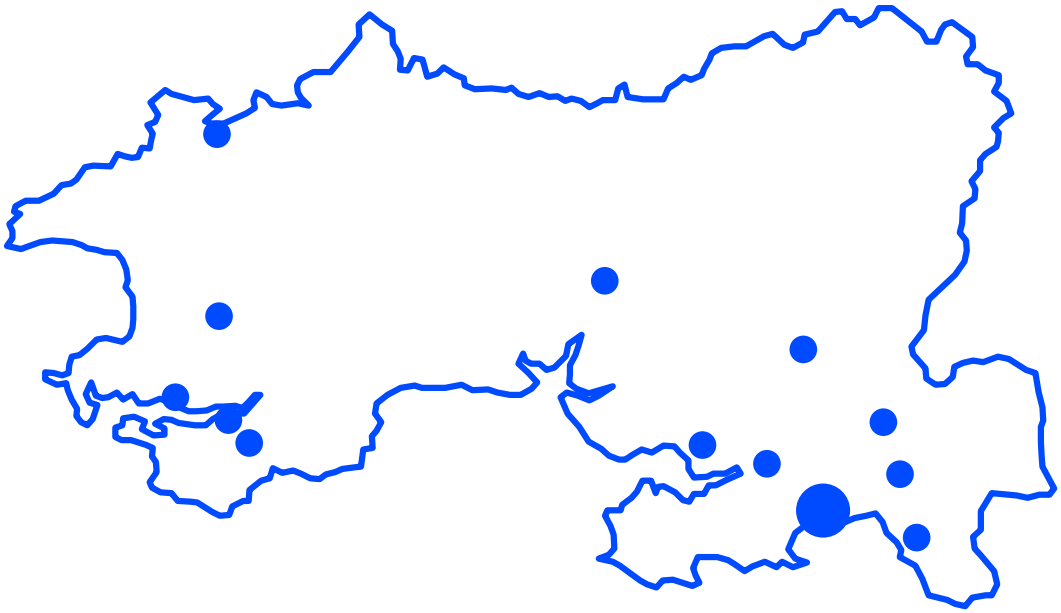
The Economic Impact of Energy Transition in Wales

A Renewable Energy System Vision for Swansea Bay City Region



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About Re-energising Wales

The Institute of Welsh Affairs' 'Re-energising Wales' project is a 3 year project (April 2016-April 2019) that will deliver a plan to enable Wales to meet its projected energy demands entirely from renewable sources by 2035.

The six core workstreams of 'Re-energising Wales' are:

1 Energy Demand

We have **established a framework** to collect and report on operational energy demand data, in order to help collate temporal and geographical data and better understand what drives energy demand.

2 Developing a future energy systems vision

We have used the Swansea Bay City Region (SBCR) as a case study exemplar, **showcasing how the SBCR** can maximise the size and location of its renewable energy resources in order to meet its projected energy demands by 2035. Lessons from this will be applied across Wales.

3 Setting the economic parameters

This report **assesses the investment and economic impacts** of developing a robust, fit-for-purpose and sustainable renewable energy supply.

4 Social and Community Issues

We will assess the values behind community engagement in energy saving and generation, and how to overcome the barriers to increasing local ownership of renewable energy assets.

5 Regulatory and political challenges

We will assess what powers are required for a new renewable energy regime to be implemented well.

6 A delivery plan

We will create a detailed, timed, and costed action plan for developing a credible renewable energy programme for Wales which brings together findings from the project.

The 'Re-energising Wales' project is supported by the Hodge Foundation, the Friends Provident Charitable Foundation and the Polden-Puckham Charitable Foundation.

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Executive Summary

The development of the low carbon Swansea Bay City Region Energy System Vision set out in the Institute of Welsh Affairs' Re-energising Wales report *Swansea Bay City Region: A Renewable Energy Future* would, according to our best current estimates, require around £4.6bn of investment in renewable electricity generation, and £1.2bn in domestic energy efficiency interventions. Other necessary elements, such as the decarbonisation of heat and in grid upgrades, are more difficult to cost.

This investment could support some 4,500 jobs across Wales during a (notional) 15-year investment period, with around £1.66bn in total Welsh GVA created in total. We consider that around 60-70% of this Welsh economic potential could be captured within the Swansea Bay City Region, around 3,200 FTE jobs.

However, in previous 'energy booms' Wales has proved able to capture only a small portion of total economic benefit, usually that related to local labour, some professional services and rental, sales or lease of landscape.

Some of this lack of past economic capture relates to a narrow economic base and lack of locally available skills and relevant companies. Additionally, there is almost no Welsh capital ownership in the energy sector.

In considering energy efficiency investments, the Swansea Bay City Region may indeed hold something of an advantage, with a specialism in innovative domestic energy systems in the 'homes as power stations' project led by SPECIFIC at Swansea University. This cutting-edge project aims to develop the holistic approach needed to address emissions and energy issues – through linking energy efficiency, storage and electrified transport, and involving both the higher education sector and the largest social housing provider in Wales.

Meanwhile, the challenges for local communities in becoming involved in renewable electricity generation have proved significant throughout this millennium. Community renewable energy schemes comprise less than 0.5% of Welsh renewables capacity and the situation is likely to worsen given the changes to reduced UK Government policy support for renewables.

These structural economic issues will, in the absence of a strong and sustained policy intervention aimed at increasing local returns, likely work to reduce Welsh and Swansea Bay City Region economic benefits, such that the numbers presented in this report will be likely unachievable. Without significant changes to the policy, regulatory and financial contexts, the Swansea Bay City Region and Wales more generally are likely to miss out on the majority of economic (and social) benefits from the investment required to move the Swansea Bay City Region, and then Wales, to a renewable, sustainable footing.

In early 2019 the Re-energising Wales project will report on the ways in which this outcome can be avoided. It will deliver a practical plan for Wales to achieve 100% renewable energy by 2035. As is the case with the IWA Re-energising Wales project overall, this document is intended to spark wider discussion and, hopefully, improvement in the sources of evidence and techniques employed.

The numbers presented in this report might be considered an optimistic or best-case scenario, or the scale of the economic opportunity. In order to grasp this opportunity, the Welsh structural economic offer would have to change, and rapidly, from its current narrow focus on relevant natural resources and locally-advantaged labour and services to encompass investment capital, truly Welsh research and innovation (as with SPECIFIC), more higher value services and perhaps even in some cases fabrication and manufacturing.

The Economic Opportunity of the Swansea Bay City Region Energy System Vision 2035

	Renewable Electricity		Domestic Refurbishment		Total	
	Wales	SBCR	Wales	SBCR	Wales	SBCR
Gross Investment (£m)	4,640	-	1,160	-	5,800	-
Spending in Wales (£m)	1,800	-	850	-	2,650	-
Economic Impact (Employment Person-Years)	34,690	23,160	33,000	24,990	67,690	48,150
Economic Impact (Gross Value Added £m)	1,140	670	520	340	1,660	1,010
Annual Employment (FTEs)	2,310	1,545	2,200	1,670	4,510	3,215

1:

Introduction and Background

1 Introduction and Background

1.1 Re-energising Wales project overview

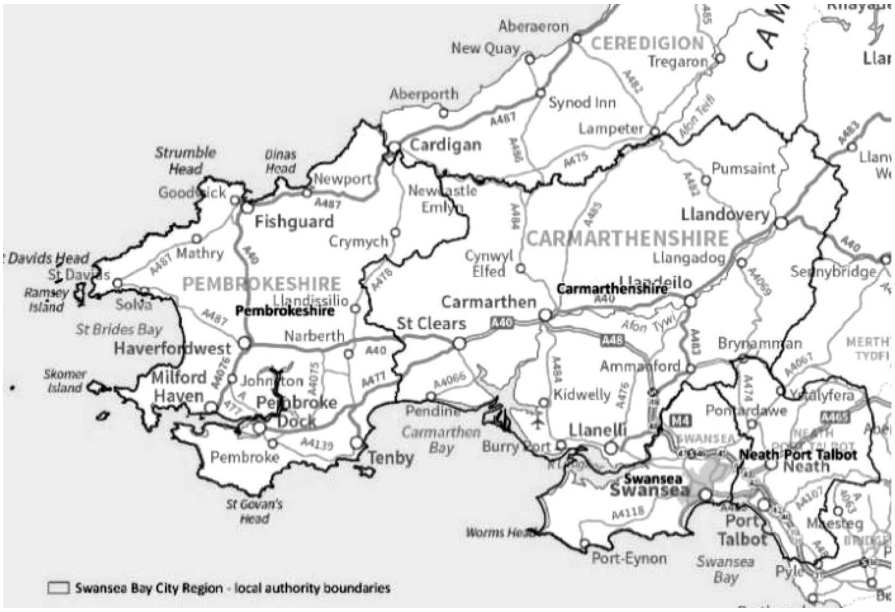
The Institute of Welsh Affairs' (IWA) Re-energising Wales project has brought together representatives from industry, regional stakeholders and academia who have an interest in the future development and transformation of energy in Wales. The overall aim of the project is to provide an ambitious and practical plan by which Wales could maximise its use of renewable energy resources by 2035, resulting in an 80% reduction in energy-related greenhouse gas (GHG) emissions.

This report follows on from that by Regen for the IWA, *Swansea Bay City Region: A Renewable Energy Future*[1] which conducted an analysis of the future energy demands and potential sources of energy generation to create a low carbon Energy System Vision for the Swansea Bay City Region (SBCR). The geography of the region includes Pembrokeshire, Carmarthenshire, Swansea and Neath Port Talbot – see Figure 1.

The choice of the SBCR as a case study recognises the ambition that has been shown by the region's leaders and stakeholders, and the region's good mix between urban and rural communities, social diversity and range of potential renewable energy resources including wind, solar and marine energy.

This report outlines the necessary investment for such a transformation to occur and the consequent economic impact – in terms of jobs and gross value added – on SBCR and Wales.

Fig 1: The Swansea City Bay Region



1 Regen for Institute of Welsh Affairs, *Swansea Bay City Region: A Renewable Energy Future*, May 2018

The energy scenario outlined below is not intended to be prescriptive. There are a number of potential pathways to achieve energy transformation and new opportunities that will emerge as energy systems develop. The case study is therefore just one potential pathway which is intended to highlight the scale of the challenge and opportunities that exist, and to explore some of the key levers and enabling actions through which a new energy system might be developed.

Similarly, estimates of cost per MW that inform this interim report may be updated, should better information come to light. Knowledgeable readers are encouraged to contact the IWA team should they consider they have useful intelligence to add.

Readers should also note that this report includes the best available information on investment cost, and utilizes a Wales-bespoke economic modelling approach, but does not benefit from any new data collection.

1.2 2035 SBCR Energy System Vision

Re-energising Wales has sought to develop a credible future of an SBCR Energy System Vision in 2035 that would make best use of the renewable energy resources and assets within the region to:

1 **Maximise the region's contribution to reaching or exceeding Wales' and the UK's decarbonisation targets**

2 **Make best use of local generation and renewable energy resources to meet the energy demands within SBCR for electrical power, heat and transport**

3 **Enable the transition of Wales to an energy efficient, smart and clean energy system by accelerating the adoption of new technology and flexible business models.**

Energy Vision for the Swansea Bay City Region 2035

Key objectives and outcomes (with targets)	
Energy efficiency	Deliver a step change in domestic and commercial and industrial energy efficiency represented by at least a 20% reduction in heat and electricity demand, with a 30% energy efficiency stretch target.
Renewable energy generation 100% of consumption	Maximise use of regional energy resources to achieve a target of renewable electricity generation equivalent to 100% of electricity consumption on an annual basis. Delivering an overall carbon intensity < 50g CO2e/KWh from local renewable generation and imported (or backup) electricity.
Decarbonisation of heat 40:40 reduction	40% of heat supply from decarbonised heat supply sources – through electrification, gas decarbonisation and use of renewable energy sources. Reducing the overall carbon emissions from supply of heat (including energy efficiency) by at least 40% compared to 2017.
Decarbonisation of transport	Become a leading region for the reduction of vehicle emissions through: — the electrification of transport with 80% of new cars, and over 30% of all cars EV by 2035 — growth and decarbonisation of public transport with 100% Ultra Low Emission Vehicles ULEV by 2035.
Local energy generation and ownership	Maximise use of local energy resources – minimising the need for imported electricity with a target of less than 15% electricity imports over the year. Support Wales ambition that all renewable energy schemes should have an element of local ownership.
Flexibility and smart energy	Use flexibility through energy storage, Time of Use Tariffs, smart charging and appliances, and demand side response, to minimise energy system imbalance, grid impacts and imports.

The SBCR Energy System Vision objectives and targets are recognised as being extremely challenging. They are, however, consistent and indeed will be required to meet Wales' and the UK's overall ambition to transition to a low carbon economy, and to meet the commitments made under the Paris agreement in December 2015 to combat climate change[2]. There is a strong sense therefore that although the way forward will be difficult, and will require radical change, such change is inevitable if we are to protect our environment and the wellbeing of our future generations.

This interim report addresses the economic impact of the *first two* elements of the low carbon SBCR Energy System Vision – renewable generation and energy efficiency and renewable generation – which are those considered to be most locally policy-amenable, have the largest economic impact, and are reasonably straightforward to model.

2 European Commission, *Paris Agreement* - Indeed, with the UK now aiming for *net-zero carbon emissions*

2:
Methodology and Data

2 Methodology and Data

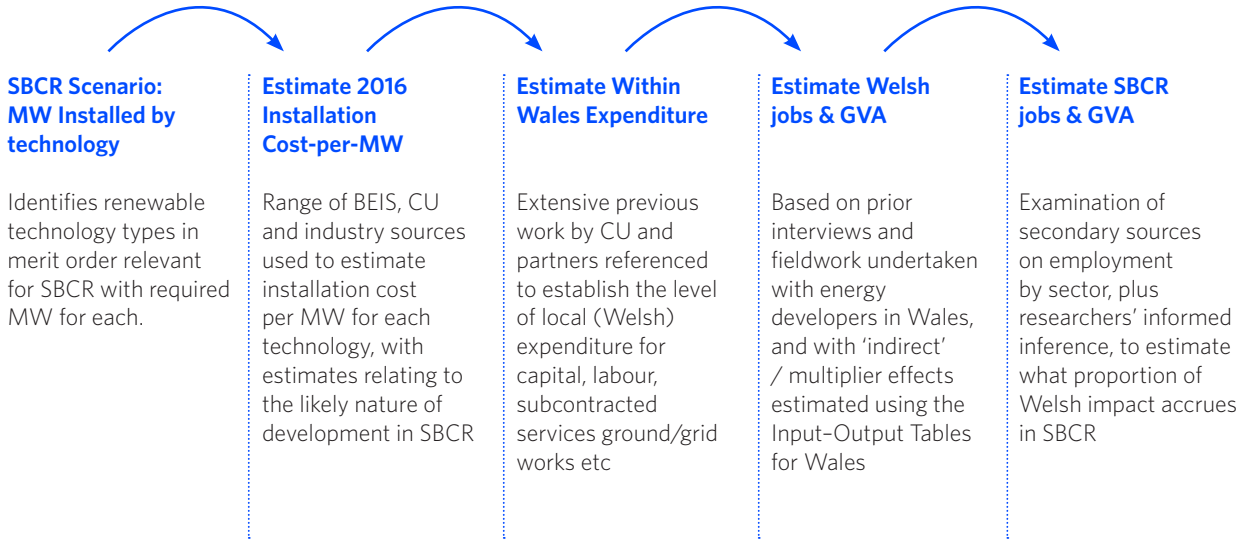
2.1 Methodology, Concepts and Assumptions

For electricity, this report uses a variety of existing data to estimate the installation cost and economic impact of the SBCR's transition to 100% renewable electricity.

It is important to note that we do not report levelized costs of electricity (LCOE) as is more typical in other reports. This is because we are interested primarily in the 'upfront' cost of developments (hence requiring financing), and in the economic impact (consequential for Wales on development and operational spending, not electricity sales). This approach also allows us to ignore the complexities of the UK electricity market (e.g. strike prices and Contracts for Difference) which are important for the 'investability' of generation, but which are not directly influenceable at SBCR or Wales scale.

Our key assumptions on the nature of the investments required for renewable transition are taken from *Swansea Bay City Region: A Renewable Energy Future*.[3] This renewables scenario has been delivered in consultation with the full Re-energising Wales steering group, and as such represents the most informed and up-to-date view of which investments are necessary and technically feasible for the region to generate sufficient power from renewable sources. Detailed information on the derivation of this scenario, plus a discussion of relevant concepts and assumptions are presented in *Swansea Bay City Region: A Renewable Energy Future*.[4] Our methodology is summarised (for electricity generation) in Figure 2.

Fig 2: Illustrative Methodology (Electricity)



3 Regen for Institute of Welsh Affairs, *Swansea Bay City Region: A Renewable Energy Future*, May 2018

4 Regen for Institute of Welsh Affairs, *Swansea Bay City Region: A Renewable Energy Future*, May 2018

In developing these estimates of economic impact, we have (following the SBCR scenario more generally) abstracted from elements of detail: this abstraction is necessary to make the analysis achievable within budget and time frame.

In summary:

— The concurrent development of different technologies or sites may increase the cost of investment (e.g. via crowding out) or decrease costs (e.g. if scale/scope economies emerge, or knowledge is shared) in ways that are not captured here.

— Whilst we of course accept that technologies are at a different stage of maturity, and will require different lead-times and implementation, we generally make no distinction as to when within the 2020-35 period consequent investment is undertaken, and thus when any economic impact relates to.

— All financial and GVA estimates are inflated current (2018) prices. Due to uncertainties over the timescale of implementation, and to retain consistency with previous reports on energy in Wales, no future discounting is applied.

— Our cost estimates are derived per MW-installed and include capital expenditure and operational periods. We assume that all impacts occur within the 2020-2035 period, although accept in reality there will be the potential for impacts to continue beyond this period.

— In most cases we do not include any impact from electricity sales, as the benefit arises to non-Welsh companies. The exception is for small hydropower, where there is an element of local and/or community ownership that is accounted for. A small proportion of onshore wind is also locally/community owned but our model does not currently include electricity sales from these installations.

— As we estimate installation costs at current (2018) costs, in practice this means reducing Wales-bespoke cost estimates from earlier periods to estimate 'current' costs by reducing these estimates with reference to the most recent data from, for example, UK Contract for Difference auctions. In some cases however (e.g. the proposed Swansea Bay Tidal Lagoon) we have higher-quality current estimates of costs.

— The exception here is for novel marine renewables, where their current high level of cost/MW reflects their experimental product-cycle stage. Here we apply cost reductions estimated by the Carbon Trust that reflect mid-2020s costs. Note that given the very slow pace of such developments (in the UK and globally) it may be that these cost reductions are optimistic in terms of the timescale assumed.

We report on two elements of economic impact: Employment (Full Time Equivalents (FTE)) and Gross Value Added (GVA). We report the annual average level of employment and GVA supported by SBCR energy investments in Wales and the SBCR during the 2020-35 period.

We explicitly include a Swansea-located tidal lagoon as part of our analysis. Despite the UK Government's recent rejection of the project based on 'value for money' considerations, we believe that no viable renewable (i.e. non-nuclear) energy mix will fail to take advantage of the world's second greatest tidal range in some form. The lagoon, as proposed by Tidal Lagoon Power, is closest to commercialisation of any such schemes, and thus an appropriate inclusion.

2.2 Our Economic Impact Methodology

The reports cited earlier in this section all estimate the 'indirect' economic impact of energy investments, that is in supply chains, and following wage spending by workers involved in projects, using the Input-Output Tables for Wales[5]. These Tables provide a 'picture' of how the parts of the Welsh economy fit together in terms of sales and purchases, labour use, taxes and imports and exports for example. The base Tables are constantly added to and improved as research is undertaken on the Welsh economy, not least on the energy sector. This means this study is informed by a significant amount of prior primary information, and a relatively sophisticated and 'localised' modelling approach. There are however a number of caveats that readers should be aware of, and a number of assumptions and simplifications that are made to enable the modelling process.

Firstly, Input-Output (IO) modelling is a relatively inflexible tool that, for example assumes linearity in economic relationships – an additional X% of demand leads to an additional X% of supply and of employment. This does not therefore account for 'real world' realities, of economies of scale for example, or a lower propensity to source locally as scale increases.

Secondly, the framework assumes constant prices between commodities and for inputs such as labour, whereas in reality increased demand might increase prices or wages.

Thirdly, the model defaults to assuming an 'industry average' behaviour in supplying sectors. Thus, second and third tier contractors to developers (not interviewed in prior studies) are assumed to use the same proportions of labour, raw materials and other inputs as Wales-average construction companies.

Whilst these limitations should not be forgotten, IO analysis remains the most appropriate and sophisticated mode of economic analysis for Wales given data and resource constraints. Additionally our primary research in the field helps 'soften' some of the inflexibilities regarding how these nascent and growing sectors would actually behave in Wales: that is to say that researchers can amend individual results from the modelling, based on richer team knowledge, in a way that improves the reasonableness of results.

Assessing the Economic Impact on the SBCR brings different challenges. At this smaller spatial scale, we do not have access to Input-Output Tables or the formal multiplier modelling they enable. It is important to understand that the complexity of estimation at these two scales is very different, and the methodologies employed – and consequent reliability of results – is also different. With no formal economic model available for SBCR, estimates of future economic impact, especially following large scale and novel investments, will always lack rigour.

5 Cardiff University for Environment Agency Wales, *The Input-Output Tables for Wales 2007*, July 2010

Thus, our approach is to use indirect variables to estimate the proportion of 'Wales level' economic impact that might occur within the SBCR boundary. We consider factors such as:

— levels of workforce employment and existing within-SBCR employment in relevant sectors

— proportions of employment generated in broadly 'local' activities (construction and installation; operations and management)

— level of specialist skills/firms required for development (e.g. various professional services).

In each case our analysis of 'local economic capture' is as bespoke to that technology as data allows, allowing for different production functions that may utilize proportionately more labour or specialist services than the average. In essence we assume SBCR captures the vast majority of Wales-arising construction-related employment and consequent labour value added; plus a proportion of the remainder dependent on the level of SBCR employment in relevant energy supply industries; plus all within-Wales operations and maintenance employment[6] (see Figure 3). Note that the region captures a smaller percentage of GVA compared with employment due to different levels of productivity between relevant industries.

Fig 3: City-Region Local Economic Capture

	Percent of Wales	
	Employment	GVA
Solar PV	76%	65%
Onshore wind	67%	55%
Offshore wind	53%	43%
Wave	51%	41%
Tidal Stream	50%	40%
Tidal Range	67%	55%
Hydro	83%	80%
Fuelled technologies (Biomass, AD, Energy recovery)	88%	70%
All Technologies	**69%**	**60%**

NB: For full sources please see Appendix 1

We of course accept that if SBCR were to move to develop renewables capacity significantly faster than other parts of Wales, the UK or EU, this may well result in both firm/worker relocation and business start-up in response to the consequent economic opportunity, and this 'first mover' advantage would increase levels of SBCR impact. Equally, our modelling may imply a level of investment and activity that implies supply side shortages – for example in terms of construction labour or firms able to supply relevant services – and consequently greater leakage to the rest of Wales and beyond.

6 Some of this labour will of course be peripatetic, or migrate in for the duration of a project, but it is impossible to estimate how much.

2.3 Our Sources: Electricity

We draw on previous reports that have been undertaken in Wales to establish the regional economic impact of renewable energy generation (and, to a lesser extent, energy efficiency measures). Other reports that included (or focused on) non-renewable generation have been consulted where the intelligence they contain is relevant to the renewables sector (e.g. around construction, skills etc). These reports have either been written by, or involved, the Welsh Economy Research Unit at Cardiff Business School and thus have the benefit of a consistent approach to methodology, concept and terminology. The most important sources here included:

— *Employment effects associated with regional electricity generation*[7]

— *Economic opportunities for Wales from Onshore Wind Development*[8]

— *The Economic Impact of the Development of Marine Energy in Wales*[9]

— *Socio-economic impact of unconventional gas in Wales*[10]

— *The Economic and Social Impact of Small and Community Hydro in Wales*[11].

A number of other reports and data sources have informed this report and they are referenced as they arise. Readers are directed to earlier Re-energising Wales reports to understand the sources that have informed scenario development.

7 Cardiff University and Regeneris for Welsh Government, *Employment effects associated with regional electricity generation*, June 2013

8 Cardiff University and Regeneris for RenewableUK Cymru, *Economic opportunities for Wales from Onshore Wind Development*, January 2013

9 Cardiff University and Regeneris for Welsh Government, *The Economic Impact of the Development of Marine Energy in Wales*, May 2013

10 Cardiff University, Regeneris Consulting and AMEC, 2015 - report not currently online

11 Centre for Regeneration Excellence Wales, Cardiff University and University of south Wales for Hydropower Stakeholder Group, *The Economic and Social Impact of Small and Community Hydro in Wales*, 2015

2.4 Data and Economic Impact Approach: Energy Efficiency, Heat and Transport

Decarbonisation of electricity is only part of the solution to mitigating the impact of climate change. Other elements of note include the reduction in climate emissions through the reduction in, and decarbonisation of, heat demand for buildings, and the replacement of diesel and petrol cars with those driven (probably) by batteries and/or hydrogen fuel cells. In each of these cases, there is the potential for economic impact to arise in Wales and the SBCR, albeit at very different scales.

Interventions in some of these areas will require investments that are geographically beyond the SBCR (for example the decarbonisation of mains gas via blending with hydrogen and/or biogas), and which will be unlikely influenceable from within SBCR or (arguably) Wales. Other SBCR scenario developments, such as the adoption of electric/hydrogen vehicles may be influenceable at the SBCR level, and certainly Wales-scale, but will have (socio)economic impacts that are very difficult to assess.

For these reasons, and those of resource, in this interim report we focus on assessing the impact of energy efficiency and demand reduction measures for domestic[12] buildings, as outlined in the Re-energising Wales SBCR report Section 4.3, covering 200,000 buildings to achieve a 20% reduction in energy use (specifically the 'Across the Board' sub-scenario). This scenario moves 34% of current properties from an existing D-G classification into A-C on the 'Energy Performance Certificate Register'.

In order to assess the cost and consequent economic impact of domestic refurbishment we must estimate a cost per dwelling, then multiply up by the 200,000 dwellings affected. Here we consulted prior UK evidence[13]; Wales-specific sources on the cost of such interventions, primarily the ARBED/Warm homes programme[14]; and work undertaken by Cardiff University for Stop Climate Chaos Cymru in 2011[15], which posited a 'Great Welsh Refurb' like that suggested here. Whilst the Welsh numbers are older, they have the benefit of being reflective of the range of properties that exist in the region.

There are a wide range in studies in estimated financial cost per KWh (of gas and electricity) saved following efficiency, fuel switching, and in some cases heat pump interventions. Moreover the format of the ARBED evaluations (on a 'per measure' basis) makes a cost per dwelling hard to assess.

12 As the earlier report points out commercial demand is forecast to fall significantly 'policy off' due to the shift away from industrial activity in the UK

13 See for example: Construction Products Association, *an introduction to low carbon domestic refurbishment*, June 2010; Department of Energy and Climate Change, *The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK*, November 2012

14 Cardiff University, *Arbed 1 Scheme Evaluation of the Warm Wales Programme*, August 2012; Cardiff Metropolitan University and Chartered Institution of Building Services Engineers, *Did ARBED I Save Energy in Wales' Deprived Dwellings*, December 2015

15 Cardiff University for Stop Climate Chaos Cymru, *CUTTING CARBON: CREATING JOBS*, March 2011

Nonetheless, our best estimate is that based on a Welsh-average dwelling type mix and inflated to 2018 prices using an appropriate construction price index, the cost per dwelling of cutting energy costs by 20% is around £5,750 (in current £). This includes both cost-efficient insulation for poor quality dwellings, and more complex and costly measures for better and already insulated houses. More sophisticated modelling of interventions could of course refine this estimate significantly.

Once an overall investment cost for refurbishment has been estimated, this provides a 'shock' for the Input-Output Tables for Wales and allows us to assess the gross value added and employment consequences as Welsh sectors gear up to deliver the interventions needed. This is conceptually similar to the process described in Figure 2, and the impacts here are summative to those for electricity generation (there is no double counting). The required investment is also additional to that for the energy generation elements of the SBCR Energy System Vision.

We must also assess the proportion of this Welsh economic impact that accrues to the SBCR area. As with the earlier analysis, this is dependent on both the willingness and ability of local people and firms to 'step up' to the opportunity[16], or of firms and people to migrate to the region (permanently or temporarily) to do the same. Following a similar local capture estimation process to that described in Section 2.3 for electricity generation, we assume (with the usual caveats) that SBCR might capture 75% of Welsh employment and 65% of Welsh GVA arising from domestic interventions.

2.5 Next Steps

Following the above process, Section 3 of this report will estimate the investment cost and economic impact of the SBCR Energy System Vision, on Wales and on the region itself. Note again that this is only a partial analysis, covering electricity generation and domestic refurbishment.

Other elements of impact – heat, transportation etc – are considered to be more uncertain and (probably) less important in terms of local (city-region) economic impact, but these elements will be included, as far as it practicable, in our Wales-level analysis report which will follow later in 2018. As is the case with the IWA Re-energising Wales Project overall, this document is intended to spark wider discussion and, hopefully, improvement in the sources and techniques employed.

16 Note that in recent years there have only been around 100-120 jobseekers in the SBCR with declared skilled trades occupations

3:
Results 1: The Economic Impact of Electricity Generation

3 Results 1: The Economic Impact of Electricity Generation

3.1 Wales-Level Impacts

We estimate that the gross investment cost[17] of the SBCR Energy System Vision for an additional 2.7 GW of electricity generation to be in place by 2035 would be around £4.6bn, based on 2018 costs. This is assuming the current cost of technology with the exception of marine renewables, assessed at forecast mid-2020s cost. Of this we suggest around £1.8bn may be spent within the Welsh economy, with this proportion varying by the type of technology and generator, ownership model, technical maturity and importance of construction/installation in overall costs.

Fig 4: The SBCR Energy System Vision – Electricity Generation MW and Investment Cost

	MW	Cost per MW (£m)	Investment cost (£m)	Estimated Wales Spend (£m)	Percent spent in Wales
Solar PV	1,215	1.5	1,800.6	821.3	46%
Onshore wind	800	0.7	584.9	207.1	35%
Offshore wind	223	2.1	470.7	102.0	22%
Wave	100	2.0	200.2	68.8	34%
Tidal Stream	30	2.4	72.6	20.8	29%
Tidal Range	320	4.1	1,299.2	515.2	40%
In stream Hydropower	13	4.8	62.1	42.5	68%
Fuelled technologies (Biomass, AD, recovery)	30	5.0	150.5	23.6	16%
All Technologies	**2,731**	**1.7**	**4,641.0**	**1801.2**	**39%**

Notes:
- All £2018 or closest equivalent.
- Does not include operational costs
- Note fuelled technologies (AD, energy recovery) have multiple value streams of which electricity is only one

17 We include elements of operational cost, notionally for 15 years for each technology, but exclude decommissioning; capital investment remains by far the largest scenario cost.

Cost per MW varies considerably, with Solar PV and Onshore wind both the cheapest and most heavily deployed in this scenario. Both technologies have (along with Offshore wind) experienced significant cost reductions per MW installed in recent years. The second biggest investment cost and regional spend falls to Tidal Range – here modelled with reference to the Swansea Bay Tidal Lagoon – which is expensive per MW, and with the developer suggesting a reasonably high level of local sourcing in the development phase.

This £1.8bn of Wales-regional spending would have significant economic impact. We suggest that given the intelligence available – proven, claimed and modelled – this additional regional economic demand would create 34,690 person-years of employment over the 15-year period; i.e. equivalent to 2,300 jobs full time jobs in every year of the period[18]. This employment estimate includes planning and development, construction and installation, and operational phases (but not decommissioning). This activity would be associated with around £1.14bn of Welsh GVA over the 15-year period.

A third of employment arises in Solar PV, reflective of both its importance in the modelled scenario, and the relatively high level of labour required for installation (even for the larger commercial developments modelled here). Solar PV also delivers a high level of Welsh GVA. Conversely, whereas Onshore and Offshore wind both deliver significant employment, levels of GVA created in Wales are proportionately lower, reflecting that the value here lies in non-local elements of supply.

We do not formally model the industries and occupations that will provide services and labour in different phases of delivery. However, prior evidence suggests that construction and related industries would be key players at a Welsh scale, as would professional services such as surveying, planning and engineering. Welsh input into electrical service provision, manufacturing and fabrication is more open to question, and technology-dependent.

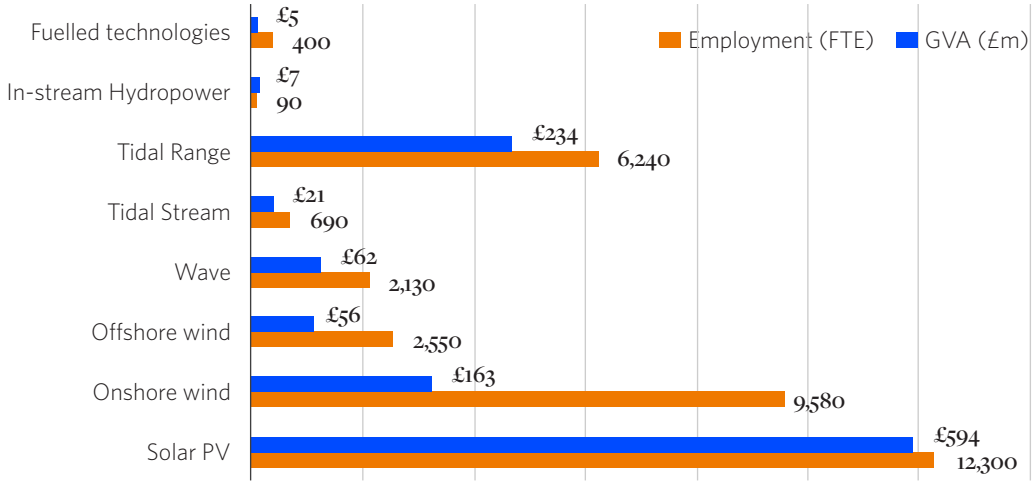
On this latter point, the ability of Welsh-headquartered companies to compete with companies from across the UK for contracts arising from the transformation to the SBCR Energy System Vision – and their interest in doing so – would be critical. There has been some evidence of Welsh-domiciled companies seeing success in the renewable energy field, albeit at rather lower scale than that suggested here[19].

18 In reality, even if all generation was built before 2035, operational employment would begin later than 2020 and stretch beyond the period.

19 Centre for Regeneration Excellence Wales, Cardiff University and University of South Wales for Hydropower Stakeholder Group, *The Economic and Social Impact of Small and Community Hydro in Wales*, 2015

Fig 5: Employment and GVA Impacts - Wales

Employment (Person-years)	34,690
Gross Value Added (£m)	1,140

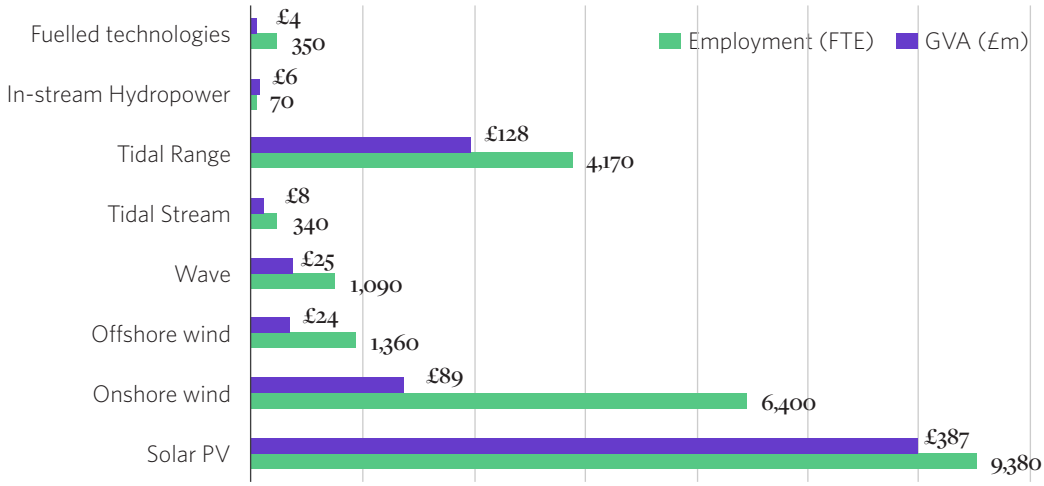


3.2 Swansea Bay City Region

Our best estimate is that SBCR might capture around two thirds of the Welsh employment arising from energy system interventions – hence around 23,160 person-years of employment, or around 1,500 FTE jobs annually. A concentration of (relatively lower value added) construction and installation employment, rather than higher-value professional, scientific and manufacturing/fabrication employment means that city-region retained GVA is somewhat lower, at £670m (or 60% of the Welsh total).

Fig 6: Employment and GVA Impacts – Swansea Bay City Region

Employment (Person-years)	23,160
Gross Value Added (£m)	670



The level of gross value added captured within the region is greatest for Solar PV, with tidal range (i.e. Swansea Bay Tidal Lagoon) in second place (although not for employment). It should however be noted that since the relevant Lagoon data was estimated in 2013[20], and based on Tidal Power project specifications, the rejection of this specific approach by UK Government in June 2018 might mean that the costs of any future tidal range investment change significantly. Note again the low (relative) level of value-capture for Onshore wind, reflecting a sector where few Welsh, let alone SBCR companies, have a strong presence as owners or developers.

3.3 Renewable Generation: Results in Summary

The results of this section imply a level of investment that would be considerable at a *Welsh* scale – for example, over double that suggested for the M4 relief road – let alone at the city-region scale described here. However, the identification of mechanisms to fund the new road (over a similar period to that described here) does suggest that such investment is not unthinkable for Wales. The £4.6bn investment posited here is at a similar level to that involved in the Transport for Wales-managed Wales and Borders Rail franchise and South East Wales Metro.

These two cases illustrate the complex investment context. The M4 has no prospect (under the current development paradigm) of generating revenue for the Welsh Government and must be financed wholesale from borrowing, whereas the rail franchise will be profitable for its multinational operators. The SBCR Energy System Vision is, in terms of renewable generation, somewhere in the middle. Elements of the 2.7 GW provision will certainly be as cost-competitive with existing fossil generation (or even cheaper) within the timescale, including for example the most favoured Solar PV and Onshore wind, and perhaps Offshore wind; whilst other elements, such as in stream hydro power and marine renewables are far more expensive and hence more difficult to fund. Note that this report does not cover the additional investments in the National Grid required to make this mix of generation transportable.

This then is an extremely ambitious vision but one which, if progressed, would result in significant economic benefits for Wales, especially in the development and construction phases – around £1.1bn of gross value added over the period for Wales, and perhaps £670m for the SBCR. Readers will recognize that Wales does not currently capture the majority of the spending or the value-added associated with these investments. With one or two exceptions, Wales currently does not have sufficient presence in terms of research and innovation, Tier 1 developers, or (especially) capital ownership to retain a higher proportion of economic value. This issue will be returned to later in this report and in other parts of the Re-energising Wales project.

The above notwithstanding, the potential for economic impact via employment generation is significant with the project estimated to support around 2,300 FTE jobs over the 15-year period at Wales-scale and with some 1,500 of these within SBCR. The latter especially would be of great value to the city-region economy but would require the people and companies of Swansea Bay to be skilled, oriented and competitive in sectors that support renewable electricity investments.

20 Cardiff University, *Turning Tide: the economic significance of the Tidal Lagoon Swansea Bay Report for Tidal Lagoon Swansea Bay*, November 2013

4:
Results 2: Domestic Refurbishment

4 Results 2: Domestic Refurbishment

4.1 The Investment

In this section we outline the required investment and economic impact of the domestic energy interventions (including efficiency and fuel switching) required to meet the Re-energising Wales SBCR target of a 20% saving in energy and emissions. As Figure 7 shows, our best estimate is that this would require £1.16bn of investment.

Fig 7: Domestic Refurbishment Investment Cost

Number of Households Covered	202,175
Average Cost per Household (£)	5,750
Total Investment Cost (£m)	1,160
Total Welsh Spend (Direct) (£m)	850

Sources & Notes:
- All £2018
- See Re-energising Wales *Swansea Bay City Region: A Renewable Energy Future* report (2018) & Section 2 of this report

Unlike the case of renewable generation, where the bulk of spending 'leaks' from Wales, we assume here (based on previous analysis) that much of the domestic refurbishment spending – around three quarters – is captured within Wales, and then goes on to have direct/onsite and 'multiplier' impacts in the country. In part this is due to the greater importance of labour in delivering the investment, and also the more 'generic' technologies involved, particularly for example insulation (where Wales has a number of relevant companies). However, the more importance that emergent technologies and non-Welsh sourced manufactures (such as heat pumps and boilers) have in refurbishment, the less likely it is that Wales, on current performance at least, will capture this spending.

It should also be remembered that Wales has a paucity of large 'Tier 1' construction contractors. Thus 'upskilling' interventions, the procurement approach, and the size of tender 'parcels' for relevant work will be important in driving local involvement and economic impact[21].

As for the Re-energising Wales SBCR scenario, our investment analysis is a relatively high-level estimate and does not take full account of the housing stock in the region, for example the number of off-gas grid properties for whom heating options are more limited, or the likely mix of new housing to be built in the region.

4.2 Wales

We suggest that this investment of £1.16bn in domestic refurbishment for energy saving could create 33,000 person years of employment in Wales – here assumed over a 15 year period and thus equating to 2,200 full time jobs on average. This employment relates to on-site installation, as well as jobs in the construction supply chain such as the manufacture of materials, and that related to other interventions.

For domestic refurbishment much of the cost (around two thirds) is related to labour or comprises company profits. Both of these constitute parts of gross value added, with GVA impacts then totalling £520m over the period, or around £35m per annum.

The relatively greater importance of labour in the domestic refurbishment scenario in comparison to the renewable generation investment drives a somewhat higher level of employment per £ of spending – 39 FTEs per £1m Welsh spend compared to 30.5 FTEs per £1m spend for renewable generation. However, recall that in the latter case most manufacturing and fabrication spending, and returns to capital, are lost to Wales, and thus in both cases the bulk of employment will be in construction, related skilled trades and professional services such as surveying, planning, engineering etc.

Fig 8: The Economic Impact of Domestic Refurbishment (Wales)

	Total	Per Annum
Employment (Person years)	33,000	2,200
GVA(£m)	517.7	34.5

Sources and Notes:
- All £2018
- Input-Output Tables for Wales
- For sources see Re-energising Wales SBCR study, section 2

21 Welsh Government, *Arbed - Strategic energy performance investment programme*, accessed August 2018

4.3 Swansea Bay City Region

Using the same rationale that sees us allocate a high proportion of refurbishment spending and economic impact to Wales – the importance of local installation employment and (for the most part) generic technologies – provides an opportunity then for the City Region to capture much of the benefit even more locally. Our best estimate (albeit one based on limited information and with no formal model; see Section 2.2) is that around 75% of employment and 65% of GVA might arise within the City-Region. This would see around 25,000 person-years of employment created in Swansea Bay, and £340m of GVA, between 2020 and 2035.

Fig 9: The Economic Impact of Domestic Refurbishment (SBCR)

	Total	Per Annum
Employment (Person years)	24,990	1,670
GVA(£m)	340.2	22.7

Sources and Notes:
- All £2018
- Input-Output Tables for Wales
- For sources: see *Re-energising Wales Swansea Bay City Region: A Renewable Energy Future* report (2018) & Section 2

The notion of 'local employment' here is a complex one. Whilst this employment would occur in towns and communities across SBCR, workers may be locally resident and working for local companies (or local workers for non-SBCR companies); temporarily resident for the period of the works; or perhaps commuting in daily. The 'real' economic impact of these 1,670 jobs might be very different under different delivery scenarios. These estimates should perhaps be considered a best-case scenario – that which applies if the 'supply side' in the City Region gears up in a timely fashion to engage fully in the domestic refurbishment programme as posited here.

4.4 Summary

Our analysis supposes that refurbishment investments follow a similar technical path to previous interventions in Wales and the UK, with, for example insulation (internal and external), boiler upgrades and fuel switching being the primary interventions. If a future programme was significantly different – for example more reliant on heat pumps or other more innovative interventions – the pattern of spending would be different, as would any consequent local and regional economic impact. Here, the SBCR may indeed hold something of an advantage, with a specialism in innovative domestic energy systems in the 'homes as power stations' project led by SPECIFIC at Swansea University[22]. This cutting-edge project aims at developing the holistic approach needed to address emissions and energy issues, for example linking energy efficiency, storage and electrified transport, and already involves both the higher education sector and the largest social housing provider in Wales.

Extending and multiplying such projects, moving from experimental to commercial scale and, for example, to cover existing stock as well as new build, would increase both the likelihood of the SBCR Energy System Vision approach becoming a reality in SBCR as well as its local economic impact.

22 Swansea University, *Turning homes into power stations could cut household fuel bills by £600 or more - report*, August 2017

5:
Wider issues

5 Wider Issues

5.1 Upskilling People and Firms: Growing the Supply Chain

Throughout this short report we have made reference to the difficulty of costing, let alone modelling, the Wales/local economic impacts of novel energy technologies. The level of economic activity 'captured' locally will depend on the regulatory contexts, capital ownership and the availability of skills and capacity within the City Region and Wales more generally.

Wales has a mixed history in these regards. Previous reports in this area have stressed the need to help the energy supply chain develop in Wales, particularly with regard to emergent sectors such as marine[23]. In this example, and despite the best efforts of stakeholders such as Marine Energy Wales, progress appears patchy with only a small number of companies extant, albeit often innovative and with good links to wider research and academia[24].

In some respects this is an unavoidable 'chicken-and-egg' situation. If UK Government energy, tax and innovation policy is insufficiently supportive of (or actively hostile to) novel renewables, companies in Wales will – even with strong regional support – find it difficult to survive during experimental stage, let alone the move to commercialisation[25]. However, it should be noted that in previous energy booms in Wales – both fossil and renewable – the nation has largely failed to capitalize on the wide range of opportunities, and has been left with a role in providing resources (e.g. wind, wave and related land/seabed) for non-regional actors who then capture innovative and capital returns[26].

This structural economic issue will, in the absence of a strong and sustained policy intervention aimed at increasing local returns, likely work to reduce Welsh and SBCR economic benefits, such that the numbers presented in this study will be likely unachievable. Again; the numbers provided by the modelling here might be considered an optimistic or best-case scenario.

23 Cardiff University and Regeneris for Welsh Government, *The Economic Impact of the Development of Marine Energy in Wales*, July 2013

24 Marine Energy Wales, http://www.marineenergywales.co.uk/supply-chain/, accessed August 2018

25 Evening Standard, *Budget 2017: North Sea oil and gas given tax breaks in push for investment*, November 2017 ; Tidal Energy Ltd

26 Bryan, J., Evans, N., Jones, C., & Munday, M, *Regional electricity generation and employment in UK regions*, Regional Studies, 51(3), 414-425, (2015)

5.2 Local and Community Ownership

It is generally acknowledged that local involvement in energy and electricity generation, particularly renewables, can have a number of economic, social and even environmental benefits. This has been recognised, for example in the setting of targets for local energy ownership by both the Scottish[27] and Welsh[28] Governments.

The potential benefits of local and community involvement range widely. For example, Cardiff University's report with University of South Wales and Keep Wales Tidy[29] on small and community hydro in Wales suggested that local and community ownership could:

— almost double local economic impact (compared with non-local, commercial developments) as development and operational expenditures were more likely to be local and, in the community ownership case, community benefit funds created further local incomes and employment

— communities could use benefit funds to further reduce emissions and energy use, and increase energy resilience – for example in Talybont-on-Usk where hydro income has enabled the purchase of both Solar PV for the community hall, and an electric vehicle

— engage local people more widely around the subjects of energy security, energy poverty and climate change.

The development of such projects has provided a beacon of community engagement, perhaps most successfully in the case of the Awel Coop outside Swansea, where the team has succeeded in developing substantive Solar PV and Onshore wind capacity against substantial odds. Given these benefits it is perhaps surprising that community energy has not played more of a role in regional or UK-national climate change mitigation. Indeed, it is notable that both Scottish and Welsh targets are for community and local energy rather than community alone; perhaps a recognition of the difficulty in duplicating the Awel success.

At the end of 2016, community renewables totalled 13.4MW; this comprises less than 0.5% of Welsh renewables capacity[30]. Figure 10 suggests that there are currently around 10MW of community and charity owned renewables across Wales greater than 50KW[31]. Although National Trust is not a Welsh organisation, it has been absolutely key in regional attempts to develop the sector.

27 Scottish Government, *Community renewables meets target early*, October 2015

28 Welsh Government, *Lesley Griffiths high on ambition for clean energy*, September 2017

29 Centre for Regeneration Excellence Wales, Cardiff University and University of South Wales for Hydropower Stakeholder Group, *The Economic and Social Impact of Small and Community Hydro in Wales*, 2015

30 Regen for Welsh Government, *Energy Generation in Wales 2016*, December 2017. Note there may be a small number of additional community projects unknown to the research team

31 Please contact the report author to suggest projects that are not included in the table

Fig 10: Notable (>50kW) Community & Charity Energy Installations in Wales since 2010

Scheme	Type	Organisation	Location	kW Installed	Date
Ynni Padarn Peris	Hydro	Ynni Padarn Peris	Llanberis	55	2017
Cwm Clydach	Hydro	Cwmclydach Comm. Development Trust	Rhondda Cynon Taff	60	2011
Hafod-y-Porth	Hydro	National Trust	Gwynedd	100	2015
Hafod-y-Llan	Hydro	National Trust	Gwynedd	640	2013
Plas Newydd	Marine heat pump	National Trust	Anglesey	300	2014
Anafon Hydro	Hydro	Abergwyngregyn Regeneration Co.	Gwynedd	270	2015
Llangattock	Hydro	Llangattock Green Valleys	Various	~60-100	2015
Taff Bargoed	Hydro	Friends of Taff Bargoed	Merthyr	100	2016
Gwrhyd Mountain Wind Farm	Wind	Aman Awel Tawe (via coop)	Neath Port Talbot	4700	2016
Rhydygwydd Salem	Wind	Carmarthenshire Energy	Carmarthen	500	2016
Ynni Teg	Wind	Ynni teg	Carmarthen	900	2018
Abergwaun	Wind	Transition Bro Gwaun	Pembs	225	2015
Egni	Solar PV	Aman Awel Tawe (via coop)	Neath Port Talbot	120	2015
Gwent Energy	Solar PV	Gwent Energy CIC	Gwent	105	2013-2015
Gower Regeneration	Solar PV	Gower Power Coop	Swansea	1000	2018
Narberth Swim. Pool	Biomass Heat	Narberth Energy	Pembs	200	2015
Swansea Community Energy Enterprise Scheme	Solar PV	Swansea Community Energy	Swansea	350	2018

Operational Employment Supported by Community Energy Projects in Wales 2016-2035

Technology	Estimated kW	FTE/MW	FTE Jobs per year
Onshore Wind	7000	1.6	10-12
Solar PV	1500	3.3	5
In Stream Hydropower	1250	10	12.5
Biomass, Heat pumps & other	600	3	3
All technologies	10000+	-	30-35

Source: Community Energy Wales (2015); Community Energy England (2018)[32]

32 Scene Connect, *Community Energy State of the Sector 2018*, June 2018

The reasons for this lack of community ownership are many and varied, and we cannot do them justice here. However, to summarise previous research, in Wales and elsewhere, key prior issues (often of variable importance across technology and place) include, not exhaustively:

— a mismatch between communities with the interest, competence and capacity to develop renewables, and an available renewable resource (wind, hydro, solar)

— related to the above, access to land required for development on a sufficiently (legally) solid basis to enable investment

— a not-fit-for-purpose, extremely expensive to upgrade grid, especially in rural areas

— a series of regulatory hurdles – planning, licensing, water abstraction etc. – which affect commercial and community developments, but with the latter often lacking the capacity to resist and overcome them

— related, the unwillingness of land use planning and other regulatory mechanisms to explicitly favour community/social developments over commercial

— reductions in support for renewables by the UK Government through Renewables Obligation Certificates and, especially, Feed in Tariffs which make renewables investments, smaller ones relevant to communities in Wales, unviable.

The individual or cumulative impact of these barriers can of course kill or significantly hinder the development of community renewables. For example, the large Awel windfarm took more than 15 years to progress from idea to generation.

Some of the above issues have been addressed by Welsh Government policy and actions by partner organisations such as local government and Natural Resources Wales. However, barriers remain higher for communities – often with access to only one site, and able to develop at a set scale – compared to commercial developers who can buy or access the best sites and 'flex' the size of investment to best meet return on investment needs. This is unlikely to change significantly over the upcoming years, at least in the absence of radically different government(s) policy.

A number of larger recent community developments, such as Awel, Carmarthenshire Energy and Gower Power, have only achieved share offer investment targets after time-extended offers, and/or have required bridging loans (from Welsh Government and others) despite offering returns on capital of 5%+, plus in addition, in some cases very lucrative tax benefits for investors. These schemes were developed under the former, far more generous renewable support mechanisms, and thus offer significantly higher returns for investors than any future community projects foreseeable under current policies, even if renewables continue to improve their cost performance vis-à-vis fossil fuels. If interest rates rise in the UK over upcoming years – as still looks fairly likely[33] – the investment offer of community renewables will be relatively even less attractive.

The mix of factors above suggests that without policy change, the investment required for the SBCR Energy System Vision – approaching £6bn at least – will probably not feature significant involvement of local communities, at least in terms of ownership. If indeed ownership does drive the benefits of energy investment[34], this is a serious issue for all stakeholders to consider.

33 The Guardian, *UK interest rates rise not a foregone conclusion, says Bank*, April 2018

34 Bryan, J., Evans, N., Jones, C., & Munday, M, *Regional electricity generation and employment in UK regions*, Regional Studies, 51(3), 414-425, (2015)

6:

Summary and Conclusions

6 Summary and Conclusions

6.1 The SBCR Energy System Vision: An Ambitious but Necessary Project

This report and the *Swansea Bay City Region: A Renewable Energy Future* report, on which our economic impact numbers are based, highlight the step change in renewable electricity generation and in domestic refurbishment that would be required to create a sustainably-powered SBCR over a fifteen year period. Our best (but contingent) estimate is that these investments would total some £5.8bn in today's money.

This investment is necessary but not sufficient. Parallel developments in grid capacity and performance, in decarbonisation of the heat system (including mains gas), and in electric and/or hydrogen vehicles will also be required to make the SBCR Energy System Vision a reality. The cost, feasibility and complexity of these latter interventions is even more difficult to judge, and impossible within the constraints of this report.

Investments at such a scale are, however, absolutely necessary if Wales and the UK are to meet their commitments on mitigating climate change emissions. The longer it is before such investments begin, the more radical they will have to be in order to help keep the climate within the 1.5 degrees of 'safe' global warming. Moreover, as the devolution process continues, the necessity of enabling such investments at regional scale is becoming clearer across a number of areas including transport, housing and utilities.

Whilst this report is open to question in terms of the estimation process underpinning this investment estimate, especially in the face of insufficient data, a clear finding will remain: that whether at city-region or national level, Wales must find mechanisms to enable such investment for these important purposes.

6.2 Levering the Economic Opportunity

If such investment is forthcoming, it comprises a significant potential opportunity for Wales and for the City Region. As summarized in Figure 11, investments in electricity generation and refurbishment alone *could* support 4,500 jobs across Wales, and 3,200 in SBCR for a 15-year development and implementation period. In total this might create £1.6bn in Welsh GVA in total.

Here though, the standard language of 'economic impact', used throughout this report, is potentially misleading. This is because we base our estimates of economic impact in this report on prior experience and behaviour in Welsh energy investments (including some fossil fuels). This includes the responses of developers to survey questionnaires, often relating to projects and technologies not yet implemented; and on the involvement of Welsh companies and workers in prior capital infrastructure developments. None of these prior investigations, with the partial exception of the Tidal Lagoon, relate to novel investments at the scale we are considering here.

Fig 11: The Economic Opportunity of the SBCR Energy System Vision

	Renewable Electricity		Domestic Refurbishment		Total	
	Wales	SBCR	Wales	SBCR	Wales	SBCR
Gross Investment (£m)	4,640	-	1,160	-	5,800	-
Spending in Wales (£m)	1,800	-	850	-	2,650	-
Economic Impact (Employment Person-Years)	34,690	23,160	33,000	24,990	67,690	48,150
Economic Impact (Gross Value Added £m)	1,140	670	520	340	1,660	1,010
Annual Employment (FTEs)	2,310	1,545	2,200	1,670	4,510	3,215

As the scale of investment increases, the limitations of the 'local economy' – be that at City-Region or Wales level – to service the investment will reduce. At the same time, the relevant contracts (especially if let in large lots) will become more attractive to national and international companies in the energy and infrastructure fields. These factors will serve to reduce the local and regional impact of the investment in the SBCR Energy System Vision, and is a particular issue for Wales with a dearth of 'Tier 1' infrastructure contractors, a small number of companies (and communities) engaged in renewables development, and a workforce that is under-qualified at most levels compared to its competitors.

As such, and to repeat earlier caveats, the numbers presented here might be thought of as representing a 'best case' scenario, or the scale of the economic opportunity. In order to grasp this opportunity, the Welsh structural economic offer would have to change – and rapidly – from its current narrow focus on relevant natural resources and locally-advantaged labour and services to encompass investment capital, truly Welsh research and innovation (as with SPECIFIC), more higher value services and perhaps even in some cases fabrication and manufacturing.

On a different but related point, a key element in an energy system transformation will be the buy-in of local populations: as owners, via direct, pension fund or community investments; as partners, in the refurbishment of their homes and their choice of transport; and as customers of a very different energy supply. Wales has, as other regions, a mixed record in communicating the necessity for, or costs and benefits of, such interventions in the past. Perhaps the new city-region level will be a more suitable level at which to co-create a new, future-proof, decentralized and globally responsible approach to energy use.

Appendix

Appendix 1 - Summary of Key Sources

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