Establish a date by which no new fossil fuel heating can be fitted

1. EXECUTIVE SUMMARY

1.1. Over a third of the Island's emissions come from the burning of fossil fuels in heating appliances (boilers and cooking appliances).

1.2. The UK Committee on Climate Change (UKCCC) has recommended that 'deep electrification' of heating is one of the core measures required to meet the UK's emissions targets, however, over the last ten years very little progress has been made despite the technology required being available. This is a good indication of how difficult it is.

1.3. There is no reason why alternatives to fossil fuels such as, heat pumps and solar thermal devices should not be used to provide heating in all new built properties.

1.4. For existing properties it is not as straight forward as simply swapping a fossil fuel boiler for an electric alternative.

1.5. Electric boilers can provide a direct swap for fossil fuel appliances but they have the highest running costs of all fuels.

1.6. Heat pumps have lower operating costs but can be significantly more expensive to buy and more disruptive to install than fossil fuel boilers.

1.7. For heat pumps to operate efficiently they require radiators to be changed or underfloor heating to be provided and where they replace a combi-boiler a hot water tank may be required, which adds additional cost and disruption.

1.8. Grid constraints, particularly older supply cables that provide power to rural properties, may mean that switching to electric heating is not possible.

1.9. If, in addition to electric heating, electric vehicle/s are also to be charged at a domestic property then a 3 phase supply may be required.

1.10. Liquid biofuel, such as Hyrotreated Vegetable Oil (HVO), could be used as a 'drop in' replacement for oil in existing systems but the sustainability of the feedstock is questionable.

1.11. Bio-methane produced from silage is explored as a viable 'drop in' option to decarbonise parts of or all of the gas network.

1.12. The potential for a hydrogen economy to develop complicates the picture and the possibility for using blends of biogas and hydrogen may play a role.

2. THE CHALLENGE

2.1. In 2017 approximately 296,000t (35%) of the Island's CO_2e emissions came from heating appliances that burn fossil fuels such as oil and gas (Aether, 2019) with a small contribution from coal and peat thought to be less than 1%. The split between oil and gas was approximately 50:50 (Cabinet Office, 2019). Of the gas consumed approximately 90% was natural gas with the remaining 10% being Liquid Petroleum Gas (LPG) (Cabinet Office, 2019).

3. EXISTING GOVERNMENT POLICY

September 2006

3.1. Tynwald approved a Council of Ministers report on Energy Policy which contained the following core energy policy and supporting aims (Tynwald, 2006).

3.2. Core Energy Policy:

- To maintain and build on the high quality of life enjoyed by the Island's community by providing the energy needed to allow economic growth at a financial price that is affordable for all consumers and at an environmental cost that does not compromise the ability of future generations to meet their own needs.

3.3. Supporting aims:

- to maintain the security of energy supply.
- to secure the efficient use of affordable energy.
- to minimise the impact of our energy use on the environment.

May 2013

3.4. Tynwald received the Council of Ministers' Report on Environment and Infrastructure Policy and agreed that the key objectives detailed in the report be the general framework for the development of Environment and Infrastructure policy. The key objectives include the following which relate specifically to climate change mitigation:

- Government will adopt a greenhouse gas emissions target for the Isle of Man of 80% reduction of 1990 levels by 2050
- Government will develop policies and strategies that will lead to reductions in greenhouse gas emissions to meet that target (Tynwald, 2013)

May 2015

3.5. The following policy was approved by Tynwald:

- To deliver the agreed scale of emissions reduction it will be necessary to ensure that net emissions of greenhouse gasses from buildings will be close to zero by 2050 (Tynwald, 2015).

Chief Minister's speech May 2019

3.6. *"Today I am announcing that we will be bringing forward a Climate Change Bill which will be presented to Tynwald in the next legislative year. We have taken on board the comments and concerns of our residents during the climate change mitigation consultation, and I look forward to working with all Tynwald members in developing this bill.*

This Climate Change Bill will commit this government and future administrations to reach net-zero carbon emissions by 2050 in line with the United Nations Intergovernmental Panel on Climate Change report.

As part of this plan we will look into a number of imminent actions. These will be: …We will ban all fossil fuel boilers in new build housing by 2025…" (Isle of Man Government, 2019).

A date by which no new fossil fuel heating can be fitted

3.7. The following electric alternatives to fossil fuel heating appliances exist on the market today:

- electric boilers (combi and system boilers).
- direct electric space heaters.
- direct electric water heaters (taps and showers).
- storage heaters.
- heat pumps.
- radiant space heaters.

3.8. Assuming that the replacement of existing fossil fuel appliances with electric would happen incrementally over the next 20 years, it is technically possible to stop installing new fossil fuel fired appliances tomorrow, however, as will be explained, this would present major challenges and other non-fossil non-electric sources of energy, i.e. solid/liquid/gas biofuels, hydrogen and solar thermal, are options. Also, the role of alternative methods of distributing low carbon heat, such as heat networks, needs to be considered.

3.9. Over ten years since the UKCCC first recommended deep electrification of heating very little progress has been made despite technology being available to do it. This is a good indication of how difficult it is.

Heating system lifespan

3.10. Estimating the life of a heating system is not as straightforward as it first seems. A reasonable estimate for the average economical lifespan of a typical gas or oil boiler would be approximately 15 to 20 years (this is reflected in the rate of turnover in gas boilers each year) but there are many other components of heating systems, including the supporting infrastructure, that need to be taken into account, which are considered in greater detail in the following sections.

Cost of heating fuel

3.11. The Office of Fair Trading regularly report on the running cost of various heating options. A summary of the costs for September 2019 is shown in Figure 1.

ISLE OF MAN DOMESTIC HEATING COMPARISON
COST PER USEFUL kWh

Prices Collected. *09 September 2019*

FUEL TYPE	APPLICATION	COST PER kWh (pence)	COST PER USEFUL kWh (pence)	ASSUMED THERMAL EFFICIENCY OF APPLIANCE	AVERAGE ANNUAL CONSUMPTION (kWh)
Electricity (COST INCLUDES STANDING CHARGES WHERE APPLICABLE)					
Standard or Prepayment	Radiator/Electric	19.45	**19.45**	100%	4,000
Comfy Heat (Composite)	Storage Heater	13.19	**13.81**	95%	6,000
Gas (COST INCLUDES STANDING CHARGES WHERE APPLICABLE)					
Natural Gas Band A	Gas Boiler	10.24	**11.38**	90%	2,500
Natural Gas Band C	Gas Boiler	8.54	**9.49**	90%	8,751
Cylinder Central Heating Gas	Gas Boiler	8.66	**9.62**	90%	10,000
Mini Bulk Gas	Gas Boiler	8.60	**9.56**	90%	10,000
LPG Gas Fire (BK & CB Tariff)	Gas Fire	13.15	**23.08**	57%	2,500
Natural Gas Fire (NB Tariff)	Gas Fire	10.13	**17.77**	57%	2,500
Heating Oil (28 Sec)					
900 Litre Quantity	Oil Boiler	5.80	**6.44**	90%	10,000
450 Litre Quantity	Oil Boiler	6.21	**6.90**	90%	10,000
Air Source Heat Pump					
Heat Pump (Composite)	Heat Pump	15.04	**5.49**	300%	10,000
Solid Fuels					
House Coal	Modern Stove	5.69	**7.59**	75%	10,000
Anthracite	Room Heater	5.81	**7.75**	75%	10,000
Phurnacite	Room Heater	6.89	**9.18**	75%	10,000
Taybrite	Multi-Fuel Stove	5.71	**7.14**	80%	10,000
Wood					
Woodchip (Moisture Content < 30%)	Woodchip Boiler	3.60	**4.00**	90%	10,000
Manufactured Heat Logs	Wood Burning Stove	6.67	**8.33**	80%	10,000

Cost Per kWh: *Expresses cost in relation to the total energy within a fuel. It is a theoretical comparator which assumes 100% efficiency with no wastage. Cost Per kWh = Cost Per Unit Sold [including standing charge] / Heat Content (kWh) Per Unit Sold.*

Cost Per Useful kWh: *Expresses cost in relation to the useable energy within a fuel, or in other words the heat energy that is likely to be extracted. It is intended to be a more realistic comparator which takes into account the efficiency of the appliance burning the fuel. Cost Per Useful kWh = (Cost Per Unit Sold / Thermal Efficiency of Appliance) / Heat Content (kWh) Per Unit Sold.*

kWh: *The kilowatt-hour is a unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour (1 h) of time.*

Heat Content: *The kWh of energy contained within a fuel. Heat contents quoted are taken from the 'Sutherland Tables':*

Thermal Efficiency: *The percentage of energy contained with a fuel, which the appliance can successfully extract and convert into useful heat. E.g. a 90% efficient boiler will extract 90% of energy within a fuel and convert this into useful heat. The remaining 10% is wasted. Efficiencies of individual appliances may vary substantially from the examples provided. In particular, the 90% efficiency for gas and oil boilers is based on a modern condensing boiler, in conditions where the return temperature is low enough to allow condensing to take place.*

Figure 1: Comparison of heating costs (OFT, 2019)

4. FUEL DELIVERY

Oil

4.1. Refined heating oil is delivered to the Island by ship, held in storage facilities near ports and then distributed via road tanker to customers. At the customer's property the oil is then held in storage tanks. In the right circumstances the life of an oil tank and the pipework that delivers oil to the boiler could be several decades longer than that of the boiler. It is likely that such tanks are capable of storing oil blended with a degree of low emissions alternatives, such as 30% biodiesel or Hydrotreated Vegetable Oil (HVO) but not 100% biodiesel.

Gas

4.2. The majority of gas customers on the Island use mains natural gas, which is brought to the Island via a high pressure subsea pipeline and distributed to customers around the Island via a network of pipes. LPG is brought to the Island via ship, held in storage facilities in Douglas and distributed to customers via tanker/ in bottles. Both the LPG and natural gas networks are described in more detail in Work Package 21.

4.3. A great deal of Polyethylene (PE) pipework has been installed over the last 20 years to enable customers to connect or remain connected to the natural gas part of the network and all of the pipework that delivers LPG is PE (Pers comms, Manx Gas, 2019). The design life of the PE pipework is approximately 80 years (Pers comms, Manx Gas 2019).

Solid Fuel

4.4. Fire wood is currently produced on Island and imported from various sources around Europe. Demand for firewood deliveries has increased with an increase in the popularity of wood burning stoves. Approximately 250 building control applications per year have recently been received for such installations.

4.5. There is also still a small amount of coal and peat imported via ship. All of these solid fuels are typically stored in solid structures, which may have a lifespan as long as the property they serve. If considering a switch from coal to wood the volume of a coal bunker may not be sufficient.

4.6. The number of solid fuel appliances that act as the primary heat source for properties is unknown but likely to be low. The vast majority of solid fuel appliances are likely to provide supplementary heating only.

4.7. The Department of Environment, Food and Agriculture (DEFA) currently produces up to 1,200 tonnes of G50 fuel grade woodchip, which is used in 5 commercial size biomass boiler applications, including sheltered housing schemes and a secondary school. It has been estimated that with current infrastructure and existing standing biomass stocks up to 10,000 tonnes per year could be sustainably produced. Full utilisation of this resource could provide approximately 375,000 kWh of heat per year. This would displace approximately 9,500 tonnes of CO_2 emissions if replacing oil fired heating or 7,000 tonnes if replacing gas fired heating. This equates to approximately 1% of the Island's emissions in 2017.

Electrical appliances

4.8. Nearly all properties on the Island have a mains electricity connection. The age and capacity of the cabling in the current network varies but once installed it should last for many decades, however, if demand increases to a point where it exceeds the rating of the supply it may be necessary to upgrade the cabling and meter, which could be very costly, particularly for those for those on the periphery of the network in rural areas. A typical domestic supply would be single phase rated at 14kW (60Amp at 230V) but in some cases this could be considerably restricted, e.g. <10kW. If, under a deep electrification scenario, additional power was needed to run a heat pump, electric hob/ induction hob and charge one or more electric cars at the same time then the cable and meter would have to be upgraded to 3 phase.

4.9. As a primary heating method both direct electric heating and storage heaters, which convert 1 kW of electricity into nearly 1kW of heat, have the highest running costs, see Figure 1. Many rented flats and houses have direct electric heating that doesn't meet the requirements of the Housing (Standards) Regulations 2017 or Housing Act 1955 respectively. In the UK there is a requirement for heating to be affordable (Williams, 2019), however, this is not the case in the Isle of Man.

4.10. As heat pumps can produce approximately 3 times more heat per unit of electricity than direct electric heating the degree to which they are adopted have significantly affect future electricity demand.

Solar

4.11. Onsite solar photovoltaic (PV) devices could supplement electricity demand and solar thermal devices, which need suitable hot water cylinders, could provide all of the required hot water in summer months and supplement a considerable amount of demand in spring and autumn.

Electricity grid constraints

4.12. The current network requires upgrades to accommodate Air Source Heat Pumps (ASHPs) and Electric Vehicles (EVs). Work Package 23 looks at the cost of grid upgrades. Until upgrades are made the banning fossil fuel boilers could make homes with no other options unfit to live in. The Electricity Act 1996 places a duty on the Manx Utility Authority MUA to provide a supply of electricity on request but they also have the power to defray the cost to the owner/ occupier of the land.

Heat storage and distribution

4.13. Fossil fuel boilers are typically used to heat water that is either; delivered via pipework directly to taps, used to heat hot water storage tanks or circulated in pipes around buildings to radiators that release the heat into rooms.

4.14. Fortunately the Island has soft water so the build-up of lime scale in a system, which can severely shorten its expected lifespan, is not a problem. This means that hot water cylinders, radiators and the pipework which delivers the hot water to the radiators could easily last 60+ years, however; given that conventional radiators are typically designed to operate with 80°C flow and 60°C return temperatures (high grade heat), they may not be capable of adequately heating a home if the boiler or solid fuel appliance is switched for a heat pump. This is because heat pumps operate with greatest efficiency when providing a steady supply of low grade heat, typically 30 °C to 40 °C. A larger surface area, such as under floor heating, is therefore required to deliver the same amount of heat.

4.15. Forcing a heat pump to provide high grade heat to small radiators severely impacts on its operating efficiency so, while they may have plenty of life left in them, radiators serving existing fossil fuel boiler heating systems may not be suitable for use with heat pumps. While more affordable to run; see Figure 1, the installation of a heat pump and suitable distribution system comes with considerable cost and disruption. They are discussed in greater detail in Work Package 26.

4.16. Companies such as Mitsubishi have recognised this barrier to heat pump uptake and now offer fan assisted radiators that have a higher heat output than traditional radiators of the same size (Mitsubishi, 2019). This helps where space constraints would be a barrier to the adoption of heat pumps.

4.17. If a combi-boiler (oil or gas) is to be replaced with a heat pump then a new hot water tank and ancillary components would be required and the hot water tank would have to be heated to 55°C for 1 hour each week for legionella control. As an alternative a heat pump could be used to provide heating only and hot water could be provided with an electric instantaneous hot water appliance, if there is sufficient capacity in the electricity supply.

4.18. While the average cost of an air source heat pump (ASHP) both now and in 2050 has been estimated to be approximately £5000 and £4000 respectively (UKCCC, 2019) a range of models from at least one UK manufacturer can be found on the market today for less than £2000 (Cool Energy, 2019). Unfortunately the additional components, such as hot water cylinders, alternative ways of delivering the heat, such as under floor heating or larger radiators and the cost of installation can push this price to in excess of £14,000. An anonymised quote for just such an amount, received by a customer who enquired about converting their system earlier this year, can be found at Appendix 1.

District heating

4.19. This involves piping hot water from a source, such as an energy from waste plant, to a property via an insulated pipe, i.e. a heat main. If properties with conventional gas/oil boilers were supplied with high grade heat in this manner this would do away with the need for individual boilers. There would be cost and disruption involved in the laying of pipework and the replacement of boilers with heat exchangers but the rest of the system within a property could remain the same.

4.20. Heat could come from waste heat sources, such as an energy from waste plant, or new sources such as heat pump, biomass boiler or combined heat and power plant. The UKCCC advise that district heating could first be rolled out in urban areas in the 2020 and then suburban areas in the 2030s.

5. LOW CARBON FUELS

Hydrogen

5.1. The UKCCC regard the use of hydrogen as one of the additional measures that may be required to meet the 2050 net zero target. They envisage approximately two thirds of hydrogen coming from advanced methane reformation with carbon capture and storage (CCS) and one third from Polymer Electrolyte Membrane (PEM) electrolysis.

Advanced methane reformation

5.2. This method involves splitting natural gas into hydrogen and CO_2 and then capturing and storing the CO_2 underground. Significant technological development is required for this process to be delivered at scale in the UK but; as the CCS component only captures 90% of the CO_2 emissions and the Island doesn’t have anywhere to store those emissions, this method of production is not an option for the Island. Gas produced in other jurisdictions could be used but the current pipeline that delivers natural gas to the Island is not compatible with hydrogen and, as natural gas is expected to remain part of the UK energy mix in 2050, it may not be replaced with one that is.

PEM electrolysis

5.3. This method involves splitting water with electricity to produce hydrogen and oxygen. Large scale PEM electrolysers are now on the market and further development of the technology is underway, which should lead to continued reduction in costs.

5.4. If the electricity used to power this process were to come from sustainable low carbon sources, such as renewables, then there would be virtually no emissions from the fuel. If indigenous renewable energy was used to produce enough hydrogen to serve the Island’s energy requirements then this would give the Island energy independence for the first time since the industrial revolution. Fortunately the Island has an abundance of renewable energy that could be harnessed to power this process.

5.5. Off shore wind is a particularly large resource and with levelised costs for offshore wind farms now as low as £45 per MW (levelised meaning it includes the costs of construction, commission, operation and decommission) the renewable electricity to power this process is now at price parity with the marginal cost of producing electricity from Pulrose, which is approximately £45 per MW (marginal meaning that it doesn't take into account embedded costs and decommissioning in 2035).

Hydrogen storage

5.6. The Island has no hydrogen storage facilities at present and without inter connection to other jurisdictions a large storage capacity may be required to cope with inter-season variability in demand. The H21 project in Leeds envisaged using salt caverns with 40 days' worth of maximum average daily demand storage capacity (coldest year) for this purpose (Leeds City Gate, 2019).

5.7. A summary of the costs of the H21 project are given in Figure 1 below. If it were funded using the UK regulatory business plan there would be negligible impact on customers' gas bills (Leeds City Gate, 2019).

5.8. Until a decision is reached on its future role by the UK Government, a hydrogen economy is unlikely to develop, however, if it does develop and supplies become abundant and affordable it could provide a range of different options for reducing emissions on the Island.

Cost

5.9. The cost of producing hydrogen from renewables in the future is uncertain but today PEM electrolysers are approximately €1600/kW of capacity and ITM power recently quoted €800/kW of capacity on 10MW installations (ITM, Power 2019). A recent article in Petroleum Review magazine stated that the cost of electrolysers had plummeted from €4,000/kW a few years ago to €500/kW now (Davis, 2019). With the falling cost of renewable electricity generation, it is anticipated that the cost of hydrogen could soon be comparable to natural gas (Glenk & Reichelstein, 2019).

Cost Summary (£m)	Cost incurred (£m)	Ongoing costs each year (£m)
Network Capacity and Conversion Preparatory Work (Section 2.2)	10	
Hydrogen Infrastructure/Conversion Costs		
Steam Methane Reformer (SMR) Costs (Section 2.1)	395	
Intraday Salt Caverns (Section 2.1)	77	
Inter-Seasonal Salt Caverns (Section 2.1)	289	
Appliance Conversion (Domestic, Commercial and Industrial users within area of conversion) (Section 2.3)	1,053	
Hydrogen Transmission System (HTS) (Section 2.4)	230	
Ongoing OPEX Costs		
Carbon Capture and Storage		60
SMR/Salt Cavern/HTS Management		31
SMR Efficiency loss (30%)		48
Total	**2,054**	**139**

Figure 2 – Financial model for the H21 project (Leeds City Gate, 2019).

6. BIOFUELS

HVO (hydrotreated vegetable oil)

6.1. This is a renewable, non-fossil fuel product that provides a 'drop in' replacement for fossil fuel diesel. As with other biofuels the industry is awaiting a decision on a standard for the sustainability of the feedstock. This will dictate whether it can be produced at scale or not. If it can be sustainably produced at scale it could allow the continued use of conventional oil boilers.

FAME (Fatty Acid Methyl Esters)

6.2. Biodiesel falls into this category. Trials by OFTEC have found that, with a few simple adaptations, existing boilers that aren't biofuel compatible can be made to run on B30K (30% Biodiesel and 70% Kerosene). The cost of these adaptations is estimated at £500-£1000. Oil boilers installed in the last 5 years should be able to run on 10% biodiesel and in some cases 30% biodiesel. Higher concentrations require more significant adaptations. (Hopwood, Mitchell and Sourmelis, 2019)

6.3. A key difference between the design of kerosene and dedicated 100% biodiesel boilers is in the burner, which can be optimally designed to burn 100% biodiesel (B100) from the outset. Amendments to the storage and supply systems must be made if the boiler is a replacement in an existing system, or new systems would need to be specified accordingly. The inclusion of a preheated fuel tank, to lower the viscosity of B100, is a prerequisite to ensure proper atomisation and thus effective combustion. The tank size and location would also need to be considered, and it must be insulated to ensure that the contents remain above -5°C at all times. (Hopwood, Mitchell and Sourmelis, 2019)

Bio-methane

6.4. Methane can be produced through the anaerobic digestion (AD) of a variety of feedstock and used as a direct replacement for natural gas. The potential role AD could play in the Island's energy mix was assessed as part of the 2010 Renewable Energy Sustainability Study (AEA Technology Plc, 2010), however, due to the dispersed nature and low volumes of feedstock considered suitable at the time, all of which were wastes, the only option assessed as being viable was one AD plant at a farm in Santon with a herd of 340 cattle. The contribution from AD was therefore thought to be minimal, however, UK energy company Ecotricty have recently revealed a project to produce methane from grass taken from marginal grasslands.

6.5. In an interview for the online programme Fully Charged the founder of Ecotricity, Dale Vince, explained that: *"There is enough marginal grassland for us to make all of the gas we need to heat all of the homes in Britain."* (Fully Charged, 2017)

6.6. The project being developed in conjunction with Sparshalt University (2019) in Southampton uses grass from 5000 acres to produce enough gas to heat 5000 homes (1 acre per home).

6.7. Similarly; as part of the Causeway Project, operated by Gas Networks Ireland, bio-methane is being collected from AD plants and injected directly into the natural gas network via validation plants. The validation plants check the quality of the gas to ensure it meets the appropriate standard before it is accepted into the network.

6.8. There would be many benefits to the use of this technology on Island:

- Grass grows well on the Island.
- Projects of this size would utilise readily available technology and could make a significant contribution to the reduction of emissions from heating on the Island (64,400t CO_2 if all natural gas was substituted with biogas) without the disruptions and costs associated with changing the existing infrastructure and consumers heating systems.
- The process of growing the grass produces a habitat for wildlife.
- The co-product from the process is used to fertilise the land thereby reducing emissions associated with the use of chemical fertilisers.
- As pesticides aren't required there are benefits for biodiversity and ecology.
- Through the sharing of common infrastructure components other feedstock, which may not be economically viable on their own, could be aggregated and processed on the same site to produce additional biogas. This could provide an alternative route for the disposal of waste, which could otherwise pose risks to the environment, e.g. cattle slurry.

- Biogas could be used as fuel to produce electricity and help balance loads from intermittent sources of renewables.
- Alternative feedstock, such as seaweed, could be grown at scale specifically for this process and used to increase output. Work Package 18 looks at the role of 'blue carbon' in greater detail.

6.9. Substituting natural gas with bio-methane from grass is the least disruptive to consumers, the technology is available and it could make a large impact on emissions in the short to medium term. Once the 'heavy lifting' is done, i.e. plant produced and connected to the natural gas network, then businesses supplying alternative feedstock may emerge.

6.10. If it is soon established that a blend of up to 20% hydrogen is acceptable in conventional boilers this affords the opportunity to blend biogas and hydrogen to a degree depending on the price and availability of both.

6.11. It is estimated that in Northern Ireland bio-methane is worth approximately 2.5 euro cents per unit and producers receive a subsidy of 6 euro cents per unit. At this combined price AD plants could pay farmers approximately 30 Euro per tonne for silage as feedstock for the AD process.

6.12. Farmers on the Island would be eligible for area payments through the existing agri-environment scheme if they were to grow grass for fuel production and this could provide a viable alternative income stream.

7. SYNTHETIC FUELS

7.1. In their 2018 analysis Zero Carbon Britain found that at times of surplus renewable electricity generation that electricity could be used to produce hydrogen and from that hydrogen synthetic liquid and gaseous fuels could be produced for use in transport and industry. Using the Sabatier process, which is used to produce methane from hydrogen, as an example 4 kW of surplus electricity can be converted into 1kW of methane. The losses in the process are considerable and Zero Carbon Britain proposed using biomass to provide the carbon dioxide, which is also required, for the process. As with other biofuels this introduces questions of the sustainability of the feedstock (Allen, 2019).

Hard to treat homes

7.2. A recent report commissioned by the UKCCC analysed the cost of retrofitting hard to decarbonise homes identified the measures required to reduce emissions and included categories with constraints such as flats and historic buildings. This report found that it was possible to eliminate emissions from approximately 97% of these properties with a range of measures of varying costs (Element Energy & UCL, 2019).

Benefits of bulk-buying

7.3. Government has experience with retrofitting buildings with ASHPs. 22 units of public sector accommodation at Ayre View in Bride were recently successfully converted from coal fire with back boilers to ASHPs at a cost of approximately £10,000 each in 2015. This figure includes nearly £1,000 for air tightness testing and remedial work. Framework agreements could be used to lower the cost of conversions.

What would be the "necessary" (2050) replacement pathway?

7.4. Given that CCS is not an option for the Island; that there are limited opportunities for carbon sequestration and there are more difficult sectors to decarbonise, e.g. agriculture, aviation and shipping, there is little if any room for the burning of fossil fuels to provide heat in 2050 if the net zero target is to be met. This leaves several options:

- Provide supplies of fossil fuel substitutes, such as HVO or bio-methane, to fuel conventional heating appliances. Uses existing delivery infrastructure, appliances and heating systems but is contingent on there being supplies of fuel for which feedstock sustainability is uncertain.
- Retain heating systems but supply alternative fuels such as biodiesel or hydrogen. Gas boilers would need to be replaced with hydrogen boilers, significant adaptations would need to be made to the gas network. Supplies of hydrogen would be required which are contingent on the availability of significant amounts of renewable electricity. Existing oil boilers, tanks and fuel lines would need to be adapted/ replaced. Availability and sustainability of biodiesel feedstock uncertain.
- Install electric alternatives, such as heat pumps. May require the replacement of entire heating systems and only possible if there is sufficient capacity in the electricity supply cabling to take the extra load.
- Supplement heating with alternative low carbon measures such as solar-thermal devices or wood burning stoves. Cost of solar thermal device and connection to existing tank/ new tank. The aspect of a building dictates how much heat could be generated from roof mounted devices. Wood burning stoves typically only heat one room and widespread use could have an impact on air quality.
- Produce synthetic fuels from renewable electricity via hydrogen from electrolysis as a direct replacement for fossil fuels. Would make use of existing infrastructure but reliant on renewable energy supplies and hydrogen production. The process is also inefficient so only used to deal with excess renewable electricity.

7.5. There is likely to be a role for blends of biofuels with fossil fuels and hybrid heat pump systems during the transition to low carbon heating systems.

The "ambitious" pathway?

7.6. In line with the UKCCC recommendation that the 2050 net zero target is achievable with 'deep electrification' a detailed assessment of every property on the island is required to establish which properties require a 3 phase supply to enable a conversion to electric heating and other factors such as the charging of electric vehicles.

7.7. As hydrogen and bio-methane have the potential to play a huge role in the future and as gas produces fewer emissions per unit of heat than oil, the initial focus could be on those properties without a gas grid connection.

The risks

7.8. Due to its size the Isle of Man is going to have to prepare for and react to technological development elsewhere in the world, particularly the UK where most of our goods, such as boilers and vehicles, come from.

7.9. The UKCCC have recommended that the UK Government make a decision on the future of hydrogen by the mid-2020s. That decision will affect what happens with heating, transport and electricity generation here on the Island.

7.10. As with the supply of liquid fossil fuels for transport; if efforts to reduce consumption of fossil fuels for heating are successful then there will inevitably come a point, before all consumers have switched to alternatives, where it is no longer commercially viable for companies to continue supplying fossil fuels. In Figure 3 the blue line represents a trajectory where rapid reductions in consumption end with a relatively small drop off, or cliff face. In this scenario large cumulative emissions reductions are made relative to the red trajectory and few people are left with fossil fuel appliances they can't get fuel for, which could be referred to as stranded assets. Alternatively the red line shows a scenario where the decline in consumption is slow and the cliff face is high. In this scenario cumulative emissions are high relative to the blue trajectory and many people are left with stranded assets. The Blue trajectory is clearly the preferred option.

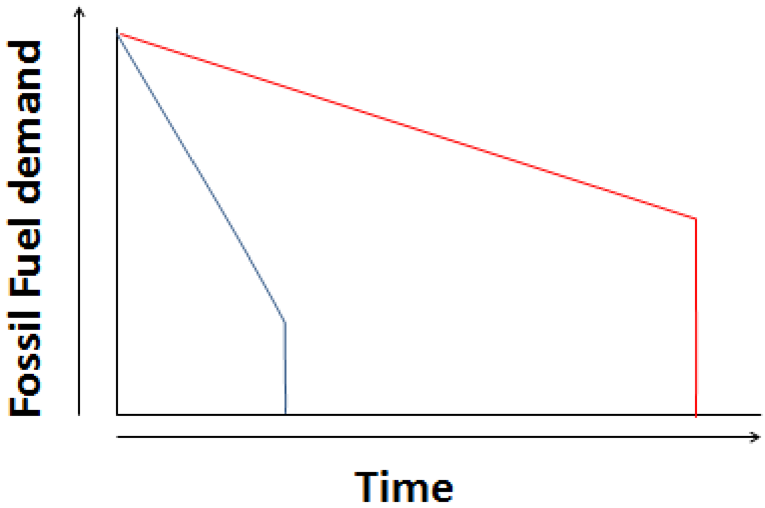

Figure 3 - Stranded assets model

Funding

7.11. While the phasing out the use of fossil fuels will result in reductions in revenue for government, i.e. fuel duty, the increase in electricity sales will generate increased profits for the MUA. A Council of Minister report prepared by the MUA found that switching to a heat pump to provide 12,000kWh of heat per year resulted in an additional 4000kWh of sales equating to £258 per year of additional profit. A proportion of this additional profit could be used to incentivise conversions (Manx Utilities, 2019).

8. REFERENCES

AEA Technology Plc (2010). *Renewable energy sustainability study – impacts and opportunities for the Isle of Man*. [online] Didcot: AEA Technology Plc. Available at: https://www.gov.im/media/624413/aeareportappendices.pdf [Accessed 16 Dec. 2019].

Allen, P. (2019). *Zero Carbon Britain Meeting with IOM CECTT*.
Analysis on abating direct emissions from 'hard-to-decarbonise' homes (Element Energy & UCL). (2019). [pdf] UKCCC. Available at: https://www.theccc.org.uk/publication/analysis-on-abating-direct-emissions-from-hard-to-decarbonise-homes-element-energy-ucl/ [Accessed 13 Aug. 2019].

Better energy, greater Prosperity. (2017). [ebook] Available at: http://energy-transitions.org/sites/default/files/BetterEnergy_fullReport_DIGITAL.PDF [Accessed 13 Aug. 2019].

Cabinet Office. (2019). [pdf], Isle of Man in Numbers 2019. p.72-73. Available at: https://www.gov.im/media/1366013/isle-of-man-in-numbers-2019.pdf [Accessed 4 Oct. 2019].

Davis, B. (2019). Hydrogen Prospects. Petroleum Review, (869), p.17.

Domestic Heating Comparison September 2019. (2019). [PDF] OFT, p.1. Available at: https://www.gov.im/media/1364386/domestic-heating-sep-2019.pdf [Accessed 8 Oct. 2019].

Fully Charged (2017). Ecotricity - Green Gas | Fully Charged. [video] Available at: https://www.youtube.com/watch?v=LDHdSNJpoXs [Accessed 3 Oct. 2019].

Glenk, G. and Reichelstein, S. (2019). Economics of converting renewable power to hydrogen. Nature Energy, [online] 4(3), pp.216-222. Available at: https://www.nature.com/articles/s41560-019-0326-1 [Accessed 24 Sep. 2019].

Hopwood, L., Mitchell, E. and Sourmelis, S. (2019). [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831069/Bioenergy_heating_options_in_off-gas_grid_homes.pdf [Accessed 27

Sep. 2019].

Isle of Man Government (2019). Chief Minister Announces Climate Change Bill. [online] Available at: https://www.gov.im/news/2019/may/10/chief-minister-announces-climate-change-bill/ [Accessed 13 Sep. 2019].

Leeds City Gate (2019). [online] Available at: https://www.northerngasnetworks.co.uk/wp-content/uploads/2017/04/H21-Report-Interactive-PDF-July-2016.compressed.pdf [Accessed 30 Sep. 2019].

Manx Utilities (2019). *Home Generation Feed-in Tariffs, Electric Heating for Buildings*. [online] Douglas: Manx Utilities. Available at: http://www.tynwald.org.im/business/opqp/sittings/20182021/2019-GD-0003.pdf [Accessed 17 Dec. 2019].

Mitsubishi (2019). iLife2 Slim Fan Assisted Radiator | Mitsubishi Electric. [online] Available at: https://les.mitsubishielectric.co.uk/products/heating/domestic/radiator [Accessed 30 Sep. 2019].

Pers. Comms. Manx Gas (2019). Discussion about Isle of Man gas network.

Sparsholt College Hampshire. (2019). Green Gas Mill FAQs - Sparsholt College Hampshire. [online] Available at: https://www.sparsholt.ac.uk/college/green-gas-mill-faqs/ [Accessed 3 Oct. 2019].

Tynwald (2006). *Energy policy Council of Ministers' Report received and recommendation approved*. [online] Available at: http://www.tynwald.org.im/business/hansard/20002020/th17102006.pdf [Accessed 16 Dec. 2019].

Tynwald 2013 https://www.gov.im/media/1349308/report-by-comin-on-environment-and-infrastructure-policy.pdf

Tynwald 2015 https://www.gov.im/media/1349306/policy-on-sustainable-development-and-mitigating-climate-challenges-comin-report.pdf

Williams, C. (2019). EHN Online | EHOs urged to act on excess cold after landmark ruling. [online] Ehn-online.com. Available at: http://www.ehn-online.com/news/article.aspx?id=14393 [Accessed 8 Oct. 2019].

Annex A

Quote as Requested

SITE ADDRESS

[redacted]

SCHEDULE OF WORKS

Please note this quotation and heat loss calculation is based on a flow temperature of 45 degrees and THE CHANGE OF ALL RADIATORS.(please note that we can quote for this work, although it will not fall into the Manx utilities purchase scheme).

To Install two new electrical circuits, one for the immersion heater used only for prevention of legionella and the second to be used for a direct supply to the outside unit with the communication and supply cable installed between the outside unit and the FTC5 controller. Please note that the installation will use two of the spare ways in the existing board.

To supply and fit a 14 kw. Mitsubishi Ecodan air source heat pump with mel cloud network tie. The wired room stat to be positioned on the kitchen wall, which backs onto the garage wall.

To supply and fit 300 litre pre-plumbed cylinder with all relevant parts including expansion vessel for hot water, magna filter, and circulation pump etc.

To magna flush the system.

To balance all heating circuits.

DESCRIPTION	
Mitsubishi Ecodan 14kw with 300l pre-plumber standard cylinder	£7,584.00
Site Survey	£0.00
Labour and additional plumbing and electrical materials as per tender work.	£4,728.00
Wifi interface for use with MELCloud	£198.00
Fernox HP-5C Antifreeze containing biocide 25ltr	£139.20
Additional warrenty	£600.00
Annual basic service cost	£1,283.04
AMOUNT	**£12,110.20**
VAT	**£2,422.04**
AMOUNT INCLUDING VAT	**£14,532.24**

If You Have any questions, Please do not hesitate to contact Stuart on 48 47 47. Estimate valid for 90 days.

REGISTERED MEMBER ECA · City & Guilds · Manx Accredited Construction Contractors Scheme · PART P · ELECSA Approved Contractor Part P www.elecsa.co.uk