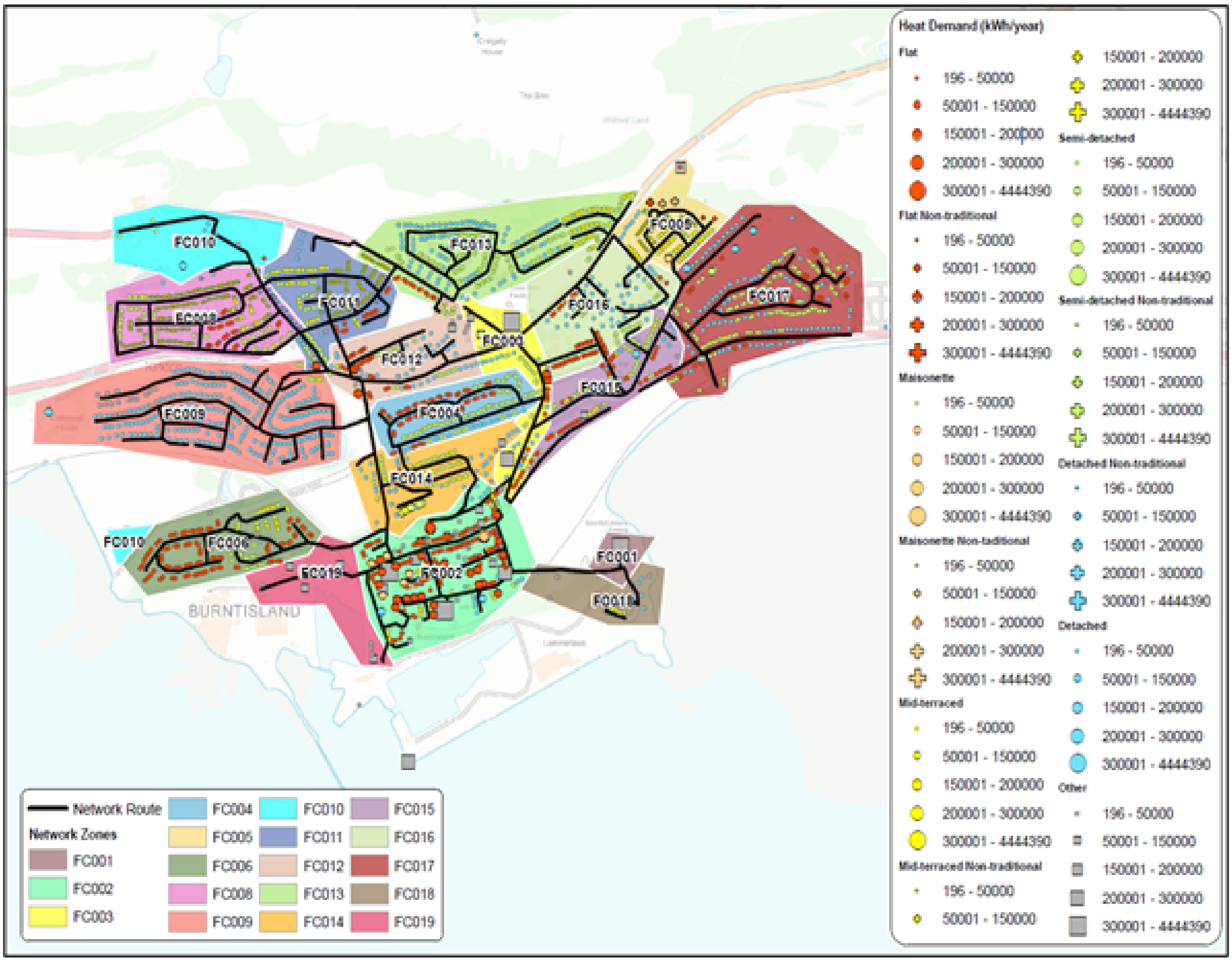
The concept of district heating was presented to the community at a series of stakeholder engagement workshops. The community representatives were positively responsive to the inclusion of district heating in the masterplan and requested further information.

The development of a district heating opportunity assessment to supply heat to a core area of the town was described further in this report and the results were presented to the community on 1st March 2017. The core scheme did not address district heating for the whole town and at this meeting the community expressed the opinion that this option did not provide benefit to the whole community. As a result a more comprehensive analysis of a DH network supplying the whole of Burntisland was considered and is presented in this report.

District heating assessment results

The identification of zones within the town was based on visual interpretation of principal indicators within the heat map. Zones in Burntisland were defined principally as areas of similar classification of property type, heat density and constraints. These zones were identified by outlining them as shapefiles in the GIS heat map. These zones can be earmarked for different heat supply technologies (i.e. district heating zones, gas zones and heat pump zones). They also effectively form the basis for the phases of DH network development.

The town of Burntisland was zoned (showing DH zones with heat demand per property by property type) as indicated below:



Source Ramboll

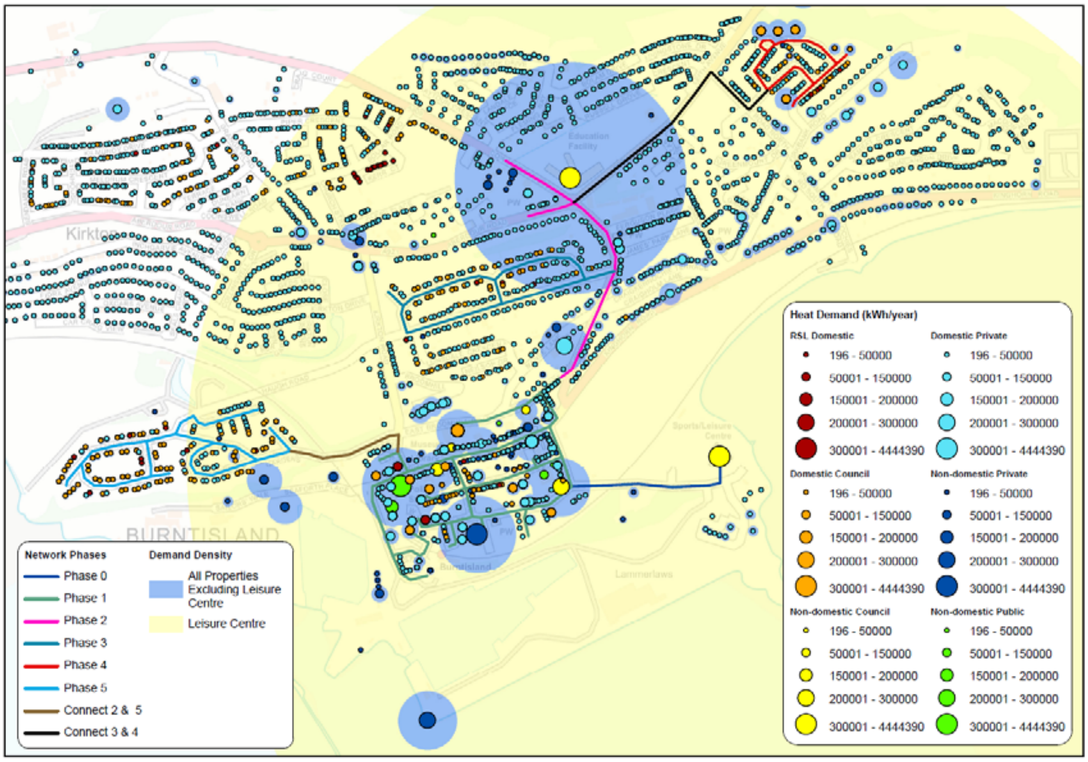
The first phase of a DH network for Burntisland would be expected to comprise the following areas:

Zone	Name	Description
FC001	Burntisland Leisure Centre	Initial phase of network to establish a seawater source heat pump to supply heating to the Leisure Centre and thereafter to afford opportunity for expansion of the network to the wider town.
FC002	Town Centre	Expansion of the district heating network to the town centre.
FC003	Primary School	Expansion of the town centre DHN to supply heat to the Primary school
FC004	Dick Crescent	Connection off the main branch feeding the Primary School from the town centre to supply Dick Crescent where a high proportion of local authority owned properties are located.
FC006	Rosslee Avenue	Connection off the town centre DHN to supply Rossend Terrace and surrounding streets where a high proportion of local authority owned properties are located.
FC007	FC001, FC002, FC003, FC004 and FC006 combined	Connections between Leisure Centre, Town Centre, School, Dick Crescent and Rosslee Avenue.
FC005	Speirs Avenue	Potentially standalone network with the possibility of a connection from the Primary School in the future. This area includes a high proportion of local authority and RSL owned properties.
FC008	Meldrum Crescent	Semi-detached and 4-in-a block properties of mixed private and Council tenure.
FC009	Development on Former Gas Site	This zone was developed since 1990 and is predominatly private detached residential.
FC010	A909	Low density residential area on the northern boundary of Burntisland
FC011	Piper Crescent	Semi-detached and 4-in-a block properties of mixed private and Council tenure.
FC012	Glebe Place and Aberdour Road	Semi-detached and 4-in-a block properties of mixed private and Council tenure.
FC013	Fleming Way	Mainly private Detached and semi-detached properties to the northern boundary of the town.
FC014	Thistle Street	Area between the town centre and Dick Crescent, mainly private semi-detached and detached residential properties.
FC015	Kinghorn Road	Area overlooking the Links comprising semi-detached and 4-in-a block properties.
FC016	Greenmount	Mainly private detached and semi-detached properties on Greenmount which is up the hill from the town.
FC017	Duncanson Drive	Mainly private detached and semi-detached properties to the east of the town.

District Heating Network Layout

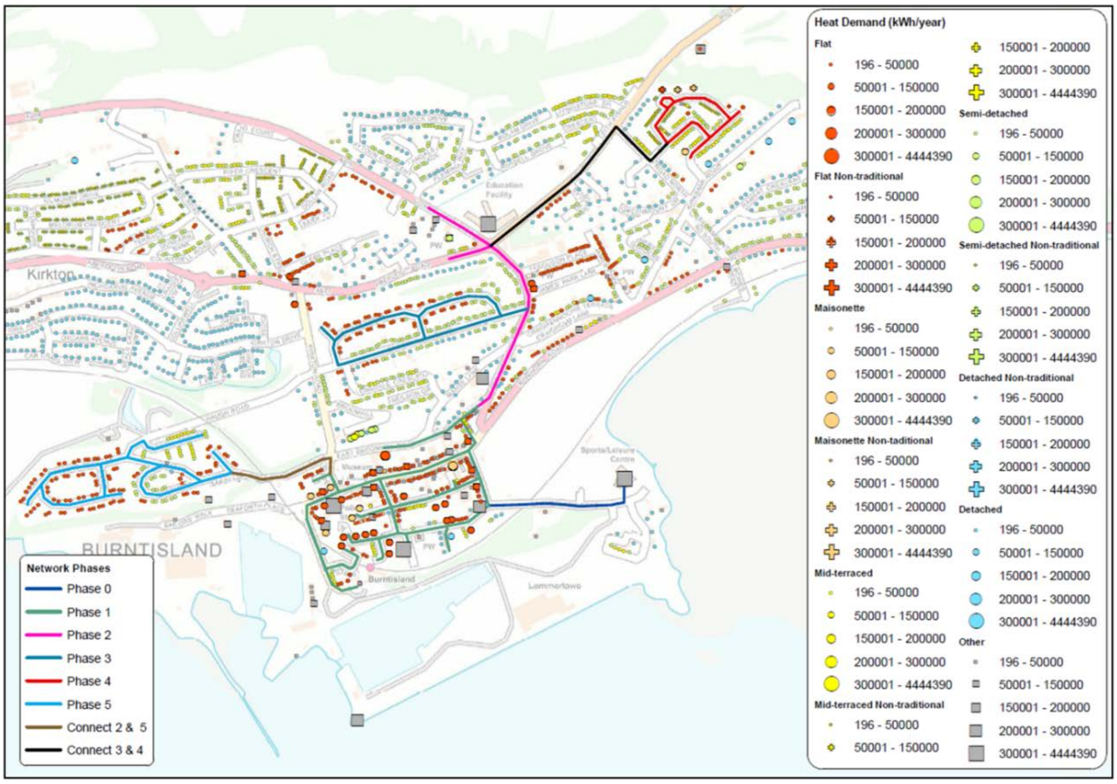
The opportunity assessment was initially undertaken on the following potential network areas. The network was laid out indicatively to provide information on an early route option to derive estimated network lengths. The heat map data was used to identify the areas of highest heat density by taking a 4MWh / m buffer [Linear Heat Density LHD 4MWm] to provide an initial estimate of the economic distance to connect properties into a network. These are illustrated in the map below which illustrates the kernel density map indicating areas of higher heat density that would indicate the principal heat network opportunities in the town.

This figure also shows the properties by tenure and it is considered likely that in the early stages of the DH network, private owner occupier customers may be less willing to sign up to heat supply agreement seeing it as an untried and untested technology. The Council, subject to economics and suitable guarantee that the heat price would be affordable to tenants, could provide the aggregation of their own properties at a scale to justify network development and showcase the technology to other residents of the town.



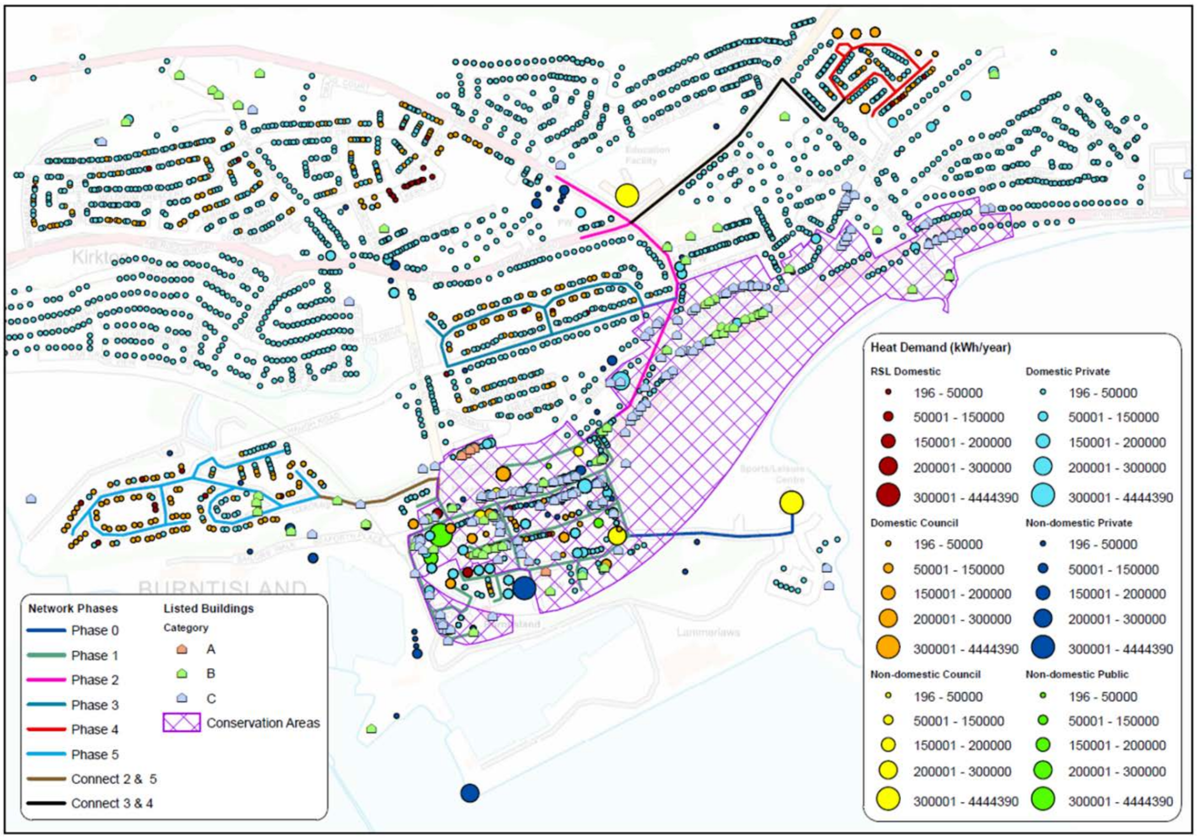
Source Ramboll

Based on this rule of thumb, combined with the areas of high Council ownership, the network areas FC001-FC006 were identified as potential initial areas of connection. FC001-FC004 and FC006 were also combined into zone FC007 which is discussed later. The following image shows district heating network zones and sources, in relation to principal heat network opportunities in the town:



Source Ramboll

The last figure shows the district heating network layout in relation to the heat demand by property tenure and indicating the location of listed buildings and conservation areas:



Source Ramboll

The DH option that is considered most viable, (i.e. FC007) would be expected to be developed as a series of clusters and over a phased development. This would potentially commence at the Leisure Centre (FC001) with an energy centre sized to feed the whole network. This would extend to the town centre (FC002) and north to the primary school (FC003). The residential areas in FC004 and FC006 could follow thereafter.

District heating model for a town-wide network

Following the March 2017 consultation event the community requested that additional analysis was undertaken to include the entire town within the DH study, as the initial network proposed was felt to be too heavily focussed on the Fife Council social housing in the town and would not truly represent a town-wide community network.

This assessment was undertaken in a separate model that considered the total system cost of DH and compared it to a scenario involving the deployment of electric and hybrid heat pumps across the town. Each of these options offers the community the benefit of significant decarbonisation of their energy system. The indicative pipe runs associated with the various zones of the district heating network for Burntisland, and the total length of heat pipe needed for the whole system are illustrated in the table below:

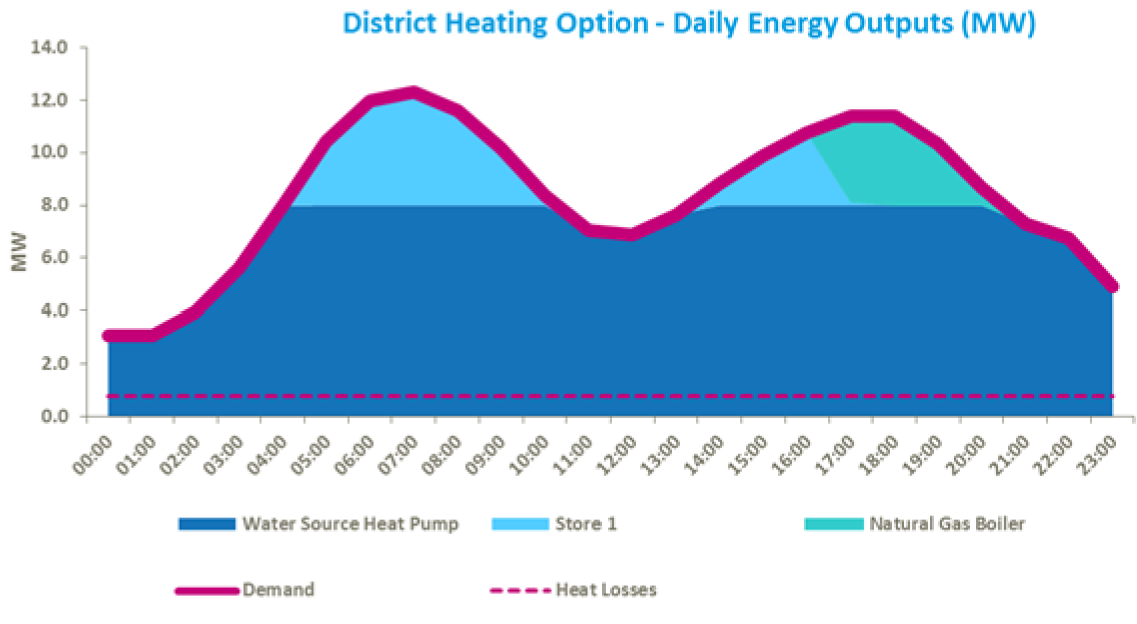
District heating zone	Total associated network length (m)
FC001	174
FC002	2615
FC003	1052
FC004	1039
FC005	845
FC006	1331
FC007	
FC008	2234
FC009	2749
FC010	562
FC011	1243
FC012	1095
FC013	2067
FC014	930
FC015	1148
FC016	1329
FC017	2158
FC018	448
FC019	440
TOTAL	23,771

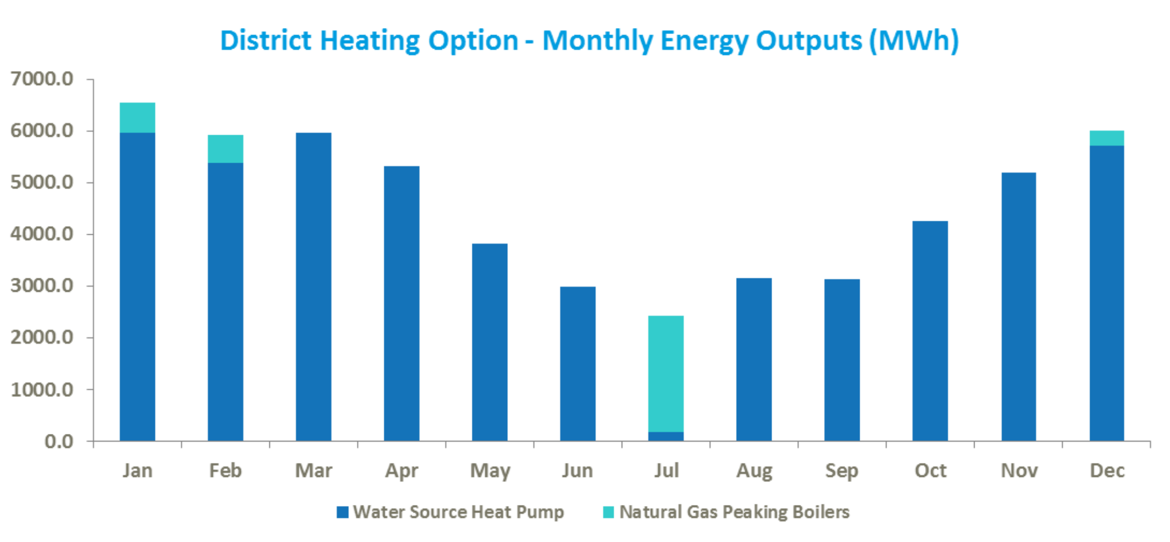
A town-wide district heating network in Burntisland would require an estimated 23.7km of heat pipes.

The modelling assumed the following parameters for the associated energy centre to supply heat to the network:

- Heat pump capacity = 8.0 MWth;
- Energy centre capacity = 14 MW;
- Default thermal efficiency / Z factor = 300%;
- Fuel type = electricity;
- Thermal store size (maximum 3 hours) = 2.5 hours;
- Equivalent thermal store size = 20 MWh;

The heat supply profile to the town-wide network is shown in the images below. They illustrate firstly the modelled daily heat supply from district heating during a typical winter's day, and secondly the modelled annual monthly heat supply from DH (which assumes a summer maintenance shutdown in July when the system would be reliant on a back-up gas peaking boiler):





Source Ramboll

The assumed CAPEX costs associated with the town-wide system are estimated to comprise:

Energy Centre	
Main plant	£5,205,000
Energy Centre building structure (and building M&E fit-out)	£1,958,271
Balance of plant	£1,222,478
Utility incomers	£202,514
Back-up gas boiler installation	£353,016
Thermal store	£50,000
Contractor Cost	£2,902,944
Infrastructure	
DH network including service pipe	£24,033,215
DH design, testing and commissioning, traffic management, valves and pits, Subcontractor and documentation	£5,636,989
Decommissioning of gas grid	£1,955,759
Retrofitting	
Replacement of gas boilers in buildings	£90,169
Replacement of gas hobs and ovens	£1,946,050
HIU / substation cost (including installation) and heat meters	£11,121,324
TOTAL	56,677,730

The annual operating costs will vary over the lifecycle of the system, but typically will include fuel and maintenance. These costs would typically be approximately £3.1M per year. Regular lifecycle maintenance and replacement of the WSHP (water source heat pump) will require additional expenditure over this figure on a 5-10 year lifecycle.

The modelled revenue from District Heating is assumed to be £2.9M per year which is assumed to inflate with RPI. It is worth noting that the cost of alternative energy is predicted by BEIS[36] to rise above RPI and so this figure may increase.

Based on the figures above the modelled IRR that is relevant to the Burntisland Community for a DH network supplying the whole town is not returned and below 0%.

This indicates that the full town network does not offer an economic payback under current energy market conditions. Incentives or capital subsidy may change these conditions. A smaller network that is concentrated around the most high density demand may, however, be viable.

District heating comparison against individual heat pump scenarios

The modelling of the alternative solutions for Burntisland are presented in the following table that sets out the hierarchy of options for each of the zones. The model calculates the indicative NPC by zone. This is compared across the alternative technology options to

[36] BEIS Energy Price Forecast

choose the lowest NPC. This has been illustrated on the attached map of Burntisland to indicate the possible areas for District Heating and heat pumps. It is important to note that these options are not compared directly against a gas boiler alternative which would have lower lifecycle costs than these alternative options. District Heating and heat pumps offer a route to decarbonisation of heat supply.

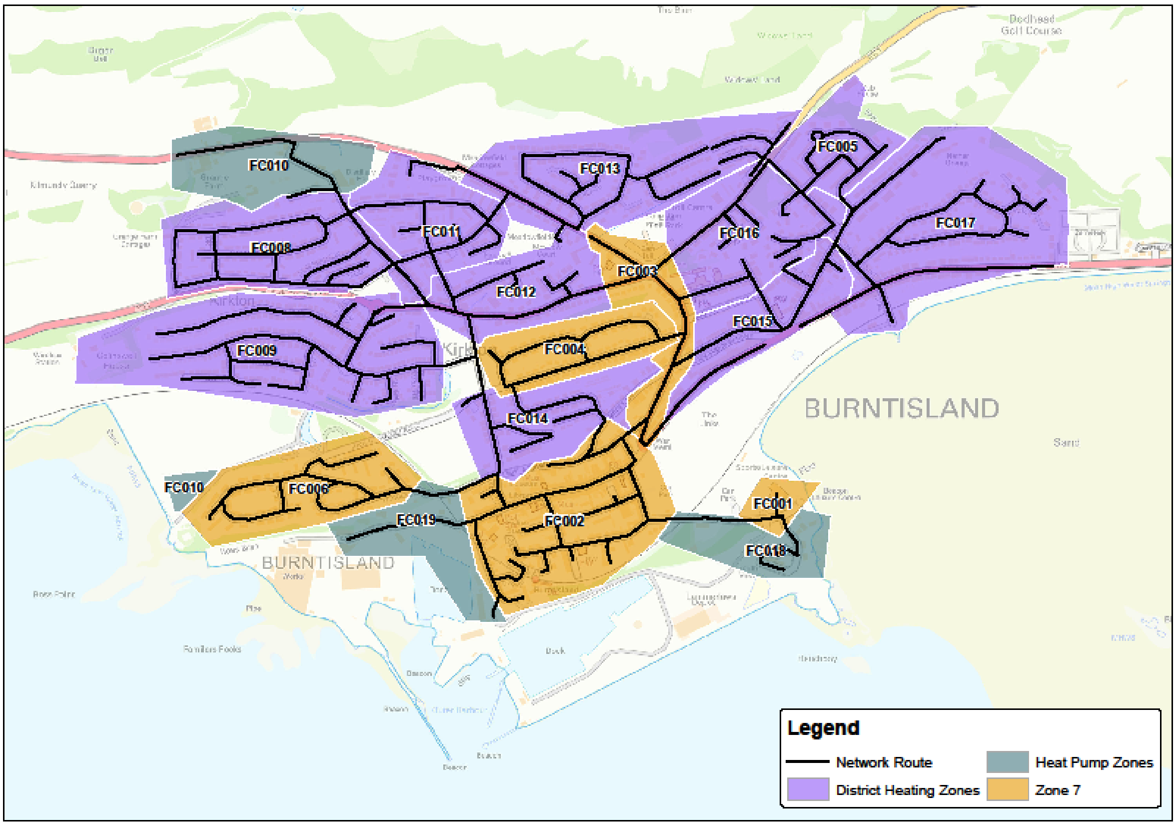
An analysis was undertaken to assess the viability of each of the proposed zones against two options for heat pumps in individual buildings as opposed to a District Heating scheme option. The results are shown below. Rank 1 is the most cost effective option. Zone 1 is a combination of Zone 1, 2, 3, 4 and 6. These show that District Heating is the most cost effective option of those considered below.

Zone	LHD (MWh/m)	AHD (MWh/Ha)	Rank (NPC)		
			1	2	3
Zone 1	19.77849	74.49558	DH	HHPs	EHPs
Zone 2	2.667818	618.0432	DH	HHPs	EHPs
Zone 3	2.329119	109.7017	DH	HHPs	EHPs
Zone 4	1.436569	68.11702	DH	HHPs	EHPs
Zone 5	1.924858	62.51007	DH	HHPs	EHPs
Zone 6	1.696302	119.6491	DH	HHPs	EHPs
Zone 7	0	0			
Zone 8	1.003743	68.142	DH	HHPs	EHPs
Zone 9	1.483917	322.0908	DH	HHPs	EHPs
Zone 10	0.530754	16.92324	HHPs	EHPs	DH
Zone 11	1.579325	143.3732	DH	HHPs	EHPs
Zone 12	1.587809	228.1639	DH	HHPs	EHPs
Zone 13	1.508857	87.75369	DH	HHPs	EHPs
Zone 14	1.700665	70.06974	DH	HHPs	EHPs
Zone 15	2.277008	62.10071	DH	HHPs	EHPs
Zone 16	1.471969	118.2138	DH	HHPs	EHPs
Zone 17	1.793565	181.103	DH	HHPs	EHPs
Zone 18	0.903207	16.5798	HHPs	EHPs	DH
Zone 19	1.029859	13.72229	HHPs	EHPs	DH

Source Ramboll using BEIS tool

The above schedule of zones indicates that much of the town could be connected to district heating. It is important to note, however, that a commercially viable scheme may not be achievable for the whole town. The initial capital investment to build the infrastructure to supply the entire town would be significant (£40 - £50M) and the risk of low uptake is high. It is considered more appropriate to develop the network in a series of smaller clusters and phasing the expansion so that the risk exposure is reduced. Over time, and with an appropriate business model that seeks to return profits into expansion, may allow connection to the wider area.

The below map shows the zones. The initial proposed network, Zone 7 is marked in orange, the further potential expansion zones are marked in purple. The grey/green zones are most viable for heat pumps.



Source Ramboll

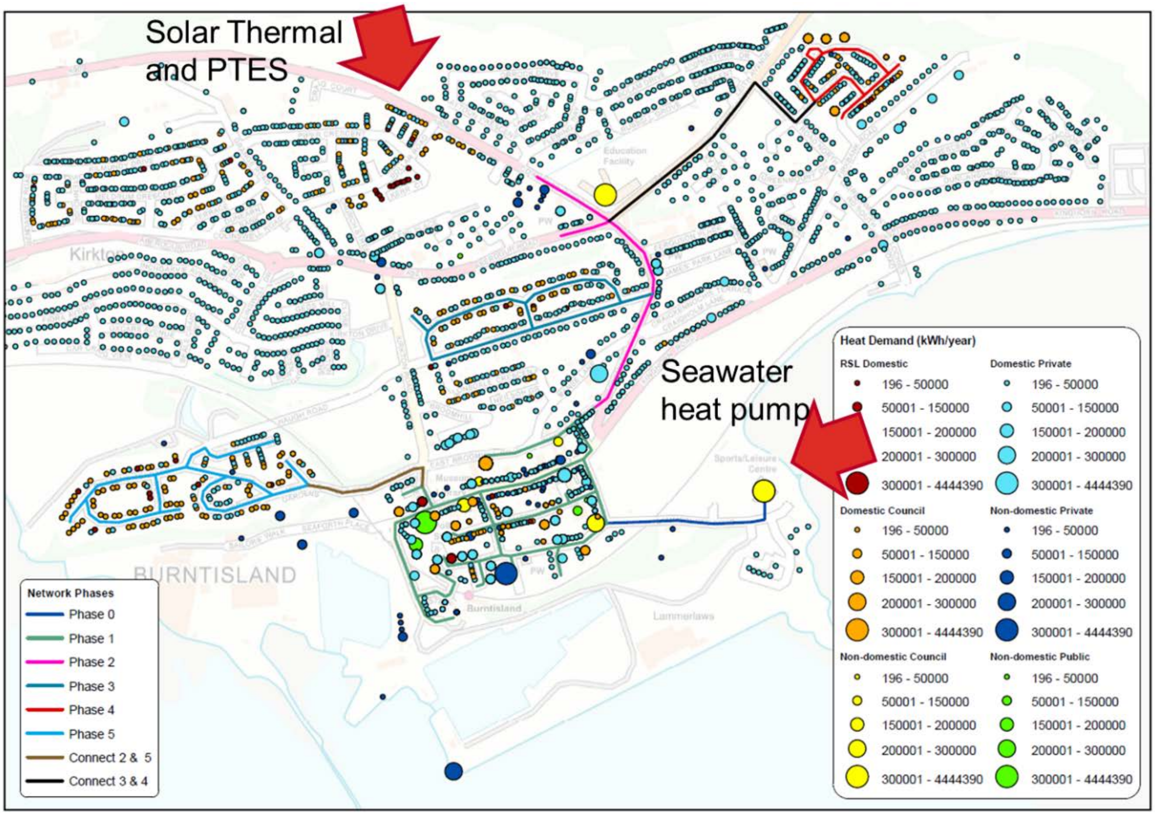
District Heat Supply Opportunities

Alongside the feasibility of a district heat network for Burntisland the study also looked at potential local sources of heat to provide low carbon heat to the district heating network. All energy (whether heat or electricity) that is used has to be generated. To provide heat to a district heating network requires a source of primary energy, such as a biomass CHP plant or electricity to power a heat pump. The heat from these energy sources can then be used to raise the temperature of water that provides heat to a building via district heating network heat pipes.

A number of opportunities for heat generation exist that may be applicable within and around the town. Some of which are low carbon and some of which are zero carbon, conventional hydrocarbon heat supply options such as gas CHP also exist. The low carbon technologies considered include biomass, solar thermal and heat recovery from water and ground sources using heat pumps. Some of the heat generation opportunities would be best suited to a district heating network for delivery of heat, other opportunities may work best at an individual property level via individual heating systems.

The analysis of sustainable heating opportunities has been undertaken assuming heat pumps are the main energy source. There are multiple potential energy sources including geothermal and the ground, seawater and sewers from which low grade heat could be utilised by heat pumps. In the longer term it may be feasible to include solar thermal with seasonal heat storage as additional renewable heat supply capacity to the scheme. Solar thermal and Pit Thermal Energy Store (PTES) is also discussed as a generation technology in *Section 10* of this report on *Low Carbon Energy Generation*. Storing solar generated heat as an inter-seasonal heat store is discussed in this section on *Moving and Storing Energy*.

The diagram below examines the location of possible heat energy sources in relation to the principal heat network opportunities in the town and a potential pit thermal energy storage location (PTES).



Source Ramboll

The technical assessment of each of the heat supply options for the district heating system are considered in more detail in this section on *Moving and Storing Energy* because, by and large, they are opportunities for reclaiming low grade heat (rather than generating energy per se) and as a result they require primary energy (such as electricity if using a heat pump) to recover the low grade heat and enable it to become useful heat. Therefore in this chapter the following technologies are considered for providing heat to the district heat network, or for storing heat:

- Sea-water source heat pumps;
- Electric air source heat pumps;
- Hybrid air source heat pumps; and
- Solar thermal heat storage opportunities;

Low carbon energy generation (rather than low grade heat reclamation technologies) are considered in the following section on *Low Carbon Generation*, which looks at wind power, solar PV, and solar thermal generation opportunities in Burntisland.

Heat Pumps

A heat pump is a device that transfers heat energy from a source of (typically) low grade heat to a destination where high grade heat is needed (a heat sink, this could be a home, a district heating network or a thermal heat store). Heat pumps are designed to move thermal energy in the opposite direction of spontaneous heat transfer by absorbing heat from a cold space and releasing it to a warmer one. A heat pump uses a small amount of external power to accomplish the work of transferring energy from the heat source to the heat sink. Heat pumps come in all shapes and sizes, and heat pump technology can take advantage of different heat sources. Heat pumps can utilise primary heat from the ground, the air, small water bodies and large water bodies such as the sea. Electrically driven heat pumps absorb low grade heat from a source such as the air, ground or river and upgrade it via an electrically driven vapour compression circuit to provide space heating and hot water.

Heat pumps produce lower output temperatures than conventional wet central heating systems, therefore in most properties internal modification will be required. These modifications may consist of:

- Upgrading radiators (larger radiators or underfloor heating are needed to ensure the same thermal comfort);
- Installing a new heat pump-compatible hot water cylinder; and
- Increased insulation measures across the building fabric to reduce heat losses and ensure that thermal comfort can be maintained despite the lower out temperatures from a heat pump, when compared to a conventional gas central heating system.
- Older properties may also require electrical upgrades to accommodate the electrical demand of a heat pump.

For older properties which cannot benefit from increased energy efficiency measures high temperature heat pump options are available.

In the case of blocks of flats it is envisaged that they would be supplied by a centralised heat pump system which will feed individual HIUs (Heat Interface Units). Customers will have full control over their heating and hot water via an integrated timer and programmer.

While there are an increasing number of heat pump manufacturers in the UK, the supply chain would need to develop substantially to cope with such a widespread uptake in this technology as posited within this study, and within the Scottish Government's draft Energy Strategy and Climate Change Plan (RPP3). Given that the supply chain involves actors from across continental Europe it is likely that BREXIT may also have some (potentially serious) implications for the wider uptake of heat pump technology in the UK.

The following heat pump scenarios have been considered for Burntisland, to provide alternatives to the current predominance of gas fired central heating in the town:

- Large scale sea-water source heat pump and district heating scenario, for brevity this has been abbreviated to the <u>DH Scenario</u>;
- Individual air source electric heat pumps, which has been abbreviated to the <u>EP Scenario</u>; and
- Individual hybrid (electric / gas) heat pumps, or the <u>HHP Scenario.</u>

These scenarios are discussed in more detail in the following subsections. General modelling assumptions and constraints associated with all heat pump technologies are presented below:

<u>Modelling assumptions</u>

The following modelling assumptions have been made about how the wide-spread use of heat pumps will alter the energy supply and demand dynamics within Burntisland, and the associated infrastructure that will be required:

- <u>Centralised Electrical Generation</u> Electrical consumption will increase in Burntisland with the introduction of electrically-driven heat pumps and electric hobs as a replacement for gas boilers and gas cooker hobs; therefore it may be essential to increase local electricity generation from centralised generation plants such as biomass power stations, wind farms or other renewable / low carbon solutions. In addition more centralised control of heating systems may be required, for example to allow the staggering of heat pump start-ups to spread out peaks in demand. The role of grid decarbonisation on the net benefit of this approach in carbon saving terms also needs to be considered.
- <u>Electrical Substations:</u> The increased electrical load associated within the introduction of electrically driven heat pumps may require additional capacity or even new substations within the area to meet the increased demand for electricity.

- Distribution system: It is likely that reinforcement of the electrical grid would also be required due to the widespread roll-out of electrically driven heat pumps in Burntisland.
- Gas distribution network: the transition away from natural gas as a heat and cooking energy source, will potentially leave the existing gas network redundant, and may require formal decommissioning of this system (to ensure safety and to generate a financial return from the reuse and recycling of component materials i.e. metals and plastics).
- Customer Interface: each property will require a heat pump with integrated controls and a (domestic hot water) DHW storage cylinder. Considerations for domestic Air Source Heat Pump (ASHP) systems is outlined below:

Constraints

Planning permission may be required for air source heat pumps in relation to the siting of the external heat pump unit because of a number of potential impacts on the surrounding environment / neighbouring properties that can arise. These chiefly relate to noise and vibration issues. The requirements are discussed in depth in *MCS 020 MCS Planning standards for permitted development installations of wind turbines and air source heat pumps on domestic premises. Issue 1.2*[37]

To summarise this, heat pumps contain a fan unit and will thus emit some noise and / or vibration so the location of the equipment may need to be carefully considered. Air source heat pumps can also be subject to noise nuisance regulations, under the *Environmental Protection Act 1990*[38]. Although, theoretically, an air source heat pump may be allowed under permitted development it could be served a *Noise Nuisance Abatement Notice* outlined in *Section 79* of the act if retrospectively it is found or suspected, that the noise emitted by the heat pump is sufficiently loud as to be considered "*prejudicial to health or a nuisance"*. Deployment of a large concentration of ground source heat pumps may have an effect of lowering ground temperature reducing the efficiency of the individual units, it is possible that deploying a large concentration of air source heat pumps in series, may have a similar effect on the local air temperature at the micro-climate scale. There are no chemical air pollutant emissions associated with the normal operation of either air source, heat source or ground source heat pumps (other than that associated with the generation of the electricity that they consume).

There is not a requirement to seek planning permission for ground source heat pumps however consent must be sought from the Coal Authority if drilling is required in an area under the jurisdiction of the Coal Authority (i.e. areas where current or historic mining activity is recorded).

There are more licensing and regulatory constraints on water source heat pumps, especially large scale systems. A large scale heat pump that took water from the Forth Estuary would need:

- Abstraction and discharging consents from SEPA;
- an Environmental Impact Assessment being undertaken to the satisfaction of consenting authorities / permission from consenting authorities for the project to go ahead (which may be subject to mitigation measures they propose as a result of the findings of the EIA), it is considered that SNH may have the most reservations about the project because of concerns that the scheme could impact on designated sites and species in the local area i.e. the Firth of Forth SSSI / RAMSAR site which is internationally important for supporting overwintering populations of birds and is an important habitat for bird migration, and post-breeding passage.
- it may potentially need a licencing agreement from Marine Scotland where any development takes place below the Mean High Water Spring;

[37] Version 1.2, published 2015. https://www.thenbs.com/PublicationIndex/documents/details?Pub=DECC&DocID=310471

[38] http://www.legislation.gov.uk/ukpga/1990/43/contents

- permission from the Crown Estate where a development crosses land in their ownership – which includes much of the foreshore and land below the mean high tide;

Sea-water source heat pump and a District Heating Network (DH scenario)

Because of its coastal position Burntisland is well-situated to benefit from a large water source heat pump system. The advantage of using water source heat pumps with large volumes of water is that this enables heat to be extracted from a very large heat source; and that extraction of heat from this heat source will not change the temperature of the water body because the amount of heat being extracted, is insignificant compared to the total heat energy available stored in the sea.

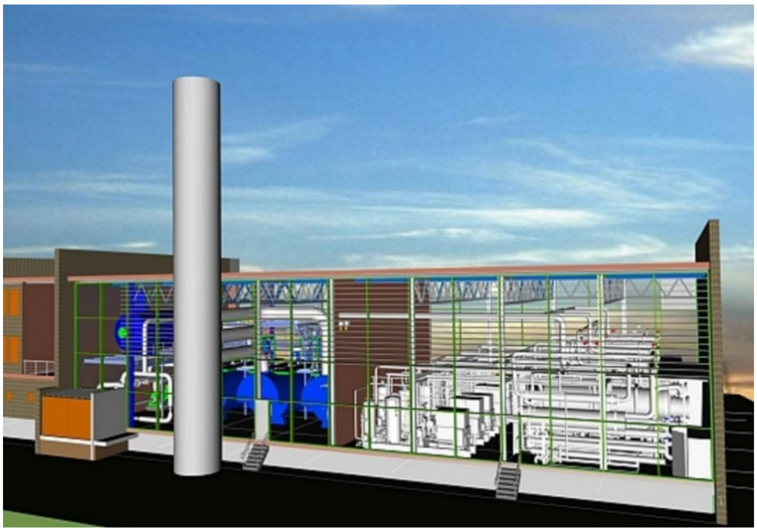
Using water as the energy source for a heat pump system has a number of advantages when compared to air or ground source heat pumps:

- The heat transfer rate from water can be higher than that in the ground or air.
- The flow / circulation of the water source provides constant energy replacement.
- The use of a water source removes the need of digging large trenches, often reducing the cost of installation compared to a ground source.
- The return temperature to the heat pump is usually higher than either the ground or winter average air temperatures, increasing the CoP (coefficient of performance) of the heat pump.

Sea-water source heat pumps can extract heat using either an ‘open’ or ‘closed’ loop system;

- ‘Open’ loop systems are where water is extracted from the source, flowed around the heat pump’s intermediate heat exchanger (or an open loop rated internal heat exchanger) and then discharged;
- ‘Closed’ loop; where, similar to a ground source heat pump, pipes or heat exchanger panels are placed within the water source and a fluid is passed through the pipes / panels absorbing energy from the water.

Both systems have advantages and disadvantages. This study considers an open loop option as being the most practical for a district heating application at Burntisland and is similar to an existing system installed at Drammen, near Oslo (see image below).



Large district-wide natural heat pump system, providing 13 MW for Drammen, near Oslo, Norway. (Star Refrigeration Glasgow, n.d.)

<u>Modelling assumptions:</u>

The modelling used in this assessment, assumes that the water source heat pump (WSHP) will operate at a seasonal performance factor (SPF) of 3.

Opportunity Assessment – Phase 1 Network

The opportunity assessment of the initial DH networks supplied by a WSHP are reported in Table 1. The results of the models are presented in Table 1. This modelling assumes each network zone would be developed in isolation (i.e. as a stand-alone development) to demonstrate the individual economic performance of DH within each zone. The individual district heating zones are presented in column one. The results indicate that not all zones may be financially viable, but the result for the DH zone number: FC007 shows the benefit of economy of scale in these projects and that at least one potentially viable project could be achievable at scale in Burntisland.

The results assume that all customers are technically able to connect to the network and that they are willing to sign up to a heat supply agreement with a district heating supplier which may not be the case in actuality. These are key risks and sensitivities to be considered, should this option be developed further.

Table 1: Economic KPIs Results of technical and economic modelling of the DH scenario

The opportunity assessment results for supplying the initial DH networks with heat from the sea via a WSHP are reported in the table below:

District heating zone	IRR (internal rate of return)	Emissions Saving (tCO_2e)	CAPEX (£)
FC001-WSHP 0.3 MW	3.72%	286	£977k
FC002-WSHP 1.5 MW	5.83%	403	£6,217k
FC003-WSHP 0.3 MW	<3.0%	243	£1,942k
FC004-WSHP 0.3 MW	-2.54%	174	£2,911k
FC005-WSHP 0.3 MW	-2.30%	152	£2,165k
FC006-WSHP 0.3 MW	-0.85%	210	£3,521k
FC007-WSHP 3 MW	4.34%	1,812	£12,734k

Economic KPIs of opportunity energy based on MSOA data from BEIS

Air source electric heat pumps (EH scenario)

This scenario considers the wide-spread roll-out of individual air source heat pumps for all residential properties. Data suggests that there is limited opportunity for ground source heat pumps within the Burntisland settlement (Home Analytics; additionally reports of rock close to surface). For larger dwellings and commercial properties ground source heat pumps shall be implemented. It is assumed that larger water-source heat pumps would be implemented where there is a suitable heat source (river, mine-water, waste heat from sewers, etc.) and large enough demand.

Electrical Substation

The increased electrical load associated within the introduction of electrically driven heat pumps may require additional capacity or even new substations within the area to meet the increased demand.

Distribution

It is likely that reinforcement of the electrical grid will also be a requirement with the widespread introduction of electrically driven heat pump solutions within the area.

The transmission away from natural gas will also leave the existing gas network redundant.

Customer Interface

Each customer/property will require a heat pump with integrated controls and a Domestic Hot Water (DHW) storage cylinder. An example of a domestic ASHP is shown below in

Heat pumps operate efficiently at lower output temperatures therefore in most properties internal modification shall be required which may consist of upgrading radiators, installing a new heat pump compatible hot water cylinder and increased insulation measures. Older properties may also require electrical upgrades.

Planning permission may be required for air source heat pumps to site the external unit. The requirements are discussed in "MCS Planning Standards For permitted development installations of wind turbines and air source heat pumps on domestic premises". There is not a requirement to seek planning permission for ground source heat pumps however consent must be sought from the coal authority if drilling is required in an area under the jurisdiction of the Coal Authority. In the event where water source heat pumps are utilised abstraction and discharge license should be sought from the Scottish Environmental Protection Agency. A heat pump that takes water from the Forth Estuary would need an Environmental Assessment / permissions: a Marine Scotland licence where any development takes place below Mean High Water Spring; Crown Estates permission (where a development crosses land in their ownership – which includes much of the foreshore and below); Scottish Natural Heritage for impact on designated sites and species, particularly the 'Firth of Forth, Stirling… Fife…. (UK9004411) - A complex of estuarine and coastal habitats; The site includes extensive invertebrate-rich intertidal flats and rocky shores, areas of saltmarsh, lagoons and sand dune.' The site is underpinned by the Firth of Forth SSSI. Regularly supporting wintering populations of birds; post-breeding (passage) populations of birds; migratory species of birds. Heat pumps contain a fan unit and will thus emit some noise so location of the equipment may need to be carefully considered. Air source heat pumps also can be subject to noise nuisance, under the Environmental Protection Act 1990. Although an air source heat pump may be allowed under permitted development it could be served a Noise Nuisance Abatement Notice outlined in Section 79 of the act 'noise emitted from premises so as to be prejudicial to health or a nuisance'. Deployment of a large concentration of ground source heat pumps may have an effect of lowering ground temperature reducing the efficiency of the individual units. There are no chemical air emissions in normal operation.

In the case of blocks of flats it is envisaged that they would be supplied by a centralised heat pump system which will feed individual HIUs (Heat Interface Units). Customers will have full control over there heating and hot water via an integrated timer and programmer.

There are an increasing number of heat pump manufacturers, however the supply chain would need to develop to cope with such a widespread uptake in this technology.

<u>Results of technical and economic modelling of the EH scenario</u>

The capital cost of replacing all heating systems in the town as well as including the cost of electrical network upgrade to install individual electric heat pump solutions to all properties in Burntisland would occur over a number of years (based on lifecycle replacement of existing boilers). The results are therefore presented in terms of the levelised net present cost (NPC) of the solution over 40 years at a discount rate of 3.5%.

Major energy systems, such as district heat networks, have long operational lifespans (considerably longer than conventional heating systems) which is why they are still considered viable with very long payback timescales. This shows that the electric air source heat pump option modelled here would represent a NPC of £78.5 / MWh year. The NPC calculated figure is presented as the net present cost, which is the accumulated cost for the investment (CAPEX, OPEX and REPEX) in today's terms assuming a hurdle rate of 3.5%. This figure does not include revenue from heat sales or other incentive mechanisms and is shown in this way to allow a comparison of the overall lifecycle cost to the community across the scenarios. For the heat pumps it includes the cost of grid infrastructure upgrade as well as cost of all heat pump investments in individual properties. These costs would be socialised across the community but at a community level represent a premium against the BAU. This premium delivers a low carbon solution and therefore may attract funding support which would lower the initial cost of investment.

Hybrid heat pumps (HHP)

Hybrid heat pumps consist of an electric heat pump combined with a gas boiler. The heat pump and gas boiler can run in combination or in isolation to maximise energy efficiency and minimise running costs. This is a transition technology and should not be considered as a truly low or zero carbon option. The heat pump absorbs low grade heat from a source such as the air, ground or river and upgrade it via an electrically driven vapour compression circuit to provide space heating and hot water. The gas boiler can be run independently to provide heat or can provide top-up heat to support the heat pump if needed.

Modelling assumptions

This scenario considered the wide-spread roll-out of hybrid air source heat pumps for residential properties in Burntisland. In large dwellings and commercial properties ground source heat pumps supported with gas boilers were assumed to be implemented. Larger water source heat pumps were assumed to be implemented where there is a suitable heat source (river, mine-water, waste heat source, etc.) and large enough demand.

Results of technical and economic modelling of the HHP scenario

The capital cost of replacing all heating systems in the town as well as including the cost of electrical network upgrade to install individual hybrid heat pump solutions to all properties in Burntisland would occur over a number of years (based on lifecycle replacement of existing boilers). The results are therefore presented in terms of the levelised net present cost (NPC) of the solution over 40 years at a discount rate of 3.5%. This shows that the Hybrid Heat Pump HHP option would represent a NPC of £67.3/MWh year.

Conclusions on future heating provision

The summary results of all options compared on the basis of the levelised NPC are below. This indicates that the DH solution is comparable to the Electric Heat Pump EHP option. The HHP solution offers an economic benefit if applied to the whole town but would not be able to reduce carbon emissions down to the zero carbon level desired by both Burntisland residents, and national Scottish targets.

	Net present cost NPC (£/MWh)		
	District heating and large-scale water source heat pump (DH scenario)	Individual electric air source heat pumps (EHP scenario)	Individual hybrid gas / electric heat pumps (HHP scenario)
Primary generation	£ 40.1	£33.5	£30.6
Infrastructure	£ 27.0	£ 0.7	£ -0
Customer interface	£11.6	£ 44.3	£ 36.8
Total NPC	£77.7	£78.6	£67.3
CO2 reduction over 40 years (from now) [tonnes]	£376,851	£350,593	£336,762
Cost per tonne of CO2	£30.8	£117.6	£68.1

Source Ramboll

A town wide district heating solution does not appear to offer a preferred solution in terms of lifecycle cost compared to alternative low and zero carbon options because of the considerable expense involved in constructing a town-wide heat network and laying kilometres of heat pipes.

DH primary generation includes life cycle costs. Primary generation for EHP and HHP includes wholesale electricity price. The customer interface for the district heat network is a Heat Interface Unit (HIU) and meter; similar to the HHP and EHP use gas and electric meter readings.

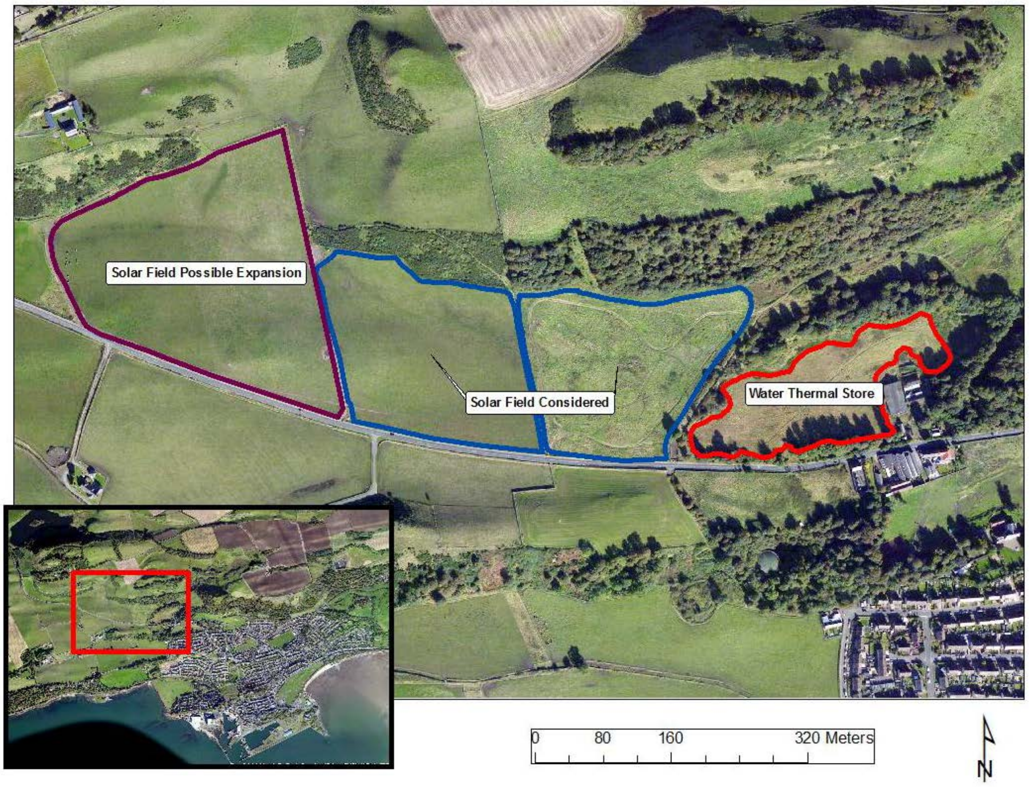
A combination of DH supplying heat to the higher density areas of Burntisland where district heating makes the most economic sense, combined with individual air source heat pumps in lower density areas is considered to be a more realistic solution for the town.

However the cost per tonne of carbon abated suggests that a district heating system may be the most economical way to progress. The option to be selected very much depends on the performance indicator selected. The option which delivers the lowest cost per tonne of carbon abated is not the same as the option which delivers the lowest NPC.

Solar thermal energy park and inter-seasonal energy storage

Introduction

Solar thermal systems, use panels to collect warmth from the sun, to directly heat water. Solar thermal panels are considered at an individual property level within the *Low Carbon Generation* section of this report. The water heated by solar thermal panels can be used immediately for space or water heating, or can be stored for later use. The heat can be stored for anything from a few hours to several months. Therefore the option of a large scale solar thermal park within the environs of Burntisland is considered within this section of the study because of the potential to store this heat and use it as an inter-seasonal heat source for the town i.e. capturing the warmth of the summer sun, and storing it for use in the winter heating season to provide some of the town's space and water heating needs via a district heating network. Seasonal thermal energy storage (or STES) also called Pit Thermal Energy Storage (or PTES) is the storage of heat or cold for periods of up to several months. Thermal energy can be collected whenever it is naturally available and be used whenever needed, such as in the opposing season. For example, heat from solar collectors or waste heat from air conditioning equipment can be gathered in hot months for space heating use when needed, including during winter months. Or the natural cold of winter air can be stored for summertime air conditioning needs. Therefore a solar thermal park was considered as another potential technology option to provide heat to the district heating network.



Source Ramboll

Location

Discussions with local stakeholders suggested that an area of agricultural (pastoral) land immediately to the north west of the town may be suitable[39] for siting a solar thermal park in the future The area suggested by Burntisland residents is illustrated in the aerial image above within the blue line boundary.

An initial assessment would suggest that the site has some ideal characteristics for solar energy generation i.e. the site faces south and slopes down from north to south in a relatively uniform fashion. It is also close to major access roads which would be beneficial during any construction works, it is also close to the settlement boundary meaning that heat would only have to be transmitted a short distance from the point of generation to where it could be used. Moreover, the

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[39] (Assuming that the landowner / s are interested in the idea and that there are no obvious constraints identified during an EIA process).

site does not appear to pose any problems in terms of over-shading of the panels from buildings or trees to the south.

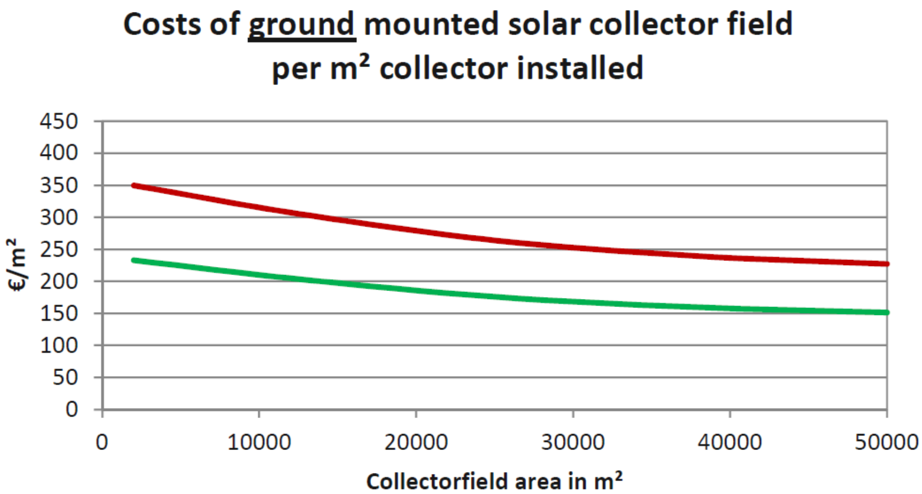
The area highlighted in blue on the aerial photograph above represents two pastoral fields currently used for grazing livestock (primarily cattle). This assessment has assumed that initially just one of the blue fields would be used as a solar thermal park (although there is the potential to expand to two other neighbouring fields, highlighted in purple and blue on the image, in the future subject to demand and interest from landowners). Assuming that the solar field would be located on the left-hand field, the available area is about 90,000 m^2.

Modelling assumptions

While generation yield can only accurately be ascertained by a detailed site-specific assessment, as a general rule of thumb, generally the solar thermal industry assumes that every 1m^2 of solar collectors requires 3m^2 of land for installation (and associated ancillary infrastructure). **Error! Reference source not found.** illustrates a potential site layout showing indicative pipe runs in the field and demonstrates an indicative layout of solar thermal panels to avoid over-shading. This basic scoping exercise suggests that there could be enough space to facilitate a relatively large solar farm comprising approximately 30,000 m^2 of solar thermal collectors. A solar field of 20,000 m^2 is assumed as the modelling scenario for this part of the project as the solar field and store were sized for the initial phase of the DH proposal.

While exact costings are site-specific a high level cost estimate for the capital cost of a solar thermal farm would be around 250€/m^2 (of panels). However it should be noted that this figure is considered relatively high for a larger scale site such as that proposed here.

The graph below illustrates the costs of ground mounted solar collectors per m^2 of collector installed. The green line illustrates the most likely case, and the red line illustrates the worst case scenario.



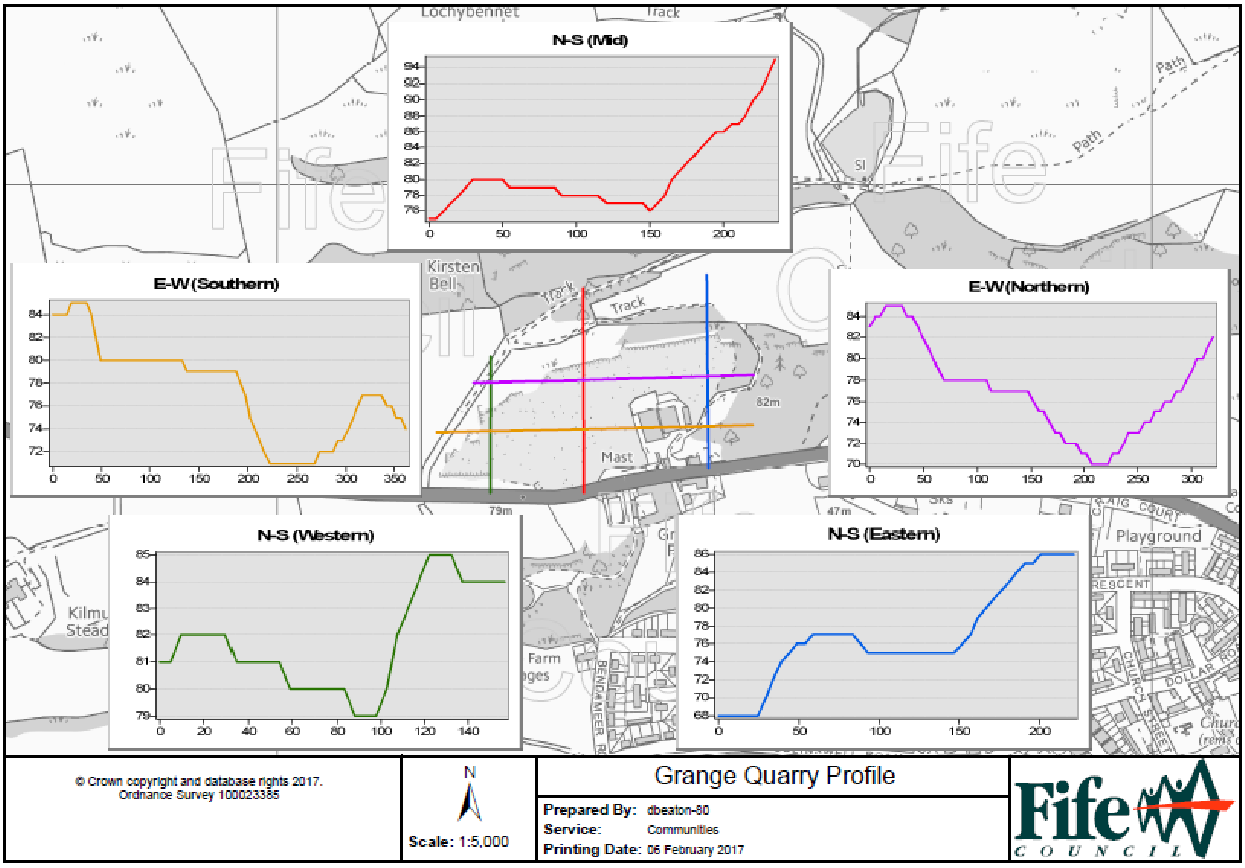
Assuming a CAPEX rate of £213.2 /m^2 (250€/m^2), the required investment for a field comprising 20,000 m^2 of solar collectors would be approximately £5 million. This CAPEX figure would include all ancillary equipment costs such as piping, heat exchangers and control equipment, but it does not take into account storage the option of creating heat storage.

This is presented in the section below on solar thermal pit storage or PTES (Pit thermal energy storage):

Solar thermal pit storage

Since this is technology has not been implemented on a large scale in the UK to date, the following section describes this opportunity in more detail, and provides a high-level assessment of the costs and benefits that are associated.

Close to the proposed solar thermal farm site, lies an old landfill site which has the potential to act as a thermal store for the heat generated by the solar collectors. The solar heat store would be created by creating a ‘solar pond’, a sealed body of water with well insulated outer walls and an insulated cap. Grange Quarry was identified by the Burntisland Community as a potential site for a thermal store and the profile of the site is shown below. The site is an old landfill, and is on lease to Fife Council. Further feasibility work regarding the site would require making contact with the land owners, and at this stage this should just be considered a high-level proposal. Due to the site’s previous use as a landfill the quarry will require an environmental risk assessment alongside other feasibility work because there could be the potential for contaminated soils and groundwater from landfill leachate.



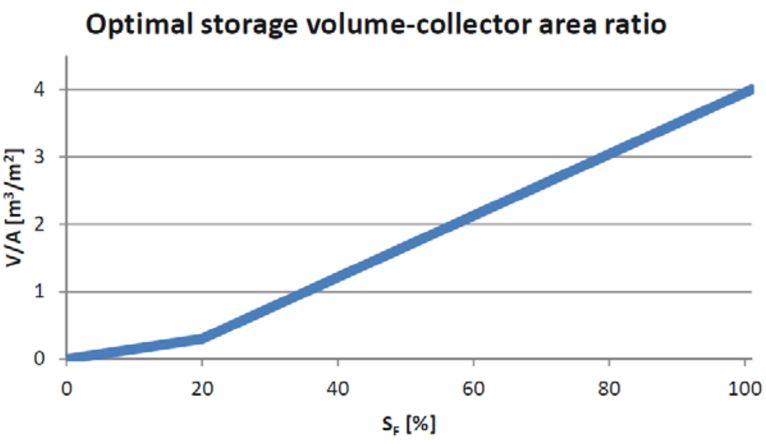
Source Fife Council

A Pit Thermal Energy Store (PTES) is a large pit used to store hot water from solar heating in an insulated covered pit.

An example of an operating system using PTES is at Vojens in Denmark. The consumer-owned district heating system is supplied by a 70,000 m² solar heating plant and a 200,000 m³ heat storage, 13 metres deep and 610 metres in circumference – in an old gravel pit. It takes about five months to fill the pit to its maximum of 200 million litres. “The floating cover makes it possible to store the hot water for the Danish winter season when consumers turn on their radiators,” says Flemming Ulbjerg, Senior Consultant at Ramboll Energy.

The existing pit for the storage has an area of 25,000 m^2, which seems too high considering that several meters of depth would be needed in order to establish thermal stratification and increase efficiency.

The existing onsite pit / depression, which may be feasible to utilise for heat storage has an area of 25,000m^2. Initial analysis suggests that this could be too large a surface area for the heat storage needs of Burntisland, compared to the existing depth of the pit (which is too shallow). It is expected that the site will need to be shaped for a solar thermal store, and several meters of additional excavation may be needed. This is in order to better contour the site, establish thermal stratification and increase the efficiency of the proposed heat store. An estimation of the optimal size of a solar pond / heat store for Burntisland is illustrated in the graph below using calculations derived from real-life Danish experience of building such systems. In the graph below S_f is the solar fraction of the storage, not of the total production.



Modelling assumptions

Assuming that the *raison d'etre* of the solar pond would be to act as an inter-seasonal store for the heat produced on the solar thermal farm nearby (80%), Danish experience suggests that a storage volume of 60,000 m^3 would be required. It is assumed that an electric heat pump would be installed to provide the remaining 20% of the heat to the thermal store during times of low electricity prices.

It is also assumed that 40% of the solar production from the solar farm would be directed to the district heating network while the rest is would be stored in the solar heat store. The solar fraction in sunny months would be high, while the pond could provide heat back to the district heating network starting from September until January / February. From February until April, an electric heat pump or an alternative heat source would be needed to facilitate the heat load.

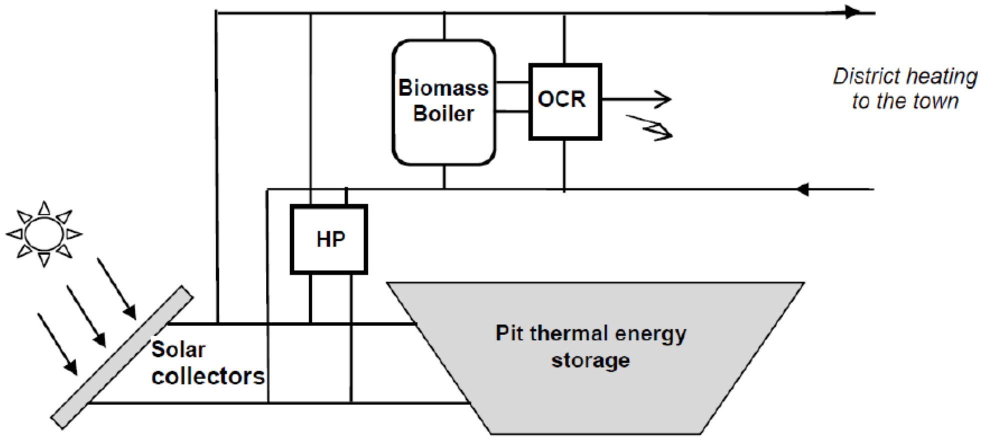
For the heat pump, production of 2000 MWh / year is assumed. (I.e. it is assumed that the heat pump is operating for 15% of the time on full load or 20-30% of the time on part load).

The actual recorded heat storage efficiency of the Sun Store system at Marstal[40] (a similar pit storage system currently in operation in Denmark) is 62-67%. A conservative approach would be to assume an efficiency of 60% in this case. Note that during the first year of operation the system efficiency would be lower, as heat losses are expected to reach 80% (due to cold ground, which will warm up after a few years of operation). A diagram of the system which has been in operation in Marstal[41] since 2011, is illustrated below:

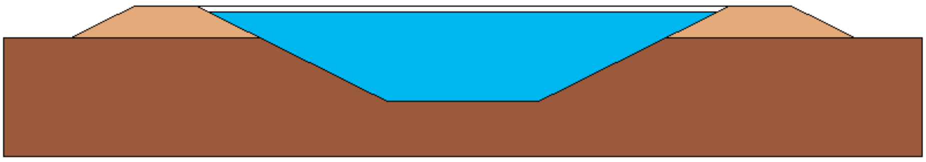
[40] http://www.solarmarstal.dk/media/2854117/summary-technical-description-marstal.pdf

[41] Other examples of similar large scale solar thermal projects within the EU can be found at: http://solar-district-heating.eu/ServicesTools/Plantdatabase.aspx#legend

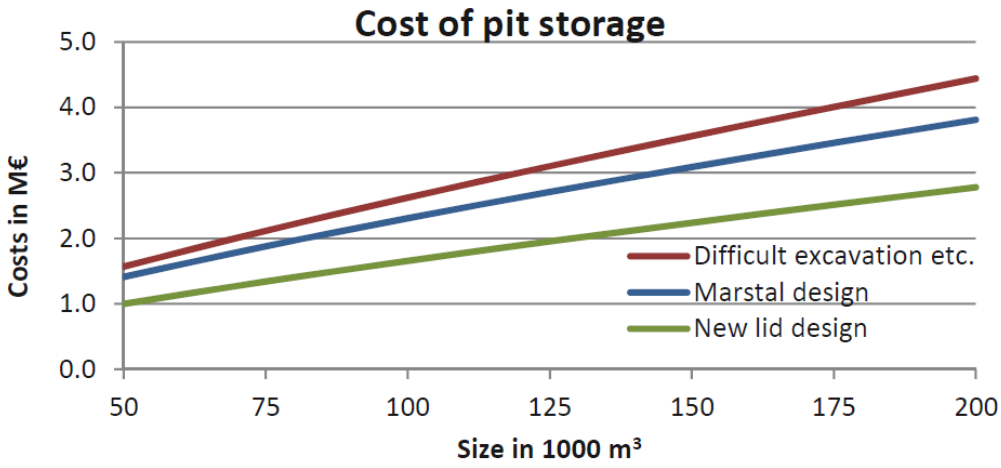
The SUNSTORE™ configuration in Marstal is



Solar ponds work best when they have an optimal ratio between depth and surface area. The optimal ratio between depth and surface area for this site would need further investigation should this proposal be taken forward as a serious consideration for decarbonising Burntisland. The shape of the solar store need not be fixed to the existing contours of the quarry site. The depression could be modified so that a more energy efficient shape is created i.e. during digging, some of the excavated topsoil could be added to the sides of the pond raising the walls of the depression; thus a deeper pond with a smaller surface area and consecutively lower heat losses would be created as shown in the diagram below, which presents a side elevation of the proposed heat store:



Assuming that the solar pond was excavated and built from scratch, initial estimates suggest that the CAPEX of the civil engineering works would be approximately 25 €/m^3 (21.3 £/m^3). This figure is an integrated figure which includes excavation works, lining the depression with insulation, capping the pond with an insulated roof and the purchase of a stratification device etc. Stratification is the natural layering of the water in the PTES due to the differential buoyancy of water at different temperatures. Hot water is less dense and will remain at the top. Stratification can only occur when turbulence and mixing in the PTES can be kept low. A stratification device will allow different temperatures of water to be introduced to the PTES at the correct levels using a diffuser to slow the flow and avoid turbulence. Because a significant depression already exists on the site, consecutively, a lower CAPEX cost of £1.5M could be expected to reflect the lesser amount of excavation works which would be required. However because ground works are not a significant component of the initial investment, this reduction in total CAPEX would be modest. The most expensive elements of creating a solar thermal pit store are the top lid, the insulation and the stratification arrangement. Costs of pit storage, derived from real-life experience in Denmark are illustrated in the graph below:



Source Ramboll

The following table presents the key modelling assumptions used in this assessment, including the estimated total investment required for the construction of the solar thermal store in the old Grange Quarry site.

Solar field size (m2 of collectors)	Total land required for solar collectors (m2)	Heat store storage volume (m3)	Solar field cost (£)	Solar thermal heat store cost (£)
20,000	60,000	60,000	£5,000,000	£1,500,000

Results: Investment

In addition to the estimated costs presented in the table above, the costs of constructing an energy centre should be taken into account (this energy centre would house the pumps for the system and heat exchangers, which are already included in the costs presented above). The case for installing a heat pump is also very strong, since it would increase system flexibility and the solar fraction which could be recovered as useful heat. The heat pump would be used to boost temperatures provided by the storage pit during times of low electricity prices, meanwhile in times of high electricity prices, a gas boiler could be useful as an additional top-up heat source.

In this analysis, a 1.5 MW Heat Pump is assumed to be connected between the storage and the district heating network. The cost of installing the heat pump is estimated to be around £600K. Overall, it would be safe to assume an initial required investment of £7.5-8 million, although this is a very high level estimation and would need to be revisited. It is important to note that costs such as land rental and power network connection are not taken into account at this stage.

Results - energy generation

In the table below the assumed yearly solar yield per m^2 of solar collector is presented. The collector efficiency, derived from previous Ramboll projects in Denmark, is corrected to Edinburgh's solar irradiance levels. It is assumed that the efficiency depends only in the ambient temperatures, that is based on average temperatures and not short term extremes which are unlikely to impact on storage temperatures, and it is degree-corrected to Edinburgh as well. The modelling is based on collectors where the working fluid is a 30% glycol-water mixture with a panel tilt of 40^o.

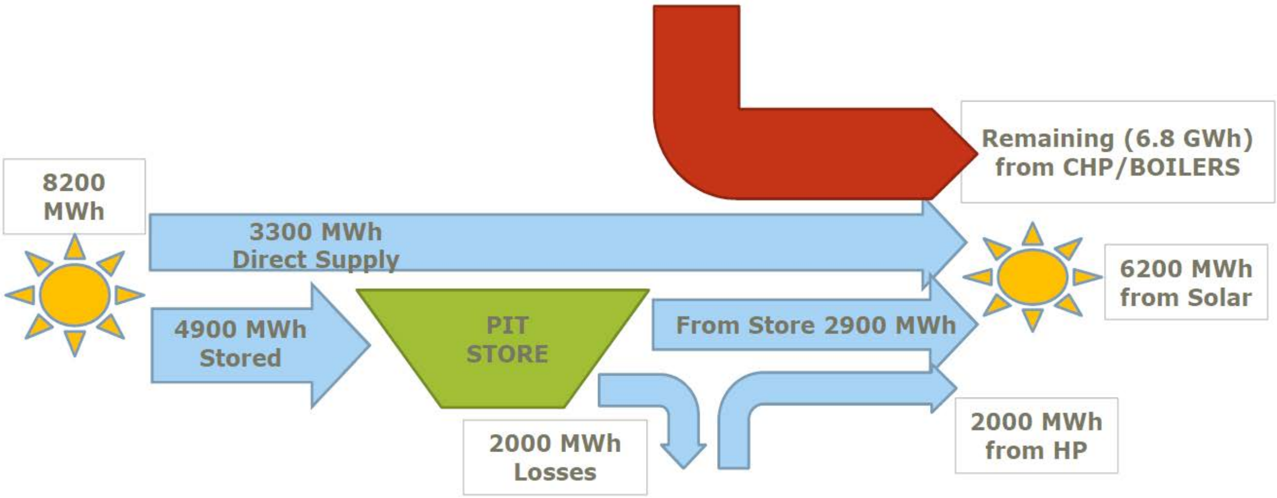
Month	Collector efficiency [42]	Degree Day Correction	Solar Radiance (Edinburgh)	Specific Solar Yield
			(kWh/m^2/day)	(KWh/m^2/year)
January	19.5%	100.0%	0.51	2.1
February	49.5%	98.2%	1.16	10.5
March	75.0%	94.4%	2.03	29.7
April	86.5%	96.2%	3.22	53.6
May	78.0%	90.0%	4.55	66.0
June	82.5%	87.2%	4.66	67.1
July	85.0%	91.1%	4.31	69.0
August	80.5%	93.3%	3.63	56.4
September	80.0%	89.4%	2.42	34.6
October	60.0%	98.0%	1.33	16.2
November	26.5%	98.1%	0.64	3.3
December	10.0%	96.4%	0.38	0.8
Yearly				409.4

Temperatures in Burntisland are expected to be slightly lower than the figures shown in the table above (which is based on annual air temperatures in Denmark), while the solar radiation is expected to be slightly higher than that cited (which is for Edinburgh). The calculations lead to a specific solar yield of 409 kWh per year for each m^2 of solar collector, while the Danish average is 400 kWh/m^2.

Based on this value, the total estimated solar production from the solar thermal farm site to the north-west of Burntisland suggested by the community, would be 8,200 MWh per year. Based on experience the peak load could be around 9-9.5 MW but this would be rare and would be directed into the storage unit. Usual midday generation peaks between 1.5 MW and 6 MW should be expected on sunny days.

The concluded energy flows, after the first couple of years of operation (i.e. once the ground has warmed up), are illustrated in the figure below:

[42] (Marstal 2016)



Source Ramboll

The solar faction[43] achieved in this case is 41%, however this could improve over the years as the ground warms up and the storage efficiency of the heat store improves. The solar field along with the heat storage potential at the Grange Quarry, could be scaled accordingly in order to achieve another solar fraction. This technology is relatively new and there is no existing data on the lifespan of such a pit storage, but there is no reason to argue that it would be less than 30 years.

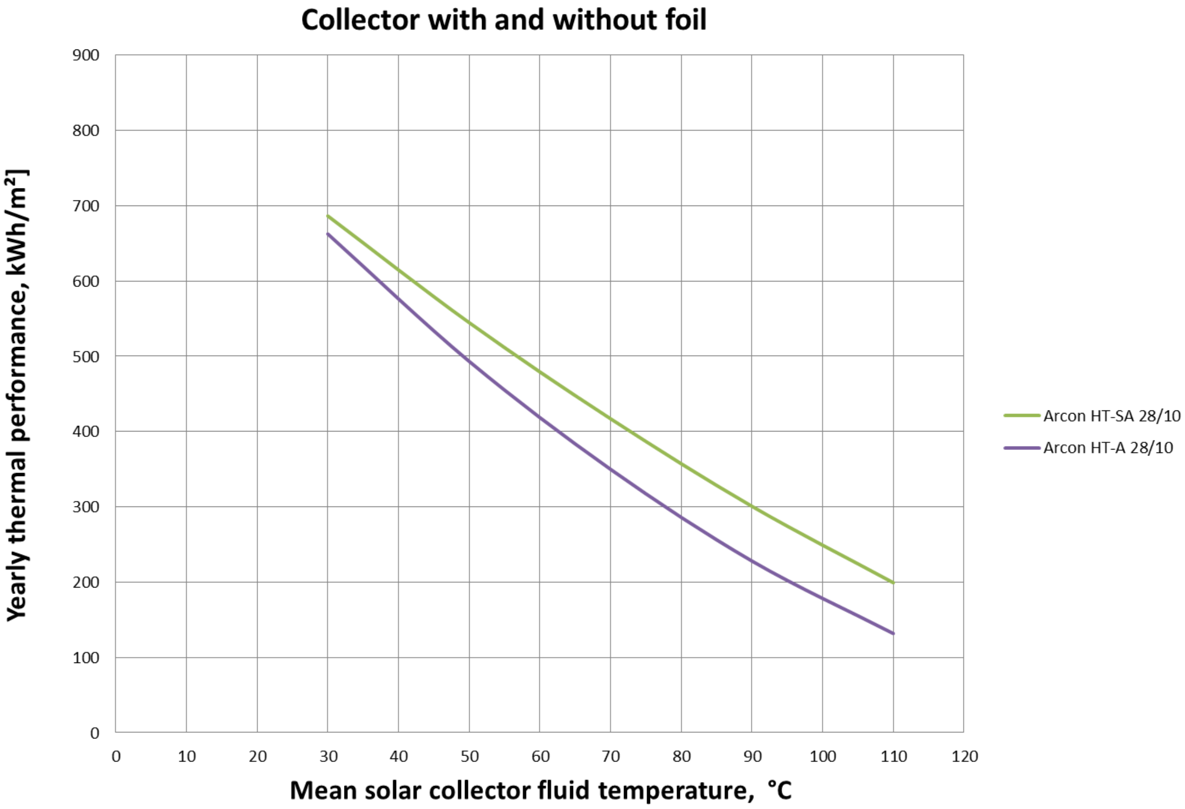
Modelling limitations

This analysis conducted here is at a very high level so there are a number of risks associated with it. The main risks which have been identified relate to working fluid temperatures and ground conditions. These risks will be discussed in more detail below.

Working fluid temperatures:

The efficiency of the solar collectors assumed in this modelling is primarily dependent on the working fluid temperatures within the panel and the pipe network. This relationship between mean solar collector fluid temperature, collector efficiency and yearly thermal performance is illustrated in the graph below.

[43] In discussing solar energy, the solar savings fraction or solar fraction is the amount of energy provided by the solar technology divided by the total energy required. The solar savings fraction thus is zero for no solar energy utilization, to 1.0 for all energy provided by solar. The solar savings fraction of a particular system is dependent on many factors such as the load, the collection and storage sizes, the operation, and the climate.



It should be noted that all of the calculations used in this chart were based on Danish experience, where lower transmission temperatures are typically achieved in district heating networks (because of higher standards of energy efficiency in Danish buildings compared to comparable UK buildings). In UK the network temperatures needed by district heating systems are expected to be much higher however this need not influence the collectors which will be connected to the storage, especially in the case that a gas boiler boosts the stream temperatures provided by the store. Overall, the integration of the thermal store and the heat pump to a district heating network with higher operating temperatures could have other impacts, and there are areas of uncertainty which require closer investigation.

Ground conditions:

The most important factor which underlies the economic and operational assumptions about the thermal store is the assumed ground conditions on the Grange Quarry site. Hard ground conditions would significantly increase excavation costs, while soft ground could prove unsuitable for a deep pond such as that needed for the thermal store. Detailed investigation of ground conditions is recommended before this option can be seriously progressed.

Humidity is also a key factor when calculating heat losses and deciding upon which insulation materials would be most appropriate.

Next steps

If the Burntisland community decide that the solar farm and solar thermal heat store is something that they would like to see developed in their town. Then the following next steps would be required to proceed with a feasibility study on implementing such solar seasonal storage. These are outlined below.

- Speak with the relevant landowners to ascertain whether they would be open to the ideas;
- Approach experts in Denmark for an in depth comparison of the relevant parameters;
- Undertake a ground condition assessment;

- Build and test a detailed annual operation energy model, where half hour consumption and production data will be projected;
- A detailed assessment of required investment as well as operation and maintenance costs should be undertaken;
- Investigation of any relevant decarbonisation subsidies which could support the development;
- The proposed installation would have a significant beneficial impact on the Scottish energy market in terms of adding flexibility and power system balancing capabilities. The Scottish energy network has some serious issues with regard to flexibility and balancing. Thus, it is not too optimistic to presume that corresponding revenues from DNOs and the National Grid could support the operation of the district heating network in Burntisland. Further investigation on revenues from providing such electricity services is required.

Energy generation potential to capital cost

	Energy generated kWh/year	CAPEX	Relative cost
Solar park	8,200,000	£6.5 million	
Water Source Heat pump	17,500,000	£2.2 million	1/6th cost

The water source heat pump is significantly lower cost that that the solar park in this analysis. The heat pump taking warmer water from the Forth Estuary, is six times cheaper that the solar park and large inter-seasonal thermal store. The heat pump taking water from the Forth Estuary is recommended to be considered for supplying the identified zone 7 of the district heat network.

10. Low carbon energy generation

RESULTS - Low carbon generation

Low carbon generation is likely to be reliant on significant community support and require some changes to the Local Development Plan policies. There is an expectation that the Local Development Plan policies will be changed following Scottish Government review. Following any change a short review will be undertaken and the strategy amended accordingly. The first phase of the estuary heat pump supplied district heat scheme, new electric vehicles and existing electricity demand would require 17,677,000 kWh of generation.

- Phase 1: includes development up to 2032. Due to the size of energy generation proposals and the scale of generation already present, a consultation with other nearby communities is proposed to investigate interest in a larger but shared scheme. Feasibility funding will be sought for three pieces of work: for a settlement wide roof solar project, a medium scale solar photovoltaic park, and medium to large scale wind to meet the electricity requirements to 2032. If this phase included all 1107 solar roof opportunities, a 4MW photovoltaic park and 7900MW turbines, then that would delivery 18,995,000 kWh of electricity.
- Phase 2: energy generation requirements will be reassessed, linked to expected improvement in energy efficiency measures and increasing take up of electric vehicles.

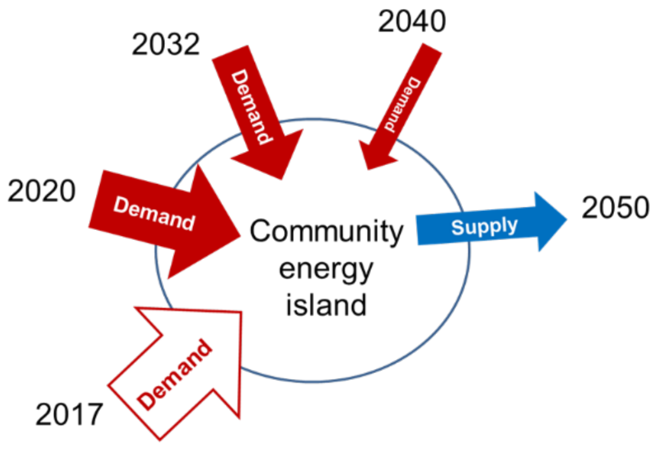
Introduction

The way we produce and use energy is central to tackling climate change and creating a low carbon economy. The low carbon generation needs to deliver on the Scottish Government Energy Strategy vision of an integrated reliable clean energy system that brings benefits across our communities, reducing social inequalities and creating a vibrant climate for innovation, investment and high value jobs. Alongside the measures to reduce demand we need to decarbonise the means by which future energy is produced. Presently, the majority of our energy is provided through three systems: a national electricity grid, a national gas grid and a network of fuel stations for transport.

This report considers renewable sources of low carbon generation. Renewable energy is from natural resources including sunlight, rain, wind, tides and waves. The energy is considered low carbon and *renewable* - being naturally replenished. The majority of renewable energy generation in Scotland to date has been electricity, through hydro, and wind (both onshore and offshore), with growing generation from solar photovoltaic and biomass powered systems. The development of more renewables is also key to the decarbonisation of the supply to the electricity grid. Fife has seen a steady increase in onshore wind. Fife is also involved in developing new markets, such as the work to use electricity to create hydrogen.

Over the last decade the Scottish Government focus has been to broaden the base of our electricity generating mix, and in turn deliver economic benefits to Scotland. The scope of the challenge has now widened to include the renewable energy for heating and transportation systems.

Alongside direct generation are additional sources of energy, such as low grade heat. Low grade heat is heat that is not of sufficient temperature to use directly for heating, but contains useful embedded energy. Examples include: sea water heated in the summer by the sun and warm waste water in our sewers. By using these warmer sources of water we can reduce the amount of energy needed to raise water temperature to use for things like heating. These small efficiencies make a big difference in the amount of low carbon generation a system needs to operate.



The discussion for future energy networks is around a mix of systems: some local to settlements and others larger at a regional or national, scale. The choice of low carbon generation technology is also be influenced by the choice of energy system and the potential energy losses and costs in moving and storing energy. The more energy can be used locally and directly without being stored, the more efficiently the use of that generated energy is likely to be. Generate locally, use locally, use directly.

This section considers; what are the future options to create and invest in the energy we choose to need from low carbon generation sources near Burntisland? How much low carbon generation technology would be needed to match potential future energy demands? To allow a local comparison, and to make the study relevant to the town the assessment will relate all of the energy needed in Burntisland to the output of local generation technology opportunities.

Would a community choose to become an energy island?

An energy island would be where a community that chose to take only some of its energy from the wider national grid. The amount of energy taken could be decided by a community. Presently this is being tested by Scottish Island communities where generation and local use are increasingly integrated, providing a partnership with national grid providers and local people.

A community could take an energy island approach to managing their energy choices. The community could chose targets around steadily reducing the energy it needs from national transmission sources, by planning to generate an increasing amount of energy locally to the point where energy independence is effectively achieved, as in the below diagram. This would be a future stage following local consideration of the energy masterplan.

The low carbon energy generation sources considered within this assessment are:

- Wind;
- Solar photovoltaic (PV); and
- Solar thermal.

Wind

The strategic importance of onshore wind to Scotland's decarbonisation ambitions is highlighted in the draft Climate Change Plan. Onshore wind is a mature sector and is now the lowest cost renewable energy in Scotland. The Scottish Government consultation on wind is looking for options to extend or improve the generation capacity of this technology. The Scottish Government are clear that approval for wind is not guaranteed and all applications will continue to be assessed on their own merit, with contribution to energy targets balanced against environmental impacts and site specific circumstances.

Modelling overview

4b. Renewable energy generation potential (wind)

Key questions	Data sources	Modelling decisions made	Results
a) What constraints and support for wind power generation is there within Fife Council and national Scottish planning policies?	Previous feasibility studies for Fife Council wind turbine proposals in the Burntisland area (Grange Quarry, Burntisland leisure centre).	This modelling phase sought to test the feasibility of erecting a community owned wind turbine, to maximise the benefit from the town's natural coastal position and coastal breezes.	a) see the policy analysis section for detailed results. A map producing a most likely area of search under the Fife Plan guidelines was produced. The team documented a number of material constraints to wind power development locally, not least the large regional TV transmitter aerial on the Binn Hill, and the town's proximity to the flight path and take off and landing surfaces associated with Edinburgh airport, and potential issues with radar shadow.
b) How feasible is the location for wind power generation. What are the average wind speeds around Burntisland? How does this vary at different heights above the ground?	Virtual Met Mast. Which provides average wind speed data (commissioned from the Met Office) for the Grange Quarry site to the north of the site	Assessed previous feasibility studies and established that wind speeds are good, but that there could be issues with grid connection costs and finding sites with an appropriate separation distance from residential properties.	b) Wind speed in m/s at different hub heights. 10m = 5.8m/s; 25m = 6.4 m/s; 45m = 6.9m/s (NOABL)
c) Reviewed wind power potential estimation methods, from a range of different sources.	EST Scotland's standard methodology for wind power estimation / feasibility	Assessed the anticipated average wind speeds fo sites in Burntisland using a variety of wind mapping tools i.e. NOABL, EST, Virtual Met Mast and extrapolated to a range of different hub heights.	c) turbine generation potential: ETW (40m hub height) =
e) Are there any sites in Burntisland which could be used for a medium sized community owned wind turbine? And what could be generated by a community turbine in Burntisland?	NOABL wind map.	Looked at manufacturers specifications from popular medium scale turbines to assess their average yearly yield, optimum wind speed operation range (typically 5-7m/s). And compared to the wind speed estimates provided in the previous step for Burntisland.	d) Output as an expression of local demand
f) What is the capacity of wind power generation which would be supported within Burntisland, and what would this produce in a typical year?	Manufacturer specifications for popular medium scale wind turbines, such as typically used by community groups (Endurance X35, ETW).	Determined the most feasible turbine sizes and an estimate of the likelihood of receiving planning permission in the area based on planning guidance, the success of previous applications, and the turbine specifications available.	e) Cost for the settlement as a whole, and for individual homes.
	Scottish House Condition Survey 10	The most likely wind turbine heights to be granted planning permission, popular turbine models were considered and the average yearly energy yield was estimated using manufacturers data and our extrapolated average wind speed. An estimate of the potential generation yield compared to Burntisland's electricity consumption was provided.	f) Recommended that wind feasibility scoping should be rescreened against the new FIFEplan once it is approved in the Spring of 2017.
		Reviewed output data for medium scale turbine within the hinterland of Burntisland. Extrapolated data to provide a metric for output linked to current Burntisland consumption. Needs further assessment of system constraints and landowner negotiations.	
		Consultated with FC planners on key policies and data to be considered in any onshore wind application. Was referred to Fife Council Supplementary Planning Guidance (2013) in the first instance and historic applications via the Planning Portal. Site screened against GIS layers illustrating Fife Council spatial planning policies including natural heritage, landscape character (landscape and visual), aviation and radar impacts. noise and vibration, built heritage, contaminated land, ecology etc. Will need to review against the new Local Plan (FIFEplan) when it is approved in Spring 2017.	

As a coastal settlement with an elevated hinterland, in theory Burntisland should have good wind energy generation potential, and there are numerous wind turbine developments in the hinterland inland behind the town. As such the potential for wind is considered in this report.

Modelling overview

The wind opportunity in Burntisland

The potential for local wind power generation in Burntisland was initially considered looking at previous applications. This included data from feasibility studies that would be pertinent to the Burntisland area.

National wind assessment resources were used to asses wind potential. Generation output was estimated using turbine manufacturer figures.

Planning and other constraints were considered.

The potential generation capacity from wind power locally was then assessed against the scale of potential electricity demand from Burntisland to assess what proportion of electricity demand could be met by wind power generated locally.

Data sources

The following datasets were used in this analysis:

- Fife Council feasibility studies in vicinity of Burntisland (Grange Quarry / Burntisland Leisure Centre). [Fife Council study].
- Virtual Met Mast average wind speed commissioned from the Met Office for Grange Quarry to the north of Burntisland town. [Fife Council study].
- NOABL wind map;
- Energy Saving Trust wind turbine assessment and costing data;
- ETW turbine energy yield, manufacturer's efficiency and optimum generation condition data; and
- Endurance X35 turbine energy yield, manufacturer's efficiency and optimum generation condition data;

Process undertaken

1. A review was undertaken of Fife Council feasibility studies in vicinity of Burntisland. These assessed the potential for turbines at: Grange Quarry and the Burntisland Leisure Centre. The site with the more potential was the Burntisland former Landfill (Grange Quarry); with wind speed 5.53m/s; and key issues: including proximity of residential properties, lack of a close grid connection and that the site is on lease to Fife Council only.
2. Wind speeds around Burntisland were assessed using the Virtual Met Mast average wind speed commissioned from the Met Office for Grange Quarry to the north of Burntisland.
3. A review of NOABL was undertaken as a comparator to the Fife Council studies. This assessed wind speeds available around Burntisland.
4. A review was also undertaken of the Energy Saving Trust wind speed tool as comparison to NOABL, but noted as more generic
5. Extrapolated the VMM (Virtual Met Mast) windspeed at 20m to a range of hub heights using a variety of web based windspeed calculators.
6. Assessed whether these were good wind speeds against a variety of popular models' optimum wind speed operation range (5 to 7 m/s)
7. Consulted Fife Council officers on key policies and data to be considered in a wind application near Burntisland.
8. Referred to Fife Council Supplementary Planning guidance (2013) in the first instance and previous planning applications in the Fife Council planning portal. Assessed Burntisland community council area against: Fife Council Supplementary Planning guidance 2013, GIS layers of Fife Council Policy (Fife Council's wind assessment planning tool available to the public) including Natural Heritage, Landscape character, Built heritage, Contaminated Land.

9. Note: Fife Council is expecting a newly approved Local Development Plan in spring 2017, which is likely to have amended wind policies, so the methodology will be reviewed after that time.
10. Determined wind turbine sizes and likelihood of receiving planning permission against Planning guidance, previous applications and turbine models available.
11. Most likely wind turbine heights linked to popular models and average yearly energy yield estimated from manufacturers' data and our extrapolated wind speeds, and related to Burntisland demand

Wind generation results

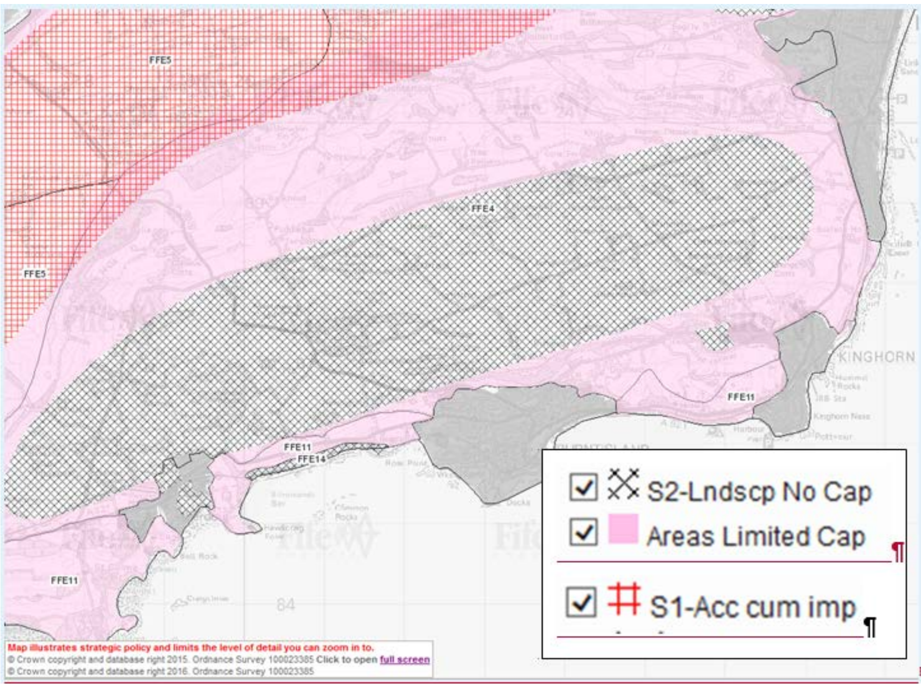
The NOABL wind speed around Burntisland are shown below:

Burntisland	
Height Above Ground	Wind Speed
At 10 meters	5.8 m/s 13 mph
At 25 meters	6.4 m/s 14.3 mph
At 45 meters	6.9 m/s 15.4 mph

Planning policy

Wind generation in Fife is constrained by a number of policies. A likely reason for refusal of planning permission for wind is insufficient landscape capacity, as this has been a consistent reason for other recent applications in the locality of Burntisland.

Below is part of the Fife Council Local Development Plan map. This shows areas impacted by landscape capacity. The hatched area in the below plan shows no landscape capacity. The green area show limited landscape capacity. Siting wind turbines within the boundary of a settlement is covered by separate policies, but is more constrained than outwith the settlement. Proximity to infrastructure also constrains wind turbine proposals, such as where they are near buildings, roads and the railway line.



Typical constraints for a 500kW turbine

Residential property	35dB ~600m unless financially invested
Water feature	40m buffer
Road network	80m buffer
Core paths/rights of way	50-80m buffer
Telecom link	100m buffer
Council landfill/ made ground	30m buffer
Housing site allocation	250m buffer
Scheduled monument	100m buffer
Gas pipeline	10m from extent
Shadow flicker	10 x rotor diameter
Listed buildings	identified within 1km
Grid connection	Within x meters
Aviation	In sight of any Radar
Wind resource	3 – 5 m/s
Road access	Delivered in sections, no sharp bends!

A number of popular medium and large scale wind turbines were reviewed to show generation potential:

Reference	Size	Hub height	Wind speed (m/s)	Yield kWh/yr
Endurance X35	225kW	35m	5.5	451,000
ETW	500kW	50m	5.86	1600000
EWT	900kW	69m	6.1	2000000

Results

Onshore wind generation is a strategically important resource for Scotland. The open aspect of the Burntisland settlement with its elevated hinterland, means it has the potential for good wind energy generation. The numerous wind turbine developments in the hinterland inland behind the town reinforce this judgement.

Wind is a great resource for Scotland. Because wind does not always happen when you want the energy, it needs to be linked with local energy storage, or the ability to move electricity around the grid from areas of wind to those without wind at that time.

Previous Fife Council feasibility studies near Burntisland demonstrated wind potential at the rear of the town near the Burntisland former Landfill (Grange Quarry); with wind speed 5.53m/s. However, a wind turbine was not pursued due to proximity of residential properties, lack of a close grid connection and that the site is only on lease to Fife Council.

The scale of wind generation matched to Burntisland demand

How many wind turbines would be needed to generate a similar amount of Burntisland's energy demand (if it was electricity). Note this does not take into account losses.

		Heat (total)	Electricity (not heat)	Transport (cars and light vans)	TOTAL
		49,139,721	10,400,131	6,092,387	65,632,239
	kWh/year	Number of turbines			
ETW 900kW	2,168,000	23	5	3	30
ETW 500kW	1,530,000	32	7	4	43

Wind turbines constraints look significant enough not to follow this generation source in the short term. However constraints are expected to be changed in the new Fife Council Local Development Plan. If wind turbines are identified in as a potential generation source then a number of feasibility studies will be required which will provide a more detailed analysis of constraints, including those not considered at this early stage such as grid capacity.

Solar photovoltaic

Solar photovoltaic panels generate electricity from exposure to the solar radiation. The critical site factors are the amount of solar radiation, the slope and aspect. Typically solar photovoltaic panels are installed in small arrays on or near buildings, or in larger solar parks out with settlements.

The East of Fife has similar levels of solar potential as areas of Denmark that already make good use of solar energy.

Photovoltaic cells are made from layers of semi-conducting material, such as silicon. When sunlight shines on the cell it creates an electric field across the layers. The stronger the light, the more electricity is produced. Groups of cells are mounted together in panels or tiles. These can be mounted on a roof or on the ground. The electricity power for photovoltaic panels or tiles is measured in kilowatts peak (kWp). That is the amount of electricity generated: at peak performance; in full direct sunlight; and during the summer.

Solar tiles can be used in place of ordinary roof tiles, but typically cost about twice as much as an equivalent panel system. Solar tile systems are usually only considered where panels are not considered appropriate for aesthetic or planning reasons.

Solar panels should only be considered for on a well maintained roof.

Solar photovoltaic panels provide the best financial return when the energy is used and not sold to the grid. There are many products that are designed to use photovoltaic panels in the home, such as heating water in tanks or storing electricity in heat batteries. A number of products have been launched that store energy as electricity in the home.

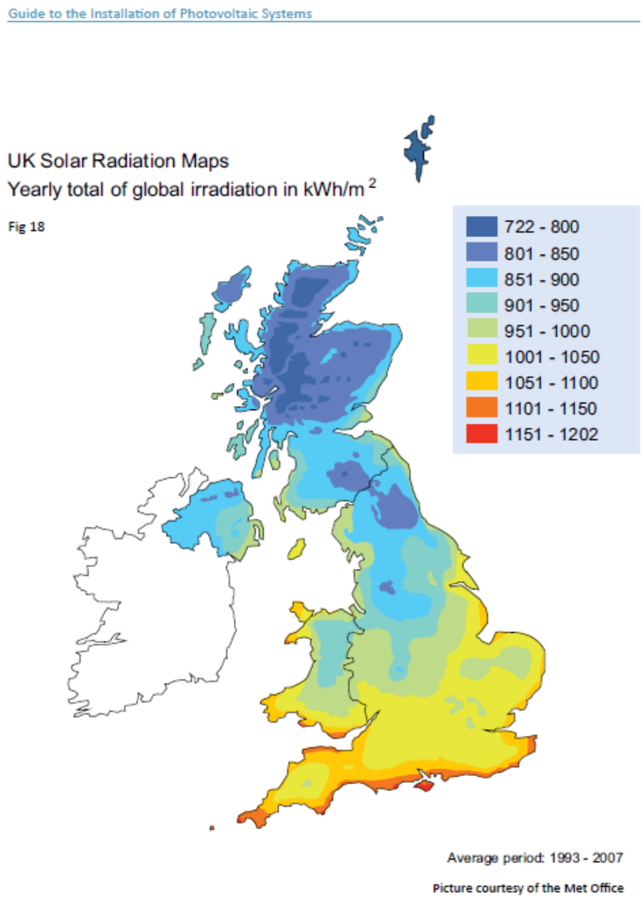
Data sources

- Energy Saving Trust
- Photovoltaic Geographical Information System - Interactive Maps
- MSC guide to the installation of Photovoltatic systems
- Home Analytics
- Presentation to the Burntisland community by Lightsource

Process undertaken

Solar radiation potential is shown in map based format in the MSC guide to the installation of Photovoltatic systems. Fife has better solar radiation potential than most of Scotland. The map below shows that the solar potential by Burntisland lies within an area with the potential for 951-1,000 kWh/m2. This is comparable to areas of Denmark that already make good use of the solar resource.

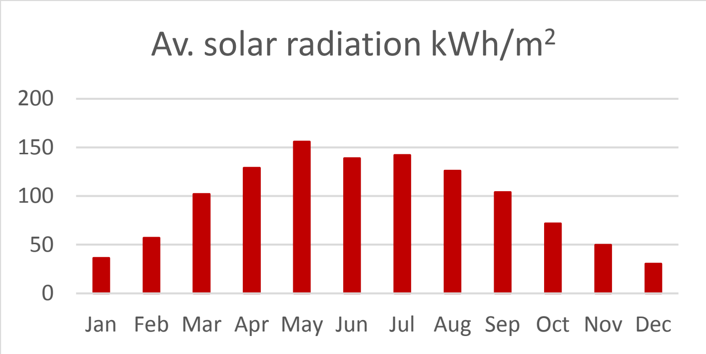
Solar potential on roof spaces was considered. A visual check was undertaken to assess if the majority of buildings were south facing. Undertook sample exercise mapping roof aspect in GIS was undertaken. However, it was quickly resolved as too time consuming. The next approach was to review existing aerial photography. Existing aerial photography image quality was unfortunately not sufficiently for detailed to accurately assess overshadowing from extensions/ chimneys, and unavailable space such as with roof windows..



MSC guide to the installation of Photovoltaic systems

Options were explored to improve data for building mounted panels to for more detailed feasibility. Perth & Kinross Council was consulted together with a review of analysis undertaken for a detailed topographic mapping project in Edinburgh. The recommendations were to use an approach utilising a drone based survey (aerial photography and surface imaging) to provide an interactive data model of the settlement. Consultants approached and costing provided. This will be included as action leading from plan development.

The available solar radiation was reviewed using the web based Photovoltaic Geographical Information System - Interactive Maps. This provided average daily and monthly sums for electricity production and global irradiation per square meter. The average sum of global irradiation per square meter in Burntisland is 95.2 kWh/m2. The average monthly solar radiation is shown below.



The Photovoltaic Geographical Information System - Interactive Maps give an average sum of global irradiation per square meter (95.2 kWh/m2). The average monthly solar radiation

Home Analytics data on available roof space for solar photovoltaic systems and expected kWh/yr generation was exported by data zone using a pivot table. The totals for number of available roofs and generation potential were summed. These are shown in the on building photovoltaic section.

The Energy Saving Trust web resource was reviewed to provide a basis for pricing the on roof solar potential for Burntisland. The average cost for a 4kWp solar photovoltaic was multiplied by the available roof space to provide a cost range. A figure for potential generation was attributed using the predicted generation for South of England and adjusting this relative to the carbon emissions as a proxy for actual electricity generated.

Solar potential for large scale solar parks was considered. The presentation by Lightsource was provided for the Burntisland community. The presentation was provided as indicative and further work would be required prior to developing a business case. The presentation provided a figure for a 4MW solar photovoltaic park on a 20acre site, generating 3,500MWh/yr for £3.5M. This was converted to potential per hectare 875MW ha/yr at £875K.

Fife Council planning and built heritage officers were consulted. Photovoltaic panels on building roofs are unlikely to require planning permission unless in conservation area or on a listed building. Larger scale proposals such as a solar park would be subject to planning permission and environmental reporting.

On building solar photovoltaic

Home Analytics gives the potential for on building solar in Burntisland. There are 1107 roofs that could have solar panels, or 3104 identified in this model. If every one of these solar photovoltaic panel installations was installed the total potential generation for these panels is calculated as approximately 894MWh/yr. Note that some buildings in Burntisland already have solar panels which were not shown in the Home Analytics data.

The Energy Saving Trust provide figures for an average 4kWp (panel) system. Adjusting this using their figures for Stirling Scotland provides a potential to generate approximately 3160 kWh/yr.

The potential by datazone is outlined below. Some caution was given as this data does not provide the impacts from actual available roof space, slope, aspect and overshadowing. More detailed surveying is recommended as a detailed feasibility.

Datazone Code	Datazone	No. of Houses	Y	Breakdown of Contribution to Solar PV Potential (kWh per kWp/yr)
S01009458	Burntisland Central	353	111	90252
S01009460	Burntisland Docks	433	18	78036
S01009466	Burntisland East	262	154	14684
S01009464	Burntisland East Toll	392	168	144525
S01009462	Burntisland Grange and Orrock	270	126	102946
S01009461	Burntisland Kirkton	276	178	122828
S01009459	Burntisland Links	514	96	133779
S01009465	Burntisland Meadowfield	275	104	84223
S01009463	Burntisland Nether Grange	328	152	123021
Totals		**3104**	**1107**	**894,294**
				894.29MWh

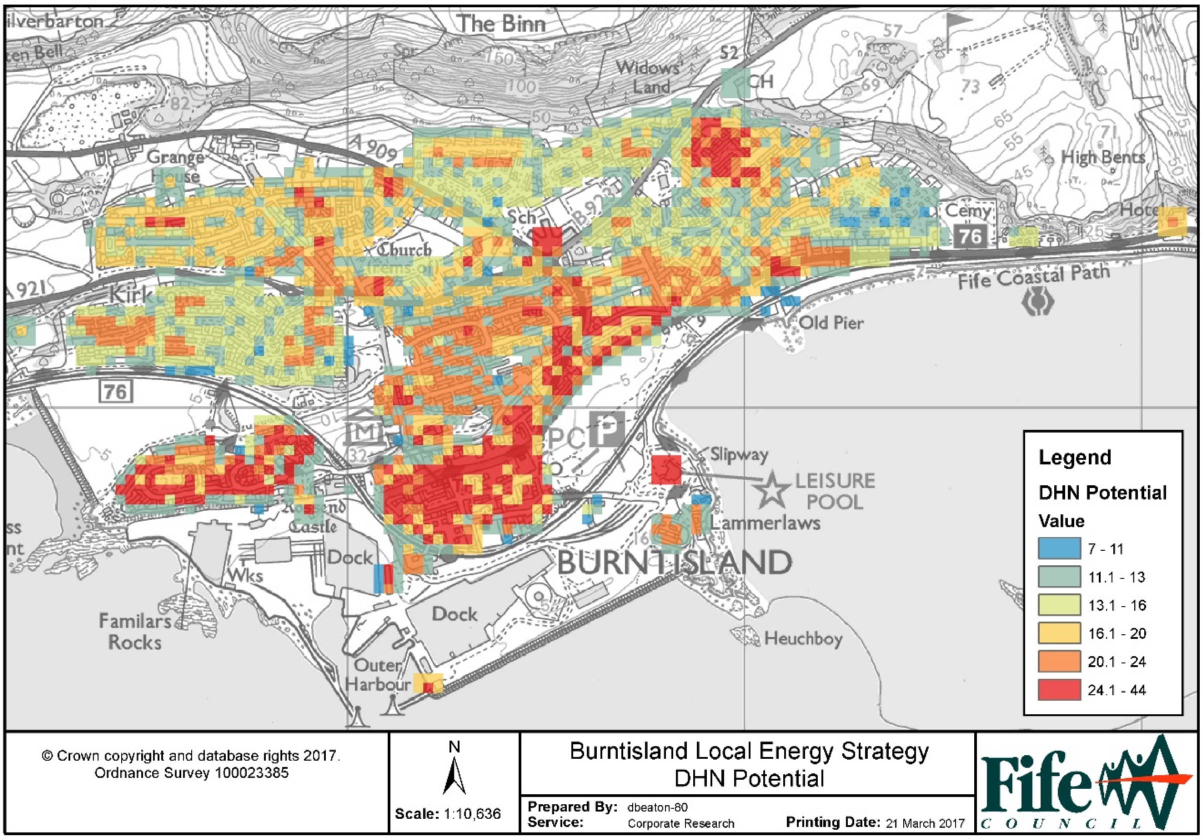
Source Home Analytics data – Energy Saving Trust

The average domestic solar PV system is 4kWp and costs £5,000 - 8,000 (including VAT at 5 per cent Energy Saving Trust. The CAPEX costs for 1107 roof systems in Burntisland would be in the range of £5,535,000 and £8,856,000. This works out at approximately £1.25-2M/ per 1,000kW/yr.

11. Policy

RESULTS - Policy

- Phase 1: The Burntisland local energy masterplan will be put forward for consideration by area committee in the new administration. Fife Council will consider local energy masterplans within the new local planning structures, particularly at neighbourhood level. Local Energy Masterplans will be considered in the development of the new Low Carbon Supplementary Guidance and Local Development Plan – particularly the role of socio-economic appraisal. The role of local community plans will also be raised during the development work of the Local Outcome Improvement Plan process.



Organisations, such as Fife Council, public agencies and the Scottish Government, use policy and plans to articulate visions and priorities. Local energy choices are impacted by these policy, and in turn energy choices be reflected in future policy.

This study considers:

- Policy implications for energy proposals
- Policy as a driver to influence which proposals are taken forward, such as socio-economic /weighted spatial data analysis
- Local energy masterplans interaction and influence on future Fife policy; including how energy masterplanning could be integrated into wider council policy and plans

Data /information sources

A number of Fife Council interests were engaged as part of this process.

- Policy interests from planning, housing and communities sat on the overall project steering group, to guide the ongoing work of developing the Local Energy Masterplan.
- The Fife Council group scoping out the Local Outcome Improvement Plan considered how Local Energy Masterplans would fit into the emerging framework of community plans. These would be fed by a suite of local neighbourhood scale plans.
- Fife Council's Community Service team, whose area includes Burntisland, considered practical options for supporting local community level plans
- A short life Policy working group was set up to consider the policy implications for the proposals emerging from the data analysis and community engagement. This group included planning and spatial data specialists covering the: Local Development Plan, Built Heritage, Natural Heritage, Housing, and Landscape. The group also provided guidance for the weighted spatial data analysis.

Local Energy Masterplans role in the wider policy process

The emerging policy framework puts a greater focus on engaging with local communities. At an area wide level

There is also a strengthening of the role for all public agencies to coordinate action through area wide Local Outcome Improvement Plans. Both of these bring new areas of work and partnerships which will need to be developed over the coming years.

A number of statutory and strategic themed plans link into the Local Outcome Improvement Plan. These plans include the Local Development Plan, the Local Housing Strategy, the Local Transport Strategy and the Fife Economic Strategy. Alongside this the Scottish Government is considering requiring local authorities to develop energy efficiency and heat plans.

A new suite of neighbourhood level plans are also expected to be considered during the next Fife Council administration. There could be a role for these plans to be more thematic, reflecting the needs and interests of a local area. Local Energy Masterplans could be part of defining the themes of local interest.

What is clear, is that processes with strong local ownership, such as a Local Energy Masterplan, has the potential to engage and enable local action, as well supporting practical delivering of area wide energy policy. There seems little doubt that Local Energy Masterplans have the potential to positively influence and support the emerging area based plans.

Actions

- Undertake a review of the Local Energy Masterplans as part of the next Local Development Plan cycle starting this year.
- Present to the Local Outcome Improvement Plan team and neighbourhood level plan teams the lessons from developing Local Energy Masterplans
- Look at how best to incorporate Local Energy Masterplans as part of wider area energy plans in Fife
- Work with leads for statutory plans to review the role of Local Energy Masterplans in their development and delivery

Consideration of policy implications of energy proposals

A range of local energy proposals were developed as part of the data analysis and community engagement process. The list of proposals was presented to the short life policy working group. These were:

- Proposals that impacted on the exterior of a building (cavity wall, roof insulation and floor insulation)
- Proposals that impacted on the exterior of a building (external wall insulation, double glazing and on building solar photovoltaic)
- Proposals for large scale low carbon generation (medium & large scale onshore wind and solar parks and large scale thermal storage)
- Proposals that would be delivered across a settlement (area wide district heating, heating plant buildings, in settlement energy storage, heat pipe installation, connection of district heat to buildings)

The short life policy working group then took time to discuss each of the proposals from their policy area perspective. This enabled a wider and richer discussion around policy impacts. The group then considered the policy implications for each of the proposals. A matrix was developed to highlight where policies had a moderate or significant impact on energy proposals. More detail were also provided on Local Development Plan policies that impacted on the proposals.

Local Development Plan Policies:

Measure LINKED to policy	Policy 1: development principles applies to all	policy 3: Infrastructure and Services: policy	policy 10: Amenity	policy 11; Low Carbon Fife	policy 13; natural heritage and access	policy 14: Built and historic environment	policy 14: Built and historic environment: plus locational	Low Carbon Fife supplementary guidance - in
External insulate buildings	Yes		Yes			Yes		
Insulation in buildings, in cavity, internal (where no cavity), in roof (including top up) and under floors, also draft proofing	Yes		Yes			Yes		
Double/triple glazed windows	Yes		Yes			Yes		
Solar on roof	Yes		Yes			Yes		
District heating, including pipe, energy centres	Yes	Yes	Yes	Yes	Yes		Yes	
Energy stores: under parks, in garage/lock ups, in Grange quarry	Yes	Yes	Yes	Yes	Yes		Yes	
Energy stores: in buildings (ie the type the size of boiler or washing machine)	Yes						Yes	
Taking heat from the sea/estuary (ie a pipe)	Yes	Yes	Yes	Yes	Yes		Yes	
Putting solar farms around the town	Yes	Yes	Yes	Yes	Yes		Yes	
Putting wind turbines in and around the town	Yes	Yes	Yes	Yes	Yes		Yes	Yes

Low Carbon Energy Proposal – key policy considerations from FIFEplan

New low carbon policies are coming in a new Fife Local Development Plan. The new Fife Local Development Plan was considered at committee Feb 2017. Following this there is 6 week consultation with the Scottish Government, prior to anticipated adoption circa. May 2017.

Below is an extract from FIFEplan Policy 11: Low Carbon Fife Council – this sets out what a Development Management officer would have to take into consideration as part of the decision on proposals for low carbon energy schemes. Information about other FIFEplan policies and Fife planning guidance that are relevant are added in red. Note: Policy 1 sets out development principles and applies to all proposals for development in Fife. Other policies specific to the location of the development may apply - such as in the town centre (policy 6), in the countryside (policy 7); in an employment area (policy 5), or impacting on mineral deposits (policy 15):

Low Carbon Energy Schemes
Development of low carbon energy schemes such as wind turbines, district heating, solar arrays, or energy from waste will be supported provided the proposals do not result in unacceptable significant adverse effects or impacts which cannot be satisfactorily mitigated, giving due regard to relevant environmental, community and cumulative impact considerations.
The assessment of proposals for renewable energy developments will be based on the principles set out in the current Scottish Planning Policy, in particular, for onshore wind developments, the requirements for spatial frameworks (as set out in Table 1).
Assessments will include the following considerations:
- all cumulative impacts, including cumulative landscape and visual impact, recognising that in some areas the cumulative impact of existing and consented development may limit the capacity for further development;
- landscape and visual impacts, including landscape character
- impacts on communities and individual dwellings (including visual impact, residential amenity, noise and shadow flicker);
- impacts on aviation and defence interests, public access, the historic environment (including scheduled monuments and listed buildings, and their settings), tourism and recreation, telecommunications and broadcasting installations, forestry and woodland, adjacent trunk roads and road traffic, hazardous installations (including pipelines), and carbon rich soils (using the carbon calculator);
- effects on the natural heritage (including birds), and hydrology, the water environment and flood risk;
- opportunities for energy storage;
- net economic impact, including local and community socio-economic benefits such as employment, associated business and supply chain opportunities;
- the scale of contribution to renewable energy generation targets, and the effect on greenhouse emissions;

- the need for conditions relating to the decommissioning of developments, including ancillary infrastructure, and site restoration;
- the need for a robust planning obligation to ensure that operators achieve site restoration.
The ‘Applying the policy’ section has the following advice:
Considerations
5. Renewable energy technologies will be assessed against a range of considerations, with their benefits being balanced against a range of potential negative impacts and effects. Supplementary guidance on low carbon energy schemes, including wind energy, will be prepared. It will set out the detailed policy considerations against which all proposals for low carbon energy schemes, including wind energy, will be assessed, based on the considerations set out in Policy 11.
6. The key to the success of an application will be to seek to minimise its impacts and effects on receptors. Important sensitive receptors include nationally and internationally designated sites, such as Natura 2000 sites, Ramsar sites and sites of special scientific interest, communities and individual dwellings, major transport routes and walking and cycling routes, defence and aviation interests, scheduled monuments, listed buildings and conservation areas, tourist attractions and key viewpoints. There are others, and the matters that have to be addressed in any particular case will be agreed with the council through the pre-application process.
7. The council expects most energy developments to be subject to appropriate environmental impact screening and scoping before submission of a planning application. In most cases, detailed supporting information will be needed to examine impacts and effects and how these can be limited.

Key points arising from the policy group discussion:

- The group very much recognised that the transition to new ways of managing energy was a Scottish Government priority and had substantial potential benefits to the Fife area.
- Detailed policy implications would be easier to assess once firm proposals were brought forward in the detailed feasibility and planning stages. Further, by considering proposals early and through the development process, obvious conflicts could be address and potentially mitigated improving the chance of success for proposals
- Specifically for heritage buildings. That more often the front of the building is the most sensitive in conservation terms, meaning that energy measures or connections to energy systems such as district heat would be more acceptable connecting from the rear. That heritage buildings require to breath and insulation systems would need to be chosen that allowed air movement through the building built fabric.

Weighted spatial policy analysis

Assessing policy alongside other drivers

Wider implications for decisions often risk being subsumed under pressing financial considerations. Some schemes consider single policy issues alongside economic ones such as Fuel Poverty reduction. However, there is not a standard approach to considering multiple policy implications in relation to a spatial proposal, such as a heat network. Such an approach might also consider connecting council assets, built heritage, or planning sites into one approach. The idea behind this piece of work was to test out an approach that could be considered in s*ocio*-economic analysis as a decision tool for energy proposals. The approach would look to provide a numerical weighting and a visual representation linked to the area being considered. The approach would also be developed with an eye to being fairly easily replicated by other public bodies.

The approach

The approach used is based on the Public Sector Heat Density analysis tool, funded by Scottish Government for use with the Scotland heat map. Perth & Kinross Council, with approval from Scottish Government, further developed the approach beyond public buildings and tested this out with their analysis of the heat network opportunity in Perth. A meeting was held with Perth & Kinross Council to share with Fife Council the lessons and the approach they undertook, including all process diagrams and programming.

The Fife Council approach took detailed geographical information in the form of points, lines and polygons for a range of factors influencing energy were identified. These vector geographic datasets were then rasterised to a common grid to allow a weighted aggregation of factors influencing energy opportunities for a high level overview and visualisation.

The range of factors was limited to a subset that had an influence on Burntisland. The use of too many factors reduces the effectiveness of the analysis at a high level and can hide important patterns.

A 25m cell size for the raster datasets was adopted to provide the most suitable resolution for a local/local energy masterplan to provide the granularity. An authority wide analysis could opt to use a larger cell size to provide a more general overview.

The tools used were Esri ArcGIS (Standard Edition) with the Spatial Analyst extension. However the methodology can be recreated in other GIS software.

The initial results were tested out on the community at the outcomes workshop. These proved valuable in raising wider policy choices, beyond financial considerations. The approach was amended following the presentation to provide more focussed outputs.

Input

- Scotland Heat Map (2015)
- Policy datasets
    - Fuel Poverty (Changeworks)
    - Gas Central Heating (2011 Census)
    - Listed buildings (Fife Council)
    - Conservation Area (Fife Council)
    - Local Development Plan proposals (Fife Council)
    - 200 year Coastal and Surface Water Flood (SEPA)
- Asset Datasets
    - Council Buildings (Fife Council)

- Council land ownership (Fife Council)
    - Council Houses (Fife Council)
    - Sewer Pipes (Scottish Water)
- Perth & Kinross Council Public Sector Heat Density analysis methodology

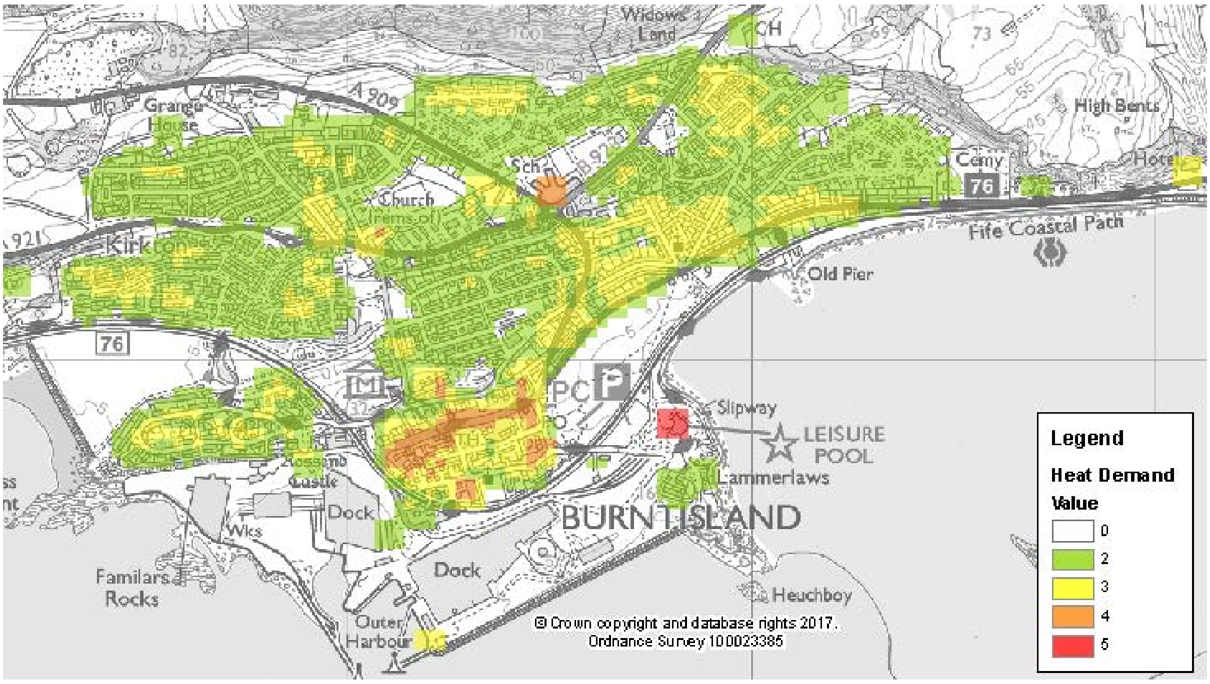
Analysis

- Reviewed Perth & Kinross Council methodology for Public Sector Heat Density analysis.
- Reviewed datasets used in the Perth & Kinross Council approach.
- Reviewed datasets with planning, heritage and housing colleagues
- Focussed Burntisland model on heat network analysis, Scottish Government priority.
- Shortlisted policy datasets to include in the model
- Determined a 25m cell size raster approach to better model inputs as working on a local energy plan rather than council wide.

Demand.

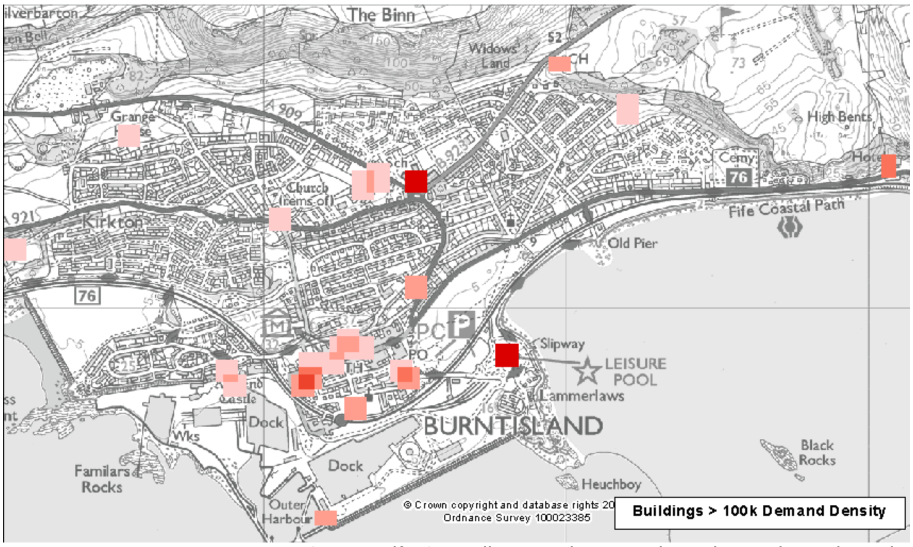
- Data from the Scotland National Heat Map 2015 was rasterised at 25m cells to:
    - o Determine total head demand per 25m cell
    - o Create a density demand based on demand per 25m cell and 3*3 neighbourhood of cells. Helps identify were demand is in close proximity.
    - o Heat demand per cell was reclassified between 0 and 5, weighted 6

Old values	New values
0 - 12.905296	0
12.905296 - 38.700073	2
38.700073 - 79.85907	3
79.85907 - 188.865509	4
188.865509 - 790.11377	5
NoData	0



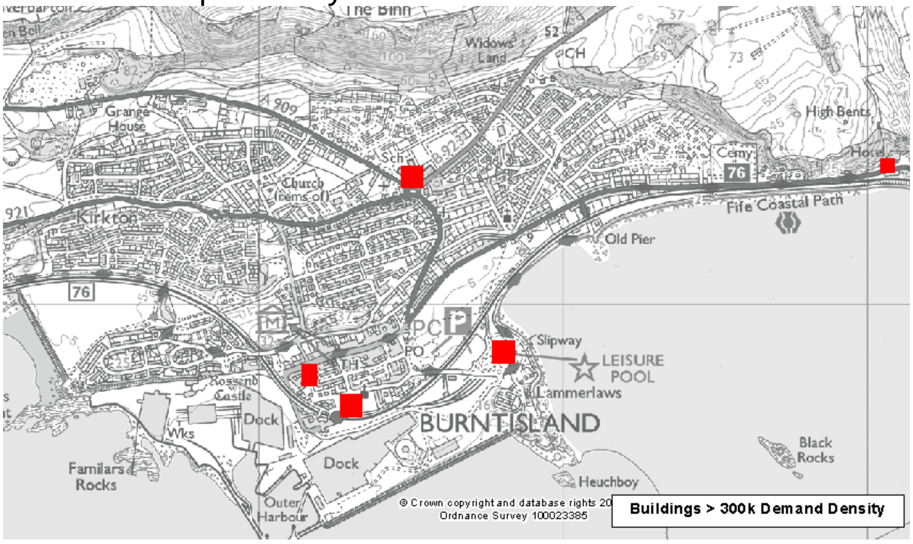
Source Fife Council research team – heat demand map 25m grid

-
    - o Determine total demand for building (aggregate properties in same building e.g. flats)
        - ▪ Identify the number of individual buildings (not individual properties) per 25m cell that have > 100k demand.
        - ▪ Create a density demand for buildings > 100k per 25m cell and 3*3 neighbourhood of cells. Helps identify where are demand > 100k is close to each other.



Source Fife Council research team – heat demand map large loads

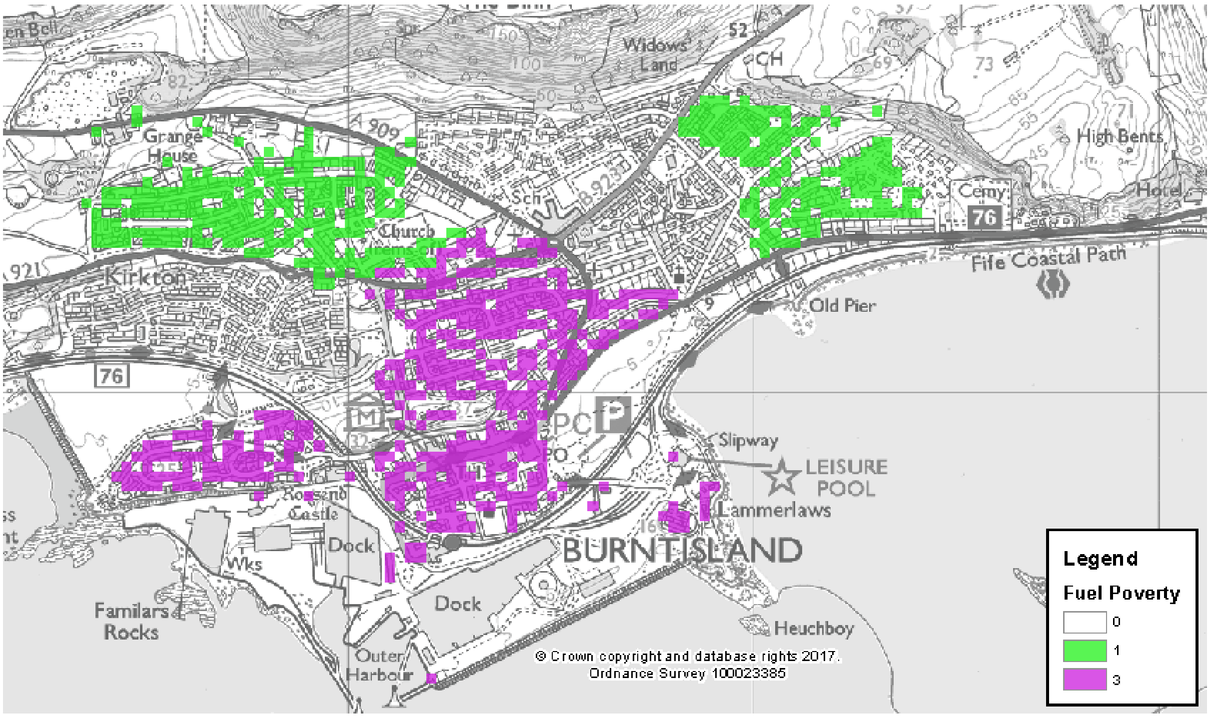
- Identify the number of individual buildings (not individual properties) per 25m cell that have > 300k demand.
- Create a density demand for buildings > 300k per 25m cell and 3*3 neighbourhood of cells. Helps identify where are demand > 100k is close to each other.



Source Fife Council research team – heat demand map 300kWh demand density

- **Opportunities**. For each 25 grid cell determine values for a range of factors. Some factors (such as conservation areas) must only be assigned where they relate to buildings with heat demand otherwise significant distortion occurs in the model. For example the whole port area is classified as a listed building, as is the cemetery. Another example is the 'Links' area is within the conservation area however is open space with no heat demand.
  - Fuel poverty percentage based on datazones (Changeworks), assigned to properties with heat demand, rasterised at 25m and reclassified as 0,1 or 3, weighted positive 2 in final model.

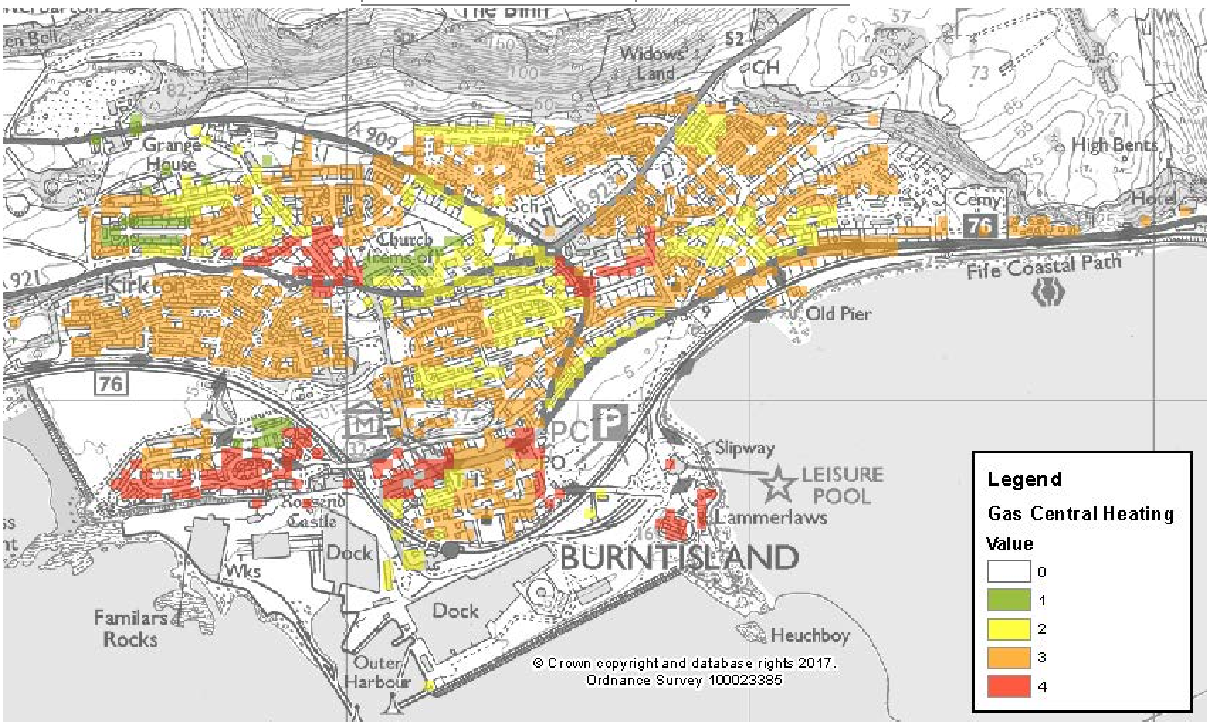
Old values	New values
16.08 - 30	0
30 - 35	1
35 - 51.86	3
NoData	0



Source Fife Council research team – fuel poverty by buildings 25m grid

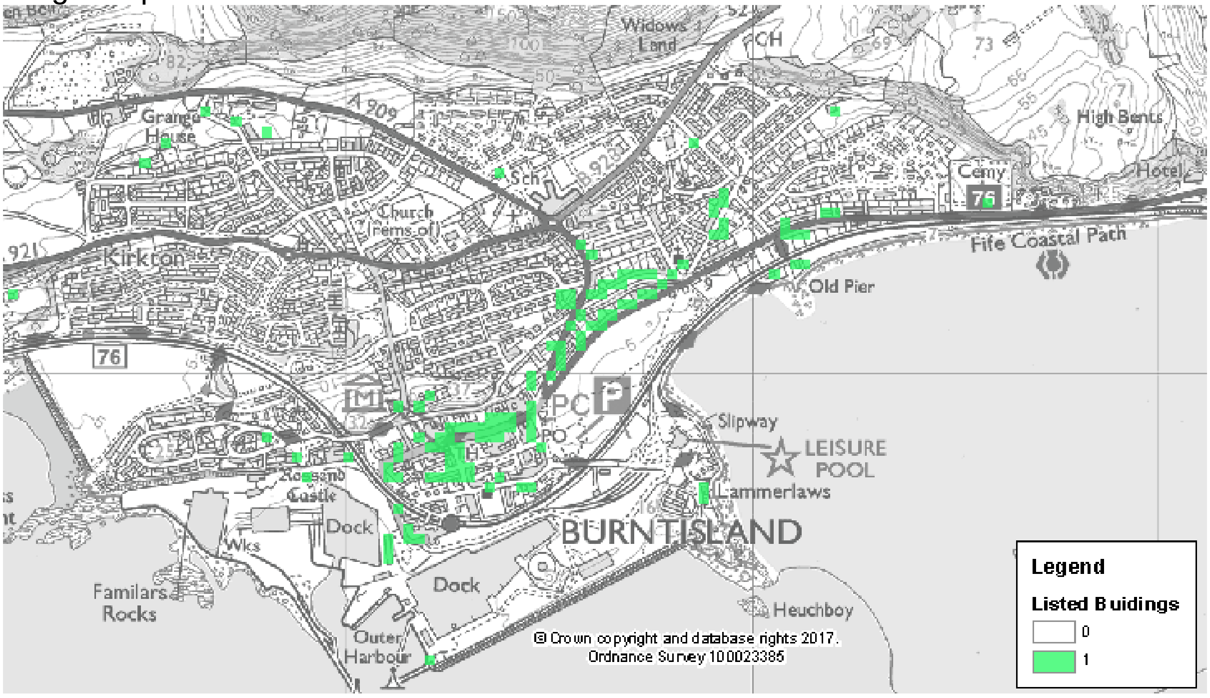
- Number of properties with gas central heating, based on census output areas (2011 Census), assigned to properties with heat demand, rasterised at 25m and reclassified between 0 and 4, weighted positive 1 in final model

Old values	New values
16 - 30	1
30 - 40	2
40 - 60	3
60 - 70	4
NoData	0



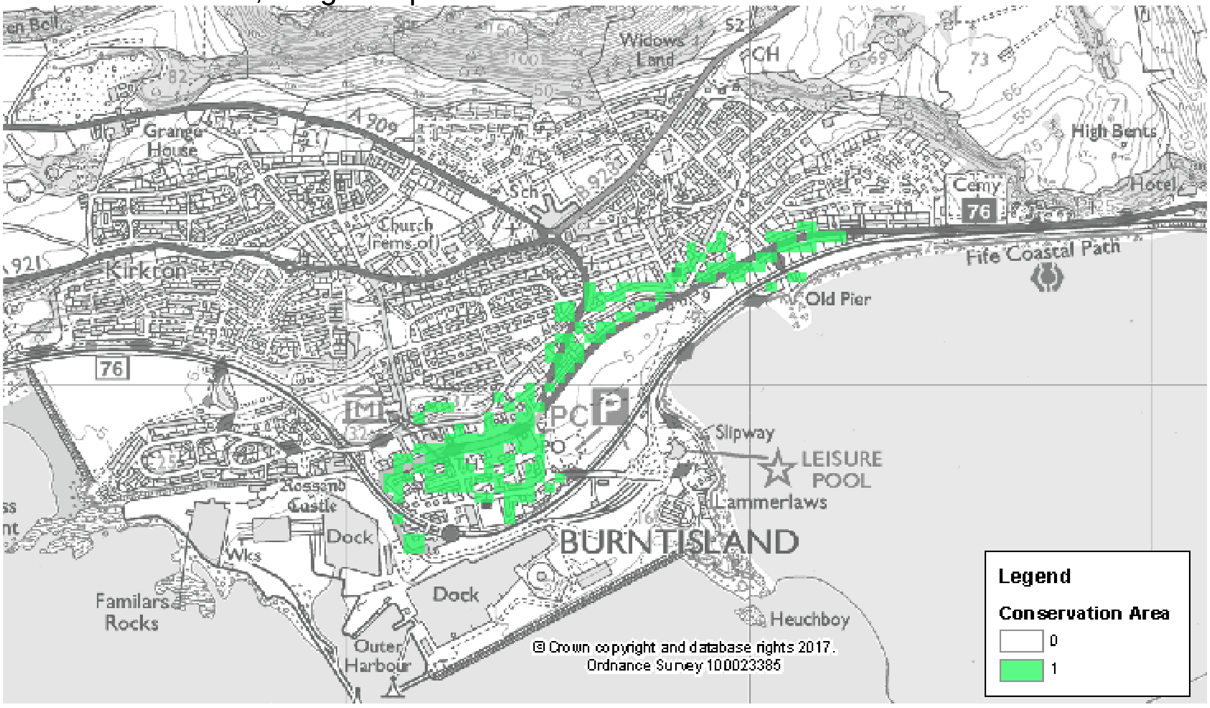
Source Fife Council research team – gas central heating (Census 2011)

- Listed buildings (Fife Council) outlines used to only identify properties with a heat demand, rasterised at 25m aggregating heat demand and reclassified 0 or 1, weighted positive 2 in final model.



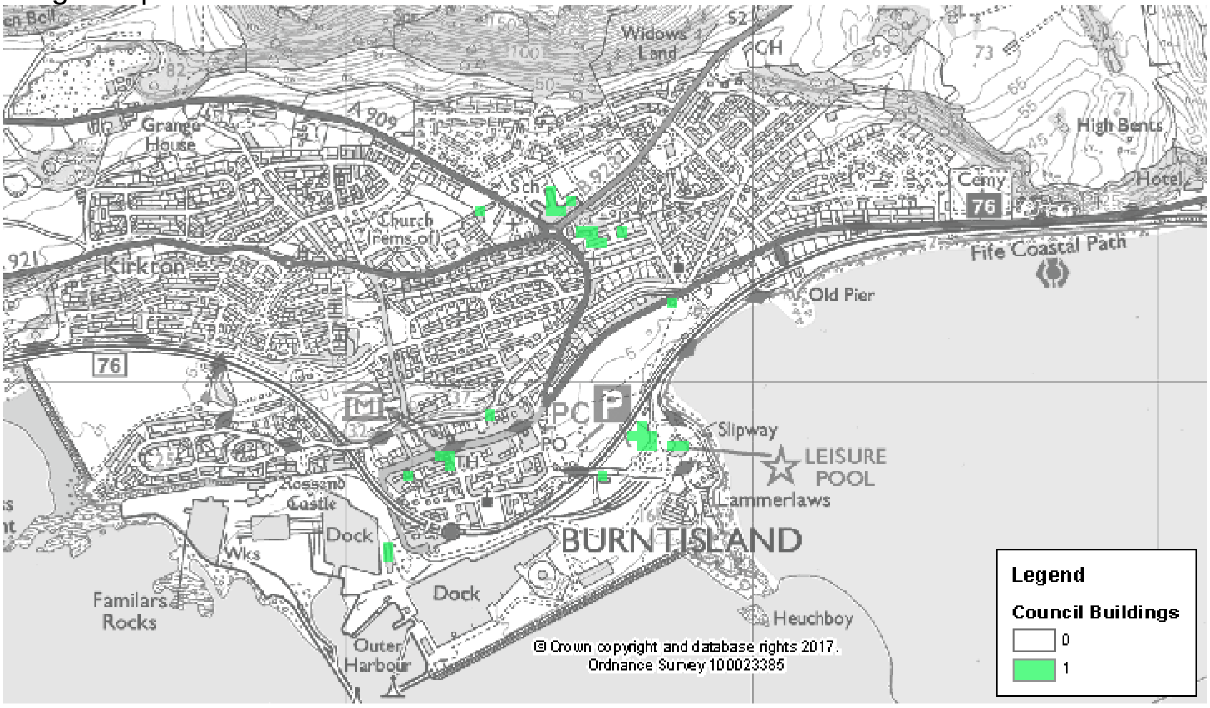
Source Fife Council research team – listed building

- Built heritage conservation area (Fife Council) outlines used to only identify properties with a heat demand, rasterised at 25m aggregating heat demand and reclassified 0 or 1, weighted positive 2 in final model.



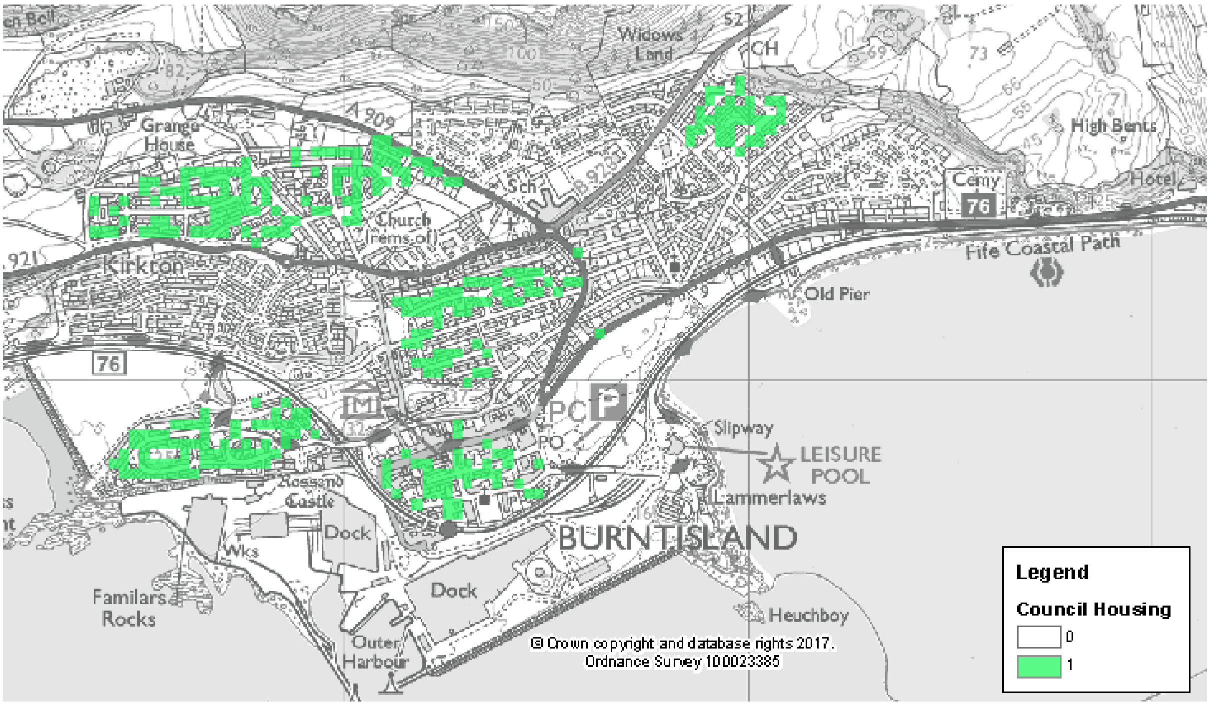
Source Fife Council research team – conservation area linked to building

- Council buildings (Fife Council) rasterised at 25m and reclassified as 0 or 1, weighted positive 2 in final model.



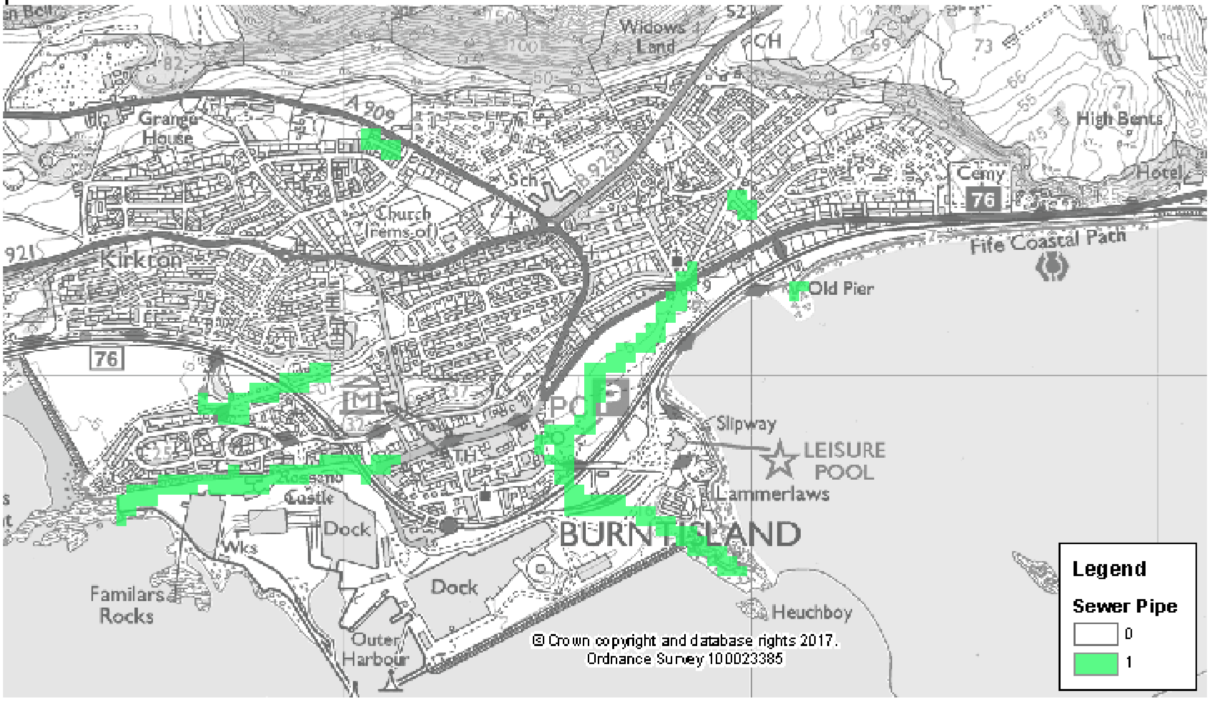
Source Fife Council research team – public buildings

- Council housing (Fife Council) rasterised at 25m, classified as 0 or 1, weighted +1



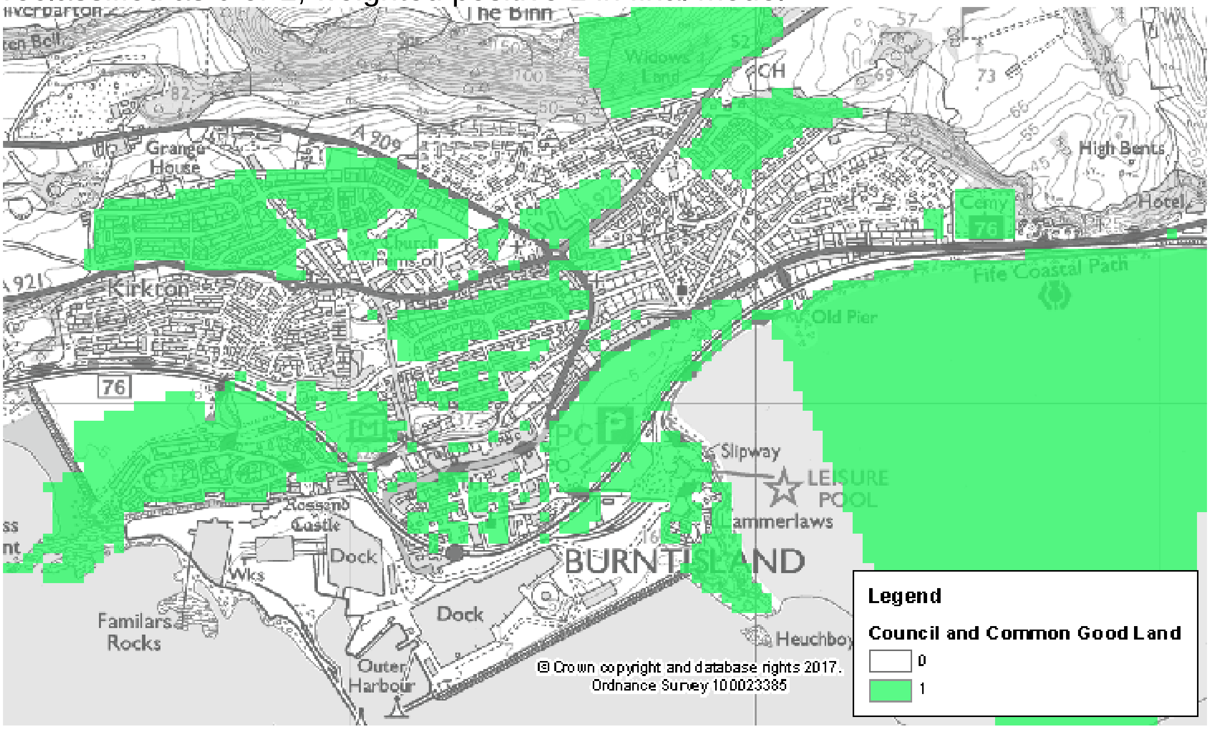
Source Fife Council research team – Fife Council housing

- Sewer pipe (Scottish Water), rasterised at 25m and classified 0 or 1, weighted positive 1



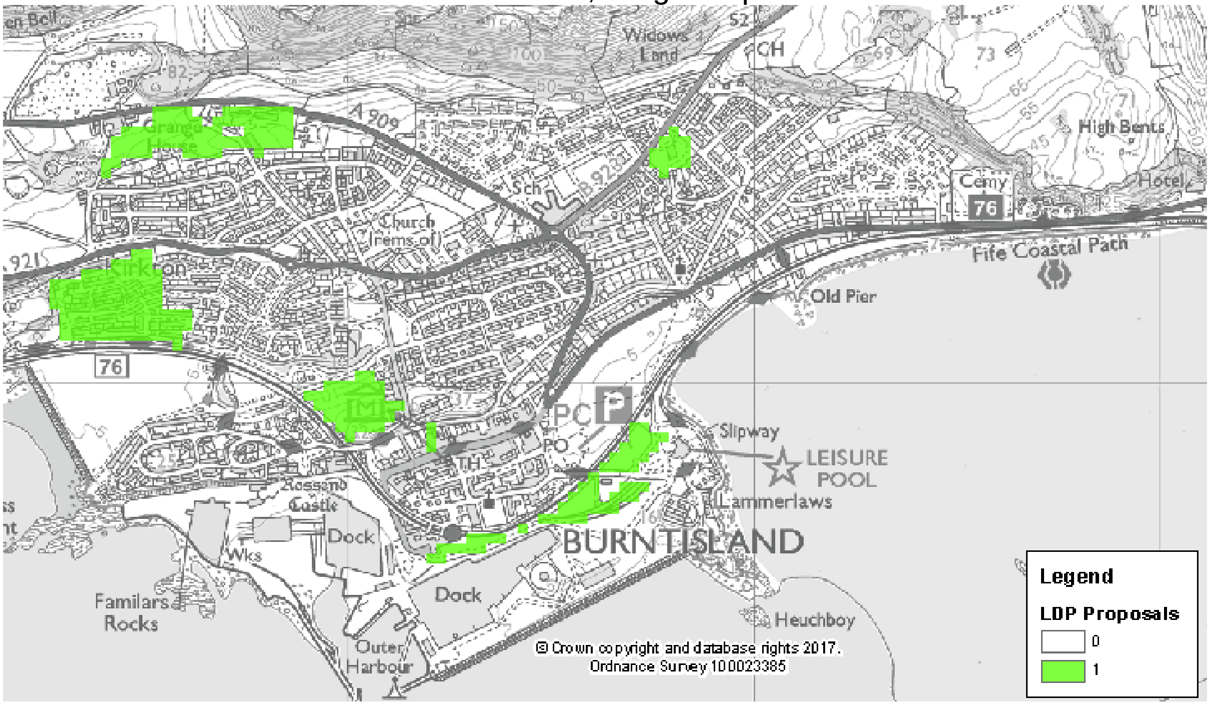
Source Fife Council research team – Scottish Water Sewer pipe opportunity

- Council and common good land ownership (Fife Council) rasterised at 25m and reclassified as 0 or 1, weighted positive 1 in final model.



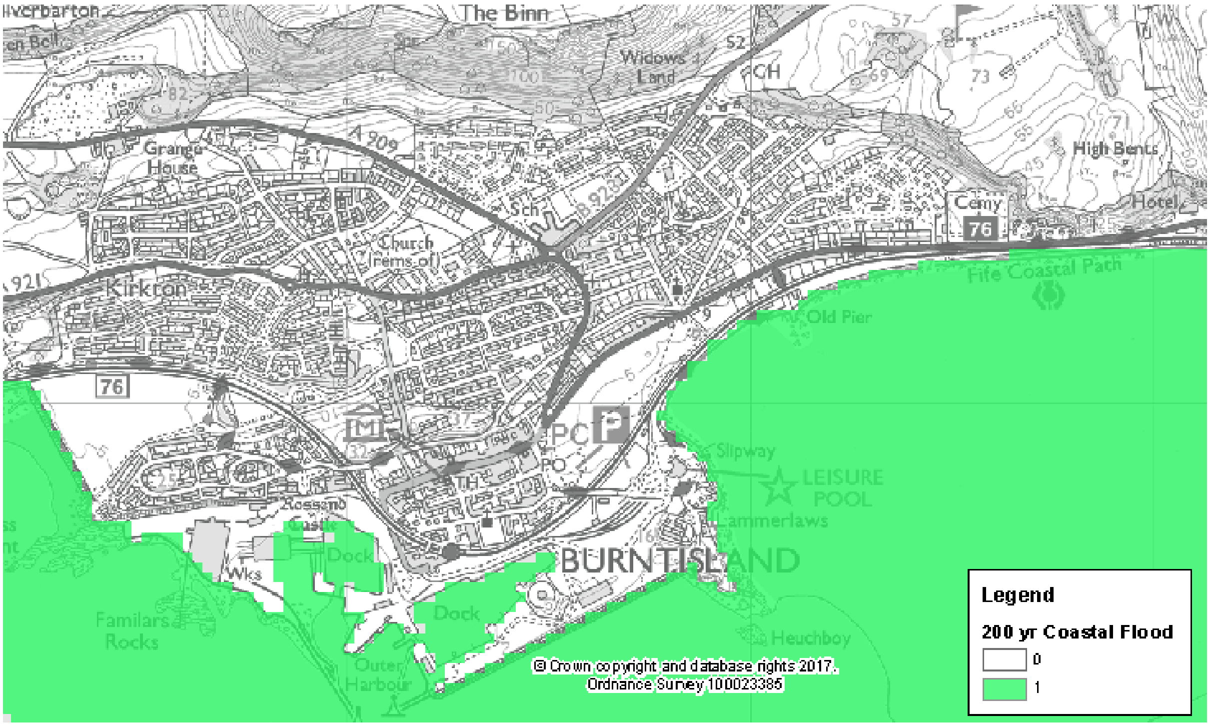
Source Fife Council research team – Council and Common Good land

- Local Development Plan proposal that exist and not yet started (Fife Council), rasterised at 25m and classified as 0 or 1, weighted positive 1



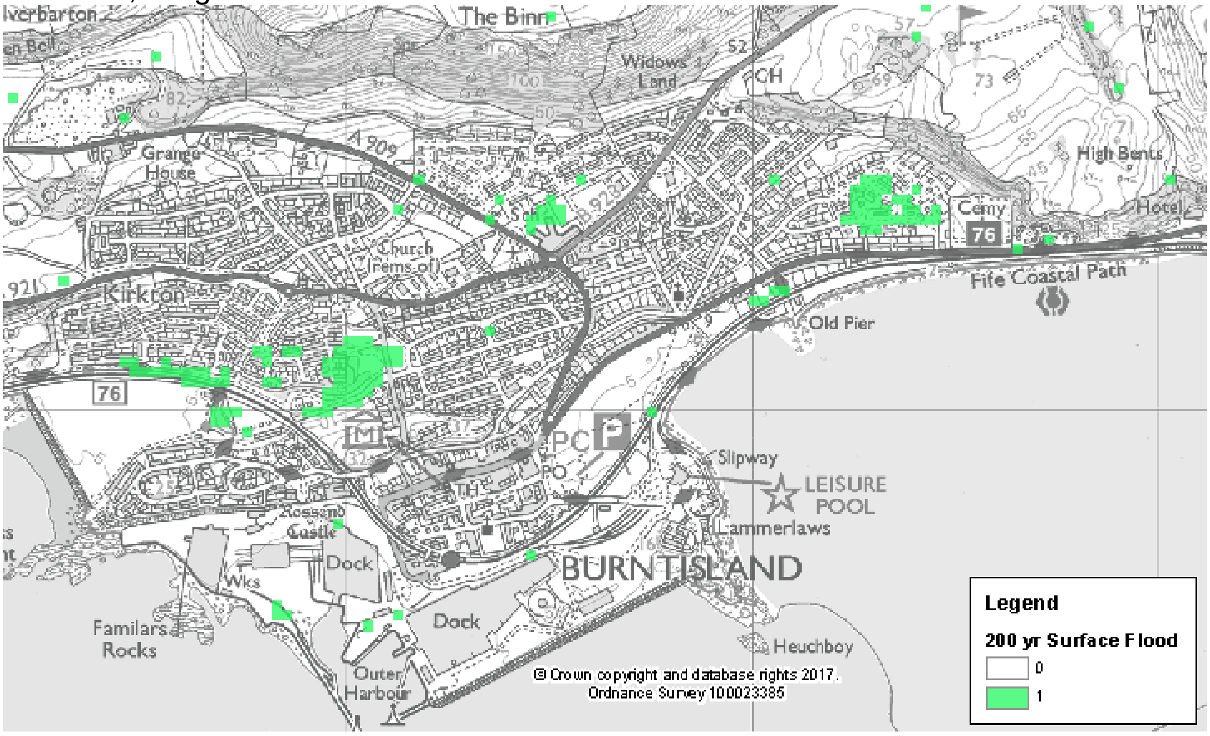
Source Fife Council research team – Local Development Plan opportunity

- **Constraints**. A limited number of constraints were chosen, and depending on the specific analysis they may not be considered a constraint. For example flood prone areas may be suitable for underground heat pipes as long as sensitive equipment is suitably sited/protected.
  - 200 year coastal flood likelihood (SEPA), rasterised at 25m and reclassified as 0 or 1, weighted negative 1



Source Fife Council research team – SEPA 200 year flood

- 200 year surface water flood likelihood (SEPA) rasterised at 25m and reclassified as 0 or 1, weighted -1



Source Fife Council research team – SEPA 200 year flood

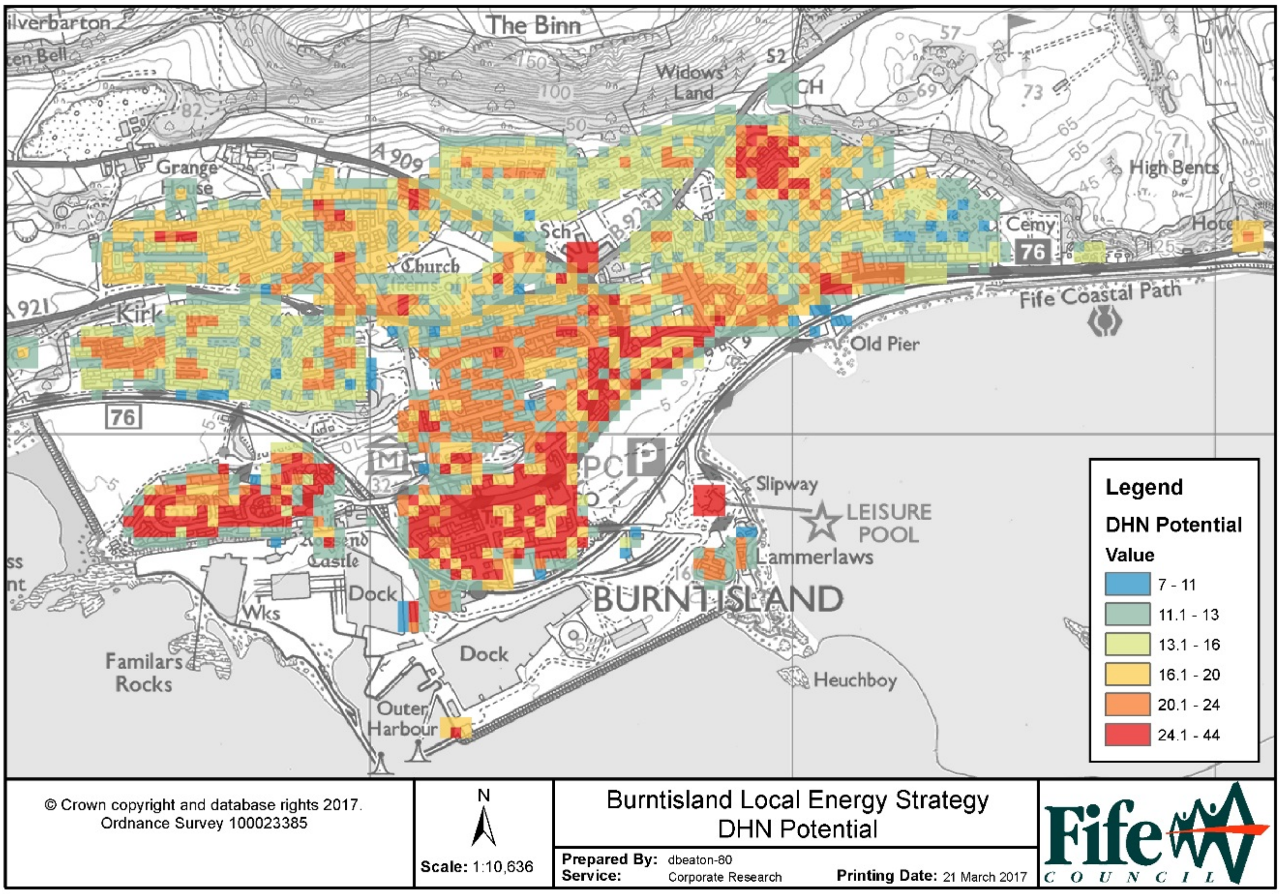
Output

- **Aggregation**. The input factors were considered individually and then aggregated using raster algebra with each factor given a weight to determine the best district heat network opportunities.

•

Factor	Weight	Reason
Heat demand	6	A significant heat demand is required
Gas Central Heating	1	A wet heating system is easier to adapt
Conservation Area	2	Less ability to insulate (reduce demand)
Listed Building	2	Significantly less ability to insulate (reduce demand)
Council Asset	3	Can guarantee 'buy in' to scheme
Council Housing	2	Single landlord to engage with
Fuel Poverty	2	Policy target area
LDP Proposal	1	Opportunity to design into scheme
Sewer Network	1	Opportunity to extract heat
Council land ownership	1	Easier to implement DHN on council land.
200 year surface flood	-1	Areas to avoid
200 year coastal flood	-1	Areas to avoid

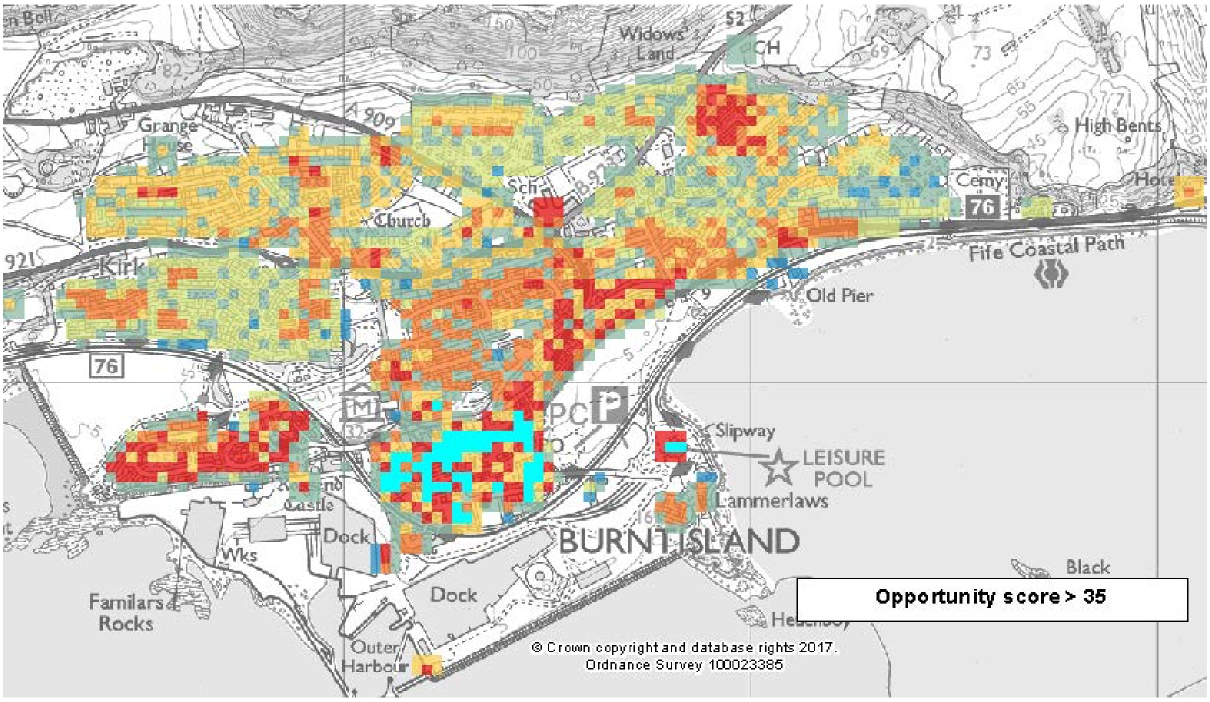
- Values of less than 7 were excluded from the visualisation since they are so low they would not be relevant to prioritising and distract from the opportunities being visualised.



Source Fife Council research team – aggregated DHN potential

DHN Opportunities				
Value	Count of 25m Cells		Value	Count of 25m Cells
-2	1		21	106
-1	3,486		22	67
0	50,496		23	69
1	726		24	89
2	114		25	62
3	26		26	27
4	6		27	17
5	13		28	10
6	4		29	20
7	4		30	20
8	4		31	45
10	3		32	12
11	30		33	8
12	366		34	4
13	228		35	6
14	43		36	8
15	258		37	9
16	84		38	7
17	82		39	9
18	147		40	2
19	68		41	1
20	129		42	1

Identifying (blue selection) those with a score > 35 identifies the local swimming pool and the centre of Burntisland.

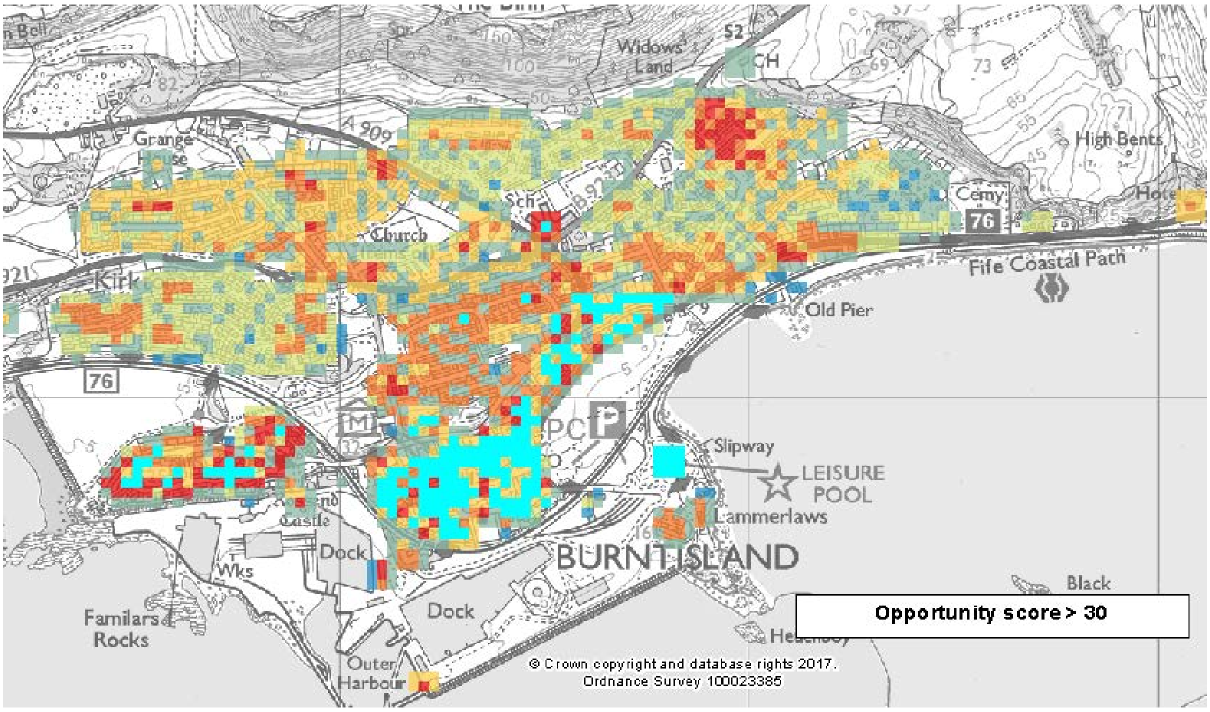


Source Fife Council research team – aggregated demand only showing larger score

Widening the score to > 30 includes the primary school, more of the conservation area and housing to the west which scores high for fuel poverty and being council housing.

Actions

- The approach to spatial analysis will be considered as an approach to assessing energy opportunity in the development of the next phase of the Fife Local Development Plan, and in developing energy efficiency and heat plans for Fife.
- Further possible developments include considering options where a greater number of policy areas might be considered. The proposed approach would test combining policy areas into weighted groups, to then highlight impact of groups of policies.



Source Fife Council research team – aggregated demand only showing larger score

The results were presented as spatial images, both individually to show the spatial impact of the underlying data, and together to show collective impact. The rasterised maps are shown below.

The layers were presented at the second community workshop (1 Mar). The layers provided a useful counterbalance to the economic and structural analysis that was presented. The spatial images strengthened the community desire to widen the heat network analysis beyond simply the existing economically viable options.

Interaction and influence on future Fife policy

The aim of this piece of work was to explore the place of Local Energy Masterplans within the Fife Council policy and plan landscape. Much of the emerging policy looks toward a growing role for communities and local planning within the wider plan and policy approach.

Many decisions around energy are controlled or influenced by local people and local decisions. Local Energy Masterplans have the opportunity to be a focus for communities and council's to explore and agree local actions and policies.

In turn Local Energy Masterplans could play an important role in guiding other spatial plans and higher level policies within an area.

Discussions were held with teams developing the new Local Outcome Improvement Plan, the Local Development Plan, and more local neighbourhood planning, to consider how the Energy Masterplan process could fit into the wider plan work in Fife.

Community Plans are being replaced by Local Outcome Improvement Plans (LOIP) across all local authorities in Scotland. The Fife LOIP will cover a whole local authority area. The LOIP will provide the strategic direction for all public bodies in Fife. Feeding into this will be a number of strategic themed plans, such as the Local Development Plan, Local Housing Strategy, and the Fife Economic Strategy. Alongside these Fife is in the process of developing a new Sustainable Energy Climate Action Plan (SECAP). The SECAP is envisaged to be the overarching energy policy document for Fife.

Supporting the LOIP, and the strategic themed plans, will be more local neighbourhood plans, providing more detailed area planning across Fife. These plans could focus on smaller geographies such as settlements, or cover locally important themes. For example, the Burntisland community has already developed its own Action Plan which was the driver for this Local Energy Masterplan pilot.

Local Energy Masterplans were seen to have a place feeding into:

- local neighbourhood and action plans; to guide decisions at a more local level
- the Fife Sustainable Energy Climate Action Plan; to input into the action list for Fife

Local Energy Masterplans were seen as valuable to influence:

- Strategic themed plan, particularly the Local Development Plans and Supplementary Guidance.
- the new Local Outcome Improvement Plan

Local Energy Masterplans also have a potential role in the Local Energy Efficiency and Heat Plans being proposed through the Scottish Government energy consultation papers.

12. Property archetype data validation exercise

The data group recognised the limitations with the agreed methodology to make it practical and able to be replicated for this and other studies. It was decided that a parallel validation exercise would be undertaken to check one of the archetypes. This would consider the energy demand reduction measures specialists in building energy modelling. By providing a sense check on the data input for the study, against site survey and existing research information, we would then be able to compare this with the approach undertaken and suggest further analysis that might be used to guide replication of any methodology in the future. The analysis was undertaken by the Scottish Energy Centre and the Institute for Sustainable Construction, Edinburgh Napier University.

The data and research papers used for this validation exercise included:

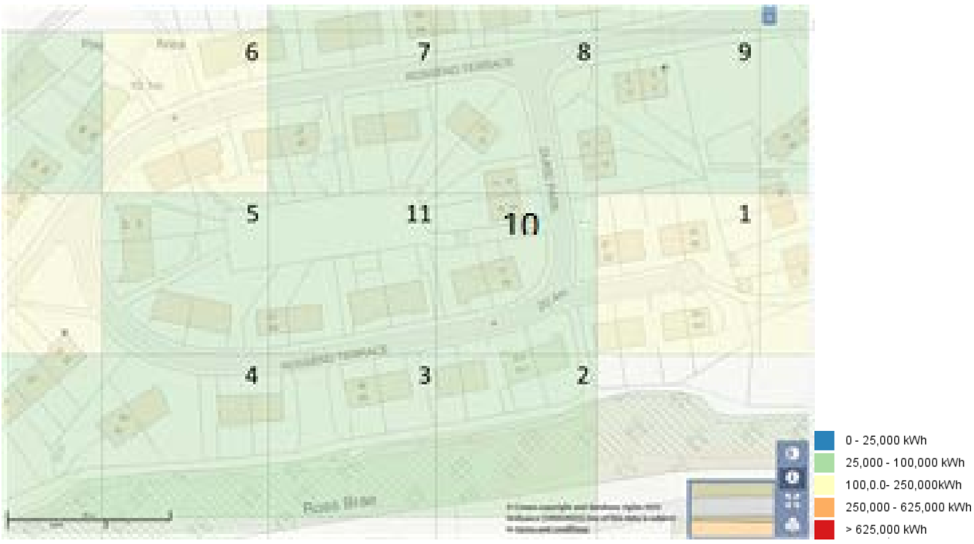
1. Scotland heat map (50m raster)
2. Scotland heat map attributes
3. Building archetype categories (supplied by the project team)
4. Standard Assessment Procedure [SAP] calculations for energy demand reduction measures (cavity wall insulation [CWI], external wall insulation [EWI], loft insulation and floor insulation) and for energy generation technologies (roof-mounted solar photovoltaic)
5. Fuel Poverty probability mapping (Changeworks data)
6. Energy Performance Certificate (for visited properties)
7. Napier University: Site assessment data (produced from physical street surveys)
8. Napier University: Site assessment (internal building surveys)
9. Napier University: Previous reports:
    - Bros-Williamson, J. (2015): *Improving traditional housing in Scotland: Refurbished Four-in-a-Block in Lochore, Fife*. Report to Sharp Construction Scotland in respect of funding by the Scottish Funding Council;
    - Currie, J., Bros-Williamson, J., Stinson, J. (2015): *ERACO-BUILD – Thermal energy report: Building performance evaluation of the four-in-a-block retrofit.* Report to BRE Scotland in respect of EU ERACO funded Sustainable Thermal Acoustic Retrofit (STAR) project;
10. Scottish Executive. (2001): *A guide to non-traditional housing in Scotland.* First Print 1987, Edinburgh: The Stationery Office.

The project data group directed the research team to focus on a common sub-archetype: namely the flat / four in a block. This was chosen because they represented a predominant archetype in Burntisland and because considerable research in the public domain was already in existence for this property archetype and could be utilised to augment any analysis.

To facilitate the validation of this stage of the data modelling, processes and data sources were shared where this could be done without additional data-sharing agreements. Data was shared at a datazone and settlement level.

The process of validating this stage of the data modelling process took the following steps:

1. Scotland heat map 50m raster squares were numbered and properties totalled per area. The raster squares were coded for analysis. An example of this is illustrated in the image below:



2. The area around Rossend Terrace was chosen as this had a predominance of the 4 in a block archetype; the advantages of this area were that it included properties owned by Fife Council; and the area is within an area of predicted high Fuel Poverty.
3. Energy Performance Certificates for owned properties (Fife Council and an owner occupier who participated in the study), were shared with Napier University.
4. A site survey was undertaken using Standard Assessment Procedure. This included a street survey of property types, photos of properties from the street, and an internal survey of an owner-occupied property.
5. Total Energy (kWh) used the Standard Assessment Procedure (SAP) methodology to calculate the 'fuel required for heating' for each dwelling based on the observations and measurements made during the street survey. These were added together to form the 'total fuel required for heating' for the block. A block was considered part of a map square when the majority of the buildings outline was within that square. Where the grid crossed on a block it was considered belonging to one or another by the location of the split. Data analysis was limited to Rossend Terrace only.
6. From the survey the buildings were categorised into 6 groups.
7. A comparison was undertaken against the Scotland heatmap 50m grid expected heat demand against surveyed Standard Assessment procedure results. This clusters the homes in each grid zone and compares them against the demand categories in the Heat Map.
8. Building type photos of the surveyed area revealed that the main differences in the properties classed as belonging to single archetypes, being the presence of extended hipped roof lines, different window sizes and also vestibules or draught lobbies in some properties. These photos were considered as part of the Standard Assessment Procedure, impacting on the results.
9. Space heating requirements and SAP score in were modelled in SAP for different future insulation scenarios featuring the uptake of different energy efficiency intervention measures. The figures used to support the insulation scenarios in SAP are:

Wall insulation scenario	Baseline	CWI (cavity wall insulation)	EWI (external wall insulation)
wall u-value (W/m²K)	1.48	0.42	0.19
wall kappa (kJ/m²K)	181.8	181.8	181.8
insulation	slightly ventilated cavity	60mm blown EPS beads 0.032 (W/mK) lambda	100mm PIR attached to external 0.022 (W/mK) lambda

Roof insulation scenario	Baseline	Cold roof[44]
roof u-value uninsulated (W/m²K)	1.75	0.16
roof kappa (kJ/m²K)	8.8	8.8
roof insulation	none	100mm mineral wool quilt between joists then 170mm mineral wool quilt above joists 0.044 (W/mK) lambda

Floor insulation scenario	Baseline	Floor insulation installed to timber floors only
floor u-value uninsulated (W/m²K)	1.41	0.22
floor kappa (kJ/m²K)	18.3	18.2
floor insulation		100mm under floorboard 0.04 (W/mK) lambda

10. The dimensional data for the properties was abstracted from the following sources:
    - Bros-Williamson, J. (2015). *Improving traditional housing in Scotland: Refurbished Four-in-a-Block in Lochore, Fife.* Report to Sharp Construction Scotland in respect of funding by the Scottish Funding Council;
    - Currie, J., Bros-Williamson, J., Stinson, J. (2015). *ERACO-BUILD – Thermal energy report: Building performance evaluation of the four-in-a-block retrofit.* Report to BRE Scotland in respect of EU ERACO funded Sustainable Thermal Acoustic Retrofit (STAR) project; and
    - Scottish Executive. (2001). *A guide to non-traditional housing in Scotland*. First Print 1987, Edinburgh: The Stationery Office

11. The information used for modelling solar PV feasibility use the tables and formulae within *The SAP Methodology*:

[44] Roof construction types can be defined as hot or cold roofs. In cold roofs, the outside air is allowed to freely flow under the roof sheathing. In hot roofs, the insulation is typically installed close to the roof sheathing, but the main characteristic is the space under the sheathing is closed to fresh air flow. According to Building Standards all structural voids not filled with some material should be ventilated.

Modelled PV system size	2.5 kWp
Assumed tilt / roof pitch	45 degree
Assumed orientation	South
Assumed over-shading	Very little

12. The four in a block archetype was subdivided again from A-F to allow consideration of minor structural differences between the actual properties defined within a sub-archetype. These modest differences to the sub-archetypes resulted in a very minor change to its performance and a slight visual alternation, which were not considerable enough to warrant a new archetype sub-classification. These were categorised as Ai, Aii and Aiii etc. The alterations covered within this process that needed to be modelled included:

    - A.1 = 2 first floor windows on side elevation, above front door larger due to smaller roof overhang.
    - C.1 & D.2 = front door on vestibule, increasing floor area and the addition of 2 narrow windows.

13. A table of results per house type was produced showing the possible energy efficiency improvements which could be installed. These were shown separately for improvements to the walls, roof and floor; and then combined. The addition of Solar PV was also included in the modelled outputs.
14. The results produced were based on the fuel required to provide space heating. The results were displayed as graphs.

The outputs from this stage of the modelling are estimated figures for the following metrics:

- Fuel space heating requirements: expressed as total kWh / year
- Archetypes are shown as ground floor GF or first floor FF.
- Results are provided for: Business As Usual (BAU), Cavity Wall Insulation CWI, External Wall Insulation EWI, Roof Insulation, Floor Insulation, and Solar Photovoltaic PV.
- Standard Assessment procedure demand categories are shown, as well as score against measures.

Results

The results from this phase of the modelling are presented in this section. The examples of the flat property archetypes was chosen. The four flats in a block property type was agreed for this part of the study. This is a common property type and one that had previous research that could be drawn on to augment this work. The sub types of four in a block identified are illustrated below:

House type - A	House type - B	House type - C
		
		

House type - D	House type - E	House type - F
		
		

The modelled space heating requirements associated with these property archetypes are presented in the table below under the baseline column. Whether the property is on the ground floor (GF) or first floor (FF) is illustrated in the second column from the left. The different energy efficiency scenarios are modelled under the subsequent columns (from left to right: cavity wall insulation, external wall insulation, roof insulation, floor insulation and a cumulative scenario of all measures. Finally the last column illustrates the impact of all measures and the installation of PV panels on the space heating requirements for these property archetypes.

		Fuel space heating requirement (kWh / per year)						
Property Type	floor	Baseline	CWI	EWI[45]	Roof	Floor	All	All + PV
A	GF	12,144	9,926	9,425	-	8,560	5,287	5,287
A	FF	13,135	10,984	10,506	8,219	-	5,090	5,090
A.1	FF	12,797	10,251	9,675	8,720	-	5,093	5,093
B	GF	14,998	12,570	12,027	-	10,500	6,933	6,933
B	FF	17,463	14,532	13,881	11,116	-	6,826	6,826
C	GF	14,730	12,332	11,796	-	10216	6,814	6,814
C	FF	15,872	13,451	12,916	9,852	-	6,313	6,313
C.1	FF	16,477	13,804	13,212	10,387	-	6,482	6,482
D	GF	14,588	12,179	11,640	-	10,066	6,641	6,641
D	FF	15,731	13,300	12,763	9,702	-	6,139	6,139
D.1	FF	16,603	13,796	13,173	10,506	-	6,408	6,408
E	GF	17,886	14,641	13,909	-	12,654	8,020	8,020
E	FF	19,194	15,975	15,260	12,226	-	7,497	7,497
F	GF	15,000	12,523	11,967	-	10,320	6,786	6,786
F	FF	16,225	13,848	13,324	10,030	-	6,569	6,569

What this results in for the same scenarios, in terms of the SAP score for each of these property archetypes, is presented in the table below:

[45] Note that Napier University assumed that both EWI and CWI would be retrofitted to properties where they were both applicable. This was not assumed in our earlier modelling, and in reality it may be unlikely to happen because the payback for EWI is so high even where CWI is not present, if CWI were present then the benefits realisable from installing EWI as well, would make the payback over 50 years which would be beyond the useful life of the EWI cladding.

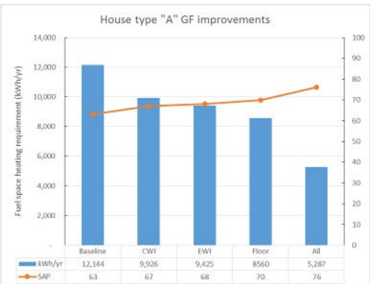
		Changes in SAP score							
Type	floor	Baseline	CWI	EWI	Roof	Floor	PV	All	All + PV
A	GF	63	67	68		70		76	76
A	FF	62	66	66	70		76	76	90
A.1	FF	62	67	68	70		76	76	90
B	GF	64	67	68		71		76	76
B	FF	61	65	66	70		72	76	88
C	GF	64	67	68		71		76	76
C	FF	62	66	66	71		74	77	89
C.1	FF	61	65	66	70		73	76	88
D	GF	64	68	66		71		76	76
D	FF	62	66	67	71		74	77	89
D.1	FF	61	65	66	70		73	77	89
E	GF	63	67	68		70		76	76
E	FF	61	65	66	70		71	77	88
F	GF	64	68	68		71		76	76
F	FF	62	66	67	71		74	77	88

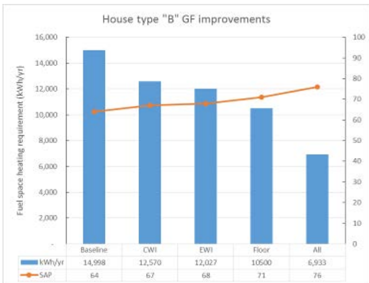
Finally these results are presented as graphs in the figures below:

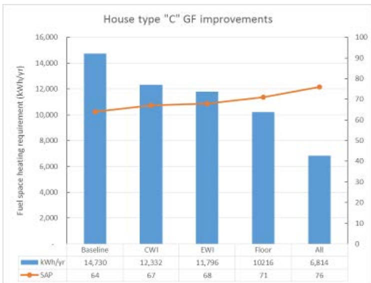
House type - A

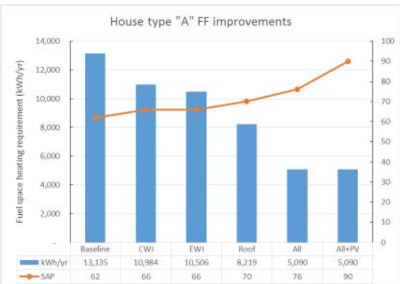
House type - B

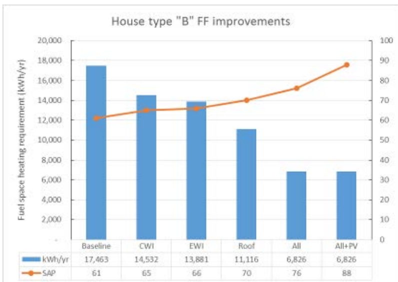
House type - C

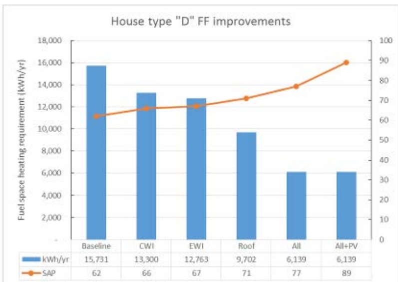


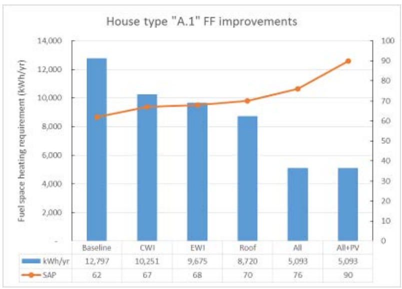


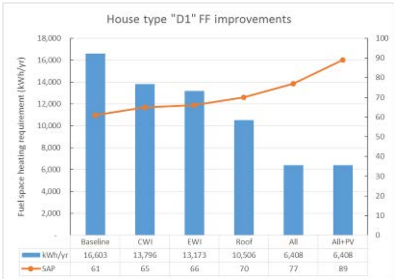




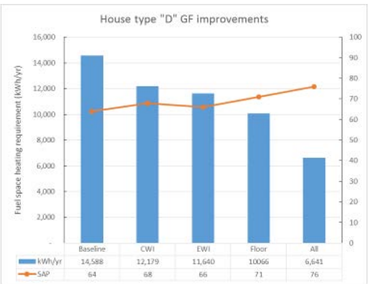


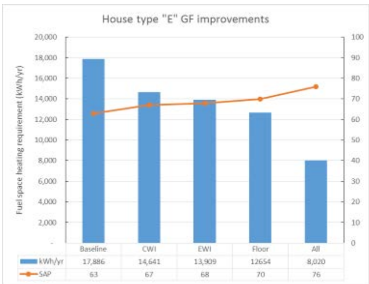


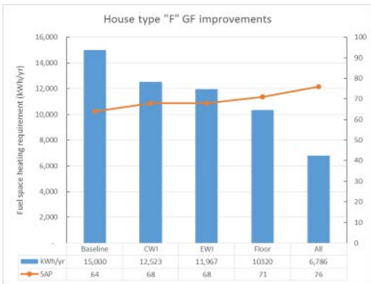


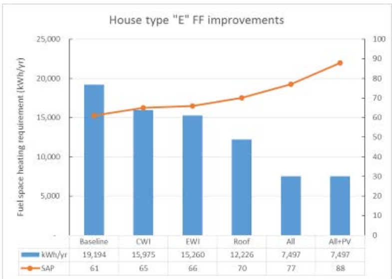


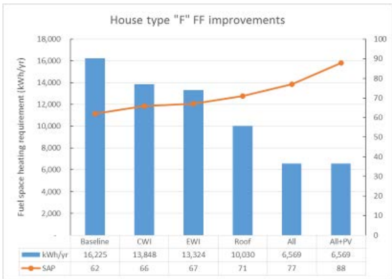
House type - D	House type - E	House type - F

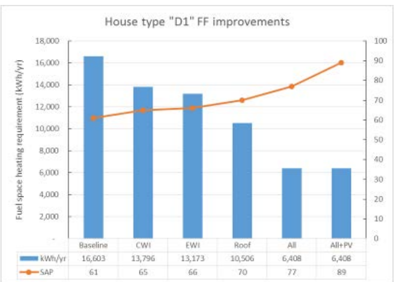












Discussion

The detailed validation was initiated provide a comparator and validation to the outputs of the other data analysis. The project team were satisfied that this approach produced robust figures for estimated energy demand from the settlement that was based on the actual property types on the ground in Burntisland rather than relying on the benchmarked data estimations from the Scottish Heat Map alone. Both approaches demonstrated that all of the property archetypes identified during the study have shown considerable potential for energy efficiency improvements.

A notable point from the detailed study is the higher energy demand returned from the street SAP survey.

The detailed analysis enabled more detailed archetypes to be considered.

The SAP Survey returned a slightly lower energy saving when both CWI and EWI were used. This does not seem to be reflected in the Energy Saving Trust figures. A further piece of work to agree figures for combining energy efficiency measures is recommended.

Due to the short nature of the project a full cross analysis of the results was not possible. The concept for this additional detailed piece of work was to demonstrate the potential of more rigorous research to support and in influence future data analysis. Consideration should also be given to undertaking similar analysis across the other archetypes.

13. Transport Energy

Overview of the modelling process

Modelling overview

2. Energy demand (vehicles)

Key questions

a) What are the boundaries of the study area?

b) How many vehicles are there in Burntisland?

c) What is the average usage pattern for car owners in Burntisland? (Miles per person and miles per car / van)

d) What does it cost to run Burntisland's private vehicles?

e) What GHG emissions are associated with this fuel consumption?

f) If Burntisland residents switched to EV what would the savings be in carbon and running costs?

g) If Burntisland did replace hydrocarbon vehicles with EV, what would the total demand be for electricity to fuel these vehicles?

Data sources

Burntisland Community Council Boundary (Fife Council GIS)

National Address Gazetteer Unique Property Reference Number (UPRN)

Burntisland settlement boundary (National Records Centre)

Datazone boundaries and Census output areas (CENSUS> 2011> output area> Locality 2010> Burntisland> household)

Department for Transport National Travel Survey (2014) 'How people travel by car' statistics

Department for Transport Annual Statistics / annual mileage (2015)

National Travel Survey (Scotland), Transport Scotland (2011-12)

NTS0903 Annual mileage of 4-wheeled cars by fuel type, age and trip purpose, UK, 2012

Energy Saving Trust vehicle cost metrics (petrol / diesel). http://www.energysavingtrust.org.uk/about-us/our-calculations

Fleetworld data and manufacturers fuel efficiency figures (including Nissan Leaf electric vehicle)

2016 UK Greenhouse Gas Reporting Emission Conversion Factors (BEIS)

Modelling decisions made

This modelling phase sought to assess the potential demand for electricity in Burntisland, if all of the existing light vehicle fleet in the town (cars and small vans), were EV.

This could then be used to assess the impact on electricity demand for different scenarios of EV take-up. The settlement boundary was used for this phase of modelling.

Discussions were held with colleagues in Fife Council's Transportation Services to develop the methodology and determine the most appropriate data sources.

Household numbers, and the number of cars and vans per household in Burntisland, were taken from the Census data.

Reviewed a number of methodologies and datasets for estimating car and van mileage per year. Statistics, most frequently, relate to mileage travelled per person, rather than per vehicle.

Reviewed car manufacturer fuel efficiency data, Fleetworld data, EST figures to derive probable kW per mile figure for an average vehicle.

Fuel costs were estimated based on Government datasets (HMRC), and then checked against EST and Fleetworld data.

Emissions factors were taken from the BEIS 2016 dataset to calculate the emissions associated with different vehicle types.

We used the emissions factor per mile driven for an average car with an unknown fuel mix to represent the emissions for the current vehicle fleet in Burntisland. This is 0.30088 kgCO2e per mile. For the EV we used the emissions factor for a popular EV (the Nissan Leaf) which is 0.071 kgCO2e per mile.

To sense check the calculations for the EV fleet we multiplied the energy consumption needed to power the vehicle fleet (3721 MWh) by the BEIS emissions factor for grid electricity including T&D losses.

In reality with a low carbon local grid, the emissions factor for this electricity would be far less carbon intensive, and the carbon savings would be much greater than shown here.

Results

a) The study area is 2.4 km2 and was defined by the settlement boundary.

b) There are estimated to be 2,855 light vehicles in Burntisland. 30.5% of Burntisland households have no access to a car. 42.2% have access to 1 car or van. 21.6% have access to 2 cars or vans. 5.6% of Burntisland households have access to 3 or more cars / vans.

c) Average trip assumed to be 29 minutes, Scottish residents travelled an average of 7,161 miles per person. This equated to an average of 8,700 miles per vehicle.

d) Petrol vehicles assumed to have an average running cost of £0.16p. Diesel vehicles assumed to have an average running cost of £0.11p and a combined average cost of £0.13p. EV cost £0.03p per kWh.

e) Outputs in kgCO2e per gross calorific value kWh, for exact factors see:

https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2013

f) A typical EV emits 71.61g of CO2e per mile driven (assuming grid electricity is used for vehicle charging, this could be reduced to zero if charging used a local renewable smart grid), an average UK conventionally fuelled vehicle, of unknown fuel (i.e. reflecting the average UK fuel mix) emits 300.88g CO2e per mile.

g) It was estimated that the total light vehicle fleet in Burntisland, drives 25,384,947 miles per year. To supply this energy from electricity would require 6,092,387 kWh / 6,092 MWh.

h) Today it costs Burntisland residents £3,439,660 to run their hydrocarbon vehicles. If all of the light vehicles in Burntisland were EV vehicles, it would cost the town £792,574 a year to run the vehicle fleet. This would be a massive saving of £2,647,085 every year. Or £927 a year per vehicle.

i) Today the car and van fleet in Burntisland, cumulatively emits approximately 7,632 tCO2e every year. Which works out at an average 2.67 tCO2e per vehicle per year.

j) Assuming these vehicles were replaced with EV and that grid electricity was used for charging these vehicles this would equate to carbon emissions of 2,737 tCO2e arising from the light vehicle fleet in Burntisland every year, which works out at a total of 0.96 tCO2e per vehicle per year. The carbon savings arising would be 1.71 tCO2e a year per vehicle. Or a total saving of 4,895 tCO2e per year for the whole of Burntisland. This would cut emissions from the light vehicle fleet by 64%.

RESULTS - Transport

Electric cars and light vans show a significant short term financial benefit to the community. Each vehicle would reduce average fuel costs by £927. Changing all the cars and light vans in Burntisland would make an annual reduction in fuel costs of around £2,667,000 at today's prices.

- Phase 1: includes development up to 2032. A target for 927 electric cars and light vans will be set for before 2032. Local community clubs and social meetings will encourage use and improve efficiency. Alongside this the community will investigate a community car club. Sustainable transport options are also being considered with funding sought for walking and cycling routes in the town, a travel hub and improved access to the railway station. At this develops the town will promote itself as an electric vehicle tourist destination.
- Phase 2: will see the roll out of electric cars and light vans across the town.

Introduction

Travel represents 24% of Scotland's energy demand. In terms of household emissions, approximately one third of the total carbon emissions associated with a typical UK household arise from travel activities. Therefore it was important that the project focus not just on building energy consumption, but also on how people travel around in their day to day lives.

This element of the project assessed scenarios whereby different proportions of Burntisland's total light vehicle fleet (i.e. cars and vans) were replaced by Electric Vehicles (EV), to understand what the potential impacts would be on electricity demand, running costs and carbon emissions.

Current EV ownership rates

In the UK in 2015-16, 87,000 low and ultra-low emission vehicles (ULEV) were registered, out of a total of 31 million cars on UK roads. In Scotland, ownership levels of low emission vehicles, has, until recently, been lower than in other parts of the UK (although there are signs that this is changing). According to Transport Scotland, 3,600 ULEV vehicles were registered in 2014 (the latest year for which data is available from Transport Scotland[46]), out of a total 2.8 million vehicles on Scotland's roads. Thus as of 2016 0.003% of all vehicles on UK roads are currently low emission vehicles; and, as of 2014, 0.0012% of vehicles in Scotland were low emission vehicles. This suggests that between 0.0012 and 0.003% of vehicles on Fife's roads can be estimated to be EV or LEV (low emission vehicles).Transposing this to Fife suggests that, given that there are approximately 162,200 households in Fife[47] and approximately 170,148 cars registered in Fife available for private use[48], approximately 204 to 510 of these can be assumed to be ULEV[49].

In terms of the type of low emission vehicles on UK roads, latest figures suggest that plug-in hybrid electric vehicles (PHEVs) currently account for around two-thirds of ULEVs being sold in the UK, and battery electric vehicles (BEVs) a third.

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[46] http://www.transport.gov.scot/report/j415388-04.htm

[47] Census data, 2011, https://www.fifedirect.org.uk/news/index.cfm?fuseaction=news.display&objectid=A02B18B5-EA79-83A9-D629D5873A89C073

[48] Transport and Travel in Scotland 2015, Transport Scotland http://www.transport.gov.scot/report/j450918-00.htm which reports that 26.4% of Fife households do not have access to a private car, 47.5% of Fife households have one private car (estimated at 77,045 cars), 20.9% have two private cars (estimated at 67,800 cars) and 5.2% have access to three or more private cars (estimated at 25,303 cars). In total this comes to 170,148 cars registered, or available for private use by households within Fife.

[49] Transport and Travel in Scotland 2015, Transport Scotland http://www.transport.gov.scot/report/j450918-00.htm

Data inputs

A core challenge was to find a way to associate vehicle demand with the same data areas used in the other parts of this analysis, namely buildings or settlement. Data for this phase of the modelling was sourced from a wide range of sources as detailed in the diagram above, including but not limited to:

- Census output areas (2011) [CENSUS > 2011 > output area 'Locality 2010' > area 'Burntisland' > Household > Number of Cars / vans per household> download;
- Department for Transport National Travel Survey (2014) 'How people travel by car' statistics to allow the team to understand the average miles travelled per person and per car/van and also to assess the context / journey purpose of why people travel by different transport modes;
- Department for Transport Annual Statistics / annual mileage (2015);
- National Travel Survey (Scotland), Transport Scotland (2011-12) and specifically table NTS0903 Annual mileage of 4-wheeled cars by fuel type, age and trip purpose, UK, 2012;
- Energy Saving Trust vehicle cost metrics (petrol / diesel). http://www.energysavingtrust.org.uk/about-us/our-calculations;
- UK Government mileage cost (petrol / diesel) and the associated HMRC mileage calculation methodology and expenses rates;
- Energy Saving Trust vehicle costs (for petrol / diesel fuelled vehicles);
- Fife Council EV data (for real world examples of EV running costs and mileage to add a more realistic slant to the efficiency data provided by vehicle manufacturers which has been subject to considerable claims of exaggeration, unreliability and even data fraud in recent years);
- *Fleetworld* data and manufacturers' quoted fuel efficiency figures (including figures for the Nissan Leaf electric vehicle as the representative EV for the study.

In addition to the written data sources documented above, discussions were held with Fife Council's Transportation Services including Fleet Services and Sustainable Travel colleagues in developing the methodology and assessing the most appropriate data sources.

Today it costs Burntisland residents £3,439,660 to run their light hydrocarbon vehicles. If all of the cars and light vans in Burntisland were electric vehicles, it would cost the town £792,574 a year to run the vehicle fleet. This would be a massive saving of £2,647,085 every year. Or £927 a year, every year, per vehicle. This would represent a saving of 5% of the average Scottish household income every year. A figure which if spent locally could offer significant benefits to the town's economy.

Analysis

The first stage of the assessment was to estimate the number of cars or vans in Burntisland.

Although DVLA data would be the ideal source, it was considered on a previous occasion and proved prohibitively costly. The project team used census data to identify the number of cars and light vans owned by Burntisland households in 2011, the latest year for which census data is available.

This revealed the following information:

Average number of cars or vans per household in Burntisland Households (2011)	
Percentage of households with access to no car or van	30.5%
Percentage of households with access to 1 car or van	42.2%
Percentage of households with access to 2 cars or vans	21.6%
Percentage of households with access to 3 or more cars or vans	5.6%
Total estimated cars / light vans in Burntisland	2,855

The baseline estimation for the total number of cars / vans in Burntisland was then used to estimate the total mileage that this fleet could be assumed to drive, on average, cumulatively, over a year and what this would require (in terms of electricity demand) was this mileage to be undertaken by a typical EV rather than the existing internal combustion engine vehicles.

These calculations are illustrated in the table below:

Average number of cars or vans per household	Miles (average)	Average EV miles per kWh
	8,766.67	0.24
% No car or van	0	0
% 1 car or van	10,562,167.67	2534920.24
% 2 cars or vans	10,812,456.00	2594989.44
% 3 or more cars or vans	4,204,844.00	1009162.56
Total	25,579,467.67	6,139,072.24

What this equates to in carbon was calculated using BEIS Greenhouse Gas Reporting emissions factors. This revealed that today the car and van fleet in Burntisland, cumulatively emits approximately 7,632 tCO2e every year. Which works out at an average 2.67 tCO2e per vehicle per year.

Using these calculations the estimated EV demand for the Burntisland vehicle fleet (assuming the same number of vehicles and the same annual mileage driven) would equate to additional electricity demand of 6,139,072.24 kWh / year, or 6,139.07 MWh / year.

Today the light vehicle fleet in Burntisland cumulatively emits approximately 7,632 tCO2e every year. Or 2.67 tonnes per vehicle.

Average number of cars or vans per household	£p mile petrol / diesel	£p kWh / mile
	£0.14	£0.03
% No car or van	£1,431,173.72	£329,774.35
% 1 car or van	£1,465,087.79	£337,588.90
% 2 cars or vans	£569,756.36	£131,284.57
Total	£3,466,017.87	£798,647.82
Annual saving for Burntisland residents and businesses:		£2,667,370.05

An annual community saving of £2,667,370 from Burntisland's 2,855 vehicles, would deliver a saving of £927 a year, every year per vehicle. Given that average household incomes in Scotland are estimated to be £23,000[50] this is a very significant saving which could have considerable social benefits and economic benefits for the local economy if some of these household savings were spent locally.

Our findings were validated by a comparative assessment undertaken using the *Fleetworld* website calculator using real vehicle models, and based on actual fleet operator information rather than manufacturer's estimated fuel efficiency data[51]. Fleet vehicles have a higher average annual mileage which is reflected in the savings. This exercise supported the case that the running costs for EV are significantly lower than for comparable petrol or diesel vehicles.

Make	Nissan Qashqai	Nissan Leaf
Model	1.5 dCi Acenta 110PS	Electric Cars isia 24kWh Auto
Annual fuel cost (average)	£2,991	£963
Savings on fuel	n/a	£2,027
Miles per gallon	57.6	n/a
Battery range (miles on one charge)	n/a	124
UK average kWh cost		14.05p
Emissions	159.33g/mi	71.61g/mi

Motivations

Private EV owners most commonly cite the following motivations for buying an EV: saving money on fuel costs; environmental factors; and interest in new technology. The most commonly cited motivations for buying an EV for fleet purchasers are: financial factors; and environmental factors (linked to CSR [Corporate Social Responsibility]).

Advice from Fife Council's Fleet Services professionals suggests that other running costs for EV would also be lower than the equivalent costs for conventional vehicles. There are a number of other financial motivations that may accelerate the transition from conventional to EV and ULEV vehicles[52] including:

- The lifetime running costs of an electric or plug-in hybrid vehicle are considerably lower than those of a conventional vehicle and offset the higher initial purchase price. Plug-in cars offer a number of potential savings compared to conventional vehicles, for example: a full charge will cost around £2 to £3 and will give a typical range of 100 miles. Driving 100 miles in a petrol or diesel car costs around £9 to £13 in fuel, that is around four times more expensive than driving the same distance in an EV.
- The cost savings will be greatest when owners have access to an overnight low rate electricity tariff or where they can access free public EV charging points (such as those

[50] 2014 figures, Resolution Foundation

[51] Which has been shown to be unreliable, in recent years.

[52] Uptake of Ultra Low Emission Vehicles in the UK A Rapid Evidence Assessment for the Department for Transport, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/464763/uptake-of-ulev-uk.pdf

distributed across Fife). For some drivers who live and work in close proximity to an EV charge point this could equate to fuelling their vehicle for free.

- Given that low emission vehicles are exempt from road tax, the only running cost in such instances would be insurance - this would offer a massive cost saving for most Scottish households and could deliver real knock-on benefits for the local economy;
- Plug-in vehicles are currently exempt from Vehicle Excise Duty (road tax); are eligible for a 100% discount from the London Congestion Charge, worth up to £2,900 a year and receive free parking in many urban areas.
- As there are fewer mechanical components than conventional vehicles servicing and maintenance costs are lower too.

These benefits need to be considered against the comparative higher purchase price for most EV, although this is falling as global take-up increases at pace. The proportion of the Scottish and UK vehicle fleet that are low emission vehicles is low when compared to other countries around the world, and suggests that the UK is somewhat behind the curve. For example, in Norway a quarter of all vehicles are electric or hybrid electric vehicles already, and China which currently has over 550,000 EVs, is installing 800,000 charging points this year and expects to produce 2,000,000 LEV or ULEV a year by 2020. Because of the dramatic increase in global take up of EV, significant reductions in the purchase price of these vehicles are expected over the coming decade.

Barriers

The EV market in the UK is growing but remains small and there is concern there is a risk that insufficient vehicles are being sold and / or manufactured in the UK relative to the rate of change suggested to meet demand. However when considered against the global uptake of EV it seems that these concerns may be overstated.

The most commonly cited barriers to private car buyers buying an EV in the future are:

- Range concerns;
- Purchase price; and
- Lack of knowledge about / familiarity with EVs.

The most commonly cited barriers to fleet purchasers are largely the same as those for private car buyers: range concerns; purchase price; and a lack of knowledge about / familiarity with EVs[53].

[53] Uptake of Ultra Low Emission Vehicles in the UK A Rapid Evidence Assessment for the Department for Transport, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/464763/uptake-of-ulev-uk.pdf

14. Evaluation and lessons learned

Community engagement

Internal evaluation undertaken by the project team considered project performance against the following objectives (which were devised at the project outset):

Engage with as many of the community as possible	We followed the guidance from the National Standard for Community Engagement. Within the timeframe we reached a wide variety of community members but recognised that a longer time frame would have allowed for engagement with even more of the community.
Engage with the hard to reach audience (many of whom are likely to be those in fuel poverty)	The project team did their best to deliver this objective within the timeframe, but recognise that some hard to reach groups were not engaged with to the degree that we would have liked. One key barrier was the ability to share data between Council Services to allow the project team to more accurately gauge the location of low income residents. Low income groups can often be hard to reach sectors of any community. Because the pop-up-shop used to be the local Fife Council office for Burntisland, many people came in because they wanted to request help from the Council. We were able, to a small extent to help them and introduce them to the project and the Cosy Kingdom energy efficiency advice service. In future projects we would also link in with primary care providers such as the NHS, Fife Council's Social Work Service and Welfare teams at the project planning stage.
Deliver events on a wide range of topics to include energy efficiency, low carbon energy and fuel poverty etc. to enable the local community to debate and make decisions for themselves around local energy	Yes we were pleased we were able to deliver to the community's needs with 18 different community events, including a range of hugely-respected external speakers in a very short timeframe. The quality of the speakers and the presentations they gave, were very high and this was appreciated by the local community. Feedback forms enabled us to check on how we were doing, as did direct contacts made via the pop-up-shop.
Ensure community know about projects and events	Yes we had a well-developed communications strategy which sought to build momentum in a phase approach. We delivered the community engagement events in 4 phases: 2 phases were delivered before Christmas and 2 phases afterwards. For each event phase we created leaflets and posters, the former were delivered to every house in the town. We also used social media and local contacts to spread the word on a weekly basis.
Get feedback from community on interest and needs	Yes through comment books and feedback forms which were available at events, and at the pop-up-shop.
Build capacity to strengthen the community's ability to be active and involved partners in community energy projects	Yes, but we would like to have done more if we had had more time. It is hoped that this new capacity will be able to be maintained and enhanced by the BCDT and through the deliverance of projects identified within the Energy masterplan.
Build energy knowledge in the community to enable more detailed engagement and interrogation of energy proposals	Yes, the community increased in their ability to interrogate energy data, clearly bringing knowledge from previous presentations and discussions.

The paragraphs below summarise the lessons learned from the community engagement element of the project. This section describes the key learning points from the project process, and a summary of what worked well and any changes that would be made to the methodology / project process to make subsequent projects more successful.

- All members of the project team and community participants agreed that the project time scales were simply too short. A 6 month project was not sufficient to capitalise on the enthusiasm for the project demonstrated by the local community and the council officers. A 12 month project would have enabled more meaningful engagement, with a 2 month period for detailed planning / preplanning; 9 months of active community engagement and 1 month to wrap up the project and write up findings.

- Because of the 6 month timescale of this project, this meant that the project team effectively had to hit the ground running, and without the benefit of a planning / a preplanning stage. As a result, staff were overwhelmed with planning, feedback gathering and delivering back to back events within 2 week turnaround periods. This was something that was simply not sustainable over a long period of time.
- The timing of the project (commencing in October) meant that the project also had the Christmas / Hogmanay holidays right in the middle of the programme, this meant that the team effectively lost 3 weeks from an already short programme. It was difficult to sustain community momentum and participation during the holiday period because of school holidays and family travel commitments, and this is not something that can be expected from community collaboration projects during the festive period.
- As the engagement programme comes to a close, both the project team and the local community have a sense that the momentum has really started to gain ground and there is a feeling that if we had longer to build on that momentum, the project could have:

    - engaged even more of the community,
    - reached the harder to reach,
    - built up more confidence and empowerment,
    - discovered other ideas and interests,
    - created more trust and transparency,
    - potentially found more solutions and partnerships; and
    - helped deliver action sooner.

- There is a real fear that the momentum and enthusiasm built up during this project could be lost in the wait for future funding opportunities to allow the project to progress. Conversely, there is a risk that providing significant support to a community could mean they are less driven to take control of a project themselves.
- The pop-up-shop was a huge enabler for the engagement process. It was one of the real stars of the project. The presence of the project team right in the heart of Burntisland, in an accessible setting highlighted to local people that this was a local project with a local space to meet and make decisions. Put simply, local people didn’t have to travel to meet the council, the council came to them.
- Over the winter when you are trying to coax people out of their homes in the cold and dark to attend events on sustainable energy (not always the most enticing topic for the average person) having a proper budget for engagement was key. This enabled us to offer hot food and drinks so people could come to meetings straight from work. There’s nothing worse than feeling hungry whilst trying to concentrate on technical information. Equally we wanted to make sure that we didn’t lose participants who may be reluctant to go back out into a cold, dark night after coming home from work to eat. We wanted people to enjoy coming to events by making it convenient and considerate, and by offering something in return to the local community for their generous donation of time.
- This money benefitted the local economy too, as facilities and catering was procured via hire of local venues and use of local catering companies. The cafes and companies hired to cook the hot food bought their ingredients from the local butcher, fish mongers and veg’ shop and hence supported the thriving local High Street within Burntisland.

- Community collaboration projects have a habit of evolving rapidly and organically. The outputs that can be generated are often far more than anticipated at the project outset. Therefore the writing of the final report and evaluation of the project took far longer than the 1 day anticipated in the original funding applications.
- The value of working with a proactive, passionate, skilled, local community group cannot be underestimated. The engagement programme would not have been a success without the residents of Burntisland. Working with the local people was considered a real privilege by all in the project team.
- Evening and weekend meetings were valuable for the community to be able to attend. Timing of meetings at the end of the working day were chosen to enable people coming home from work and Council staff to all attend meetings, without having to go home first.

Data evaluation and lessons summary

Building data	• **Data Group**: the data group provided an overall validation check to the choice of data sources and the use of data. Data sets were chosen where they met the agreement of the data group. For example: a wide review of available energy demand reduction data that gave potential values for energy efficiency measures was considered by the group. At another stage of the process the group rigorously debated the options to use Home Analytic data (which could only be used at datazone) and the use of more detailed data with less complete overall coverage. • **Front end validation**: Building data sources were validated as the initial stage of the process. This is outlined in the initial data section. Examples include checking outlying data, such as large heat loads. For example duplicate entries were found in heat demand for swimming pool, sailing club with unusually high value. The data group agreed that a validation exercise would be useful for the building energy process. This would take one of the building archetypes and do a very detailed evaluation. The approach would use site survey, EPC's, any previous research that is available, and the Standard Assessment Procedure. The results are outlined in SECTION. It would be useful to test out other archetypes should the approach be more widely used • Validation of datasets for use at a local level needs to be considered for the next stage of detailed planning. Local Development Plan opportunities need to be assessed as to their relevance and not yet designed. Further evaluation of the national heat map heat demand values is needed using local knowledge, e.g. sailing club 246,371 looks a high demand as does the Golf club. These were found by listing the highest demands in Burntisland. This may be that the demands were generated using commercial figures. Also it was noted that both the leisure centre and the police station were in twice. There needs to be a reliable mechanism to ensure local knowledge is fed into the national map for future iterations. • **Formative validation:** A further process of validation was undertaken at the end of the process. This did simple sums to cross check data with final outputs. A small number of errors were identified and corrected at this stage using this approach.
Transport data	• This was a much more experimental part of the data analysis process so relied on validation by transport colleagues throughout the iterations of its development. • Transport data did not readily link to settlements or buildings in many datasets. Data about transport was more often linked to how many miles a person travels rather than the vehicle. Data about energy use for electric vehicles is not as readily available from government sources as some of the other data. Most vehicle data is about how people use vehicles. A core challenge was to tie vehicles to settlements. • DVLA data was only available at substantial cost. Census data 2011 provided a baseline for cars and vans linked to settlements. • Due to emerging nature of the EV market again much of the miles/kW data required a reasonable amount of inventiveness to make an acceptable correlation to how much energy the settlement needed for petrol/diesel and in the future electricity.

	• A follow up external review is recommended on this exercise to provide additional rigour. We would like an external party (such as Transport Scotland) to work with us to verify and if necessary improve on these figures.
Weighted analysis	• The weighted analysis used a number of spatial data and GIS specialists to create the datasets. These were tested on the community and then further developed. The community view of where to place measures was positively influenced after seeing these visuals. The weighted data will be further evaluated, with invites to Perth & Kinross Council.
Providing the breadth of expertise and data	• Due to the fast innovation of the integrated energy field which in turn brings a great variety of potential solutions, this meant that not all ideas could be taken forward because the specific skills were not available in the consulting group. For example, where new approaches were considered, such as the use of large scale solar thermal combined with thermal stores, expertise was sought from the consortium. • The decision was made to put some of the funding aside until later on in the PROCESS more knowledge was known of the desired energy choices form the community and what was driven by the data .Due to the time taken to let the contact and then undertake the initial data analysis the funder was not convinced that this second phase of contracts could be let and completed within the remaining time frame. This meant that not all the consultant funding was spent and not all areas of work were completed as envisaged at the start of the project • The short time frame and perceived funder risk meant no flexibility was permitted to bring a new contractor up to speed. • These issues could be addressed in future funding schemes A flexible or iterative approach may be needed to bring on board additional skills. This is likely to be an ongoing issue as understanding about integrated holistic energy systems develops. • Energy efficiency impacts for buildings proved hard to get hold of and interpret. Agreeing energy efficiency data that could be used took up a lot of debate with the data group. The outputs of the EPC looked useful but there is not clear metadata to explain what the figures – for example linked to different insulation options means. The Energy Saving Trust standard figures were the chosen fall back for energy efficiency measures was the only easily accessible data. More energy interventions would have been considered if the data was available. The validation study used SAP data to cross check the Energy Saving Trust figures. More work is suggested in this area for future analysis. • Many datasets need a human interpretation with respect to the technology being considered. •
Assessing the combined approach	• An important task will be to seek external input to comment on the combined approach undertaken in the study. Key groups to present to are suggested as: the Local Authority Energy Mapping • A workshop is planned to be delivered to Scottish Government to present the methodology and consider potential next steps. Additionally has been given to a Scottish Government Consultation, led by the Scottish Futures Trust, to take lessons from the methodology as part of the Energy Strategy work. A valuable step would be to test the approach against other data analysis systems used by the Scottish Government, such as soft linking to the TIMES model and building models used in the LCITP and HEEPS programmes. • A workshop is planned for the Local Energy Scotland conference in late April to present the findings.
Public contracts	• Time allocated to developing complex funding bids is unlikely to include tendering as this would be a substantial time commitment to undertake the rigorous process required for a public body. Tendering in the public sector is rightly heavily controlled to ensure proper process is followed. The short term nature of this project brought about issues in tendering the work and approving contractors.

	• The requirement for Scottish Government IP for the work is understandable, but meant significant time lost to working with legal teams agreeing fine details for this outcome. More time is needed for this. Rigid adherence to IP rules means some previous work by contractors might need to be funded again under these terms. As IP had to be completed before any full contract could be signed then this in turn meant that data could not be shared fully until substantially later on in the contract. • The contract management from the funder required agreement of every sum, however small. Additionally contractors were only allowed to be approved once tendering had happened. The level of management of finance and project decisions was felt to be greater than other government granted programmes. As the council has strong financial and procurement processes as well this added substantial time onto every decision, reducing time to deliver the project. The practicality of the detail and the needs of numerous checks and balances meant that a lot of time was lost undertaking this work. Time taken to respond from all parties had a big knock no effect to the time available for data analysis.
Data availability	• Accessing data and sharing data sometimes proved challenging. It would have been useful to allow more time for this part of the work. This mirrored the lessons learned developing the Scotland heat map. Some data sets were not available. Some were only available to limited audiences, so could not be used at the most detailed levels. Some looked good to start with but proved less useful once these had been viewed • It would have been useful to have access to approaches to modelling data in the TIMES model, in case any of these could have been used in the local energy masterplan work. It is hoped that because the TIMES data can be soft linked to the heat map then it should in theory be able to soft link it to this data also.
Data quantity	• The more complex the analysis the more data is needed, and the greater the risk for some error in use of that data. As some of the processes for analysing data were developed in the project it was only at the review of the steps undertaken that it became clear another step was needed. This required a number of additional steps during the latter stages of the project to improve the quality of the results. Leaving time for this is very important. • There is always a balance to make a model work and to have completely rigorous data. There are some further questions on the data used that would be good to seek more external views on. The results can be tested again should significantly different data be preferred.
Data sharing	• Not all data can be shared. Not all data that can be shared, can be shared in the same way with different bodies. Who data can be shared with and at what level it can be shared has significant impacts on the way data is used in a project. • Some data can only be shared with a body under contract. For example the Scotland heat map. This meant that the core data could not be shared until well into the project timeline – due to the constraints with public contracts and the detail required for project management and reporting. This required more time in preparing data that could be shared pre-agreement, to test out the processes, prior to data being shared and manipulated for real. • Some data did not allow sharing publically. For example Home Analytics. An approach was made to the Energy Saving Trust. Approval was given to pilot sharing the data by datazone as part of this project. This added significant value in giving the BAU for energy measures and the potential for Solar (on roof). It constrained the data by meaning the outputs for energy measures could only be analysed at datazone level, even though some data was available under data sharing agreements at building level. • A large number of data sets that would need to be used were identified during the project. It became clear early on that the option for choosing an external consultant would prove challenging. First the short time frame would conflict with the need to conclude data sharing agreements covering certain data sets prior to being able to

	pass them to a contractor. Due to short time scales the Council research team was approached and time agreed to take on this additional piece of work.
Composite data sets	• A number of datasets used were composites. These included the Home Analytics and the Fife Council housing data. Composite data sets meant that data could only be used on its own and not in combination with more accurate data. Making underlying data available (as in the Scotland heat map) means that there is much greater potential for further analysis for linked purposes. Combined data sets mean that all the data is constrained by the terms the most restricted data. It makes much more sense to allow data to also be used in its least restrictive form for those times or bodies that wish to do other analysis, such as innovation in energy mapping.
Data groups	• Having a supportive group of people is crucial to developing a new idea. The group included: engineers, housing, conservation building specialists, research specialists in building. It was important for the group to meet regularly, as this proved really valuable in agreeing data used and options for analysis. • The group was able to draw on expertise from outwith the council including Historic Environment Scotland, EST, and historic building specialists in Fife. These provided very valuable information to guide specialist elements of the data analysis work • The concept for the approach was heavily influenced by the Local Authority Energy Mapping Group, in particular the work of Highland Council and Perth & Kinross Council and Fife Council.
Community	• The initial presentation of data gave economically and practically driven outcomes at a community level. Some community interest was limited to the individual only. The lesson is to look for opportunities to relate area wide data in a way that it can also be used at a smaller level, such as by an individual or household.
Conservation buildings	• The energy efficiency data was probably less attributable to conservation buildings. The needs of conservation buildings (for breathable measures) will need to be taken forward in a further piece of work.
Spatial analysis	• Whilst there are a set of key factors to model, however too many factors can hide important characteristics. A common sense audit of a local area and opportunities is needed to focus the modelling, a single generic model for local energy planning is not ideal, local opportunities and constraints need to be understood on a settlement by settlement basis. • Particularly with combined data linked to spatial analysis, there is a risk that the amount of modelling exceeds ability to understand what the inputs, parameters and configuration should be, to be appropriate for the questions that need answering. Care is need with datasets to understand how to apply them to analysis being undertaken. In this case several factors needed to be applied only to properties where a heat demand existed otherwise large areas were no heat demand were given opportunity scores. For example… - Listed Buildings – The port and cemetery are examples where large areas of open space are listed but have no heat demand for the majority of the area. - Conservation Areas – The Links are included in the conservation area but as open grassland has no heat demand. - Fuel Poverty – A data set at data zone level, but only valid for domestic properties. The data zone that the port is in gets a high score and is a large area but no domestic properties. Data sets such as these need to apply the statistic to the individual domestic properties and then be rasterised. • Geographical data and analytical methodology can provide a lot more insight to assist in the determining opportunities. Teams that are working on energy would benefit from having a dedicated geographical professional with detailed knowledge of the energy subject area to get the best results. • Some data was deliberately kept out of the initial weighted spatial analysis that would be in a Fife wide approach. This was to not over complicate the first version, and to test out the principle. In future versions the data is expected to include Fife wide

	created datasets such as proximity to Mean Low Water Spring MLWS, to show potential for heat from the sea. There is concern that adding too many data sets will mean individual data might be lost in any weighted analysis. The suggested approach would be to combine data into groups, and weight them as groups, to allow more data to be assessed at one time.
Public body rules and issues around contracts	• Time allocated to developing funding bids does not include tendering. Tendering in the public sector is rightly heavily controlled to ensure proper process is followed. The short term nature of this project brought about issues in tendering the work and approving contractors. • The requirement for Scottish Government IP for the work is understandable, but means significant time lost to working with legal teams agreeing fine details for this outcome. More time is needed for this. Rigid adherence to IP rules means some previous work by contractors might need to be funded again under these terms. • The contract management from the funder required agreement of even small sums. Additionally contractors were only allowed to be approved once tendering had happened. As the council has strong financial and procurement processes. The practicality of the detail and the needs of numerous checks and balances meant that a lot of time was lost at the start of the project securing the contractors. Time taken to respond from all parties had a big knock no effect to the time available for data analysis.
Data sharing	• Not all data can be shared. Not all data that can be shared, can be shared in the same way with different bodies. Who data can be shared with and at what level it can be shared has significant impacts on the way data is used in a project. • Some data can only be shared with a body under contract. For example the Scotland heat map. This meant that the core data could not be shared until well into the project timeline – due to the constraints with public contracts and the detail required for project management and reporting. This required more time in preparing data that could be shared pre-agreement, to test out the processes, prior to data being shared and manipulated for real. • Some data did not allow sharing publically. For example Home Analytics. An approach was made to the Energy Saving Trust. Approval was given to pilot sharing the data by datazone as part of this project. This added significant value in giving the BAU for energy measures and the potential for Solar (on roof). It constrained the data by meaning the outputs for energy measures could only be analysed at datazone level, even though some data was available under data sharing agreements at building level.
Replication of the analysis	• Consideration could be given to widening out the analysis. This could be undertaken as a pilot for one or a limited number of authorities. Alternatively, this could be rolled out more widely – as with the heat map

15. Project reporting

Conclusions

"There will be an enhanced role for local authorities and city regions in this strategic approach, which will help to deliver new investment and to manage the local challenges of decarbonisation. Collaboration between a variety of organisations and levels of government, communities, and private sector partners is essential to its success"[54] (*Scottish Energy Strategy – the future of energy in Scotland*).

Project summary

Providing or supporting the generation, storage and delivery of low carbon energy locally, as proposed in the draft Scottish Government Energy Strategy, would represent a new role for Scottish Local Authorities. Like many Scottish Local Authorities, in the last decade Fife Council has delivered a number of sustainable energy projects within its own asset portfolio including the development of building integrated-solar PV, onshore wind, heat pumps, biomass boilers and district heating projects. However to partner or support local community energy projects, is at present, beyond both our funding and staff capacity. Equally, for local communities to lead the development of local energy generation, storage and supply would represent a significant challenge. The Scottish Government is putting in place measures which ensure that at least half of newly consented renewable energy projects will have an element of shared ownership by 2020. We sought not only to investigate the capacity of a typical Scottish community for taking on the development of community energy projects but also that of Fife Council.

The draft Scottish Energy Strategy encourages Local Authorities to undertake deep engagement with local communities around energy and decarbonisation. The Burntisland energy masterplan project delivered deep engagement, but this was only possible because external funding enabled it to take place by funding staff time, event budgets and marketing materials. Fife Council considered this a development opportunity to learn lessons for the wider choices for energy. The external funding helped fund key elements of the work. Additional resources of specialist staff time provided guidance and support for the data collection and analysis work.

It should be recognised that further staff time for community engagement was beyond what was received with original grant funding and Fife Council bore the cost of that. To take this project forward and translate the ideas generated into real community energy projects on the ground, will require additional external funding. Given the pressures on Local Authority budgets alongside increased demand for Council services, it is not possible for Fife Council to provide the funding to develop these ideas through implementation and operation.

The Fife Council staff members who led the data and engagement programmes for this energy masterplan project acted as the gateway for information flows between the different departments of Fife Council, the BCDT and community members. When the project finishes on March 31st 2017, the funded staff will leave the project, and the pop-up-shop that acted as a community gateway will close. For partnership working and joint decision making to continue beyond this initial pilot stage, will need additional funding to fund staff to continue this gateway role.

In the Scottish Energy Strategy, the Scottish Government states that: "Our priorities for supporting the developing of Smart, Local Energy Systems are:

- directly supporting the demonstration and growth of new innovative projects; and
- developing a strategic approach to future energy systems in partnership between communities, the private and public sectors."[55]

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[54] http://www.gov.scot/Resource/0051/00513466.pdf, pp68

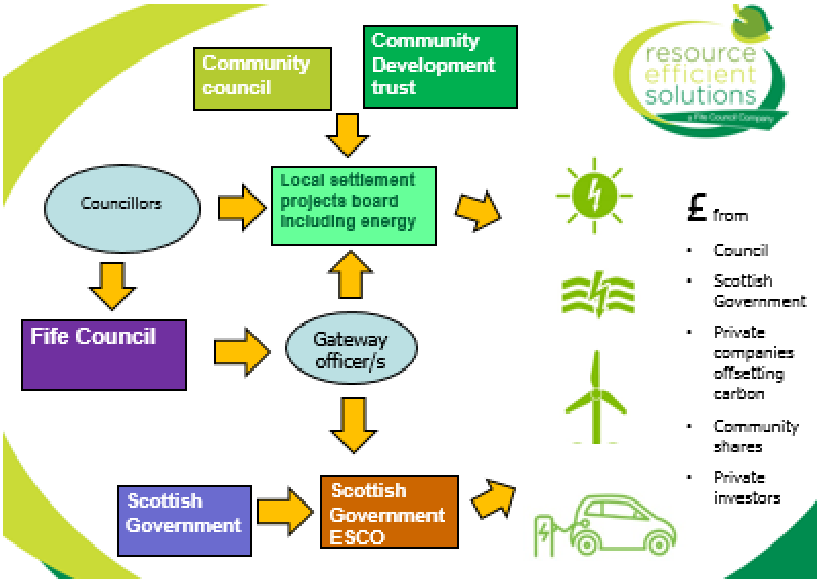
[55] http://www.gov.scot/Resource/0051/00513466.pdf, pp66

The project team and community involved within the Burntisland Community Energy Masterplan would wholeheartedly welcome the Scottish Government's support in the growth of this new innovative project and discuss opportunities for the external funding to enable it.

As it stands, from April 2017, if the Burntisland community wish to progress any of the community energy project ideas they will have to contact numerous staff across many different Fife Council departments. Not all of the Fife Council staff contacted will have the knowledge required, or sufficient capacity to take on this support in addition to their core job functions, or the authority to make decisions. Furthermore, the Energy Strategy urges community energy projects to become the norm across Scotland and this will pose cumulative challenges for Local Authorities. If multiple community energy projects are being developed simultaneously it would not be practical for council staff, as the Council structure currently stands to provide the support needed. Yet not having this support from Planning, Energy, funding, engagement and Housing officers could risk the success of projects.

There may be a role for new institutions and delivery agencies. In the 2016 Programme for Government, which sought to support the growth of renewables in Scotland, suggested that the creation of a government owned energy company (GOEC) to help the growth of local and community projects. A GOEC could address specific market failure or add value through accelerating progress towards relevant policy aims and goals, and could take on a number of potential roles:

- to deliver / support existing and new schemes and initiatives;
- deliver energy infrastructure including district heating;
- coordinate the procurement of energy efficiency and heat technology measures;
- act as an energy supplier, delivering on a not-for-profit basis; or
- administer a Scottish Renewable Energy Bond.



Our experience of the Burntisland energy masterplan pilot inclines us to agree with the need for a GOEC or similar body, to help deliver and support community energy schemes. At present there are delivery gaps and market failures which, given the reduction in financial support mechanisms for renewable energy since the reductions in FIT rates, deployment caps and eligibility criteria are only set to become more pressing in the future.

A key consideration for any GOEC would be making the most of local skills and knowledge from the community and local authority, while bringing benefits of large scale development, feasibility, implementation and operation for energy systems.

Whether community energy projects are delivered by a GOEC, an ESCO, by Community Councils, local development trusts or Local Authorities – regardless of the structure, this pilot project has demonstrated that a local staffed gateway to facilitate communication between the different parties and enable joint decision making, will be essential. The gateway staff could sit within the staff structure of the ESCO, community group or the council. Funding would need to be found for this role.

Funding would also need to be found to staff roles within the community groups. Community members are not charities and should not be expected to work for free. There has to be a funding structure in place that acknowledges the need to fund community roles as well as include volunteer time.

As a Burntisland community member said: "The level of expertise needed to co-ordinate and project manage energy projects is not going to happen with a mixed bag of volunteers"

With the continual withdrawal of financial support for renewable energy development from the UK government, the economics of community energy schemes have become even more difficult. FIT payments which could have funded paid community energy scheme staff, no longer exist for most technologies. In fact many of the successful community energy projects operating today in the UK acknowledge they would not have been financially viable in a post-FIT era. For example, Edinburgh Community Solar Co-operative[56] and Harlaw Hydro[57].

[56] http://www.edinburghsolar.coop/

[57] http://www.harlawhydro.org.uk/

15. Project reporting

Engagement Recommendations arising from this pilot project, that should be considered when replicating this project idea include:

1) It is not feasible to expect sustainable energy projects to be self-financing in the earliest stages. A budget is needed to enable sustainable energy and heat to be delivered as a local service. A practicable long term solution, as suggested in the Draft Scottish Energy Strategy, is to have an ESCO to manage local energy projects, run by the community, local government, or other actors with a social enterprise commitment.
2) To be successful energy master-planning projects (from engagement through to implementation) need funded 'gateway staff' to act as a conduit of communications linking communities, community decision making bodies (such as Community Councils and Development Trusts) a local energy ECSO and the many different departments and decision-makers within Fife Council. Typically, energy projects need to communicate with most Council departments through the planning, development and operation phases of the project lifespan. Gateway staff should ideally be present throughout the timeline of projects from first community engagement right the way through to project commissioning and operation. It is important partnership ideas are generated collaboratively via community energy masterplans.
3) Funding is necessary for roles and responsibilities needed by energy master-planning projects – whether the participants are from Community Councils, Development Trusts and / or other local governing bodies. The responsibility of the roles and the time commitment involved is too extensive for local residents to be expected to always provide their time for free. If decisions around services, as well as the delivery of those services, is to be collaborative and community-owned then funded local positions are needed to assist this process. This will also help to prevent those residents who do volunteer their time, from experiencing burn-out. The best solution to facilitate the decarbonisation of Scottish settlements could be a move towards the Danish model of empowered and funded local township Councils to enable locally embedded, co-owned and co-decided energy projects.
4) Fife Council, alongside other Scottish Council's is currently developing Local Outcome Improvement Plans (LOIPs) with local communities within their region. LOIPs reiterate the strategic direction, priorities and outcomes which have been agreed for delivery with community planning partners. LOIPs are based on local need - identified via engagement with local people and communities together with data taken from the 2011 Census and 2012 Scottish Index of Multiple Deprivation. They identify progress on achievement of a Council's long-term outcomes; and are generally aimed at reducing inequality and disadvantage across Scottish communities and engaging with local people in the design and delivery of public services. The development of LOIPs for Fife communities needs to take, energy projects and the services that local sustainable heat / energy projects could provide, into consideration. It is important that climate change and sustainable energy is a key principle in the LOIP documents produced by Fife Council and Fife communities.
5) Sustainable energy services and the importance of energy provision to local communities needs to be enshrined as a core principle, which is fully-integrated into local neighbourhood plans.
6) National energy efficiency funding policies are not fit for purpose for delivering the decarbonised Scotland that the Scottish Government aspires to within the draft Energy Strategy and Climate Change Plan. For example ECO funds rules preclude the addition of EWI (external wall insulation) to homes with cavity and loft insulation. Yet EWI is essential to reduce the energy consumption of many buildings down to the levels needed for a total decarbonisation of the Scottish built environment to be a reality. Funding needs to be more inclusive in terms of the technology covered and in terms of who can apply (it is vital that community groups are able to access SEEP funding). At present the funding levels available for energy efficiency improvements allow only modest improvements in the energy efficiency of many older buildings – a greater ambition is needed in terms of what will be funded and the energy performance levels that we aspire to for retrofit properties. Changes are needed to national policy and energy

efficiency funding if we are to achieve the decarbonisation of the Scottish built environment envisaged in the draft Energy Strategy and Climate Change Plan.

7) Energy masterplan projects need to be undertaken over a minimum of a 12 month project period. It is recommended the initial deep community engagement programme, if replicated, be extended to 12 months. If a number of energy masterplan projects were run with communities across Fife simultaneously, then speakers and presentations could be on tour and the effort in developing events programmes would be considerably reduced. Lessons learnt and ideas shared from the different communities could cross-pollinate across the region through established networks like the Fife Communities Climate Action Network (FCCAN).At least 2 months of any similar project needs to be devoted to planning / preplanning activities.

Data and policy recommendations arising from this pilot project, that should be considered when replicating this project idea include:

8) That the community and Fife Council take a short time to consider the outcomes of the Local Energy Masterplan. The short intense nature of the project would benefit from a period of contemplation and wider engagement on the next steps.

9) That the council will explore with the Burntisland community taking forward the next steps identified. That projects could be jointly considered, and where appropriate seek joint funding to take parts of the proposals forward.

10) That the data analysis is peer reviewed through a number of meetings and workshops. This will include Scottish Government, local authorities, academia and others with an interest in local energy masterplanning. That discussions are held with the Scottish Government to test out this methodology on a local authority area basis, as part of both the wider heat and energy plan; and socio economic modelling developments. That lessons learned are also shared to enable others to use and build on this work.

11) That local energy masterplans can be part of the community response and input to other local planning and policy development. That local energy masterplans role is considered in neighbourhood plans. Additionally that they are discussed as potential material consideration in statutory plans such as Local Development Plans, and in the emerging Local Outcome Improvement Plans.

Next steps

Theme	Action	Lead	Community priority	Achieved by
Burntisland Local Energy Masterplan	Undertake a short review of the Burntisland Local Energy Masterplan following the formal approval of the updated Fife Council LPD. The short intense nature of the project would benefit from a period of contemplation and wider engagement on the next steps.	Fife Council		2017
	Burntisland Local Energy Masterplan to be put forward for consideration by Fife Council Committee early in the next administration.	Fife Council		2017/18
	Fife Council will explore with the Burntisland community taking forward the next steps identified. These projects could be jointly considered, and where appropriate seek joint funding to take parts of the proposals forward.	Fife Council/BCDT	Yes	2020
Energy Masterplanning	Presentations to be made to Scottish Government and Local Energy Scotland to outline the methodology and results.	Fife Council		2017
	Fife Council to encourage a review of the data processes through peer review, meetings and workshops. Fife Council approach Scottish Government to repeat this methodology across Fife as a trial for Local Heat plans.	Fife Council		2017
	Fife Council review the final plan and methodology and the potential for this to be part of the emerging new plans at neighbourhood level and the LOIP. Present findings to the Fife Environmental Partnership.	Fife Council		2017/18

	Fife Council gives consideration to the different skills and roles that may be required to take forward local energy policy and projects. These will be fed back to Scottish Government in the ongoing Energy Strategy consultations.	Fife Council		2017/18
	Fife Council will take lessons from the Local Energy Masterplan process into account in the development of statutory plans, including the LDP and Local Housing Strategy; and the Fife Sustainable Energy Climate Action Plan	Fife Council		2020
	Fife Council to consider a wider area based scheme reflecting the opportunities arising from scale. Area for initial consideration to include: Aberdour, Kinghorn, Auchertool, Kirkcaldy, Glenrothes, Leven and Methil. Encourage discussions with nearby communities regarding Local Energy Masterplanning and shared energy generation opportunities. Local small settlements: Aberdour, Kinghorn, Auchertool.			2020
Energy demand reduction	Loft insulation (<150MM). Look for opportunities for a programme of insulation up to 2032	Fife Council & partners	Yes	2032
	Loft insulation (>150MM). Look for opportunities for a programme of insulation up to 2032	Fife Council & partners	Yes	2032
	CAVITY WALLS. Look for opportunities for a programme of insulation up to 2032	Fife Council & partners	Yes	2032
	EXTERNAL WALL. Look for opportunities for a programme of 332 insulation measures up to 2032	Fife Council & partners	Yes	2032

	Investigate using the area roll out scheme process as mechanism to support joint community action for energy efficiency measures. Include option for a joint campaign with Fife Council, BCDT, promote EWI cladding and solar PV to Burntisland homes and businesses, including bulk purchase of the measures to reduce the unit price and increase affordability. This campaign would be undertaken in partnership with Home Energy Scotland, Fife Council and the BCDT.	Fife Council/ BCDT	yes	2025
	Investigate potential for a staffed, local energy hub (to build on the momentum established by the pop-up-shop) and create a solid hub for community collaboration.	Fife Council/ BCDT	yes	2018
	Funding for an infra-red survey of all buildings in the town to allow prioritisation of energy efficiency works and to check that the energy efficiency measures installed historically, are not defective.	BCDT	Yes	2025
	A showcase home or hub to show what can be achieved with energy efficiency and low carbon energy. Somewhere to sell the ideas, products and get people to sign up to joint projects	BCDT	Yes	2032
	Promotion materials showing the 5 most common properties with the energy efficiency ideas most suitable to that property	BCDT	Yes	2032
	Funding for a Case study for fuel poverty- using outer cladding on a small area of high FP to monitor reduction rates	Fife Council and BCDT	Yes	2025
	A study on using heat exchangers as well as heat pumps to look at reducing damp within an air tight home.	Fife Council and BCDT	Yes	2025
	Seek government guidance or if not available funding for a detailed feasibility study to gauge the technical suitability of Air heat pumps for individual homes	Fife Council and BCDT	Yes	2025

Moving and storing energy	Seek an agreement for the district heating option to be explored in Burntisland, based on Zone 7 with heat from an estuary supplied heat pump. If approved seek funding for a next stage feasibility for a district heating scheme in Burntisland	Fife Council		2017/18
Low Carbon Generation	Seek funding for a drone based analysis to provide a detailed review of on roof solar opportunity. This would consist of a detailed scan and photography the available roof area, suitability of roof types and orientation of roofs to more accurately measure the potential opportunity for building mounted solar PV / solar thermal, within Burntisland. Analyse data alongside the Fife Council GIS system. Provide assessment of viability, and if positive then seek funding for a detailed feasibility study for individual solar on buildings.	Fife Council	Yes	2020
	Seek funding for a detailed feasibility study for Solar farm. Approach landowners to ascertain is land might be available. If suitable ground available then: seek a wider range of expert views; seek feasibility funding to assess ground conditions, build and test a detailed annual operation energy model, where half hour consumption and production data will be projected, with detailed investment, operation and maintenance costs.	Fife Council /BCDT	Yes	2025
	Review of wind turbine opportunity following release of the new Fife LDP	Fife Council		2025
Transport	Apply for funding to TFS for funding for car club officer.	BCDT	Yes	2017/18
	Electric charge points audit. This might focus first on the 869 Semi-detached and 677 Detached	BCDT	Yes	2020

	properties. Starting with the low hanging fruit first.			
	Run a number of electric EV events to promote the savings electric cars can create locally as well as benefits for air quality and carbon emissions. Look to have a test drive showroom locally	BCDT	Yes	2025
	Survey in town on how people use their cars	BCDT	Yes	2025
	Set up an EV social club	BCDT	Yes	2025
	Set up meetings with local business Briggs Marine , Scott's Palettes and Bi-fab to discuss electric charging points and hybrid hydrogen haulage trucks and marine tugs	Fife Council and BCDT	Yes	2018
	Pursue proposal for sustainable travel hub. Seek funding options. Consideration for charging points for electric bikes as well as cars. Initial proposal for Links carpark	Fife Council and BCDT	Yes	2020
	Initiate discussions between FC/BCDT on potential for Burntisland as alternate fuels fuelling station with hydrogen	TBA	Yes	2032

Appendices

Appendix 1 Burntisland district heat analysis – longlist model
Appendix 2 Solar thermal
Appendix 3 Events and workshops
Appendix 4 Engagement plan
Appendix 5 Agreed active travel route map for Burntisland

Report credits

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