Gwasanaeth Ynni
Energy Service

Cefnogi ymdrech Cymru i greu economi carbon isel lwyddiannus
Supporting Wales' drive towards a successful low carbon economy

Swansea Bay City Region
Regional energy strategy

Technical Annex A:

Energy modelling

Final

May 2021

Contents

1. Introduction

This technical annex (annex A) provides detail on the methodology for the **energy modelling** presented in the regional energy strategy for Swansea Bay City Region (SBCR).

Technical annex B provides additional detail on the methodology used to assess the **economic modelling** results presented in the regional energy strategy.

All data sources referenced in this technical annex are listed in section 3.

1.1 Defining the 'energy system'

The regional energy strategy is focussed on the greenhouse gas emissions associated with the energy system in the region, covering:

- **power**
- **heat**
- **transport**

The energy system modelling **does not** include emissions or sequestration from:

- non-energy activity such as agriculture and land use;
- aviation and shipping, where emissions are treated nationally / internationally rather than regionally;
- very large industrial energy users, due to data limitations.

1.2 Quantifying the energy system 'baseline'

The energy system baseline year was set as 2017 due to data availability at the time of the modelling. The baseline was compiled using the following types and sources of data:

Table 1: Energy system baseline

Type of data	Source
National and local datasets of energy consumption	01
Current standards of energy efficiency	02 - 03
Current energy generation data	04 -13
Building heating technology data	14 - 18
Road transport data	19 - 26

1.3 Future energy system scenarios

The energy modelling covers two scenarios for the future energy system in 2035:

1) The **business as usual (BAU) scenario** describes actions that are expected to take place if the region's energy system continues to develop on the current trajectory; and

2) The **energy system vision (ESV) scenario** defines a series of actions that puts the region on a pathway towards net zero.

Table 2: Energy modelling scenarios

Scenario	Summary	Source
Business as usual (BAU)	Based on **National Grid's Steady Progression** scenario, continuing existing trends, policies and deployment rates for reducing emissions from the energy system. This is a UK-wide scenario and does not reference specific Welsh, regional or local decarbonisation policies or programmes.	27
Energy system vision (ESV)	Unique to the region, reflecting local resources, opportunities and priorities informed by the regional stakeholders. Accelerates the trends in carbon emission reduction scenarios such as **National Grid's Two Degrees and Community Renewables** in order to be on track for a net zero 2050 scenario as per an Absolute Contraction emissions method.	

This annex sets out the **data sources**, **key assumptions** and **key modelling outcomes** for the energy system vision scenario (ESV) for the Swansea Bay City Region in 2035, showing how these compare to the business as usual scenario (BAU) for the region in 2035.

'Data sources' and inputs refer to any existing data sets that were used in the energy modelling. These sources are listed in section 3 of this technical annex and in the energy modelling data workbook, available on request.

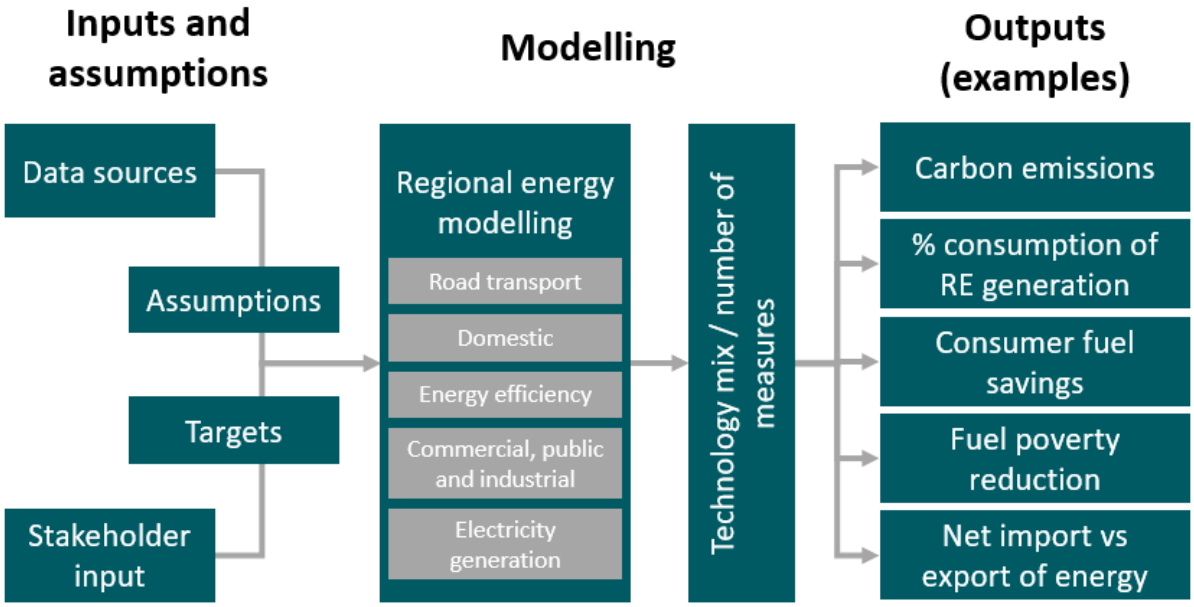
'Key assumptions' refer to the collection of conventions, choices and other specifications used in the energy modelling. Full assumptions are provided in the energy modelling data workbooks.

'Modelling outcomes' refer to any data produced through the modelling. Full outcome tables are provided in the energy modelling data workbooks and the SBCR energy strategy.

All modelling outcomes presented in this annex relate to the 2017 baseline. For example, Table 4 shows a 52% reduction in domestic heat carbon emissions by 2035 in the energy system vision scenario. This is a 52% reduction from the 2017 baseline.

Figure 1 shows the overall approach to the energy modelling that was used to produce the energy strategy, including the interactions between the data inputs and assumptions, the modelling process and the outputs from the energy models.

Figure 1: Overall approach to energy modelling used in the energy strategy



Notes: RE = renewable energy

Emissions resulting from the region's energy consumption are estimated based on industry standard values derived from BEIS conversion factors (source 32) and Defra conversion factors (source 33), in addition to baseline emissions (source 34). Projections of how emission factors could change over time, particularly for electricity and gas where informed by National Grid ESO's FES (source 27) and Regional Future Energy Scenarios for Gas (source 17).

Domestic energy consumption represents the most detailed part of the energy model. This is due the number of technologies involved, the relatively high proportion of total emissions, and the number of sub-sections that were modelled such as energy efficiency, domestic heat and domestic electricity consumption. As a result, the domestic energy consumption chapter in this annex is more detailed than the other chapters for energy generation, commercial and industrial energy use and road transport.

2. Energy modelling assumptions

2.1 Domestic energy consumption

This section covers the various components of domestic energy consumption, including domestic heat, domestic cooking and electrical appliances, and domestic energy efficiency.

The BAU and ESV scenarios assume the same housing growth rate from 2017 to 2035, based on the average build out rates for the region between 2008 and 2018.

Table 3: Assumptions: **Cumulative number of homes in SBCR**

Year	BAU	ESV	Source
2017 (baseline year)	306,043 homes		28
2025	317,306 homes		
2030	324,345 homes		
2035	331,384 homes		

The energy modelling explored three components of domestic energy consumption, linked to the housing growth rate:

1. Domestic heat
2. Domestic energy efficiency
3. Domestic electrical demand (non-heat)

Table 4: Assumptions: **Domestic heat technologies in SBCR (2035)**

	BAU	ESV	Source
Proportion of biogas blended with natural gas in the gas network (by energy)	5%	5%	17-18
Hydrogen blending in the gas network	0%	0%	
Average gas boiler efficiency	85%	90%	
Average heat pump coefficient of performance	3.19	3.26	

Notes: See “Box 1: Assumptions regarding the decarbonisation of domestic heating in SBCR” and “Table 2. Regional Growth Scenarios for Gas and Heat compared with energy modelling” in the SBCR energy strategy for further information on the content of biogas injection assumptions.

Table 5: Key modelling outcomes: **Domestic heat technologies in SBCR (2035)**		
	BAU	**ESV**
Proportion of domestic heat energy from low carbon sources	24%	37%
Change in domestic heat carbon emissions	-32%	-52%
Number of domestic heat pumps installed	53,900	78,100
Proportion of homes heated by heat pumps (Air source heat pumps (ASHP), ground source heat pumps (GSHP) and hybrid gas)	16%	24%
Proportion of homes heated from fossil fuel sources	76%	62%
Number of homes heated by heat networks	1,400	12,000
Proportion of homes heated by heat networks	<1%	4%
Proportion of new homes heated by gas, oil, LPG or other fossil fuels from 2025	0%	0%

Notes:

- Radiant electric heating is considered a low carbon heat source before 2035 in both the BAU and ESV scenarios due to decarbonised electricity supply.
- Baseline heating technology numbers were evaluated from a range of datasets, including MHCLG Energy Performance of Buildings Data (2), Welsh Housing Condition Survey (3), Census data (14), BEIS Renewable Heat Incentive statistics (15), and BEIS gas connections estimates (16).

Table 6: Key modelling outcomes: **Domestic energy efficiency in SBCR (2035)**		
	BAU	**ESV**
Number of homes in SAP band A, B, C & D	N/a*	327,415
Number of homes in SAP band E, F & G	N/a*	3,969
Number of thermal efficiency measures installed in homes	58,140	100,424
Change in thermal energy demand of homes	-12%	-18%

Notes:

- *Not projected; SAP band (or Energy Performance Certificate (EPC)) ratings are illustrative only. Thermal energy demand of homes is the key thermal variable. The key modelling variable with regards to domestic energy efficiency is the gross thermal energy demand of homes.
- The number of thermal energy efficiency measures installed in homes in the BAU and ESV is estimated by reviewing efficiency recommendations and their resulting energy savings published on EPC certificates.

Table 7: Key modelling outcomes:
Domestic electricity consumption (non-heat) in SBCR (2035)

	BAU	ESV
Change in domestic non-heating emissions	-69%	-77%
Change in electric cooking energy	56%	88%
Change in appliance energy consumption	-4%	-39%

Notes:

- Non-heating domestic energy consumption predominantly comprises of appliances, gas cooking and electric cooking. Projections on appliance and cooking consumption are derived from the National Grid Future Energy Scenarios (27).
- While the home charging of electric vehicles (EVs) could be categorised as a domestic energy consumption, it is modelled and accounted for in the transport section.

2.2 Commercial and industrial energy consumption

Table 8: Key modelling assumptions:
Commercial and industrial (C&I) energy consumption in SBCR (2035)

	BAU	ESV	Sources
Estimated change in coal energy consumption	-15%	-29%	29
Estimated change in petroleum energy consumption	-15%	-30%	29
Estimated change in gas energy consumption	-3%	-16%	27
Estimated change in electricity energy consumption	-2%	-7%	27

Notes:

- Without more local data evidence, change in coal and petroleum energy consumption within the scope of the commercial and industrial sector is modelled on CCC's Central scenario for the Fifth Carbon Budget (29). This is an area that can be built on with local studies, such as through the work of the South Wales Industrial Cluster (SWIC).
- Estimated electricity and gas energy consumption projections are unique to the region, but modelled on an accelerated trend seen in the ESO FES scenarios (27).

Table 9: Key modelling outcomes:
Commercial and industrial (C&I) energy consumption in SBCR (2035)

	BAU	ESV
Change in energy consumption	-5%	-14%
Percentage of total C&I emission reduction that results from electricity consumption	88%	77%
Percentage of C&I decarbonisation that arises from reducing the electricity carbon factor	-42%	-72%

Notes: The BAU scenario has a higher percentage of emission reductions that result from electricity consumption since emission reductions from other fuels are less.

2.3 Road transport

Table 10: Key modelling assumptions: **Electric vehicle efficiency**			
	2017	**2035**	**Source**
Electric buses & coaches (miles/kWh, including vehicle and charging efficiency)	0.59	0.83	Calculated, based on 19-20
Electric cars (miles/kWh, including vehicle and charging efficiency)	2.9	4.08	22
Electric heavy goods vehicles (miles/kWh, including vehicle and charging efficiency)	0.43	0.61	Calculated, based on 19-20
Electric light goods vehicles (miles/kWh, including vehicle and charging efficiency)	1.92	2.70	22
Electric motorbikes (miles/kWh, including vehicle and charging efficiency)	4.02	5.66	Calculated, based on 19-20

Notes:

- Efficiency assumptions are consistent across both the BAU and ESV scenarios
- Calculated figures are based on a combination of published manufacturer efficiencies and fuel consumption calculations (Sources 19 and 20).
- The efficiency figures above include vehicle efficiency, in addition to charger efficiency.
- Vehicle usage and behaviour insights were gained from the UKPN Recharge the Future (23) and WPD Electric Nation (24) EV charging trials.

Table 11: Key modelling outcomes: **Road transport in SBCR (2035)**		
	BAU	**ESV**
Change in private vehicle mileage assumption	0%	-10%
Number of pure electric vehicles (incl. cars, motorcycles, LGVs, HGVs, buses & coaches)	67,244	343,179
Proportion of all vehicles that are electric	14%	77%
Change in road transport emissions	-10%	-52%
Proportion of cars that are pure electric	16%	89%

Notes:

- The 10% reduction in private vehicle mileage target was agreed with stakeholders at the region's consultation workshops. This percentage is less than the reduction in other regions, which has resulted in more EVs in the SBCR Energy Vision by 2035.
- Baseline vehicle numbers were evaluated from a range of DfT vehicle licencing statistics and related datasets (19-21) and SMMT vehicle registration statistics (26).

2.4 Electricity generation

Table 12: Key modelling assumptions: **Renewable electricity load factors (2035)**

	BAU and ESV	Source
Anaerobic digestion	66%	30-31
Biomass electricity and CHP	66%	
Hydropower (large-scale)	20%	
Hydropower (small-scale)	32%	
Landfill gas	47%	
Offshore wind	33%	
Onshore wind	27%	
Sewage gas	40%	
Solar PV	11%	
Nuclear	91%	
Energy from Waste	66%	
Tidal stream	40%	
Wave	50%	
Tidal lagoon	19%	

Notes:

- Where possible, a 5 year average load factor has been calculated from DUKES load factors (30) and BEIS renewable generation data (31) to represent an average load factor.
- Renewable electricity average load factors were calculated in 2019 and may have changed in the interim period.

Table 13: Key modelling outcomes: **Electricity generation in SBCR (2035)**

	BAU	ESV	Source
Proportion of electricity demand met by local low carbon electricity generation (including electric vehicle demand)	62%	149%	n/a
Electricity carbon intensity	62 grams CO_2 per kWh	30 grams CO_2 per kWh	27
New renewable electricity capacity	519 MW	2,408 MW	n/a

Notes:

- See “Box 3: A note on grid carbon factors” in the SBCR energy strategy for more information on electricity grid carbon factors.
- Baseline electricity capacity figures were primarily evaluated from the Welsh Government’s Energy Generation in Wales 2019 report (9). Additional data and more granular insights were gained from a variety of sources (4-8, 10-13).

3. Data sources and references

Source	Reference	Category
1	BEIS, 2018. Sub-national energy consumption statistics	Energy system baseline
2	MHCLG, 2018. Energy Performance of Buildings Data: England and Wales	Energy system baseline
3	Welsh Government, 2018. Housing Condition Survey	Energy system baseline
4	BEIS, 2019. Feed-in Tariff Quarterly Reports	Energy system baseline
5	BEIS, 2019. Renewable Heat Incentive statistics	Energy system baseline
6	BEIS, August 2018. Renewable Energy Planning Database	Energy system baseline
7	Ofgem, 2019. ROC Register Public Reports	Energy system baseline
8	Ofgem, 2019. REGO Register Public Reports	Energy system baseline
9	Welsh Government, 2019. Energy Generation in Wales	Energy system baseline
10	Western Power Distribution, 2019. System Wide Resource Register connection offer data	Energy system baseline
11	EMR Delivery Body, 2018. Capacity Market registers	Energy system baseline
12	Carbon Trust, December 2018. Future potential for offshore wind in Wales	Energy system baseline
13	National Grid ESO, TEC register	Energy system baseline
14	Office for National Statistics, 2011. Census data	Energy system baseline
15	Ofgem, 2019. Renewable Heat Incentive Freedom of Information Request for project information.	Energy system baseline
16	BEIS, December 2019. LSOA estimates of properties not connected to the gas network	Energy system baseline
17	Regen, Wales and West Utilities, January 2019. Regional Future Energy Scenarios for Gas	Energy system baseline
18	Regen, 2019-2020. Net Zero South Wales 2050	Energy system baseline
19	Department for Transport Vehicle, December 2018. Licensing statistics: Tables VEH0132b, VEH0132c, VEH0132, VEH0130, VEH0105, VEH0101, TRA8902, VEH0124, VEH0150	Energy system baseline

20	Department for Transport, July 2013. Vehicle mileage and occupancy	Energy system baseline
21	Department for Transport, October 2019. Bus statistics	Energy system baseline
22	WhatCar, February 2020. Fuel economy research	Energy system baseline
23	UK Power Networks, May 2019. Recharger the Future	Energy system baseline
24	Western Power Networks, 2018. Electric Nation charging data	Energy system baseline
25	Department for Transport, November 2018. TAG Data Book	Energy system baseline
26	SMMT, 2019. EV and AFV registrations	Energy system baseline
27	National Grid ESO, 2019. Future Energy Scenarios	Energy modelling scenarios
28	Welsh Government, 2017. Household projections for Wales	Housing projections
29	CCC, 2015. Sectoral scenarios for the Fifth Carbon Budget	Energy modelling scenarios
30	Dukes, 2019. Load factors for renewable electricity generation (DUKES 6.5)	Generation estimates
31	BEIS, 2019. Renewable electricity by local authority, 2014 to 2019	Generation estimates
32	BEIS, 2018. Greenhouse gas reporting: conversion factors 2018.	Emission estimates
33	DEFRA, 2018. GHG conversion factors	Emission estimates
34	BEIS, 2019. Sub-national total final energy consumption data.	Emission baseline

Disclaimer

The Welsh Government Energy Service ("**WGES**") is funded by the Welsh Government with the aim of developing energy efficiency and renewable energy projects that contribute to public sector decarbonisation and national energy targets. The WGES is delivered by the Carbon Trust, Energy Saving Trust and Local Partnerships (the "**Delivery Partners**"). This report (the "**Report**") has been produced by the Delivery Partners and, whilst the views expressed in it are given in good faith based on information available at the date of this Report:- (i) these views do not necessarily reflect the views of the Welsh Government, which accepts no liability for any statement or opinion expressed in the Report; (ii) the Report is intended to provide general guidance only, rather than financial, legal or technical advice for the purposes of any particular project or other matter, and no-one in receipt of the Report should place any reliance on it in substitution for obtaining their own advice from an appropriate third party advisor; and (iii) any person in receipt of this Report should therefore obtain their own financial, legal, technical and/or other relevant professional advice insofar as they require specific guidance on what action (if any) to take, or refrain from taking, in respect of any project, initiative, proposal, involvement with any partnership or other matter to which information contained in the Report may be relevant; and (iv) the Delivery Partners accept no liability in respect of the Report, or for any statement in the Report and/or any error or omission relating to the Report