South Wales Net Zero 2050

Socio-economics
Final report

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Ove Arup & Partners Ltd
63 St Thomas Street
Bristol BS1 6JZ
United Kingdom
www.arup.com

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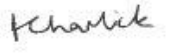
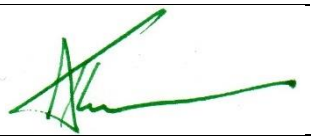
		Signature	-		
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1 Executive Summary

As South Wales moves towards decarbonisation, we must consider the socio-economic impacts of this transition. This report provides a baseline understanding of the socio-economic context, offers scenarios as to how it may change in the future, and details the potential impact of future, decarbonised energy system.

The socio-economic baseline illustrates a high-level summary of the analysis undertaken for South Wales Net Zero 2050 in 2019. It highlights the importance of South Wales and the Cardiff Capital region to the total Welsh economy, the growing Gross Value Added (GVA) in the manufacturing sector, and an increase in jobs primarily in the finance, property, science, and engineering sectors.

We demonstrate three plausible development pathways for South Wales, which differ in terms of their economic growth rate and energy demand. This informs the energy modelling, whose outputs show the characteristics and variation between socio economic scenarios.

The characteristics of an optimised energy system that are common to each plausible future forms the basis of the job creation opportunity analysis, which highlights the potential job creation opportunities for different parts of the energy system, including generation, storage, transmission & distribution, and efficiency measures.

The modelled costs of energy prices for a decarbonised energy system suggests that electricity prices would likely be lower in 2050 than today, whereas the energy costs for heating would likely increase. Whilst energy bills might be similar, significant capital investments by households will be needed to change heating systems and improve energy efficiencies, which come with significant upfront costs which may require government intervention in the form of grants or other incentives.

This report stresses that all actors, including government, business, non-governmental organisations (NGOs), and individuals have a role to play in supporting a *Just Transition.* A key role for Welsh Government is to set an enabling framework to capture the jobs and economic benefits associated with the transition, whilst mitigating the risks. Further work would be required to understand the roles, responsibilities, capacities and dependencies of each actor.

2 Introduction

2.1 Introduction to Zero 2050

Zero 2050 is a collaborative project to consider how we can achieve net zero greenhouse gas emissions for the whole energy system in South Wales. With the energy system contributing to the vast majority of greenhouse gas emissions in Wales, this work has implications for reaching Wales' carbon budgets and avoiding the worst impacts of future climate change.

This project aimed to consider plausible pathways to a net zero energy system in 2050, developing an evidence base for decision making and testing collaborative methodologies. We aimed to identify low regrets options, and to identify areas of particular sensitivity.

To achieve these aims, Zero 2050 brought together partners across a series of work packages, including energy utilities, Welsh Government and other public and private sector representatives.

2.2 The purpose and structure of this report

As we move towards net zero, the concept of a *Just Transition* is critical to make sure that nobody is left behind and that we maximise on the wider benefits of this transition. To this end, it is critical to understand the local context in which a future energy system will apply and to consider opportunities to maximise socio-economic benefits and reduce risks.

This report provides an understanding of the socio-economic baseline in South Wales, provides scenarios as to how the economy of South Wales might change in the future, and describes the potential socio-economic impacts of the future energy system on the people and economy of South Wales.

3 Socio-economic baseline

Overview

This section provides an overview of the socio-economic baseline, including population changes, employment mix and the changes in the business sector. This is a high-level summary of the socio-economic analysis baseline undertaken in 2019[1].

Population

Apart from Blaenau Gwent, all local authorities in South Wales have experienced population growth in the past 30 years. Furthermore, the number of households has also risen steeply, driven primarily by more people living alone, and an aging population[2].

GVA

On a Gross Value Added (GVA) per capita basis, in 2018 Wales was placed second from bottom of the 12 regions of the UK, just ahead of the North East of England[3]. One reason for this is that many residents commute to English towns and cities for higher paid work. However, unlike many other places in the UK, the GVA of the manufacturing sector continues to grow. For example, between 2000 and 2017 the GVA of the manufacturing sector fell by 17% in real 2000 prices, but in Wales it grew by 6%[4]. A significant proportion of Welsh manufacturing output is exported overseas. This creates threats as well as opportunities, as highlighted by the industrial job losses announced in 2019, e.g. Hi-Lex, Liberty Steel, Triumph Furniture, Orb Electrical Steels and Ford Bridgend[5].

Focusing on South Wales, in 2018 it generated approximately 73% of the UK average GVA, contributing more per capita than mid and North Wales. The importance of South Wales to the Welsh economy is emphasised in the Top 300 Businesses in South Wales report prepared by Wales Online and the University of South Wales whereby turnover of 90% of those Top 300 businesses in Wales are based in South Wales[6]. The Cardiff Capital Region alone accounts for more than 50% of the total Welsh turnover.

Employment

On an employment level, between 2001 and 2017 the Welsh workforce rose by 180,000 people to 1.47 million in 2017. More than half of the 180,000 has been in public sector jobs

[1] Arup for National Grid Electricity Transmission, *Part I: Socio-economic analysis baseline*, April 2020. Note that this analysis was undertaken before Covid-19 and therefore does not attempt to assess the implications of Covid-19

[2] https://statswales.gov.wales/Catalogue/Population-and-Migration/Population/Estimates/Local-Authority/populationestimates-by-localauthority-age

[3] Office National Statistics. Regional gross value added (balanced) per head and income components. Accessed at: https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalregionalgrossvalueaddedbalancedperheadandincomecomponents

[4] https://statswales.gov.wales/Catalogue/Business-Economy-and-Labour-Market/Regional-Accounts/Gross-Value-Added-GDP/gross-value-added-gdp-gva-by-welshnuts3areas-industry
https://gov.wales/sites/default/files/statistics-and-research/2018-12/181031-workplace-employment-industry-2001-2017-en.pdf

[5] https://www.bbc.co.uk/news/uk-england-51049906, https://www.bbc.co.uk/news/uk-wales-50068988, https://www.walesonline.co.uk/news/wales-news/tata-orb-newport-close-wales-16851654, https://www.bbc.co.uk/news/uk-wales-49977014, https://www.bbc.co.uk/news/uk-wales-47089571

[6] https://www.business-live.co.uk/economic-development/wales-top-300-2019-biggest-17396726

and the other half in the finance, property, professions, science and engineering sectors. Despite its growth in GVA, the manufacturing sector has suffered job losses in this period[7].

High-level overview of the economic impact of Covid-19 on Wales

As a result of Covid-19, fewer local and regional statistics have been prepared, but in February 2021 the Welsh employment rate was 73.2%, 0.8% lower than in February 2020. The Welsh unemployment rate has also increased from 3.7% in February 2020 to 4.8% in February 2021[8].

4 Future socio-economic scenarios

Overview

In order to enable us to think about how the energy system in South Wales might need to adapt to respond to a range of economic futures, we developed three future socio-economic scenarios. Each of these contained some common features, in addition considering areas of uncertainty, which drive the different scenarios.

Future trends with a level of certainty

There are three main demographic changes projected for Wales by the Office of National Statistics in the next 30 years. These are:

- A declining population. In 2018 the Office for National Statistics (ONS) revised its population projections for Welsh population decline from 2024 onwards. This will be the first time in a century the Welsh population is projected to decline, principally because of declining fertility[9]. By extrapolating ONS's 2018-2043 projections to 2050, by 2050 only three local authorities (Bridgend, Newport and the Vale of Glamorgan) will still be growing.
- An increasingly ageing population. Although there will be fewer under 16s, there will be more over 65s such that the dependency ratio (ratio of under 16s and over 65s to the population of working age) will have reached 69%, compared to 63% for the UK[10].
- Even though the population overall will be shrinking, due to the gentrification of the population there will be more single people living at home, increasing the number of households across South Wales by about 10% from 963,000 in 2018 to 1,058,000 in 2043[11].

[7] Welsh Government (2018) Workplace employment by industry in Wales, 2001 to 2017. https://gov.wales/sites/default/files/statistics-and-research/2018-12/181031-workplace-employment-industry-2001-2017-en.pdf
[8] Welsh Government. *Labour Market Overview, April 2021*. 22 April 2021 accessed at https://gov.wales/sites/default/files/statistics-and-research/2021-04/labour-market-overview-april-2021-627.pdf
[9] https://statswales.gov.wales/Catalogue/Population-and-Migration/Population/Projections/Local-Authority/2018-based/populationprojections-by-localauthority-year
[10] https://www.ons.gov.uk/file?uri=/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/tablea25principalprojectionwalespopulationinagegroups/2018based/previous/v1/wapppsumpop18.xls
[11] https://statswales.gov.wales/Catalogue/Housing/Households/Projections/Local-Authority/2018-based/householdprojections-by-localauthority-variant-yea

Uncertainty and future scenarios

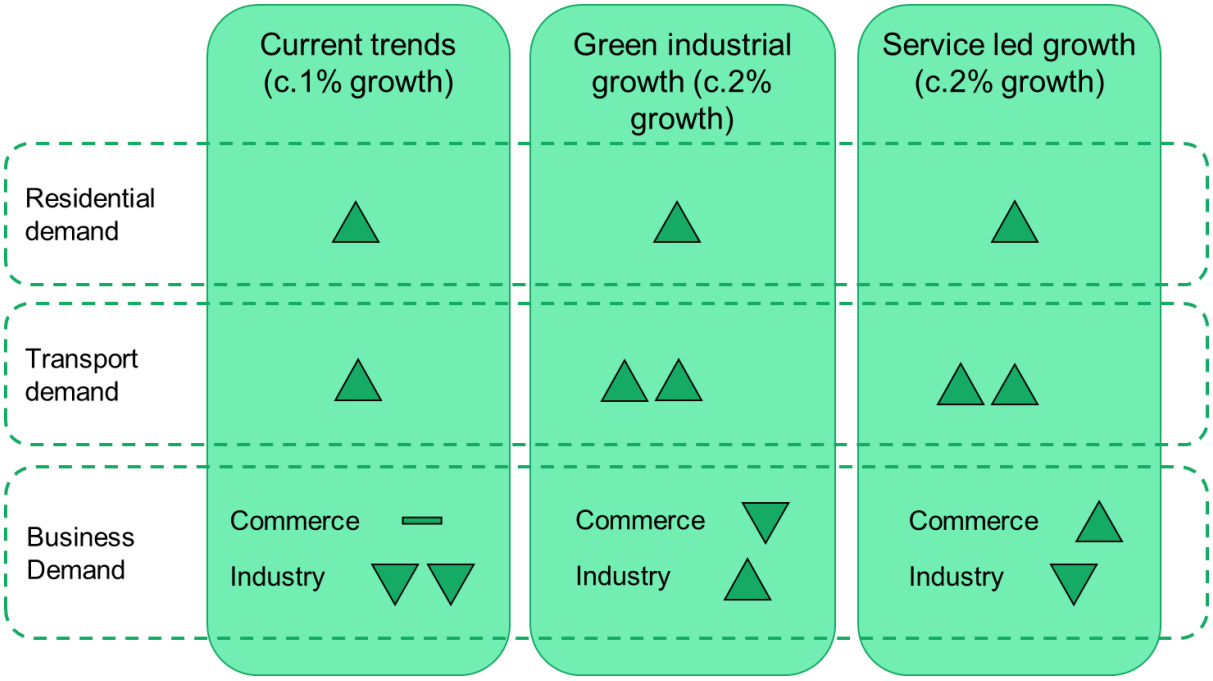
In order to account for uncertainty in the future economic development of South Wales, the project considered three different scenarios, representing distinct, plausible future economic development pathways. The details of these scenarios are shown below in Figure 1 overleaf. All scenarios indicate the energy demand (MWh) before energy efficiency savings.

The three scenarios consist are described as:

1) **Current trends** with an economic growth rate of 1%, an increase in commercial and transport energy demand, and a significant reduction in the manufacturing capacity;
2) **Green industrial growth** with an economic growth rate of 2%, an increase in transport and industrial energy demand, but a reduction in commercial energy demand; and
3) **Service led growth** with the same economic growth rate of 2%, and with increasing commercial and transport energy demand but with a decrease in industry energy demand.

Annex 1 to this report provides a narrative of what South Wales could look like in 2050 in the three scenarios.

Figure 1: Economic scenarios – growth and energy demand before efficiency savings



5 Summary of energy system

Introduction

Modelling a complex energy system and its pathways to net zero cannot deliver a single result. The project has identified a range of pathways that are consistent with the governments net zero target by 2050.

What might the 2050 energy system look like in South Wales?

South Wales' future energy system will comprise a higher level of renewable energy, dominated by onshore wind and solar, backed up by dispatchable power and imports.

Domestic and commercial properties will have achieved significant efficiency improvements, and heat will likely be provided by a combination of hydrogen (in boilers and hybrid systems) and electricity (heat pumps), depending on the availability of alternative energy sources and constraints that haven't been modelled, including space and consumer preference.

Industrial demand will decarbonise by fuel switching (to hydrogen) and electrification, reducing demand for natural gas, and increasing demand for both hydrogen and electricity.

Transport demand will largely be met by electricity (for cars, which are the biggest proportion), with a range of sources for other transport modes.

The balance between local dispatchable power in South Wales and reliance on imports from the rest of the UK electricity system will be determined by multiple factors, including cost.

Energy system characteristics and variation between cases

Figure 2 presents an overview of the energy system elements and how they vary across the cases tested in the Zero 2050 modelling. The energy system that can meet the demand of each of the socio-economic scenarios looks broadly similar, with slightly less energy generation required in the "Current trends" scenario to meet a reduced energy demand from industry.

Element of energy system	Consistent across all cases	Variation between cases
Electricity generation	**Onshore renewables** including wind and solar, and offshore wind, provide the majority of electricity	Greater **dispatchable electricity technology** capacity if imported electricity not available Selection of dispatchable technologies will be determined by multiple factors including required load factor and cost Dispatchable technologies modelled include nuclear small modular reactors and hydrogen CCGT
Networks	**Existing networks** are reused where possible, local energy generation is preferred	
Energy storage	**Hydrogen storage** in salt caverns (longer term, larger scale) and tanks (shorter term, smaller scale) is the preferred energy storage mode	**Greater amounts of storage** are required when South Wales has no imported electricity **Batteries** provide additional storage in times of low renewable electricity availability
Hydrogen production	A mix of production technologies could be used to produce green and blue hydrogen Hydrogen production by **electrolysis** is preferred in 2050, although there is use of **blue hydrogen** in 2030 as a transitional fuel	When hydrogen fuels domestic heat demand, **more electrolysis and imports** are used to meet this demand
Domestic and commercial energy demand	Energy **demand is reduced** through housing retrofit and efficiency measures The majority of heating is provided by heat pumps, hydrogen boilers and hybrid systems, supported by limited resistance heating and biomass	There is potential to meet the majority of heat demand using either heat pumps or hydrogen boilers with heat pumps in off-gas grid locations, or a combination of technologies
Industrial energy demand	Energy **demand is reduced** through efficiency measures A combination of electricity and hydrogen is used to meet demand	
Transport energy demand	Transport energy demand is mostly met through **electrification**, with hydrogen, ammonia and synthetic fuels providing energy to modes including rail, freight, shipping and aviation	

Figure 2: Variations between cases

The interventions that are common across all cases are the focus of the job creation opportunities section below.

6 Job creation opportunities

6.1 Introduction

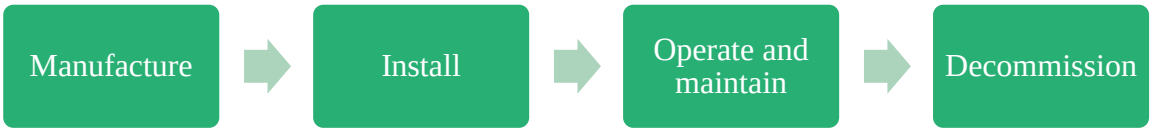
As set out in section 4, we've developed multiple sensitivity cases, each presenting a different energy future, but there are many elements that we expect to see in all cases.

There are challenges to assessing the job opportunities associated with the future energy system and this section provides a narrative to explore the potential opportunities for these consistent components.

6.2 Specific energy related opportunities

For the energy related opportunities an attempt is made to estimate the job creation opportunities that could arise in South Wales. For many job creation estimates, it is difficult to comment on the location of jobs. For example, tradespeople might travel into South Wales for the installation of air source heat pumps, and other building retrofit measures, whilst job estimation factors for manufacturing of key products might be higher than average due to multiplier effects of a strong manufacturing base in Port Talbot and Newport.

Jobs will be created for each of the phases of manufacturing the assets required, installing the assets, operating and maintaining the assets and removing or decommissioning the assets; as shown in the infographic.



Depending on where one is in the lifecycle, the job creation and GVA will vary depending what is involved, and how much is imported from outside South Wales. For example, most parts of wind turbines are sourced from outside South Wales, but there could be opportunities for building the steel towers of wind turbines.

These jobs are created across the whole energy system including:

- **Energy generation** – jobs from manufacturing the electricity generators, installing, maintaining and operating the energy generation equipment, e.g. wind turbines, solar farms, anaerobic digesters;
- **Energy storage** – jobs from manufacturing the storage solution (batteries, compressed air, hydrogen, hydropower dams, flywheels, etc) and the operation of the stores;
- **Energy transmission and distribution** – the upgrades to pipes, cables, overhead lines, switch-gear, transformers, etc;
- **Energy balancing services** - National Grid is responsible for balancing the Great Britain electricity system and for acting as the 'residual balancer' for the gas network of Great Britain. However, Western Power Distribution Ltd. (the electricity Distribution Network Operator (DNO) for South Wales), is transitioning to become a Distribution Service Operator which will require it to operate the distribution network as efficiently as possible using active network management to avoid, where possible, large grid investments;

- **Energy efficiency measures** - these include manufacturing energy efficient products and insulation materials, and then installing them;
- **Changing fuel uses** - for example, for the steel industry to transition be able to burn hydrogen instead of coke it will need to invest in different types of furnaces. To transition to hydrogen heating, new types of hydrogen compliant boilers will be needed, and to transition to heat pumps not only will heat pumps need to be installed but the 'wet' heating system in properties may need to be upgraded with larger radiators to accommodate the lower flow temperatures of heat pumps. All these transitions will be costly, but necessary.

As well as job creation, there will also be job losses or the displacement of existing jobs with new economic activity. For example, the UK Government has announced it is banning all new petrol and diesel cars from 2030 and all new hybrids from 2035. As another example the IEA has just released a report recommends that no new domestic gas boilers are built from 2025 onwards[12].

6.2.1 Onshore renewables

Compared to large gas fired power stations per megawatt (MW), wind farms generate more jobs. There is a wealth of research into the job creation opportunities with different technologies but obtaining comparison across different technologies is difficult as there are many metrics presented. For example, there are the **direct jobs** created (for instance the actual workforce who erects a wind turbine), the **indirect jobs** created (the extra jobs created by the tools and components the workforce use, i.e. additional supply chain jobs) and the **induced jobs (**as a result of the spending by the workforce of the extra direct and indirect jobs in shops). However, there is then a need to consider the **net jobs** created. For example, if unemployment is low the extra jobs installing solar panels may mean the roofer then doesn't fix roofs in the area – i.e. some jobs have been displaced. Finally, at all stages in the process there is **leakage**, i.e. the extra jobs are created, but created in another location. For instance, the wind turbine blades may come from the Netherlands or Denmark.

The Energy Watch Group, working with Lappeenranta University of Technology in Finland produced a detailed report into the potential for global Net Zero with estimations for the number of **direct jobs** created at different stages of a renewable project and over the lifetime of the project, with information shown in **Table 1**. Usefully all the information is on a consistent basis.

[12] IEA. *Net Zero by 2050 A Roadmap for the Global Energy Sector.* May 2021. Accessed at: https://iea.blob.core.windows.net/assets/0716bb9a-6138-4918-8023-cb24caa47794/NetZeroby2050-ARoadmapfortheGlobalEnergySector.pdf

Table 1: Lappeenranta University of Technology and Energy Watch Group direct job creation per MW for selected renewable, non-renewable and storage technologies

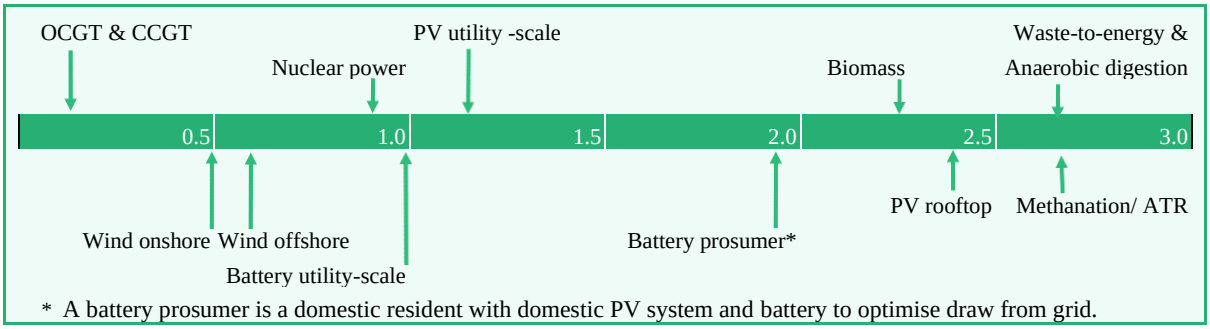
Technologies	Manufacturing [Job-yrs/MW]	Installation [Job-yrs/MW]	Operation& Maintenance [Jobs/MW]	Decommissioning [Job-yrs/MW]	Lifespan [years]	Average [Jobs/MW]	
						With manufacturing	Without manufacturing
Renewables							
Wind onshore	4.7	3.2	0.3	0.7	25	0.6	0.5
Wind offshore	15.6	8.0	0.2	3.0	25	1.3	0.6
PV utility-scale	6.7	13.0	0.7	0.8	30	1.4	1.2
PV rooftop	6.7	26.0	1.4	1.2	30	2.5	2.3
Biomass	2.9	14.0	1.5	0.3	25	2.2	2.1
Biogas (Anaerobic Digestion)	2.9	14.0	2.3	0.3	30	2.8	2.7
Non-renewable							
Waste-to-energy	2.9	14.0	2.3	0.3	30	2.8	2.7
Methanation	2.9	14.0	2.3	0.3	30	2.8	2.7
Nuclear PP	1.3	11.8	0.6	1.0	40	1.0	0.9
OCGT	0.9	1.3	0.1	0.2	35	0.2	0.2
CCGT	0.9	1.3	0.1	0.2	35	0.2	0.2
Gas Storage	0.0	0.1	0.0	0.1	30	0.0	0.0
Waste-to-energy	2.9	14.0	2.3	0.3	30	2.8	2.7
Storage							
Battery utility-scale	16.9	10.8	0.4	0.8	20	1.8	1.0
Battery prosumer*	16.9	21.6	0.8	1.2	20	2.8	1.9

* A battery prosumer is a domestic resident with domestic PV system and battery to optimise draw from grid.

Source: Lappeenranta University of Technology and Energy Watch Group. *Global Energy System Based on 100% Renewable Energy: Power, Heat, Transport and Desalination Sectors.* April 2019. Accessed at: http://energywatchgroup.org/wp-content/uploads/EWG_LUT_100RE_All_Sectors_Global_Report_2019.pdf

South Wales will be challenged to ever become a global manufacturer of wind turbines or most other renewable generation technologies, but may be able to capture some of the installation, operating and maintenance and decommissioning jobs, i.e. a proportion of the last column in the table which reports the average numbers of **direct jobs** created per technology if one excludes the manufacturing component. Figure 3 summarises this graphically.

Figure 3: Lappeenranta University of Technology and Energy Watch Group average direct job creation per MW per year for installation, operation and decommissioning



6.2.2 Energy efficiency buildings retrofit

The retrofit and refurbishment of existing buildings is crucial if emissions from the buildings sector are to reduce in line with Net Zero targets. Multiple sources have pointed to the economic benefits of building retrofit stimulus packages, particularly as the installation of insulation and retrofitting domestic properties is very labour intensive[13]. For example:

- The New Economics Foundation has modelled ambitious yet feasible building retrofit scenarios averaging c.£12,000 per house which could generate on average 5.5 jobs per 100 houses renovated[14].
- The Construction Leadership Council estimates that 7.2 jobs are created per 100 houses renovated[15].
- Cardiff City Region has developed a Regional Energy Strategy[16] and drawing on research in the United States estimates that every £1m spent on energy efficiency generates approximately 5 more jobs than investing in the existing heavily fossil fuel reliant energy system[17].
- In November 2020, the Welsh Government launched a £20 million Optimised Retrofit Programme (ORP) which in the first year will upgrade at least 1,000 existing social homes through a mixture of new energy efficient materials and technologies. It will

[13] Examples include:
- Decarbonisation of Homes in Wales Advisory Group. *Better Homes, Better Wales, Better World*. Welsh Government. July 2019. Accessed at: https://gov.wales/sites/default/files/publications/2019-07/independent-review-on-decarbonising-welsh-homes-report.pdf
- Allan, J., Donovan, C., Ekins, P., Gambhir, A., Hepburn, C., Reay, D., Robins, N., Shuckburgh, E., & Zenghelis, D. (2020). *A net-zero emissions economic recovery from COVID-19*. Oxford Smith School of Enterprise and the Environment. May 2020. Accessed at: https://www.smithschool.ox.ac.uk/publications/wpapers/workingpaper20-01.pdf
- New Economics Foundation. *A Green Stimulus for Housing: The Macroeconomic Impacts of a UK Whole House Retrofit Programme*. July 2020. Accessed at: https://neweconomics.org/uploads/files/Green-stimulus-for-housing_NEF.pdf

[14] See New Economics Foundation report referred to in footnote above.
[15] Construction Leadership Council (CLC). *Greening Our Existing Homes National retrofit strategy: A consultative document*. December 2020. Accessed at: https://www.constructionleadershipcouncil.co.uk/news/national-retrofit-strategy-consultative-document/
[16] Cardiff Capital Region Energy Strategy, December 2020, https://cardiffcapitalregion.wales/wp-content/uploads/2020/02/item-8-energy.pdf
[17] Garrett-Peltier, H. *Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model*. Economic Modelling. Volume 61, 2017, Pages 439-447. Accessed at: https://www.sciencedirect.com/science/article/abs/pii/S026499931630709X

particularly focus on off gas grid properties. They state "*Evidence shows that for every £1.4 million of investment in the delivery of domestic energy efficiency, 32.6 jobs are created or supported*."[18]

> "Using data from the Climate Change Committee (CCC)'s balanced scenario, our modelling suggests that an additional 12,000 FTE workers will be needed in Wales by 2028, primarily to deliver improvements to existing buildings to reduce energy demand. That represents an increase of around 11% on the current size of the workforce in Wales. Based on current technologies and ways of working, this has the potential to give thousands of people a valuable new career opportunity as we emerge from a time of national crisis."
>
> Construction Industry Training Board. *Building Skills for Net Zero in Wales*. March 2021. Accessed at: https://www.citb.co.uk/media/knskhuch/building_skills_net_zero_wales_summary.pdf

In summary, there is a wide range of estimates of the number of jobs created with energy efficiency measures, but if correctly targeted as a whole house solution, even if it does not provide a financial return to the householder, increasing energy efficiency measures offers many job creation opportunities, opportunities for apprenticeships and can give significant health improvements. Further, most of the analysis of financial returns from an investment are calculated at the level of an individual house, but if properties can be agglomerated this could lead to avoiding the need to upgrade electricity networks and importantly reduce the overall loads on the grid, particularly in the winter when solar insolation is poor.

In the work package 7, high electrification scenario the modelling undertaken assumes that c.£7.2bn is spent on domestic energy efficiency investments by 2030. By 2030 the Welsh Government project that there will be about 1,020,000 households in South Wales, equating to an expenditure of just over £7,000 per property[19]. For more modern houses, the energy efficiency expenditure will be less, for older more draughty properties energy efficiency expenditure will be greater.

6.2.3 Fuel switching - heating

There are two options for how heating might be provided in the modelling undertaken – electrification (predominantly through the installation of heat pumps in domestic properties), or hydrogen (and the associated installation of hydrogen boilers).

The Construction Industry Training Board using data from the Climate Change Committee (CCC)'s *'balanced net zero scenario'* suggests that an additional 2,800 plumbers and HVAC workers will be required in Wales by 2028 primarily for the installation of heat pumps. Translated into the south wales context this amounts to approximately 2,000 installers[20].

In another piece of research, the Welsh Government Energy Service has estimated the impact on gross jobs from low carbon domestic heat in the 'energy system vision' in the Cardiff City Region (CCR) regional energy strategy. They estimate over the period 2020 to 2035, gross

[18] https://gov.wales/social-housing-sector-set-wales-path-decarbonise-thousands-homes-and-boost-green-economic-recovery accessed 15 May 2021.
[19] https://statswales.gov.wales/Catalogue/Housing/Households/Projections/Local-Authority/2018-based/householdprojections-by-localauthority-variant-year
[20] CITB. Building Skills for Net Zero in Wales CITB Industry Insights and Analysis. March 2021. https://www.citb.co.uk/media/knskhuch/building_skills_net_zero_wales_summary.pdf

jobs associated with low carbon heating would be 3,971, with the vast majority of these related to the installation of air source heat pumps[21].

Therefore, there is an opportunity for South Wales to investigate whether it could start making components for heat pumps or the entire units. Research commissioned by BEIS has indicated there are opportunities[22]. There may also be opportunities for companies in South Wales to make some of the components for hydrogen boilers.

6.2.4 Fuel switching - vehicles

As with heating systems, there is a need to transition away from petrol and diesel to low carbon forms of fuel, which will be electric batteries for cars, small vans and fork lift trucks and probably hydrogen for HGVs, long distance buses and coaches and train lines that are not electrified. This move is being accelerated by the UK Government's ban on all new petrol and diesel cars from 2030 and all new hybrids from 2035.

South Wales has historically had an active motor vehicle business but in recent years there have been closures and job losses, e.g. the Ford plant in Bridgend[23], Hi-Lex Cable Systems in Port Talbot[24] and the recent March 2021 announcement there would be job losses at Aston Martin at St. Athan. In April 2021, Toyoda Gosei announced it is putting 207 jobs at risk at its factory in Gorseinon, and Kautex Textron is considering the closure of the plant in Ystrad Mynach.[25] Nevertheless, there remain opportunities for car battery manufacturers and other car parts.

The transition to EVs will mean a dramatic change in the way vehicles are refuelled, and the Welsh Government has already supported 1,000s of EV chargers to be installed in car parks and similar sites across South Wales.

6.2.5 Fuel switching – heavy industry

Whilst there remains some uncertainty as to the level of new infrastructure that will be required, it could be that jobs are generated for building the components needed such as large hydrogen compatible distribution pipes, and South Wales could develop an advantage by being the first to build hydrogen distribution networks. For example, a study completed by Element Energy consultants for Equinor in 2019 argues that hydrogen plays critical role in the decarbonisation of UK industry[26]. They estimate that hydrogen demand from UK industry could reach 115TWh/year by 2050 and would generate a total of 43,000 gross jobs in the total value chain.

[21] Cardiff Capital Region. *Towards and Energy Strategy & Implementation Plan for the Cardiff Capital Report.* December 2020. p.66. Accessed at: https://cardiffcapitalregion.wales/wp-content/uploads/2020/02/item-8-energy.pdf
[22] BEIS. Heat Pump Manufacturing Supply Chain Research Project Final Report. Accessed at:
[23] https://www.bbc.co.uk/news/uk-wales-54267443#:~:text=Ford%20Bridgend%20is%20ending%20production,months%20to%20support%20the%20decommissioning.
[24] https://www.walesonline.co.uk/business/business-news/hi-lex-port-talbot-closing-17092375
[25] https://www.walesonline.co.uk/news/wales-news/toyoda-gosei-close-swansea-gorseinon-20480375 and https://www.walesonline.co.uk/news/wales-news/kautex-textron-ystrad-mynach-jobs-20398114
[26] Element Energy. *Unlocking jobs and GVA whilst reducing emissions in the UK*. 2019. Accessed at: http://www.element-energy.co.uk/wordpress/wp-content/uploads/2019/11/Element-Energy-Hy-Impact-Series-Study-1-Hydrogen-for-Economic-Growth.pdf

7 Domestic and commercial retail energy prices and fuel poverty

Companies and residents in South Wales do not pay the wholesale prices for electricity and gas. Rather they pay the retail prices which are significantly greater than the wholesale prices.

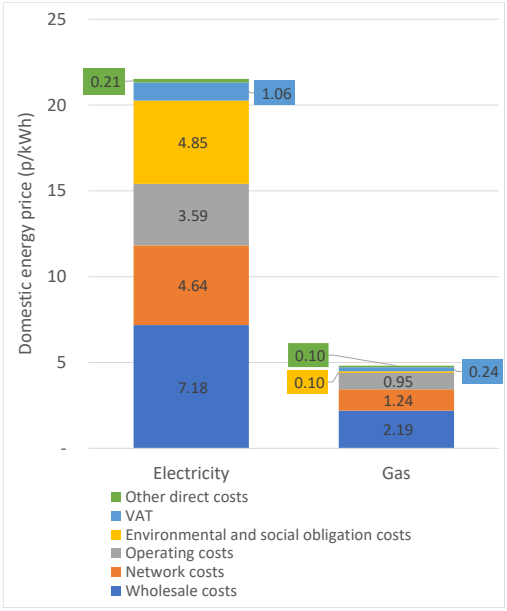
A report from Ofgem April 2021 reports that in 2019 the average domestic energy customer consumed 2,900kWh of electricity at an 'all-in' energy price of 21.1p/kWh and 12,000kW of gas at an 'all-in' energy price of 4.8p/kWh[27]. The 'all-in' energy price is shown by the formula:

$$\frac{\text{Reported tariff (p/kWh) x consumption (kWh) + standing charge (£)}}{\text{Total energy consumption}}$$

Figure 4 presents a breakdown of these prices into the relevant constituents, namely:

- **Wholesale costs** – the costs of purchasing the energy from the electricity generators and gas shippers;
- **Network costs** – the costs to build, maintain and operate the gas pipes and electricity lines;
- **Operating costs** – the costs for energy suppliers to collect billing information and run their businesses;
- **Environmental and social obligation costs** –the costs of publicly supported incentives such as encouraging renewable energy and pay for the social programmes like the Warm Homes Discount;
- **VAT** – 5% on retail prices;
- **Other direct costs** – A very small cost for running the energy trading markets.

Figure 4: Breakdown of an average domestic energy bill of 21.1p/kWh for electricity and 4.8p/kWh for gas



Source:https://www.ofgem.gov.uk/publications-and-updates/infographic-bills-prices-and-profits

7.1 Electricity prices

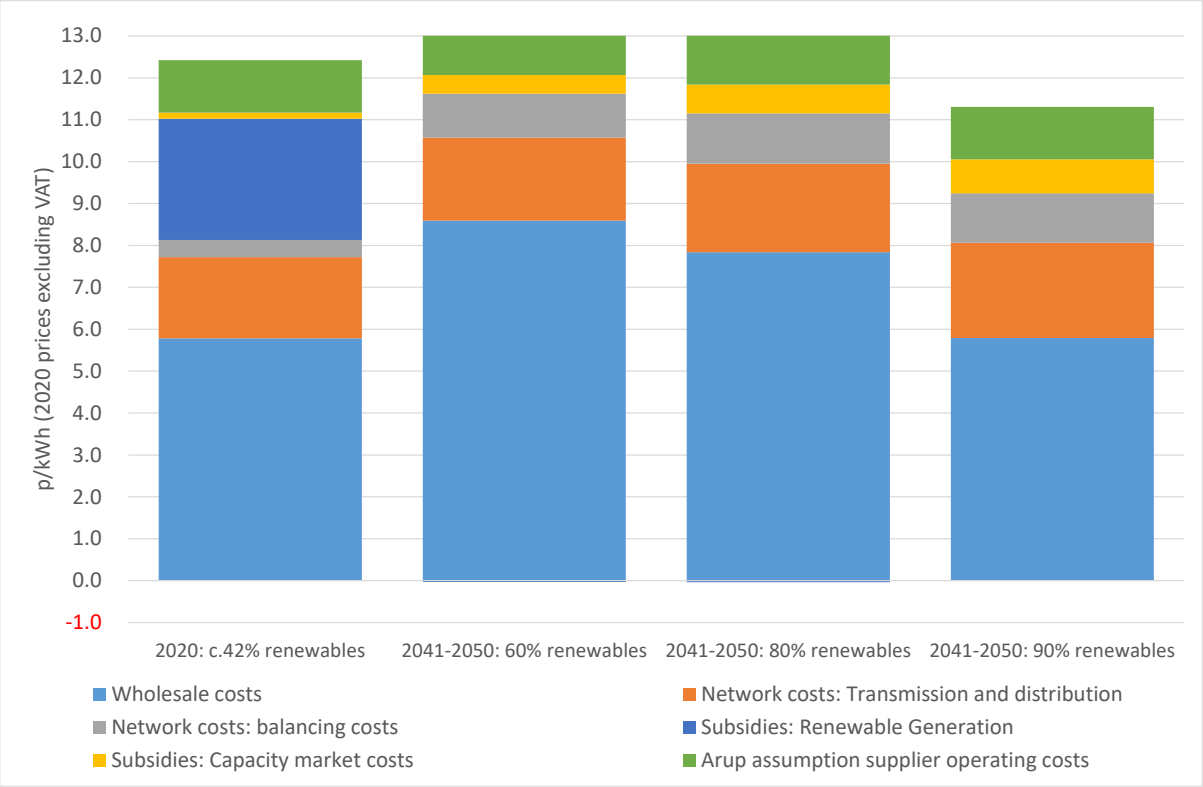
Aurora Energy was commissioned by the National Infrastructure Commission (NIC) to analyse what the impact of changes to the energy system could be for energy customers, i.e. estimating not only the wholesale costs, but also the network costs and the environmental and social costs[28]. They have prepared a number of scenarios analysing how the UK could operate with varying percentages of renewable electricity while all emitting c.2.9MtCO_2 (Million tonnes of CO_2) which equates to c.4.5gCO_2/kWh from the power sector - the "indicative net zero consistent scenario the Committee on Climate Change (CCC) has

[27] https://www.ofgem.gov.uk/publications-and-updates/infographic-bills-prices-and-profits accessed 15 May 2021.
[28] National Infrastructure Commission. *Net Zero: Opportunities for the power sector*. March 2020 accessed at https://nic.org.uk/net-zero-6-march-2020/

allowed"[29]. The remaining balances are met with a mix of nuclear, interconnectors, energy stores, demand side response and natural gas Carbon Capture and Storage (CCS) - i.e. gas fired power stations with post combustion CCS.

Accompanying the report are various models prepared by Aurora Energy[30]. Figure 5 overleaf provides details of the average electricity costs (2020 prices) for three scenarios with 60%, 80% and 90% respectively of renewables (principally wind and solar) averaging electricity prices over the 10 years 2041-2050 to avoid issues in the data in one particular year. Aurora Energy's projections exclude VAT and exclude the costs of the electricity suppliers for running their businesses, invoicing and bill collection. Whilst for domestic customers these operating costs were estimated by Ofgem at c.3.6p/kWh (see Figure 4 above), as the costs cover all consumers (including heavy industry) a value of 1.25p/kWh is

Figure 5: Complete system electricity prices (ex. VAT): 2020 and three 2041-2050 Scenarios with 60%, 80% and 90% of renewable electricity generation each with c.2.9MtCO_2 of carbon emissions (p/kWh - 2020 prices)



Sources: Aurora Energy model for NIC Report *Net Zero: Opportunities for the power sector* accessed at https://nic.org.uk/app/uploads/Aurora-Energy-Research-net-zero-electricity-system-modelling-Annual.xlsx
Ember Press Announcement. *Milestone Reached as Renewables Overtake Fossil Fuels in the UK*. January 2021. Accessed at: https://ember-climate.org/commentary/2021/01/28/milestone-reached-as-renewables-overtake-fossil-fuels-in-the-uk/

[29] Idem, p.13.
[30] https://nic.org.uk/app/uploads/Aurora-Energy-Research-net-zero-electricity-system-modelling-Annual.xlsx

used given that commerce and heavy industry consumes over two thirds of electricity in South Wales[31].

The messages from the NIC report are that:

- It appears that the more renewable electricity generation in the system the lower the wholesale electricity prices could be, but another earlier Aurora Energy report emphasises that at 90% from wind and solar the system will be at risk of loss of load (brown outs) if wind capacity factors fall below 5% in winter – see Figure 5;
- Whilst there will need to be a massive investment into the distribution and transmission grids, as electricity demand will be c.80% higher than at present the investment costs are shared across a much larger demand;
- With 80% or greater renewable energy loads the costs of balancing the network are going to quadruple. As more and more wind farms are built across Britain generators are finding that electricity prices on very windy days are sometimes negative – what is known as cannibalisation. For example, on Easter Monday, 5 April 2021 power prices fell to (-4.5) p/kWh[32]. This issue will become exacerbated, and unless there are sufficient Government incentives wind farm investments will not happen unless the wind farm investors can find a solution to leverage these periods of negative pricing, e.g. generating hydrogen for export. Similarly, very high electricity prices during certain half hours are happening. For example, during a particular half hour on 6 January 2021 wholesale electricity prices exceeded £15/kWh[33];
- Government subsidies for renewable generation are very limited, but there are still subsidies to operate the capacity market (which is akin to the balancing market making sure there is enough generation capacity to reduce the risk of black outs).

Nevertheless, the inference from this modelling is that Aurora Energy's 90% renewables case wholesale costs are modelled at just under 6p/kWh which is higher than the 3.6p/kWh calculated from the Work Package 7 Green Industrial Growth high electrification scenario, but not dissimilar to the 5.4p/kWh in the Green Industrial Growth local energy production scenario.

This being the case, the conclusion is that domestic, commercial and industrial electricity customers could end up paying slightly lower electricity prices than in 2020 (7.18p/kWh), even though the electricity supply has been largely decarbonised. This gives an average annual electricity expenditure of £551 compared to £612 at present per household.

7.2 Hydrogen prices

The NIC's report does not present projections for the costs of hydrogen. The results of the modelling undertaken in Work Package 7 show that in most scenarios, from a wholesale

[31] BEIS. *Sub-national total final energy consumption in the UK (2005-2017).* September 2019. Accessed at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833987/Sub-national-total-final-energy-consumption-statistics_2005-2017.xlsx

[32] https://www.elexon.co.uk/documents/industry-insights/bsc-ops-headline-reports/2021-bsc-ops-headline-reports/bsc-ops-headline-report-reporting-on-march-and-april-2021/

[33] https://www.theguardian.com/business/2021/jan/12/uk-electricity-prices-hit-record-level-as-britains-big-freeze-looms#:~:text=The%20UK's%20market%20price%20for,levels%20of%20renewable%20energy%20generation

market perspective, it will be more cost effective to electrify domestic heat than use hydrogen.

For hydrogen required by industry the modelling has calculated that on-site electrolysis using electricity from the grid (thereby allowing hydrogen demand to be varied constantly throughout the day) appears more cost effective than gas reformation, however the modelling assumed a constant efficiency for the electrolyser which may not be the case with fluctuating use.

Further analysis is warranted to investigate the likely commercial models involved in hydrogen delivery. For example, the benefits of agglomeration of hydrogen demand and storage, drawing from balanced renewable electricity or centralised gas reformation may outweigh the advantages to industry of building hydrogen generation assets on site. This may also support individual industrial users from being responsible for high upfront costs, which could be challenging within their business models.

7.3 Energy costs for heating

By moving to electric heat pumps, the average domestic consumer will be paying slightly more for their heat than the majority of domestic residents who rely on gas central heating. Today the average domestic customer spends about 4.8p/kWh for the 12,000kWh of gas they purchase to secure c.10,800kWh of heat if the gas boiler is 90% efficient. If domestic electricity prices end up being slightly lower than the current Ofgem-reported 21.2p/kWh at say 19p/kWh, then with an air pump Coefficient of Performance of 3, heat will cost about 6.3p/kWh (19p/kWh / 3) or £684 per year, greater than the £572 at the moment.

However, this is before some of the energy efficiency savings in the model. Even without these, combining the lower electricity expenditure from section 6.1 with the cost for heating, the total energy bill will be £1,235 which is slightly higher than the £1,185 at present.

7.4 Fuel poverty

Whilst the analysis shows that with a low carbon energy system, domestic energy bills will be similar to today's prices, over the next 30 years households are going to need to change their heating systems and improve energy efficiency – with significant upfront capital costs.

Finding a way to equitably cover these costs will be a challenge, and may require tax-payer funded Government grants. At c.£30,000 for installing heat pumps and thermal insulation into older properties, if grants were offered to 30% of households in South Wales this could cost the Government c.£9.5bn, a considerable sum considering that in 2020/21 the Welsh Government's budget was £19.9bn[34].

[34] Welsh Government. Final budget 2020/21. Accessed at: https://gov.wales/sites/default/files/publications/2020-02/final-budget-2020-2021-megs.pdf.

8 Conclusions and suggested next steps

8.1 Conclusions

A net zero energy system in South Wales presents exciting opportunities for new jobs and industry. However, a *just transition* won't happen without support, both for businesses who are highly sensitive to energy costs, and for domestic consumers.

Opportunities for new jobs

A number of technologies that appear in all of the future energy cases developed in this project present opportunities for job creation throughout the value chain including in renewables, building retrofit and fuel switching. Additional analysis would be required to develop more detailed projections associated with individual investments.

Energy prices

Overall, by 2050 wholesale costs to the consumer are expected to remain similar to 2020 prices. However, this does not take account of capital costs that would, under the current system, be borne by individual consumers in upgrades to home insulation, heating systems and vehicle upgrades.

Risks to existing jobs

The socio-economic scenarios represent plausible future growth scenarios. These inherently have implications for jobs in South Wales. Furthermore, the cost of energy could have implications for businesses and their viability, particularly for high energy industrial users. As with individuals, supporting the capital costs borne through the transition is likely to be important.

Fuel poverty

Fuel poverty is based on a combination of energy demand, energy prices and income. Energy demand and energy prices could be expected to decrease. There is some uncertainty around income and employment levels, but overall this could mean a reduction in levels of fuel poverty by 2050. This doesn't take account of upfront capital costs that would often be met by the householders.

8.2 Embedding consideration of socio-economic factors into an adaptive approach

More detailed delivery plans will be required in order for us to understand the roles, responsibilities and therefore socio-economic impacts of the future energy system. Government and the public sector, the private sector, individuals and the third sector will all have important roles to play. The combination of roles, investment levels and benefits distribution will all have an impact.

Whilst all actors undoubtedly need to play a role in supporting a *just transition*, government, at all levels, is likely to need to take the lead in setting the framework for preventing the worst inequalities from occurring. Policies and grants can support a transition at the pace required, in a way that is accessible to all.

Annex 1: Contextual description of three scenarios

Current trends

Globally 50% of the world's population now live in countries which have achieved carbon reductions of 80% or more of 1990 emission levels (Europe, Japan, Australia, and the United States) which has created a real global demand for products with low embodied carbon. World temperatures are now at 2.5°C above pre-industrial levels, but projections that this can now slowly fall are promising.

South Wales' transition to a Net Zero energy system has been very challenging and has been achieved against the odds making the UK the fourth country in the world to achieve this status.

Despite there being Government support to a number of heavy industries in the 2020s, global competition and continued low labour productivity has meant that there is little heavy industry left in South Wales, with most companies now either service companies or light industrial assembly and distribution companies. Growth has averaged about 1% per year, and with the rise in automation, the flux of call centres that came to Wales in the 2020s and 30s has been and gone, with AI technology making call centres nearly obsolete.

With carbon taxes at £300/tonne and energy prices being so high 50% of Welsh households now spend more than 10% of their salary on energy bills, with 15% of the population being classified as in Severe Fuel Poverty (20% or more of salary on energy). Like some other peripheral parts of the UK, unemployment rates are at 14%, but with the rebasing of the UK Barnett formula there is more support for the unemployed and these households in Severe Fuel Poverty.

To boost growth the UK Government's brave decision to invest in the Pembrokeshire – Lancashire oil fields carbon pipe, and the upgrade to National Grid's hydrogen trans-Wales hydrogen pipe has breathed new life to Pembrokeshire, with blue hydrogen being produced and distributed across Wales.

Apart from the hydrogen connections from Pembrokeshire to demand centres in the Midlands and the Bristol area, the demise of heavy industry has avoided the scale of electrification upgrades that were talked about in the 2020s.

As a whole, consumers are now much more frugal than they were in the 2020s, and there is much more repair and reuse of buildings, appliances. Residential waste has dropped from the 1½ tonnes per household common in the 2020s to less than ½ tonne by 2050. Welsh people are ever appreciative of our green and beautiful country, and with overseas holidays so expensive Welsh tourism has been massively boosted with Pembrokeshire, the Gower and rural Wales attracting more than 200 million visitors per year, mostly people from other parts of the UK on their staycations. This demand accelerated EV charging point infrastructure across Wales.

Despite continuing to have a GDP per capita less than 75% of the EU average, the efforts to start reforesting much of upland Wales are starting to bear fruit, and seeing the scourge that climate change has created in Southern Europe for the eighth year running, the *Welsh Happiness Index* (*Mynegai Hapusrwydd Cymru*) has increased.

Service Led Growth

Globally 50% of the world's population now live in countries which have achieved carbon reductions of 80% or more of 1990 emission levels (Europe, Japan, Australia, and the United States) which has created a real global demand for products with low embodied carbon. World temperatures are now at 2.5°C above pre-industrial levels, but projections that this can now slowly fall are promising.

South Wales' transition to a Net Zero energy system has been met, and the UK is the fourth country in the world to achieve this status.

Despite there being Government support to a number of heavy industries in the 2020s, global competition and continued low labour productivity has meant that there is little heavy industry left in South Wales. The demise of heavy industry has been offset by a growth in light industrial clusters recycling in what was seen in the 2010s as too dirty or complex into valuable products - with nappy recycling, mattress recycling, electrical appliance repair centres and the Wales East cluster using new technologies to clean and reuse bricks and export these new processes.

But driving most of the growth has been Wales' global niche in Augmented Reality software development, with technology enabled virtual experiences such as swimming alongside Welsh sharks now being regarded by the few that actually dare to risk taking to the waters as nearly as realistic as the real thing…..

The two other main engines of growth have been the expansion of the financial services industry and with overseas holidays so expensive Welsh tourism has been massively boosted with Pembrokeshire, the Gower and rural Wales attracting more than 300 million visitors per year, mostly people from other parts of the UK on their staycations. This demand accelerated EV charging point infrastructure across Wales.

Overall growth has averaged about 2% per year, and South Wales has been able to avoid the high levels of unemployment that the AI automation of call centres created. Wales has moved up from its bottom of league position of Gross Value Added of all the 12 regions of the UK, to now being fourth placed.

With carbon taxes at £300/tonne and energy prices being so high 15% of Welsh households now spend more than 10% of their salary on energy bills, with 4% of the population being classified as in Severe Fuel Poverty (20% or more of salary on energy). Unlike some other peripheral parts of the UK, unemployment rates remain at 5%.

To boost growth the UK Government's brave decision to invest in the Pembrokeshire – Lancashire oil fields carbon pipe, and the upgrade to National Grid's hydrogen trans-Wales hydrogen pipe has breathed new life to Pembrokeshire, with blue hydrogen being produced and distributed across Wales. Electrolyser prices have fallen so much in the last 10 years that green hydrogen production is starting to take hold, and there is now public acceptance that despite the higher costs than Auto Thermal Reformation with the 3% of CO2 losses green hydrogen is the next step forward, avoiding the need for carbon offsetting schemes in Uganda.

Apart from the hydrogen connections from Pembrokeshire to demand centres in the Midlands and the Bristol area, the demise of heavy industry has avoided the scale of electrification upgrades that were talked about in the 2020s.

As a whole, consumers are now more discerning than they were in the 2020s, and there is much more repair and reuse of buildings, appliances. Residential waste has dropped from the 1½ tonnes per household common in the 2020s to less than ½ tonne by 2050.

The efforts to start reforesting much of upland Wales are starting to bear fruit, and seeing the scourge that climate change has created in Southern Europe for the fifteenth year running, the *Welsh Happiness Index* (*Mynegai Hapusrwydd Cymru*) has increased.

Green Industrial Growth

Globally 50% of the world's population now live in countries which have achieved carbon reductions of 80% or more of 1990 emission levels (Europe, Japan, Australia, and the United States) which has created a real global demand for products with low embodied carbon. World temperatures are now at 2.5°C above pre-industrial levels, but projections that this can now slowly fall are promising.

South Wales' transition to a Net Zero energy system has been met, and the UK is the fourth country in the world to achieve this status.

The costly decision by Government to support five industrial clusters in the UK has been successful with South Wales now having more heavy industry than it did in 2000. Manufacturing now contributes 30% of South Wales Gross Value Added, nearly double the 17% contribution in 2017. To understand the scale of the change the South Wales Industrial Cluster which listed 42 members in 2020 met its 100 members target three years earlier than its ambitious 2040 target, and now has 123 members.

Government subsidies to industries all but ended in 2037, following the end of the 10-year World Trade Organisation's allowance of State Aid for Climate Emergency measures, but having a first-mover advantage particular niche products remain cost competitive with similar products produced in Europe. This was in no small part due to the distinctive **Green in Wales™** logo and branding guaranteeing products are net zero. Luckily many of the industrial sites were able to avoid the steep hikes in energy prices by self-generating much of their own power on or adjacent to their factories. With the price premium for energy and greenhouses heated by the low-grade industrial heat now surround many factories growing vegetables that seem a distant memory – like out of season avocados, grapes and even mangos.

Despite the hydrogen revolution, there exists a significant electric battery demand from EV's and domestic, commercial and industrial scale batteries. Wales' semiconductor business remains as strong as ever, with our industries providing some of the high-purity metal content for batteries.

Contributing more than half of the 30% of GVA, light industries have emerged in industrial clusters recycling in what was seen in the 2010s as too dirty or complex into valuable products - with nappy recycling, mattress recycling, electrical appliance repair centres and the Wales East cluster using new technologies to clean and reuse bricks and export these new processes.

Outside manufacturing, the other main engine of growth has been the expansion of the financial services industry and with overseas holidays so expensive Welsh tourism has been massively boosted with Pembrokeshire, the Gower and rural Wales attracting more than 300 million visitors per year, mostly people from other parts of the UK on their staycations. This demand accelerated EV charging point infrastructure across Wales.

Thus, overall growth has averaged about 2% per year, and South Wales has been able to avoid the high levels of unemployment that the AI automation of call centres created. Wales has moved up from its bottom of league position of Gross Value Added of all the 12 regions of the UK, to now being fifth placed.

With carbon taxes at £300/tonne and energy prices being so high 15% of Welsh households now spend more than 10% of their salary on energy bills, with 4% of the population being classified as in Severe Fuel Poverty (20% or more of salary on energy). Unlike some other peripheral parts of the UK, unemployment rates remain at 5%.

To boost growth the UK Government's brave decision to invest in the Pembrokeshire – Lancashire oil fields carbon pipe, and the upgrade to National Grid's hydrogen trans-Wales hydrogen pipe has breathed new life to Pembrokeshire, with blue hydrogen being produced and distributed across Wales. Electrolyser prices have fallen so much in the last 10 years that green hydrogen production is

starting to take hold, and there is now public acceptance that despite the higher costs than Auto Thermal Reformation with the 3% of CO_2 losses green hydrogen is the next step forward, avoiding the need for carbon offsetting schemes in Uganda.

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The efforts to start reforesting much of upland Wales are starting to bear fruit, and seeing the scourge that climate change has created in Southern Europe for the fifteenth year running, the *Welsh Happiness Index* (*Mynegai Hapusrwydd Cymru*) has increased.