Future energy demand and policy considerations for Guernsey

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pwc

Contents

For a more detailed explanation of the results, we have prepared a separate annex for each model.

Introduction to the study

Introduction to the study

PricewaterhouseCoopers LLP (PwC) was commissioned by the Office for Environment and Infrastructure for the States of Guernsey (SoG) and Guernsey Electricity Limited (GEL) to provide an energy demand forecast and analysis of potential policy considerations.

We have performed the following pieces of analysis to help GEL make informed infrastructure investment decisions and to help inform energy policy for SoG:

1. Forecast energy demand in Guernsey out to 2050 for the baseline and several scenarios. This model has been handed over to SoG and GEL to allow them to alter certain sensitivities to understand the impact on energy demand over the forecasted period.

2. Modelled costs and benefits of energy infrastructure options for Guernsey.

3. Discussion of the implications of competition for the Guernsey energy market.

4. Evaluation of tax options for their ability to achieve key objectives for Guernsey.

5. Consideration of Guernsey as an exporter of electricity.

We have assessed multiple options that an energy policy might pursue and find that none would result in a significant negative economic impact. This gives the island the flexibility to pursue objectives surrounding economic growth or decarbonisation. Deciding the overall objective is therefore important to how the island proceeds.
Please bear this fundamental finding in mind throughout the report.

The following slides introduce these pieces of analysis to explain their results and implications for Guernsey's energy policy and energy infrastructure investment decisions. For further detail, we have prepared technical reports for each component of the analysis performed.

The following pieces of technical analysis have been completed to help GEL make informed infrastructure decisions and inform SoG energy policy

We have performed the following pieces of technical analysis:

The likely demand for energy now and in the future	• We have forecast baseline demand for electricity (including heating and transport), non-electricity heating fuel, marine fuel, aviation fuel and road transport fuel for 2018-2050 using econometric and other models. • This allows SoG and GEL to understand the impact of different policies on the demand for energy. • The energy demand forecast also enables a tracking of the forecast carbon emissions from energy. • The baseline provides context to understand the energy security risk to Guernsey and the expected transition to electricity if no changes to policy are made.
The infrastructure required to deliver the energy demanded	• We have modelled the costs and benefits of six energy infrastructure options. These options were chosen through collaboration with SoG and GEL and so are targeted for Guernsey. • The results of this analysis demonstrate the impact of each infrastructure option in comparison to the baseline energy demand forecast. • The results show which infrastructure option would be best suited to achieve different objectives.
The impact of any tax policies	• We have evaluated the impact of six tax options in comparison to the baseline. • The results of this analysis demonstrate the impact of each tax option in comparison to the baseline energy demand forecast. • The results show which tax policy option would be best suited to achieve different objectives.

Five drivers of change in the energy sector

We have identified five drivers of change in the energy sector and considered their impact for each piece of analysis.

As part of our work we have considered how each of these drivers will bring about changes in consumption patterns to assist in the development of Guernsey's energy policy.

Driver 1: Population growth

- Guernsey's population is expected to grow 0.2% annually in the next 10 years (Annual Guernsey Population Projection Bulletin, 2018). Population growth presents **economic benefits and challenges**.
- We have modelled the **economic impact** of population growth on the energy demand forecast and included sensitivities around the growth rate.

Driver 2: Energy transition away from carbon

- The transition to electricity leads to **greater reliance** on the grid both on and off the island.
- We have **forecast the transition to electricity** and have taken this into account when evaluating different energy infrastructure and tax options.

Driver 3: Energy market structure

- There are five main players in the energy sector and very little competition in electricity supply.
- We have identified the major **benefits and costs** of introducing competition to the electricity market.
- The transition to electricity will affect the fuel market. We have examined the **competitive consequences** for fuel suppliers.

Driver 4: Taxation

- Fuel duty revenue is becoming unsustainable as vehicles become **more fuel efficient**. This will be accelerated by the **uptake of electric vehicles**.
- A number of tax options have been evaluated and the **behavioural change** in hydrocarbon demand they could encourage.

Driver 5: Development of renewable energy

- Guernsey has the opportunity to explore their **renewable energy capabilities**, potentially producing and exporting renewable energy.
- This report has evaluated the costs and benefits of different renewable infrastructure technologies, including some that could be used to export electricity.

Options are compared on their ability to achieve different possible objectives for energy policy

The overall objective for energy policy needs to be determined by the States of Guernsey. We have identified the following possible objectives against which to assess policy options during our work:

Cost efficiency	• This compares the cost of implementation with the resulting benefits. • For tax options, this is measured as the loss to GDP for every £1 of revenue raised. As a benchmark, an efficient tax tends to achieve efficiency of less than 30p reduction of GDP per £1 of revenue raised. • For energy infrastructure, this is measured as the benefit accrued for every £1 spent on implementation and maintenance. An efficient infrastructure option tends to achieve a benefit-cost ratio greater than 1.
Energy security	• As an island that must import all sources of energy, energy security is of utmost importance. • Energy security refers to the island's ability to meet energy demand even if certain generation or importation assets are unavailable. This includes maintaining adequate hydrocarbon reserves to mitigate the risk of supply chain disruption. • Energy infrastructure options have a greater impact on energy security than changes in tax policy.
Carbon reduction	• The extent to which an infrastructure or tax option reduces CO_2 equivalent emissions. • This may be driven by reducing energy consumption overall or by replacing CO_2 intensive energy consumption with greener alternatives, or a combination of the two.
Revenue sustainability for tax policy	• Changes to tax policies can encourage behavioural change. Therefore, any tax on certain energy sources will incentivize consumers to either substitute taxed energy consumption for non-taxed energy consumption or to reduce their energy consumption overall. • Behavioural change reduces the revenue raised by the tax. A more sustainable tax from a revenue perspective will encourage less behavioural change.

Executive summary

Introduction to energy markets in Guernsey

There are five main players in the energy sector and very little competition in electricity supply.

Currently, GEL is the sole commercial supplier of electricity on the island. Electricity is either imported from France, using interconnectors via Jersey (up to 85%, however the GJ1 interconnector is currently running at reduced capacity due to reliability concerns) or generated on the island using heavy fuel oil and gas oil (at least 15%). Since 2009, on average 65% of electricity has been imported (GEL Annual Reports). There are also approximately 500kW of consumer owned solar generation assets on the island plus 100kW of utility-scale solar owned by GEL, this is likely to grow in future. For comparison, GEL has 145MW of generating capacity installed on the island.

An N-2 policy is imposed to ensure there will be adequate generation capacity, excluding the interconnector, even if the two largest generation assets are unavailable for service. Relying on this generation during times of interruption puts Guernsey's ability to meet environmental policy requirements at risk but allows the island to continue to operate fully. Electricity is distributed to households via GEL's distribution network. The Electricity Law (2001) gave the Channel Islands Competition & Regulatory Authorities (CICRA) the power to set maximum prices that suppliers can charge and requires energy suppliers to obtain a licence from the regulator to operate at any stage of the electricity supply chain.

However, this market structure could be set to change. CICRA has granted International Energy Group (IEG) a licence to generate electricity on Guernsey using combined heat and power systems. IEG has been exempted from having to obtain a licence to supply.

There is more competition in the hydrocarbon market, with two fuel farms and several commercial suppliers. Petrol, diesel/gas oil, heavy fuel oil (HFO), heating oil, liquid petroleum gas (LPG), avgas and jet fuel are primarily imported to Guernsey using specialist tankers and delivered to island suppliers and end users by road.

Demand for electricity will increase while other sources of energy fall

Over the next 31 years, we predict that demand for electricity will increase from 29% of energy consumption on the island to 58%, assuming no policy direction given.

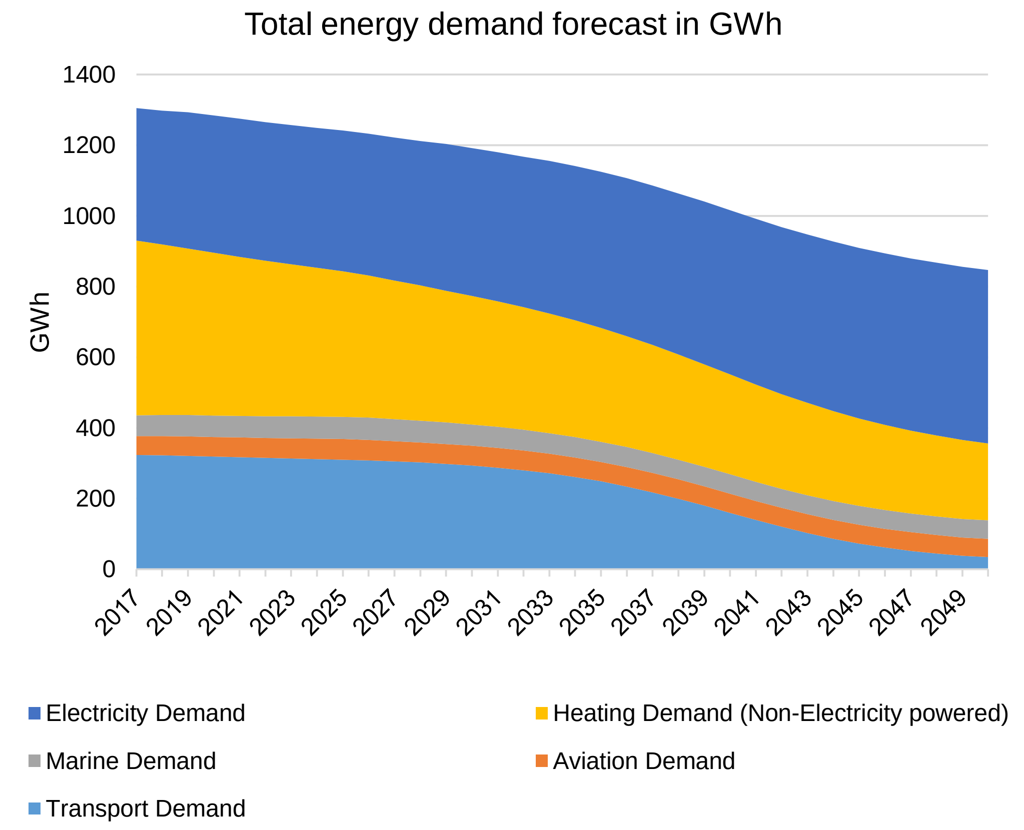
We have forecast demand for electricity, non-electricity heating, road transport fuel*, marine fuel and aviation fuel out to 2050. There are two key findings from our energy demand forecast:

1. The **growing share of electricity demand** and declining share of non-electricity heating demand and road transport fuel demand due to the transition to electricity. This is driven by consumers installing electric heating and replacing internal combustion engine vehicles with electric vehicles.

2. The **fall in total energy demand** due to improvements in efficiency that reduce the need for energy consumption. For example, electric vehicles require less energy per mile than internal combustion engine vehicles.

This transition will have a significant impact on energy security and tax revenue generated via fuel duty.

These findings are in line with previous work, such as the PwC Hydrocarbon Demand Study.



*Note that road transport fuel demand refers to petrol and diesel demand for vehicles, electricity demand for electric vehicles is considered electricity demand.

The importance of an energy policy for Guernsey

The expected transition to electricity makes Guernsey's energy policy a question of utmost importance.

Energy security: Guernsey imports up to 85% of its electricity supply from France via interconnectors with Jersey. If this system is unexpectedly disrupted, as was the case in 2012 and 2018, Guernsey's electricity demand is satisfied using on-island generation.

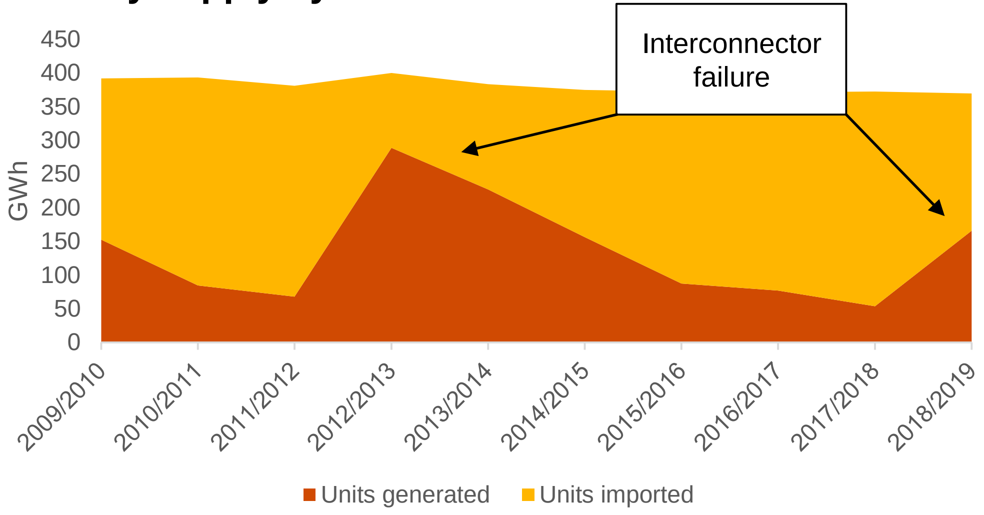
This is not only more expensive and requires large fuel stocks but also increases pollution, which reduces the island's ability to meet environmental targets.

The transition to electricity makes this security risk more serious as reliance on electricity increases, therefore a comprehensive energy policy is required to ensure energy security is maintained throughout this transition.

Fuel duty: Fuel duty currently generates around £20m of revenue for SoG which accounts for almost a fifth of tax revenue. As internal combustion engine (ICE) vehicles become more fuel efficient and consumers transition towards electric vehicles, this revenue will fall.

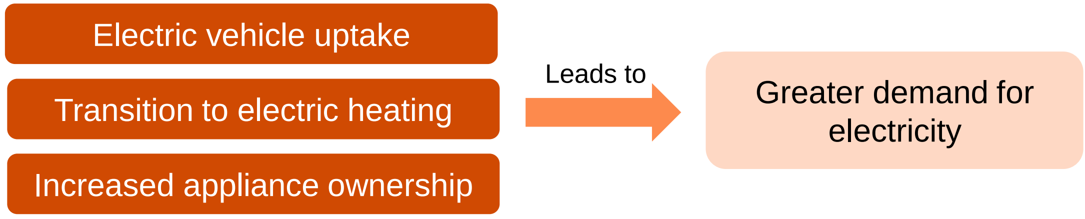
SoG will need to either accommodate this fall in revenue or replace fuel duty with an alternative tax policy, as is already being investigated.

Electricity supply by source



Source: Guernsey Electricity Limited Annual Reports
Note that units generated includes utility-scale PV and buy-back units.

Drivers of the transition to electricity



These drivers are the result of external decisions and global changes.

We have completed the following pieces of analysis to inform Guernsey's energy policy

Pages 13-21 present the high level findings of each piece of analysis. Pages 22-23 present our recommendations for Guernsey's energy policy as a result of our work.

1. **Energy demand forecast:** forecast energy demand in Guernsey out to 2050 for the baseline and several sensitivities.
2. **Energy infrastructure options:** modelled costs and benefits of energy infrastructure options for Guernsey.
3. **Implications of competition:** discussion of the implications of competition for the Guernsey energy market.
4. **Tax policy options:** evaluation of tax policy options for their ability to achieve key objectives for Guernsey.
5. **Electricity export for Guernsey:** consideration of Guernsey as an exporter of electricity.

Note that for all our analysis we have assumed that 85% of electricity will be imported and 15% will be generated on island from now until 2050. However, we have not forecast the electricity grid load shape in 2050 so we cannot say how feasible this split will be.

Drivers of change

Driver 1: Population growth

Driver 2: Energy transition away from carbon

Driver 3: Energy market structure

Driver 4: Taxation

Driver 5: Development of renewable energy

Key drivers of the energy demand forecast

Energy demand forecast

Driver 1: Population growth

Driver 2: Energy transition away from carbon

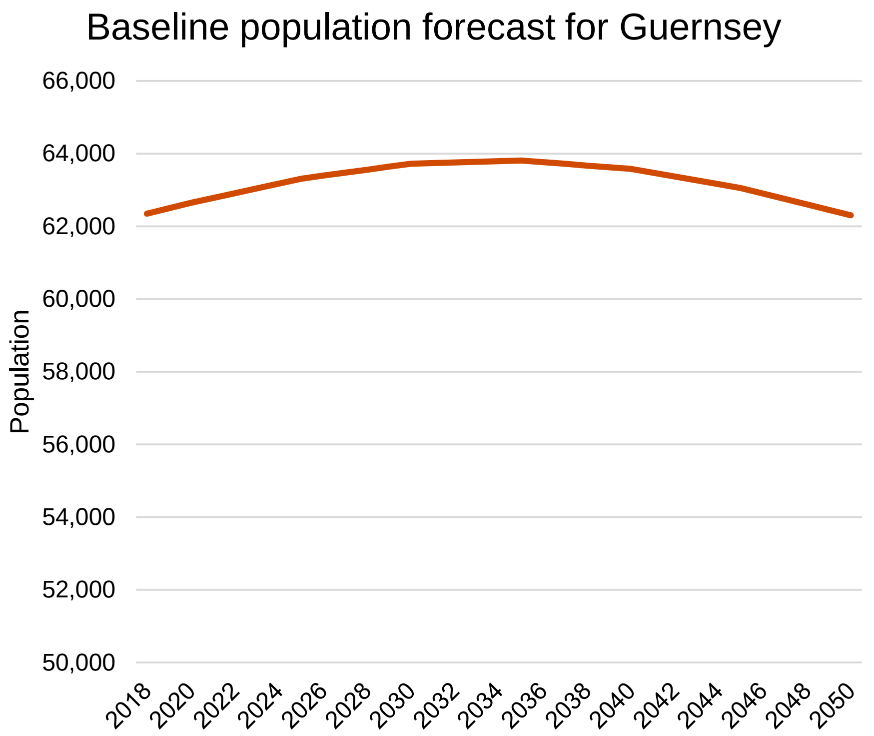
Of our five drivers of change in the energy sector, population growth and the transition away from carbon based fuel sources are key drivers of energy demand.

Page 10 shows our baseline forecast of energy consumption out to 2050. Our forecast is driven by several factors, including:

Population is an important driver of energy demand because all people in Guernsey will require energy. Therefore, we have factored it into our energy demand forecast. We have included sensitivities in the model handed over to the SoG and GEL that vary the rate of population growth over the period analysed.

The States of Guernsey predict that the population of Guernsey will grow to a maximum of 64,000 people by 2034, then fall to 59,000 by 2065 (Annual Population Projection Bulletin, 2018). This peak of 64,000 people is 2.7% larger than the current population.

The transition away from carbon is another important driver of energy demand as decarbonisation can be achieved through a movement towards electricity. Therefore, we have modelled this transition in our energy demand forecast. However, decarbonising through the transition to electricity depends on interconnector availability or developing alternative sources of low carbon energy.



Increased demand for electricity will require additional investment in energy infrastructure

Energy infrastructure options

Driver 2: Energy transition away from carbon

Driver 5: Development of renewable energy

We have evaluated six energy infrastructure options to model, two with policy sensitivities.

The energy infrastructure options whose impact we have modelled can be split into grid-level infrastructure and domestic infrastructure options.

Investing in solar PV (either utility-scale or for microgeneration), offshore wind or the GF1 interconnector would increase Guernsey's supply capacity and provide a greener source of electricity. Investing in electric vehicles and thermal efficiency improvements would reduce energy demand.

All the scenarios we have modelled have a neutral or positive impact on the island.

To analyse the impact of these energy infrastructure options we have:

- Calculated the direct costs and benefits of the infrastructure.
- Simulated the wider economic benefits using our economic model, e.g. the creation of jobs during construction and the money retained on the island by reducing imports.

Grid-level generation infrastructure options

- Utility-scale solar PV
- Offshore wind farm
- GF1 infrastructure (with N-1 or N energy policy)

Domestic energy use infrastructure options

- Solar PV microgeneration
- Electric vehicle uptake (with and without fuel duty)
- Thermal efficiency improvements to housing

Evaluating energy infrastructure options

Energy infrastructure options

Driver 2: Energy transition away from carbon

Driver 5: Development of renewable energy

The key results of the energy infrastructure analysis are presented on page 16. We have used the following measures to evaluate each option.

Direct benefit-cost ratio: For every £1 spent on infrastructure installation and maintenance, the direct benefit-cost ratio reflects the benefit generated from fuel savings.

Benefit-cost ratio including wider economic benefits: To ascertain the full impact we then model the benefit of the investment in terms of employing local suppliers to install and maintain the infrastructure and reducing the leakage of money from the island to pay for imports.

Energy savings in 2050: The energy savings in 2050 reflect the scale of each infrastructure option. For grid-level generation infrastructure options, this figure reflects the generation potential of the infrastructure. The total consumption of electricity remains constant, however the source of electricity changes so the quantity of HFO, gas oil and imported electricity required is reduced. For domestic interventions, households can increase their energy efficiency therefore their demand for energy is reduced. For example, thermal efficiency measures mean consumers require less energy to heat their households.

Emissions savings in 2050: The reduction in CO_2 equivalent emissions in 2050 also reflects the scale of the infrastructure option. This is calculated by multiplying the reduction in energy consumption by the relevant emission factors.

__Example__ Utility-scale solar PV

Direct benefit-cost ratio: £1.12

- Every £1 spent on implementing utility-scale solar PV will generate £1.12 of benefits in terms of fuel savings (HFO, gas oil and imported electricity).

Benefit-cost ratio including wider economic benefits: £3.22

- Every £1 spent on implementing utility-scale solar PV will generate £3.22 of benefits in terms of fuel savings and wider effects such as the creation of construction jobs to implement the infrastructure.

Energy savings in 2050: 40.7 GWh, 4.79%

- Utility-scale solar PV will generate 42.4 GWh of electricity to replace imported and generated electricity. This amounts to 4.79% of total energy consumption in 2050.

Emissions savings in 2050: 1.31 $ktCO_2e$

- The imported and generated electricity that utility-scale solar PV will replace will reduce CO_2 equivalent emissions by 1.31 kt.

All infrastructure options are net neutral or net beneficial

Energy infrastructure options

Driver 2: Energy transition away from carbon

Driver 5: Development of renewable energy

All possible options at least pay for themselves when wider economic benefits are included, therefore the choice of energy infrastructure option depends on the objectives for the energy policy.

Domestic energy use interventions tend to be more efficient, as shown by their higher direct benefit-cost ratios, and create greater spillover effects, reflected in their higher benefit-cost ratio including wider economic benefits.

However, in general **grid-level generation infrastructure allows for greater energy saving** in terms of imports by 2050. Electric vehicle uptake is the exception to this. Electric vehicles lead to greater energy saving because these vehicles are more energy efficient than ICE vehicles and their uptake is expected to accelerate.

	Scenario	Direct benefit-cost ratio	Benefit-cost ratio including wider economic benefits	Energy saving in 2050		Emissions saving in 2050* ($ktCO_2e$)
				GWh	%	
Grid-level generation	Utility-scale solar PV	£1.12	£3.22	40.7	4.79	1.31
Grid-level generation	Offshore wind	£0.91	£1.98	98.4	11.6	5.80
Grid-level generation	GF1 interconnector and N-1 policy	£0.71	£1.96	69.8**	8.21	30.66
Grid-level generation	GF1 interconnector and N policy	£0.81	£2.43	69.8**	8.21	30.66
Domestic energy use	Solar PV microgeneration	£3.36	£5.60	17.1	2.01	0.53
Domestic energy use	Electric vehicles with fuel duty	£3.48	£6.19	238.3	28.0	63.59
Domestic energy use	Electric vehicles without fuel duty	£1.98	£3.94	238.3	28.0	63.59
Domestic energy use	Thermal efficiency for housing	£2.15	£3.92	22.5	2.65	3.41

*Assuming 85% of electricity is imported.

**This refers to hydrocarbon savings, as all hydrocarbon generation will be replaced by imported electricity. Total energy consumption will remain constant.

Competition in electricity and fuel markets is a central question for energy policy

This transition to electricity reinforces the importance of having a market structure that works in Guernsey's best interests.

The current lack of competition in the electricity market means that the transition to electricity will result in a fall in competition across the energy sector as a whole. This is because competitive fuel markets will decline as demand shifts towards electricity.

To address this challenge, we have assessed the implications of introducing competition in the electricity market. We have identified the costs and benefits as detailed in the adjacent diagram. Given the size of the Guernsey energy market, competition may not generate adequate benefits to outweigh the costs of that competition. While wholesale competition in supply may not be worthwhile, competition in renewable generation may be beneficial if niche suppliers have more expertise in developing renewable generation capacity.

A proportionate regulatory regime should be developed to allow Guernsey to realise the benefits of competition while minimising the costs. Further analysis of the costs and benefits may be required to determine what the appropriate level of regulation is.

We have also considered the implications of the transition to electricity on competition in fuel markets. As demand for hydrocarbons declines, competition in the market will be weakened. The welfare of consumers who cannot transition to electricity must be considered as the market becomes less competitive which could push up prices and reduce the quality of service.

Potential benefits

- Lower prices for consumers due to the entry of suppliers with fewer mandatory overheads
- Efficiency gain to GEL from sharing the burden of capacity reserve with new entrants

Costs of competition

- Loss of revenue for GEL
- Cost to suppliers of complying with the required regulation

We have evaluated six tax policies to assess their ability to achieve certain objectives

Tax policy options

Driver 2: Energy transition away from carbon

Driver 4: Taxation

We have collaborated with SoG to determine which tax options to model and source the required data.

There are two drivers of the decline in demand for fuel:

Transition to electricity: the movement towards electric vehicles and electric boilers will increase demand for electricity while reducing demand for fossil fuels.

Improvements in efficiency: technological developments will lead to improvements in efficiency meaning less energy will be required to achieve the same outcome, e.g. hybrid petrol vehicles need less fuel for the same distance.

Less demand for petrol and diesel will reduce the revenue collected by fuel duty.

If the States of Guernsey want to **support the energy transition**, new taxes can be used to incentivise behavioural change.

Hydrocarbon tax	• The tax is levied on all energy sources except imported electricity • The tax rate is based on the heat content of fuel
Carbon tax	• The tax is levied on all energy sources except imported electricity • The tax rate is based on the CO_2 equivalent emissions of the fuel
Pollution tax	• The tax is levied on all energy sources, including imported electricity • The tax rate is based on the CO_2 equivalent emissions of the fuel
Mileage tax	• The tax is levied on all drivers and varies by type of vehicle and distance travelled • Electric vehicles will be taxed at a lower rate than ICE vehicles
Heating efficiency tax	• The tax is levied on all houses and varies depending on the heating efficiency rating • More efficient houses will be taxed at a lower rate
Appliance efficiency tax	• The tax is levied on all appliances and varies depending on the efficiency rating • More efficient appliances will be taxed at a lower rate

Evaluating tax policies

Tax policy options

Driver 2: Energy transition away from carbon

Driver 4: Taxation

The key results of the tax option analysis are presented on page 20. The following measures have been used to evaluate each option.

- We have calculated the tax base for each tax policy and the expected revenue the tax will raise. Note that we assume a flat tax policy throughout the period analysed.
- We have then simulated the impact of each tax using our economic model to understand the consumer response and the impact this would have on GDP and carbon emissions.

We have measured the impact of each tax policy using the following:

Economic efficiency and **% GDP impact:** the reduction in GDP caused by the tax for every £1 of revenue raised. A good tax in terms of efficiency tends to be one that leads to a less that 30p reduction in GDP for every £1 of revenue raised.

Sustainability: the extent to which consumers change their behaviour as a result of the tax. This is measured as the proportion of tax revenue still recovered after behavioural change.

Affordability: the proportion of income that an average household will spend on the tax. For reference, households currently spend 1% of their income on fuel duty.

Complexity: how difficult the tax will be to implement, e.g. the heating efficiency tax is highly complex as an efficiency rating system would need to be introduced and maintained.

Example Hydrocarbon tax

Economic efficiency: 39p

- Every £1 of revenue raised by the hydrocarbon tax will lead to a 39p reduction in GDP in 2030.

% GDP impact: -0.17%

- Every £1 of revenue raised by the hydrocarbon tax will lead to a -0.17% reduction in GDP in 2030.

Sustainability: 64.8%

- 64.8% of the revenue predicted by our energy demand forecast will be raised by the tax in 2030, this is less than 100% because consumers will change their behaviour to reduce their tax burden.

Affordability: 0.34%

- The average household will spend 0.34% of its income on the hydrocarbon tax in 2030.

Complexity: Low

- The constant ratio between BTU and kWh, means the hydrocarbon tax can be added onto energy bills so the tax would not be difficult to implement.

None of the tax options considered would have a significant negative effect on the Guernsey economy

Tax policy options

Driver 2: Energy transition away from carbon

Driver 4: Taxation

The results of our tax option evaluation are below. Only the indicators for 2030 are shown as by this point most behavioural change has occurred.

The appliance efficiency tax is not presented here as the revenue it would raise is too small to be analysed by our economic model. It is likely to encourage some behavioural change, however we have not been able to quantify it.

All the tax options except the hydrocarbon tax are economically efficient. This means that none of these taxes would have a large negative impact on the Guernsey economy. **A good tax in terms of efficiency tends to be one that leads to a less that 30p reduction in GDP for every £1 of revenue raised.** However the hydrocarbon tax is a borderline case and would still not have a large negative impact.

While the sustainability of the mileage tax is relatively high, this does not reflect the transition to electric vehicles modelled in the baseline which play a tax rate. Over the period analysed the revenue raised will decline but this is not due to behavioural change caused by the tax.

Options	Revenue realised in 2020 in £m	Revenue realised in 2030 in £m	Revenue realised in 2050 in £m	**Economic efficiency** (reduction in GDP per £1 of revenue raised)	**% GDP impact** (% of GDP Loss)	**Sustainability** (% of expected revenue recovered)	**Affordability** (% of annual income for average household)	**Complexity** (How costly is implementation)
Hydrocarbon tax	16.8	10.8	3.1	39p	-0.17%	64.8%	0.34%	Low
Carbon tax	17.0	13.9	4.8	21p	-0.09%	83.6%	0.44%	High
Pollution tax	16.9	13.9	4.9	21p	-0.09%	83.6%	0.44%	High
Mileage tax	17.3	16.5	3.9*	34p	-0.16%	86.7%	0.73%	Medium
Heating efficiency tax	12.6	10.3	6.4	17p	-0.05%	92.5%	0.32%	High

*Note that the mileage tax rate could vary as the composition of vehicles changes to prevent the decline of the tax base as drivers transition to electric vehicles over time.

Guernsey has an opportunity to develop a propensity to export electricity

If Guernsey chooses to invest in certain infrastructure options, there is an opportunity to develop a propensity to export electricity.

As renewable energy technology advances, Guernsey could **invest in renewable technologies** to provide a clean source of electricity.

Of the six energy infrastructure options we have analysed, two could be used to **generate electricity to export**. However, a full cost-benefit analysis would be required to give a comprehensive recommendation regarding exporting electricity.

Tidal stream and wave power have not been considered in this analysis as they are still undergoing development to reach commercialisation, which makes it difficult to analyse them in the same way with any reliability. Tidal range has also not been considered as, whilst the technology is available, the potential output is small and the required infrastructure (walled embayment) is significant and would be better considered as part of a wider infrastructure project.

Offshore wind

We have modelled the impact of constructing a 30MW wind farm, expanding this capacity further could allow Guernsey to **generate surplus electricity** to export.

However, the viability of this initiative depends on the **price of renewable electricity** that Guernsey could ask for when surplus electricity is available.

GF1 interconnector

The proposed GF1 interconnector we have analysed has a **greater import capacity** than Guernsey requires.

Guernsey could explore **exporting this excess electricity** to other Channel Islands, bolstering their energy security while generating income for the island. However, this would come at an **additional infrastructure cost** to transport the electricity, e.g. to Herm, Alderney or Sark.

Recommendations for Guernsey's energy policy

Our recommendations for energy infrastructure and tax options depend on the objectives for Guernsey's energy policy.

Energy infrastructure and tax options

Page 23 sets out which energy infrastructure and tax options are best suited to achieving each of these objectives. Given that our analysis finds that none of the policy options we have assessed would result in a significant negative economic impact, you have the flexibility to pursue objectives surrounding economic growth or decarbonisation. Deciding the overall objective is therefore important to how the island proceeds.

Competition

Opening the electricity sector to competition would have important implications for Guernsey. Our analysis suggests that the size of the market may not be big enough to attract adequate competition to reap the benefits of wholesale competition. However, there may be sections of the market where external expertise may be able to introduce an energy source either as the infrastructure provider or operator. For example, if niche suppliers have more expertise in installing extensive renewable generation infrastructure, introducing external providers to do so could be beneficial.

Electricity for export

Developing a propensity to export electricity could generate additional income for Guernsey. However, the associated cost may outweigh the benefits. A comprehensive cost-benefit analysis would be required to determine whether this would be worthwhile for Guernsey as a whole.

Energy infrastructure and tax choices to achieve different objectives for energy policy

Cost effectiveness	• Energy infrastructure: interventions to affect domestic energy use, such as **electric vehicle uptake** or **solar PV microgeneration**, are more cost effective than grid-level interventions • Tax policy: **heating efficiency tax**, has the least negative impact on GDP
Energy security for infrastructure options	• **GF1 interconnector**: the additional capacity this infrastructure creates would allow Guernsey to strengthen its energy security while relaxing the N-2 policy. • Renewable energy technology provides limited additional energy security. Although not analysed in this report, incorporating energy storage technology could provide a short-term renewable energy reserve.
Carbon reduction	• Energy infrastructure: **electric vehicle uptake**, due to the scale of the substitution from petrol and diesel to electricity, has the greatest potential to reduce carbon emissions. Note that this assumes 85% of electricity is imported out to 2050. • Tax policy: **hydrocarbon tax**, this tax does not cover all sources of energy so will encourage consumers to move away from the most polluting fuels
Tax revenue sustainability	• **Mileage tax**: this tax encourages the least behavioural change beyond the baseline, however the baseline includes the transition to electric vehicles meaning that tax revenue will decline substantially as electric vehicles are taxed at a lower rate than ICE vehicles. • **Heating efficiency tax**: this tax is the second most sustainable as households have limited ability to avoid the tax, however the total tax revenue is relatively low.

Key findings

1

Energy demand forecast

Methodology used to forecast energy demand on Guernsey out to 2050

This section of the report summarises the baseline forecast produced by PwC, the methodology undertaken, as well as a detailed breakdown of the forecast results by energy market segment and over time.*

The overall methodology we have undertaken has been to forecast energy demand separately for each energy market segment on the Island of Guernsey using a 'drivers-based' approach. This means that the forecast for each energy market component is based off the relationship between the underlying drivers of energy demand in each segment, and energy demand itself.

Where historical data is available, we have used econometric analysis and multiplicative analysis to quantify the relationship between each energy demand component in Guernsey, and the underlying drivers. The methodology subsections of each energy demand component explain this in more detail. In terms of the 'drivers' themselves, we have used a combination of external data sources (notably the National Grid Future Energy Scenarios), econometric forecasting, prior analysis (PwC Hydrocarbon Study 2016) and expert input (from GEL and SoG) to forecast out the individual drivers. In each case, the exact approach used has been made explicit.

Note, this methodology is broadly comparable to the methodology undertaken by PwC in the previous Hydrocarbon Demand forecast produced for SoG in 2016. The forecasts are broadly consistent across the two studies, with any differences in quantified changes in energy demand being driven by two factors: 1) new data made available since the Hydrocarbon study was published, 2) Use of econometric methods with historical data to produce more refined relationships between energy demand and its drivers.

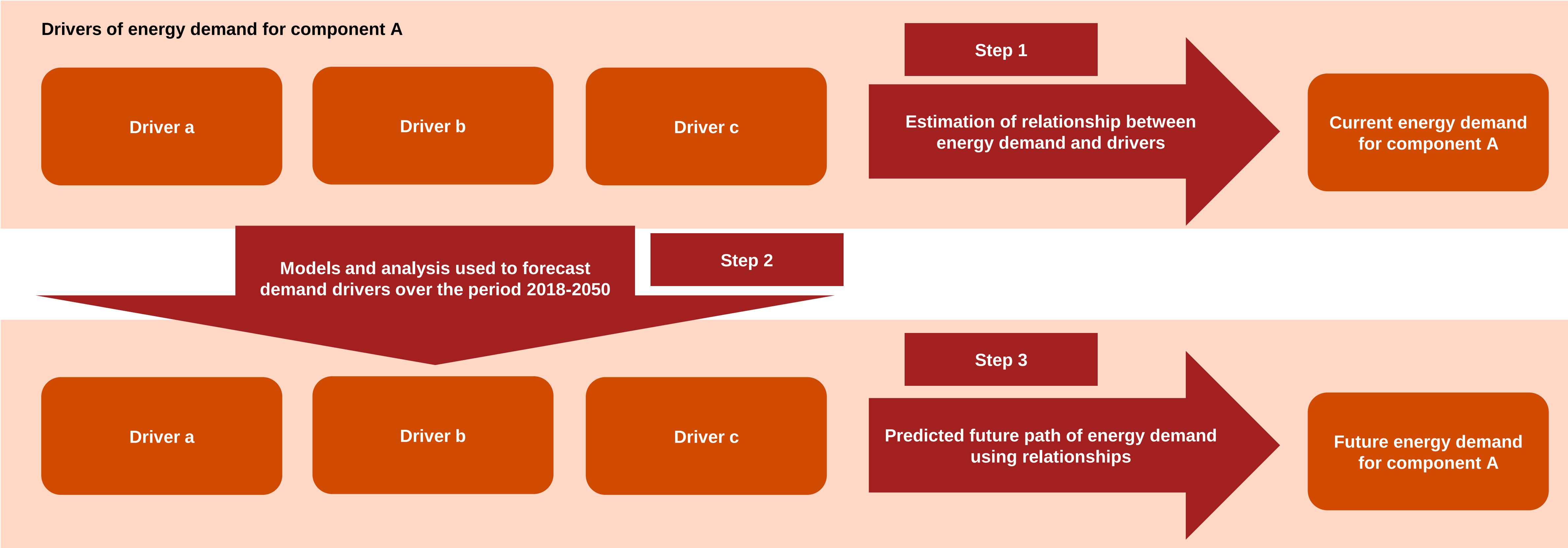
For a more detailed explanation and presentation of further results, please refer to the technical report (Annex A).

*Note in our approach we aim to utilise as much information as possible in order to produce our long term forecast. However, in reality there may be additional factors that push and pull energy demand away from our forecast. These factors may accumulate over time, making our forecast less accurate the further away it is from today.

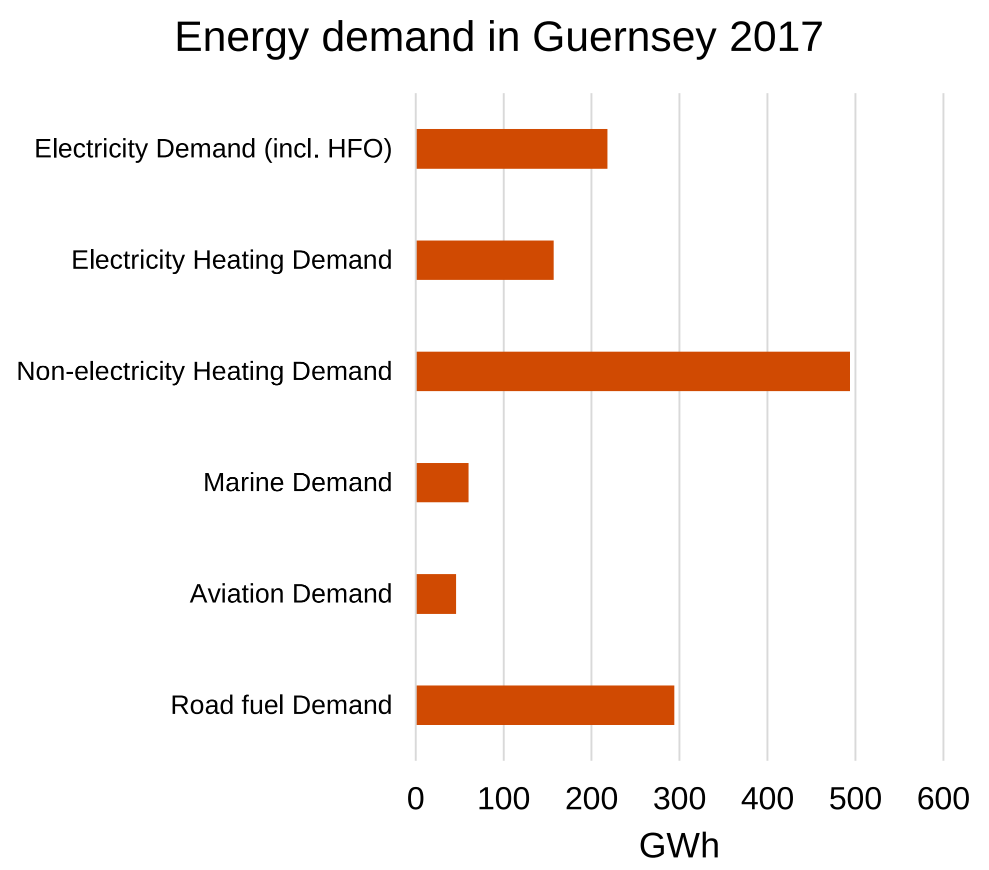
Our framework for modelling each energy market segment

Our approach to modelling energy demand for Guernsey over the period 2018-2050 followed three steps for each energy demand component:

- **Step 1** build a model to estimate the relationship between energy demand and its drivers – either using historic data or prior analysis
- **Step 2** use forecast assumptions and – where feasible – additional econometric models to project out the drivers to 2050
- **Step 3** combine the forecast for the drivers of energy demand with the estimated relationships from step 1 to forecast energy demand



Summary of Guernsey energy market segments and forecasting approach taken



Source: States of Guernsey Facts and Figures 2018 and PwC analysis

Energy component	GWh (2017)	Approach used	Key drivers
Road fuel demand	294	Econometric analysis	EV uptake, business activities and fuel efficiency
Aviation demand	46	Econometric analysis	Aircraft movement, passengers per aircraft and fuel efficiency
Marine demand	60	Multiplicative Model	Population, number of visitors and fuel efficiency
Non-electricity heating demand	494	Multiplicative Model	Population and fuel efficiency
Electricity heating demand	157	Multiplicative Model	Population, boiler efficiency and insulation
Electricity demand (incl. HFO and exclude electricity. Heating)	218	Econometric analysis	Appliance ownership per person, appliance efficiency EV uptake and underlying commercial demand

Electric vehicle uptake is one of the most important drivers of future changes to energy demand in Guernsey

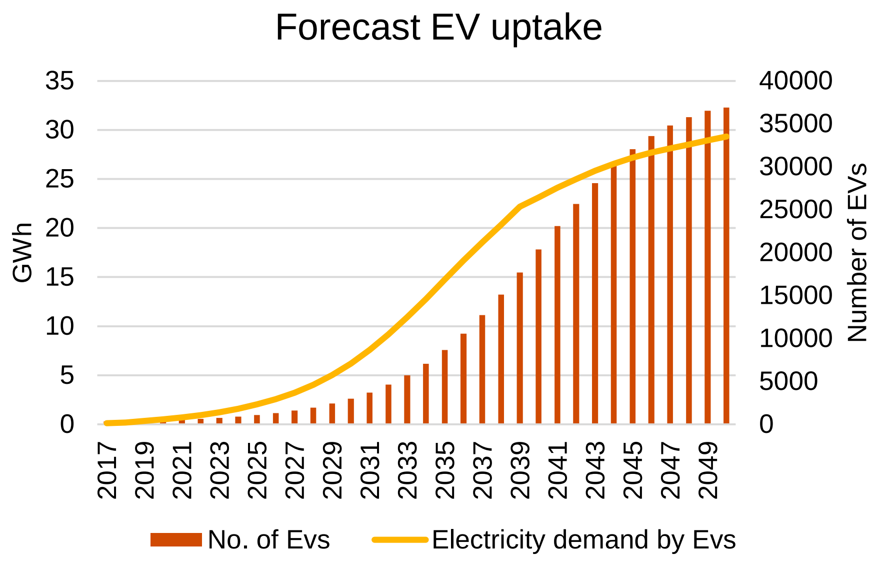
We have modelled EV uptake using a combination of data analysis, modelling and assumptions.

Our analysis has explicitly forecasted rates of changes in these factors using data analysis, modelling and informed assumptions.

We used the average of conservative National Grid Future Energy Scenario 2018 forecasts of EV uptake as a 'naïve' measure of Guernsey EV uptake. Our analysis adjusts this naïve measure using **population differences**, data on **average miles travelled per person** and assumptions around **relative market penetration** – when comparing Guernsey to the UK as a whole.

When considering market penetration we have taken into account the fact that the average Guernsey household owns more vehicles that its UK counterpart and therefore a lower proportion are likely to be in regular use. This has enabled us to analyse the transition from ICE vehicles towards electric vehicles only for the vehicles in active use, rather than the total number registered in Guernsey.

The EV uptake forecast plays a substantial role in boosting electricity demand and reducing road transport fuel demand. The transition also results in a reduction in energy consumption per mile as electric vehicles are more energy efficient than ICE vehicles.



Source: PwC analysis

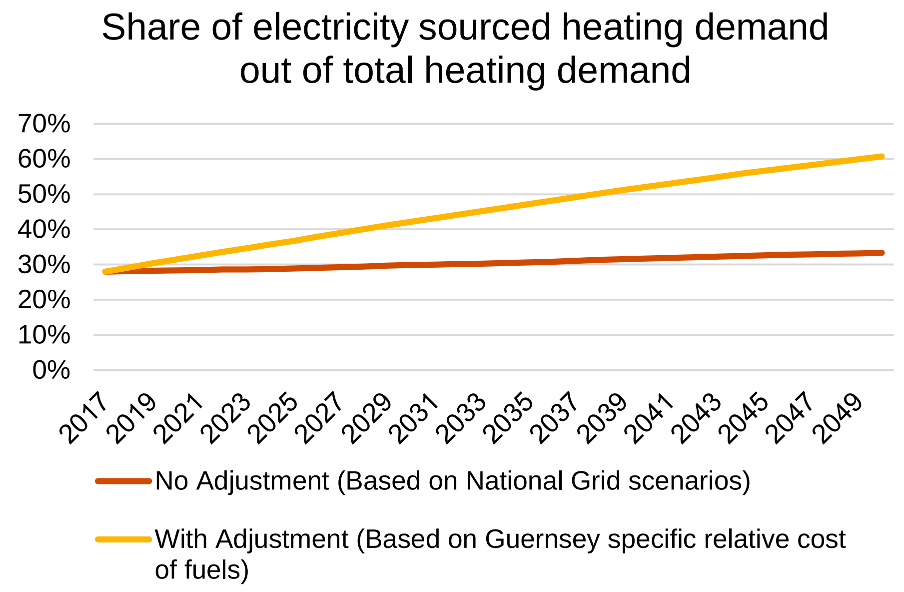
We have modelled the transition to electric heating using a combination of data analysis, modelling and assumptions

The transition rate towards electricity sourced heating, alongside EV uptake, is an important driver of future changes to energy demand in Guernsey.

As for the electric vehicle uptake, our analysis has explicitly forecasted rates of changes in these factors using data analysis, modelling and informed assumptions.

National Grid Future Energy Scenarios (2018) also produce forecasts for heating transition rates towards electricity sourced heating. We have modified these transition rates using a model-based approach relating the transition rate to the relative total cost of electricity heating versus competing technologies.

Applying this model to Guernsey by using information on their **relative fuel prices** and **market shares of different fuels**, we have been able to adjust this forecast to reflect Guernsey's economy. The resulting transition rate is considerably faster and plays an important role in curbing non-electricity heating demand, whilst increasing electricity demand in our baseline.



Source: PwC analysis

Our baseline forecast predicts a decline in total energy demand of over 450GWh by 2050

This slide presents our headline forecast results by energy demand component.

Although numerous factors drive the individual forecasts in each component, one consistent factor contributing to the overall demand decline is an increase in **technological efficiency.**

This is captured both in terms of **greater inherent efficiency** (for example in diesel efficiency, petrol efficiency, and thermal efficiency), as well as uptake of **new technologies** (such as electric vehicles replacing ICE vehicles of greater inherent efficiency).

Although the level of carbon emissions is expected to fall to 215 ktCO2e by 2050, **this natural transition might not be sufficient to meet the Kyoto/Paris carbon goal**. If this is the case, Guernsey will need to take action to increase the rate of carbon reduction.

Fuel segment	2018*			2050		
	Energy demand		Carbon emissions	Energy demand		Carbon emission
	GWh	%	ktCO2e	GWh	%	ktCO2e
Road transport fuel demand (petrol and diesel)	322	24.8	76.9	34.3	4.04	8.19
Aviation demand	55.1	4.23	13.6	52.2	6.14	12.9
Marine demand	60.6	4.66	16.8	52.1	6.13	14.4
Heating demand (non-electricity)	482	37.1	119	218	25.6	53.7
Electricity demand	379	29.3	41.6**	491	58.1	42.1**
Non-energy emissions***			130			84
Total	1299		398	847		215
% of 1990 level			72.0%			39.0%

*Note that at the time of this work the latest data available for energy consumption and carbon emissions was for 2017. The figures stated here are the predictions from our model for 2018.
**Assuming on average 85% of electricity is imported.
***This includes agricultural, land use, land use change, forestry, waste, fluorinated gases and other emissions

Road transport fuel and non-electricity heating demand are forecast to fall the most

The largest absolute and relative declines in demand are forecasted to come in the road transport fuel and non-electricity heating demand segments.

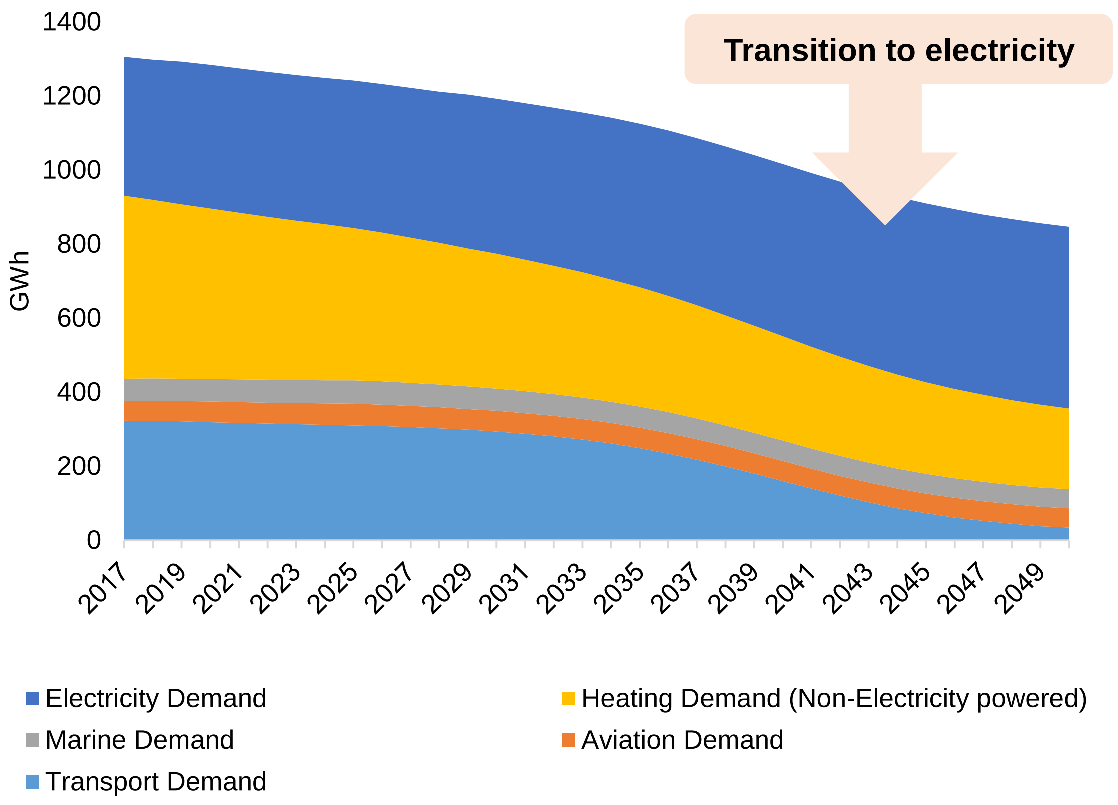
Road transport fuel demand, i.e. petrol and diesel, is forecasted to substantially decline from roughly 322GWh to 34GWh in the baseline, taking up only a 4% demand share by 2050. This is due to assumptions around EV uptake, which are expected to predominantly replace ICE vehicles by 2050. The increase in electricity demand for electric vehicles is captured in the electricity demand segment.

Non-electricity heating demand is forecasted to decline from roughly 482GWh to 217GWh and this is cause by a forecasted transition towards electricity sourced heating. Total heating demand including electricity sourced heating is also forecasted to decline due to thermal efficiency improvements.

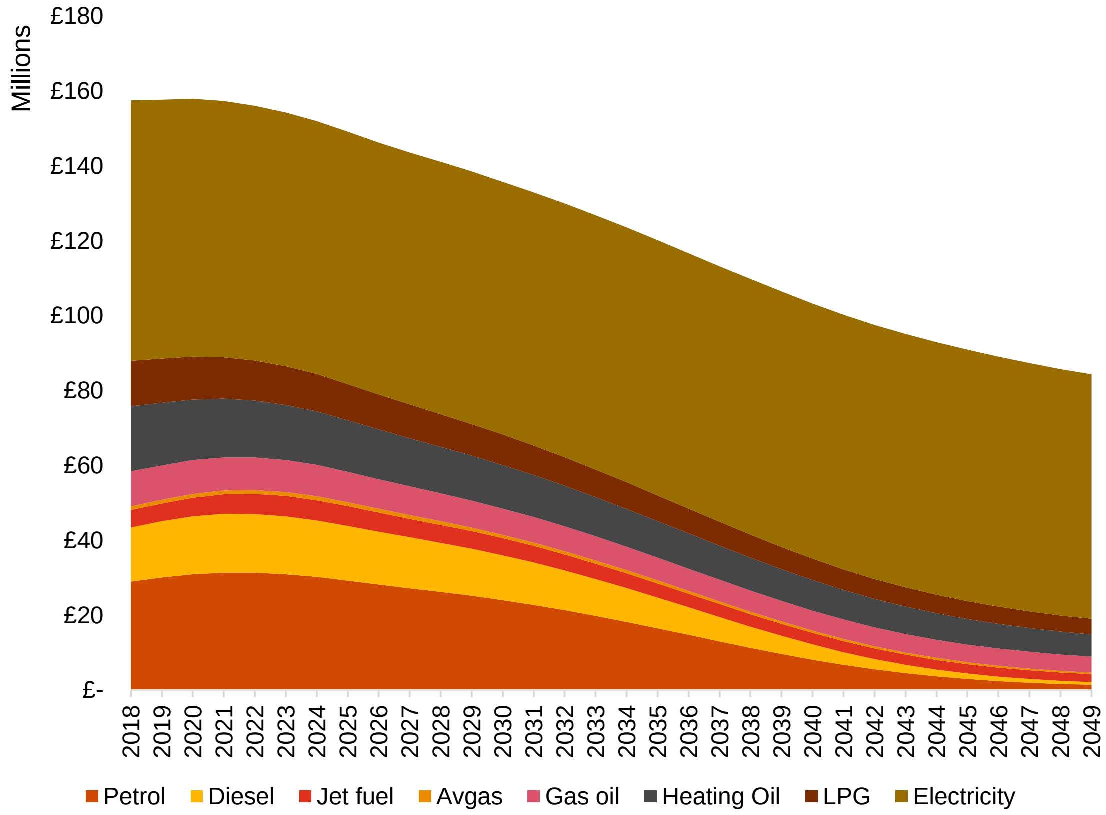
Electricity demand is the only component forecasted to expand in both volume and demand share. This is predominantly caused by absorbing demand from road transport fuel and non-electricity heating sectors through EV uptake and heating technology transitions.

Key results of the energy demand forecast

Baseline total energy demand forecast in GWh

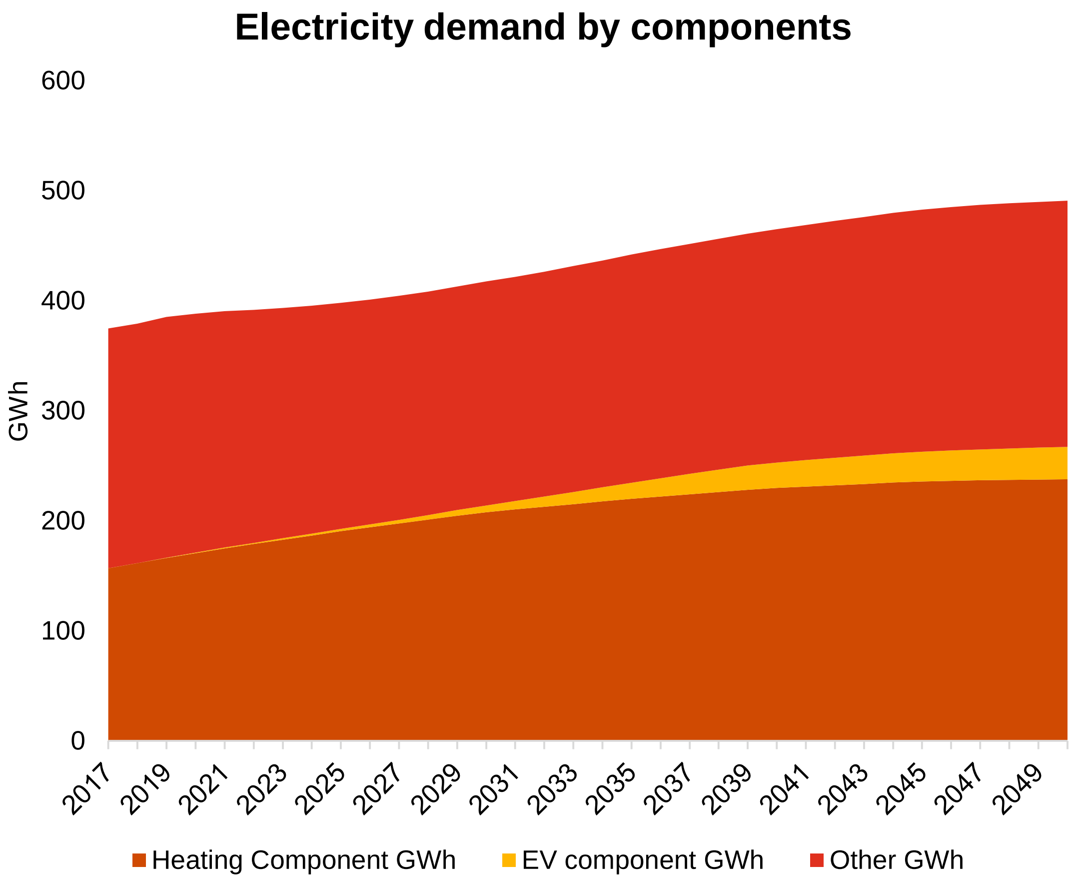


Net present value of energy market size*

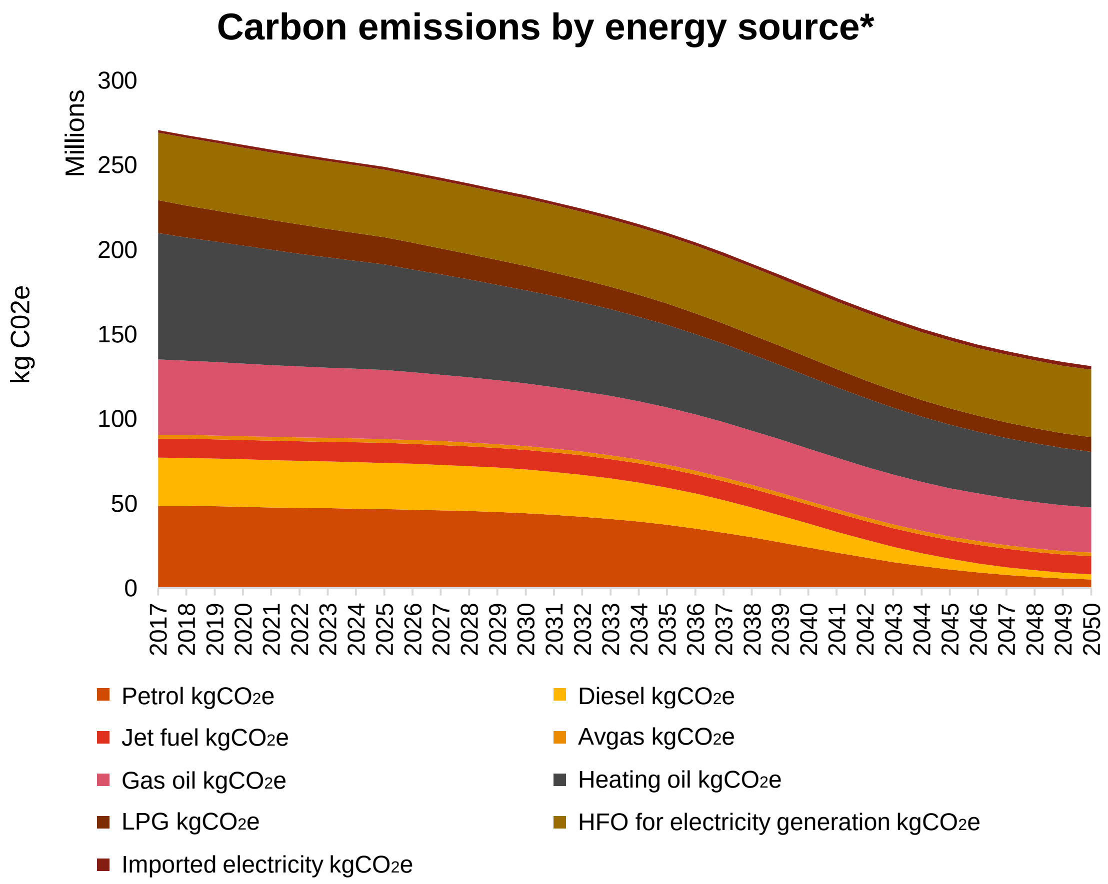


*We have applied a 3.5% discount rate in line with Green Book advice.

Key results of the energy demand forecast



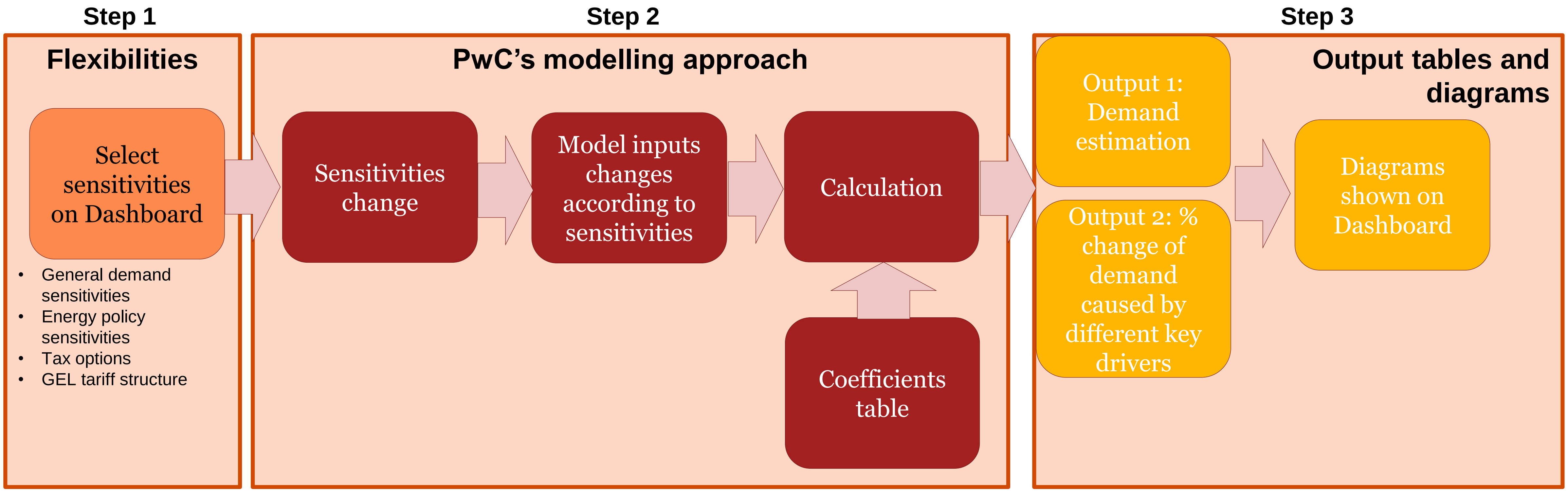
Source: PwC analysis



*Note this only refers to emissions of CO_2, CH_4 and N_2O but does not include fluorinated gases (which accounted for around 5% of emissions in 2016).

**Assuming on average 85% of electricity is imported.

Graphical illustration of the Excel model for different forecast assumptions



Step 1: Select sensitivities on the Dashboard tab.

Step 2: Check Cell AP5 on the Dashboard tab. If it displays “Need to update", press the “Update" button above to update model output. If it displays “Up to date", proceed to next step.

Step 3: Diagrams and output tables are updated on the Dashboard tab, based on PwC’s modelling approach.

Step 4: Outputs are shown on the Output-Demand tab.

2 Energy infrastructure options

We have modelled six energy infrastructure options for Guernsey

To analyse the drivers regarding the transition away from carbon and the development of renewable energy, we assessed infrastructure options for the Guernsey energy sector.

We concluded that the following infrastructure options were the most pertinent:

Grid-level generation
- Utility-scale solar PV
- Offshore wind
- GF1 interconnector

Domestic energy use
- Solar PV microgeneration
- Electric vehicles
- Thermal efficiency improvements

We have modelled the implementation of each infrastructure option using marginal abatement cost curves to assess the scenario against a baseline model of the Guernsey energy sector.

This analysis compares the cost of installing and maintaining the technology, with the benefits associated with each technology.

Therefore, the following key pieces of information have been taken into account:

- Capital and operating cost of each technology
- Reduction in energy use as a result and the monetary value of that saving
- Greenhouse gas abatement potential

For a more detailed explanation and presentation of further results, please refer to the technical report (Annex B).

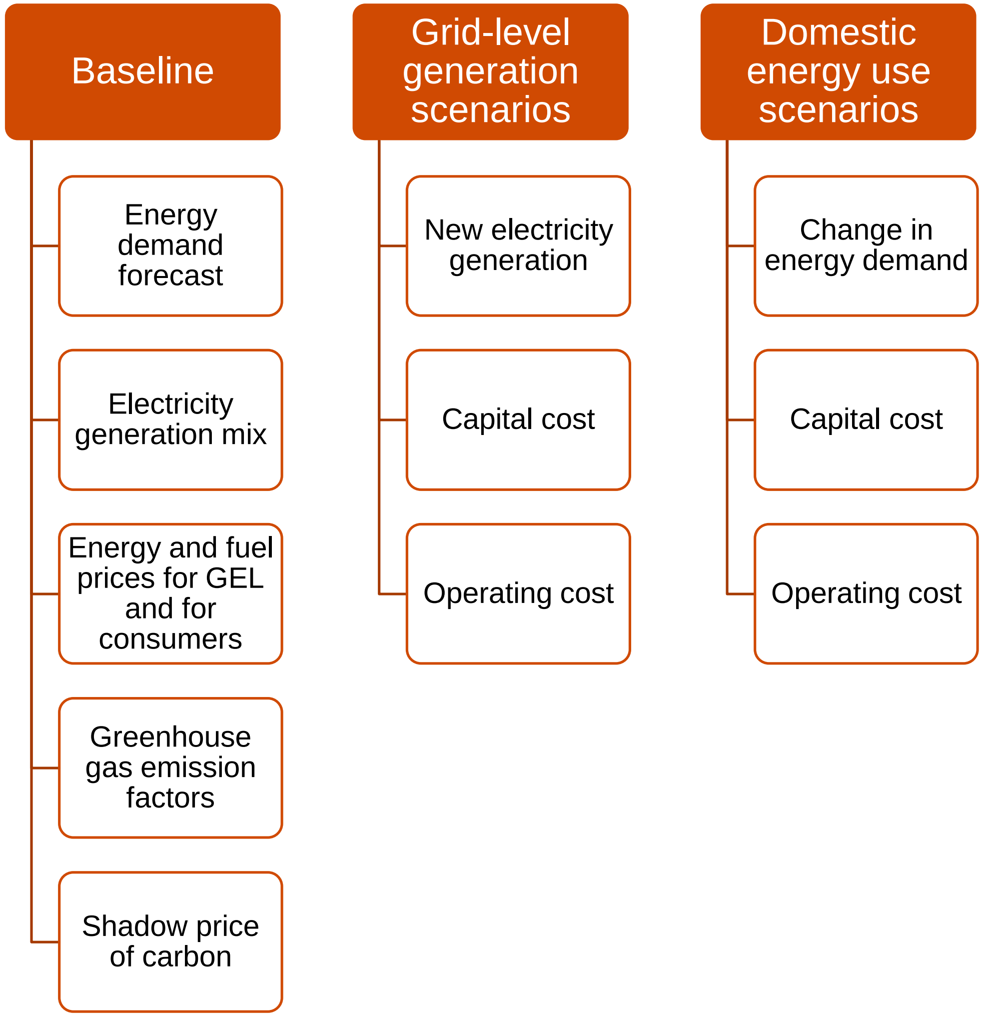
The costs and benefits of each infrastructure scenario have been compared with a baseline view of the energy market

Modelling the baseline.

The baseline is based on the PwC energy demand forecast, using data from GEL and the States of Guernsey, UK greenhouse gas emission factors and the shadow price of carbon as calculated by Defra.

The shadow price of carbon is the price set by Defra as the price of the negative environmental impact caused by carbon emissions that is not included in the market price of a good.

We have assumed that GEL will be able to import 85% of electricity demand using the GJ1 interconnector. However, we appreciate that this does not reflect current electricity supply as the interconnector is running at reduced capacity due to reliability concerns. Guernsey is in a binary emissions situation as when the cable is operational emissions are low, but any unplanned disruption to the cable increases emissions substantially. To incorporate this uncertainty we have modelled a sensitivity whereby Guernsey imports 75% of electricity each year, which is more akin to the average level of importation achieved over the last few years.



Marginal abatement cost curves

We have used marginal abatement cost curves to compare each scenario with the baseline.

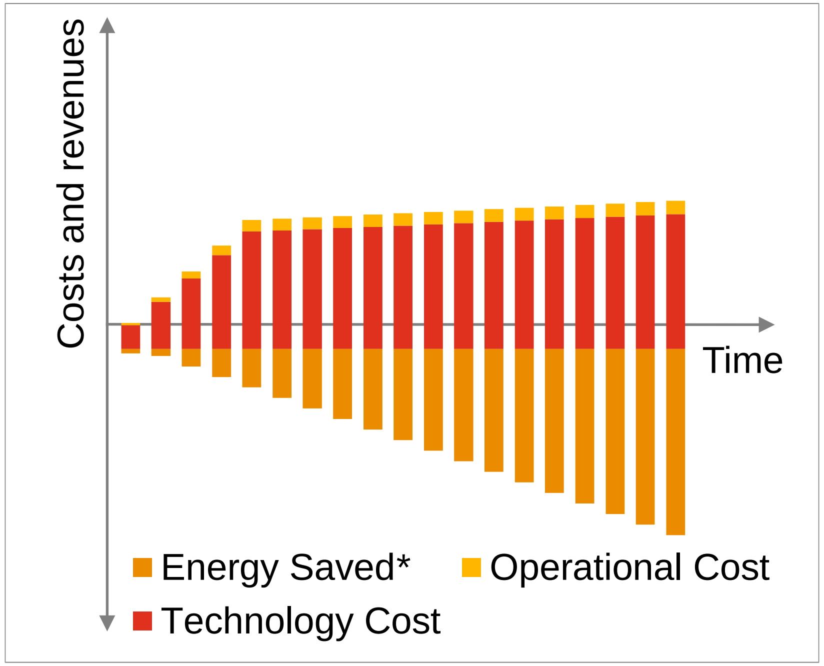
This model compares the cost and benefit of each infrastructure option.

For each grid-level generation scenario we assessed the electricity generation potential then compared the savings on alternative generation sources and the resulting emission abatement with the capital and operating costs incurred.

For each domestic energy use scenario we compare the change in demand for energy from the island grid and its effect on consumers' energy bills and greenhouse gas emissions with the capital and operating costs associated with the technology being employed.

We have then calculated the benefit-cost ratio for each infrastructure option for ease of comparison. The benefit-cost ratio reflects the monetary benefit generated for each £1 spent on the implementation of the infrastructure.

Using our economic model we then estimated the wider economic impact of each infrastructure option. This robust modelling technique forms the basis of the OECD GREEN model used to assess the economic impact of imposing limits on carbon emissions, and the MIRAGE model for trade policy analysis.



Example marginal abatement cost curve

*Please see slide 81 for further explanation

We have examined the impact of three grid-level generation options, two of which expand on-island capacity

Utility-scale solar PV	Offshore wind
GEL currently has 100kW of solar PV installed, which could be scaled up to 1MW by 2021. Beyond 2021, we have modelled a linear increase in capacity to achieve 20MW by 2050. This technology would allow Guernsey to rely less on imported electricity and fuel, leaving more money in the Guernsey economy. It is important to note that we have not incorporated the cost of any energy storage technology in this scenario.	We have modelled the impact of building a 30MW wind farm off the North Shore of Guernsey to begin generation in 2023. As this is a possibility that the States of Guernsey and GEL have previously explored. This technology has an important wider benefit as it creates jobs and keeps more money on the island. It is important to note that we have not incorporated the cost of any energy storage technology in this scenario.

We find that the benefit-cost ratios for each generation technology are largely similar. Based on our cost assumptions we find that these investments are nearly neutral over the 2018-2050 time period. Accounting for the wider economic impact turns them all into a net benefit.

Both technologies have a lifetime shorter than the period analysed by the model. Therefore, in some instances the model captures the cost of replacement but only a fraction of the years for which the benefit is accrued. As a result, we have scaled down these costs to reflect the number of years for which we capture the benefit. For example, if solar PV is replaced in 2045, only five years out of its 25 year lifetime are captured in the model therefore we have only included 5/25 of the cost.

The third grid-level generation option is the GF1 interconnector

GF1 interconnector
We have analysed the impact of building a direct interconnector to France. This would allow for energy security to be maintained while relaxing N-2 policy to N-1 or N, which helps GEL operate more efficiently. The increase in imported electricity is limited given that the GJ1 interconnector normally enables GEL to import up to 85% of Guernsey's electricity demand, therefore the difference between the direct benefit-cost ratio and the benefit-cost ratio including wider economic benefits is low. The difference between the direct benefit-cost ratio including and excluding the shadow price of carbon is large due to the low carbon intensity of imported electricity. Note, the emissions produced during construction have not been accounted for as we were unable to determine its carbon intensity. For other methods of generation, these emissions are captured by the solar or wind emission factor. The model only captures 27 years of the infrastructure's 30 year lifetime. Therefore, as with utility-scale solar PV and offshore wind, we have only included 27/30 of the cost to reflect the number of years for which we capture the benefit. We have assumed GEL will manage the two interconnectors simultaneously, this mode of operation is more expensive but means that if any fault occurs the other interconnector will be able to meet demand immediately.

We find that the benefit-cost ratios for the GF1 interconnector is similar to the direct benefit-cost ratio for utility-scale solar PV and offshore wind. Based on our cost assumptions we find that these investments are nearly neutral over the 2018-2050 time period. Accounting for the wider economic impact turns this option into a net benefit.

We have examined the impact of three interventions to change domestic energy use

Solar PV microgeneration

There are currently approximately 500kW of small-scale solar PV installed on Guernsey.

Using the UK National Grid's forecast of solar PV uptake in the UK, we have modelled the impact of increasing capacity on Guernsey up to 10MW in 2050.

Given that the average capacity of a domestic solar installation is 4kW, this amounts to an additional 2,375 households installing solar PV technology.

This deployment will be able to supply 3.7% of Guernsey's electricity demand in 2050.

Electric vehicle uptake

We analysed this transition using the National Grid forecast of UK uptake. We do not assume a ban on ICE vehicles in 2040.

Due to uncertainty around the future of fuel duty in Guernsey, we have assessed this option both with and without this tax.

We have included the cost of installing public and private charging points using current cost data and predictions of charging behaviour.

Electric vehicles are currently more expensive than ICE vehicles. We have included an additional capital cost for the years before expected cost parity in 2025.

Thermal efficiency improvements

We assessed the impact of households investing in improving the thermal efficiency of their dwelling.

The payback period for these investments will increase over time as Guernsey construction costs tend to rise by 3.5% per annum, faster than energy prices which may rise by 2.5% per annum.

All three options generate a direct net benefit, meaning these are very efficient interventions. The benefit-cost ratio including wider effects is much higher than the direct benefit-cost ratio as money that previously left the island to pay for fuel imports is now spent in the island economy.

As for the grid-level generation options, we have scaled down these costs to reflect the number of years for which we capture the benefit. For example, if solar PV is replaced in 2045, only five years out of its 25 year lifetime are captured in the model therefore we have only included 5/25 of the cost.

The direct benefit-cost ratio for grid-level generation infrastructure shows these measures are net neutral, while domestic interventions are more efficient

We have analysed six energy infrastructure options that would affect the generation and use of energy in Guernsey using marginal abatement cost curves.

We compared the scenarios using the benefit-cost ratio of the scenario over the period 2018-2050. This measure gives the benefit accrued for every £1 spent on implementation in order to compare the viability of each scenario – both including and excluding the shadow price of carbon, as calculated by Defra (2007).

Any benefit-cost ratio greater than £1 therefore indicates a net direct benefit to the Guernsey economy. This has been discounted at 3.5%, in line with UK Green Book (2013) advice.

For the GF1 interconnector and electric vehicles scenarios, two versions have been calculated to reflect sensitivities around government policy.

	Scenario	Direct benefit-cost ratio	Direct benefit-cost ratio including shadow price of carbon*
Grid-level generation	Utility-scale solar PV	£1.12	£1.13
	Offshore wind	£0.91	£0.93
	GF1 interconnector and N-1	£0.71	£0.80
	GF1 interconnector and N	£0.81	£0.91
Domestic energy use	Solar PV microgeneration	£3.36	£3.36
	Electric vehicles replacing ICE vehicles – with fuel duty	£3.48	£3.74
	Electric vehicles replacing ICE vehicles – with no fuel duty	£1.98	£2.24
	Thermal efficiency for housing	£2.15	£2.23

*Assuming on average 85% of electricity is imported.

Assuming only 75% of electricity can be imported from Jersey increases the benefit-cost ratio for all interventions

We have modelled a sensitivity of only importing 75% of electricity to reflect uncertainties surrounding electricity supply from the GJ1 interconnector.

On-island electricity generation is more expensive than importing electricity, therefore increasing the proportion of electricity that is generated on-island increases the generation cost. Therefore, this sensitivity increases the benefit-cost ratio for grid-level infrastructure options as the cost savings of each intervention are greater.

The impact on the benefit-cost ratio is most pronounced for the GF1 interconnector, as this infrastructure option would remove almost all need for Guernsey to produce electricity from fossil fuels. Therefore, if the baseline level of fossil fuel generation is higher, the benefit of this intervention is greater.

Benefit-cost ratios for domestic interventions are affected less as the cost of energy to end consumers is not affected by the generation ratio. However, the benefit-cost ratio including the shadow price of carbon is affected due to the increased carbon intensity of electricity in the baseline.

	Scenario	Direct benefit-cost ratio	Direct benefit-cost ratio including shadow price of carbon*
Grid-level generation	Utility-scale solar PV	£1.16	£1.18
	Offshore wind	£0.94	£0.97
	GF1 interconnector and N-1	£0.87	£0.98
	GF1 interconnector and N	£0.96	£1.08
Domestic energy use	Solar PV microgeneration	£3.36	£3.38
	Electric vehicles replacing ICE vehicles – with fuel duty	£3.48	£3.74
	Electric vehicles replacing ICE vehicles – with no fuel duty	£1.98	£2.24
	Thermal efficiency for housing	£2.15	£2.24

*Assuming 75% of electricity is imported.

Accounting for the wider economic impact substantially increases the net benefit of all infrastructure options

The results of the direct impact assessment have been simulated in our model of Guernsey to fully understand their impact on the wider economy.

In this way we can assess the impact of each technology on the Guernsey economy, stretching beyond GEL and the consumers' costs and benefits.

There are two types of wider benefit in our economic model:

- While much of the technology will have to be imported, the construction and ongoing maintenance creates jobs on the island
- The money that no longer leaves the island to pay for imported fuels and electricity will instead be spent in the Guernsey economy. Note that this is not the case for the GF1 interconnector, therefore the jobs benefit is more important.

The multiplier effect means that each £1 now spent on-island will have a greater overall impact on GDP. Therefore, the benefit-cost ratio including the wider economic impact is greater than that which only considers the direct impact.

	Scenario	Benefit-cost ratio including wider economic impact	Benefit-cost ratio including wider economic benefits and shadow price of carbon*
Grid-level generation	Utility-scale solar PV	£3.22	£3.22
	Offshore wind	£1.98	£2.00
	GF1 interconnector and N-1	£1.96	£2.06
	GF1 interconnector and N	£2.43	£2.53
Domestic energy use	Solar PV microgeneration	£5.60	£5.60
	Electric vehicles replacing ICE vehicles – with fuel duty	£6.19	£6.45
	Electric vehicles replacing ICE vehicles – with no fuel duty	£3.94	£4.20
	Thermal efficiency for housing	£3.92	£4.01

*Assuming 85% of electricity is imported.

Choosing which energy infrastructure option to invest in depends on which objectives are most important

In this analysis we consider three possible objectives for energy policy.

Objective for energy policy	Selection criteria	Most appropriate energy infrastructure option in 2050
Economic efficiency Achieve the greatest benefits at the lowest cost	Choose the energy infrastructure option with the highest direct benefit-cost ratio and benefit-cost ratio including wider economic benefits.	**Electric vehicle uptake** or **solar PV microgeneration**
Energy security Increase Guernsey's energy security by expanding reliable generation capacity	Choose the grid-level generation infrastructure option with the most reliable supply that would enable N-2 policy to be relaxed to N-1 or N without increasing the risk to energy security.	**GF1 interconnector**
Carbon reduction Maximise the reduction in carbon emissions by replacing the consumption of fossil fuels the most significantly	Choose the energy infrastructure option that leads to the greatest scale of energy saving and therefore carbon emissions reduction.	**Electric vehicles** GF1 interconnector results in the second largest reduction in carbon emissions. If the GJ1 interconnector is unavailable, the GF1 interconnector would lead to a larger reduction.

Electric vehicles and the GF1 interconnector provide avenues for achieving carbon reduction in an economically efficient way. Alternatively, thermal efficiency for housing is economically efficient and can generate relatively large carbon reduction.

3

Competition analysis

Electricity in Guernsey

Electricity supply chain

- GEL generation assets (on average 35%)
- Imports from France (on average 65%

- Interconnectors
- Grid network

- Meters at consumers' home
- Electricity tariffs

In Guernsey, electricity accounts for around 30% of the total energy market and is forecast to grow to 60% by 2050. This transition to electricity indicates the importance of having a market structure that works in Guernsey's best interests.

Currently, GEL is the sole commercial supplier of electricity on the island. Electricity is either imported from France, via an interconnector with Jersey (up to 85%, however the GJ1 interconnector is currently running at reduced capacity due to reliability concerns) or generated on the island using heavy fuel oil and gas oil (at least 15%), a brief supply chain diagram is shown above. There are also approximately 500kW of consumer owned solar generation on the island plus 100kW of GEL-owned utility-scale solar generation. N-2 policy is imposed to ensure there will be adequate generation capacity, excluding the interconnector, even if the largest two largest generation assets are unavailable for service. Relying on this generation during times of interruption puts Guernsey's ability to meet environmental policy requirements at risk. Electricity is distributed to households via GEL's distribution network. The high value of the grid infrastructure creates a natural monopoly for GEL in transmission and distribution.

The Electricity Law (2001) gave the Channel Islands Competition & Regulatory Authorities (CICRA) the power to set maximum prices that suppliers can charge and requires energy suppliers to obtain a licence from the regulator to operate at any stage of the electricity supply chain. This remains the case today, albeit with extant States resolutions from 2015 & 2016 to remove GEL from CICRA's regulatory remit. The legislative changes have not followed and the law regulating GEL remains unchanged.

We have identified four key considerations for energy market regulation

Regulatory independence	Security of supply	Investor and consumer protection	Long term value for Guernsey
CICRA currently regulates Guernsey's energy market and it is funded by supplier licences which ensures regulatory independence. Regulatory independence is important to maintain effective regulation. Regardless of whether competition is introduced to the electricity market, Guernsey should make sure the high level of independence of the regulator is maintained throughout the transition to electricity.	As an island that imports all sources of energy, security of supply is a top priority for any energy policy. Introducing competition could increase generation capacity, increasing energy security and sharing the burden of the N-2 policy. However, if private companies are not held to the same standards as a public supplier, uncertainty around supply could put energy security at risk. Regulation can ensure security of supply is maintained.	The regulatory body must balance the interests of energy suppliers and consumers. Energy suppliers want to receive a adequate rate of return on their investment but consumers want lower prices. If competition is introduced to the Guernsey electricity market, regulation will be required to ensure these interests are balanced. This may also be the case if the transition to electricity depletes competition in fuel markets to the point that suppliers have more power than consumers.	The regulator must also consider the welfare of future consumers. Without competition in the electricity market, it is the role of the regulator to ensure GEL operates as efficiently as possible. Regardless of competition, energy suppliers must be able to invest in infrastructure projects that deliver long term value for Guernsey despite large up-front costs, e.g. renewable electricity generation technology.

There are two options for the future of the electricity market

Option 1 – Increasing the level of competition

The level of competition essentially **determines the price** that consumers pay. The greater the extent of competition, the lower the price of electricity. In a competitive market framework, the **price will be driven down to marginal cost** and the benefit of the price reduction will be fully captured by consumers. There will be a level playing field for all firms as they will all be contributing to N-2 policy.

However, if the number of firms is inadequate to create a high level of competition, firms will be able to earn higher profits. If all the firms are local suppliers and prices do not fall then the economy as a whole will still benefit as the profits will remain within the economy. However, if new entrants are external firms, part of the **profit may be extracted** from Guernsey. In this case, competition will only be beneficial if the efficiency gain is larger than the summation of the leakage of profits and the regulatory cost.

Developing a proportionate regulatory regime will be key to realising the benefits and minimising the costs of competition.

Option 2 – Retaining the current market structure

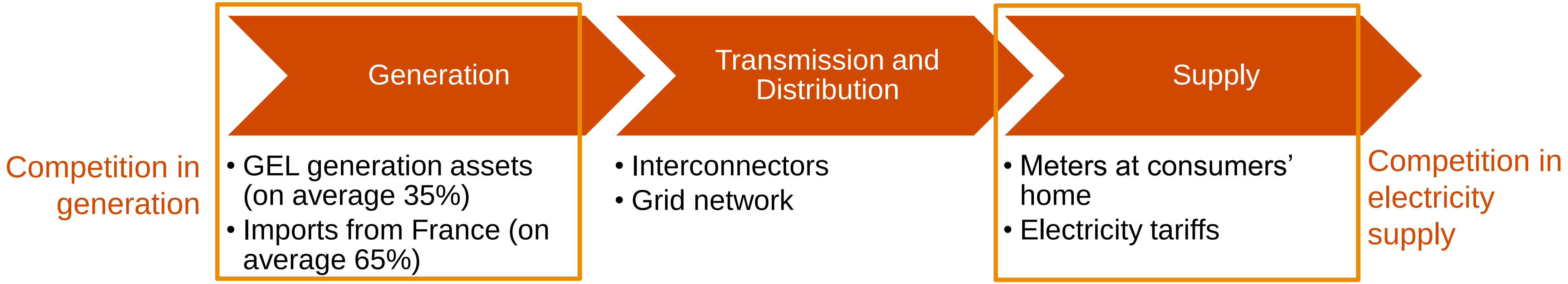
An alternative option is to retain GEL as the sole player in each of the three stages of the electricity supply chain. In this scenario, **GEL must become more efficient for electricity prices to fall.**

However, GEL faces mandatory overheads due to **regulatory targets for fuel stocks** on the island and N-2 policy which requires GEL to **maintain additional generation capacity.** The small scale of energy production in Guernsey also provides **limited scope for economies of scale**.

The States of Guernsey voted to take GEL out of the regulatory remit of CICRA, creating an environment **relying solely on shareholder pressure** to maintain efficiency. If GEL is to remain the monopoly provider of electricity in Guernsey, regulatory pressure may be required to ensure that **consumer and investor interests are balanced** and that **GEL continues to operate as efficiently as possible within the constraints it is set**.

Option 1 – Increasing the level of competition

Electricity supply chain



The first option would be to open the electricity market to competition from external suppliers.

Given the large fixed costs associated with transmission and distribution networks, it is unlikely that GEL would face any large scale competition in this segment of the supply chain at a large scale. However, external suppliers could begin to compete with GEL in generation or supply.

Regarding generation, IEG has already been granted a licence by CICRA to generate electricity on Guernsey and has been exempted from having to obtain a supply licence. Other suppliers, such as EdF who currently supply GEL and Jersey Electricity Company (JEC) could also enter the market, to export excess electricity at a low price. Regarding supply, competition on tariffs would have to reduce prices to the extent that a significant proportion of consumers change supplier in order to exert competitive pressure on incumbent suppliers. Additionally, renewable suppliers could invest in Guernsey to supplement on-island generation.

There will be a level playing field for new entrants and GEL. I.e. They will contribute to the N-2 policy and spreading the fixed cost of supplying electricity to the Guernsey market which will reduce the burden on GEL.

If new entrants are able to either offer lower tariffs to consumers or generate at much lower cost, GEL could be forced to reduce its operations in either the generation or supply element of the supply chain. Any movement away from local firms would mean money would flow off-island, therefore the efficiency gains should outweigh the associated cost to be of value for the Guernsey economy.

The extent of the costs and benefits of competition will determine whether it would add value to the market

For the introduction of competition to be worthwhile for Guernsey, the benefit of efficiency savings should exceed the associated cost.

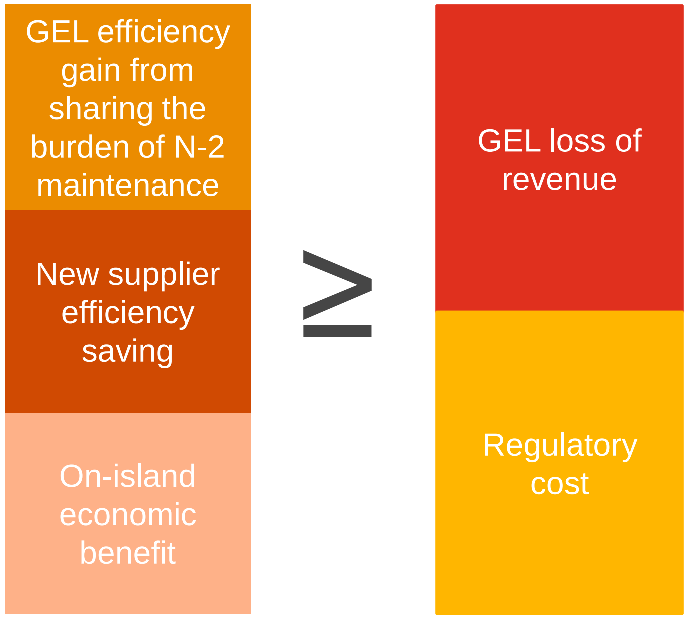
The benefit of introducing competition to the Guernsey electricity market would be the efficiency saving generators or suppliers entering the market could bring and/or the economic upturn from additional on-island generation. This assumes that this efficiency gain would be passed on to consumers in the form of lower tariffs rather than extracted as profit overseas.

GEL would also be able to operate more efficiently as the cost of maintaining N-2 level of energy security would also be spread out by new entrants.

However there are costs associated with the introduction of competition:

- If new suppliers offer lower tariffs, this will bring a cost to GEL in the form of lost revenue as their market share is reduced.
- In order to harness the benefits of competition, proportionate regulation of the electricity market would be needed. Complying with regulation presents a substantial time- and monetary-cost to the regulated firms, therefore excessive regulation could prevent new entrance to the market.

Costs and benefits of electricity market competition



Competition would allow the burden of N-2 to be spread between a greater number of suppliers

The cost of maintaining N-2 prevents GEL from operating more efficiently. Sharing this cost with new suppliers would allow GEL to realise an efficiency gain.

GEL is obliged to retain additional fuel stocks to meet a regulatory target and ensure extra generators are kept in order as back up to meet N-2 policy. New suppliers would have to contribute to the cost of maintaining N-2 and meeting the regulatory fuel stocks target to some extent, lightening this burden on GEL. With less expenditure on N-2 and maintaining fuel stocks, GEL could operate more efficiently and pass on these savings to consumers.

This arrangement could take two forms:

- GEL maintains the additional generation capacity required for island-wide N-2 and fuel stocks to meet the regulatory target. External suppliers are obliged to contribute to the cost to GEL based on the proportion of capacity they supply.
- Each supplier is obliged to maintain N-2 level generation capacity and fuel stocks for its own electricity provision. However, this could result in an unnecessarily high level of spare capacity.

In either scenario, regulation would be required to ensure the level of supply is guaranteed and is paid for by all suppliers. Essentially, regulation should create a level playing field for all operators in the market.

GEL currently charges a low mark-up on prices, a new supplier could increase this mark-up and extract it overseas

Approximately 1% of GEL's electricity price is a mark up on system and energy costs.

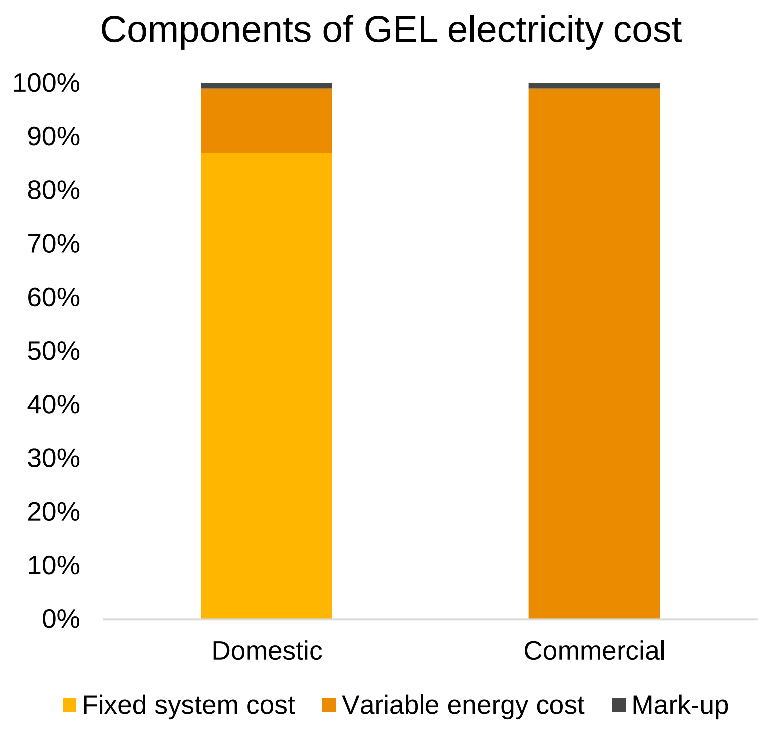
This low mark-up is due to regulations setting a maximum price electricity suppliers can charge, and is predominantly affected by the timing of major infrastructure investments.

In a competitive market, if a new supplier is able to enter the market and operate more efficiently, then consumers may benefit from lower tariffs. Lower tariffs would attract consumers away from GEL, leading to a loss of revenue. The downward pressure on prices would also squeeze the mark-up GEL is able to charge, further reducing their revenue. Given that GEL is state-owned, this would then place additional financial pressure on the States of Guernsey.

Alternatively, new suppliers could increase their mark-up and extract the proceeds overseas rather than contributing to investment in Guernsey.

This introduces a need for electricity market regulation to protect consumers' interests in terms of both price and quality of service. If a new supplier is able to operate more efficiently through offering a lower quality of service, this efficiency gain may not be beneficial.

In order to exert downward pressure on prices, a certain level of entry will be necessary to stop the market from becoming an oligopoly. Given the limited size of the Guernsey market, it is uncertain whether adequate competition could be achieved to prevent the extraction of profits.



Source: Guernsey Electricity Limited

With the introduction of competition, regulation would be needed to protect the interests of consumers

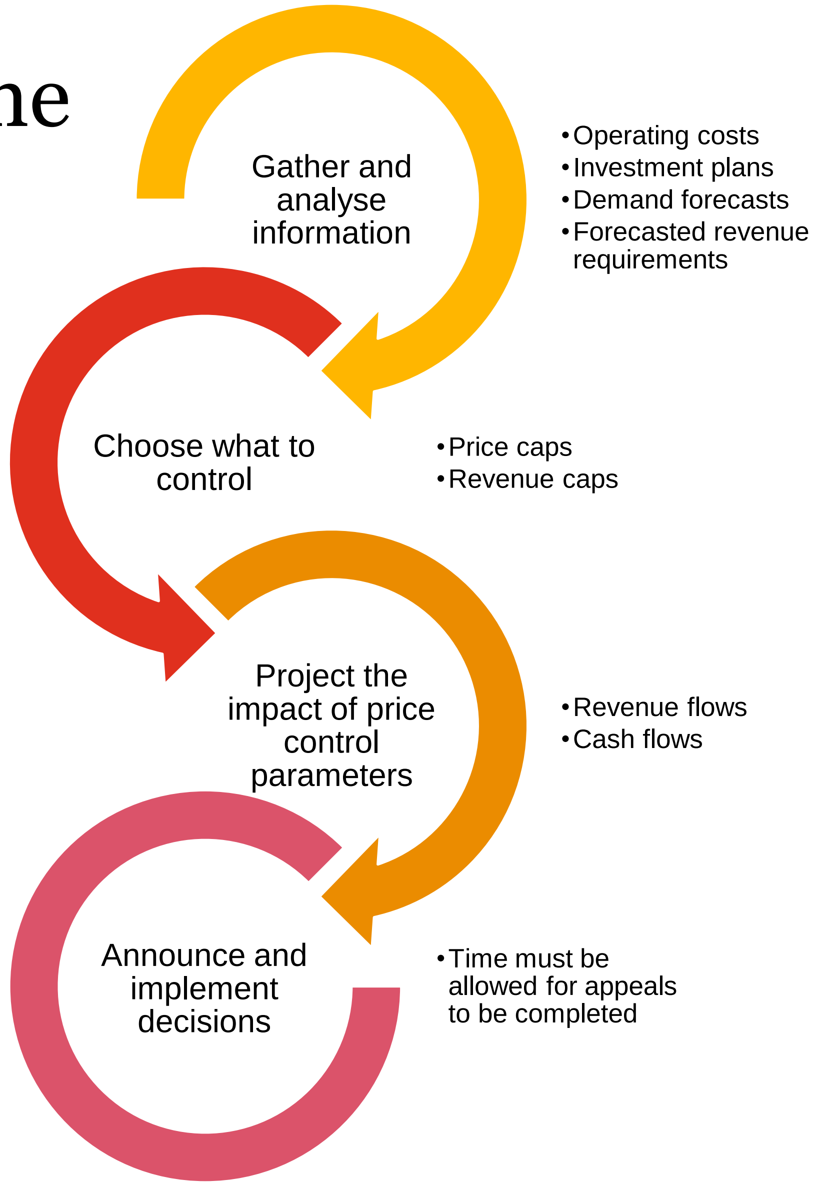
The States of Guernsey historically voted to remove GEL from the regulatory remit of CICRA, however a competitive market would require regulation.

In a competitive market, shareholder pressure would not be adequate to guarantee long term value for Guernsey. Energy market regulation will be of utmost importance to ensure consumer interests are balanced with investor interests. Therefore, if the electricity market is to be opened to new entrants, a greater role for CICRA would be required to prevent external suppliers from extracting excess profits from the island.

However, excessively complex regulation would introduce a greater monetary- and time-cost for firms operating in the market. This may deter entry to the market due to the high barriers to entry, reducing the potential level of competition.

Currently CICRA is funded through revenue from supply licences. However if this ceases to cover the cost of regulation, the price of supply licences may have to rise and may be passed onto customers, or the States of Guernsey may have to contribute financially to CICRA.

It will be necessary to identify the proportionate level of regulation for the Guernsey electricity market to ensure the economy can realise the benefits while minimising the costs.



Stages of a price review process

The scale of the Guernsey electricity market suggests that wholesale competition may not be worthwhile, competition in renewable generation may prove more viable

GEL's customer base is already limited by the size of the island. This may not be large enough to attract adequate competition in supply. However, local renewable generation may provide an opportunity to introduce competition.

If only a small number of new suppliers were to enter the market, this is unlikely to introduce adequate competition to deliver better outcomes for Guernsey. In this scenario it is likely that there would be little impact on prices while any profits are extracted overseas. Proportionate regulation would be necessary to protect customer interests.

This is not to say that there is no place for competition in the Guernsey electricity market. There may be sections of the market where external expertise may be able to introduce an energy source either as the infrastructure provider or operator. For example, utility-scale renewable electricity generation.

As the technology develops, there may be opportunities for new entrants to generate electricity using renewable infrastructure. If niche suppliers have more expertise in installing extensive renewable generation infrastructure, introducing external providers to do so could be beneficial. Just as in the case of introducing wholesale competition, this may mean allowing a share of profits from electricity generation to be extracted off the island.

Privately owned hydrocarbon suppliers already extract profits overseas, which has not had a significantly negative economic impact on Guernsey. Allowing private electricity suppliers to enter the market will increase this economic leakage, particularly as the size of the electricity market is forecast to increase. The States of Guernsey should be aware of the need to manage this changing risk as the transition to electricity and the reduction in overall energy demand continue.

Achieving the proportionate level of regulation will be key to ensuring the benefits of competition are realised

In a competitive market, shareholder pressure would not be adequate to guarantee long term value for Guernsey. However, excessive regulation would deter new entrance to the market.

The greater the number of players in the market, the more complex the regulatory structure will become. Yet more complex regulation increases the fixed cost to new entrants, potentially reducing the extent of entry to the market.

In a state monopoly market structure the question of whether GEL or the States of Guernsey pays for the regulator is less significant as the overlap between end consumers and taxpayers is significant. Introducing greater competition reduces this overlap, meaning this decision will have a greater impact.

The consequences of the changes to the regulatory regime that would be required should be carefully considered. A cost-benefit analysis would help to determine the proportionate level of regulation for a more competitive market.

Option 2 – Retaining the current market structure

Electricity supply chain

Cost reduction in the whole production process

Generation
- GEL generation assets (on average 35%)
- Imports from France (on average 65%)

Transmission and Distribution
- Interconnectors
- Grid network

Supply
- Meters at consumers' home
- Electricity tariffs

Without competition, GEL may need to be able to operate more efficiently to see prices fall.

This option retains the current market structure in Guernsey. In this scenario, the objective would be to increase the level of efficiency at which GEL operates without introducing competition from external suppliers.

The burden of maintaining N-2 prevents GEL from operating more efficiently. As we have discussed, local renewable electricity generation technology could contribute to N-2 capacity. This would allow GEL to reduce expenditure on other generation assets and fuel stocks. Our energy infrastructure options analysis assess the costs and benefits of certain grid-level generation infrastructure options.

If any of these options could be included as part of N-2 and could operate more efficiently than existing generation assets, this would allow GEL to operate more efficiently without the need for competition.

Without competition, regulation may be advisable to ensure long term value is delivered to Guernsey. The need for regulation will be lesser than in a competitive market but some regulation can help guarantee positive outcomes for consumers.

GEL will require regulation to ensure customer outcomes are improved without competitive pressure

In the absence of competition, GEL has less incentive to seek further ongoing efficiency savings which could result in lower prices for consumers.

CICRA has regulated GEL since 2001, however the States of Guernsey has voted in favour of taking back the responsibility of regulation, albeit the legislative changes were not made to enact this decision.

Regulatory pressure protects consumer interests and maintains efficiency pressure on GEL. There are three regulatory models that could be possible for Guernsey:

- Fully independent regulator: regulators are independent of any ministry, they have a substantial role in policy formulation.
- Regulator as ministerial advisor: regulator is attached to a ministry, and advises on, rather than formulates policy solutions.
- Light handed regulation: the industry mostly self-governs, and market intervention tends to take the form of enquiries after specific events.

Regulatory bodies require resources to hire a high quality workforce to monitor, conduct, process and enforce rules and sanction systems, and to invest in technology to facilitate communication and therefore the effectiveness of decision-making. Evidently, the greater the role of the regulator and the greater the number of entities being regulated, the higher the cost of financing the regulator. Therefore, a judgement must be made as to the appropriate level of regulation for GEL and the energy market.

It is also important to ensure that the regulatory system is not only fit-for-purpose in today’s market structure, but would be able to adapt to any future developments.

Electrification may introduce a need for greater scrutiny of other energy markets

Our energy demand forecast demonstrates the extent to which Guernsey will transition away from fuel and towards electricity as its main source of energy.

Guernsey currently has two fuel farms and several fuel suppliers. GEL also has substantial fuel storage capacity. With greater electrification, demand for fuels will inevitably decrease. In this case, fewer fuel farms and suppliers will be able to operate and these markets may become less competitive.

In this case, there may be a need to introduce regulation of energy markets other than electricity to ensure consumers continue to receive a fair price and a good quality of service. This is particularly important as those who are unable to transition to electricity usage may be the more disadvantaged in society. Similar considerations as to those regarding the regulation of electricity markets will be necessary to decide the appropriate extent of regulation.

As the transition to electricity gets underway, the States of Guernsey will need to act early to manage the speed of transition and ensure customers who are unable to switch to more electricity intensive energy use do not lose out.

4

Tax options

We have modelled six tax options for Guernsey

We have considered the impact of six potential tax policies and their potential to assist in managing and supporting the energy transition. As ICE vehicles become more efficient and the transition to electric vehicles accelerates, fuel duty revenues are set to decline.

Working with the States of Guernsey we decided the following tax options were the most pertinent:

Tax policy	Explanation
Hydrocarbon tax	A unit tax on the heat content of all energy sources, excluding imported electricity
Carbon tax	A unit tax on the carbon emissions of all energy sources, excluding imported electricity
Pollution tax	A unit tax on the carbon emissions of all energy sources, including imported electricity
Mileage tax	A unit tax on the distance travelled by different types of vehicles
Heating efficiency tax	An annual tax on housing based on heating efficiency
Appliance efficiency tax	A sales tax on purchases of inefficient appliances (% of price)

The carbon and pollution tax both tax carbon emissions, the difference in their tax bases is 0.6% in 2019.

We have evaluated these taxes against five principles of taxation to help the States of Guernsey make an informed choice for Guernsey's energy policy.

For a more detailed explanation and presentation of further results, please refer to the technical report (Annex C).

Modelling the impact of a tax option

There are three stages in our approach to modelling the impact of each tax option:

Stage 1

Identify the tax base, i.e. what energy sources would be taxed → Forecast the tax base out to 2050

Stage 2

Identify the tax revenue that needs to be recovered → Calculate the unit tax rate under the new regime to raise the required amount of revenue

Stage 3

Forecast tax revenue out to 2050 → Model the wider impact of the tax, e.g. behavioural change and GDP loss

Stages of the approach for each option

Stage 1:

- Hydrocarbon tax: the tax base is the heat content of all energy consumption, excluding imported electricity, each year.
- Carbon tax: the tax base is the carbon emissions of all energy consumption, excluding imported electricity, each year.
- Pollution tax: the tax base is the carbon emissions of all energy consumption, including imported electricity, each year.
- Mileage tax: the tax base is the total miles travelled by different vehicle types each year.
- Heating efficiency tax: the tax base is the number of houses in each EPC rating band each year.
- Appliance efficiency tax: the tax base is the value of appliances of each efficiency rating sold each year.

Stage 2:

- The hydrocarbon, carbon, pollution and mileage are unit taxes, meaning they are set at a flat rate per unit of the tax base. The tax base crosses over with the existing fuel duty tax base.
- The heating and appliance efficiency taxes are not intended to replace any tax, therefore the tax rates have been chosen. The heating efficiency tax is a unit tax, meaning it is set at a flat rate per house of each EPC rating. The appliance efficiency tax is an ad valorem tax, meaning it is calculated as a percentage of the value of the appliance.

Stage 3:

- Multiply the tax base by the tax rate for each year out to 2050 to calculate tax revenue
- Using our economic model we then estimated the wider economic effects. This robust modelling technique forms the basis of the OECD GREEN model used to assess the economic impact of imposing limits on carbon emissions, and the MIRAGE model for trade policy analysis.
- We have not simulated the wider economic effects of the appliance efficiency tax as the revenue it raises is too low to model.

Principles for evaluating tax option

To compare tax policies, we measure each against the following principles:

Tax principles	Explanation
Economic efficiency	We measure the economic efficiency as the costliness of the tax to GDP. All taxes have a negative impact on GDP which we refer to as the deadweight loss (DWL). However, a tax is deemed to be relatively efficient if it results in a less than 30p reduction in GDP for every £1 of revenue raised.
GDP impact	The negative impact on GDP is also presented as a percentage of GDP to demonstrate the scale of the impact of different taxes.
Sustainability	Taxes increase the price of a good, therefore encourage consumers to reduce their consumption. This is referred to as behavioural change. The more consumers change their behaviour as a result of a tax, the less revenue will be raised by the tax and the tax is less sustainable. The tax revenue after behavioural change has been accounted for is referred to as the revenue realised.
Affordability	We calculate the proportion of household income that would be spent on the tax on average to understand whether the tax will be affordable for households. For the tax policies that may replace all or part of fuel duty we provide the affordability of fuel duty (referred to as pre-change) to compare against affordability post-change.
Complexity	We consider the difficulty of implementing the tax. For example, in order to introduce the heating efficiency tax a heating efficiency rating system would need to be introduced and all houses would need to be rated.

Summary of key indicators in 2030

We have found that none of the potential taxes would have a significant negative effect on the Guernsey economy. As each tax is better for achieving different objectives, the SoG needs to be clear what its overall objectives are for energy policy.

We report the indicators for evaluating tax options for 2030 as by this stage most behavioural change has occurred. We find that none of the taxes would have a significant negative effect on the Guernsey economy and none would place a large burden on household income.

Given developments in technological efficiency, energy consumption in Guernsey is forecast to decline. Therefore, even before behavioural change revenue raised by taxes on energy consumption will fall over time. Implementing a tax on energy consumption will accelerate the transition towards less energy intensive technology, as the sustainability figure indicates.

				Key indicators in 2030				
Options	**Revenue realised in 2020 in £m**	**Revenue realised in 2030 in £m**	**Revenue realised in 2050 in £m**	**Economic efficiency** (reduction in GDP per £1 of revenue raised)	**% GDP impact** (% of GDP Loss)	**Sustainability** (% of expected revenue recovered)	**Affordability** (% of annual income for average household)	**Complexity** (How costly is implementation)
Hydrocarbon tax	16.8	10.8	3.1	39p	-0.17%	64.8%	0.34%	Low
Carbon tax	17.0	13.9	4.8	21p	-0.09%	83.6%	0.44%	High
Pollution tax	16.9	13.9	4.9	21p	-0.09%	83.6%	0.44%	High
Mileage tax	17.3	16.5	3.9*	34p	-0.16%	86.7%	0.73%	Medium
Heating efficiency tax	12.6	10.3	6.4	17p	-0.05%	92.5%	0.32%	High

*Note that the mileage tax rate could vary as the composition of vehicles changes to prevent the decline of the tax base as drivers transition to electric vehicles over time.

Choosing which tax to implement depends on which objectives are most important

In this analysis we consider three possible objectives for tax policy.

Objective for tax policy	Selection criteria	Most appropriate tax policy in 2050
Economic efficiency Minimise the loss to GDP caused by a tax	Choose the tax that results in the lowest deadweight loss and the smallest percentage impact to GDP.	**Heating efficiency tax**
Sustainable revenue Maximise the revenue raised by the tax to generate additional Government funding	Choose the tax with the highest forecast revenue realised. Sustainability is a useful indicator but this does not reflect the scale of revenue raised.	**Heating efficiency tax**
Carbon reduction Maximise the reduction in carbon emissions as the tax encourages consumers to use less carbon intensive energy	Choose the tax with the lowest sustainability. Low sustainability indicates consumers change their behaviour to avoid paying the tax, which means switching to less energy intensive consumption.	**Hydrocarbon tax** Pollution tax has the second lowest sustainability. However, this tax is levied on a wider tax base so the impact on carbon reduction may be more pronounced.

Note, there is an inherent trade-off between generating a sustainable revenue stream and encouraging carbon reduction as any tax successful at incentivising consumers to reduce their carbon usage will erode its own tax base.

Hydrocarbon tax: a tax on energy consumption, excluding imported electricity, based on energy intensity

Under this model, all sources of energy are taxed, except imported electricity. Heat content is measured in terms of million British Thermal Units.

Economic efficiency: the hydrocarbon tax is the least efficient of the taxes we have analysed. For every £1 of revenue raised, 38p of GDP will be lost in 2050. Given the large size of the tax base, this is also the greatest loss to GDP.

Sustainable revenue: the hydrocarbon tax has the lowest sustainability in 2050 and will raise the least revenue of all the taxes we have analysed

Carbon reduction: the low sustainability of the hydrocarbon tax indicates that this tax would cause the most behavioural change and therefore generate the greatest reduction in carbon emissions.

Affordability: the hydrocarbon tax would be more affordable than fuel duty until 2044. Regardless of the comparison, the average tax burden is very low.

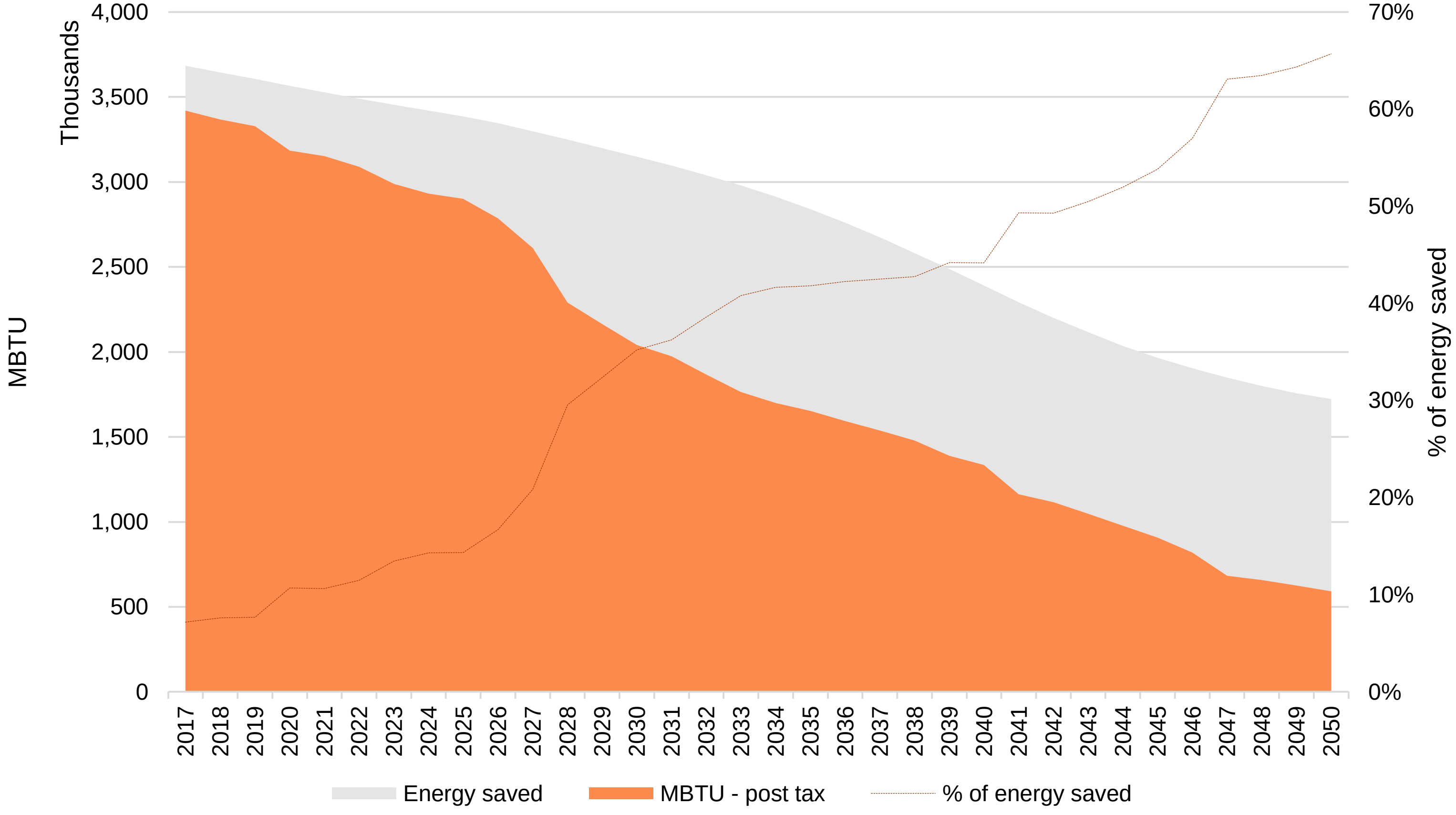
Complexity: given the transparency of energy consumption, the tax will not be difficult to implement as it can be calculated from energy bills.

Tax Principles		Forecast outcome		
		Low Scenario		
		2018	2030	2050
Revenue realised (£m)		17.8	10.8	3.1
Economic efficiency (Dead weight loss in £ per unit of tax)		40p	39p	38p
Economic efficiency (% loss to GDP)		-0.25%	-0.17%	-0.07%
Sustainability (% of expected revenue recovered)		92.4%	64.8%	34.3%
Affordability (% of annual income for average Household)	Pre*	1.03%	0.55%	0.03%
	Post	0.94%	0.34%	0.05%
Complexity		Low		

*This refers to the affordability of fuel duty

Following the introduction of a hydrocarbon tax, energy consumption would be 66% lower in 2050

Energy consumption measured in heat content – pre and post behavioural change

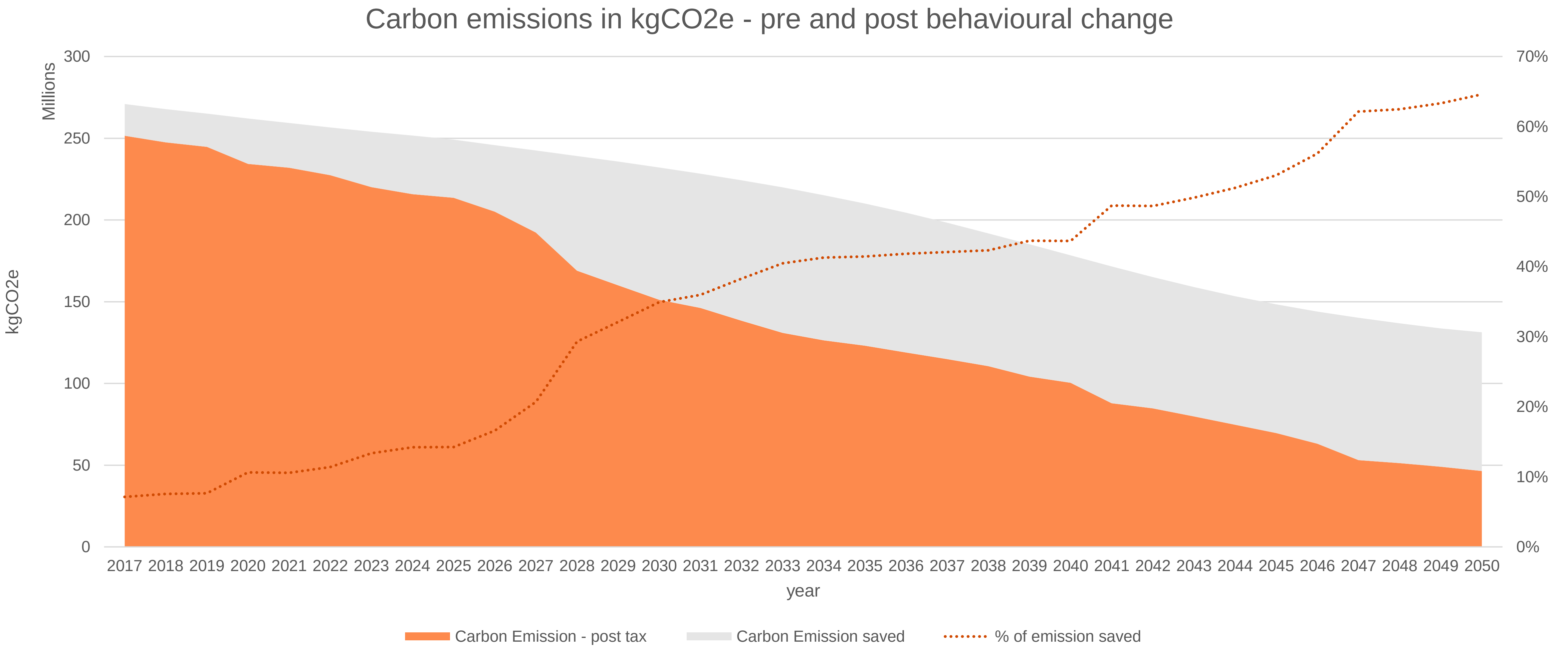


In the absence of the tax, energy consumption is forecast to decline. The grey section of this graph depicts the fall in energy consumption, measured in million British Thermal Units (MBTU) predicted by our energy demand forecast. MBTU measures the heat content of energy, which corresponds directly to kWh.

In comparison to the baseline forecast of energy demand, the hydrocarbon tax would have the following effects:

- The consumption of energy sources taxed by the hydrocarbon tax (all energy sources excluding imported electricity) would fall by 8% in 2019 and by 66% in 2050.
- Until 2025 this tax would have limited impact on consumption, but from 2025 onwards the impact would be more significant.
- The reduction in energy consumption remains roughly the same after 2033.

Following the introduction of a hydrocarbon tax, carbon emission would be 66% lower in 2050



Carbon tax: a tax on carbon emissions from all energy consumption on the island

Under this model a tax is paid on all on-island carbon emissions, so all sources of energy are taxed except imported electricity.

Economic efficiency: the carbon tax is the second most efficient of the taxes we have analysed. For every £1 of revenue raised, 18p of GDP will be lost in 2050. Despite the large size of the tax base, the loss to GDP is minimal.

Sustainable revenue: the carbon tax has the second lowest sustainability in 2050 but would raise more revenue than the hydrocarbon or mileage taxes.

Carbon reduction: the relatively low sustainability of the carbon tax indicates that this tax would cause moderate behavioural change and therefore generate a large reduction in carbon emissions.

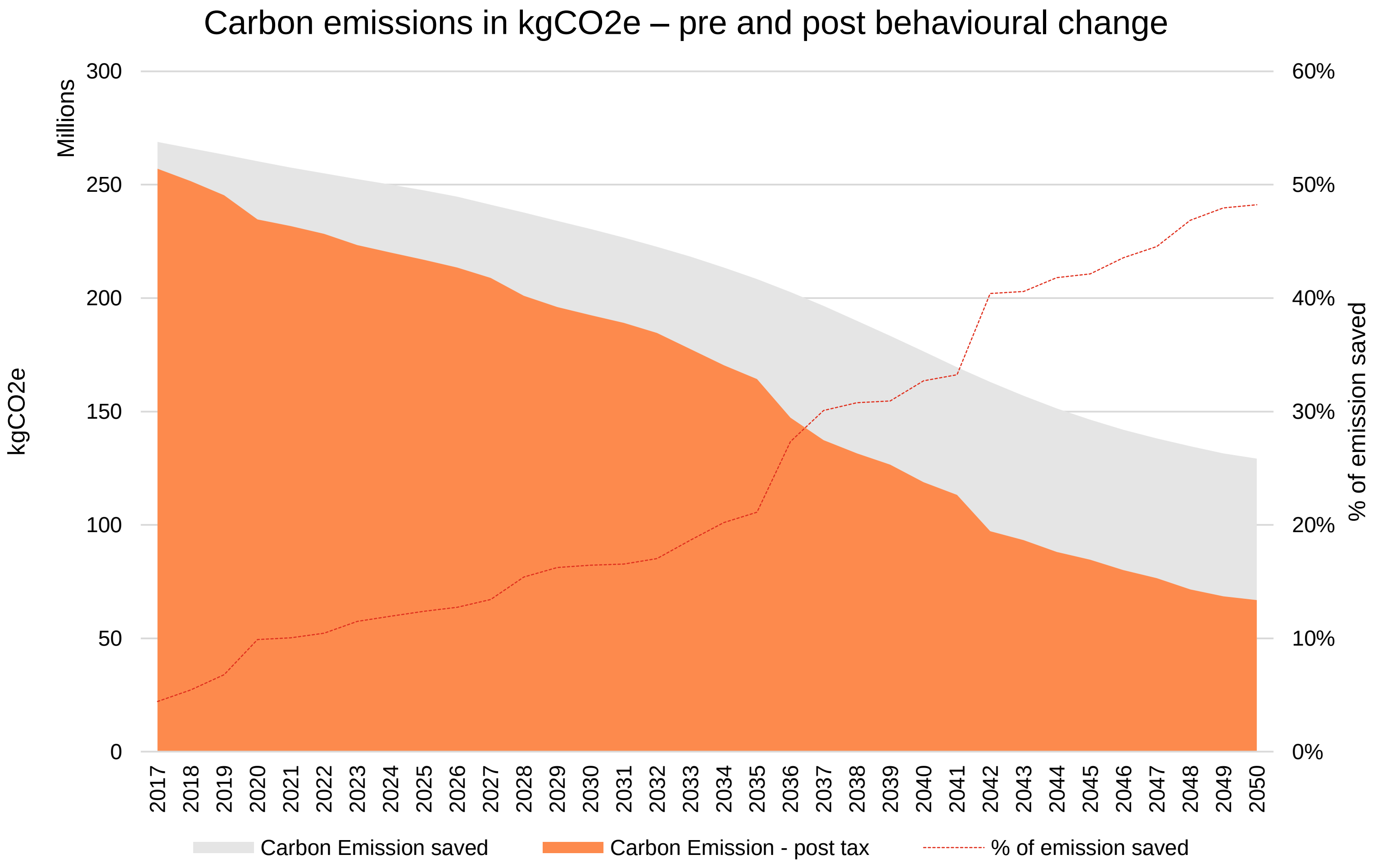
Affordability: the carbon tax would be more affordable than fuel duty until 2042. Regardless of the comparison, the average tax burden is very low.

Complexity: given the transparency of energy consumption, the tax will not be difficult to implement for households as it can be added onto energy bills on the basis of carbon emissions per kWh used. However, the tax will be difficult to implement for companies who use energy to power polluting activity. In these cases, carbon monitors will need to be installed to track emissions.

Tax Principles		Forecast outcome		
		Low Scenario		
		2018	2030	2050
Revenue realised (£m)		18.2	13.9	4.8
Economic efficiency (Dead weight loss in £ per unit of tax)		25p	21p	18p
Economic efficiency (% loss to GDP)		-0.15%	-0.09%	-0.03%
Sustainability (% of expected revenue recovered)		94.6%	83.6%	51.8%
Affordability (% of annual income for average Household)	Pre*	1.03%	0.55%	0.03%
	Post	0.97%	0.44%	0.07%
Complexity		High		

*This refers to the affordability of fuel duty

Following the introduction of a carbon tax, carbon emissions would be 48% lower in 2050



In the absence of the tax, energy consumption is forecast to decline. The grey section of this graph depicts the fall in energy consumption, measured in the carbon emissions produced predicted by our energy demand forecast. Carbon emissions are calculated using the UK emission factors.

In comparison to the baseline forecast of energy demand, the carbon tax would have the following effects:

- Carbon emissions from energy sources taxed by the carbon tax (all energy sources excluding imported electricity) would fall by 7% in 2019 and by 48% in 2050.
- Until 2035 this tax would have limited impact on emissions, but from 2035 onwards the impact would be more significant.
- The reduction in energy consumption remains roughly the same after 2041.

Pollution tax: a tax on carbon emissions from all energy consumption, including imported electricity

Under this model a tax is paid on all carbon emissions. Due to the low carbon intensity of imported electricity, the tax base is only 0.6% larger than that of the carbon tax.

Economic efficiency: the pollution tax ranks third for economic efficiency in 2050. For every £1 of revenue raised, 18p of GDP will be lost in 2050. Despite the larger size of the tax base, the loss to GDP is minimal.

Sustainable revenue: the pollution tax ranks third for sustainability in 2050 but would raise the second most revenue due to the size of the tax base. The tax base includes all sources of energy so consumers are less able to avoid paying. The Tax Revenue realised only differs from Carbon tax by 0.6% in 2040 and 1.1% in 2050.

Carbon reduction: the relatively low sustainability indicates that this tax would cause some behavioural change and generate a large fall in carbon emissions.

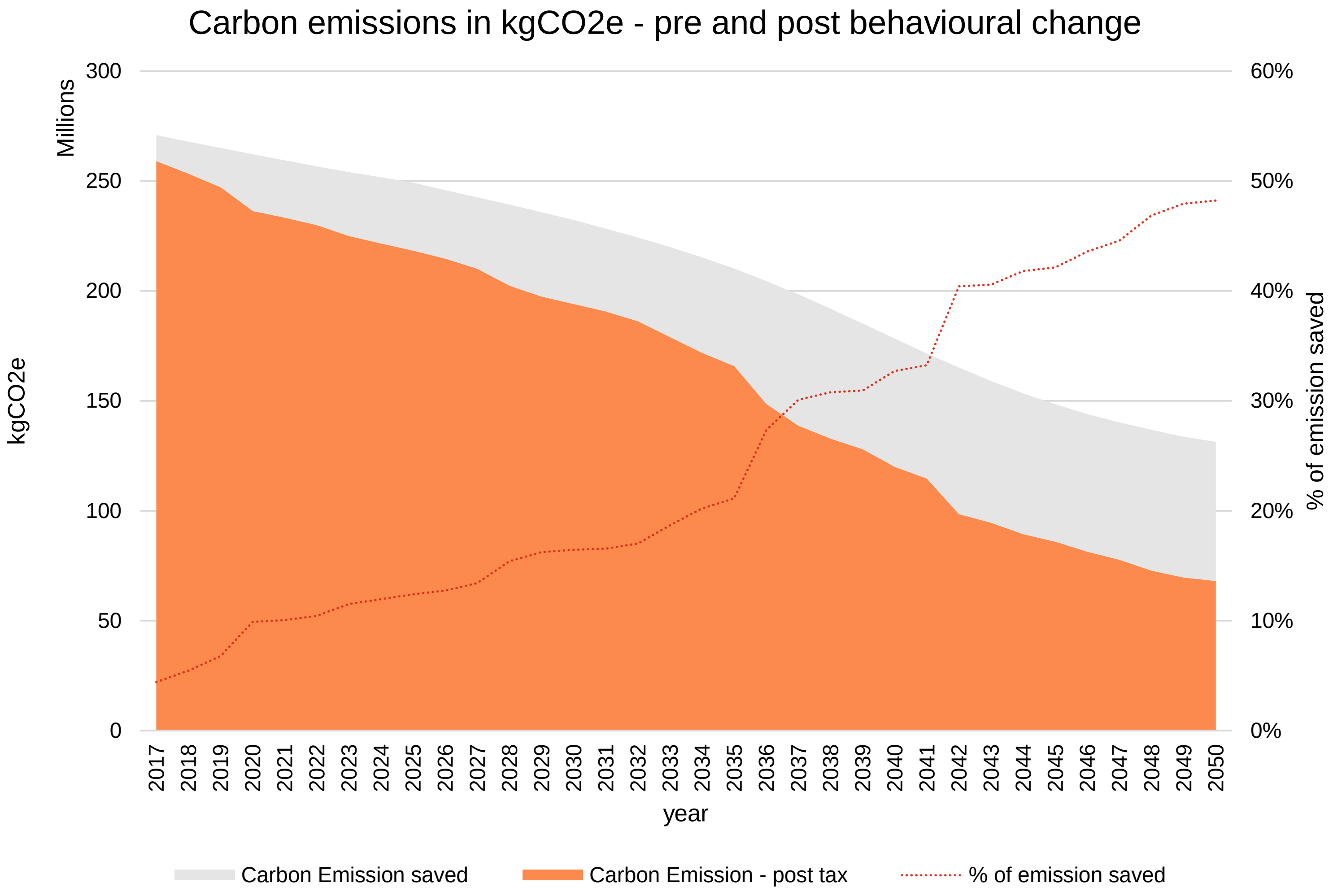
Affordability: the pollution tax would be more affordable than fuel duty until 2038. Regardless of the comparison, the average tax burden is very low.

Complexity: given the transparency of energy consumption, the tax will not be difficult to implement for households as it can be added onto energy bills on the basis of carbon emissions per kWh used. However, the tax will be difficult to implement for companies who use energy to power polluting activity. In these cases, carbon monitors will need to be installed to track emissions.

Tax Principles		Forecast outcome		
		Low Scenario		
		2018	2030	2050
Revenue realised (£m)		18.2	13.9	4.9
Economic efficiency (Dead weight loss in £ per unit of tax)		25p	21p	18p
Economic efficiency (% loss to GDP)		-0.15%	-0.09%	-0.03%
Sustainability (% of expected revenue recovered)		94.6%	83.6%	51.8%
Affordability (% of annual income for average Household)	Pre*	1.03%	0.55%	0.03%
	Post	0.96%	0.44%	0.07%
Complexity		High		

*This refers to the affordability of fuel duty

Following the introduction of a pollution tax, carbon emissions would be 48% lower in 2050



In the absence of the tax, energy consumption is forecast to decline. The grey section of this graph depicts the fall in energy consumption, measured in the carbon emissions produced predicted by our energy demand forecast. Carbon emissions are calculated using the UK emission factors.

In comparison to the baseline forecast of energy demand, the pollution tax would have the following effects:

- Carbon emissions from energy sources taxed by the pollution tax (all energy sources including imported electricity) would fall by 7% in 2019 and by 48% in 2050.
- The behavioural impact of the tax will become more pronounced after 2035.
- The reduction in energy consumption remains roughly the same throughout the period.

Mileage tax: a tax on the distance travelled according the vehicle type

Vehicles are taxed per mile travelled. Electric vehicles are taxed at a lower rate than ICE vehicles.

Economic efficiency: the mileage tax is the second least efficient tax in 2050. For every £1 of revenue raised, 25p of GDP will be lost in 2050. Despite the large size of the tax base, the loss to GDP is minimal.

Sustainable revenue: the mileage tax is the most sustainable tax in 2050. However, it generates the second least revenue in 2050 due to the transition to electric vehicles assumed in the baseline. Electric vehicles pay a lower rate of tax therefore as the transition gets underway, the revenue realised declines.

Carbon reduction: the high sustainability of this tax indicates this tax would cause limited behavioural change beyond the transition to electric vehicles assumed in the baseline.

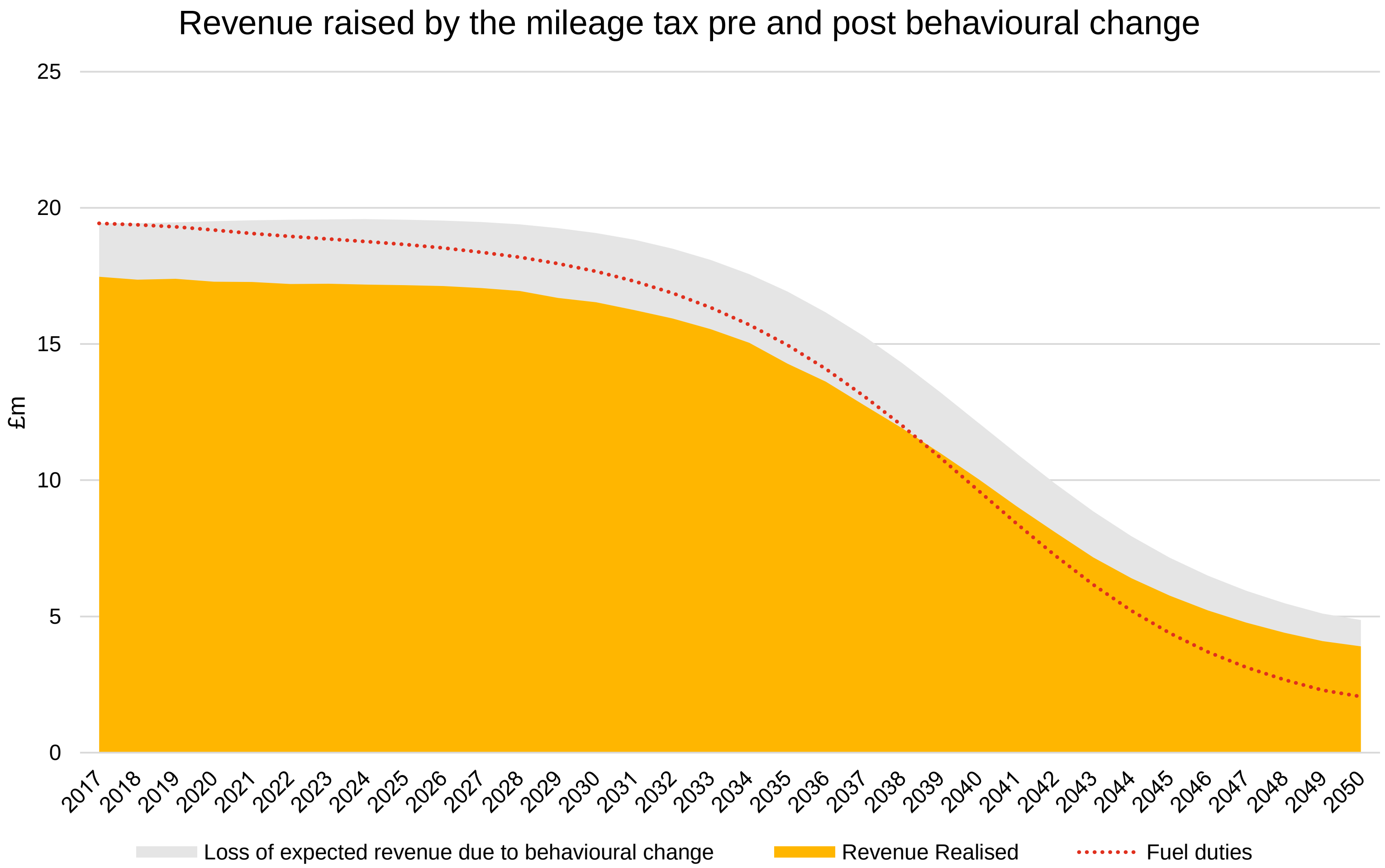
Affordability: the mileage tax would be more affordable than fuel duty until 2039. Regardless of the comparison, the average tax burden is very low.

Complexity: all cars have a milometer that tracks distance travelled therefore measuring the tax base would not be difficult. However, a central system would need to be introduced to monitor mileage driven each year.

Tax Principles		Forecast outcome		
		Low Scenario		
		2018	2030	2050
Revenue realised (£m)		17.4	16.5	3.9
Economic efficiency (Dead weight loss in £ per unit of tax)		38p	34p	25p
Economic efficiency (% loss to GDP)		-0.24%	-0.16%	-0.04%
Sustainability (% of expected revenue recovered)		89.4%	86.7%	80.0%
Affordability (% of annual income for average Household)	Pre*	1.03%	0.55%	0.03%
	Post	0.95%	0.73%	0.13%
Complexity		Medium		

*This refers to the affordability of fuel duty

The mileage tax will raise £17m in 2030, post behavioural change



The mileage tax will raise the highest revenue in 2030, however this is forecast to decline as the transition to electric vehicles accelerates.

Electric vehicles pay a lower tax rate than ICE vehicles, therefore as consumers switch to electric vehicles the revenue raised by the tax declines.

Above the baseline transition to electric vehicles, the mileage tax would encourage limited behavioural change meaning in comparison to the baseline the tax is highly sustainable.

However as the mileage tax is not based on the efficiency of vehicles like fuel duty is, the mileage tax will raise more revenue post behavioural changes than fuel duty from 2039 onwards.

Heating efficiency tax: a tax on the heating efficiency of the housing stock

Households are taxed based on the heating efficiency of their dwellings, i.e. the lower the efficiency, the higher the tax rate.

Economic efficiency: the heating efficiency tax is the most efficient tax policy in 2030 and 2050. In 2050, there is no loss to GDP as a result of this tax.

Sustainable revenue: the heating efficiency tax is the second most sustainable tax in 2050, meaning it will lead to limited behavioural change beyond that assumed in the baseline. The revenue stream will decline over time as households are assumed to improve their heating efficiency in the baseline, however this tax will raise the second most revenue in 2050.

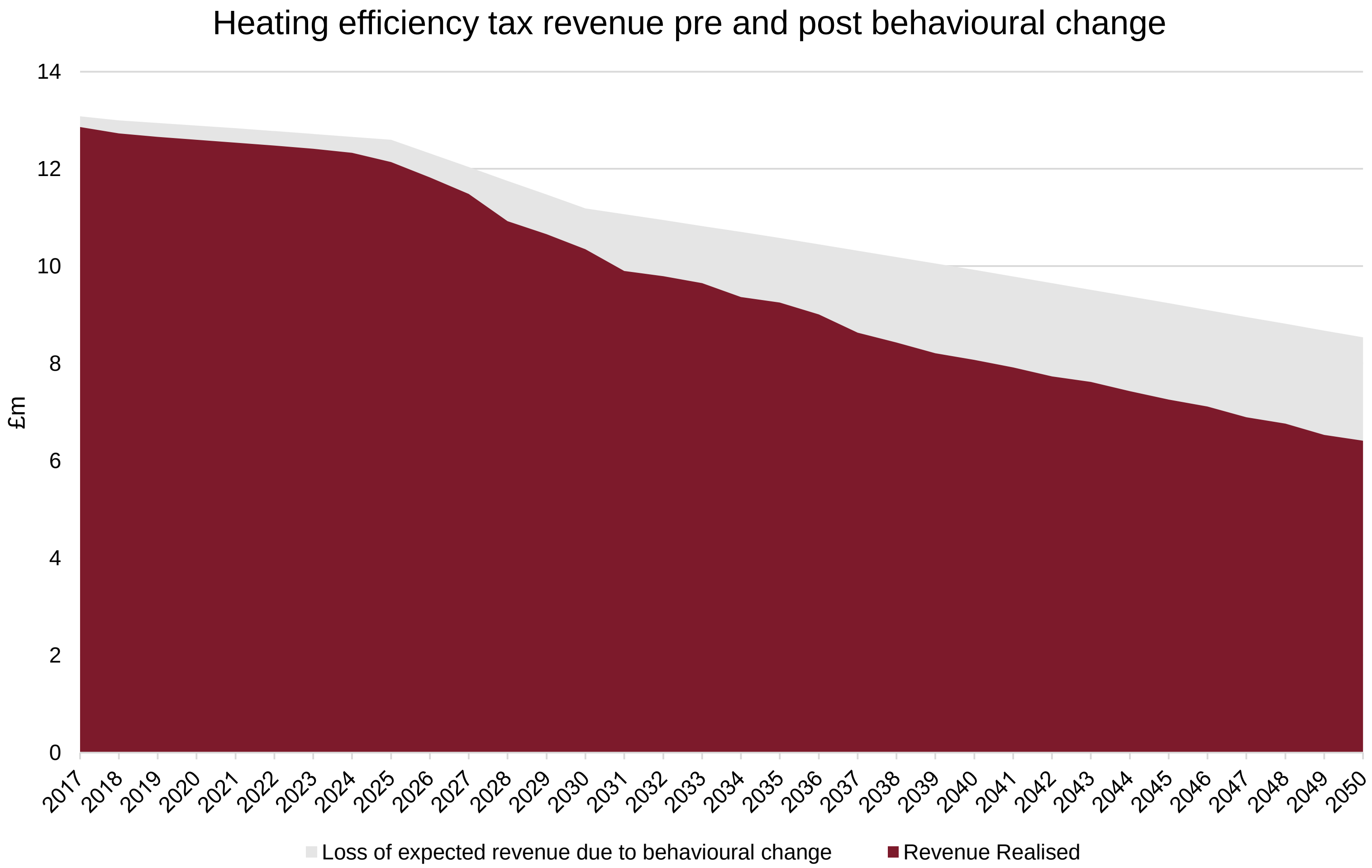
Carbon reduction: the high sustainability of this tax indicates this tax would cause limited behavioural change beyond the improvements assumed in the baseline.

Affordability: the average tax burden of the heating efficiency tax is very low.

Complexity: the tax policy would be complex to implement as an efficiency rating system would need to be introduced, and applied to all of the housing stock. Houses then have to be reassessed after any improvements to measure the extent to which their heating efficiency had improved. Note that some houses may need exemptions, i.e. listed buildings are prohibited from installing double glazing.

Tax Principles	Forecast outcome		
	2018	2030	2050
Revenue realised (£m)	12.7	10.3	6.4
Economic efficiency (Dead weight loss in £ per unit of tax)	30p	17p	0p
Economic efficiency (% loss to GDP)	-0.13%	-0.05%	0.00%
Sustainability (% of expected revenue recovered)	97.9%	92.5%	75.1%
Affordability (% of annual income for average Household)	0.68%	0.32%	0.09%
Complexity	High		

The heating efficiency tax will raise £13m in 2018, post behavioural change



The heating efficiency tax would raise £13m in 2018, after behavioural change has been accounted for.

In the absence of the tax, heating efficiency is forecast to decline. The grey section of this graph depicts improvements in heating efficiency and therefore the fall in tax revenue in the baseline predicted by our energy demand forecast.

In the baseline, houses with an EPC rating in band E, F and G are expected to gradually improve to band A to D due to improvements in heating efficiency.

The tax would lead to some behavioural change, shown by the difference between revenue raised before and after behavioural change.

Appliance efficiency tax: a tax on the sale of inefficient appliances

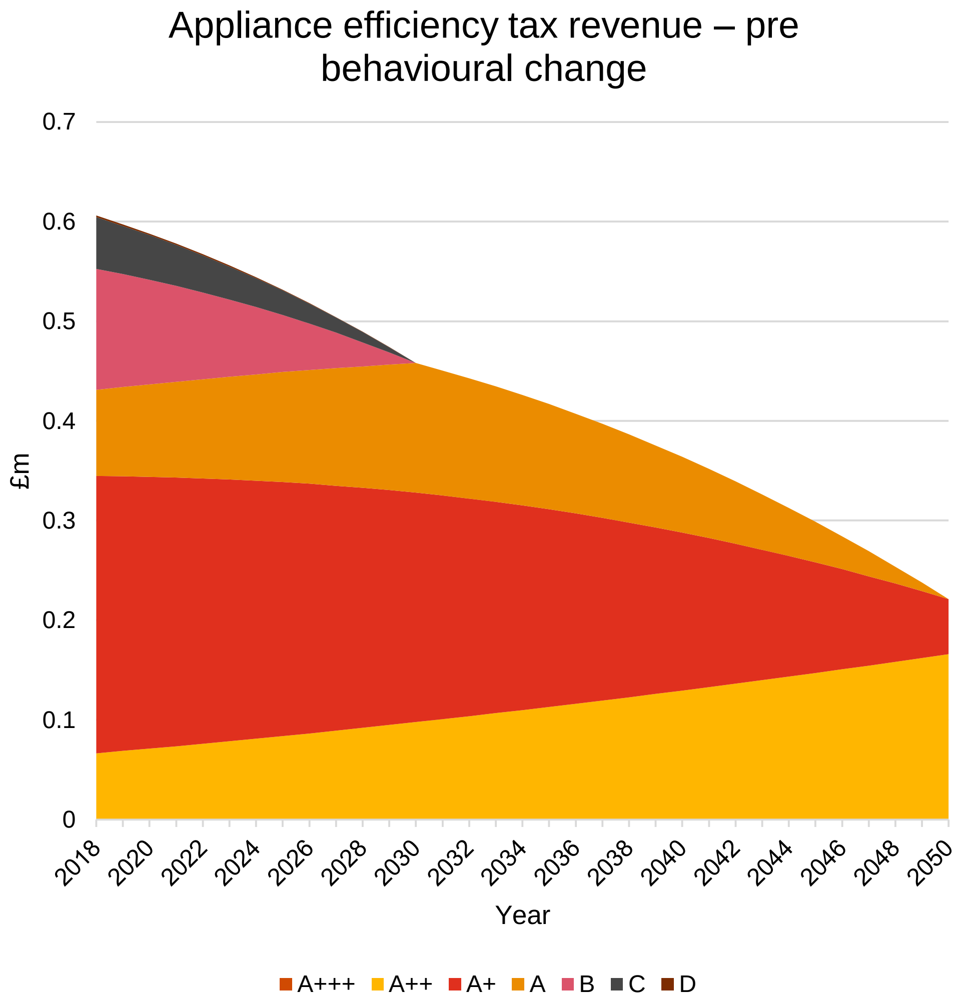
Sales of inefficient appliances are taxed, so consumers are incentivised to purchase more efficient appliances.

Guernsey's manufacturing sector only accounts for approximately 1% of the economy, meaning most appliances are imported. Tax revenue is expected to decline over time due to improvements in appliance efficiency resulting from technological developments.

We have estimated the change in the distribution EU energy labels for appliances to reflect the following goals of the EU energy target:

1. There will be almost no appliances with band B, C and D from 2030 onwards
2. The share of band A+++ will take up around 65% of the market, with A++ and A+ taking 30% and 5%, respectively from 2030 onwards

We expect that the transition towards efficient appliances would accelerate as a result of this tax. However, due to the low level of revenue raised we have not been able to simulate the resulting behavioural change in our economic model.



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Electricity for export

We have identified two infrastructure options that could enable Guernsey to develop a propensity to export electricity

The electricity generation from a 30MW offshore wind farm would already enable Guernsey to reduce electricity imports from Jersey.

By maintaining current imports of electricity from Jersey and using electricity generated by wind power, Guernsey could offset a proportion of HFO and gas oil generation, and could export any excess electricity generated.

The States of Guernsey have already published a Preliminary Feasibility report investigating a potential 30MW wind farm.

Going further, by increasing their investment Guernsey could expand the capacity of the offshore wind farm in order to export. A greater investment would also reduce the levelised cost of electricity due to the economies of scale associated with a larger project.

However, if the times at which Guernsey has a surplus of wind-generated energy coincide with times at which there is a similar surplus across Europe, the price achieved for such electricity may be lower.

GF1 interconnector has greater electricity import capacity than Guernsey requires.

Rather than using only a portion of the interconnector's capacity, Guernsey could import excess electricity to export either to other Channel Islands or to the UK.

Further investment would be required to install the cables linking Guernsey with the electricity export destination. The extent of the investment necessary to export electricity to the UK may mean this venture is unviable.

Jersey already has three interconnectors between the island and France, therefore is unlikely to need exports from Guernsey. However, this opportunity could be used to bolster the energy security of islands in the Bailiwick of Guernsey or Channel Islands further afield.

Glossary

Glossary of terms

Drivers-based approach: Forecasting energy demand by identifying the drivers of energy demand and forecasting their values in future.

Econometric modelling: A forecasting technique that uses statistical relationships between economic variables based on historical data.

Energy saved: The reduction in energy usage due to investment in energy infrastructure. For grid-level generation infrastructure this refers to the reduced need for HFO, gas oil and imported electricity due to the additional on-island generation potential. For domestic energy use infrastructure this refers to the reduced demand by households due to improvements in energy efficient, e.g. electric vehicles require less energy per mile than ICE vehicles.

GF1 interconnector: GF1 is the project to install a subsea cable directly from France to Guernsey.

Marginal abatement cost curves: An analytical technique that compares the costs of installing and maintaining energy infrastructure with the resulting fuel and carbon emissions saving.

Multiplicative modelling: A forecasting technique that uses percentage changes in the drivers to calculate percentage changes in the variable in question.

N policy: A policy that requires GEL to maintain adequate generation capacity to be able to meet total electricity demand on Guernsey in the event that the interconnector is out of service.

N-1 policy: A policy that requires GEL to maintain adequate generation capacity to be able to meet total electricity demand on Guernsey in the event that the interconnector and largest on-island generation asset are out of service.

N-2 policy: A policy that requires GEL to maintain adequate generation capacity to be able to meet total electricity demand on Guernsey in the event that the interconnector and two largest on-island generation assets are out of service.

Thank you

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