Isle of Man Government

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ISLE OF MAN FUTURE ENERGY SCENARIOS

Supporting Background Information

GD 2021/0250 - Appendix 4 of Consultation on the outline and principles for the first statutory Climate Change Plan 2022-2027

NET ZERO ISLE OF MAN

EXECUTIVE SUMMARY

In December 2020, the Isle of Man Government launched its Future Energy Scenarios Strategy to determine the pathways to meet the following:

TO ENSURE 75% OF THE ISLAND'S ELECTRICITY IS GENERATED FROM RENEWABLE SOURCES BY 2035 AND TO DELIVER NET ZERO EMISSIONS BY 2050

Electricity generation is responsible for approximately 33% of all greenhouse gas emissions on the Isle of Man, and a majority of this is currently sourced from fossil fuels (natural gas). Without the decarbonisation[1] of electricity, it will not be possible to reduce carbon emissions significantly in other areas such as heating and transport.

FUTURE ENERGY SCENARIO OPTIONS

An independent international engineering and consultancy firm, Ove Arup, was appointed to prepare future energy scenarios to provide:

- The most cost-effective pathway to achieve Government emission targets.
- Pathways which balanced **of security of supply, low cost to consumers, and the environment**.

Arup were assisted by a technical team consisting of representatives from the Climate Change Transformation Team, DEFA, DfE, Manx Utilities, Treasury and DOI. Independent, technical and economic modelling was then carried out to create five future scenarios for electricity generation, which show how these targets can be achieved.

ESTIMATED FUTURE COST PER HOUSEHOLDS

The first three scenarios (Scenarios 1 – 3) all feature interconnectors[2], biomass[3] generation and varying amounts of small-scale solar and wind generators. These are the most cost-effective solutions for the residents on the island. The two final scenarios (Scenarios 4 and 5) also feature interconnectors, but include a much higher proportion of on island generators and storage facilities, which result in higher costs to residents.

The following table summarises the estimated costs to households on the island compared to the current average cost of electricity per household, as calculated from Ove Arup's evaluation of cost over the life-span of each scenario:

	Continued use of Gas Infrastructure 2050	*Scenario 1 2050*	*Scenario 2 2050*	*Scenario 3 2050*	*Scenario 4 2050*	*Scenario 5 2050*
Total Cost of scenario (£)	1.3bn	1.49bn	1.4bn	1.07bn	1.8bn	4.5 – 6.1bn
Cost per household per year (£)	996	1142	1073	820	1379	3450 - 4700

Source: Ove Arup and Manx Utilities

Regardless of whether the island deviates from using natural gas to generate electricity, significant investment will still be required, with existing stations requiring replacement in the next ten – fifteen years. An illustrative cost of this is also shown in the table above. The current cost per household is £645 but does not include road fuel costs or heating costs, whereas the other options do, via the predicted electrification of vehicles and heating.

1. *Decarbonisation: reduction of carbon (which makes up a majority of the greenhouse gas emissions)*
2. *Interconnectors: high voltage cables that are used to connect different transmission networks*
3. *Biomass: plant or animal material used as fuel to produce electricity or heat*

Scenario 3 is the most cost-effective solution of all possible future scenarios; it is even cost-effective when compared to scenarios that continue to use fossil fuels. Scenario 1 and Scenario 2 are of similar costs to scenarios which continue to use fossil fuels. Pathways to achieve net zero by 2050 are therefore feasible.

These total costs for the scenario illustrated in the table above, could be funded by the Government, or Private sector companies, or a combination of both. Regardless of which funding solution is used, the projects are ultimately paid for by the residents of the Isle of Man either through taxes or through electricity bills.

MAINTAINING SECURITY OF SUPPLY

Balancing the Isle of Man's electricity network requires stabilising power; this cannot be provided from sources which are reliant on the weather to produce electricity as these sources cannot be guaranteed at all times. **In all scenarios the most cost-effective solution of providing this stabilising power is a new interconnector to the UK**. Regardless of which future energy scenario is identified as the best pathway to net zero, an interconnector will be required; it is therefore a no regret solution.

Ove Arup's analysis has shown that importing this renewable energy from GB is also more cost-effective than generating power on island from intermittent renewables. On-island renewable biomass generation however, can help to maintain affordable electricity.

The UK is rapidly increasing its capacity for large-scale renewables, in particular offshore wind and solar energy. By 2025, GB will have an excess capacity of offshore wind and will become a net exporter of electricity.

It is clear that a net zero future for electricity can be achieved in a cost-effective manner. Enabling this transition will first require substantial work to upgrade the existing infrastructure to accommodate carbon neutral technology. Such projects can involve significant planning and fairly long construction time-scales. The UK for example, started its transition to net zero over thirty years ago. This means that in the short-term, emissions reductions will not come from on-island generation.

Large infrastructure projects take 5-10 years, immediate reductions within 5 years are only possible from importing power

This document provides further details on these future scenarios and the scope of the work involved to produce these. Commentary is also provided on possible economic opportunities for the Island following on from this piece of work.

A consultation with members of the public and key stakeholders on the scenarios mentioned above will take place over the summer, as part of the 5 Year Climate Change Plan. A decision on preferred pathway as a result of this consultation will follow the publication of this plan in February 2022.

4. *Stabilising power: a balanced combination of baseload (see page 12) and dispatchable generation (see page 13) of power supply, to ensure sufficient minimum stable power supply at all times, as well as supply to meet demand.*

Contents

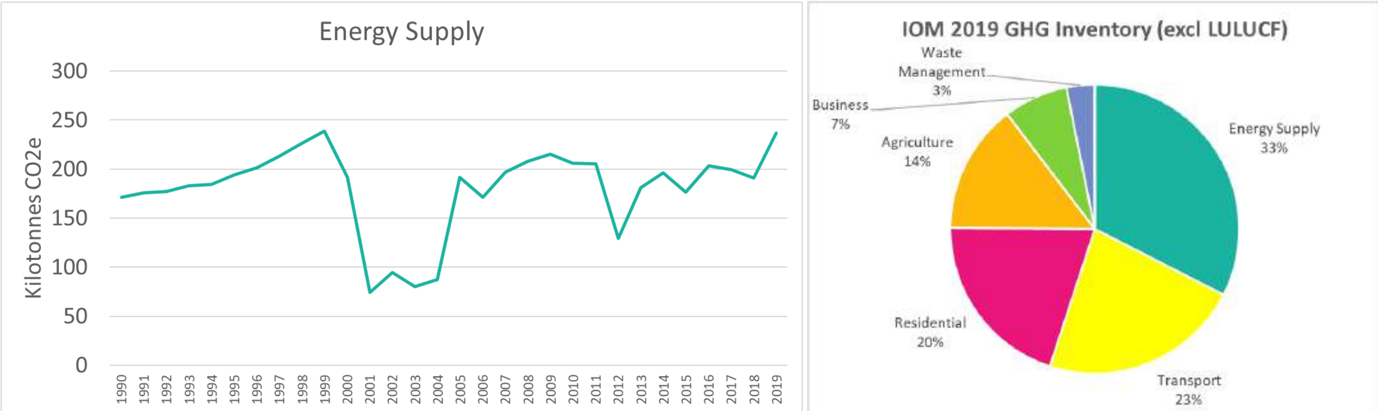
INTRODUCTION

NET ZERO AMBITIONS

The Isle of Man Government has committed to two ambitious targets for Electricity generation in support of the Climate Change Transition:

1) Securing no less than 75% of the Island's electricity from renewable sources by 2035
2) Net zero emissions from electricity generation by 2050.

FIG. 1 – ELECTRICITY EMISSIONS (1990 – 2019)



Source: Isle of Man Greenhouse Gas Inventory 1990 – 2019

CLIMATE TARGETS AND EMISSIONS

Electricity is possibly the most important sector to decarbonise as the decarbonisation of other sectors (especially heating and transport) is dependent on this sector. As the uptake for electric heating and electric vehicles increases, the electricity sector will have to grow to meet future demand.

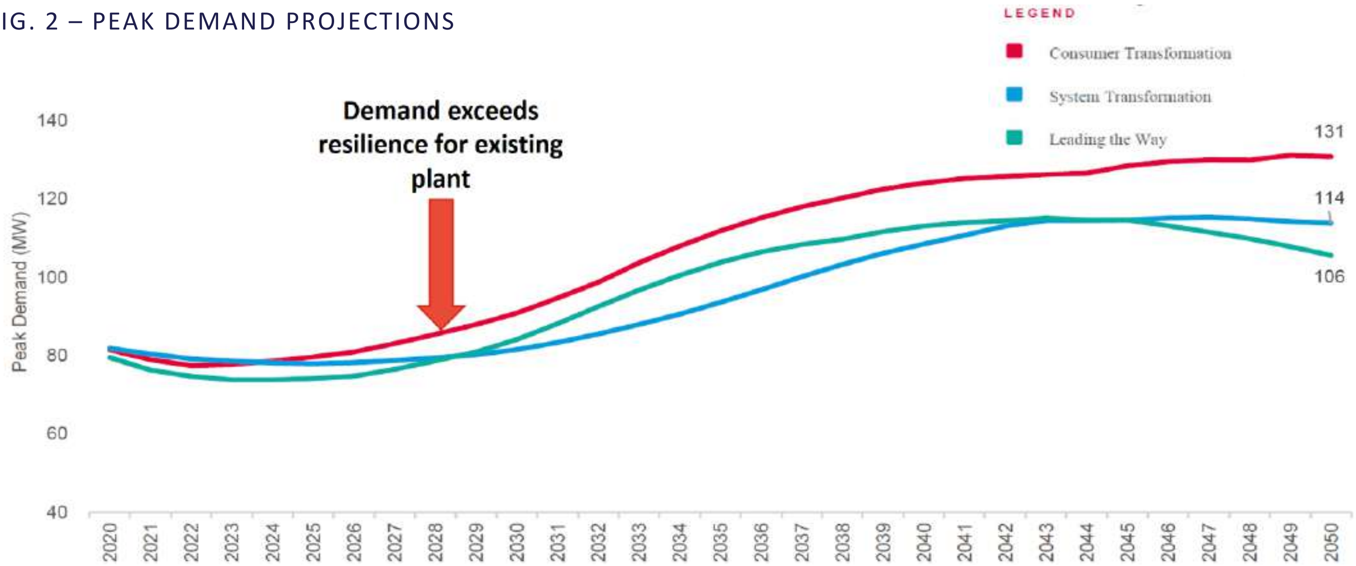
The majority of the Isle of Man's electricity is currently sourced from fossil fuels. The interconnector is a source of carbon neutral electricity on island and also provides a route to export electricity to the GB Market. While UK Gas stations are larger and more efficient than island-based fossil fuel stations, exports to GB are still viable due to the differences in legislation between UK and IOM (e.g. Clean Air Act, Carbon Tax), which means it is often cheaper to generate electricity from fossil fuels on island, compared to GB. Emissions from these exports are attributed to the Isle of Man's Greenhouse Gas Inventory. With the GB Market becoming increasingly short of stable generation to help balance its renewables, there is greater opportunity to export this stable power there is greater opportunity to export this stable power if capacity allows. Consequently, emissions in this sector are increasing as other sectors decarbonise and electrify.

Electricity generation (including emissions from both the Manx Utilities and the Energy from Waste plant) is currently the dominant source of carbon emissions on the Isle of Man, accounting for 33% of the island's emissions at 245KT per year. It is also the only sector where emissions have increased over the last five years.

THE CHALLENGE FOR 2050

As other sectors are electrified, demand is expected to grow. Peak demand is the point of the highest electricity use across a day – usually coinciding with consumers returning home from work. In the future it is expected this demand will increase as consumers switch on their electric heating and start charging electric vehicles. The projected increase in Peak demand modelled across three different consumer behaviours is shown in Fig. 2.

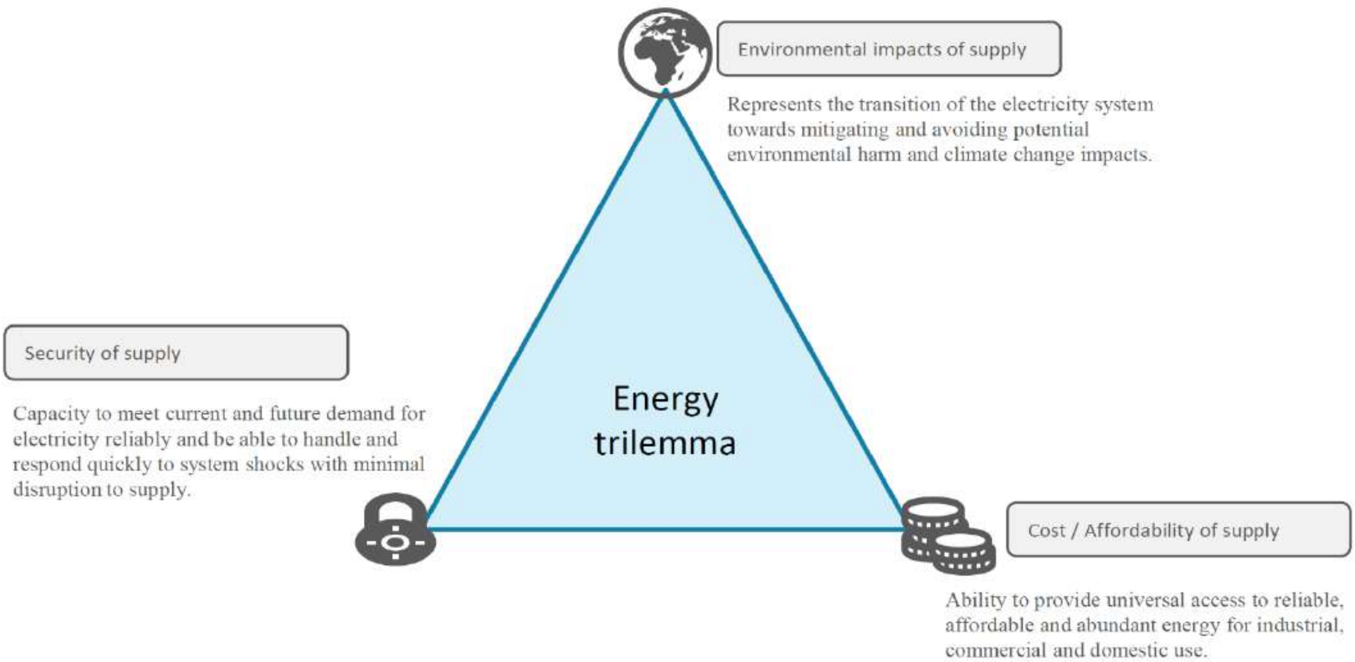
FIG. 2 – PEAK DEMAND PROJECTIONS



Source: Arup Analysis

This increase in Peak Demand presents the greatest challenge. Firstly, there is insufficient existing capacity available to meet the demand projections by 2028 if the same level of resilience is to be maintained on Island e.g. a major fault such as a fire or flooding event could remove all of the generators located at Pulrose, which would leave the Island entirely reliant on Peel and the interconnector to meet Maximum Peak Demand. Secondly, all existing generation units are expected to retire between 2025 and early to mid-2030s. These assets will need to be replaced with technology of the same capability to maintain supply.

FIG. 3 THE ENERGY TRILEMMA



Source: World Energy Council

It is globally recognised that future generation must be balanced against three conflicting measures: Cost/Affordability of supply, Security of supply and Environmental impact of supply (often simplified to low carbon or carbon neutral generation). There will always be a compromise between these areas, with no one solution being able to achieve all three. For example electricity generated from 100% wind power may have low environmental impact but will give neither stable nor secure generation.

The 'best' solution for future generation could therefore be seen to be one which sits directly in the middle of all three aspects. This should be seen as the target to ensure the correct balance between these three areas.

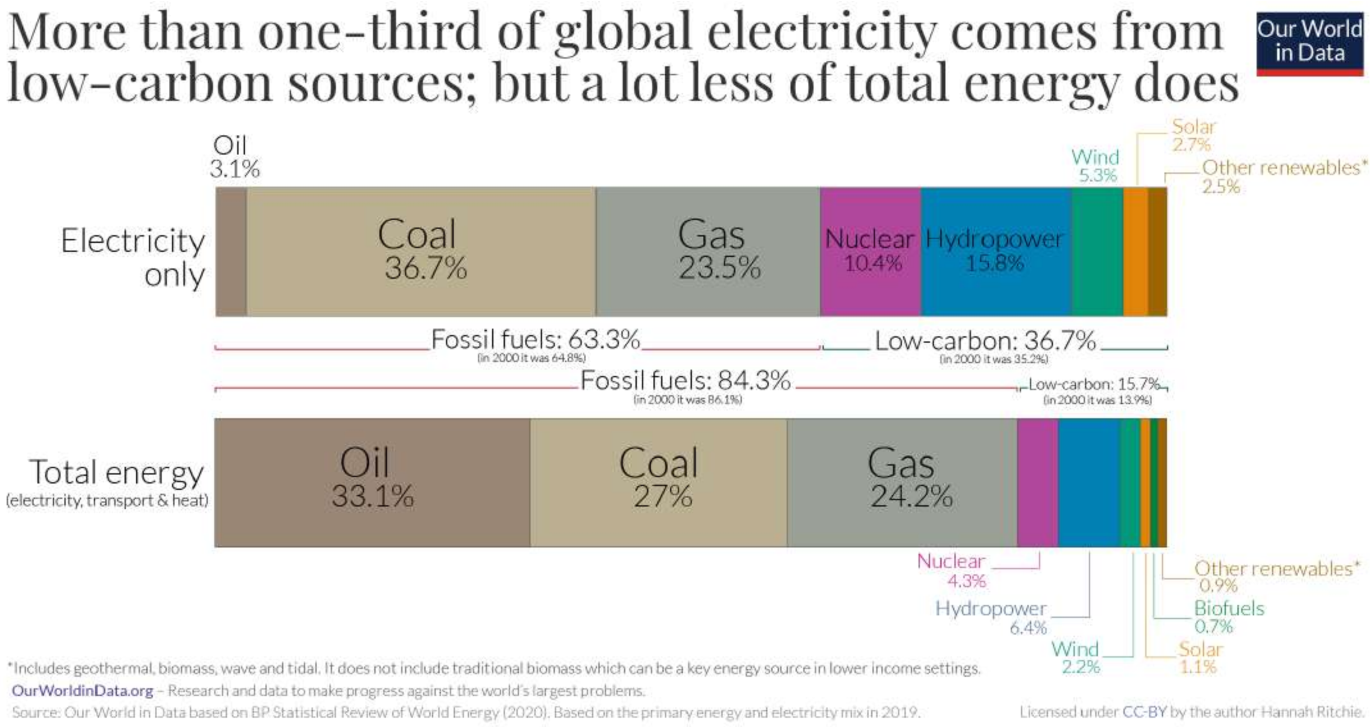
ELECTRICITY GENERATION

INTRODUCTION

Electricity can be sourced from carbon-producing technology (fossil fuels), low carbon technology (nuclear/Hydrogen) or renewable energy sources (including sustainably sourced biofuels).

Despite growth in renewable and carbon neutral sectors, globally electricity production is still heavily reliant on fossil fuels. This will need to change to enable countries to meet their net zero emission targets.

FIG. 4 - GLOBAL ENERGY GENERATION BY SOURCE



Source: Our World in Data

FOSSIL FUELS

Traditionally, energy is generated from the burning of fossil fuels, such as oil, coal and natural gas. Heat energy is released from fossil fuels when burnt. This also releases carbon dioxide. It is this release of carbon dioxide that contributes to the forming of an invisible blanket of greenhouse gases in our atmosphere trapping heat from the sun, increasing global average temperatures and contributing to more severe and less predictable weather conditions. This is generally referred to as anthropogenic (human-caused) climate change.

All fossil fuels originate from the breaking down of dead organisms (plants, cyanobacteria, algae), which store carbon in their structures. The length of time fossil fuels take to form also means that they are a limited resource and will eventually run out.

RENEWABLE ENERGY

Renewable energy is energy made from resources that nature will replace, like wind, water and sunshine. Some examples of this are solar power, geothermal power, hydro power, wind power, tidal power and wave power. They do not produce carbon dioxide.

Biomass energy (from burning plants, wood, bio-liquids, biogas and waste) can also be included as a renewable energy, providing the material for burning is sustainably produced. Of all the various renewable energy types, biomass is the only technology that provides consistent energy production as it is not reliant on weather conditions.

Each technology used for producing renewable energy has its own advantages and disadvantages that must be carefully considered.

CARBON NEUTRAL ENERGY

Carbon neutral energy sources are those that do not produce carbon dioxide as energy is produced. Hydrogen Gas Turbines and Nuclear are currently regarded as carbon neutral or low carbon technologies.

At present, no technology for producing energy (including renewables) is truly carbon neutral. This is because the transportation, construction and maintenance of these technologies releases carbon dioxide. To remove this carbon, technologies such as carbon capture, which is the process of capturing carbon dioxide from the atmosphere and storing it in sites where it cannot enter the atmosphere, will need to be used to achieve carbon neutrality.

Carbon Capture may also be used to remove carbon dioxide emissions from the exhaust stacks of fossil fuel power stations to avoid release to the atmosphere, or biomass plants to achieve 'carbon-negative' generation.

EXISTING GENERATION IN THE ISLE OF MAN

OVERVIEW

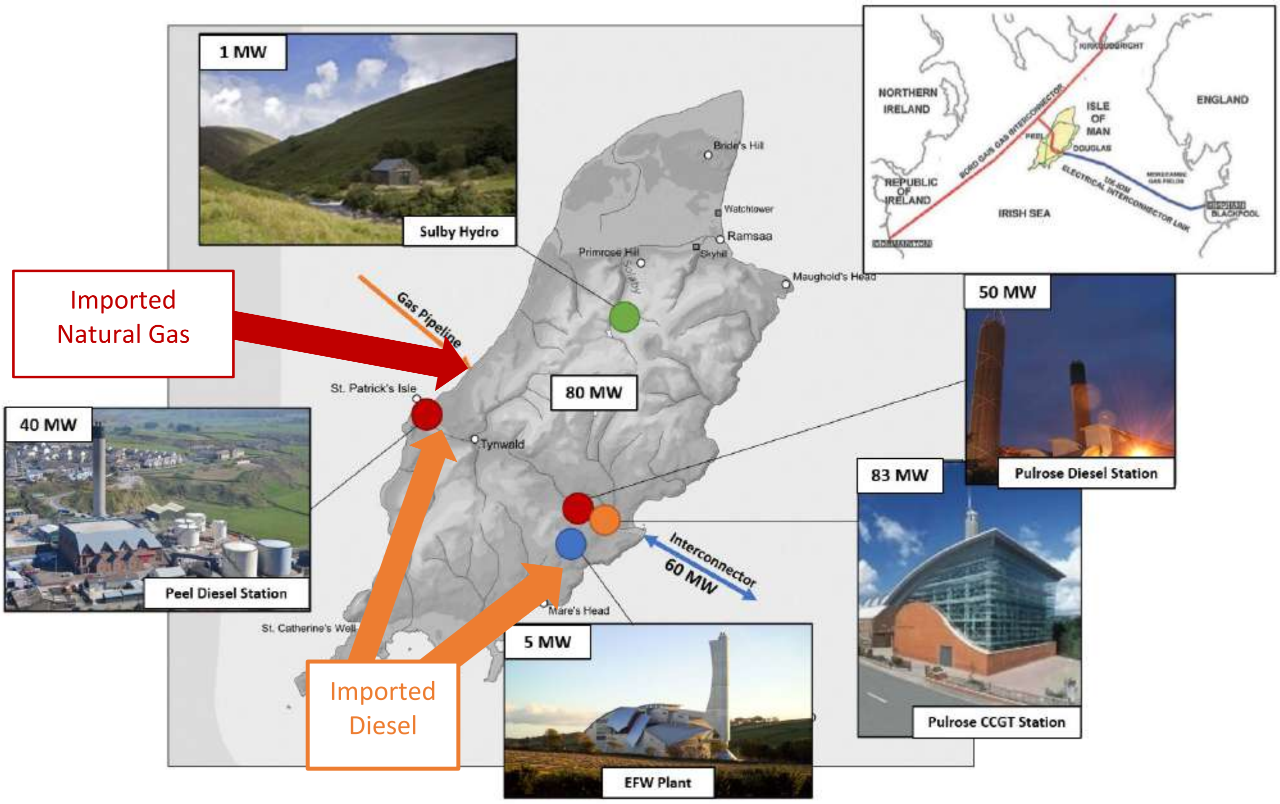
Generation on the Isle of Man currently follows two principles, which are defined in the Electricity Act, 1996:

(1) Affordability (power is generated from the cheapest source of electricity – on the whole this is the Combined Cycle Power Station at Pulrose Power Station)
(2) Security of Supply (There are backup options in the event that two sources of electricity are simultaneously unavailable, which can meet Peak demand e.g. during or routine maintenance, or following a fault)

There are currently 3 major power stations on the Island, 2 small scale power stations and a subsea cable used to import/export electricity to the UK. Currently 84% of the Islands electricity is generated from imported fossil fuels, with the remainder either imported via a cable from GB, or generated at the EFW plant or Sulby Hydro.

These are shown in Fig. 5. Electricity is fed to our homes via the Island's transmission and distribution network. This mix of electricity currently allows us to meet the two principles even if the two largest generators are unavailable.

FIG. 5 – MAP OF GENERATION UNITS ON THE ISLE OF MAN



Source: Isle of Man Government

CURRENT GENERATION MIX AND RETIREMENT OF ASSETS

PULROSE CCGT

Primarily, electricity on the Island is generated at the Combined Cycle Gas Turbine (CCGT) Station at Pulrose in Douglas. The CCGT consists of two gas turbines (similar to those on aircraft) and one steam turbine. The gas turbines burn natural gas, to produce up to 30 MW of electricity each. Carbon dioxide and water vapour are released during the burning process. The steam turbine utilises waste heat captured from the exhaust stacks to produce an additional 20 MW. As this waste heat would otherwise be released to the atmosphere, the steam turbine can therefore be regarded as a 'clean' source of electricity. The use of this recycled heat increases the efficiency of the power station from 35% to around 50%. The Gas Turbines (GTs) are themselves flexible and could be used to balance up to 20 MW of intermittent renewables. Balancing is the process required to maintain the Transmission Network within its limits and ensure there is no loss of supply. While the gas turbines are flexible enough to provide this balancing, the steam turbine cannot currently operate in all of these conditions and may need to be turned off, which could mean the 20MW of electricity from recycled heat would be lost. The introduction of these 20MW renewables may therefore not reduce carbon emissions.

The CCGT will reach the end-of- its design life by 2035. However, this could be brought forwards depending on the concentration of hydrogen in the UK Gas Network. The GTs (GE LM2500+ SAC) are not designed to run on more than 5% hydrogen (unless carbon monoxide can also be added to the gas stream). With carbon monoxide present, a minor modification could allow this limit to be raised to 25%. By 2031, hydrogen in the Gas Network may exceed the limit of the current GE turbines would need to be replaced or modified to allow the plant to continue to operate. There is currently no viable modification that will allow the GTs to continue to operate so an alternative may need to be available to replace these assets in 2030s should they be unable to operate using hydrogen. If a suitable modification did become available or if the gas turbines were replaced with alternative GTs it *may* be possible to continue operating the CCGT beyond 2035. Nonetheless, as hydrogen is currently one of the most expensive carbon neutral options available, it is unlikely this will prove to be cost-effective for consumers unless its cost reduces as its availability increases. If viable, an alternative option could be converting the GTs to run on biofuel such as biodiesel and bioethanol.

PEEL B-STATION AND DOUGLAS D-STATION DIESELS

There are five 10 MW Diesel Generators at Pulrose and a further four 10 MW Diesel Generators at Peel Diesel Station. The diesel engines burn diesel (currently light fuel oil) to produce energy. The diesel engines release c.700 kg carbon dioxide per MWh generated, which increases at lower loads. This is greater than the amount produced from the CCGT plant. However, the diesels are generally only used as a back-up to guarantee a reliable electricity supply.

The diesel generators at Peel and Pulrose have already reached their notional end-of-life and it is rarely considered commercially viable to operate these assets. However, they will be maintained until at least 2025 to ensure an emergency back-up is available in case there is a fault with the CCGT. Continued maintenance of these assets past 2025 would be more costly than replacement with new infrastructure, even carbon neutral assets such as dispatchable generation using biofuel.

AC INTERCONNECTOR

In addition to these major stations the Island can import and export electricity via the Alternating Current (AC) subsea cable to and from Great Britain. This also helps to maximise the efficiency of the GT. At 65 miles long, it is one of the longest AC interconnectors in the world. Importing electricity via the interconnector (especially from resources such as nuclear and wind) has no carbon cost for the Isle of Man. GB also provides balancing capacity for the Isle of Man, which will be explained in the Network Stability section. The cable is fixed at a maximum continuous capacity of 60MW and a new cable would need to be laid in order to export or import more electricity. It would also be necessary for balancing any intermittent renewables e.g. Solar or Offshore wind.

In general, the UK is short of stable generation capacity and the Isle of Man can export electricity, at a profit, to the UK when it is short of supply. This helps to keep electricity bills as low as possible for Isle of Man consumers.

The interconnector will reach the end of its original design life in 2040. It is likely possible to carry out some refurbishments of the auxiliary equipment to allow its operational life to be extended through to 2060. It would not be possible to increase the capacity (uprate) the existing cable beyond 60MW. Additionally, if signs of fatigue are showing in the 2030s, replacement of worn assets would need to be planned.

ENERGY FROM WASTE (EFW) PLANT

The Island also has an energy from waste (EfW) plant that burns waste, producing up to 5 MW of electricity. The process releases greenhouse gases including carbon dioxide. These are significant for the size of the plant, but the same emissions would still be produced from the decomposition of waste, whether it is burned or not, therefore the EfW plant makes use of emissions that would occur anyway to turn them into useful energy. For example, historic landfill waste is still emitting greenhouse gases and will continue to do so for some time, even though there is limited ongoing landfill activity in the Isle of Man.

SULBY HYDRO

The Hydro Plant in the Sulby Glen generates up to 1% of the Island's energy from renewable sources (1MW of electricity at maximum capacity). There are two hydro generators located beneath Sulby Reservoir which utilise water from both Blockeary Reservoir and Sulby reservoir to produce energy.

While 1 MW seems a very small scale, this type of generation is one of the most efficient energy sources in existence at 90% - 95% efficiency and has minimal running costs. However, Sulby reservoir is also the Island's largest water resource for provision of drinking water. To ensure drinking water supplies are not compromised, the output from the hydro-electric station is limited, particularly during the summer months. Sulby therefore rarely operates more than 4 months per year.

ISLAND DEMAND AND SECURITY OF SUPPLY

The island requires an average of c.60 MW throughout the day to power homes and businesses. This power use is not evenly distributed across the day. At night electricity demand can be as low as 25 MW but Peak demand in the day time (usually between 7am – 9am and 5 pm – 7pm can reach 85 MW) The CCGT can alter its load by varying the gas supply, which allows the station to match the island demand profile across the day. The CCGT alone is sufficient to meet island demand. At full capacity (peak demand), the CCGT station produces c.400 kg CO_2 per MWh generated. Low CCGT loads have a cost of reduced station efficiency and increased carbon dioxide production per MWh, although total emissions are reduced. In order to ensure that the island has a reliable electricity supply, additional capacity is required to support the grid in the event of a fault scenario.

If there is any fault on the steam turbine, the GTs at Pulrose can still continue to operate to deliver up to 60 MW of variable load, depending on whether or not the boilers remain in service. Without the boilers, the GT output can be limited to avoid damage to the boiler structure. The GTs alone can therefore provide enough power to meet most of the demand, however the emissions will be seen to increase to c.600 kg CO_2(e) per MWh generated. The interconnector can be used to supply the additional energy demand, as well as balancing capability.

The diesel engines at Peel and Pulrose with a collective output of 90 MW can together meet island demand.

These generating assets and the interconnector can meet the Isle of Man electricity demand requirements. If there is any risk of a fault developing (e.g. network maintenance in the NW of England, which could cause the interconnector to trip), the diesel engines can be put into service allowing them if required (e.g. if the CCGT has reduced capacity) to take the demand in the event of any trip.

The level of resilience on the Island is referred to as 'N-2'. This means that two of the largest sources of generation can develop a fault, or be taken out for maintenance, and there is still enough capacity available to meet demand. 'N-1' resilience means only one of the largest sources can fail, and that no sources can fail when a large source has been taken out of service for maintenance. However, this does not necessarily mean the risk of losing supply is greater with N-1; for example, if existing sources are replaced with more robust plant such as interconnectors which have a much lower chance of developing a fault.

Any future source of electricity on island must be able to meet this demand in a controllable manner to maintain security of supply and economic stability.

NETWORK STABILITY

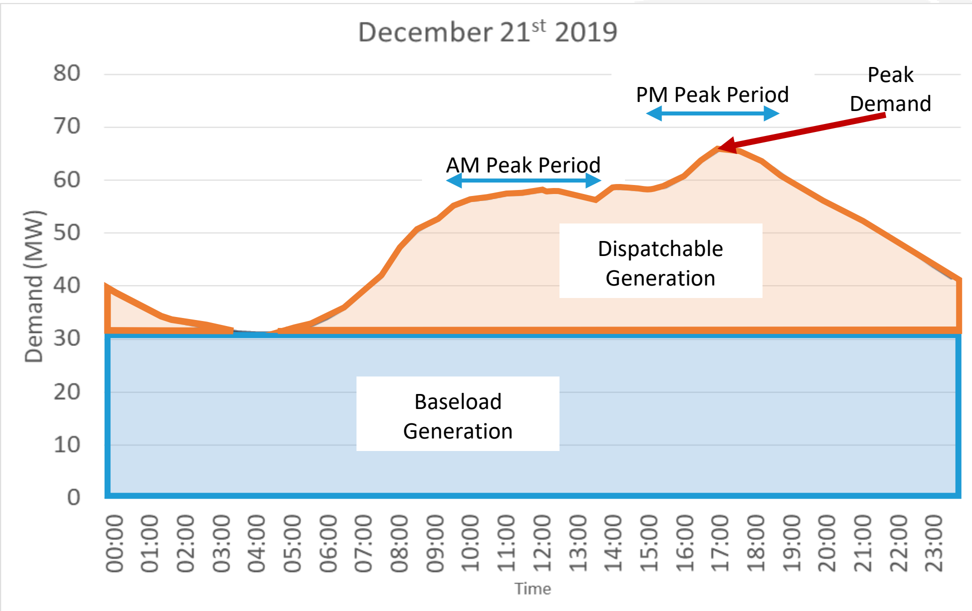
SUPPLY, DEMAND AND STABILITY

The GB and Isle of Man grid networks supply electricity in the form of Alternating Current (AC) to our homes. The appliances in our homes are designed to operate under specific conditions:

Voltage	33kV (Bulk transmission) 11kV (Local distribution) 230V (Domestic Supply)
Grid Frequency	50Hz ± 0.5Hz
Reactive Power	To balance voltage To match customer use
Fault Current	Sufficiently high for grid protection to operate
Maximum Demand	131 MW (2050)
Minimum Demand	60 MW (2050)
Inertia	To maintain system stability

If the network moves too far from these set points, network and customer protection can operate to return the system back within these set points, which may involve disconnection of some customers. Ensuring these limits are maintained requires a balance of what is called 'baseload' and 'dispatchable' generation. Intermittent renewables such as wind and solar cannot replicate baseload plant however, they can offset some of the dispatchable capacity when they are available. Provision of these stabilising services is known as balancing.

FIG. 6 – GRAPH SHOWING ISLAND DEMAND PROFILE FOR DECEMBER 21ST 2019



Source: Manx Utilities Energy Services Application

BASELOAD GENERATION

Baseload generation can be fairly inflexible generation units, but is essential to ensure the transmission network operates within its limits and meets the minimum required electricity demand. By operating at a stable steady load, voltage and reactive power can be varied using transformers. The units are often coupled with large steam turbines, which provide inertia along with the interconnector. Inertia reduces the grid frequency spikes on the network caused by sudden power swings (e.g. power line failures, gusting wind with wind generators, sudden increases in demand). Baseload generation is usually built to match the minimum demand as shown in Fig. 6.

Examples include nuclear power stations, coal-fired power stations and large scale gas-fired power stations. These can be combined with Carbon Capture and Underground Sequestration technologies to provide Net Zero generation, but this technology is still in development. Geothermal Energy and large scale Hydro as seen in Iceland can also provide baseload. However, nuclear and large scale biomass provide the only alternatives that would be suitable for the British Isles. Jersey and Guernsey currently utilise French nuclear power to stabilise their networks by importing electricity through their Interconnectors.

Baseload generation on the Isle of Man can be provided by the CCGT, the interconnector, or in emergencies the diesels, which are also designed to provide flexible, dispatchable generation as required. Across Europe, most countries are either investing in nuclear technologies, or utilising interconnectors to stabilise their grids by providing resilient routes to alternative sources of energy.

DISPATCHABLE GENERATION

Dispatchable generation is flexible plant which can be started and shut down on demand and power output can be varied quickly ensuring grid frequency remains stable and secure. Intermittent Renewables such as solar and wind can off-set some of the dispatchable generation when these sources are available. However, dispatchable generation is always required to ensure Peak Demand can be met where there is a shortfall of generation i.e. when intermittent renewables are not available, or if there is an unexpected loss of load due to a fault with a baseload generator or a change in output from intermittent renewable generators.

Examples include gas-turbines and diesel generators. These technologies are gradually being replaced with alternative fuels e.g. biofuels and hydrogen. However, currently hydrogen remains one of the most expensive alternatives.

INTERMITTENT RENEWABLES

Intermittent renewables are sources of generation powered by natural resources i.e. wind, tide and solar. The power output (or availability) of these generation units is highly dependent on prevailing weather conditions. The lack of ability to vary power output from intermittent renewables means voltage and frequency (along with many other stabilising factors) cannot be controlled on their own. These technologies can off-set some or all of the dispatchable generation assets when they are available but must still be stabilised.

Intermittent renewables typically have low load factors – this is the average output of the generator divided by the maximum installed capacity of the same type of generators over a given period. Wind typically has an average load factor of c.37%, (c.25% onshore wind and 50% offshore wind) which means on average it produces 37% of the rated maximum output. Solar has less favourable performance, with a load factor of c.10% in the British Isles. For obvious reasons, solar power does not generate electricity on winter evenings when demand is generally the greatest. Therefore, to ensure Peak Demand could be met using intermittent renewables alone, the excess generation capacity would have to be enormous, even where storage solutions were deployed. For this reason, dispatchable generation units are also required to avoid excessive CAPEX[5] costs.

STORAGE

Over short time scales, storage (e.g. pumped hydro, batteries) can temporarily manage some aspects such as the frequency swings by absorbing and releasing power. These help to provide some inertia to the transmission network. In the event of a sudden loss of load (e.g. large-scale trip) the stored energy can be released rapidly to maintain capacity on the network. This is a short-term solution to the problem as the stored energy is finite and it is currently expensive. However, it buys sufficient time to allow dispatchable units come on-line and meet the generation shortfall.

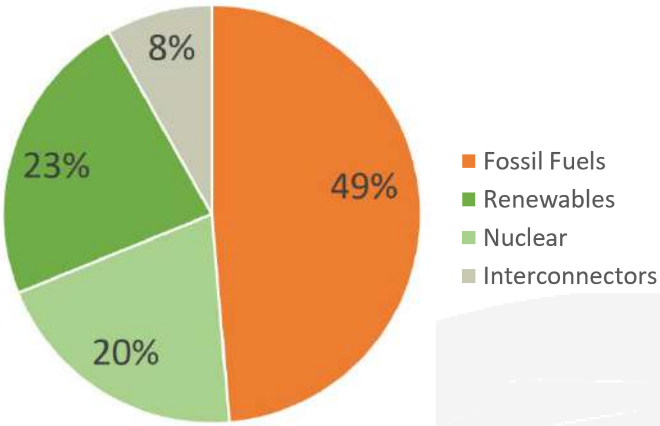
5. CAPEX (Capital Expenditure) are funds used by a company or government to acquire, upgrade and maintain physical assets such as property, plants, buildings, technology and equipment.

THE UK SOLUTION

BACKGROUND

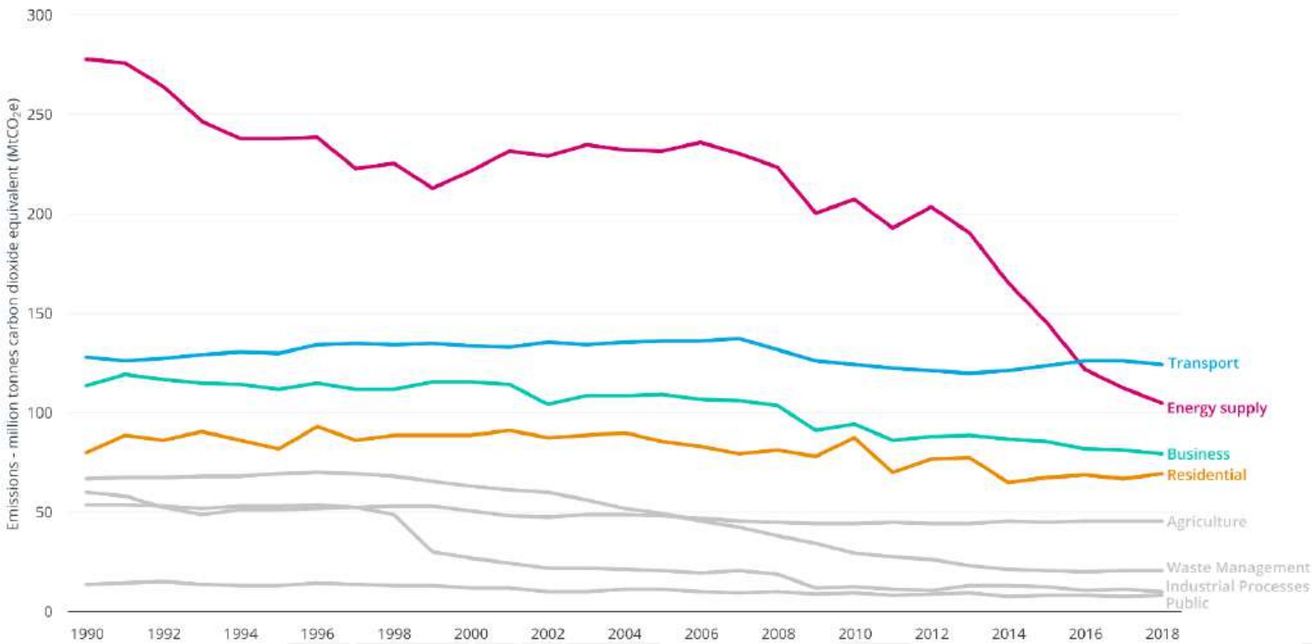
The UK is already transitioning towards Net Zero and currently generates 52% of all of its electricity from low carbon sources. Substantial investment has already been carried out on the Transmission Network to accommodate intermittent renewable technologies, which has also locked the centralised grid into the future of UK energy. As discussed, this has numerous implications for the grid in terms of stability. However, this journey to net zero actually started in the 1950s with the construction of Magnox nuclear stations and pumped storage schemes such as Dinorwig. This has continued through to 1980s with the construction of the Advanced Gas Reactors (AGRs) and finally the commissioning of Sizewell B (a Pressurised Water Reactor) in 1995. These stations are baseload plants and are critical to maintain Grid stability in the absence of fossil fuels. They provide the balancing power required for the operation of offshore and onshore windfarms.

FIG. 7 – CHART SHOWING UK ELECTRICITY MIX – 2019



Source: BEIS, UK Government

FIG. 8 – GRAPH SHOWING REDUCTION IN UK EMISSIONS BY SECTOR BETWEEN 1990 - 2018

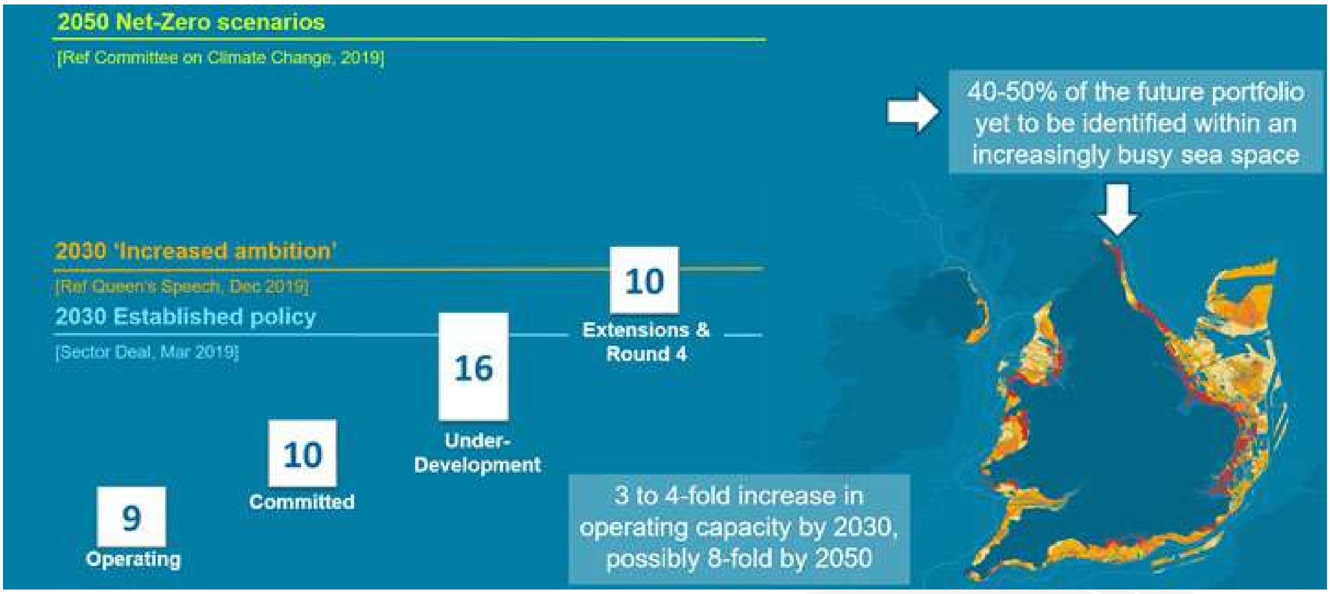


Source: Institute for Government, after BEIS, UK Government

UK FUTURE GENERATION

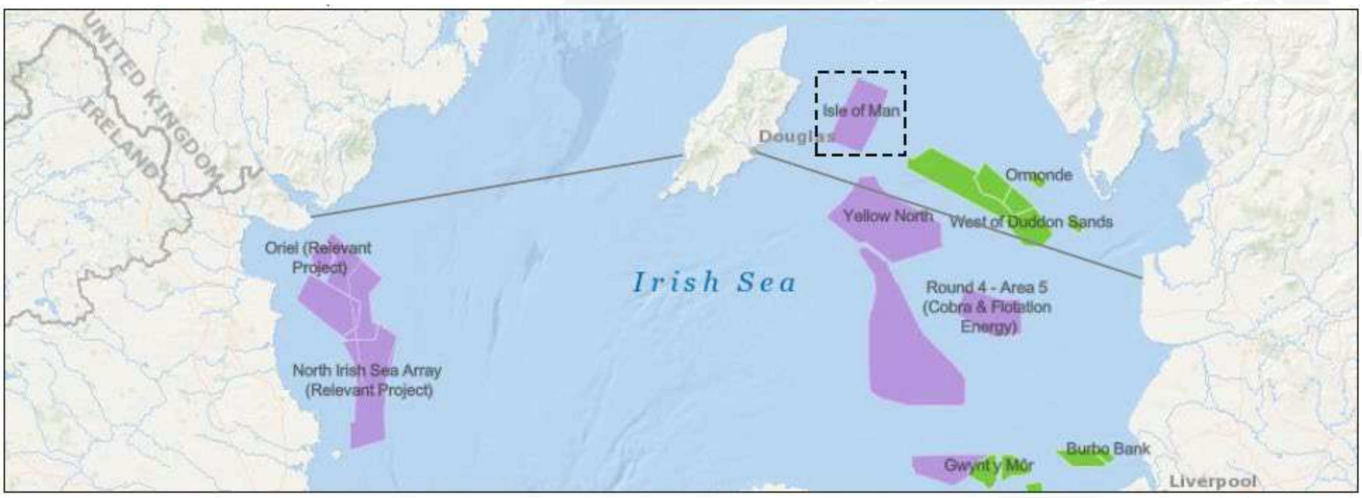
The UKs is expected to commission 40GW of offshore wind to meet its 2030 target (see Fig. 9). It is able to do this due to its nuclear baseload capacity. At times the GB Market will have surplus generation from wind farms compared to demand, which means there would be limited opportunity for a neighbouring jurisdiction with similar wind resource to export excess power to GB. The UK has also committed to building a new generation of nuclear reactors, biomass combined with CCS, and hydrogen storage, which allows it to increase this wind capacity even further towards 2050.

FIG. 9 – MAP SHOWING PLANNED OFFSHORE WINDFARM DEVELOPMENTS (ENGLAND, WALES, N. IRELAND)



Source: The Crown Estate

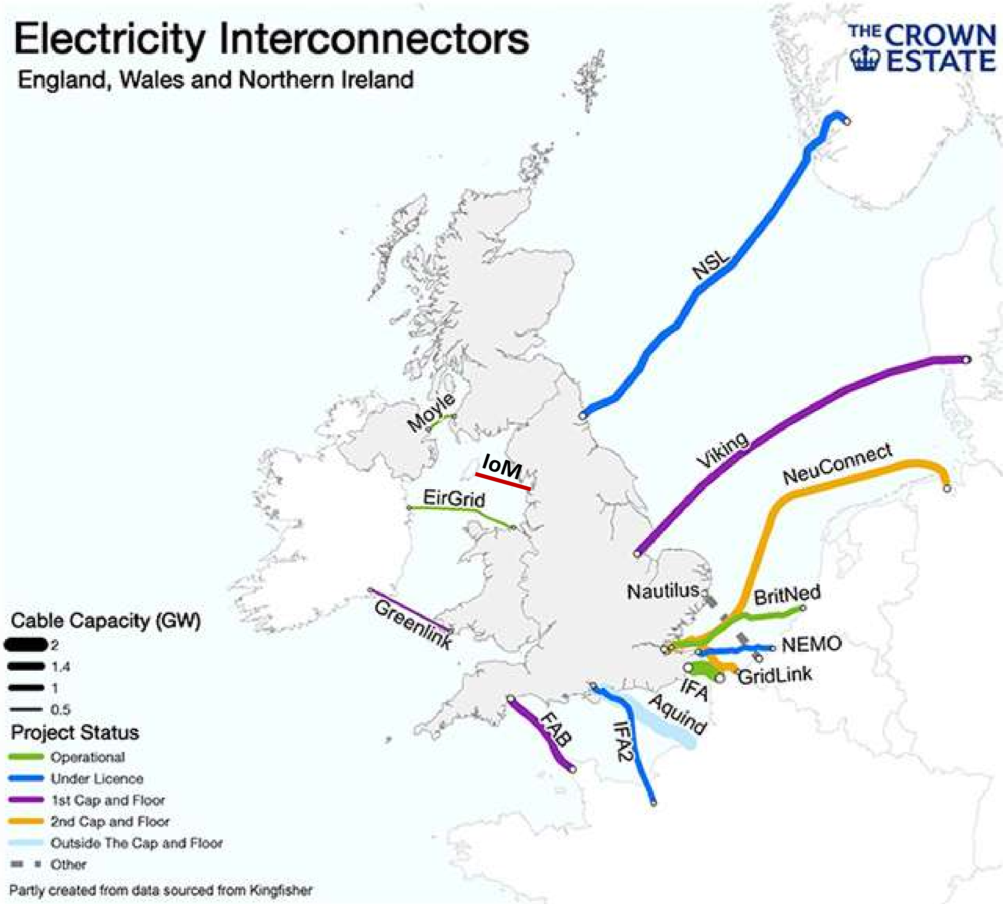
FIG. 10 – MAP SHOWING PLANNED OFFSHORE WINDFARM DEVELOPMENTS – IRISH SEA



Source: Arup Analysis

The UK is also currently in the process of constructing Hinkley Point C (a European Pressurised Reactor), which will be the largest nuclear generating plant in the UK by the time it has been commissioned, and is already in consultation to construct an additional large-scale EPR at Sizewell C. There is a further commitment to build additional stations potentially including up to 17 Small Modular Reactors (SMRs), which it will need to stabilise the excess wind capacity. However, currently it is struggling to find suitable sites to deploy its first SMR.

FIG. 11 – MAP SHOWING CURRENT OPERATIONAL AND COMMISSIONING UK INTERCONNECTORS



Source: after the Crown Estate

As further back-up the UK has also invested in large scale interconnectors, which also allow the UK to export its excess wind power to mainland Europe and import baseload from other countries e.g. France (Nuclear) and Norway (large-scale hydro) when it is short. Presently the UK is short of dispatchable and baseload power over peak Winter periods and this leads to very high market prices e.g. on January 12th 2021, France charged the UK £8/kWh (£8000/MWh) at peak demand, compared to typical wholesale prices of £0.06/kWh (£60/MWh). There is therefore a potential economic opportunity for countries with baseload units to export to the UK.

There also is ongoing investment in hydrogen and battery storage to assist with the short-term frequency swings. The UK also has started the conversion of Drax coal station to biomass although, there are issues with the sourcing of sustainable biomass. Drax is due to decommission the last of its two coal units by September 2022.

Despite these commitments, the UK has accepted that is not possible to achieve net zero carbon in generation without also capturing the emissions from construction and maintenance of carbon neutral technologies.

ISLE OF MAN FUTURE ENERGY SUPPLY

FUTURE ENERGY SCENARIOS STRATEGY

Ove Arup were appointed to identify transition pathways to allow the Island to reach Net Zero for its electricity supply by 2050, as well as showing how 75% of all electricity could be sourced from renewables by 2035.

There were three controls on the project:

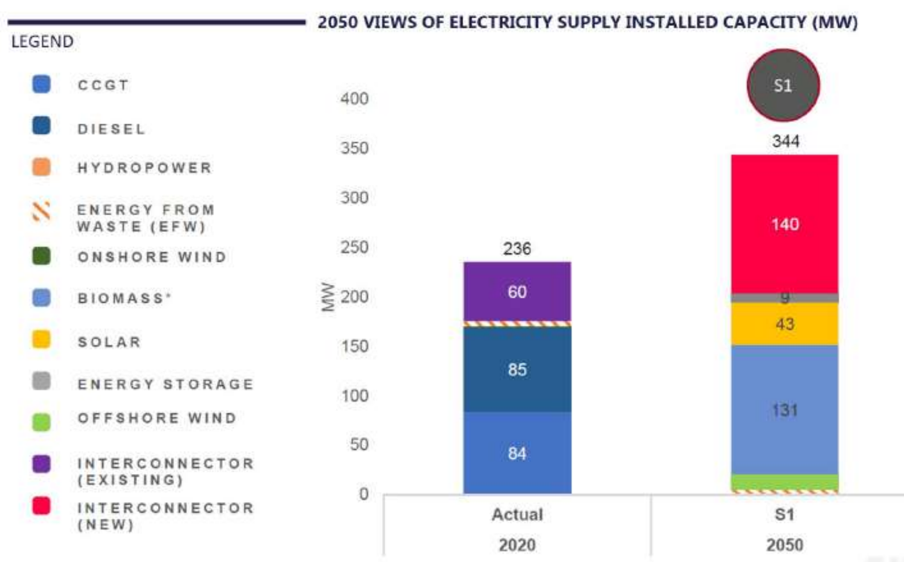
a) The pathways must meet the emissions targets;
b) The scenarios must provide the most cost effective pathway to achieve these targets, to ensure the principles of the *Just Transition* were followed;
c) The study must consider the balance of security of supply, low cost to consumers, and the environment.

Ove Arup carried out independent, technical and economic modelling to create three scenarios based on technologies which were appropriate for the Isle of Man. They were assisted by a technical team consisting of representatives from the Climate Change Transformation Team, DEFA, DfE, Manx Utilities, Treasury and DOI, who provided relevant data and information on local factors throughout the process.

The analysis has shown that in all future scenarios, importing renewable electricity will result in the lowest costs to customers. Interconnectors provide baseload in all scenarios. The greater the amount of installed intermittent renewables on island, the higher the costs to consumers. This is because the UK is building large-scale intermittent renewables (i.e. wind, solar), which generate electricity more efficiently than small generators and benefit from economies of scale. There is also limited opportunities for Isle of Man to export electricity to GB, due to the excess capacity of renewable generators expected to be in operation by 2050. Isle of Man assets also have an 11% CAPEX uplift compared to equivalent UK installations, due to labour, available skill-set, transport and economies of scale.

While intermittent renewables lead to higher consumer costs, dispatchable generation can actually lead to lower wholesale costs on the Isle of Man than in the UK. The times where the UK is short of capacity, are those when intermittent renewables are unavailable (e.g. winter nights where there is no wind). During these times, there isn't sufficient capacity from dispatchable generators to meet demand so the UK is reliant on imports from Mainland Europe. Dispatchable renewable biomass generators are present in all three scenarios, and these are operated where GB prices are high to minimise costs for consumers. All costs discussed include CAPEX network upgrades, operations and maintenance, insurance, fuel and price of electricity.

FIG. 12 – SCENARIO 1 – SOLAR, WIND AND LARGE-SCALE BIOMASS



Source: Arup Analysis

43MW solar farm with **9MW** storage

16 MW Offshore wind turbines

Biomass provides up to **131 MW** dispatchable generation

Estimated cost **£1.49bn**
(N-2 cost £1.66bn)

£1142 per household per annum

57% on island generation capacity;
20% demand met by island sources

Scenario 1 has the highest proportion of intermittent renewables and therefore has the highest cost to consumer. Both the cost of electricity in p/kWh and the cost to the taxpayer is expected to be higher than Scenarios 2 and 3. The base-retail electricity price is estimated to be between 9.3 – 11.1 p/kWh* depending on the preferred resilience level.

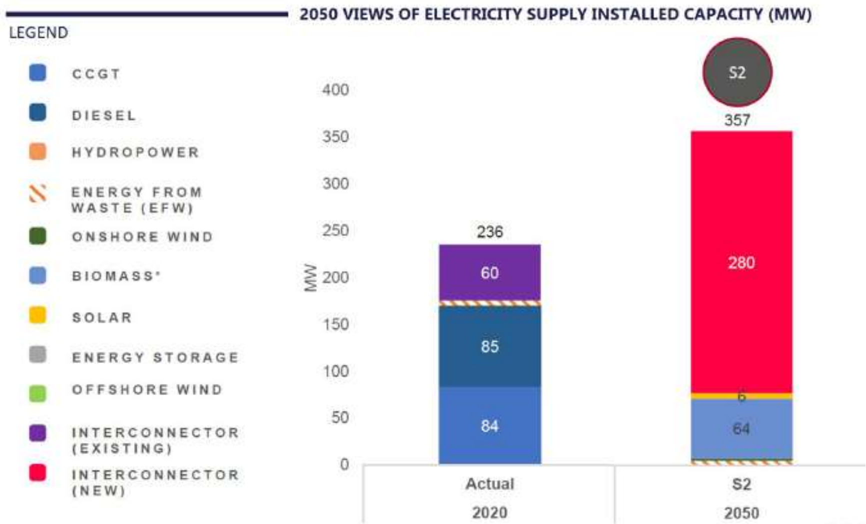
In this pathway, small-scale solar capacity starts to gradually build throughout 2020s, with biomass displacing the diesel engines at Douglas D-Station and Peel by 2028. Increased biomass capacity in the early 2030s, allows the CCGT to be phased out of use with increased solar, offshore wind and biomass then making up over 50% installed generation capacity. A 140MW interconnector displaces the existing 60MW interconnector in 2040 to ensure maximum demand can be met during maintenance periods.

The biomass station also provides baseload electricity during interconnector maintenance and critically would allow the Isle of Man to maintain supply, even if GB suffered an all-island black-out.

Biomass use is limited by the amount of sustainable material, which can be grown on island. Importing biomass from GB could allow for increased generation, with potential to export electricity for profit to GB when there is a shortage of dispatchable generation. This could subsidise electricity for consumers on Island.

**The base-retail rate is taken as the estimated cost of the assets and associated infrastructure over the life-span of the asset, divided by the electricity demand.*

FIG. 13 – SCENARIO 2 – IMPORTED RENEWABLE POWER & BIOMASS



Source: Arup Analysis

6MW Small scale roof-top solar e.g. installed on public buildings

2 x 140MW interconnectors supply renewable electricity from GB and provide baseload

Biomass provides up to **64 MW** dispatchable generation

Estimated cost **£1.4bn** (N-2 cost £1.57bn)

£1073 per household per annum

20% on island generation capacity; **8%** demand met from island sources

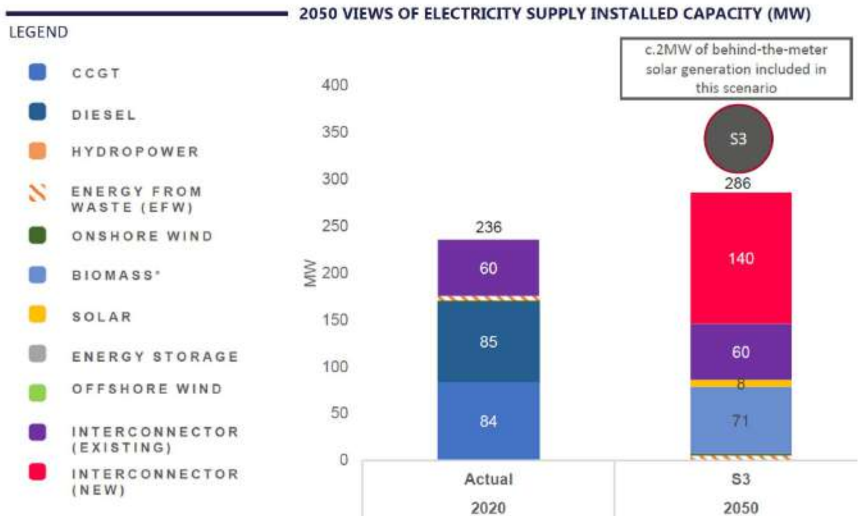
Scenario 2 has the lowest proportion of on-island generation with 91% of demand met by imports. The base-retail electricity price is estimated to be 8.5 p/kWh for either N-1 or N-2. However, the overall cost per household could be up to £130 per year higher if increased resilience is preferred.

In this pathway, the diesels generators are replaced by a 140MW interconnector by 2028, with biomass increasing to phase out the CCGT in the early 2030s. A further 140MW interconnector displaces the existing 60MW interconnector in 2040 to ensure maximum demand can be met during maintenance periods.

The biomass generators provide dispatchable generation to off-set high peak-charges in GB. The biomass generators would allow the Isle of Man to maintain supply to key sectors (e.g. buildings providing public services, data-centres) in the event of a GB black-out, with other sectors quickly reconnected following restoration of supply. Note that a total GB black-out is considered highly unlikely.

Roof-top solar, which is of suitable scale for 6MW solar generation, could be installed on public buildings from 2022.

FIG. 14 – SCENARIO 3 – DECENTRALISED GENERATION & BIOMASS



Source: Arup Analysis

6MW Small scale community solar

2.3 MW roof-top solar on new builds

2 MW Community wind projects

Biomass provides up to **71 MW** dispatchable generation and interconnector provides baseload

Estimated cost **£1.07bn** (N-2 cost £1.24bn)

£820 per household per annum

30% on island generation capacity; **9%** demand met by island sources

Scenario 3 results in the lowest cost to consumer and the lowest retail price of all scenarios. This is mostly due to it having the lowest installed capacity. The base-retail electricity price is estimated to be 6.7 – 7.2 p/kWh.

In this pathway, 50% of new builds have roof-top solar panels, giving a capacity of 2.3 MW. An additional 6 MW of solar is installed on public buildings (or used for community generation projects), and small-scale community wind projects provide 2 MW total power. The diesel generators are replaced with a 140MW interconnector, with biomass increasing to phase out the CCGT in the early 2030s. The existing 60MW interconnector is re-conditioned to facilitate life-extension.

The biomass generators provide dispatchable generation to off-set high peak-charges in GB. The biomass generators would allow the Isle of Man to maintain supply to key sectors (e.g. buildings providing public services, data-centres) as well as an increased domestic area relative to Scenario 2 in the event of a GB black-out, with other sectors quickly reconnected following restoration of supply. Note that a total GB black-out is considered unlikely.

INCREASED RENEWABLE CAPACITY

In all scenarios, renewable capacity could be increased further to provide additional on-island generation. Biomass generators can also provide balancing services for intermittent renewables by acting as 'sub-synchronous condensers' – this means that they can absorb some of the excess power generated from renewables when the capacity exceeds demand.

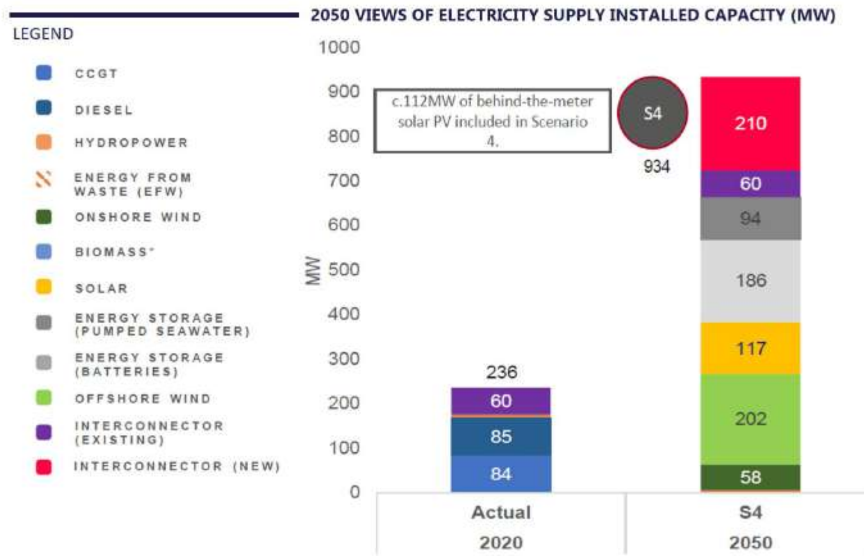
60 MW of intermittent renewable capacity consisting of 40MW solar and 20 MW of offshore wind can be added to each scenario at an approximate cost of £100M. This high level estimate also includes network and operating costs. The change in price for each scenario with increased renewable capacity. For each scenario this would increase the cost per household per annum by approximately £76.50.

ADDITIONAL SCENARIOS

It was requested by the Climate Change Transformation Board that additional work was carried out to identify the costs of significantly more intermittent renewable generation. Two additional scenarios were requested, which required the removal of low cost to consumer and the trilemma balance from the model inputs.

To ensure most of the Island's demand can be met with intermittent renewable generation an excess of intermittent renewable capacity and storage is required. This is so that on cloudy, non-windy days, there will be sufficient stored energy available to maintain supply. This is shown in both scenarios 4 and 5. The storage solutions are also expected to have significant environmental impact both in terms of materials required, and area required for the schemes. In both of these scenarios, imported electricity is still required to avoid a shortfall.

FIG. 15 – SCENARIO 4 – HIGH INTERMITTENT RENEWABLE CAPACITY



Source: Arup Analysis

377MW intermittent renewable capacity

280MW storage (including onshore marine pumped hydro) required for balancing.

GB provides all baseload stabilisation through **270MW** interconnectors

Estimated cost **£1.8bn*** (N-2)

£1379 per household per annum

345% on-island generation capacity; **58%** demand met by on island sources

*Excluding constraint costs

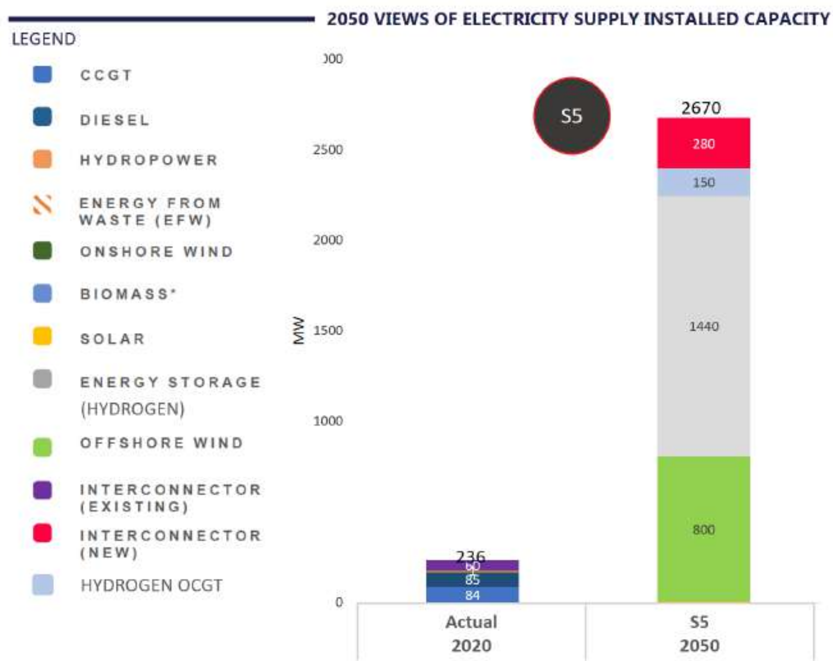
Scenario 4 results in higher cost to customers than all three previous scenarios. This is result of the high required installed capacity. In addition the lack of dispatchable generation means that high peak charges from GB cannot be avoided. The high peak charges occur when local weather conditions do not allow for generation from intermittent renewables in GB, which will also affect the Isle of Man. The base-retail energy is estimated to be 11.2p/kWh compared to 5.4 p/kWh for existing units. However, unlike the previous scenarios the very high proportion of intermittent renewables means that at times there could be 317MW of excess generation capacity compared to demand (e.g. Midday in summer). Storage can only provide a temporary solution to this over-generation. As GB will also have a similarly high capacity of renewable generation at these times, the Island will either have to pay generators to switch-off their units, or export to the UK at a potential loss. This could result in higher charges.

In this scenario interconnectors are still required to replace the diesel engines by 2028. This then allows for renewables to start to be introduced. Further interconnectors replace the CCGT in the early 2030s, which allows for a further increase in intermittent renewables. The existing 60MW interconnector is re-conditioned to facilitate life-extension and storage is deployed on island. The capacity of storage is significant, requiring large areas of land to be made available. By 2050, 50% of all buildings on island will have solar panels installed on their roofs.

Marine pumped hydro is required for this model to work. There is insufficient rainfall on the Isle of Man to allow for freshwater storage as this would compete with drinking water supply. Therefore, pumped salt-water from the sea must be utilised instead. The volume required would be roughly equivalent to 66% of Sulby Reservoir. Storing this quantity of salt water on island could have consequences for the eco-systems and agricultural land.

Without any on-island baseload (or dispatchable generation), the Isle of Man is entirely reliant on GB for providing stability to the network. Despite the high level of generation capacity, the Isle of Man will still need to import 42% of the electricity required to meet demand throughout the year. In the event of a GB black-out (or brown-out in areas of connection points), there would be no power to the Island's key sectors. This would mean they would require their own dispatchable generators (e.g. biodiesels) to ensure essential services could be maintained. Restoration of power to the Isle of Man network could also prove challenging and would have to be staggered. Note that a total GB black-out is considered highly unlikely.

FIG. 16 – SCENARIO 5 – OFFSHORE WIND AND HYDROGEN



Source: IOM Government, after Arup Analysis

800 MW Offshore wind farm

1440 MW Hydrogen storage to provide up to 4h electricity generation

150 MW Open-cycle Hydrogen gas turbines to convert the stored Hydrogen back into electricity

GB provides all baseload stabilisation through **270MW** interconnectors

Estimated cost **£4.5 – 6.1bn*** (N-1+)

£3450 – £4700 per household per annum

954% Island-based generation capacity.

60 – 90% demand met by on island sources

*Dependent on cost of electrolysis. Excluding constrainment costs

Scenario 5 was requested to estimate the high level costs of bringing power to the Island from an offshore windfarm in Manx waters. Due to the high-level nature of the analysis, there is no estimated p/kWh. It should be noted that the overall costs are over six times higher than Scenario 3. Despite there being nine times more generational capacity in this scenario compared to scenario 3, this capacity does not provide greater resilience. Given the high proportion of wind being installed in both UK and Irish waters over the next ten – thirty years (see Fig. 9 and Fig. 10) there may be limited opportunity to export power generated from offshore wind from the Isle of Man to GB, if it has to be brought onto the island first. This is because the operational costs are greater due to on-island balancing. To make use of this excess capacity the wind will either need to be converted to Hydrogen for storage using electrolysis, exported at a potential loss, or generation constrained.

In this scenario the diesels and CCGT would still be phased out by the construction of new interconnectors. The large offshore wind farm could then be constructed. Excess wind would be converted to Hydrogen using electrolysis. Electrolysis is currently expensive, with costs averaging almost £200/MWh gas produced once storage costs have been taken into account. Both the electrolysis process and the combustion of Hydrogen in Gas Turbines is inefficient, which is why 1440 MW of Hydrogen storage is required to support on-island demand for 4 hours. The storage of Hydrogen is challenging and would require considerations to ensure safety of residents. The infrastructure costs could therefore be significant. Only the fuel costs have currently been considered in the costs for this model.

Hydrogen produced in this scenario could also be used for Transport or Heating, instead of electricity as shown in previous models. However, it should be noted that Hydrogen heating is predicted to be more expensive than other renewable alternatives.

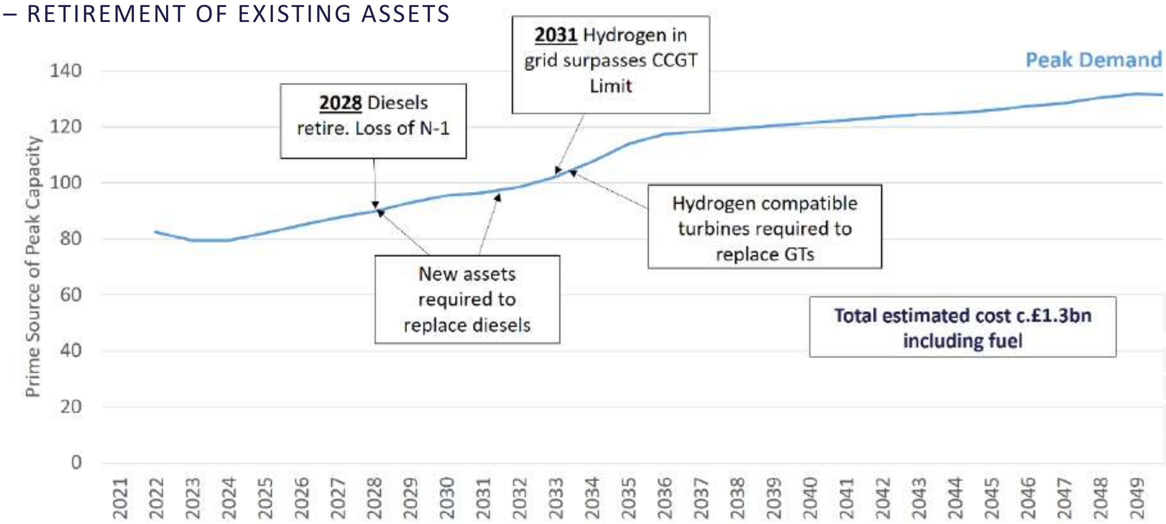
The Isle of Man would require a Power Purchase Agreement (PPA) or merchant trading of power to allow export to other jurisdictions. This would also require additional interconnectors between the Island and GB. As mentioned, these are unlikely to be economically favourable. Contracts for Difference (CFDs) are often discussed with relation to offshore wind export to the UK. These would require a direct connection to GB, which means power generated from the wind farms could not be brought onto the Island. With interconnectors the Isle of Man could re-import electricity generated from an offshore wind farm, allowing GB to manage the balancing. This would likely result in much lower costs to consumers. CFDs are not currently open to the Isle of Man as it is not part of the UK. If this route does become available in the future, it would be preferential to export all of, or a proportion of the power, directly to the GB, rather than to bring the power to the Island for onward export via a PPA.

CONTINUED USE OF NATURAL GAS

Regardless of the Government's commitments to Net Zero, investment will be required to ensure security of supply can be maintained on Island. The existing assets are reaching their end of life and will likely need to be replaced within the next ten years. Demand is still expected to rise due to change in consumer habits (e.g. adoption of Electric Vehicles and electric heating). Continued reliance on natural gas was not modelled in Arup's analysis as it was not thought to be appropriate.

Continuing to produce electricity from fossil fuels (i.e. natural gas) will still have a high cost associated with it. This cost will increase further if Hydrogen does increase in the UK Grid. New assets will be required to have greater flexibility than currently offered by the existing infrastructure. To calculate an expected cost, it has been assumed that the diesel engines will be replaced by a new interconnector, and the CCGT will be replaced by Gas Turbines capable of running on Hydrogen. The cost of fuel required to support the running of this new Hydrogen Gas power station have been estimated based on Arup's demand projections; the assumed fuel prices and costs of infrastructure have been estimated from BEIS, UK Government. However, natural gas has been assumed as the fuel. Even if the new GTs could continue to operate on natural gas, the total estimated cost over the next thirty years would still be £1.3 billion (CAPEX and fuel costs). This could be higher if the GTs were running on Hydrogen as shown from Scenario 5. The retirement dates of existing assets is shown in Fig. 17.

FIG. 17 – RETIREMENT OF EXISTING ASSETS



Source: IOM Government, after Arup Analysis and BEIS, 2020

This pathway is not supported by any of the Government Departments as a 'Do Minimum' comparator was produced for illustrative purposes to compare against Arup's scenarios. Alternative scenarios involving the conversion of the existing GTs to run on biofuel could be investigated further by Manx Utilities.

SUMMARY

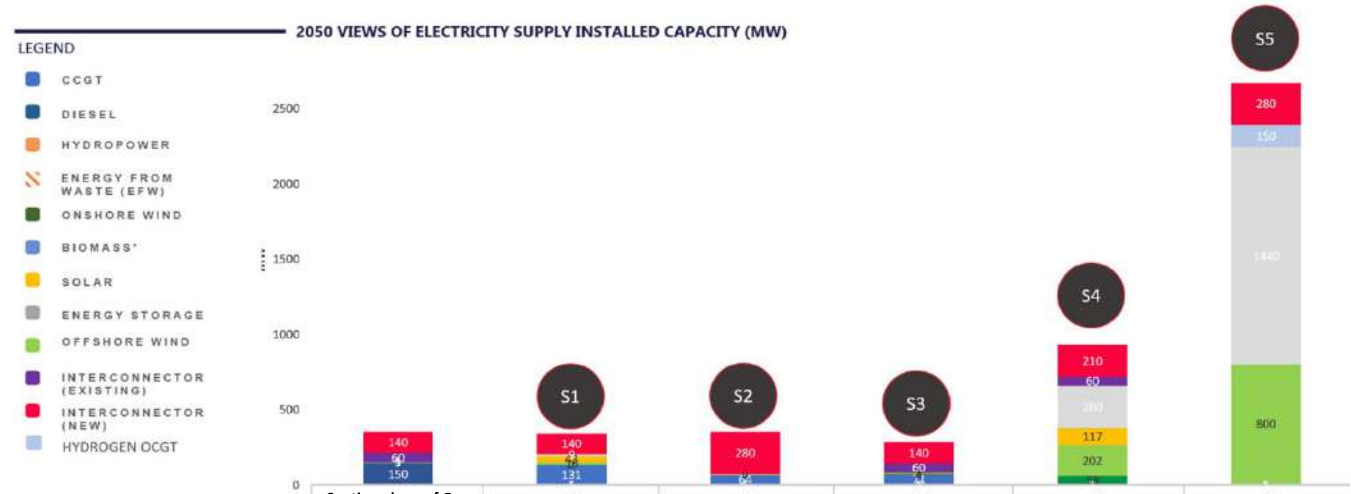
Ove Arup's analysis has shown that there are feasible pathways to achieve Net Zero for supply of electricity by 2050. In all scenarios a substantial reduction in emissions can be made by 2035, leaving only the EFW Plant producing emissions on-island after the retirement of the CCGT. As previously discussed the emissions from waste would be present even if the EfW plant was shut down and landfill was resumed.

The economic modelling has also shown that the cost of generating on island from renewables is more expensive than importing power. In all scenarios, new interconnectors are required to maintain security of supply and provide baseload power. Interconnectors should therefore be seen as a no regret decision. In order to maintain the current resilience level on island, the initial feasibility studies and surveys will need to start this year, as deployment could take up to ten years and all scenarios require interconnectors online on or before this date.

The analysis also shows that the availability of dispatchable generation (biomass) is also necessary to ensure that the average cost per unit price of electricity remains affordable to customers. Feasibility studies will be required to determine how biomass (e.g. wood or miscanthus) can be produced sustainably and whether there will be capacity to increase this further to allow for exports to GB.

One of the scenarios (Scenario 3) would also be cheaper than continuing to maintain the status quo by burning fossil fuels, and Scenario 1 and Scenario 2 are still both comparable to the costs incurred maintaining the status quo. The addition of up to 180MW intermittent renewables on to Scenarios 1 – 3 would still be more cost effective for the consumer than either Scenario 4 or Scenario 5.

The costs of each scenario (including the continued reliance on natural gas) are shown in Fig. 18. The costs per household have been estimated by dividing the total cost of each scenario over the life-span of the assets and dividing this further by the estimated number of households present on island by 2050. By comparison, the current average cost per household is estimated to be £645 based on 3200 kWh/year as taken from the Manx Utilities Charges Review 2021 – 2022 document. However, this figure does not include the cost of Heating and Transport, whereas the Future Energy Scenarios all do.



	Continued use of Gas Infrastructure (2050)	S1 2050	S2 2050	S3 2050	S4 2050	S5 2050
Estimated Total Cost	£1.3bn	£1.49bn	£1.4bn	£1.07bn	£1.8bn	£4.5 – 6.1bn
Estimated Cost to Households p.a.	£996	£1142	£1073	£820	£1379	£3450 - £4700
On Island Generation Capacity As % of minimum capacity required	53%	73%	25%	32%	345%	954%
Total Supplied from Island sources	91%	20%	8%	9%	58%	60% – 90%

Source: Isle of Man Government, after Arup

FUNDING

Regardless of which is the preferred route for future generation on the Isle of Man, there will be scope for private partners. Jersey and Guernsey for example have a private-owned interconnector; biomass generators could be privately operated in a similar way to the EFW Plant. Private-sector routes would require Manx Utilities to take on a similar role to National Grid in GB by utilising the cheapest generation source that meets the system operational requirements. The costs detailed in Fig. 18 would therefore be recovered from consumers via electricity bills. This would also represent a different model for on-island generators as private sector companies would be accountable to shareholders and will operate to ensure profit margins are maintained.

Retaining publicly-owned electricity generation is likely to result in the general public paying costs through taxes instead. However, this could then allow for more competitive bills for consumers. Either solution would mean the projects are ultimately paid for by the residents of the Isle of Man.

Exporting electricity from dispatchable or baseload generators could allow for subsidising of bills using the income generated from GB. However, these options have not been considered in any of the scenarios. It is unlikely that the export of intermittent renewables will be profitable for the Isle of Man given the reasons outlined in this document.

INDEPENDENCE

The Isle of Man currently imports all of its energy from the UK (with the exception of what is produced from Sulby). In all future models, the Isle of Man remains dependent on GB for the provision of baseload. This is the case even where capacity is increased by building excess renewables, as the stabilisation is still provided by interconnectors. As intermittent renewables are inherently variable, a reliable back-up source of power will still be required. Scenarios 4 and 5 could be seen as having greater independence than other models because more electricity will be *generated* on the Isle of Man. However, the intermittent renewables would be reliant on the interconnector to operate. A GB black-out would mean no electricity could be generated on island until power was restored. Scenarios 1 could also be seen as having a high level of independence because it does include the capability to generate baseload from biomass. However, it would be dependent on imported biomass to generate electricity constantly from this source.

Mainland Europe and the UK are becoming more connected as part of their future energy strategies. This allows the natural resources to be distributed evenly to ensure there is always sufficient generation at low cost to consumers. The Isle of Man would be unique if it opted for total independence and it is likely to be much more costly to consumers as shown in Scenario 5.

RESILIENCE

The current level of resilience for electricity supply on the island is considered essential for many of the businesses on the island. The analysis has shown that N-2 resilience can be achieved in all pathways. The higher the level of resilience, the greater the cost. For Scenarios 1 – 3, this increased level of resilience equates to an additional spend of £170 - 200 million over the life of the assets. It must be noted that not maintaining N-2 resilience on Island, does not necessarily mean that the island would be at a higher risk of black-out. This is because equipment which is more robust has a lower risk of failing. In order to determine what the likelihood for loss of supplies is in each scenario, a risk assessment will have to be carried out.

EMISSIONS REDUCTION PATHWAYS OVER NEXT 5 YEARS

The CCGT is currently the main source of electricity supply on the island. There are several issues with this for meaningful short-term emissions reductions. While the GTs release carbon dioxide, the waste heat from the two GTs is used to generate 20MW of carbon neutral electricity from a steam turbine. This heat would otherwise serve no useful purpose. The steam turbine is not flexible by design and cannot adjust load rapidly in the same way that GTs can. To accommodate significant intermittent renewables on island alongside the existing infrastructure and ensure they are balanced would likely mean operating the CCGT more flexibly. This could mean that the steam turbine would no longer be able to operate. Without the steam turbine the GTs run less efficiently; this means that they cost more to operate and also produce more emissions per MWh. This means that significant onshore renewables will not result in emissions reductions in the short term. Some small-scale renewables can be accommodated, though the cost of balancing on island is likely to rise as a result. However, these will not have any meaningful reductions in emissions, due to the loss in CCGT Efficiency.

GB is often short of dispatchable generation when intermittent renewables are not available, allowing the Isle of Man to export electricity produced from the CCGT. Emissions from electricity generated in the Isle of Man are attributed to the Island's Greenhouse Gas inventory, even if this power is exported for use in the UK. Similarly, the emissions from any electricity generated in the UK and imported for use in the Isle of Man is counted in the UK's inventory and not included in the Isle of Man inventory.

The most significant reductions in emissions from electricity on island would actually stem from ceasing exports to GB and importing more renewable electricity via the interconnector. This could reduce emissions on island by as much as 195,000 tonnes CO_2(e) per year relative to the 2019 total. This is also likely to result in increased costs for consumers, but would be more effective both in reducing emissions and have a lower cost to consumers than generating electricity from on-island renewables.

ECONOMIC OPPORTUNITIES

EMPLOYMENT AND NEW SECTORS

Renewable energy is expected to create new, economic growth areas globally; not all of these areas are in the generation of electricity. The Isle of Man is surrounded by neighbours which are rapidly increasing their intermittent renewable capacity. It is therefore unlikely that the same areas will provide opportunities. However, this rapid transition has left shortfalls in stability. The Republic of Ireland for example experienced blackouts in May 2021 following the decommissioning of its baseload coal stations. The UK has been hit by very high electricity prices in January 2021 as a result of not having sufficient dispatchable generation. In both scenarios, the shortfall was caused by over-reliance on offshore wind relative to more reliable generation sources.

New employment opportunities will also likely be created by the transition from traditional fossil-fuel generators. However, existing jobs can also be displaced as existing assets retire. There are currently between 60 – 80 people required to ensure the safe, reliable operation of Pulrose, Peel and D-Station equipment.

Much of the opportunities are actually in manufacturing, which is unlikely to be suited to the Island. For this reason, renewables do not necessarily represent a net increase in tax-paying employees on the Isle of Man.

INTERMITTENT RENEWABLES

Exports to both GB and Republic of Ireland from wind and solar on island are likely to be limited. This is because the UK and ROI are already constructing a large amount of intermittent renewables at much larger scale. The UK has committed to 40GW of offshore wind by 2030, and aspirations for 100GW offshore wind by 2050. As the Island is in the same geographical region as both of these jurisdictions it is unlikely that there will be periods of high winds, or high solar radiance on the Isle of Man, when there isn't also similar conditions on the neighbouring islands.

If the Isle of Man gains access to GB's CFD market then there may be opportunity to export offshore wind directly from an offshore wind farm to GB. This avoids high costs of on-island balancing, which would make exports non-competitive, as seen in Scenario 5. This would allow the Island to gain income from the lease of the seabed though wouldn't provide the island income from sales of electricity.

An Offshore windfarm typically only requires two employees permanently based on island for every 20 to 30 wind turbines over a 20-25 year lifespan, with up to 30 specialist contractors per wind farm moving between installations across the British Isles carrying out repairs; these are unlikely to be island residents. To minimise transportation costs, an installer may also chose to utilise a base in Great Britain rather than the Isle of Man. For smaller installations, there may not be a dedicated Operations and Maintenance team, with the wind farms instead visited by regional teams. The construction phase for wind is estimated to be between 3-5 years and may provide employment for up to 50 contractors on-island throughout that period, who would be supporting the local economy. These roles would not be expected to stay on island once construction was complete.

Solar farms employ even fewer individuals with 1-3 people carrying out minor maintenance on large installations. This creates fewer job opportunities for employment than the existing infrastructure. Greater opportunities would lie in the installation of solar panels on roofs. However, these would likely be filled by those with existing experience of similar sectors on island, rather than creating additional jobs. Little maintenance is required over the 20 year life-span of a solar farm as there are no moving parts.

DISPATCHABLE GENERATION

The shortage of dispatchable generation in the UK allows the Island to export dispatchable power from the CCGT to the UK. This helps to subsidise electricity on island. Arup's scenarios show generating electricity from biomass is viable on island and off-sets high peak charges from the UK during times when the UK is short. The importation of sustainably-sourced biomass would allow the Island to generate more electricity from biomass in Scenarios 1 – 3, which could then be exported to GB. This has not been explored in the Future Energy Scenarios work.

Dispatchable biomass generators also require fewer employees than the existing infrastructure and can be operated by approximately 30 people over a 30 year life-span. However, the supply chain for biomaterial could create additional jobs in logging and forestry. A pellet mill could also provide further jobs.

The construction phase (typically 5 years) would typically employ as much as 200 people, who would be on-island supporting the local economy. These roles would not be expected to stay on island once construction was complete.

BASELOAD

Both the UK and Republic of Ireland are predicted to become short of baseload power over the next decade. In Ireland, this has already been demonstrated with the black-outs of May 2021. The retirement of the remaining coal stations by 2024 and the early retirement of six of the UKs nuclear reactors (Dungeness B, Hinkley Point B and Hunterston B) could make GB reliant on France. There would be opportunities for the Isle of Man to provide stabilising power to GB or ROI from a large-scale baseload power station, e.g. biomass or a small modular reactor. Neither option is without challenge, but likely provide the greatest potential for export. These options have not been explored in the analysis.

Baseload generation also offers the greatest employment opportunities of all sectors. A large-scale biomass plant could typically employ up to 200 people over a 30 year lifespan with an additional 500 people on island during outage periods. The construction phase could employ as many as 1000 people. Small Modular Reactors in contrast employ up to 500 people over a 50-60 year lifespan with an additional 2000 – 3000 people on-island every 2 years for outage work and refuelling. The construction phase could employ up to 10,000 people.

INNOVATION – DEMAND SHIFTING

Traditionally, electricity supply has been based around the demand curve, as shown in Fig. 6. This approach means much greater capacity is required than average consumer demand to ensure peak demand can be met. For countries that have moved quickly with the transition, this high capacity can start to cause problems during low demand periods, especially in the case of intermittent renewables. During these times, generators must be constrained off by the network operators and are paid to facilitate this. This leads to higher consumer costs. Instead, shifting the demand peak by changing energy consumption can avoid excess capacity. This will ultimately be required as part of the transition pathway. However, the rush to increase supply first has meant progress has so far been limited. This leaves an economic opportunity for countries which have maintained a steady pace in decarbonisation of electricity, and have stable, controllable generators to become world leaders.

ELECTRICITY STORAGE

Storage can work by increasing the demand during times of low customer demand to avoid constrainment charges. This flattens the demand profile but acts to raise the average demand. Inefficiencies in storage technologies means that excess capacity is still required.

Some countries in Europe are making economic cases for greater storage potential e.g. Norway, Switzerland. Due to geography, these countries have fantastic potential for pumped hydro storage, which is the cheapest storage medium due to its relatively high efficiency.

Such options are not available on the Isle of Man and the island would have to utilise sea water instead. The negative environmental impacts of bringing sea water onto an island, could harm the Island's Biosphere Status. As demonstrated from scenarios 4 and 5, storage can increase the cost of generation.

SMART GRIDS AND APPLIANCES

Smart networks and smart appliances instead act to reduce Peak demand and raise minimum demand to flatten the curve. These work by switching on energy intensive devices (e.g. washing machines and tumble driers) when there is low demand on the network. Alternatively electric heating (combined with storage systems) can be switched on by smart systems at low demand periods, enabling heat to be released as required during high demand periods.

There has been little progress in innovation in this area. The scale of R&D required would also fit well on island, and link in well with the Isle of Man's digital economy. Companies manufacturing appliances on island could also work with the digital sectors to create hybrid smart appliances.

BIOMASS GROWTH

The provision of Biomass for dispatchable generation would require a supportive on-island supply chain. Solid biomass could be obtained from two major sources on island. The existing plantations can already provide up to 30 kilo tonnes sustainable solid biomass per year, but further feasibility study into plantation management will still need to be completed to confirm how this can be achieved in practice.

Opportunities would be available for investors looking to carry out logging and afforestation operations, as well as the operation of a pellet mill. Miscanthus grass is one of the most energy dense crops and could be grown on farm-land during fallow periods. This would enable farmers to increase their yields. Future sectors which may have large quantities of waste-biomaterial could also provide solid biomass. Other biofuels such as bioethanol or biodiesel would instead require importation from GB.

NEXT STEPS FOR THE ISLE OF MAN

TRANSITION TO NET-ZERO

To achieve the Isle of Man Government's commitment to achieve Net Zero emissions from electricity by 2050 and to guarantee the same level of service currently enjoyed, there are numerous areas that required investigation in terms of environmental benefit, security of supply, costs to consumers, maintenance of existing transmission network, diversity of supply and stable generation.

This requires a unique solution, suitable for the Isle of Man, which takes into account the Island's current position.

The Future Energy Scenarios has highlighted five possible pathways to deliver net zero emissions from electricity by 2050, which also meets the Government's 2035 target of securing 75% of generation from renewable sources.

SHORT TERM EMISSIONS REDUCTIONS

The scale of capital projects required to deliver Net Zero emissions from electricity means that little significant reduction in electricity emissions can be achieved during the next 5 year period – though the work will commence and the future reductions will be "in the pipeline". Upgrades to the transmission network would be required before additional capacity can be integrated with the Island's infrastructure and the chosen transmission pathway would determine how significant these upgrades would need to be. During this period, renewable electricity could instead be imported from GB, which would reduce the Isle of Man's emissions from the electricity sector. However, that would most likely increase electricity prices for local customers.

For businesses or residents who are keen to reduce their carbon footprint, there are two realistic pathways, which would not adversely affect other consumers by raising prices. These are in keeping with the "Just Transition" principle:

1) A green tariff is already available for business customers, which would allow existing consumers to purchase imported renewable energy as well as energy generated on island from Sulby Hydro. The more customers that uptake this tariff, the greater the amount of electricity that would need to be imported. Greater uptake could allow this tariff to be opened up to domestic customers as well.

2) New businesses, which would require more electricity to operate than could be accommodated by the current network could be encouraged to go 'off-grid'; existing consumers, especially where retail units are grouped together and can 'share assets' looking to decarbonise could also adopt this approach. This would allow them to generate 100% of their energy from renewable sources e.g. by coupling solar roofs with wind, battery storage and a biofuel generator as a back-up for when the weather conditions do not allow for generation from the intermittent renewable sources.

NO-REGRET DECISION

All future energy scenarios require the installation of interconnectors. Installing additional interconnector capacity should therefore be seen as a no-regret decision. In order for the Isle of Man to maintain its current resilience levels, a feasibility study should be initiated as soon as possible as deployment can take up to 10 years. Manx Utilities has taken the first steps to initiate a feasibility study on a new interconnector.

This information has been compiled using information taken from the Background Reading provided to the Island's Climate Change Citizens' Forum, the Future Energy Scenarios report and combined with the information contained in the Climate Change Five Year Plan Consultation document. This background is intended to be read in conjunction with the Future Energy Scenarios Executive Summary and Full Report.

Appendix 1 – The Climate Change Bill and Consideration for Future Energy Scenarios

The Climate Change Bill will shortly come into operation and will set down a statutory requirement for the Isle of Man to achieve net zero greenhouse gas emissions by 2050. The Bill also gives public bodies, including Manx Utilities, a statutory duty to act in a way which contributes to the reduction of emissions and achieving the net zero emissions target, supports climate justice and a just transition, contributes to the delivery of the UN Sustainable Development Goals (SDGs) and protects and enhances biodiversity, ecosystems and ecosystem services.

A specific amendment is also made to the Electricity Act (1996) which requires Manx Utilities to have regard to its duties under section 21 (climate change duties of public bodies) of the Climate Change Act (expanding on its current statutory duty to deliver security of supply at a reasonable cost).

A key commitment in the Climate Change Bill is for 100% domestic effort to achieve net zero greenhouse gas emissions by 2050. This provision is intended to ensure that the Island's emissions are significantly reduced and that offsetting (balancing our books with increased carbon storage for example in planting new woodland, restoring peat habitat or establishing new seagrass meadows) is only carried out locally to balance a small number of emissions that we will inevitably have to retain to 2050 and beyond (for example from food production). The commitment is not intended to prohibit the import of electricity.

The commitment to 100% offsetting also does not mean that we cannot import biofuels or biomass and use them on the Isle of Man, but commitments elsewhere in the Climate Change Bill, e.g. to climate justice and to ecosystems and biodiversity and the SDGs mean that sources of biofuels or biomass would need to be sustainable and appropriately accredited. The requirement to consider impacts on public health would also mean that the air quality issues associated with biomass would need to be fully assessed and mitigated. Further work is required to understand the best local and imported sources of sustainable biomass, minimising impacts on ecosystems and biodiversity and also emissions associated with transportation.

Appendix 2 – Explanatory Note on Estimated Future Tariffs

This document makes reference to a "base-retail" price of electricity. This is defined in the Ove Arup report as the total cost of each scenario in pence divided by the total predicted demand in kWh. This has been used to generate a cost in p/kWh. As this estimate includes both dispatchable and baseload costs, it has not been possible to derive a deconstructed balancing cost. It is assumed that there will be additional costs e.g. Network Operating costs, but these are unknown variables

As all Future Energy Scenarios include vastly different technologies compared to the current generation mix on Island. It is therefore unlikely that these additional costs would be similar to current prices. For this reason, existing prices of generation in p/kWh have not been referred to in this document.

An equivalent "base-retail" price of electricity has already been calculated in the 2018 ECA report on Manx Utilities pricing structure. As with the Ove Arup scenarios, this "base-retail price" is calculated from the life-time cost of existing assets in pence, divided by the actual and predicted demand. This current "base-retail price" is 5.4p/kWh. However, there are additional costs associated with balancing. When these additional costs are factored in, the true domestic and pre-payment tariff is realised.

Similarly, it could be expected that the Future Energy Scenarios will have slightly higher tariffs once balancing costs have been factored in. This is why a cost per household has been used to aid comparisons of Future Energy Scenarios with current costs of generation.

Appendix 3 – Manx Utilities Charges Review 2021 – 22

Manx Utilities Charges Review 2021 – 22

Appendix 4 – Future Energy Scenarios Executive Summary

[Future Energy Scenarios Executive Summary]

Appendix 5 – Future Energy Scenarios Report

[Future Energy Scenarios Report]

NET ZERO

ISLE OF MAN