Delivering Net Zero for Heating of Buildings

- A Challenge for the Scottish Government

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Our Scottish Future

Focus of this paper

We focus primarily on the Scottish Government's aim to decarbonise the heating of Scotland's buildings as a key element of achieving 'Net Zero' carbon emissions in Scotland as a whole. It is acknowledged that not all buildings can be completely decarbonised due to technical or heritage/conservation restrictions. The ambition is to minimise emissions so that residual emissions can realistically be offset by planting forests or other methods.

Recent political twists reveal greater divergence between the UK Government which is considering a delay to new regulations enforcing better energy efficiency and the Scottish Government which is proposing to extend the scope of regulations in Scotland. There is no mention of government cooperation on key issues of public concern such finance schemes for householders or building supply chains for the insulation of millions of buildings and installation of decarbonised heating systems to replace gas boilers.

One of the key challenges we identify is that this project intrudes into millions of peoples' homes and finances. Not surprisingly, there are reports of citizens' dissent across Europe and in the UK. How will people respond as the impacts become clearer? Will they be inspired, cajoled or forced to change? Or will the targets be missed? We believe the public will respond to better political leadership but will not tolerate inefficiency and muddle.

The Climate Change Committee is an independent government agency set up to monitor and guide all UK nations in their approach to and delivery of the transition towards Net Zero. They acknowledge Scotland's considerable achievements but are highly sceptical about future delivery for reasons we examine.

We consider how best to deliver this immense project, proposing that government take the example of the COVID Vaccine Task Force to inspire the formation of a Task Force to Decarbonise Heating of Buildings in Scotland and the UK. This would best be located within the umbrella of the proposed Great British Energy headquartered in Scotland.

Scotland's Net Zero targets in context

Most developed nations aim to achieve Net Zero greenhouse gas emissions by 2050 or thereabouts, i.e. a net zero balance between emissions and removals of carbon dioxide (CO2) and other greenhouse gases.

The UK target date is 2050 but Scotland has committed to 2045. This slightly earlier target date for Scotland may cause problems when the governments need to set firm dates for new regulations like phasing out gas boilers. Managing different target dates will require close cooperation.

The impact on global CO2 emissions of Scotland and UK achieving Net Zero is modest.

Global emissions are approximately 52 billion tonnes of CO2 equivalent/year.

UK emissions are very approximately 1% of the global total.

Scotland's emissions are approximately 10% of UK total and 0.1% of global total.

However, there are other reasons, moral, political and economic, so the target dates have been legislated and are legally binding.

The sector of Heating of Buildings (domestic, commercial and public) accounts for approximately 20% of Scotland's emissions.

Details of targets and progress are presented in Appendix 1.



What changes do these future targets require?

CO2 emissions from domestic properties will be mainly heating systems burning natural gas or oil (and lesser use of wood and coal) and also gas for cooking. The magnitude of the emission will depend on:

- The effectiveness of the building's insulation (known as heat transfer). The internal air will tend to rise and therefore roof insulation is the most important followed by external walls and then the flooring.

- The weather: cold weather means a higher temperature gap between desired in-door temperature and the outdoors temperature. Windy and wet weather increases heat transfer from the external walls.

- The occupancy pattern for the dwelling determines the heating needs.

Overall, Scotland's short winter days and generally colder, windier weather mean that a building's insulation is even more important than for its southern equivalent. The emerging overall strategy recognises that insulation should be applied before or at the same time as installing new low-carbon heating systems as this will reduce the demands and system costs. The level of insulation is a key factor in the Energy Efficiency Performance, EPC, and it will become mandatory for dwellings to achieve EPC Level C.

Recently, the Scottish Minister, Patrick Harvie, has proposed that the EPC process be revamped and that it should include in its 'rating' of a household the type of heating system in use. If so, then homes would not just be assessed on levels of insulation and energy efficiency but on whether a gas boiler had been replaced or not by an ASHP. If enacted, this would be a marked extension of regulation by what might be considered as stealthy means. This is no way to build public support.

The task ahead is enormous: in 2020 the Scottish Government published the 2019 house condition survey which revealed that 81% of approximately 2.55 million households use mains gas for heating and hot water with just 11% using electricity and 8% using fuel oil, wood and coal.

Within households the greatest energy use is for heating, just over 75%. Hot water takes 11% with the remainder used for cooking, lighting etc. over a year.

One important consideration is that many gas-fuelled households have combi-boilers for instant hot water without having a hot water storage tank. Changing from gas to electricity may require installation of a new tank. If the change is to fit electrically-powered Air Source Heat Pumps (ASHP's) then the dwelling may need new radiator systems to accommodate the lower operating temperatures of ASHP's.

In general, households that can access mains gas do so as gas is historically cheaper per unit of energy than electricity. Consequently, fuel poverty is significantly skewed to areas not on the gas grid. In 2019 the Scottish Government estimated that around 25% of Scottish households were living in fuel poverty, i.e. around 613,000 households. Recent energy costs will have exacerbated the situation.

It is also worth noting that the same reasons that Scottish housing has a tougher job keeping warm also means that solar power cannot provide a full solution through the winter months when the sun (if shining) is low in the sky. Conversely wind power is effective and could be more available as is demonstrated by the prolific installation of domestic wind turbines in Orkney.

Translated into physical progress the Scottish targets require huge delivery of insulation and low-carbon heating systems:

- By 2033 the target is to raise practically all buildings to EPC Level C, an increase of 1.4 million homes or 55% of the housing stock

- By 2030 the target requires 1.2 million homes and 50,000 non-domestic buildings to have low-carbon heating systems installed at a rate of 200,000 per year.

While an ambition to drive faster decarbonisation is commendable, these deployment rates are extremely stretching. The Scottish targets imply around double the annual deployment rates the CCC considers realistic. For example, the target rate of deployment slightly exceeds the natural replacement rate of heating systems, implying a requirement for scrapping some boilers before they reach their end of life. Will the public accept this?

It is possible that continuing high fossil fuel prices coupled with electricity market reforms would make low-carbon heating more competitive and could drive adoption at higher rates than in CCC scenarios. However, electricity market reform is reserved to the UK Government. At present we are stuck with an electricity market where electricity prices remain stubbornly high in spite of promises of cheap renewable electricity. This situation works powerfully against fitting electrically-driven heat pumps as their running costs may be higher than for gas boilers.



How is Scotland and the UK doing? What is the expert view?

The legislated targets are extremely demanding. The Scottish Government has failed to meet targets in many of its responsibilities.

What is the expert view of the situation in delivering the transition to Net Zero?

The Climate Change Committee is an independent non-departmental public agency tasked with reviewing the UK and devolved administrations on targets, progress and process. Their most recent review of Scotland's targets, progress to date and forecasts was in December 2022.

Their Report acknowledges the Scottish Government's ambition and performance to date but is scathing about future progress because of a lack of a Delivery Plan and lack of cooperation between the Scottish and UK Governments.[1]

“Scotland’s climate targets are in danger of becoming meaningless.”

“In recent years, the Scottish Parliament has committed to extraordinary ambition to decarbonise its economy, with a welcome focus on a fair and just transition. That ambition should be applauded, but only if targets are achieved. The integrity of the Scottish climate framework is now at risk.”

“The Scottish Government lacks a clear delivery plan and has not offered a coherent explanation for how its policies will achieve Scotland’s bold emissions reduction targets.”

“Working with the UK Government: many aspects of policy, especially in the industry, engineered removals and electricity supply sectors, are reserved to the UK Government. Finding a way to cooperate with the UK Government effectively is key for realising both Scotland’s ambitions and the full potential of Scotland’s contribution to the UK’s own decarbonisation plans.”[2]

Devolved and Reserved Powers

Lack of cooperation and alignment between the Governments is flagged by the CCC Report as a risk, so what powers, relative to decarbonising buildings, are reserved or devolved?

The devolution of powers is complex and contentious and a simple overview is given in Appendix 2.

In summary most powers relevant to heating of buildings and energy efficiency are devolved to the Scottish Government, for example:

Building standards and energy efficiency rating, fuel poverty, domestic energy efficiency, public sector energy efficiency, promoting business energy efficiency.

But the gas and electricity infrastructure is reserved to the UK Government. So, without close inter-governmental cooperation there is a real risk of dislocation.

For example:

- Widespread adoption of electrically-powered heat pumps in Scotland requires strengthening the electricity distribution infrastructure (reserved).

- Introducing hydrogen requires modification of the gas distribution networks (reserved).

- UK-wide market-based mechanism to support low-carbon heating is needed (reserved).

- UK Government will reform the electricity market, affecting the relative prices of gas and electricity, a key driver for householder decisions on switching (reserved).

- Alignments of EPC system reform and Heat Network regulatory frameworks are clearly needed.

Unless there is real, cooperative alignment between Governments on these and other Net Zero issues there is a significant risk of de-motivating the public as they perceive bickering and indecision.



Can the Scottish Government avoid another delivery fiasco?

Sadly, the Scottish Government has a consistent record of over-promising and under-delivering in diverse sectors as NHS targets, educational attainment, recycling schemes and even straightforward infrastructure projects such as the A9 doubling and two ferries.

Achieving the target emissions reductions will require the Scottish Government to develop new policies and regulation. Some elements are in place or planned such as:

- Heat in Buildings Strategy – achieving net zero in Scotland's buildings 2021

- Energy and Transition to Net Zero Strategy in draft

- Heat Networks Delivery Plan

- Heat in Buildings Supply Chain Delivery Plan

- Reform of EPC process – in progress

- Request to all Local Authorities to produce a local Heat and Energy Efficiency Strategy and Delivery Plan for 2023/4

- Heat in Buildings Public Engagement Strategy to be developed

- Heat in Buildings Bill consultation in 2023

- Set up a dedicated National Public Energy Agency by 2025



These Scottish Government policies and plans lack hard-edged delivery targets supported by realistic processes and plans at all levels from Scottish Government through to Local Authorities.

One might observe that many key ingredients have been sourced but not a practical recipe.

The CCC judgement concurs:

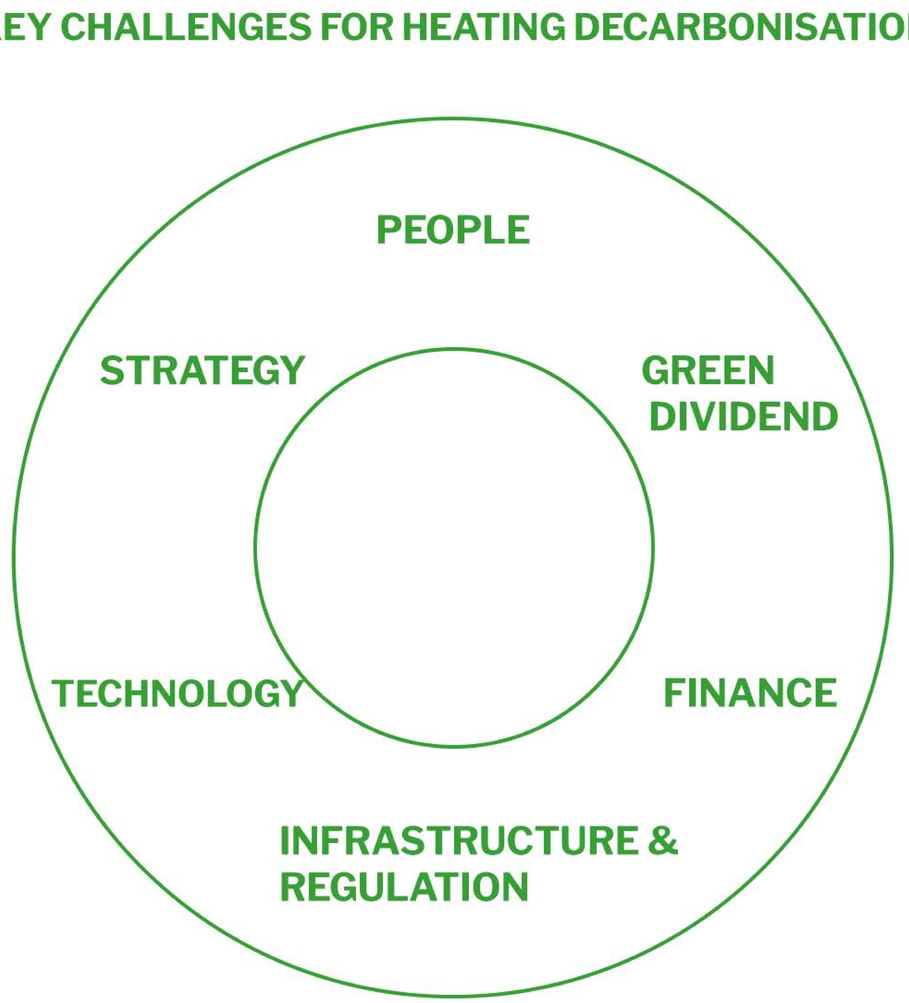
"The Scottish Government has ambitions to decarbonise buildings faster than our pathways and the UK as a whole but does not have sufficient policies in place to deliver on these ambitions. It has made substantial funding commitments, and good progress on enabling measures such as local energy and heat network planning, however it does not have adequate policies in place to deliver low-carbon heat and energy efficiency at the required rates and lacks the powers required to implement certain policy levers."[3]



Government must plan for, and deliver, tangible benefits for the Scottish economy through creation of well-paying and long-lasting employment. That means attracting businesses, investing, education and training to establish successful supply chains. Hard-edged and believable delivery plans will build public support for the disruption and cost of delivering Net Zero.

What are the key challenges to achieving Net Zero?

We suggest that there are 6 key challenges which need hard-edged policy to be resolved before decarbonising Scotland's buildings can be seriously started:



The challenges are complex and highly interactive, ‘chicken and egg’ problems:

People – we need to see much greater engagement with individuals, communities, businesses and local government. They need clarity on how their home improvements can be financed and they need assurance that the new systems such as ASHPs will work satisfactorily. Support for the idea of environmental necessity of decarbonising will fade if the reality is costly or disruptive or badly delivered without assured quality.

Strategy – the UK reserved powers means that upgrades of the electricity or gas distribution systems are UK decisions and hence implementation of Scotland’s NZ plans, which will require considerable consumption changes, are virtually impossible without close cooperation between the UK nations’ Governments. A coherent strategy is needed to devolve agency and budgets across nations, city-regions local government and local communities to engage people, business, city-regions and local government, academia and the markets of suppliers and investors.

Technology – the technologies currently seen as needed to deliver the NZ targets are either not yet fully proven or sufficiently effective to justify full-scale planning.

Gaps include improved heat pumps, hydrogen replacing natural gas, insulation methods, district heating schemes, Carbon Capture Utilisation and Storage (CCUS).

Infrastructure and Regulation – electricity grid and local distribution networks require remodelling to suit much greater power demand, while networks for hydrogen and CO2 may also be required. The pace of these changes and the quality of their delivery will all be driven by Government regulation such as phasing out hydrocarbon-fuelled cars, phasing out gas boilers, regulatory codes for quality delivery, etc.

Finance – where does the investment come from: public, private or individual citizens?

Current estimates of the cost of the NZ changes are in the area of £10,000 per dwelling. Expecting the citizenry to pay such sums is simply unrealistic.

Green Dividend – Government must plan for, and deliver, tangible benefits for the Scottish economy through creation of well-paying and long-lasting employment. That means attracting businesses, investing, education and training to establish successful supply chains. Hard-edged and believable delivery plans will build public support for the disruption and cost of delivering Net Zero.

We address each of these 6 Challenges in turn, leaving ‘People’ to last as public reaction will be shaped by progress in the other challenges.

In addition we address the huge challenge of Delivery. Delivering the 2045 target to decarbonise domestic heating is a far bigger and more complex project than anything previously attempted; the technology maybe relatively established compared to, for example a project such as HS2, but due to its widespread impact reaching into everybody’s home, **it is complex and we argue it needs a dedicated task force.**



Delivery Task Force for De-carbonising Heating of Buildings in Scotland

The Scottish Government's delivery record is poor (e.g. overdue and over-budget ferries or the deposit returns scheme) and the UK's is little better. Therefore we propose that the Governments establish a **Delivery Task Force** modelled on the UK Vaccine Task Force which was highly effective and the best model available.

It was set up by and as part of UK government in April 2020 and took a dynamic and innovative approach to accelerating vaccine development, leading to one of the most successful vaccine roll outs globally. Bringing together government, academia and industry, the VTF was created to develop and produce a vaccine for COVID-19 as fast as possible. The VTF had 3 main objectives:

- secure access to promising COVID-19 vaccines for the UK population as quickly as possible

- make provision for international distribution of vaccines

- strengthen the UK's on-shoring capacity and capability in vaccine development, manufacturing and supply chain to provide resilience for future pandemics

Therefore the VTF could, and should, be the inspiration for the complex and awkward challenges of decarbonising home heating.

It has been proposed by the Labour Opposition to set up 'GB Energy' as a publicly- controlled organisation based in Scotland. We suggest this would become the obvious home for a UK Building Decarbonisation Task Force with the following remit and responsibilities.

Task Force Remit

1. It would be a public agency within Great British Energy not another privatised corporation exploiting monopoly opportunities.

2. It does not determine overall policy for Climate Change, which is rightly reserved to Ministers.

3. Its remit is to develop the strategy, planning and efficient operations needed to achieve Net Zero for heating of domestic and commercial buildings by 2045/2050

4. Based in Scotland within Great British Energy it should first develop a pilot scheme focused on Scotland which can be rolled out across UK.

Task Force Key Actions

1. Within the framework set by Ministers organise the set up and administration of a range of finance schemes for householders for whatever mix of loans and grants is offered.

2. Create the delivery organisation within the umbrella organisation of GB Energy but involving all layers of devolved government, R&D institutions, supply chains and installers.

3. Whilst the Task Force will need to operate at national level it must ensure devolution down through city/region to local and c ommunity level. Without devolution the planning and coordination is too distant from the action, e.g. converting a tenement block.

3. Provide the quality control and assurance needed at two key stages to satisfy householders that they won't be exploited. Firstly, householders need expert and objective advice from accredited organisations on the options available and costs. Secondly, the works need proper inspection and certification by accredited organisations to assure householders on quality.

4. At national level, stimulate necessary research, development and innovation so that there is a supply chain of ideas feeding the Task Force requirements.

5. Work with the UK's energy utility providers to ensure a match of expectations, utility usage versus supply, and timing of utility expansion or decommissioning.

We believe it essential this Task Force within GB Energy be publicly-controlled. The argument for public ownership is strong. Achieving Net Zero is biggest socio-economic challenge confronting Scotland and the UK. The nations must undertake an unprecedented investment and innovation programme to decarbonise building heating. Governments and publicly-accountable agencies are needed to step up.

Six Challenges

With A GB Taskforce established the 6 Challenges could be properly addressed, as suggested for each Challenge in turn below.

Challenge 1: Strategy

- Context and Framing the Strategy

Is there clarity on the respective responsibilities of UK Government and Scottish Government for setting strategies and plans? The CCC does not think so as one of its recommendations is for both Governments to cooperate to map out reserved and devolved matters.

Is there alignment of Scottish and UK targets and strategies? Clearly not as Scottish Government targets have been deliberately set more ambitiously than UK targets. This provides endless scope for the Scottish Government blaming the UK Government for lagging behind and hindering Scottish progress. The end result is more complication in planning and actual delivery and, therefore, more cost.

One specific example of efficiency: would it not be sensible for both governments to set up a truly joint effort to set up a supply chain for heat pumps and to fund R&D for the next generation of heat pumps?

The Scottish Government has drafted an Energy and Just Transition Strategy which is out for public consultation. However, we do not believe the Scottish Government is properly organised for decision-making and delivery as between politicians and civil servants and key government agencies. The SNP must find room for its Green allies so all ministers are in a rapidly-spinning revolving door of appointments, which to the outsider have over-lapping responsibilities. We believe the complex structure of Ministers and Directorates brings duplication, overlap and lack of transparency and accountability. If everyone is responsible then no one is truly responsible.

The sector comprising home and buildings decarbonisation and energy efficiency will mostly be implemented at local level. So, what devolution of agency and budgets will SG introduce to ensure effective delivery? They must develop Delivery Plans in place, agreed with City/Regions and LAs?

We believe the complex structure of Ministers and Directorates brings duplication, overlap and lack of transparency and accountability.

If everyone is responsible then no one is truly responsible.



- Essential features of a Strategy for Net Zero

Public support is an essential. All decisions should thoroughly assess their likely impact on public support and should always seek to improve support.

Local issues may be important and virtually invisible at the top of the hierarchy. Delivery needs devolution from the outset. Therefore full and early involvement is needed (not consultation or telling) with all tiers of national, regional and local bodies.

Finance will clearly be a major challenge for public support. The overall finance planning should be to absolutely minimise the cost to householders and to push payment into the future.

Where there is a choice between cost and schedule then minimising cost should always be preferred, providing the schedule remains compatible with the 2045 goal.

If R&D options have potential to decrease householder costs then R&D should be the preferred decision.

Technology is an important factor. Technologies must be chosen which will be effective and easy for householders. Reducing the intrusion of the installation and its continuous improvement must be measured and managed to learn and improve.

Within “technology”, Insulation will be a very important feature. There is no point in rushing to decarbonise heating if the building is “leaky” so insulation has a high priority. The potential for robotic installation should be thoroughly investigated (if necessary at the expense of schedule) and clear-cut and easily measurable techniques incorporated into regulation for both housing stock, prior assessment and work completion.

There must be a visible ‘Green Dividend’ in terms of jobs, skills development and economic growth.

The quality of work (considerate planning, thoughtful about intrusion, high finished quality, time-keeping) must be high quality, trustworthy and effective to gain public trust.

A unified Delivery Task Force is required.

Challenge 2: Technology

Technologies to decarbonise heating in buildings

Technology is frequently not as simple as the backers hope. The technologies applicable to achieving Net Zero in heating buildings seemed simple at first pass but are proving more complex. This section reviews those available technologies needed to replace their carbon based forbears.

There are three main needs:

1. Replacing carbon based heating.

2. Upgrading the utilities to support the new ways to heat homes.

There are a number of carbon-free, renewable energy technologies but it must be stressed that none of these are proven to provide robust domestic heating. They are listed below and then the following sections assess their likely fit for Scottish building heating:

- Solar Panels (using photo-voltaic cells) to convert sunlight into electrical energy and solar panels (effectively mini roof mounted flat “greenhouses”) as the 1st stage heating for domestic hot water
- Heat pumps (with various sources of carbon-free heat: air, water, ground)
- Wind
- Geo-thermal
- Hydrogen
- Insulation

3. Insulation.

The heat loss from buildings costs means either wasted energy or cold interiors. Therefore better insulated buildings have to be part of the decarbonising project and, although generally perceived as “insulating the loft,” i.e. a no-technology, it now needs a technology revolution to deliver highly effective insulation at low cost and low intrusiveness.

Carbon-free, renewable energy technologies:



Solar:

this is proven technology for domestic generation of electricity. Obviously, its biggest drawback is dependency on clear skies but even then it is not available at night or under heavy cloud cover. That could be partially overcome by adding heat or electricity storage batteries but size and cost for multiple days of storage make this a limited option.

Heat pumps:

this is the answer currently favoured by governments. It is a long standing, mature and safe technology, being a variant of refrigeration and air conditioning. Its seductive selling point is that heat pumps can output 3-4 units of energy as heat from each input unit of electrical energy. This is termed the Co-efficient of Performance (COP) but I is dependent not only on the heat pump design but the climatic conditions. When the heat source is ambient air then the machine's efficiency will be dependent on the air temperature.

So, a heat pump will use more energy to produce heat when the ambient temperature is low (say -4°) than when it is moderate (say 10°). So a pump that has a COP of 4/1 at 10° may only have a COP of 2/1 at -4° and so use twice as much energy to run it when the weather is below freezing.

Clearly Air Source Heat Pumps (ASHPs) will be less effective in northern latitudes unless the dwelling has a low heat requirement (i.e. very well insulated). The situation in Scotland with low winter temperatures and frequently high winds is that an ASHP will not operate at high efficiency and hence require some 5 KW of input electricity to generate perhaps 10 kW of heating, i.e. expensive to the home owner and overly demanding for the electricity grid. The situation becomes worse in old housing, with poor insulation, and small modern housing currently using "combi" gas boilers.

The demanding challenges are:

- Retrofitting better insulation (to roof space, external walls, and flooring)

- Increasing the size of the radiators to compensate for their lower running temperature

- Installing a hot water tank (as the ASHP cannot heat domestic hot water at the rate of existing combi gas boilers)

- Current prices for electricity supply mean that ASHP's are more expensive to run than gas boilers.



Although ASHPs are the cheapest form of heat pump and can be easily retro-fitted in most (but not all) types of housing they still cost around £10,000 to install. Just as important is the issue of relative gas and electricity prices to domestic consumers. It is claimed that ASHPs typically offer a 3:1 leverage or COP, i.e. input 1kWh of electricity and get 3kWh of heat energy into the building. However, currently the cost of electricity is more than 3 times the gas cost, outweighing the heat pump's leverage and making it more expensive to run than a gas boiler.

Water source and ground source heat is widely available and will allow heat pumps to generate the range of temperature house-holders enjoy with gas central heating. There are several such installations (e.g. Stockholm has a sea-water scheme) providing heat to near-by apartment blocks or large civic buildings. There is a water source district heating scheme at Queens Quay in Clydebank Glasgow. The drawback is that the complexity and cost of the heat pump installation demands multiple users so this approach, like all district heating schemes suits new-build projects.

Ground source heat is a steady and higher year-round temperature (around 40 C at 100m depth) and the disadvantage is the cost of drilling the deep holes. Again a Ground Source Heat Pump scheme might be viable by serving multiple dwellings by spreading the bore-hole costs.

As the cost of a bore-hole is the main disincentive there should be a search for drilling developments from the North Sea drilling industry and possibilities explored and exploited for GSHP bore-holes.

A lower cost GSHP option is a relatively shallow network of small bore water pipes. At around 1 metre depth the ground temperature is steady at some 10 degrees C which enables GSHPs to achieve efficiencies of 5:1 and above. However the ground-work disturbance from installing the pipe network is prohibitive for most homes in terms of cost, space needed, and inconvenience. A developing technology which would radically change this position is **digging robots** (and such a technology would also bring economies to the construction/ installation of other utilities - gas, water piping and electrical and telecoms cabling).

As the cost of a bore-hole is the main disincentive there should be a search for drilling developments from the North Sea drilling industry and possibilities explored and exploited for GSH bore-holes.



Wind:

is well-proven in the form of large (3 MW or greater), through medium sizes for community onshore projects down to 1-10kW turbines for domestic use. Intermittency in wind and power generation is inevitable but many domestic users, chiefly in rural areas, use battery storage with grid supply as fall-back. Micro-turbines are not really suitable for urban deployment because of complex air-flows and noise and safety considerations. However large single turbines with storage may be viable as power supply in community sized Net Zero developments

Geo-thermal heat:

is from deep hot rock. New Zealand, Iceland and Italy have geo-thermal power stations and district heating schemes. The geology of the UK doesn't enjoy hot rock relatively close to the surface to make these schemes attractive.

However the Eden project has drilled into granite and found 180C rock which they plan to use for a small power station and local buildings heating.

Hydrogen:

is often proposed as the clean fuel of the future, including for heating homes and buildings. It can seem an attractive, or even seductive, option and it is proposed that the UK gas distribution could be converted from carrying natural gas (mostly methane) to 20% and ultimately 100 % hydrogen. A trial at Keele University using 20% hydrogen has been successfully concluded with apparently no problems. A gas/hydrogen mix with 20% hydrogen needs no change to domestic gas appliances but higher percentages would need modification (such as different burners and some added safety measures). Trials of 100% hydrogen are planned, for instance in Fife, to probe for any unknowns. One attraction is that householders would need to do relatively little to accommodate hydrogen. However, planned trials at the scale of 1000-2000 homes are experiencing local public push-back on safety grounds and one (at Whitby) has been cancelled.

Whilst the distribution side of the system is already being tested in some areas questions also arise concerning the supply of hydrogen, its cost, or lifetime. Taking these questions in turn:

Supply and Cost: carbon free hydrogen is and will remain, expensive. The main production methods are electrolysis which is, so far, expensive and inefficient or steam reforming of methane (natural gas) followed by capture of the CO2 by-product which is not yet proven at scale. Whichever production method is used the hydrogen has to be stored and transported which implies large pressure vessels, pipelines and possibly trucks.

Lifetime: Hydrogen is a small molecule and, historically, its containment requires special steels. New technology is being developed and perhaps the most hopeful involves carbon nano-tubes. It is in this storage/transport area that learning and continuing R&D will be required: an inevitably costly process.

The conclusion has to be that hydrogen may appear seductively attractive as the fuel- of-the-future - but at a cost and requiring effective measures to overcome its safety issues. A quote from a recent item in the journal “Joule” found “*that heating homes with hydrogen is less efficient and more resource-intensive than using electrical heat pumps*.”

Overall, it seems unlikely that hydrogen will be part of the energy transition for heating buildings.

Insulation:

to reduce the leakage of heat energy from a building or dwelling. Crucially, this reduces the quantity of a heating source to keep a building comfortable. In general terms Britain has lagged behind Scandinavia in its building regulations for heat retention but now new buildings are far more heat efficient than even 20 years ago. Clearly, a massive programme of new homebuilding is required for several reasons but achieving proper standards of energy efficiency is crucial.

The challenge posed by the Net Zero target is not only decarbonising the energy source but also to reduce energy demand.

This is especially important for the Air Source Heat Pumps option as described earlier. The problem in Britain is greater than most other countries as having industrialised earlier we have a larger stock of old houses which were essentially uninsulated. Over the last 40 years there have been government campaigns to particularly insulate roof spaces but now (and especially for ASHPs) floor and wall insulation has become important.

Clearly retrofitting insulation under floors or onto or into walls is far more technically difficult, intrusive and disruptive than insulating an empty roof space - and therefore very expensive. Even if the finance is acceptable there simply is currently insufficient skilled manpower to undertake the necessary “insulation revolution.”

Insulation - **R&D and Innovation needed**

We propose the funding of an urgent R&D competition to find less intrusive, faster and cheaper ways to upgrade home insulation. We suggest that this is a need which could be met by soft robots (think octopus arms and wriggly worms) which are developing fast in fields such as medicine but, as far as could be discovered, there is no activity or perceived need by the UK Net Zero projects. The leading universities in the field have a consortium of researchers in Robotics (including soft robots) and the biggest laboratories are Bristol University and Heriot-Watt (The National Robotarium). Robots and methodologies should be found for at least these objectives:

- To inject foam insulation into wall and floor spaces.

- The applications where such robots could transform the ability to undertake the modifications of housing to meet the Net Zero objectives are:

- to place insulation slabs or spray foam for underfloor insulation.

- to install underfloor heating.

- development of safe external insulation and its installation.

Successful development of practical and commercial robots would mean funding a university for the development of existing research together with a suitable industry partner. The objective would be to produce a range of low cost and robust robots which could be inserted into walls or under floors (with relatively low intrusiveness), suitably equipped with cameras, programmed where to crawl, able to avoid cables, and to successfully spray foam insulation.

A robot development project could also enable better or cheaper forms of insulation which should be industrial developments with less need for university R&D.

These suggested innovations would need to be worked closely with building regulations to ensure that challenges such as moisture control, ventilation needs and electrical safety, are all proven.

Such a programme would typically take 10 years to enter commercial operation (including certification and technician training) but if treated with the urgency of the Covid vaccine development it could possibly be reduced to 5 years.

In parallel with research into ‘robotics for insulation’ we identify an urgent need to improve heat pump performance or alternative low/no carbon heating systems.

We suggest two prizes named, for the pioneer, James Watt Prizes to stimulate the development and innovation with these objectives:

- to produce the best ‘cost per kW heat delivered’ aiming to achieve parity or better with current gas-fired central heating.

- to install insulation in confined spaces such as wall cavities and underfloor spaces and to install underfloor heating to produce the ‘best cost per kW saved’.

Support Utilities also need new technology

The second need for new technology is the support utilities, particularly the electricity supply grid, needed to support Net Zero domestic energy. For instance and assuming all gas, oil and coal heating is abandoned then electricity usage will greatly increase to power:

- Electrically driven heat pumps
- Cooking
- Charging EVs

The local supply side of the grid works up from individual dwellings to street level and thence district level transformers. Individual dwellings typically have 100 amp fuses which should allow a potential 20 KW of load. However the local district's grid distribution system assumes that the average load per dwelling is much less than 20 kW, maybe 4 kW which is far less than the Net Zero average will demand. New supply cabling will be needed.

Community Schemes will need to pay careful attention to utilities supply. It seems likely that the most cost-effective approach to improving both energy efficiency with insulation or installing low-carbon heating systems is on a campaign basis delivering to whole communities. This allows economy of scale but also brings into consideration smart local electricity distribution, with smart meters and demand management assisted by electrical or heat storage batteries.

Where ASHPs for individual buildings may not be appropriate or feasible (e.g. tenement flats) then community level schemes may offer a practical answer. These could be based on one or more renewable energy sources with suitable battery back-up for windless days. For instance a community scheme might consist of a deep borehole GSHP and pipe its hot water around the community and itself be powered by a small wind turbine with battery back-up.

At the other end of the grid is the change from a relatively few large power stations strategically placed around the country to a multiplicity of wind-farms which generate electricity. New electronic technology is enabling the national grid to be upgraded to the new supplies and to maintain its strict 50 Hertz synchronicity.

The other utility facing disruption is natural gas distribution. Either it faces abandonment or switching to a hydrogen-natural gas mix and finally to pure hydrogen. Hydrogen, due to the smallness of its molecules compared to natural gas, is hard to guarantee complete and safe containment hence any plan to move a 100% hydrogen distribution network will need both proving safety containment of the pipeline materials and then upgrading to effectively a new distribution system.



Challenge 3: Infrastructure & Regulation

In some key areas regulation must drive infrastructure development, e.g. regulation to stop fitting gas boilers will drive up usage of heat pumps or a switch from natural gas fuel to hydrogen. Where the technology is not yet mature (e.g. hydrogen domestic usage and/or unsatisfactory heat pumps) it may be difficult to choose between alternatives and yet regulation and infrastructure development is needed.

- Regulation

Regulation is the hard edge of government policy on Net Zero. This is where citizens are abruptly faced with unpalatable rules which affect their daily lives and finances. For example, many people will feel little attraction to being compelled to drive an electric vehicle, still more will object to replacing familiar gas boilers with new and expensive heating systems. Governments need to show leadership to keep the public on board with a judicious mix of carrots and sticks.

There is a triangle formed by Technology/Cost, Regulation and the Public. For example, we currently assess ASHPs as in need of improvement in performance and cost. The public will find this out and quite possibly push back very hard on new or extended regulation. Governments, both UK and Scottish, should realise that they cannot achieve Net Zero by stealth – they need to show real leadership to carry the public with them.

Reform of the electricity market is long-overdue. As noted earlier the current ratio of electricity price to gas price is nearly 4:1, which makes ASHPs more expensive to run than a gas boiler as well as costly to buy and install.

The CCC recommends that the Scottish Government "C*oordinate with the UK Government to develop and implement proposals for a market-based mechanism for heat pump deployment. Evaluate the likely impact of this policy and if needed develop additional plans in to deliver heat pump installations at the rate required by Scotland's Heat in Buildings Strategy.*"

But without firm dates set by government the supply chains necessary for mass insulation, or ASHPs or Hydrogen systems may not be set up in time. So, setting regulatory frameworks is difficult for government trying to retain flexibility in the face of rapidly-changing technologies but also trying to stimulate the new technologies.

The public will not sympathise and, at least, will demand assurance that government knows what it is doing and that necessary changes are made available at least cost and to high standards. Hence our proposal for a dedicated Delivery Task Force to reassure citizens.

Challenge 4: Finance

Two issues are of key public interest: costs and financing schemes for householders.

The consequences of failing to curb CO2 emissions may well be existential for much of humanity so investment and action are clearly required. However, governments also insist that these are not just ‘insurance against climate disaster’ but investments which will yield a good return in more affordable and secure energy systems.

Governments have shied away from claiming accurate estimates but we need to estimate order of magnitude costs, say for Scotland achieving Net Zero in heating buildings. Are these viable investments?

To achieve upgrade and re-equipment of homes and buildings a trustworthy scheme offering finance to householders is required otherwise take-up will falter.

- Cost-Benefit estimates

The Scottish Government has deemed that achieving EPC Level C by 2033 in Scotland’s homes and public and commercial buildings is a sensible interim target en route to net zero by 2045. This would include both energy efficiency measures such as insulation and the installation of low-carbon heating systems.

In 2021 the Scottish Government Minister, Patrick Harvie, estimated it would cost £33bn to upgrade Scottish homes and pubic and commercial buildings to EPC Level C by 2033. There were 2.67 million dwellings in Scotland in 2021 plus approximately 220,000 non-domestic buildings in Scotland, including around 23,000 buildings in public ownership. Sadly, the Government has failed to publish any breakdown of the £33bn for dwellings although it must have done so in private to compile the £33bn total estimate.

However, in a Freedom of Information response[4] the Government attempts a ‘bottom up’ estimate for home owners to achieve Level C. It notes that a typical cost of energy efficiency measures including simple insulation is around £2000 with a further £10,000 to, say, install a heat pump.

Of course there will be significant variation in difficulty and costs. Costs will be much higher where there are constraints on technology choice (such as noisy ASHPs in tenements), or location in highly-regulated conservation areas, or capacity constraints on electricity supply.

Taking these ‘typical’ cost figures of £2000 for energy efficiency per dwelling and £10,000 for low-carbon heating per dwelling how does this look to a property owner as an investment?

Government in 2023 estimates the average cost of energy per dwelling as £2000/year. Upgrading the insulation, if done properly, might save 25% of the £2000/year, i.e. £500. So, the payback on simple insulation of lofts and cavity walls is attractive.

But underfloor insulation and internal or external cladding of non-cavity walls will cost several thousand pounds and may not be an attractive investment.

Taking the ‘typical’ cost of installing an ASHP for £10,000, only enthusiastic homeowners would invest. At present the running costs for an ASHP are similar or higher than for a gas boiler. So there is no payback. This problem of high running costs is created by the relatively high price of electricity compared to gas. Heat pumps offer a 3:1 leverage, i.e. 1kWh input to an ASHP generates 3kWh of useful heat. But if electricity prices are more than three times gas prices (as they are in 2023) the cost advantage lies with gas boilers and the heat pump leverage drops to 2:1, or less, at low winter temperatures.

Fuel poverty in Scotland affects 24% of homes. This problem is one of many that the Scottish Government has promised to solve but not delivered on. The problem tends to be worse in Scotland’s 170,000 off-gas-grid homes, mainly in the Highlands and Islands. Upgrade costs and fuel costs tend to be higher but special attention will be needed to financing upgrades. It will be scandalous if the opportunity is not taken to reduce fuel poverty.

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- Financing Schemes and Trustworthy Delivery

To its credit, the Scottish Government set up a public agency, Home Energy Scotland, to provide expert impartial advice to the public on upgrade options and to manage financing schemes to facilitate uptake.[5]

There are some issues with the scheme relating to the limited amount of funding from Government that HES can access and make available as grants and loans to the public but the essence of scheme seems sound.

To support the full implementation of this vast project a greatly enlarged scheme of grants/loans is needed. We suggest:

- UK Government, working together with Scottish Government, sets up a Project Task Force under the umbrella of the proposed Great British Energy located in Scotland to oversee scheme's implementation at national and local level.

- Government provides funds or guarantees to trusted financing organisations, e.g. mortgage lenders used to managing many customers.

- Trusted experts, e.g. HES assess options for householders.

- Householders apply for Home Upgrade Package of grants and loan from Lenders.

- Period of loan say 10-15 years and transfers to new owners if dwelling is sold

- Installation Contractors are vetted and certified

- Installation work is inspected and certified.

A key issue would be the amount of funding or guarantee made available by Government and whether they attempt to attract commercial investment in the scheme. Different terms could be tailored to customers in different financial situations.

Challenge 5: Green Dividend

All the 6 Challenges overlap and interact but the triangle of Technology, Green Supply Chains and Finance is crucial if there is to be a Green Dividend. There is a reluctance by government to 'pick winners' but without strategic direction and regulation there is a risk that new technologies will fail to be adopted, supply chains will not be financed and jobs will only be created abroad (as has happened with offshore wind).

An example of where there is a real opportunity is the robot development suggested earlier in this paper. Such an innovation could be a real player for early adopters and hence be a real contributor to the much-vaunted Green Dividend. It would mean less pressure on the labour market but better opportunities for high skilled employment.

This is exactly the sort of challenge where a specific delivery vehicle is needed to activate and manage development, certifications, manufacture, training and commercialisation. Unlike other needed innovations the question of home insulation is more relevant in the UK, and especially Scotland, than in most countries and hence less likely to be undercut by overseas lower cost mass production.

Progress so far?

The delivery of a Green Dividend, with thriving industries and well-paid jobs is, so far, a mirage and the public is beginning to see that the 'Emperor has No Clothes'. For example, Scotland has provided huge offshore licence areas for wind farms but almost all the supply chain from design to construction is based outside the UK. Furthermore, the wind farms themselves are largely foreign owned. Only the maintenance activity is based in UK seaside towns by geographical necessity. No UK innovation, no UK supply chain, no UK ownership and revenue, few Green jobs.

Both governments must seize the chance to apply all possible strategies and tactics to ensure a much higher UK content of the huge projects needed to deliver Net Zero.

...the wind farms themselves are largely foreign owned. Only the maintenance activity is based in UK seaside towns by geographical necessity. No UK innovation, no UK supply chain, no UK ownership and revenue, few Green jobs.

Examples from other Energy Sectors of Green Dividends missed

Green Dividends need to be earned. Governments, both UK and Scottish, have never been shy of proclaiming their Green credentials and global leadership and promising Green Dividends. But this 'leadership' has tended to be in rhetoric and photo-opportunities rather than in timely and consistent planning and investment. Many examples of failures to develop technology and applications through reluctance to invest in research, development and innovation are now visibly constraining government freedom of action and delaying progress to Net Zero.

Carbon Capture Utilisation and storage (CCUS) could be a huge enabling technology especially for Scotland and the UK with its existing petro-chemical expertise and its North Sea infrastructure for CO2 transport and storage. Yet pilot schemes promoted in the early 2010s for Peterhead and Yorkshire were shelved in 2015 by a government reluctance to invest what now look like trivial amounts. Consequently governments do not know whether CCUS can contribute to allowing continuing use of oil and gas for steel, cement and power generation. Strategic choices cannot be made as between energy sources and, possibly, opportunities for a UK supply chain may be missed.

Elsewhere, offshore wind development leases were sold too cheaply by Scottish Government and Crown Estate, missing an opportunity to generate funds for Green investment. Furthermore, there has been a fatal lack of using the terms of offshore licences to require use of UK-produced equipment and services. Scotland provides the wind resource but other countries secure the supply chain and profits. There may be a second chance with future floating wind turbines but competitor countries will be ahead in experience.

Tidal flow power generation is a possible growth area. Currently focused in an Orkney-based demonstrator this technology may well have wider application around the UK and globally.

Managing the intermittency of renewable power generation requires energy storage and Scotland has a major opportunity for new pumped storage schemes. Whether any can survive the permitting process is doubtful.

Aside from pumped storage there are massive opportunities for designing and manufacturing battery systems, heat storage and demand management systems to mitigate intermittency.

Intermittency of wind will require excess wind farm capacity. This will allow opportunities for use of otherwise constrained power output to generate hydrogen, alleviate fuel poverty, heat greenhouses, etc.

The role of remote but enterprising communities such as Orkney, Shetland and Gigha can be crucial in providing test beds for demonstration projects of emerging technologies. For example Orkney currently hosts tidal and wave power projects, hydrogen generation from wind power plus storage and usage, and local integrated networks of household and commercial power users.

What can be done?

The first and essential action is the **establishment of the GB Taskforce** under the umbrella of Great British Energy based in Scotland. After that address these points:

• In Scotland/UK government funds university research quite well so research output is healthy. However, we need a 'supply chain of ideas' where the supply of inventive ideas from research is balanced and driven by a demand for innovation.

• We argue that an Industry Strategy is needed for Scotland to set alongside the Energy and Transition Strategy.

• Scottish Government must be bolder and wiser in supporting growth opportunities. For example: the CCC recommends that Scottish Government coordinate with the UK Government to develop and implement proposals for a market-based mechanism for heat pump deployment. Evaluate the likely impact of this policy and if needed develop additional plans in to deliver heat pump installations at the rate required by Scotland's Heat in Buildings Strategy.

• Timing and agile government will be crucial. The response to COVID revealed that the UK could deliver on a mission to vaccinate the population. But does government have enough confidence, expertise and resources to replicate this?

• The scale and complexity of changing Scotland's domestic heating and cooking systems from burning hydrocarbons to clean renewable power is huge. It will need a very considerable workforce which in itself brings some prosperity and many other opportunities are already apparent and many others will appear as the change-over progresses.

Probable opportunities are:

• **Equipment design, manufacture and supply**: there are a variety of technologies from already-in production through to development projects:

• air and ground source heat pumps
• geothermal power,
• boreholes for both GSHPs and geothermal
• roof mounted wind turbines,
• small hydro power,
• novel electrical heating (ceiling and under-floor,)
• local electrical supply upgrades,
• HV grid upgrades
• All above will be subject to continuous improvement through R&D and users' reports

Services:

• installation and through-life: likely to be more complex than today's boiler and radiators installation
• education and training
• building survey, insulation and new heating system design and cost estimation, project oversight and inspection
• finance provision by loan or grant
• final inspection, sign-off and certification

Decommissioning redundant hydrocarbons household and supply equipment:

• Gas heating and cooking, and oil/wood/coal heating appliances will need to be removed and scrapped
• Gas distribution grid and distribution pipework will either need removal or re-purposing

Challenge 6: People

Ultimately, success in achieving Net Zero will depend on millions of citizens accepting the need for change, disruption and personal spending. Politicians of all parties try hard to present the transition to Net Zero not just as a necessary cost but as a sensible investment to generate a Green Dividend of cheaper heating, better living conditions and new Green jobs. They will be hard-pressed to convince a sceptical population suffering a continuing fall in real income.

Opinion polling tends to show strong public support for the goal of Net Zero in Scotland by 2045 and for the measures required to achieve this, such as phasing out gas boilers and petrol cars. However, as the actual deadlines approach there will need to be clarity and honesty from government on costs and benefits and how finance will be arranged. Unless government provides clarity on where the cost burdens will fall there seems a risk of growing dissent. Signs of this have been reported from Germany and reported in London regarding the extension of the low-emission zone.

We believe setting up a Delivery Task Force as a public agency working to deliver changes efficiently and transparently can help overcome public scepticism.



The waterfall graphic shows some of the questions a sceptical Scottish public might ask:



It would be unwise to assume the public is deeply engaged in the issues. And even more unwise to assume they will be cooperative and supportive if the questions above are not properly addressed.

Conclusions - What we need from Government in Scotland

Any sector of Net Zero needs these ingredients to combine:

1. **Cooperation not conflict** between the Scottish Government and UK Government to achieve the best outcomes for Scotland. Encouragement for similar cooperation in academia, industry, business and finance between the two nations.

2. **Organisation** of Scottish Government for transparency and clear accountability. This requires clear Ministerial and Directorate structures to set out targets, strategies, policies, regulation, Road Maps, supply chain strategy, etc.

3. **Analysis** commissioned by Government with expert input from academia and industry, of technology readiness and gap analysis, assessment of Supply Chain capabilities, skills audit, and investment requirements from state and private sources.

4. **Engagement and devolution** of agency and budgets between Scottish Government, City/Regions and Local Government with devolution of agency. This is particularly needed for domestic heating decarbonisation which will require city-regional and local innovation in the business and public sectors together with training programme under local authority and HE/FE leadership.

5. **Mission-based cooperation** between Universities, FE colleges, Innovation Hubs and government to focus on innovation needed to deliver change, e.g. better heat pumps, cost-effective district heating retrofits, novel insulation materials and methods, and modular housing.

6. **Honest political leadership** to retain the existing public support for Net Zero in Buildings. This support will fade if technologies such as ASHPs are over-hyped, if finance support packages are not defined in the near future and if regulations are seen as oppressive.

7. **Agreement** to create a Special Project Task Force for Delivery requiring plans at national, city-regional and local levels with target dates and delivery projects identified and integrated.

Appendix 1 - Emissions Reductions Targets and Progress in Scotland

Scotland's Net Zero targets in context.

Most developed nations aim to achieve Net Zero greenhouse gas emissions by 2050 or thereabouts, i.e. a net zero balance between emissions and removals of greenhouse gases, usually expressed in amounts of carbon dioxide including equivalent amounts of other greenhouse gases.

The UK target date is 2050 but Scotland has committed to the earlier date of 2045.

The impact on global CO2 emissions of Scotland (or UK) achieving Net Zero is modest. However, there are other reasons, moral, political and economic, so the target dates are legally binding.

Currently, global emissions are around 52 billion tonnes CO2 equivalent per year.

UK (territorial) emissions in 2021 were estimated at 426 million tonnes CO2 equivalent (MtCO2e/year). That is very approximately just under 1% of the global total.

Scotland's territorial emissions in 2021 were estimated at 40 MtCO2e/year, approximately 0.1% of the global total.

It is useful to split these figures for Scotland to understand the importance of 'Heating in Buildings'.

	Emissions in MtCO2/year	% of Scotland Total
Total Scotland	40	100%
Sector within total		
Transport	10.3	26%
Industry	10.1	25%
Buildings	8.5	21%
Agriculture and Land Use	8.4	21%
Electricity	1.7	4%
Waste	1.5	3%

What progress is Scotland making?

The **overall** Greenhouse Gas (GHG) Account basis is used to assess progress against the legislated targets.

The overall results and future targets for emissions reductions are:

For 2020 the Scottish Government legislated interim target 56% below 1990 levels. The reduction achieved was a very creditable 59%.

For 2030 the legislated target is a 75% reduction on 1990 levels. The Climate Change Committee (an independent Government-funded agency charged with oversight of governments' progress) notes that this target exceeds CCC advice and will be extremely challenging.

For 2040 interim target date is legislated for 90% reduction on 1990 levels

2045 is legislated as the Net Zero target.

Emissions from buildings (includes residential, commercial and public buildings).

For 2020 Emissions from buildings were 8.5 MtCO2e, reduction of 6% on 2010 levels

This is estimated as a reduction of 20-25% since 1990.

2030 interim target is for a 70% reduction on 2020 levels but CCC notes policies are not yet in place to allow achieving this 'very challenging' target.

CCC notes 'Scotland has ambitions to decarbonise buildings much faster than the UK as a whole' but warns that adequate policies are not yet in place for low-carbon heat and energy efficiency improvements.

Appendix 2 - Devolved and Reserved Powers Relating to Heating of Buildings

Devolved and Reserved Powers

Lack of cooperation and alignment between the Governments is flagged by the CCC Report as a risk, so what powers, relative to decarbonising buildings, are reserved or devolved?

The devolution of powers is complex and contentious and a simple overview is given in Appendix 2.

The CCC Report (Page 145), makes these distinctions:

Largely devolved areas

• Agriculture, forestry and fisheries
• Economic development
• Environment (climate change policy, air quality, water policy)
• Waste policy and management
• Biodiversity and conservation
• Local government and housing (local government funding, renovation, housing policy)
• Planning (planning policy, local planning authority guidance, land use planning system, planning for major electricity generators and offshore wind)

Partially devolved areas

• **Buildings (building standards and rating, fuel poverty, domestic energy efficiency, public sector energy efficiency, promoting business energy efficiency)**
• Surface transport (highways construction and maintenance, freight transport, bus services, rail transport and railway services and regulation, active travel – road transport is reserved)
• Infrastructure (nationally significant infrastructure, EV charging infrastructure, CCS, hydrogen, engineered removals)

Largely reserved areas

• Economic and fiscal policy, financial services, and financial markets
• Home affairs
• Power (generation, transmission, distribution and electricity supply – coal – nuclear energy)
• Energy supply (security of supply, oil and gas ownership, exploration, exploitation of deposits, offshore installations, and pipelines)
• Trade and industry (regulation of competition, import and export control, product standards, safety and liability)
• Shipping and aviation (except for Air Passenger Duty, which is devolved) • F-gases

For Heating of Buildings policy many areas as above are devolved to the Scottish Government but the areas reserved to the UK Government cut across the sector. With the general lack of cooperation and coordination between the Governments this brings the risks to both of confusion, delay and inefficiencies.

For example:

- UK Government reserves the control of gas and electricity supply infrastructure. So a widespread switch from gas boilers to electrically-powered air source heat pumps will require massive upgrades to the electricity distribution system.
- UK Government will decide a UK-wide market-based mechanism to support low-carbon heating.
- UK Government will reform the electricity market, affecting the relative prices of gas and electricity, a key driver for householder decisions on switching
- Alignments of EPC system reform and Heat Network regulatory frameworks are clearly needed.

Unless there is real, cooperative alignment between Governments on these and other Net Zero issues there is a significant risk of de-motivating the public in both nations as they perceive bickering and indecision.

Endnotes

1 https://www.theccc.org.uk/2022/12/07/scotlands-climate-targets-are-in-danger-of-becoming-meaningless/

2 https://www.theccc.org.uk/publication/scottish-emission-targets-progress-in-reducing-emissions-in-scotland-2022-report-to-parliament/

3 https://www.theccc.org.uk/publication/scottish-emission-targets-progress-in-reducing-emissions-in-scotland-2022-report-to-parliament/ page 95

4 https://www.gov.scot/publications/foi-202200315222/

5 https://www.homeenergyscotland.org/funding/grants-loans/overview