Maintain gas grid until future decision on hydrogen generation by renewables

1. EXECUTIVE SUMMARY

1.1. The Island's gas grid is made up of a continuously piped natural gas supply and discrete clusters/ individual supplies of Liquid Petroleum Gas (LPG).

1.2. The grid is largely compatible with hydrogen distribution with the exception of several critical components such as:

- The high pressure pipeline that brings natural gas to the Island from the Scotland Ireland IC2 interconnector.
- The high pressure pipeline that carries gas from Glen Mooar to Douglas.
- The high pressure pipeline that supplies the Combined Cycle Gas Turbine (CCGT) at Pulrose.
- LPG storage tanks and road tankers are currently rated for LPG only.

1.3. None of the gas boilers currently installed on the Island are compatible with 100% hydrogen.

1.4. It may soon be acceptable to blend up to 20% hydrogen with natural gas for use in existing boilers.

1.5. Those parts of the network that are hydrogen compatible should last approximately 60+ years.

1.6. The UK Committee on Climate Change (UKCCC) have recommended that in the next decade a decision is made on the future role of hydrogen in the UK energy mix.

1.7. Hydrogen has the potential to perform many more functions than natural gas and LPG, such as fuel for transport, generating electricity and as a storage medium for intermittent electricity from renewables.

1.8. At present hydrogen can be produced on Island from indigenous renewable energy resources. If hydrogen alternatives to fossil fuelled technology become mainstream this could present the Island with the possibility of supplying its own energy needs for the first time since the industrial revolution.

1.9. Use of any parts of the existing gas network to export natural gas from the Island's territory would sterilise it for future alternative uses, i.e. transporting hydrogen.

2. THE CHALLENGE

2.1. By 2050 CO_2e emissions from the burning, handling and transmission of fossil fuels on the Island will have to be near zero for the net zero emissions target to be achieved. This is because not enough capacity exists in carbon sinks such as peat bogs and forests to offset those emissions that can't be captured, e.g. those from vehicles and heating appliances that burn fossil fuels, in addition to the difficult to treat sectors, e.g. agriculture, shipping and aviation.

2.2. The UKCCC has stated that it is possible for the UK to both meet its 2050 net zero emissions target and have natural gas as part of its energy mix but, in order to do so, the successful large scale deployment of Carbon Capture and Storage (CCS) will be essential, not optional (Committee on Climate Change, 2019). With no history of gas and oil extraction on the Island there is nowhere to store the emissions that could potentially be captured from large point sources, such as fossil fuel fired power stations. CCS is not an option within the Isle of Man territory and, even if emissions were captured and piped to the nearest depleted gas fields off Morecambe, it still wouldn't be a viable option as the process only captures 90% of emissions and, as already mentioned, there isn't enough capacity to offset those emissions. Any reliance on exporting captured emissions would be detrimental to energy security.

2.3. While natural gas is the predominant fuel used for heating in the UK, the split between oil and gas on the Island is approximately 50:50. Approximately 90% of the gas consumed was natural gas with the remaining 10% being LPG (Cabinet Office, 2019). Emissions from the burning of natural gas and LPG in 2018 were approximately 72,450t CO_2e (8.64% of emissions in 2017).

3. THE NATURE OF THE ISLAND'S GAS NETWORK

3.1. The Island's gas network has evolved over time into two distinct parts.

Part 1 – Natural gas network

3.2. Figure 1 below illustrates the components of the Island's existing network. Figure 2 shows a simple schematic explaining the location and degree of pressure change at locations identified in Figure 1. Further detail about flow rates and system pressures can be found in Annex A.

3.3. The Isle of Man is supplied with natural gas from a connection into the Gas Networks Ireland interconnector IC2 that conveys gas from Scotland to Ireland. The tee-piece and valve arrangement is 11.7km offshore from the Isle of Man and 35m below sea level. The offshore spur pipeline supplying the Isle of Man lands at Glen Mooar beach where the pipeline continues inland, buried below ground, for another 0.6km to arrive at Glen Mooar 1 AGI (Above Ground Installation). The purpose of Glen Mooar 1 AGI is to meter the gas and reduce its pressure. The inlet pressure to Glen Mooar 1

AGI could be as high as 146bar but is typically around 110bar. The outlet pressure from Glen Mooar 1 AGI is normally 70bar but could be as high as 90bar.

3.4. A 250mm (10”) diameter steel high pressure transmission pipeline runs across the Island from Glen Mooar to Pulrose. This is buried below ground to a minimum depth of 1.1m. There are three connections off the high pressure pipeline namely Glen Mooar 2 AGI, Glen Vine AGI and Pulrose AGI. The purpose of these AGIs is to further reduce the gas pressure. At Glen Mooar 2 and Glen Vine AGIs the pressure is reduced from the nominal 70bar to a set point of 4bar for onward distribution. At Pulrose there are effectively two AGIs. One reduces the gas pressure from the nominal 70bar to circa 32bar for the combined cycle gas turbines (CCGT) in Pulrose Power Station. The other’s outlet pressure is ≤ 2bar for supply into the distribution network of Manx Gas.

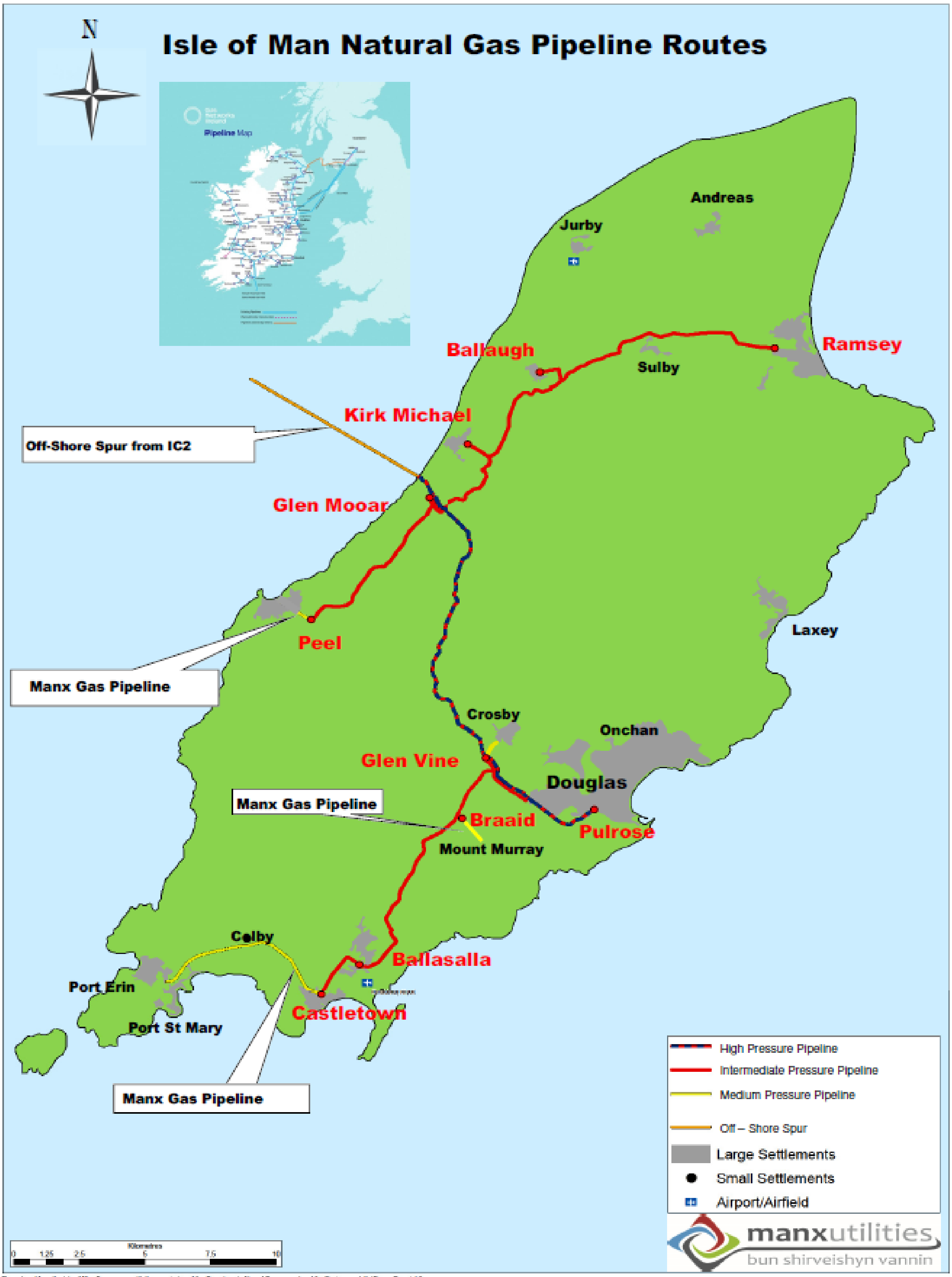

Figure 1 Natural Gas distribution network (Donnelly, 2019b)

3.5. Intermediate pressure pipelines from Glen Mooar 2 and Glen Vine AGIs convey gas at a pressure of 4bar to district regulating installations (DRIs) at Ramsey, Ballaugh, Kirk Michael, Peel, Braaid, Ballasalla, and Castletown. These pipelines are predominantly constructed of 315mm polyethylene (PE) with the exceptions being the legs to Ballaugh, Kirk Michael, and Cooil Road Braddan (capped off) which are 125mm PE. There is also a short length of 315mm PE medium pressure pipeline that facilitates a back-feed from Glen Vine AGI into Manx Gas' distribution network. Again these pipelines are buried below ground to a minimum depth of 1.1m. At each of the DRIs the pressure is further reduced from 4barg to a set point of ≤ 2bar for supply into the distribution networks of Manx Gas.

3.6. Glen Mooar 1 AGI and the upstream spur pipeline are owned by Gas Networks Ireland but the Manx Utilities Authority (MUA) are contracted to locally operate and maintain these on their behalf. MUA own and operate the cross-island high pressure pipeline; the 3 AGIs at Glen Mooar 2, Glen Vine, and Pulrose; the intermediate pressure pipelines and the short medium pressure pipeline at Glen Vine; and the 7 DRIs at Ramsey, Ballaugh, Kirk Michael, Peel, Braaid, Ballasalla, and Castletown. Ownership of the gas transfers to Manx Gas at Glen Mooar 2, Glen Vine and Pulrose (2bar outlet) AGIs. Ownership and operational responsibility for physical assets transfer from MUA to Manx Gas at the 2bar outlet valve immediately inside the fence-line of Pulrose AGI and at the below ground external outlet valves of the 7 DRIs. (Donnelly, 2019).

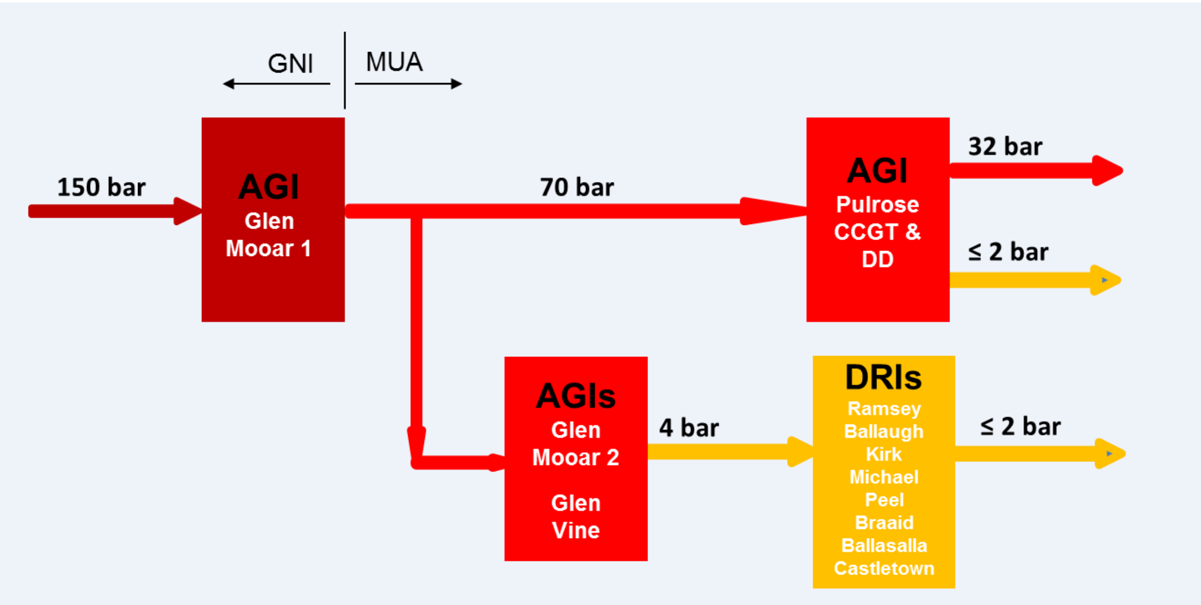

Figure 2. Simple schematic: gas flow and pressure reduction (Donnelly, 2019b)

Part 2 – LPG network

3.7. The natural gas network does not extend to all parts of the Island and some customers instead rely on the supply of LPG to meet their energy needs. Figure 3 illustrates where the clusters of small LPG networks are located.

3.8. The Island's LPG network is different in nature to that of the natural gas network as, rather than a continuous network of underground pipework, a variety of methods are used to transport gas to the final consumer.

3.9. LPG first arrives by ship and is stored at the Princess Alexandra Pier in Douglas. From here it is delivered by road tanker to storage tanks at discrete LPG networks in Foxdale, Laxey, Andreas, Santon, Jurby, Maughold and St Johns as well as individual customers with mini-bulk tanks (Manx Gas, 2019). Some customers also receive deliveries of bottled gas.

Compatibility of the current gas network with hydrogen:

3.10. The following components of the natural gas network are made of a type of steel that is not compatible with the transmission of hydrogen (Donnelly, 2019a):

- IC2 Scotland to Ireland interconnector,
- Spur from IC2 to the Isle of Man,
- High pressure pipeline from Glen Mooar to Douglas, and
- 32bar pipeline from the one of the two Pulrose AGI's to the CCGT

3.11. The intermediate pressure pipelines, medium pressure pipelines and a lot of the Manx Gas distribution network is made of PE and is compatible with the distribution of hydrogen (Donnelly, 2019a) (Pers. Comms. Manx Gas, 2019). Some parts of the distribution network in Douglas, Port Erin and Port St Mary are made of steel, which is not compatible with hydrogen (Pers. Comms. Manx Gas, 2019).

3.12. The LPG storage facilities at Princess Alexandra Pier, the road tankers and discrete network LPG storage tanks are all currently rated to store LPG only and it is not clear if they are compatible with hydrogen but all of the pipework serving the discrete LPG customers is PE and therefore compatible with hydrogen (Pers. Comms. Manx Gas, 2019).

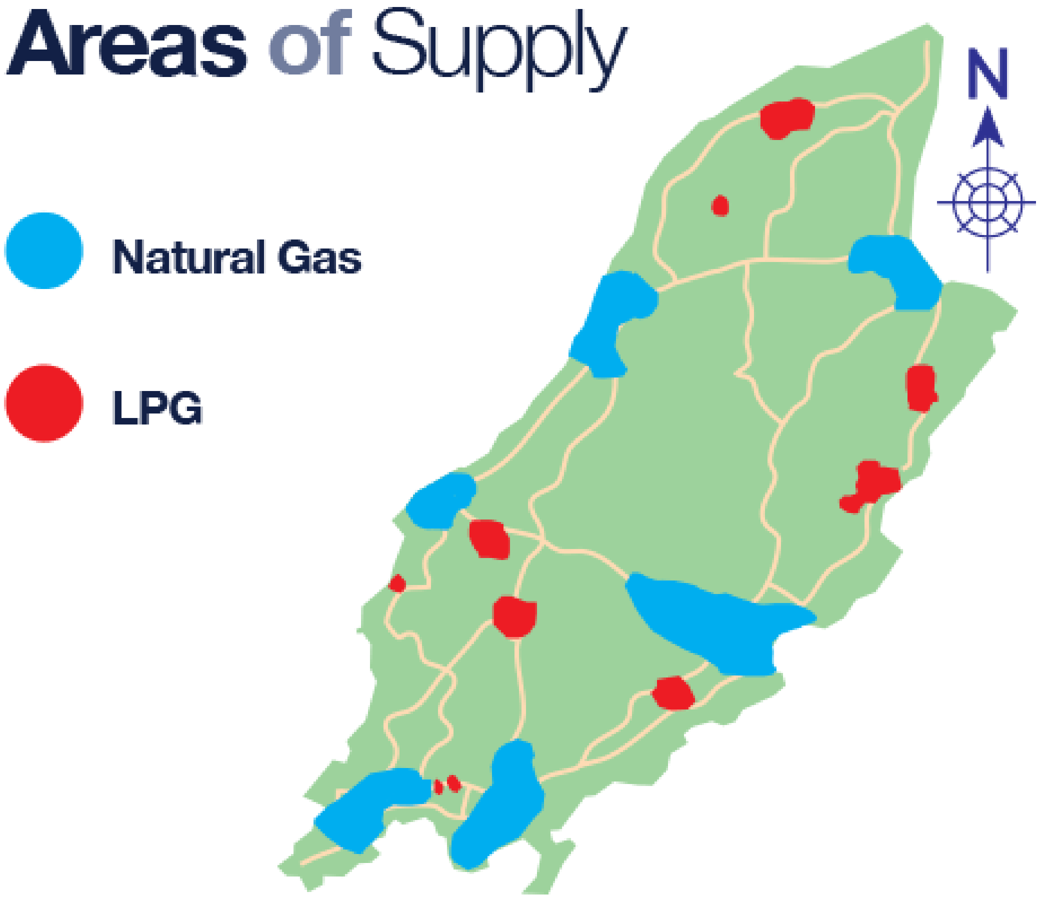

Figure 3 – Areas served by the natural gas and LPG networks (Manx Gas, 2019)

Compatibility of appliances with hydrogen:

3.13. Boilers are not yet being manufactured to run on hydrogen so none of the appliances on the Island are compatible with 100% hydrogen fuel. There is one product about to come onto the market but it is significantly larger than a conventional gas boiler (Pers. Comms. Manx Gas, 2019).

3.14. The current specification for natural gas allows for a small proportion of hydrogen in the mix (>0.1%) but blending hydrogen with natural gas for use in conventional boilers is possible (Pers. Comms. Manx Gas, 2019). Trials at the Health and Safety Executive Laboratory using a 20% hydrogen blend are ongoing and the results are due to be published in the next 6 months. While blending mixtures of fossil fuel gas and hydrogen could help reduce emissions in the short to medium term the residual emissions mean it is not a long term solution for the Island.

4. SOURCES OF HYDROGEN

Advance Methane Reformation (AMR):

4.1. This process converts natural gas into hydrogen and CO_2 so it is essential that it is combined with CCS if the hydrogen is to be considered low carbon. Given that natural gas is expected to form part of the UK energy mix in 2050 it is possible that it will continue to remain available to the Island through the IC2 interconnector, however, as CCS is not an option for the Island using this process would be of no benefit.

4.2. If, however; in line with the UKCCC further ambition scenario, hydrogen is produced at scale in the UK using AMR and it is made available to the Island then it could be used to significantly reduce emissions.

Polymer Electrolyte Membrane (PEM) Electrolysis:

4.3. 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.

4.4. 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.

Uses of gas as a fuel:

4.5. At present fossil fuel gas is mainly used in space heating appliances but also serves as a fuel for cooking appliances and there is one garage supplying auto gas for road use on the Island.

4.6. Hydrogen, however, has a number of potential uses. These include use as fuel for:

- hydrogen fuel cell vehicles (including HGV), vessels, plant and machinery
- static hydrogen fuel cell electricity generation
- gas fired power stations
- gas fired boilers and hybrid heat pumps
- cooking appliances

4.7. During times of surplus renewable electricity generation, hydrogen could be produced and stored for the production of electricity when it is needed. In this function it could help with load balancing and dealing with the issue of intermittency of supply from renewables. The (Surf 'N' Turf, 2019) project in Orkney uses this approach.

4.8. The purpose of renewable electricity generation could specifically be to produce hydrogen. A project aiming to deploy a 4GW offshore wind array in the North Sea to produce hydrogen and transport it to shore by pipeline has recently received UK Government funding (Recharge News, 2019).

5. THE COST OF HYDROGEN

Producing hydrogen

5.1. The cost of producing hydrogen from renewables 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 €4M/MW a few years ago to €500,000/MW now (Davis, 2019). The UKCCC view deep electrification of transport and heating, with electricity coming from low carbon sources, as a core activity that will achieve the bulk of emissions reductions (Committee on Climate Change, 2019), however, a recent blog posted by Carbon Commentary making reference to an academic paper by Glenk & Reichelstein (2019) stated that: "*within a few years… water electrolysis will have become cheaper than manufacture from fossil fuels across all sizes of hydrogen manufacturing plant, including the very largest.* " (Goodall, 2019).

Hydrogen appliances

5.2. With no market presence at the moment the cost of changing appliances is unknown but the cost of upgrading domestic pipework and boilers alone in the UK has been estimated to be approximately £17bn (BBC News, 2019).

Upgrading the network

5.3. While the exact cost of converting the current network to hydrogen is unknown it is thought to be high (BBC News, 2019). The cost of hydrogen storage in the UK has been estimated to be £5bn. It is worth noting that some parts of the Island's network would require less expenditure than others and it is possible to split the network to deliver hydrogen conversion in phases. The conversion to natural gas required the existing network to be divided into 74 distinct zones.

6. THE RISKS

6.1. 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 come from.

6.2. 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.

6.3. Use of any parts of the existing gas network to export natural gas from the Island's territory would sterilise it for future alternative uses, i.e. transporting hydrogen.

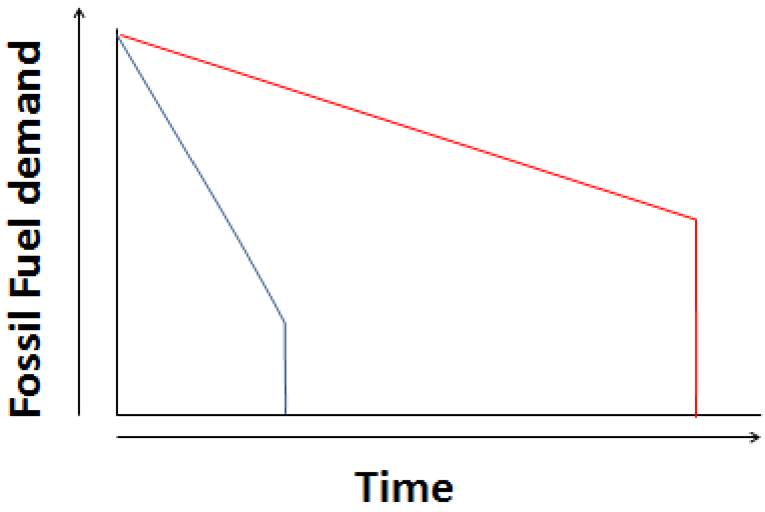

Figure 4: Stranded assets model

6.4. As with the supply of liquid fossil fuels for transport and heating, if efforts to reduce consumption of fossil fuel gas 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 4 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.

7. THE CO-BENEFITS (THE POSITIVE BENEFITS ASSOCIATED WITH THE CLIMATE ACTION)

7.1. As the only emission from using hydrogen is water, significant improvements could be made to ambient air quality and ambient noise levels (if used in fuel cell applications that replace internal combustion engines).

7.2. The use of indigenous renewable energy to produce hydrogen on Island could give the Island energy independence for the first time since the industrial revolution and therefore dramatically improve energy security.

7.3. With enough production capacity the Island could serve as a refuelling point for shipping which could be powered by hydrogen in the future.

Bio-methane

7.4. Bio-methane produced from silage is explored as a viable 'drop in' option to decarbonise the gas network inWork Package 9 This has the benefit of already being compatible with the existing natural gas network. Depending on the availability of both gasses and the compatibility of the infrastructure and appliances, the blending of bio-methane with hydrogen could be an option but this would require further investigation.

8. CONCLUSION

8.1. The high pressure pipework that brings natural gas to the Island and the pipe that carries gas across the Island from West to East (including to the CCGT) is not compatible with 100% hydrogen. Significant parts of the rest of the network are potentially compatible with 100% hydrogen.

8.2. Bio-methane is a 'drop in' replacement for natural gas and it may be possible to blend it with hydrogen to decarbonise the gas network or at least segments of it.

8.3. The PE pipework installed over the last 20 years that is compatible with hydrogen has a design life of 80 years (Baglow, 2019).

8.4. A decision by the UK government on hydrogen's future role in the energy mix expected in the 2020s. This will directly impact the options that are available to the Island.

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Annex A (Donnelly, 2019b)

Glen Mooar 1 AGI	
Design maximum flow-rate	82,000 Sm^3/h
Anticipated maximum flow-rate during operating year	30,000 Sm^3/h
Set point for Pressure Control	70 barg
Glen Mooar 2 AGI	
Design maximum flow-rate	24,500 Sm^3/h
Anticipated maximum flow-rate during operating year	2,500 Sm^3/h
Outlet Pressure	4 barg
Glen Vine AGI	
Design maximum flow-rate	16,000 Sm^3/h
Anticipated maximum flow-rate during operating year	2,000 Sm^3/h
Outlet Pressure	4 barg
Pulrose AGI - CCGT	
Design maximum flow-rate	19,270 Sm^3/h
Anticipated maximum flow-rate during operating year	17,000 Sm^3/h
Outlet Pressure	32.0 barg
Pulrose AGI – Douglas Domestic	
Design maximum flow-rate	16,000 Sm^3/h
Anticipated maximum flow-rate during operating year	9,500 Sm^3/h
Outlet pressure	0.75 barg
Ramsey DRI	
Design maximum flow-rate	7,500 Sm^3/h
Anticipated maximum flow-rate during operating year	n/a
Outlet pressure	0.85 barg
Ballaugh DRI	
Design maximum flow-rate	368 Sm^3/h
Anticipated maximum flow-rate during operating year	n/a
Outlet pressure	70 mbarg
Kirk Michael DRI	
Design maximum flow-rate	742 Sm^3/h
Anticipated maximum flow-rate during operating year	n/a
Outlet pressure	0.85 barg
Peel DRI	
Design maximum flow-rate	2,824 Sm^3/h
Anticipated maximum flow-rate during operating year	n/a
Outlet pressure	0.85 barg
Braaid DRI	
Design maximum flow-rate	850 Sm^3/h
Anticipated maximum flow-rate during operating year	n/a
Outlet pressure	1.0 barg

Ballasalla DRI	
Design maximum flow-rate	1,700 Sm^3/h
Anticipated maximum flow-rate during operating year	n/a
Outlet pressure	0.85 barg
Castletown DRI	
Design maximum flow-rate	7,138 Sm^3/h
Anticipated maximum flow-rate during operating year	n/a
Outlet pressure	0.85 barg
Glen Vine 'back-feed' DRI	
Design maximum flow-rate	8,000 Sm^3/h
Anticipated maximum flow-rate during operating year	n/a
Outlet pressure	tbc