Employment effects associated with regional electricity generation

Final report from Cardiff University and Regeneris for:

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Summary of the Research

Objectives

Cardiff Business School and Regeneris Consulting were commissioned in December 2012 to examine the employment connected to different electricity generation technologies in Wales. The main objectives of the research were:

- To estimate Welsh employment supported by the operation of electricity generation facilities in Wales, and to examine potential employment effects connected to developing electricity generation technologies.
- To estimate Welsh employment supported during power station construction and development phases.
- To provide a high level assessment of the skills context facing the main electricity generating technologies in Wales, with particular emphasis on how demand and supply issues are likely to influence future developments in renewables generation.

Electricity Generation in Wales

The Digest of UK Energy Statistics reveals that the total electricity generated in Wales in 2011 was around 27,000 Gigawatt hours, and with around 40% of this from natural gas. While coal generation contributes over one fifth of the total, this is expected to decline with new investment unlikely. The other key contributor in 2011 was nuclear, although with this contribution being depreciated by the decommissioning of the Magnox Wylfa plant on Anglesey.

Table 1 Electricity Production in Wales (2011)

	GWh	% Welsh generation
Coal	6,170	22.6
Oil	215	0.8
Gas	10,670	39.1
Nuclear	5,364	19.7
Thermal renewable	443	1.6
Hydro (natural)	268	1.0
Hydro (pumped)	2,301	8.4
Non thermal renewables	1,447	5.3
Other	405	1.5
Total	**27,283**	**100.0**

Source: *Derived from Digest of UK Energy Statistics*, 2012

Welsh employment in electricity production in 2011 was estimated to be around 1,900 and with the vast majority of these opportunities being full time as opposed to part time. Between 2008-2011 Welsh electricity production employment increased by around 25%. This reflects, in part, the development of new onshore wind capacity. With environmental regulations tightening, future employment at older coal fired facilities is vulnerable, and with newer gas fired stations requiring far lower numbers of employees. (see Table 2).

Estimates of employment effects of electricity generation technologies

Table 3 provides estimates of person years of employment in Wales connected to the construction, development and planning stages of different electricity generation technologies. The estimates are in terms of person years of employment in Wales per MW installed. The Table also relates this to a typical investment (i.e. a scenario facility in terms of installed MW). This is not a complete coverage and with no estimates in terms of capital construction for coal. However, the Table covers those electricity generation technologies that will feature predominantly in Wales in the period to 2025.

Table 2 Major Power Stations in Wales and Estimated Operational Employment 2012

Company	Fuel	Estimated Investment	Installed MW	Estimated employment
Baglan Generation	CCGT	£300m	510	c.32
Beaufort Wind (N Hoyle)	Wind (offshore)	£80m	60	
Centrica (Barry)	CCGT	na	230	c.36
Dong Energy (Severn)	CCGT	£600m	848	c.40
EDF (Aberdare)	Gas	na	10	na
EON (Connahs Quay)	CCGT	£580m	1380	c.80
GDF Suez (Shotton)	Gas CHP	na	210	c.32
IP/Mitsui(Dinorwig & Ffestiniog)	Pump storage	na	2088	c.130
IP Mitsui (Deeside)	CCGT	£200m	515	c.50
Magnox Wylfa	Nuclear	na	490	c.580
RWE npower (Aberthaw)	Coal	na	1586	c.270
RWE npower (Pembs)	CCGT	£1000m	2180	c.100
RWE npower renewables	Hydro x 3	na	42	na
RWE Rhyl Flats	Wind offshore	Euro 216m	90	na
SSE Uskmouth	Coal/biomass	na	363	107
Statkraft (Rheidol)	Hydro x 3	na	49	na

Source: Digest of UK Energy Statistics 2013, Jordan FAME, and research team estimates. Note: na- not available

Table 3 Estimates of Person years of Welsh employment per installed MW connected to development and construction phases of electricity generation technologies*

	Gas	Nuclear	Biomass	On-wind	Off-wind	AD	Solar/ PV	Tidal stream	Wave
Job years in Wales per MW installed	4.5	8.6	14.8	12.8	8.3	45.3	20.8	35.3	32.3
Scenario (typical) facility MW installed	500	1,900	50	100	300	3	30	30	30
Job years scenario for typical facility	2,250	16,340	740	1,280	2,490	136	624	1,059	969

*Note: Figures here include job directly and indirectly connected to construction and development.

There is wide variation in person years of employment per installed MW. The scale of the estimated all-Wales employment effects per installed MW are determined by a series of factors:

- Absolute spend per MW installed will be high for newer technologies and where prototypes are still being developed and tested (e.g. wave and tidal stream).
- [illegible] services in the Welsh economy.
- The amounts paid to Welsh households in wages and salaries, and with the review suggesting the propensity of larger multi-year capital projects to draw in labour from as far afield as Eastern Europe.
- The extent to which supported household incomes lead to spending on Welsh goods and services as opposed to spending on imported goods.

Table 4 considers FTE employment supported through the operational phase of power station operations. Immediately evident is that the employment supported through construction and development phases tends to be much larger. Moreover, construction phase employment is [illegible] 20- 25 years depending on the underlying technology.

Table 4 Full time equivalent Welsh employment supported per MW installed capacity during operational phase

	Coal	Gas	Nuclear	Onshore wind	Offshore wind	Solar/PV	Tidal stream	Wave
FTE jobs per MW installed	1.4	0.3	0.7	0.6	0.6	0.4	0.9	0.8
Scenario facility MW	500	500	1,900	100	300	30	30	30
FTE jobs in Wales pa in Scenario facility	700	150	1,330	60	180	12	27	24

Note: Figures in this table in first row are rounded up to one decimal place.

Table 4 reveals that FTE employment supported in Wales per installed MW varies from a high of 1.4 in the case of coal, to just 0.3 in the case of gas (CCGT). It was not possible in the research to derive figures for biomass and anaerobic digestion. More conventional technologies tend to be related to a greater scale. It is accepted here that the employment effects linked to gas, coal and even wind are better understood than those technologies such as tidal stream and wave. In these latter cases estimates are based on prototype, sometimes one-off devices, and with the scope for scale economies and cost reductions through time less well understood.

Among the determinants of the all-Wales employment effects during operational phases are the following:

Labour intensity associated with the energy generation technology. Selected technologies are very capital intensive with few direct labour requirements during normal operations. For example on-site employment in gas (CCGT) is very low in comparison to the maximum power output. On-site employment can step up during scheduled outages.

Extent to which the operational phase employs regional staff and whether planned maintenance turnarounds involve local contractors or specialist teams brought in from outside Wales or the UK.

Extent to which charges and payments relating to grid, land rents etc are leakages from the local economy.

The level of incomes paid to local staff employed at power stations or those engaged in routine maintenance.

The distribution of employment across energy generation technologies in Wales will change. A possible scenario is shown in Table 5. Assuming nuclear new build and the rundown of coal generation, the period to 2025 could see much of the future operational phase employment in Welsh power generation focused in gas (CCGT) and in supporting one nuclear installation. Table 5 uses the information from Table 4 to provide an estimate of the total Welsh employment currently supported in the operations of major existing power generation facilities, and then offers a scenario based on a forecast of installed capacity in 2025 (excluding biomass, AD, and hydro-electric/pump storage). It is estimated that current capacity in the technologies listed supports around 5,400 jobs. The broad changes scenario to 2025 could see overall employment maintained but with renewables making a greater contribution.

Table 5 Estimates of operational employment supported in Wales in 2012 by electricity generation, and a 2025 scenario.

	Coal	Gas	Nuclear	Onshore wind	Offshore wind	Solar/PV	Tidal stream	Wave	Total
Estimated 2012 MW installed	1,949	5,883	980	254	150	46	0	0	9,262
Estimated Employment supported 2012	2,729	1,706	715	160	84	18	0	0	5,412
Scenario 2025 MW installed	0	7,000	2,000	1,600	1,600	100	30	30	12,260
Estimates Employment supported 2025	0	2,100	1,400	960	960	40	27	24	5,511

It is important to recognise that the employment reported here is that estimated to be supported in Wales through construction and then operational phases of different technologies. Care needs to be taken in using these estimates particularly given limits on knowledge on spending and local sourcing characteristics of newer generation technologies. Furthermore, job estimates should not be used in isolation when considering the implications of the growth or contraction of sectors. For example, employment estimates do not speak to the quality of employment being provided, neither do they speak to the externalities connected to selected power generation technologies.

Skills

Whilst there are numerous gaps in the research base (particularly regarding the skills context facing some of the more nascent energy technologies), the report finds that the supply of skills does not appear to be constraining the development of the energy technologies in Wales. This partly reflects a situation where the level of employment supported by these energy technologies in Wales is still relatively low, and also reflects the proactive approach being taken to low carbon skills training provision within Wales.

If realised, projected growth across many of the renewables sectors in Wales could result in a significant increase in the demand for labour and skills. The report concluded that the regional labour market can be positioned to act as a catalyst for the growth of the technologies rather than as a constraint. However, there are a number of core challenges to overcome including uncertainty about labour and skills requirements in the face of developmental uncertainty, particularly in nuclear and on/offshore wind, and with other (marine and tidal) technologies at the pre-commercialisation stage. There are also a series of spatial challenges ςthe spatial demand for labour in Wales varies significantly according to energy technology and phase of activity.

Whilst skills needs vary from one energy technology to the next, a general trend is expected of increasing demand for higher level skills. This partly reflects the increasing levels of sophistication associated with the emerging energy technologies. As such, the existing challenges associated with the supply of higher level STEM skills are expected to intensify in the future. Skills planning will play a large role in responding to these challenges. There is a strong base to build upon in this respect ςin recent years, strong relationships have been forged between the sector skills councils, the large employers and providers, resulting in the establishment of National Skills Academies, the development of bespoke FE and HE courses and Apprenticeships. It is also important that these relationships also extend where possible to include smaller employers to ensure an all-encompassing approach to skills supply right through the value chain. This is particularly key in the more nascent technologies which are characterised by the presence of smaller operators.

Conclusions

The changing Ŝ ƴ ŜNJ∃ è Ƴ ƛ È ƛ ƴ ² Ǝ ƒ Ŝ ă ǿ ƛ ƒ ƒ NJŜŘdzŎŜ ű Ƙ Ŝ Ŝ Ǝ ă ƛ **employed in electricity generation**. The current pattern identified is direct employment focused in a small number of sites. The rundown of coal-fired capacity together with uncertainty on the progression of nuclear will see much of future employment more spread out, more mobile and more difficult to identify ςfor example, much employment will be in construction and engineering companies and trades as opposed to on-site in power stations. Given these changes it becomes far more important to look at the entire employment supported by, regional operational spending rather than attempting to differentiate in detail the difficult dividing line between direct and indirect employment in what are increasingly extremely capital intensive operations.

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It is difficult to escape from the opportunities lost in Wales due to the absence of capacity in terms of the high value added elements surrounding device manufacture, and the absence of large scale developers with integrated bases of operation in the region. Permeating much of the analysis in the report are assumptions reflecting that major decisions on capital investment are made elsewhere, developers are typically based elsewhere, managing contractors are based elsewhere, and then the risks and rewards of new infrastructure development are in large measure internalised elsewhere. Then one context of the employment effects reported (and then resulting gross value added effects) for electricity generation is a Ψbranch plantΩtype economy, and a linked low skills equilibrium. Such an economy which will find it difficult to capitalise on future opportunities in renewables, in spite of being adjacent to one of the highest quality natural resources in Western Europe.

Recommendations and Implications for Welsh Government Policy

Some recommendations that follow from our employment effects analysis:

There are significant uncertainties involved in assessing the jobs impact of electricity generation (quite apart from methodological and modelling issues). For many important elements, developers either do not yet know, or are unwilling to say. **The Welsh Government should thus exercise caution in using any prior assessment of jobs connected to the construction and development phases of large scale new power infrastructure to drive policy especially when originating from parties with a vested interest**. Our review suggests on-site employment estimates made in advance are rarely followed up by a later analysis of out-turn, and without due consideration of balance between local, Welsh and travelling workers from the rest of the UK and overseas.

As with any economic impact assessment assumptions on local sourcing have effects on the estimates made. Targeted Welsh Government interventions in terms of improving supply chain performance (information provision; supplier diversification and new inward investment) could lever welcome employment returns.

Further research is merited to investigate how multinational managing contractors involved in power infrastructure and other major projects in Wales actually go about the task of selecting suppliers and subcontractors. In particularly here whether there are path dependencies in the selection process that could be changed by better information on the regional supply side, or by other Welsh Government interventions.

This report has focussed on the regional employment impacts of electricity generation in Wales. There are a number of key themes that arise from the work (and from associated projects and literature) that are perhaps not directly policy-relevant for Welsh Government in the short term, but might inform longer-term policy in this area. We summarise these below.

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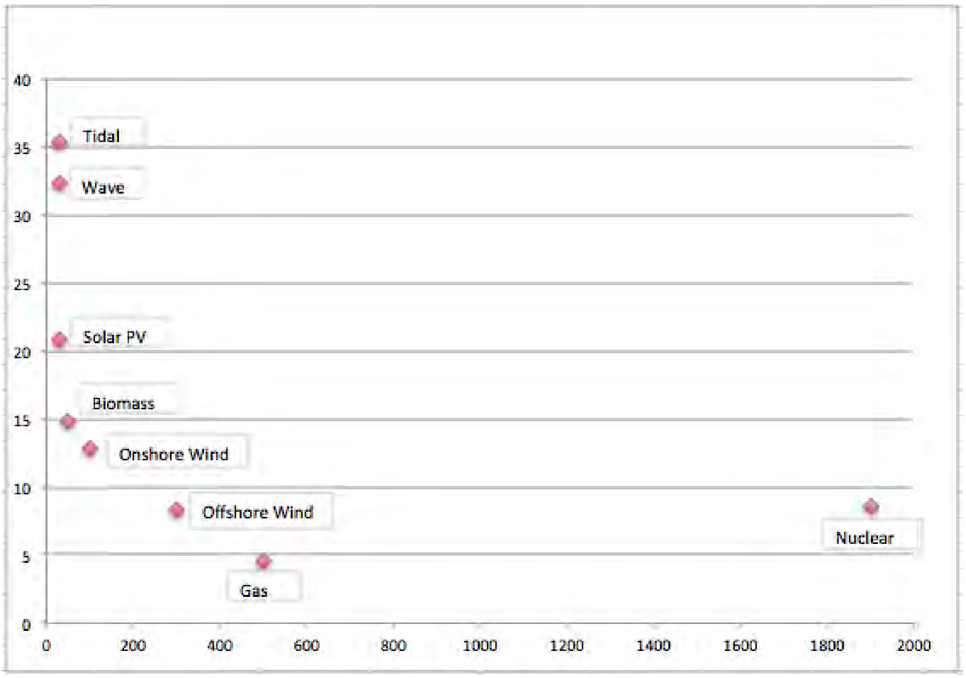
As Figure 1 derived from this report shows, there is a trade off between large-site, centralised and often more established technologies; and novel (renewable) and more diffuse technologies in terms of employment generated per MW installed. With some caveats, the latter have higher employment impacts per MW but with these likely to be spread across a number of sites as technologies move to scale.

Clearly, from a pure regional-employment perspective large centralised development has a number of planning, electrical-technical and potentially public acceptance benefits. Nuclear, in particular will have significant and visible employment effects at a site already prepared, and where public and political opinion is arguably benign (certainly relative to electricity developments elsewhere in Wales).

Clearly, however, such development has indirect costs. There is virtually no opportunity for Welsh- (indeed perhaps UK) based companies to engage in technological development, or to constitute a ō Ŝ l· Ŏ K K Ŝ l· Ř ΨLJNJ Ƨ Ǿ ƛ ƴ ∃ own but other technologies (albeit at a UK rather than ŎNJ Welsh level). Additionally the very ease of such big developments close to existing large transformers may arguably slow the development of more diffuse technologies, and the grid to support them. This may, in time be seen as a lost opportunity.

Figure 1 Jobs per MW (development) and Likely Facility Size (horizontal axis; MW)



There is a tension between economic impact and viable power generation

The report shows that the best performers in terms of regional employment generation are the novel technologies of wave and tidal stream but they are still by far the most expensive to install per MW ςdouble the cost of any other reported technology.

It is this cost which to a large degree drives regional economic impact in both development and operational phases. Novel technologies will not be viable (in the absence of technology specific subsidy) unless they can be made whole-cost competitive with competing generation technologies, whether fossil or nuclear. As cost per kWh diminishes, so will regional economic impact. Given the ỵ ŀ ű dzNJŜ ƻ Ŧ ădzLJLJƻNJű ⅄ ỵ∃ ŀ Ŏ ű ⅄ Ø ⅄ ű ⅄ Ŝ ă Σ Ř Ŝ Ø Ŝ ŧ ƻLJŜNJă ŀ ỵ Ř between generating types, one might expect regional economic impact to be reasonably convergent between technologies over time, and with the overall trend of impact (per MW) downward as cost savings are made, and the balance shifts from installation to maintenance.

Ownership matters more than technology

Following the above, it is probably the case that technology type is far from the biggest driver of regional economic impact. What is notable is that regional impacts largely come as returns to labour (directly or in subcontractors) rather than returns to capital employed or land/sea owned. There are of course exceptions ςMabey Bridge for example, or the monies paid to Natural Resources Wales for onshore wind leases. Leases for offshore wind are paid to the Crown Estates Trust with hence no *direct* benefit to the devolved region, and the same is true of ongoing payments for grid connections. Inevitably for very capital intensive developments, and particularly where fuel is not a large relevant cost, returns to capital are likely to significantly outweigh returns to labour.

Employment impacts: welcome but modest

Clearly, here the majority of the economic benefit (rather than economic impact) of electricity generation is, in the UK at least, in the form of privatised returns to capital with this then serving to repay initial investments and generate profits for generating companies. Under this paradigm, regional economic and employment benefits from electricity generation are likely to be modest but welcome. For example, the roll out of a significant 1GW of power generation might generate annual employment in the order of 0.05% - 0.15% of Welsh total annual employment, dependent on technology and supply chain take up.

Given the lack of other economic benefits evidenced so far from large electricity investments in Wales, across fossil and renewable technologies, it is very unlikely that development of this sector will be in any way transformational for the Welsh economy without a parallel transformation in underlying economic and proprietary relationships.

1 Introduction

1.1 Objectives of the research

Cardiff Business School and Regeneris Consulting were awarded a contract to undertake this study for Welsh Government during December 2012. The main objectives of the research were:

- To estimate the Welsh employment connected to the existing operation of electricity generation technologies, and the Welsh potential employment that could be supported by technologies expected to develop in the near future.
- To estimate the person years of Welsh employment associated with the development, planning, construction and planned maintenance phases of different electricity generation technologies.
- To standardise where possible these Welsh employment effects during construction and operational phases in terms of total Welsh employment per MW of installed electricity generation capacity i.e. estimating not just the direct employment supported, but also indirect employment supported in other parts of Wales through the operation and construction of different electricity generation facilities.
- To provide a high level assessment of the skills context facing the main electricity generating technologies in Wales, with particular emphasis on how demand and supply issues are likely to influence the future development of these technologies.

1.2 Scope of energy generation technologies examined in this report

Given the research objectives a key issue is which energy technologies should be considered. Typically in segmenting and analysing industrial activity in the UK use is made of Standard Industrial Classifications to sub-divide industry employment, output and value added. Unfortunately in official statistical and other publications, energy generation sectors tend to be added together to create an electricity production, distribution and supply sector, but with very little information available that actually sub-divides electricity generation itself into different types of technology. This notwithstanding, at the outset a decision has to be made on a subdivision to treat with the research objectives above. In large measure we follow Department of Energy and Climate Change (DECC)[1] electricity generation technology subdivisions as follows:

- Gas
- Coal
- Biomass
- Nuclear
- Hydro/pump storage

[1] See for example analysis in Digest of UK Energy Statistics, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65881/5949-dukes-2012-exc-cover.pdf

Onshore and Offshore wind
Shoreline wave and tidal (but excluding barrage schemes)
Landfill gas, anaerobic digestion (AD) and sewage sludge digestion
Waste combustion
Solar PV.

It is accepted that analyses of employment effects connected with additional capacity in some of the above is difficult with several of these technologies in early evolution, and/or with existing facilities at trial stages or small scale. One of the challenges of this report is to estimate employment effects in these nascent technologies. We also acknowledge that there is a foundation for estimates of employment effects in some generation technologies in Wales already. For example, funded research by the team within Wales for Welsh Government and Renewable UK provides much of the information needed in meeting the research objectives for onshore wind, and wave and tidal stream (see Regeneris and Cardiff University 2013a, 2013b). We return to issues of technical scope of the report in Section 2.

1.3 Structure of the report

The remainder of the report is structured as follows.

Section 2 describes the assessment method used in the report, focusing in particular on the methods used to estimate the employment effects associated with electricity generation technologies in Wales.
Section 3 summarises the findings from reviews undertaken of prior work into the economic and employment effects associated with different energy technologies.
Section 4 briefly reviews the make-up of the power generation sector in Wales, and describes the existing information available on the economic effects associated with selected electricity generation technologies in Wales.
Section 5 provides an analysis and narrative of the employment effects associated with different power generation technologies.
Section 6 provides findings from our consultations on skills issues surrounding current and future energy production in Wales.
Section 7 provides conclusions on the employment effects associated with different electricity generation technologies and recommendations for further research and analysis.

There are a series of appendices with survey materials/topic guides used in the research, and with the appendices also including further details of the reviews undertaken to support the research.

2. Assessment Approach

2.1 Introduction

In this section we set out the method used to estimate the employment effects associated with the construction and operation of different electricity production methods. The section outlines the economic impact framework and the different research strands undertaken to support the economic modelling work.

2.2 Technologies examined

The technologies considered were outlined in Section 1 of this report. This report covers most of the technologies relevant to future additional electricity generation in Wales, with two main exceptions. At the larger end, and following guidance from the sponsor, we exclude electricity generation via tidal impoundments, with this then including a potential Severn Barrage or Swansea Tidal Lagoon.

We also do not explicitly model hydropower. Although Wales does have some larger hydro and pumped storage schemes (Dinorwig and Rheidol for example) the topography of Wales means they are very unlikely to be an important source of *additional* electricity for the region in aggregate. While, there is very limited additional scope in Wales for electricity generation via large hydropower ς˫ ƴŘ ƛ ű ƛ ă ǿ ƻ NJ ű K NJ Ŝ Ɣ Ŝ Ɣ ō Ŝ NJ ƛ ƴ Ǝ ű K Ŝ ƒ ˫ NJ Ǝ Ŝ ă ű Ψ K è Ř NJ ƻ Ω storage, taking advantage of inexpensive overnight electricity generated by Wylfa but actually net users of power. The largest hydro generation scheme in Wales currently in planning is less that 2MW.

There are, of course significant opportunities in Wales at a smaller scale from micro hydro, often privately or community owned. These schemes are relatively small ςranging from 5kW (i.e. 0.05MW) up to perhaps some 100kW or more per site. There are currently a small number of schemes operating in Wales, and with significant barriers to growth centered (according to the industry) more around bureaucratic rather than capital or topographical issues.

These schemes bring significant potential benefits at smaller spatial scales. Up to now this has been through the levering of feed-in-tariffs (and hence individual or community income), related energy and climate education. There is also a modest, but welcome local economic impact. Developers estimate spend, including survey and planning, of some £5-10,000 per kW installed (so £5-10m per notional MW). Half or more of this is related to labour, with this very often locally supplied.

Micro hydro development, albeit modest in aggregate then provides an important local and/or community resource, not least in the development of project management and other skills necessary to further such schemes.[2]

2.3 Economic Impact Framework

The economic effects assessment is based on an economic model of the Welsh economy (see Appendix D) that was developed to track the existing and potential economic impacts for Wales of different electricity generation technologies.

2.3.1 Sources of Economic Impact

Each of the phases in the development of a power station supports economic activity; through the capital investment incurred in developing and constructing the installation and the operational expenditure incurred in operating and maintaining it. Our economic modelling then has to consider the following elements:

Development and planning: An extended period of work is required before any on-site development of power infrastructure. This covers design and feasibility work, various surveys and the planning permission process. This can take a long time depending on the technology involved.

Plant manufacturing: A range of different types of generation technology are currently available and in development and being tested. This comprises the actual device that is used to generate electricity, for example the turbine installation, and the immediate ancillary devices surrounding the device and control system. Whatever the technology the manufacturing of the devices is typically the largest component of the overall capital cost associated with power station projects.

Balance of plant manufacturing: This includes all the components that are not part of the generation device but are required for its operation (e.g. electrical ancillaries).

Installation and commissioning: The different devices for generating electricity must be assembled and/or housed. This can involve activities such as civil engineering and general construction, and include site development, buildings, installation of electrical systems, installation of foundations, and finally device installation.

Operations and maintenance: Once the installation becomes operational, various on-going activities are required to facilitate this, including monitoring, routine and unplanned maintenance, insurance, and grid charges.

We do not model decommissioning activities in this report due to the extreme uncertainties involved in assessing its timing, scale and scope for a number of the novel technologies.

[2] See: http://www.thegreenvalleys.org/ http://groups.energyshare.com/cwmclydach-community-development-trust http://www.cynnalcymru.com/sites/default/files/Cwm%20Clydach%20May.pdf http://talybontenergy.co.uk/?p=1639

For analytical purposes in the economic modelling and assessment we group the first four headings above as **development and construction** phase. Put simply the developer of the power station purchases inputs in terms of power generation equipment, balance of plant and development services. We then model **operations and maintenance** activity separately.

2.3.2 Types of Employment Impact

The core economic benefits have been assessed quantitatively through an economic impact model which estimates:

- **Direct Welsh Employment Impacts**. This measure captures the employment supported directly through the construction, operation and maintenance of a power station. This, for example, covers direct spending of power station operators on goods and services and their own staffs.
- **Indirect Welsh Employment Impacts**. This measure accounts for supply chain impacts in Wales. For example, as a power station operator spends money on Welsh goods and services, these same suppliers also have to purchase goods and services in Wales to meet these demands. Therefore indirect employment is supported in the regional economy. The additional economic activity in these companies is passed down through their supply chains and so on to generate additional, indirect benefits for many other companies.
- **Induced Welsh Employment Impacts**. This captures the knock on benefits that additional employment supported directly and indirectly has in the economy as salaries, earned by those employed in additional jobs, are spent on goods and service elsewhere in the economy.

Rather than separately, the above employment impacts are reported in aggregate, and per MW installed (see 2.4.4 below).

2.3.3 Measures of Impact

The assessment uses different measures to quantify the nature and scale of economic impacts associated with the development and construction phases of power stations, and then their operational and maintenance phases:

- **Employment**. This is the number of jobs that are created within Wales. We express these as **Full Time Equivalents**, a measure that converts full- and part-time jobs into a common currency. (Two part time jobs are assumed to equal one full time job).
- **Person years of employment in Wales**: For the development and construction phases we estimate the person years of employment associated. **The person years of employment in Wales comprises all direct, indirect and induced employment effects**. For example this would cover the employment associated with not just the on-site development and installation of the power station, but also cover the employment supported in the Welsh supply chain as managing contractors purchases goods and services in Wales, and

employment supported as direct and indirect employees concerned spend their incomes within Wales. Effectively, these impacts tend to be Ψ ƻ ƴ Ŝ as they are ƻ Ŧ Ŧ Ω connected to capital phases of projects. The time period across which this employment is generated remains undefined; for example, 100 person years may be 10 full time workers on site for a decade or 100 workers for one year.

Person years of employment in Wales per MW installed. As different electricity technologies operate at different scales we seek to standardise the person years of Welsh employment measure in terms of the installed capacity of the power station in terms of Megawatts installed ς ƛ ƴ ŀ ƚ ƚ Ŏ ŀ ă Ŝ ă ű Ķ Ŝ Ψ ō ƻ ƛ ƚ ŜNJLJ ƚ ŀ ű Ŝ Ω Ŏ ŀ LJ ŀ

FTEs per MW of installed capacity. For operations and maintenance phases of power station operation we report annual FTEs supported in Wales per MW of installed capacity at a power station to aid comparative analysis**. This comprises all direct, indirect and induced employment effects estimated to be associated with operational and maintenance phases**. These employment effects will persist as long as the plant is generating electricity.

Person years of Welsh employment: Example

If it is assumed that a typical power station takes 3 years in development and construction. If it is assumed that on average over this 3 year phase there are 600 Welsh employees on site per annum. Then this would equate to 1,800 person years of Welsh employment (3 years multiplied by 600 people). However, during the development and construction phase, the managing contractor will purchase goods and services in Wales supporting further person years of employment in Wales, and moreover, the Welsh employees on the site also spend part of their wage incomes in the region. Then, for example the total person years of Welsh employment would be greater than the 1,800 ō Ŝ Ŏ ŀ dz ă Ŝ ƻ Ŧ ű Ķ Ŝ ă Ŝ Ψ ƛ ƴ Ř ƛ NJ Ŝ Ŏ ű Ω ŀ ƴ Ř Ψ ƛ ƴ Ř dz Ŏ Ŝ ŀ Ř Ω Ŝ Ŧ Ŧ Ŝ Ŏ ű employment per annum are supported in this way over three years of development and construction, then the total person years of Welsh employment would be 3,000 (i.e. 1,800 plus 1,200). If the installed capacity of the station is 750MW then this would equate to 4.0 person years of Welsh employment per installed MW (i.e. 3,000 person years divided by 750MW).

Table 2.1 ςThe Employment Impact Metrics in Summary

Person years of Welsh employment per MW Installed (Development & Construction)			
Metric	**Units**	**Example elements**	**Notes**
Person years of Welsh employment.	Person-years of employment (Wales) per MW installed comprising direct, indirect and induced effects	On-site surveys and preparation Professional advice Device manufacture Associated electrical infrastructure Supply chain employment related to the above Induced employment impacts	All employment associated with capital works on-site, or in supporting activities across Wales (e.g. ports; devices) irrespective of ǿ ƻNJ ˩ ŜNJăΩ ƻNJ Ŏƻ Y residence. Includes all elements of the supply chain in Wales, plus any employment in Wales associated with wage spending by direct/supply chain development-related employees. No R&D activity included.
FTE/MW Installed (Operational)			
Metric	Units	Example elements	Notes
FTEs per MW of installed capacity	FTE jobs (Wales) per MW installed comprising direct, indirect and induced effects.	On-site surveys and preparation Professional advice Device and electrical maintenance Supply chain employment related to the above Induced employment impacts	All employment associated with operations on-site, or in supporting activities across Wales (e.g. device maintenance; on-going surveys). Includes all elements of the supply chain in Wales, plus any employment in Wales associated with wage spending by direct/supply chain operational employees.

We believe that the metrics developed illustrate broad differences in the level of potential economic impact for different generation technologies in terms of employment in Wales. Later in Section 5 of this report we seek to explain what drives these differences.

2.4 Uncertainty and Scenarios

2.4.1 Typical plant size scenarios

This report seeks to cover both existing, prototype and evolving technologies. With selected technologies at evolutionary stages there is a lack of clarity of future scale. With existing technologies it is easier to make assumptions on likely scale. To aid the comparative analysis we report our measures of impact alongside an expected scale of facility such that the overall jobs effects can be linked not just to a MW of installed capacity but also an expected size of new plant. The scale scenarios are based on our review of the literature see (Section 2 and Appendix F). We use the following scenarios:

Table 2.2 Plant size scenarios (MW installed) for comparative analysis

Gas	Nuclear	Biomass	Onshore wind	Offshore wind	Anaerobic Digestion	Solar/ PV	Tidal stream	Wave
500	1,900	50	100	300	3	30	30	30

2.4.2 Capital and operational costs

The early stage of some of the technologies covered means a relative lack of evidence on costs associated with development, construction and operation, since no projects have been developed at commercial scale. This is complicated by the fact that it is not possible to predict the future mix of technologies. However, the literature review revealed sources of generic cost information based on intelligence from developers. We have made use of this information and supplemented it with consultations with project developers in Wales in order to arrive at reasonable estimates.

2.4.3Sourcing from Wales

A real source of uncertainty centres on the extent to which Welsh industry is able to benefit from the opportunities generated by different power station projects. The extent to which Welsh industry benefits from opportunities depends on: the procurement approach pursued by the developer; the current capabilities of the Welsh supply side; the extent to which Welsh firms already serving other sectors such as oil and gas can adapt to the requirements of power station developers; their ability to form strategic alliances in order to bid for large packages of work and so on. In some cases of evolving technologies there have as yet been none developed commercially so that it is not possible to extrapolate from previous experience. We have therefore made use of the following sources to arrive at a reasonable view on Welsh sourcing propensities:

- From third party reports and sources we gleaned a variety of information related to [illegible] amounts of spending, direct employment or occasionally both (see Appendix E).
- Review of research (see Appendix F) including evidence from other impact assessments.
- Structured consultations with developers to understand procurement routes and views on the availability of suitable goods and services in Wales.
- A detailed understanding of the current supply side in Wales, derived from a series of prior projects on renewables, and related impact projects for other industries. Moreover, the Input-Output Tables for Wales can, for more established fossil and nuclear technologies (see Section 4), provide information on both direct, on-site activity and that arising across Wales through the supply chain.

Table 2.3 provides indicative estimates of local sourcing for relevant technologies. It should be noted that these exclude the re-entry of former leakage. For example, grid connection charges or seabed lease monies (to Crown Estate Trust) may have future, positive implications for Wales if the relevant UK national organisations re-invest that money in part in Wales, but the relevant numbers are probably unknowable and not included in the modelling. Clearly here the higher the percentage, the higher the level of Welsh employment, but with this dependent on the level of initial spending and the labour intensity of the relevant supplying sector.

Table 2.3 Regional Sourcing Assumptions

	Coal	Gas	Nuclear	Onshore wind	Offshore wind	Solar PV	Tidal energy	Wave
CAPITAL & DEVELOPMENT COSTS								
Grid connection & installation		60%	30%	50%	30%	70%	70%	50%
Nacelles / turbines /device manufacture		0%	0%	0%	0%	50%	30%	30%
Other Electrical (inc. solar cells)		20%	10%	40%	30%		20%	20%
Metalworks		10%	10%	50%	40%	80%	10%	10%
Foundations, mooring & other site & port works		50%	35%	80%	30%	90%	40%	70%
Planning, project management, surveys, consultancy		60%	20%	55%	50%	90%	70%	90%
OPERATIONS								
Maintenance inc. port operations & on-going surveys	70%	70%	50%	80%	50%	100%	90%	70%
Grid connection charges	0%	0%	0%	0%	0%	0%	0%	0%
Insurance	10%	10%	0%	30%	20%	20%	0%	0%
Other	50%	45%	40%	50%	50%	50%	0%	0%
Rates/seabed lease etc.	100%	100%	100%	100%	50%	100%	0%	0%

Note:
These percentages and classes of expenditure should be considered indicative only due to differences in the nature of developments across technologies. They comprise our best estimate of most likely regional sourcing behaviours in aggregate and do not relate to specific current or future developments.

Sources:
The Economic Opportunity of Onshore Wind in Wales, Regeneris/WERU 2013; Input-Output Tables for Wales, 2007; Authors' own calculations.

2.4.4Other uncertainties and issues

We list below a series of other uncertainties that users of this report need to heed.

Decommissioning ςis extremely uncertain for many of the technologies modelled, in terms of when this will happen and the relevant employment impacts. In order to maintain comparability, we do not include decommissioning employment for any technologies[3] even where this is already occurring (e.g. Nuclear).

The link between installed capacity and generation ς We report employment in terms of megawatt installed rather than gigawatt-hours of power generated. This is due to extreme uncertainty over the likely load factors for novel technologies.

Technology Assumptions. It is not possible, across novel generation types, to ascertain the likely level of cost savings made as technologies develop and become commercialised. Each generation type impacts are therefore based on current production and installation methodologies but with the expectation these must change for technologies to become commercially viable[4].

Ψ ² Ŝ ƭ ă K Ω 9. As far as possible we report here employment generated on-site at Welsh locations during capital and operational phases, combined with off-site impacts across Wales. This will then include, particularly in development phases, some elements of the workforce that are peripatetic/short term migrants, and indeed some which may commute daily from outside Wales. The data do not exist to separate out these elements of the workforce, at least for a national study of this nature.

Impact measures per installed MW. In section 5 we report figures for person years/FTEs in Wales LJŜNJ a ² ƛ ƴ ă ű ŀ ƭ ƭ Ŝ Ř Ŏ ŀ LJ ŀ Ŏ ƛ ű è ó ă Ŝ Ŝ ŀ ō ƻ Ǿ Ŝ ύ Φ ¢ K ƛ larger employment number. The implication here of a linear relationship between capacity and employment (either in development or operational phase) is false. This is demonstrable with reference to a large CCGT (gas turbine) where generation capacity depends wholly on the size of the turbine and hence gas input but where control systems might not change between two differently rated turbines ς and hence with operational employment largely unchanging also. The analysis here, based on scenarios should be considered as relating to a Ψ ű è LJ ƛ Ŏ installation of the technology referred to (although with even this uncertain for many novel technologies) rather than a hard ratio that holds as scale of generation increases.

Ψ / ƻ ă ű LJŜNJ Ͽ ƻ ƃ ΩΨ Ŝ ƻ ă ű ƛ ·LJ ŜNJ ă Ƨ ƻ ō Ω Ŝ of the capital Ŝ ǿ ƻ dz ƭ Ř investment per employee supported for each technology (with this potentially then for capital and operational phases separately). The provision in the report of such a figure, when combined with estimates of employment per MW installed (already included) could enable the easy back-calculation of totals for capital and operational cost per MW for each technology that have informed our modelling. With a small number of developers (actual and potential) responding with information on development costs for novel and renewable technologies, publication of this information would therefore potentially reveal information about individual companies and projects that is commercially confidential and we do not feel this is appropriate.

Employment multipliers. We do not report employment multipliers in the discussion of results of the modelling process in Section 5. The employment multiplier is the relationship

[3] There is a small caveat here as onshore wind employment includes a small element for decommissioning, as it is not possible to separate from repowering of sites with larger turbines.
[4] Again a caveat here in that wind and wave have been subjected to some cost savings consistent with a 30MW array roll out.

between total employment effects (direct, indirect and induced) and direct employment effects and shows the numbers of jobs in an economy supported by direct employment in an industry or activity. The employment multiplier approach is potentially misleading. For ŝ È ŀ ϒ LJ ƚ ŝ Σ ű K ŝ ∃ NJ ŝ ŀ ű ŝ NJ ű K ŝ ŝ È ű ŝ ʆ ű ƻ Ŧ ă dz ō Ŏ ƻ ʆ ű NJ ŀ employment and the greater then the multiplier ͼeven though overall employment involved in operating, servicing or building a power station might be the same. Moreover, during Ψ ʆ ƻ NJ ϒ ŀ ƚ Ω ƻ LJ ŝ NJ ŀ ű ƛ ƻ ʆ ă Ř ƛ NJ ŝ Ŏ ű ŝ ϒ LJ ƚ ƻ è ϒ ŝ ʆ ű ă dzLJLJ ƻ NJ because of the capital intensive nature of energy generation. The corollary is relatively high employment multipliers as more employees are supported indirectly than are actually supported directly at power generation facilities. We concluded, for decision making purposes job multipliers are erroneous, and more important is a steer on the expected scale of impacts associated with the technologies, during their respective stages of development.

Induced effects. Linked to the above we do not report separately induced effects. However, as a guide, across all technologies the following division can be used to show how total Welsh employment is likely to arise in these three areas (leaving aside subcontracting issues):

Direct/Onsite Effects	*70%*
SupplyChain/Indirect Effects	*25%*
Wage-Related/Induced Effects	*5%*

Finally, in the light of the novel stage of much of this technology discussed in this report it is important to summarise the limitations of the modelling method adopted:

The identification of a particular technology here does not speak to its likely commercial viability.

Some estimates for established technologies (e.g. coal) are based on relatively old plants in Wales, and may not fully represent a new investment.

The estimates largely relate to technology in its current state and make no allowance for the cost saving that will be needed to drive the viability of novel technologies. These cost savings may in some cases cause a decline in the levels of regional employment supported compared to that reported here.

In emerging or concentrated supply chains, the making or breaking of individual contracts can have a significant impact on the level of Welsh impact.

The level of Welsh impact will depend in large part on the willingness of the Welsh supply side to bid for and win relevant contracts, and in some cases to adapt their businesses to enter emerging intermediate input markets. The extent of this flexibility and competitiveness is largely unknown.

Due to the above factors there is likely to be a high level of volatility in the system, but one we cannot measure.

2.5 Research strands

In developing this report it was important to make the best use of existing knowledge on different energy technologies and to identify gaps in knowledge. The initial research tasks therefore comprised three reviews of existing information and analysis i.e.

- Analysis of academic material and prior reports and impact assessments both for the UK and internationally that provided insights into the spending patterns and economic impacts connected to the operations and maintenance of power generation facilities using different energy technologies.
- Investigation of how electricity production is described and disaggregated in national accounting and economic modelling frameworks (input-output tables) and then investigation of the typical patterns of goods and services purchases connected to different electricity production methods.
- Review of impact assessments and research literature dealing with construction activity in different energy generation technologies. It is necessary to understand the construction and developmental phases of different energy technologies with much of the associated employment provided early in the project life cycle.

The three separate reviews (see Section 3 of this report and Appendix F) helped the research team identify, for different energy generation technologies, the likely determinants and scale of employment effects. The review also provided initial estimates of the employment directly and indirectly connected to existing and potential energy generation technologies.

For a series of energy technologies, including many renewable generation categories as defined by DECC, there is extant capacity within Wales such that there is value in seeking to consult with developers/operators to gain direct inference on spending patterns and employment. A consultation instrument was developed to seek details of existing operations, maintenance turnarounds, capacity, and related spending profiles and employment supported. Inevitably it was difficult to encourage firms to provide these types of data for discrete sites given commercial sensitivity.

Gaining information on existing generation-sites still leaves problems in relation to nascent technologies, and problems where future development profiles cannot easily be gained from inference to existing capacity (e.g. nuclear). This then required a more focused period of industry and expert consultation on the development and operational implications of these technologies, and expected employment effects. We undertook a series of expert consultations and the topic guides for these industry consultations are found in Appendix A of this report.

An additional element of consultation was undertaken to specifically explore the skills demand and supply side for different technologies while in construction, operational and maintenance stages, and with this reflecting on the quality of employment that could be supported and resulting earnings spent in the regional economy (this linking through to the magnitude of overall employment effects i.e. levels of induced employment effects through wage spending). Appendix B contains the topic guides used in the skills consultations, while Appendix C provides a list of organisations and institutions that were consulted as part of the overall work.

3 Review: Employment effects of energy generation technologies

3.1 Introduction

This section of the report examines evidence of the employment effects connected with the construction and operation of power stations using different technologies. There are some nascent technologies where limited review material was available on employment effects. The expected potential connected with nascent technologies was examined through a series of consultations which feed into the analysis in Section 5 of the report.

One purpose in the review was to reveal the relative magnitudes of employment supported during construction and development of power stations set beside that supported in operational phases. The review used both UK and overseas evidence. The majority of power generation technologies support considerable person years of employment through development and construction but small amounts of employment in routine operation. In the Welsh context, recent increases in installed generation capacity do not tend to involve managing contractors from Wales, and neither is there the potential to source high value components such as turbines and other devices from within the region. Furthermore, research reveals that some proportion of rental incomes on lands, and profits from electricity generation in Wales leaks to the wider UK economy and overseas.

The full review examines each generation technology in turn. It is accepted that the review contains both *ex post* and *ex ante* evidence of effects. Moreover, we accept differences within technologies in terms of economic effects, but the commentary provides something of a check on employment potentials at different stages. We accept that care needs to be taken with generalising from studies reviewed, because of specific geographical and economic contexts which determine the scale of indirect employment effects. Finally, the review did not treat explicitly with tidal stream and wave technology because this is reviewed in parallel research undertaken by the authors for Welsh Government (see Regeneris and Cardiff University, 2013b).

In examining employment in operational and maintenance phases in particular we relied largely on an analysis of academic materials and industry reports providing insights into spending patterns and economic impacts. These were combined with website material, reports and environmental impact statements, to reveal relevant case studies.

In what follows we summarise in bullet point form the main points from the review for each energy technology in turn. For the full review and references please see Appendix F. Appendix F also includes a review of how energy generation is treated in national accounting and economic modelling frameworks (i.e. input-output tables) .

3.2 Coal Fired Generation

Around 1,200 coal plants across 59 countries are in planning, with 75% of these in China and India (World Resources Institute). In Europe, little new coal fired capacity is coming on line currently.

Literature focuses on Ψ ăŊĺ ê Ŏ ĺ Ŝ ű ƛ ƴ ∃ Ω Ŏ, and the lack of commercially viable ă ű ă carbon-capture technology.

US sources suggest a typical plant will take up to four years to construct with capital costs of around $2bn per GW of installed capacity, and involving a construction workforce of 1,900 at peak (or around 6,000 person job years, compared to around 90 permanent jobs when plants become operational).

Typical employment multipliers (indirect and induced effects) are around 3 or 0.1 direct jobs per MW of installed capacity.

Limited information is available on coal power generation employment effects in the UK.

Analysis for Wales of existing coal fired capacity would suggest around 0.2 direct jobs (FTE) per MW of installed capacity.

3.3 Gas Power Generation (Combined Cycle Gas Turbine Technology)

Planning applications and permissions for CCGT power stations are often adjacent to existing coal-fired sites in decommissioning phases. In these cases there is some expectation of reduced construction phase impacts because of existing infrastructure.

Employment effects through the construction phase are commonly reported imprecisely with few citations of equivalent job years through stages of the development process.

Employment on-site during construction can vary daily by many hundreds, and construction impacts are commonly overstated. There is little post development research to verify claims and estimate equivalent job years.

Power station projects reviewed included a 1.3GW facility on the River Trent (West Burton CCGT) with total capital investment estimated at £450m, and with a construction phase employing on average 1,000 people, but with operational employment expected of around 40-50 skilled operators, and operational and maintenance costs of approximately £15m annually.

Drakelow E CCGT Derbyshire (around 1.3GW), expected to be operational during 2013. During peak-construction phase 800 workers were required at the site. Construction and commissioning phase is around 3 years.

Baglan Bay Power Station (525MW). The construction phase ran from 2000-2003, at a capital cost of £300m. Estimated 1,000 workers employed during the construction phase, with over 600 mechanical and electrical construction jobs filled by local workers, and with around 40 people employed when fully operational.

DONG 0.85GW Severn Power (Newport) started in 2008 with a 34 month construction and commissioning phase. In September 2009 500 people were estimated to be employed on the site (only half were either British or Irish), peaking in December 2009 at around 1,200 people. The project, completed in November 2010, had an operational employment of around 40 people.

RWE npower [illegible] bn [illegible]. Construction phase was estimated to have employed around 2,000 at peak (managed by Alstom). Operational employment is an estimated 100 people. 100-200 additional people on-site would be typical for an 8 week turbine outage. RWE npower estimates £10m of operational spending per annum and with a maintenance budget of around £10m.

Review found that that six Centrica UK gas fired stations ranging in capacity from 230MW to 895MW employ between 31 and 42 people in each case.

3.4 Nuclear Power Generation

Construction Phases

Relatively high employment effects through construction and operational phases compared to other energy technologies. Evidence reviewed included:

Glasson *et al.* (1988): report peak employment of 3,500 in the fourth year at £1.15bn Hinkley Point (north Somerset) over a 7-8 year construction phase. 1,650 of these employees were commuting 35-40 miles. During construction an annual *wage* injection into the local economy of between £2.5m at the start of construction to £49m at peak. Contractor expenditure on goods and services in the locality was estimated to be around 1% of construction costs.

Glasson and Chadwick (1995) examined the local (county level) socio-economic effects associated with the construction of the £2bn Sizewell B facility (1988-1995). The total workforce rose from 883 (64% assessed as local people) in Year 1 to 4,638 (45% local) by year 5. Observed falls in the local share was linked to a shift from civil engineering to mechanical /electrical engineering activity as the construction progressed. 61% of civil engineering activities were sourced locally compared to 38% of mechanical and electrical activities, and 33% of project management. 96% of site services and security was sourced locally.

EDF (2012) estimates peak workforce at Hinkley Point C of 5,600 in 2016. They state [illegible] the entire construction phase it is anticipated that 20,000-25,000 individual posts (person years) [illegible] i.e. an average [illegible] over the nine year construction period, with 50% of this being Somerset residents. Total wage impacts are estimated at £45m per year with £45m per year of construction supply chain benefits in Somerset.

Wylfa B Anglesey. If this were to go ahead, the £8bn site could create a 60 year demand for employees, with 6,000 peak construction jobs at peak. GE Hitachi Nuclear is likely to use its own extant supply chains on reactor work. Construction expertise is likely to be sourced from internationally experienced firms. General civil engineering and construction (earthworks etc) will provide local opportunities.

Operational Phases

Nuclear generation supports significant operational employment. EDF Energy (2012) reports 44,000 people currently employed in the British nuclear industry. This includes 24,000 who are employed directly (with 12,000 in decommissioning, 7,500 in electricity generation and 4,500 in fuel processing) and 20,000 with contracted indirect jobs in the wider supply chain.

1.2GW Torness nuclear power station in Scotland estimated to contribute £56 million to regional GDP (made up of £35 million direct, £18 million indirect, and £3 million induced). The site contributed nearly £33 million in income into the local economy, representing nearly 4 per cent of all economic output in the East Lothian region. 545 people were directly employed with a further 756 jobs supported through spending and wage effects.

EDF Energy Torness had over 450 suppliers; the top 20 accounted for nearly 70% of the total (2008-2009). Planned plant outages occurred every 18 months. In 2009, £15m of outage-spending accounted for 27% of total expenditure of goods and services. Annual expenditure increased by 55% between non-outage year (2008) and an outage year (2009). In 2008 non-outage year, Scottish suppliers accounted for 77% of total spend on goods and services; this dropping to 32% in outage year (2009).

EDF Energy (2012) estimated the economic impact of an investment of £10bn over the life cycle of the Hinkley Point C site. EDF estimated £40m annually would be added to the local economy during the sixty years that the plant would be operational and the creation of 900 operational jobs, (700 full-time directly employed staff and 200 contract staff). They identified a temporary workforce of 1,000 during the periodic one month outage periods (occurring every 18 months).

Wylfa B if successful would directly support around 1,000 (mostly highly skilled and specialised) operational jobs.

3.5 Biomass

Our review reveals that employment linked to biomass tends to include jobs supported in growing the biomass, and majors on issues of displacement i.e. increases in food costs and ƒ ŀ ƴ Ř ǊŜ ƴ ű ă ƻ ƴ ƒ ŀ ƴ Ř ∃ ƛ Ǿ Ŝ ƴ ƻ Ǿ ŜǊ ű ƻ Ψ∃Ǌƻ ǿ Ω ŦdzŜ ƒ

Review focuses on employment supported in development and operation of biomass facilities of different scales.

RES are planning a 100MW North Blyth wood-based biomass plant which will use 500-900,000 tonnes of fuel per year. A construction period of 30 months is estimated, with a peak construction workforce of 300, and an operational workforce of 40-50.

The RWE npower Tilbury B power station is being converted from coal to run on 100% imported wood pellets. Construction phase is expected to last 17 months (in 2013-2014). Around 1,000 workers on-site at peak, and with the modifications expected to sustain operational employment at previous levels.

Forth Energy is currently planning a 100 MW £360m biomass facility at the Port of Dundee. The 3 year build will involve 300 jobs on-site, peaking at 500. Forth Energy assume 80% local sourcing through development and with only 10% leakage at the Scotland level. With an estimated indirect and induced employment of 49 FTE jobs, the total net additional local employment would be around 140 FTE jobs, and around 160 FTE jobs at an all-Scotland level.

3.6 Onshore and Offshore Wind Power Generation

Regeneris and Cardiff University (2013a): reveal an estimated £1.25m per MW spend (£2012) during construction, development and planning of onshore wind in Wales. They estimated an average of £39,000 per MW of spend during annual operations of which around 25% are employment costs.

Regeneris and Cardiff University estimate that between 2005-11 onshore wind in Wales supported an average of 335 FTE jobs per year through construction, development and planning alone (including jobs supported directly, and jobs created through indirect and induced effects).

Offshore maintenance activities have a larger spread and are more uncertain than onshore, requiring specific vessels and cranes to access high rise turbines, trained personnel and the need for suitable weather. Offshore wind farm operations and maintenance could be anywhere between £50,000 and £100,000 per turbine, and twice the cost of an onshore equivalent.

Oxford Economics (2010) estimated that 40 per cent of all people employed in the operation and maintenance of offshore wind were technicians who ά X NJ Ŝ ǀj dz ƛ NJ Ŝ ŀ ƴ ŀ ƒ Ƴ ƻ ă ǘ dz skills. In addition to possessing a technical background, technicians must be multi-disciplined and flexible, be able to work in extreme conditions and outside normal office hours and Ŝ ƴ Ǿ ƛ NJ ƻ ƴ Ƴ Ŝ ƴ ǘ ă X ε ó h È Ŧ ƻ Assuming 9.14GW of UK generating capacity Σ LJ Φ м ф by 2020, the offshore wind energy sector would support an estimated 4,600 jobs in operation and maintenance with a further 1,100 jobs in the supply chain, and an additional 1,000 jobs from the spending of those employed directly in operations and maintenance.

Cambridge Econometrics (2011) estimated the number of FTEs working directly in the UK offshore wind energy sector at approximately 3,100 (planning and development 15%; design and manufacture 7%; construction and installation 41%, and operations and maintenance was estimated to have around 17% of the total) between 2007 and 2010.

RWE npower renewables ƛ ă ō dz ƛ ƒ Ř ƛ ƴ Ǝ ǘ K Ŝ Gwynt y Môr in Liverpool dzNJ ō ƛ ƴ Ŝ ŀ Bay with an installed capacity at end 2014 of 576MW. It is estimated that 66% of the total contract value could be spent in the UK, with 9% sourced from North Wales, Merseyside and Cheshire. The construction phase would create 1,330 permanent full-time equivalent jobs, with direct and induced effects supporting 1,180 jobs in the UK, including around 140 in the local regions. 90 full-time permanent workers would be employed locally in the operation and maintenance of the project and with further indirect employment summing to 124 full-time equivalent jobs in the UK.

EON completed the 180MW Robin Rigg windfarm on the Solway Firth in 2010. BVG Associates reported a total project value of £381m (£2.1m per MW). UK content of the capital expenditure was estimated at 32% (4% North West of which 1.4% Cumbria, 8% Scotland of which 0.2% Dumfries and Galloway). UK was held to be strong on offshore operations in installation and commissioning (foundations and cables), grid connection and in providing infrastructure for the onshore base. Turbines were imported. Low value projects were sourced in Cumbria. Port of Mostyn was used as one of the construction ports.

3.7 Hydro Generation

Hydropower in the UK is mainly represented by large-scale storage or dam-based sites, built in the first part of the last century, hence construction employment estimates are scarce, as are operational and maintenance employment costs and levels. Recent and future hydro in Wales is expected to be small-scale (less than 5MW).

3.8 Landfill Gas & Anaerobic digestion

Methane is a natural by-product of landfill. Its collection relies upon low technology well systems where it is treated and fed to an internal combustion engine/turbine. Research material majors on reductions in greenhouse gas emissions, energy benefits and toxicity reduction rather than employment impacts.

There is some uncertainty on the number of operational landfill sites, and then how many produce gas. According to OFGEM there were 377 UK landfill sites generating electricity from gas in 2008.

Major operator BIFFA has 24 landfill sites generating 49,954 kilowatts of energy. The BIFFA annual 2011 report identifies 213 employees in its Landfill Division (out of 6,140 in total), with only a proportion of these involved in activity generating electricity.

Infinis operate 123 landfill sites which generate electricity (i.e. 343MW of capacity which they claim is 40% of the UK electricity generation from landfill). Total employment across the whole organisation is only 386 (in 2012) and of these only 264 are operational staffs.

In Wales the operational employment potential of landfill gas in Wales is exemplified in the case of the BIFFA Trecatti near Merthyr Tydfil. There are five methane gas burners on the site and estimated installed capacity is 5.3MW. The site employs two people to run the machines. A specialist contractor that travels around the UK comes in to relocate devices around the site.

Anaerobic Digestion (AD) refers to the capture of gases from anaerobic processes for energy. The term covers farm-based digesters, sewage sludge digestion and non-sewage waste biological matter.

Bioenergy identifies 214 anaerobic digestion facilities in the UK linked to a total installed generating capacity of over 170MW of electricity (baseline established in September 2011). Employment linked directly to energy production on farm sites is small. On larger sites employment would likely be indirect, created through the supply chain when plant needs servicing.

The £8M 1.4MW Emerald Biogas anaerobic digestion facility in County Durham which will convert 50,000 tonnes of food waste annually into electricity will create just 8 new jobs.

Dwr Cymru Welsh Water has 13 (sewage sludge) sites in Wales. Dwr Cymru estimate that they will produce 47GWh (estimated to equate to a notional 5MW of installed capacity) from anaerobic digestion in 2013/14 across 11 of their sites. Just two of the eleven sites ŀ ǑǑ ƨ dzƴ ű Ŧ ƨ NJ o л D ² K ŀ ƴ Ř dz ă Ŝ Ψ ŀ Ř Ø ŀ ƴ Ǒ Ŝ Ř Ω ŀ ƴ ŀ Ŝ NJ ƨ hydrolysis). 22 FTE jobs can be linked to these facilities. A very approximate benchmark would be around 0.5 FTE for every GWh on energy produced.

3.9 Energy from waste

Advanced thermal processes can be divided into Gasification, Pyrolysis and Plasma Arc. Incineration creates energy directly from the combustion process whereas more advanced techniques convert the waste into products from which energy can be generated.

DEFRA (2007) identified 19 Municipal Solid Waste (MSW) incineration plants in the UK. The total energy recovery summed to around 300MW of capacity. Operational employment for an incineration plant of 50,000tpa capacity would be 2-6 workers per shift and with a three shift system, to allow for 24-hour operations.

The UK Without Incineration Network website currently (2013) reports 31 plants, but with м м п Ř Ŝ ă ǑNJ ƛ ō Ŝ Ř ŀ ă ΨLJ ƨ ű Ŝ ƴ ű ƛ ŀ ƫ Ω Σ ǿ ƛ ű K ŀ LJNJ Ŝ ă dzƳLJ planning process. Using DEFRA MW figures, 31 plants with a total waste capacity of 7 million tonnes per annum (tpa), could yield a total energy capacity of around 650MW. Using DEFRA employment figures (and excluding outage supplier employment) total employment of 1,680 is estimated. Using the same inferences, the 114 potential sites could be linked to a further 5000 FTEs.

Construction times can be very protracted; a result of strong opposition and multiple appeals.

According to the UK WIN there is only one waste incinerator in Wales (which is included in the above estimations) at Crymlyn Burrows in Swansea (owned by Neath Port Talbot Recycling Ltd and NPTC) with a waste capacity of 166,000 tpa. This was reportedly recently shut down because of high dioxin emissions.

Viridor is looking to increase generating capacity to 300MW by 2017 (3-4% of the UKs renewable supply).

ViridorΏfirst Energy from Waste scheme in Wales at Trident Park, Cardiff is currently under construction and is the first Combined Heat and Power waste to energy facility in Wales and is designed to treat residual household waste (and some waste collected from local businesses), with distribution via a heat network system. The £185m scheme will treat 350,000 tonnes of waste a year and with a generating capacity of 28MW. Completion is anticipated in 2014/15. 300 construction jobs are anticipated at peak. Once operational, the plant is estimated to require 50 employees (this is taken to include employees in the supply chain delivering waste etc).

A series of energy from waste projects are in different stages of development at Deeside Industrial Estate (North Wales Residual Treatment Project); Barry Dock (Biogen/Energos); Hirwaun Industrial Estate (Enviroactive Ltd and Marlborough Developments); Newport Docks (Biogen/Energos); and Swansea (Clean Power Ltd and Network Rail).

3.10 Solar Photo Voltaic Power

Solar thermal systems (trough, dish-Stirling, power tower) transfer heat to a turbine or engine for power generation. Concentrating photovoltaic (CPV) plants provide power by focusing solar radiation onto a photovoltaic (PV) module, which converts the radiation directly to electricity. The latter is a focus of activity in Wales.

Sharp (Wrexham) employs around 500 people making Solar Crystalline Photovoltaic Modules with a manufacturing capacity of 600MW/year. Sharp estimate the scale of the commercially exploitable resource within Wales would link to 750MW/year manufacturing capacity, involving 2000 workers in the whole supply chain.

Because UK capacity is small scale it is difficult to assess the direct employment effects. Employment is almost entirely in the supply chain rather than operations.

At October 2011 the UK Renewable Energy Association estimated that there were 4,000 solar industry registered companies, supporting 7,000 solar jobs at April 2012.

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Because companies undertake other activities apart from solar panel installation, it is not possible to derive an estimate by simply adding together employment in solar installation companies.

Sunsolar (at Oldbury, West Midlands) is setting up a £10 million facility plant capable of producing 65MW of PV solar panels per year, by May 2013. It will use Swiss/German made automated machinery to produce highly competitive 60/72 cell panels. It is expected to create 600 jobs.

W ƻ ō ă Ŏ Ͱ ʆ ō Ŝ ă dz ō Ƨ Ŝ Ŏ ű ű ƻ Ͱ ά ō ƻ ƻ Ƴ subsidies and then ƻ NJ ē dz ă ű ɛ Ŏ è Ŏ ƒ falling production costs. For example, reported employment increases in the sector in the first half of 2011 were attributed to generous feed-in tariffs which were then reduced causing a fall in the number of solar panel installations resulting from the lower private return.

Some inference of costs on installing and operating larger solar arrays is available from the planned £15m 5MW array of solar panels at an old BP Chemicals works site in Port Talbot (St. Modwen). The Virtus feasibility study (2011) found that 92% of the capital cost was for the supply of panels and installation, with the balance being grid connections, security fencing and lighting, consulting and design fees. Total operational costs per annum would be in the order of £136,000 (around £27,000 per installed MW), made up of grid charges (9%), security (11%), rates (12%), insurance (29%) and with the balance (39%) being the maintenance contract with limited employment opportunities during the operational phase.

3.11 Conclusions

A series of conclusions arise from the review:

There is a diverse literature covering the economic impacts of different electricity production methods but with huge variability in reporting styles, standards, objectives and content.

Analysis of impact assessments dealing with construction activity in different energy generation technologies reveals a relatively small amount of academic (peer-reviewed) case-study reports. Moreover variations in assumptions make it difficult for comparisons, and with a strong predominance of advocacy led *ex ante*impact studies that are rarely cross checked for reality during or after the construction process.

Where better quality case material is available on the employment effects of the construction and development of different types of electricity generation, care needs to be taken on generalising because of specific spatial and economic factors that influence the scale of multiplier effects. Moreover employment multiplier numbers where provided, do not always take into account differences in the quality of jobs between different energy types.

For some renewable electricity generation technologies there is an issue from the literature regarding what the direct component of production includes. With biomass energy generation, for example, studies typically included agricultural jobs (preparing land, growing and harvesting energy crops) and transport jobs along with the actual plant jobs. This is also an issue with energy from waste.

It was difficult to find any evidence of employment impacts connected to newer technologies and smaller scale activity in solar PVC and Anaerobic Digestion for example.

Investigation of accounting and economic modelling frameworks in other countries and regions reveals few attempts to disaggregate for different types of electricity production; for this reason there are few benchmarks on which to explore the indirect employment effects resulting from changes in the technology mix to produce electricity. Furthermore, where input-output tables have been used to explore construction activity associated with power ă ű ŀ ű ƛ ƻ ƴ ō dz ƛ ƭ Ř ű Ķ Ŝ NJ Ŝ ƛ ă ŀ LJ NJ ƻ ō ƭ Ŝ Ƴ ű Ķ ŀ ű ű Ķ Ŝ Ψ ŀ might poorly represent elements of more specialist activity involved in major builds, and that basic modelling frameworks may deal less well with large scale construction engineering projects which change the supply side of local economies.

4. Power Generation Activity in Wales

4.1. Introduction

In this section of the report we outline economic activity in the power generation sector in Wales. The focus here is on direct employment levels in the main power stations. The estimation of *total* Welsh employment connected to different generation technologies comes later in this report. Moreover, finer details of the composition of energy generation capacity in Wales are available in the *Digest of UK Energy Statistics*

4.2. Welsh Energy Generation in Summary

The most recent figures within the Digest of UK Energy Statistics reveal that the total of electricity generated in Wales in 2011 was 27,284 gigawatt hours (*GWh*). Around 92% of the electricity generated was by major power producers. Table 4.1 shows how the electricity generated was divided between the main technologies. Around 40% of energy generated in Wales is from natural gas. While coal generation (mainly SSE Uskmouth and RWE npower Aberthaw) still contributes over one fifth of the total, this is expected to decline with new investment unlikely at the 50 year old SSE ¦ ă ĩ Ÿ ƻ ƽ ű K ǈ ƭ ŀ ƴ ű ŀ ƴ Ř ǿ ƛ ű K ! ō Ŝ Nj ű K ŀ ǿ Ω ă Ŏ ƻ ƴ ű Nj ƛ ō ƽ ű ƛ ƻ ƴ after 2018. The other key contributor in 2011 is nuclear although with this contribution depreciated by the decommissioning of the Magnox Wylfa plant on Anglesey.

Table 4.1 Electricity Production in Wales (2011)

	GWh	% generation
Coal	6,170	22.6
Oil	215	0.8
Gas	10,670	39.1
Nuclear	5,364	19.7
Thermal renewables	443	1.6
Hydro (natural)	268	1.0
Hydro (pumped)	2,301	8.4
Non thermal renewables	1,447	5.3
Other	405	1.5
Total	**27,283**	**100.0**

Source: *Derived from Digest of UK Energy Statistics*, 2012

Important context for our report is the development of electricity from renewable sources. Table 4.2 shows that in 2011 there were an estimated 15,786 separate sites in Wales developing electricity from renewable sources; a very high proportion of this relates to solar PV installations. Of the 348 sites not involving solar/PV some 209 are classified as wind. Table 4.2 also shows the installed capacity from renewable energy sites; this reveals the predominance of onshore and offshore wind in renewable generation in Wales, and with this installed capacity set to rise sharply with a series of large projects in planning including the 120MW Pen y Cymoedd wind farm near Neath.

Table 4.2. Electricity from Renewables in Wales, 2011

	Hydro	Wind	Landfill Gas	Sewage Gas	Other Bioenergy	Solar PV	Total
Number of sites	91	209	23	15	10	15438	15786
Installed capacity MW	149.9	582.4	45.2	11.9	21.2	46.3	856.9
Generation of electricity GWh	268.4	1438.5	204.7	34.9	203.4	8.5	2158.4

Source: see Table 4.1

4.3. Employment

Data is not available to accurately discriminate between employment in production of electricity and in transmission and distribution. Within the Office for National Statistics Business Register and Employment Survey (BRES) and its predecessor the Annual Business Inquiry (ABI) employment in production of electricity (Standard Industrial Classification (SIC) 35110 currently) is separated out (see Table 4.3). Employment in electricity production in 2011 was estimated in BRES to be around 1,900 and with the vast majority of these opportunities being full-time as opposed to part-time. Since 2008 Welsh electricity production employment has increased by around 25%. This reflects, in part, the development of new onshore wind capacity. However, employment prospects for the production of electricity sector are uncertain. Older technologies such as coal fired generation tend to employ larger numbers of people because of the nature of the process and needs for materials handling. With environmental regulations tightening, employment at older facilities such as Aberthaw and SSE Uskmouth are vulnerable. Newer gas fired stations require far lower numbers of employees.

Table 4.3 Employment in Electricity Production, Transmission and Distribution in Wales 2011

	Production	Transmission & distribution
2003	1,400	2,600
2004	1,500	2,000
2005	1,300	1,600
2006	1,300	1,400
2007	1,600	2,000
2008	1,500	1,700
2009	1,500	1,700
2010	1,700	1,800
2011	1,900	2,300

Source: NOMISWEB; numbers here are rounded to nearest 100.

A further complication with the numbers in Table 4.3 is how far this represents employment of the owner of the power station or employment in a company that manages the operations and maintenance contract. For example, at Uskmouth there are two power stations side by side owned by SSE and DONG. The older coal fired station features largely SSE employment. However, the adjacent gas fired station owned by DONG predominantly features employment from Siemens of Germany who have the operations and maintenance contract for the site for 10 years, and with a relatively small number of DONG employees on the site.

The employment in Welsh electricity production is concentrated in a few large facilities. A more detailed examination of the BRES data from Table 4.3 reveals that although it covers some 41 separate sites (defined here through lower level super output areas), 67% of the employment is in just five of these super output areas, and with 64% of employment in just three local authority areas - Anglesey, Vale of Glamorgan and Gwent. The estimated size distribution of electricity production-sites covered in the BRES is shown in Table 4.4. We stress that this is an estimated distribution based on some sites that are known to host more than one electricity production operation. Clearly, cross referencing with information in Table 4.2 reveals that a very large number of small scale operational sites are difficult to link to employment. This conclusion extends to large scale renewables where linking direct employment to the installed capacity is far more challenging than it is for gas or coal fired electricity generation.

Table 4.4 Employment size distribution of electricity production-sites in Wales (2011)

Employment size band	Number of production-sites
More than 500	1
100-499	4
50-99	3
20-49	8
10-19	5
5-9	6
1-4	14
Total	**41**

Source: Estimated from BRES, NOMISWEB.

This noted, the figure of 1,900 employees in Welsh power generation from Table 4.3 may be an underestimate of employees in electricity production. For example, there is a question on how far ű K Ŝ . w 9 { Ř Ꞁ ű Ꞁ ƛ ă LJƛ Ŏ ꞁ ƛ ƴ Ǝ dzLJ Ŝ ϒ LJ ſ ƻ è ϒ Ŝ ƴ ű ădzLJLJƻNJű Ŝ Ř
database of company accounts (search undertaken in March 2013) reveals that across Wales there were 128 entries for firms who both had a registered office or primary trading office in Wales and that listed production of electricity among their activities.

In Table 4.5 we list the major power stations in Wales that were operational as at May 2012. This excludes major CHP schemes at the Murco Oil Refinery in Milford Haven and at Dow Corning in Barry. The list in Table 4.5 also excludes a very large number of onshore wind farms with less than

50MW of installed capacity. However, the Table includes the major electricity generation sites in Wales at 2012, and includes an estimate of employment at each site(s) derived from company information and other sources. The employment total for sites where some information is available totals 1,457 people. Table 4.5 demonstrates the variation in employment across the different generation technologies. For example, for the two coal fired plants the operational staff per MW of installed capacity varies between 0.2 and 0.3. For the newer gas powered CCGT facilities the operational employees per installed capacity per can be as low as 0.05 per MW (i.e. RWE npower Pembroke Dock). Nuclear is something of a special case where at Wylfa the operational employees per installed MW is 0.6 (assuming 980MW of total installed capacity rather than the 490MW in one reactor still generating electricity in 2012).

Table 4.5 confirms the relatively high capital intensity characteristic of much of the sector. This is confirmed by Table 4.6 which shows historical information from the Welsh Input-Output tables for 2007 relating to different energy technologies. In 2007 it was estimated that the electricity production sector supported around £480m of gross value added (GVA) in Wales. Employment multipliers varied between 2.6 for nuclear to 12.4 for gas (high values for gas relate to issues where ΨŎ ƨ NJ Ŝ Ω ƨ LJ Ŝ NJ ŀ ű ƛ ƨ ƴ ŀ ƭ ă ű ŀ Ŧ Ŧ ă ŀ NJ Ŝ ŀ Ŏ ű dz ŀ ƭ ƭ è ă dz ō Ŏ ƨ ƴ ű NJ ŀ company employees). Taking these multipliers together and applying them to the estimated FTE employment by energy technology in 2007 suggested that around 1,500 full time equivalent jobs in Welsh electricity production supported around 6,700 FTE Welsh jobs in total. On average in 2007 it was then estimated that some 4.3 FTE jobs in Wales were supported per FTE employee in electricity generation.

Table 4.5 Major Power Stations in Wales 2012

Company	Fuel	Estimated Investment	Installed MW	Estimated operational employment	Average Remuneration Est £000s	Year of commission or generation began
Baglan Generation	CCGT	£300m	510	c.32	na	2002
Beaufort Wind (N Hoyle)	Wind (offshore)	£80m	60		na	2003
Centrica (Barry)	CCGT	na	230	c.36	43.0	1998
Dong Energy (Severn)	CCGT	£600m	848	c.40	60.2	2010
EDF (Aberdare)	Gas	na	10	na	na	2002
EON (Connahs Quay)	CCGT	£580m	1380	c.80	46.3	1996
GDF Suez (Shotton)	Gas CHP	na	210	c.32	na	2001
IP/Mitsui(Dinorwig & Ffestiniog)	Pump storage	na	2088	c.130	48.6	1961 & 1983
IP Mitsui (Deeside)	CCGT	£200m	515	c.50	48.6	1994
Magnox Wylfa	Nuclear	na	490	c.580	60.1	1971
RWE N power (Aberthaw)	Coal	na	1586	c.270	51.9	1971
RWE npower Pembs	CCGT	£1000m	2180	c.100	51.9	2012
RWE npower Renewables	Hydro x 3	na	42	na	63.3	1926/2002
RWE npower Renewables Rhyl Flats	Wind offshore	Euro 216m	90	na	63.3	2009
SSE Uskmouth	Coal/biomass	na	363	107	41.5	2000
Statkraft (Rheidol)	Hydro x 3	na	49	na	52.7	1961

Source: Digest of UK Energy Statistics 2013, Jordan FAME, and research team estimates.

Table 4.6 Estimated Output, Value Added and Employment in Welsh Electricity Production (2007)

	Coal	Gas	Nuclear	Hydro	Other Renewables	Total
Total Output £m	414.6	493.5	369.6	194.9	35.3	1507.9
Estimated FTE employment	514.0	120.0	751.5	118.5	52.5	1556.5
GVA £m	94.8	178.9	76.6	147.1	-22.8	474.6
GVA per FTE (£000)	184.5	1491.0	101.9	1241.4	-434.3	na
Estimated Multiplier	4.4	12.4	2.6	3.3	11.6	na

Source: Welsh Input-Output Tables (2007)

Table 4.6 confirms that in policy terms it is not so much the employment multiplier (i.e. relationship between direct employment and total of direct, indirect and induced employment supported) that is of interest but the total employment effects connected to installed generation capacity in Wales. Furthermore, there is an expectation that considerable Welsh level impact from electricity production comes through household spending. Salaries in the electricity production sector are relatively high in Welsh terms. For example, Table 4.5 reveals average earnings net of pension costs ranging from £41,500 to over £63,000. Importantly many of the households supported are in poorer parts of the regional economy including Anglesey, Gwynedd and Pembrokeshire.

4.4 Conclusions

The material in Section 4 points to some problems in how employment and activity in electricity ℲŜƴŜNJŀűƛƨƴ ƛă NJŜŎƨNJŘŜŘ ƛƴ ƨŦŦƛŎƛŀ ƭ ăűŀűƛăűƛŎă ŀƴ employment in power generation to that supported in the regional supply chain through local purchases and through the spending of wage incomes.

The analysis in Section 4 also suggests changes in the direct employment that can be linked to power generation in Wales with the reduction in coal capacity and growth of generation capacity that employs less people in terms of the MW of capacity installed. A further corollary of this is subtle changes in the geography of power generation employment in Wales. We return to these issues in the conclusions in Section 7 of this report.

5. Employment effects associated with Electricity Generation technologies

5.1 Introduction

In this section of the report we provide estimates of the employment connected to different electricity generation technologies. Section 2 of the report showed how the Wales Input-Output framework was used in conjunction with other material derived in the research to estimate both the person job years associated with the construction and development phases of power stations, and then the employment that can be connected to operational phases.

The section examines the findings and explains differences in employment effects across the technologies during the construction and operational phases.

5.2 Estimates of overall employment effects

5.2.1Construction anddevelopment phases

Table 5.1 provides our estimates of person years of employment connected to the construction, development and planning stages of different electricity generation technologies (see also Figure 5.1). While the estimates are in terms of person years per MW installed, we also seek to relate this to a typical investment (scenario facility) gaining inference from our review in Section 3 of the report, and information about existing installed capacity in Wales in Section 4. Table 5.1 does not provide a complete coverage with no estimates in terms of capital construction for coal and hydro-electric. However, we believe that Table 5.1 covers those electricity generation technologies that will feature predominantly in Wales in the period to 2025, with coal capacity being run down, and limited possibilities for extensive new capital investment in hydro-electric or pump storage.

Table 5.1 Estimates of Person Years of Welsh employment per installed MW connected to development and construction phases of Electricity generation technologies*

	Coal	Gas	Nuclear	Biomass	On-wind	Off-wind	AD	Solar/PV	Tidal stream	Wave
Job years in Wales per MW installed	na	4.5	8.6	14.8	12.8	8.3	45.3	20.8	35.3	32.3
Scenario facility MW installed	na	500	1,900	50	100	300	3	30	30	30
Job years for facility scenario		2,250	16,340	740	1,280	2,490	136	624	1,059	969

*Note: Employment effects in this table include direct and indirect employment effects.

Table 5.1 shows the wide variation in person years of employment per installed MW. This ranges from a high of around 45 in case of anaerobic digestion and linked technologies (we question later whether comparing this technology on a like for like basis with others here is warranted), to a figure of 4.5 for the latest generation of gas fired capacity (CCGT). The lower figures for person years of employment per installed MW are associated with larger absolute size of plant.

The scale of the estimated all-Wales employment effects per installed MW are determined by the following:

- Absolute spend per MW installed is higher for newer technologies and where prototypes are still being developed and tested (e.g. wave and tidal stream).
- ł ƌ ǿ Ŧ ŀ NJ Ψ ŀ Ŏ ǘ ƌ NJ ă Ω ƛ lopment phases can purchase goods and ƴ ŀ ƴ Ř Ř Ŝ Ǿ services in the Welsh economy. The review in Section 3 suggested that the supply side in Wales associated with selected technologies is limited by the size of the economy, regional (and UK) demand thresholds, skills supply side issues and then simple scale economies.
- The amounts paid to Welsh households in wages and salaries. Our review in Appendix F suggests that larger multi-year capital projects draw in labour from as far afield as Eastern Europe.
- The extent to which supported household incomes lead to spending on Welsh goods and services as opposed to spending on imported goods.

Figure 5.1 Variation in person years of Welsh employment in development and construction per installed MW

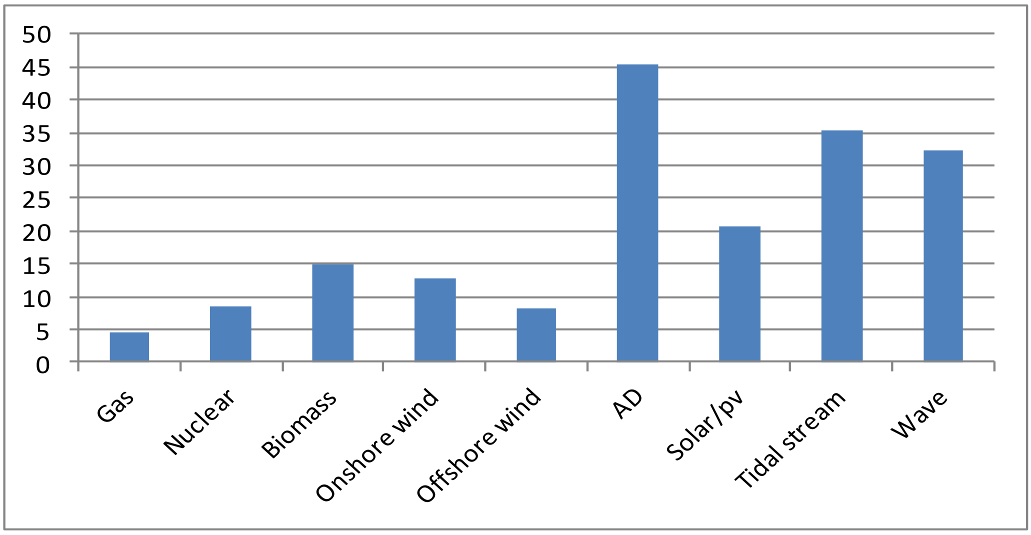
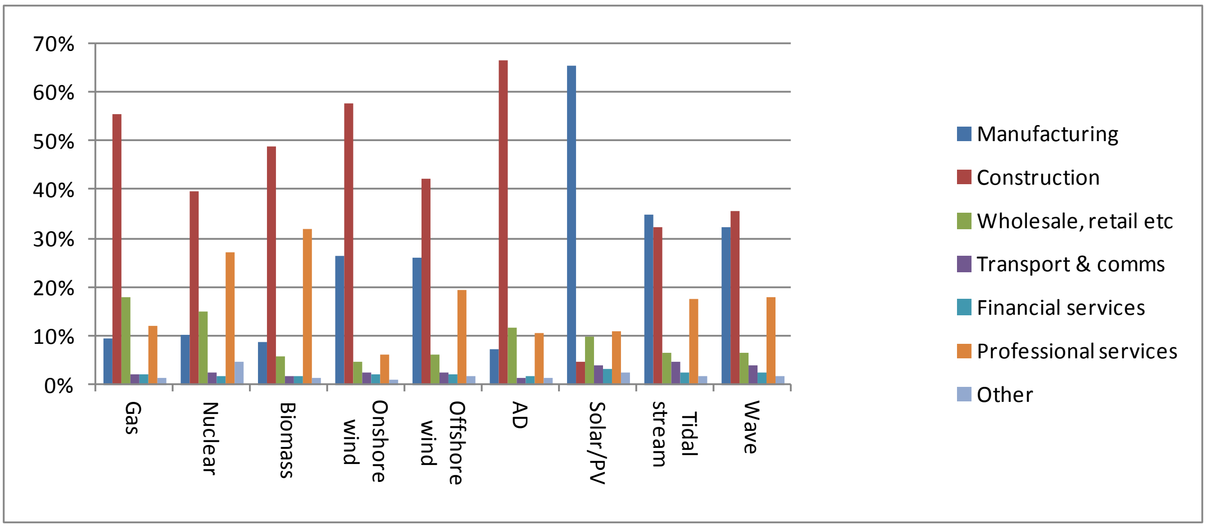


Table 5.2 (and Figure 5.2) provide estimates of how the person years of employment reported in Table 5.1 for the different energy technologies are distributed across Welsh industries.

Table 5.2 Estimated distribution of person years of employment by Welsh industry (Construction and development phase).

	Gas	Nuclear	Biomass	Onshore wind	Offshore wind	AD	Solar/PV	Tidal stream	Wave
Manufacturing	10%	10%	9%	26%	26%	7%	65%	35%	32%
Construction	55%	40%	49%	58%	42%	66%	5%	32%	36%
Wholesale, retail etc	18%	15%	6%	5%	6%	12%	10%	7%	6%
Transport & comms	2%	2%	2%	2%	2%	1%	4%	5%	4%
Financial services	2%	2%	2%	2%	2%	2%	3%	2%	2%
Professional services	12%	27%	32%	6%	19%	10%	11%	18%	18%
Other	1%	4%	1%	1%	2%	1%	2%	2%	2%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Figure 5.2 Distribution (%) of person years of employment by Welsh industries through development and construction phases.



The foregoing figures refer to total person-years of employment across Wales. Clearly, this investment is uncertain in timing, and then insofar as how long facilities will take to build. It is not possible to be definitive here, especially in regard to new technologies. Furthermore, conversations with developers suggests that the timing of construction activity and demand for related employment (peak and average) will likely vary significantly between individual projects. However, there is some evidence from on-going projects that can illuminate the likely timescale of construction activity in Wales:

> For example, the 576MW Gwynt y Mor offshore wind facility is expected to be completed around 5 years after the inception of works http://www.rwe.com/web/cms/en/1202906/rwe-innogy/sites/wind-offshore/under-construction/gwynt-y-mr/);

- Onshore, the 120MW+ Pen-y-Cymoedd scheme is expected to take around two years to develop (http://www.vattenfall.co.uk/en/penycymoeddwindfarm/pen-y-cymoedd-wind-energy-project.htm);
- Two large nuclear construction projects currently underway in Europe are expected to take at least a decade to complete (both are very significantly over time and budget).
- Chinese developments of similar nuclear technology are on track to deliver power within 5 years of construction beginning.
- If a strike price is agreed, Hinkley Point C is expected to be producing power by the early 2020s.
- Onsite construction activity for the 575MW Baglan CCGT lasted under 18 months (http://www.power-technology.com/projects/baglan/).

5.2.2 Operational Phase

Table 5.3 (Figure 5.3) considers FTE employment supported through the operational phase of power station operations. Employment supported through construction and development phases tends to ōŜ ϒdzŎĶ ƒŀNJ∃ŜNJΦ aⱻNJŜⱻØŜNJΣ Ŏⱻƴăű While the LJĶŀăŜ ŜϒL operational phase jobs are supported over a period typically of 20- 25 years depending on the underlying technology, and over an even longer period where decommissioning processes are costly. In this context the total years of employment supported in operational phases can exceed the estimates of job years supported in the construction and development phase of the different technologies.

Table 5.3 reveals that FTE employment supported in Wales per installed MW varies from a high of 1.4 in the case of coal, to just 0.3 in the case of gas (CCGT). It was not possible to derive figures for biomass and anaerobic digestion here because of lack of information relating to operational phases. Once again in Table 5.3 we relate the estimates to a typical expected size of plant. More conventional technologies tend to be related to a higher plant scale. It is accepted that the employment effects linked to gas, coal and even wind are better understood than tidal stream and wave. In these latter cases our estimates are based on prototypes and with the scope for scale economies and cost reductions through time less well understood.

Among the determinants of the all-Wales employment effects during operational phases are the following:

- Labour intensity associated with the energy generation technology. Selected technologies are very capital intensive with few direct labour requirements during normal operations. For example on-site employment in gas (CCGT) is very low in comparison to the maximum power output. On-site employment can step up during major scheduled outages.
- Extent to which operational phases employs regional staffs. In particular whether planned maintenance turnarounds involve local contractors or specialist teams brought in from outside of Wales or the UK.

Extent to which charges and payments relating to grid, land rents etc are leakages from the local economy.

The level of incomes paid to local staffs employed at power stations or those engaged in routine maintenance. Material in Section 4 of our report, for example, testifies to the relatively high wages paid in power stations.

Table 5.3 Full time equivalent Welsh employment supported per MW installed capacity during operational phase*

	Coal	Gas	Nuclear	Biomass	Onshore wind	Offshore wind	AD	Solar/pv	Tidal stream	Wave
FTE jobs per MW installed	1.4	0.3	0.7	na	0.6	0.6	na	0.4	0.9	0.8
Scenario facility MW	500	500	1,900	50	100	300	3	30	30	30
FTE jobs in Wales pa in scenario facility	700	150	1,330	na	60	180	na	12	27	24

*Note: Figures in this table in first row are rounded up to one decimal place. Jobs estimates include direct and indirect employment supported in Wales.

Table 5.3 shows that Welsh energy generation might be expected to employ fewer people directly once the infrastructure is in place. A possible scenario working through the numbers in Table 5.3 and assuming nuclear new build and the rundown of coal generation, could see much of the future operational phase employment in Welsh power generation focused in gas (CCGT) and in supporting one nuclear installation. Table 5.4 then uses the information from Table 5.3 to provide an estimate of the all Wales employment currently supported in the operations of major existing power generation facilities, and then offers a scenario based on a forecast of installed capacity in 2025 (excluding biomass, AD, and hydro-electric/pump storage). It is estimated that current capacity in the technologies listed supports just over 5,000 jobs. The broad changes scenario to 2025 could see overall employment maintained at over 5,000 but with renewables making a greater contribution.

Figure 5.3 Range of Estimates of Welsh Employment Supported by different technologies through Operational phase (FTE jobs per MW installed)

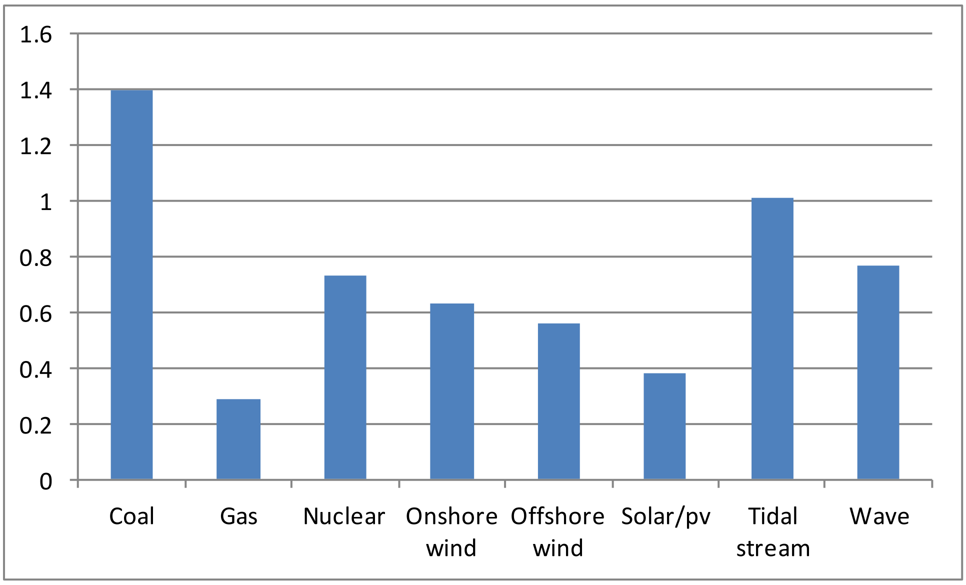


Table 5.4 Estimates of employment supported in Wales in 2012 by electricity generation, and a 2025 scenario.

	Coal	Gas	Nuclear	Onshore wind	Offshore wind	Solar/PV	Tidal stream	Wave	Total
Estimated 2012 MW installed	1,949	5,883	980	254	150	46	0	0	9,262
Estimated Employment supported 2012	2,729	1,706	715	160	84	18	0	0	5,412
Scenario 2025 MW installed	0	7,000	2,000	1,600	1,600	100	30	30	12,260
Estimates Employment supported 2025	0	2,100	1,400	960	960	40	27	24	5,511

5.2.3 Combined Development/Operational Scenario

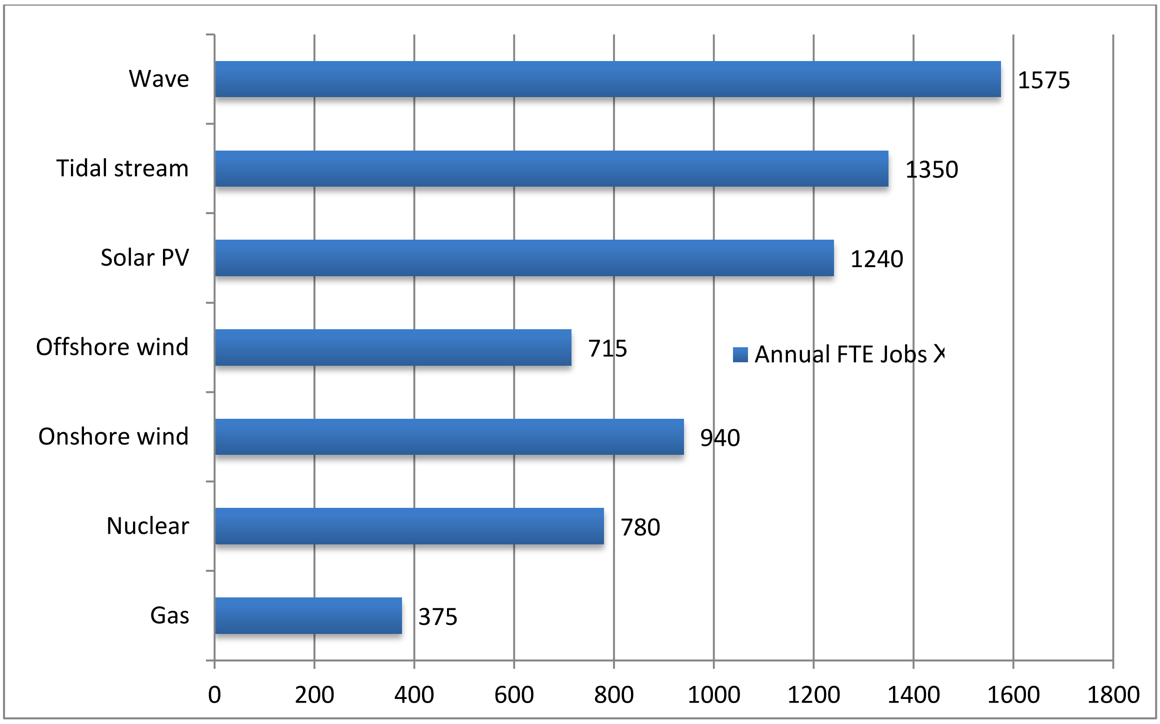
Assessing the likely overall impact of generation installation on Wales is no easy task, with development timelines uncertain, but certain to vary across technologies. Nonetheless, below we have provided a broad indication of the FTE jobs that might be supported regionally following technology roll out, and then including the first decade of operation (with an implicit assumption here that development of facilities to 1GW takes a decade ςpessimistic for gas, very optimistic for marine energy).

This analysis then adds the development-related impact to operational impact (with a ration of ten construction person-years = one FTE job) although of course in reality the impacts would be staggered.

Whilst earlier tables indicated the per site employment impact of generation (thus favouring large, centralised developments) here we look at the employment impact associated with 1GW installed capacity (although with no implication here that this roll out is economically or technically feasible).

This level of new installation (in Wales) is feasible across all technologies at current levels of development with the exception of Wind and Tidal Stream, which will be subject to significant cost savings following commercial roll out. For these two scenarios alone therefore, we apply cost (and hence employment-impact) reductions as utilised in Regeneris/WERU 2013b (Marine Renewables) and hence these totals will not be comparable with other sections of this report.

Figure 5.4 Twenty-Year Scenario: Annual Impacts of 1GW Development phase Plus 1st Decade of Operation



Despite these amendments, even after significant roll-out the novel marine technologies remain expensive and with the largest impact per GW installed, supporting 1.575 and 1,350 FTE jobs per annum for wave and tidal respectively over the next twenty years.

The employment effects for wind and nuclear are broadly in line at between 700-1,000 FTE jobs supported, although with much here dependent on the size of sites and relevant economies of scale.

The next part of this section moves to consider the figures for the individual electricity generation technologies in more detail, seeking to focus on factors determining Welsh employment effects in each case.

5.3 Review of employment effects in Wales by technology

5.3.1 Coal

There are very few instances of new coal fired capacity being developed in the UK which made it difficult to estimate the employment years connected to any new development. However, it was possible to estimate the employment supported through the operational phase using information from the Welsh Input-Output framework. Table 5.3 reveals that coal fired stations in Wales are connected to an estimated 1.4 FTEs supported in Wales per MW of installed capacity. On this basis existing Welsh capacity in two facilities (Aberthaw and Uskmouth, together around 2GW) supports an estimated 2,800 FTE jobs in Wales in a typical year.

5.3.2Gas (CCGT)

The analysis reveals that in the case of gas (CCGT) an estimated 4.5 person years of employment per installed MW are supported in Wales through construction and development phases. This is the lowest value in the range in Table 5.1, however, this needs to be placed in the context of the average scale of plant typically constructed. On the basis of the development of a 500MW single turbine facility this would equate to some 2,250 person years employment supported through construction and development. On the same basis the completion of the RWE npower 2.2GW CCGT facility at Pembroke Dock could have been associated with as many as 9,900 person job years over its three years development and commissioning stages. In the case of Pembroke Dock it has been estimated that the first phase of construction in the first four months involved an average of 500-600 people on-site undertaking steel fabrication and civil construction, but that on-site employment quickly grew as construction and commissioning activity became co-terminous such that employment on the site was maintained at over 2,000 people for an 18 month period. However, it is also estimated that on average through the development and commissioning phases that 30% of workers were from Pembrokeshire; a further 20% from the remainder of Wales, 20% from the rest of the UK, and the remainder from overseas. This case would suggest that the off-site employment supported is greater than the on-site employment. Recall from Table 5.1 that the person years of employment is that supported across the whole of Wales and includes effects linked to employees spending their wages in the region.

Table 5.2 showed our estimate of the sectors in Wales where employment is supported through the construction and development phase of CCGT. An estimated 55% of the employment effects would be in the construction sector, with 10% in manufacturing, and an estimated 12% in professional services. While the highest value device elements of a contemporary CCGT station are produced outside Wales, there is potential for regional involvement in providing civil contracts and ancillary work to managing contractors on CCGT sites.

During the operational and maintenance phase Table 5.3 showed that a CCGT plant would be associated with an estimated 0.3 FTE jobs in Wales per installed MW. A 500MW turbine during operation might then be supporting directly and indirectly around 150 FTE jobs in Wales. The highly capital intensive nature of a modern CCGT plant was revealed in Section 4 of the report. For example, the state of the art RWE npower facility in Pembroke Dock has an installed capacity of 2.2GW but employs directly less than 100 people during normal operations. On this basis the 5.7GW on installed CCGT capacity in Wales in 2011 (see Table 4.5) might be connected in a typical year of operations with around 1,700 FTE employment opportunities directly and indirectly supported in the Welsh economy.

5.3.3 Nuclear

Table 5.1 showed that construction and development of new nuclear is estimated to be connected to 8.6 person years of employment per MW installed. There is a great deal of uncertainty regarding plans for Wylfa redevelopment. However, based on a 1900MW dual reactor facility our estimates would equate to over 16,000 person years of employment in Wales. The projected scale of new nuclear means that the numbers of Welsh job years in construction and development dwarfs those in other technologies, even other large capital investment associated with CCGT.

In terms of where regional employment would be supported, the modelled assessment (Table 5.2) suggests around 40% of the effects would be in Welsh construction and as much as 27% in various professional services. Just 10% of the effects are expected to be in Welsh manufacturing. We accept that there could be marked variation in the nuclear development case according to reactor design. For example, if the final design permits device modules being developed and assembled on-site, employment effects would possibly be larger than if modules are assembled off-site. Prior analysis ó ă Ŝ Ŝ Ŧ ƻ NJ Ŝ È ŀ ŶLJ ƚ Ŝ Σ b ! a ¢ 9 / Σ н л л у ύ Ʀ ŀ ă Σ Ʀ ƻ ǿ Ŝ Ø Ŝ NJ Σ Ŏ ƻ construction (nuclear and turbine islands, other plant and supporting infrastructure) could be dz ƴ Ř Ŝ NJ ű ŀ ʅ Ŝ ƴ ō è ¦ Y Ŏ ƻ ŶLJ ŀ ƴ ƛ regional firms to win business in terms of ă LJ ƻ ű Ŝ ƴ steel erection, fabrication, and selected elements of construction engineering.

Nuclear generation would also be expected to support relatively high levels of FTE employment through the operations of plant. Table 5.3 showed that a nuclear facility in Wales could be connected to 0.7FTE jobs per installed MW. Then a 1.9GW power station could support around 1,300 to 1,400 FTE jobs in Wales each year through its operational life. The information in Table 5.3 suggests that, were new nuclear build to commence in the next few years, this technology would Ŏ ƻ ƴ ű NJ ƛ ō dz ű Ŝ ŀ ƚ ŀ NJ ∃ Ŝ LJNJ ƻ LJ ƻ NJ ű ƛ ƻ ƴ ƻ Ŧ ² ŀ ƚ Ŝ ă Ω Ŝ ŶLJ ƚ ƻ è Ŷ generation (particularly given the forecast rundown on coal capacity).

5.3.4 Biomass

In the research it was more difficult to gain inference on the development and construction profile of biomass. The estimated person years of Welsh employment (assumed not to include co-firing) is estimated at around 15 per installed MW. Then a 50MW biomass facility could be associated with an estimated 740 years of employment during the construction and development process. It was not possible during the research process to derive reasonable estimates of the operational spending linked to biomass boilers but with some expectation that the materials handling aspects of power generation from biomass would lead to higher levels of employment connected to the operations of such facilities. Moreover, the source of the raw material (whether imported or from Welsh forests etc) would also have a marked effects on the levels of Welsh employment supported through the operations phase.

5.3.5 Onshore wind

The construction and development profile of onshore wind has been extensively discussed in the Regeneris (2013a) report for Renewable UK and Welsh Government. In comparison to offshore wind the number of employment years supported through development and construction is higher at 12.8 (offshore 8.3). A typical onshore wind development at larger scale would be around 100 MW such that this would translate to an estimated 1,280 person years of employment in Wales through development and construction.

Table 5.2 revealed that these Welsh employment effects would be focused in the construction sector (58% of the employment effects) and manufacturing (26%). It is accepted that the latter estimate is sensitive to the sourcing assumptions of discrete components such as towers. However, it has been shown that much of the civil engineering aspects of onshore wind have involved regional companies. Regeneris (2013a) reveals that typical spending through development and construction in onshore wind is of the order of £1.25m per installed MW and that 35% of this reflects regional spending.

In similarity to other technologies covered, the scale of operational spending compared to capital spend is low in onshore wind. Once again Regeneris and Cardiff University (2013a) report operational spending at an estimated £40,000 per installed MW but with 76% retained in Wales in terms of land payments, payments to labour, rates etc. On this basis we estimate (Table 5.3) each MW of installed capacity in onshore wind could support 0.6FTE jobs per annum in Wales, with much of this linked to maintenance of facilities and inspection, and then the multiplier effects of payments to labour and rents, whereas grid connection charges and insurance of facility payments generally leak from the region. Then a 100MW onshore wind facility might support around 60 FTE jobs in Wales per annum.

5.3.6 Offshorewind

Table 5.1 revealed that offshore wind is connected to an estimated 8.3 person years of employment in Wales per installed MW in development and construction phases. Applying these figures to the two major offshore wind sites in operation in Wales (North Hoyle and Rhyl Flats ς together around 150MW of installed capacity) would suggest that these were connected with an estimated 1,245 person years of employment in Wales through the construction and development process. Recall that this is employment supported directly and indirectly in Wales and does not include employment being supported in other parts of the UK or overseas by such investment. Given that projects in planning around the Wales coastline could be up to 500MW then this would translate to over 4,000 person years of employment in development and construction in Wales. The figure of 8.3 person years per installed MW is towards the lower end of the range of the figures in Table 5.1.

The estimate of person years of employment in Table 5.1 reflects the amounts of goods and services that can be locally sourced. In the case of offshore wind:

> Previous research on the offshore wind supply chain suggests that the UK supply chain is focused more in terms of assisting development and service phases, rather than in R&D and the manufacture of key components. This conclusion is emphasised for Wales.
> Main device manufacturers are Vestas, Siemens and General Electric each having a limited presence in the UK, in some cases limited to sales, marketing and after sales service.
> Multinational turbine manufacturers differ in their degree of vertical integration according to specific proprietary knowledge involved. Less vertically integrated device manufacturers may buy in items such as blades, gearboxes, generators, towers and controllers from other international firms (i.e. tier 1 suppliers and these have limited presence in Wales).
> Tier 2 manufacturers service the needs of the tier 1 firms (and managing contractors on construction-sites). In the second tier there are some limited opportunities for regional firms in terms of structures, and selected construction activity.

Table 5.2 provided insight into which Welsh sectors the employment effects associated with construction and development phases of offshore wind are situated (see also Figure 5.2). Note that this Table is explaining the distribution of total estimated employment effects and should not be confused with the direct supply chain of the sector, because Table 5.1 includes, for example, employment effects associated with the spending of local employees involved with the construction and development of offshore wind capacity. Table 5.2 revealed that some 26% of the total person years of employment are linked to Welsh manufacturing (focused here in sectors such as non-ferrous metals, forging and pressing, electrical motors, wire and cables and industrial electrical installation). An estimated 42% of effects are connected to Welsh construction, and with much of the remainder in professional services supporting planning and construction.

Turning next to the employment supported by offshore wind generation through the operational phase, Table 5.3 showed that this is estimated at 0. 6 FTEs per MW installed. Based on this, a large 300MW offshore wind facility could support an estimated 180 FTE jobs in the Welsh economy over each year of operations.

5.3.7 Tidal stream

Our analysis in Table 5.1 revealed that tidal stream technology is associated with an estimated 35 person years of employment in Wales per installed MW of capacity. In per MW terms this is considerably higher than comparable figures for nuclear, gas and offshore and onshore wind. On the basis of a future tidal array of 30MW (see Regeneris and Cardiff University, 2013b) such a project could support around 1,060 person years of employment in Wales. Regeneris and Cardiff University, (2013b) suggest that there are potentials to source goods and services in the region to support the development of marine renewables. Furthermore, there are expected to be commonalities between some parts of the supply chain serving offshore wind and tidal stream (and wave) devices. Our analytical assumptions are based on the main elements of tidal stream device manufacturing being outside Wales, but with local potential in terms of other plant categories of spend, and activity around foundations, moorings and on-site working and installation.

Table 5.2 revealed that the Welsh employment supported during construction and development phases is largely in manufacturing (35% of employment effects - expected to be in terms of metal works, forging, pressings, structural metals, non ferrous metals, and manufacturing categories linked to electrical and electronic engineering). Construction would account for an estimated 32% of employment effects, and with much of the remaining employment effects in professional services. Marine device developers contacted as part of the research informing Regeneris and Cardiff University (2013b) suggested that they were confident that much of the professional services were available in Wales to expedite planning and development phases of tidal stream technologies.

Table 5.3 showed that FTE employment in Wales supported through operational phases is towards the upper end of the range in the table standing at an estimated 0.9 FTE per MW installed. This is based on an expectation that the main elements of operational spend (net of grid connection charges) will be maintained in Wales (i.e. relating to maintenance, on-going surveys and monitoring/testing, repairs). On this basis the analysis suggests a 30MW tidal stream could support around 27FTE jobs in Wales per annum.

5.3.8 Wave devices

Wave devices are expected to support broadly similar levels of activity to tidal stream. During construction and development Table 5.1 suggests that around 32 person years of employment in Wales would be supported per installed MW. Then a 30MW array would support an estimated 1,000 person years of employment in the development and construction phase. There is a broadly similar pattern in terms of the sectors in which employment is supported to tidal stream. Developers contacted as part of the Regeneris and Cardiff University (2013b) study revealed an expectation that capital costs per MW installed would be similar to tidal stream, but believing that there was less regional (Wales) scope to source electrical, metal work, foundations and moorings, and rather more regional scope in terms of the final assembly of device components. In the case of wave power devices (see Table 5.2) around 32% of employment supported in development and construction is in manufacturing, around 36% in construction, and 18% in supporting professional services.

Operational employment supported per MW installed in wave devices is expected to be lower than tidal stream devices (i.e. around 0.8 FTE jobs per installed MW). A 30MW array might support around 24FTE jobs in Wales per annum over the operational life of a project. The expectation is that annual operational costs per MW installed are similar to the case of tidal stream (see Regeneris and Cardiff University, 2013b), and with this having some effect on the relative magnitudes of operational employment numbers connected to the two technologies.

5.3.9 Solar PV

Table 5.1 showed that during development and construction phases a solar/PV facility would be connected to an estimated 20.8 person years of employment per installed MW. Section 3 (see also Appendix F) of this report revealed that in 2011 Wales had less than 50MW of installed capacity in solar/PV and much of this is very small scale. Our estimates here are based on a potential 30MW scheme (linking to thresholds on Renewables Obligations Certificates currently). In comparison with other technologies in Table 5.1 the figure of 20.8 person years per MW is above the average. Then a 30MW array could be linked to some 624 person years of employment in Wales.

A series of factors influence effects associated with solar PV in our analysis. First, Wales does have some manufacturing Ŏ ŀ LJ ŀ Ŏ ƛ ǘ è ƭ ƛ ƴ ʅ Ŝ Ř ǘ ƻ ă ƻ ƭ ŀ NJ ĸ t ± ΨŘŜǾƛŎŜăΩΦ leaders in the production of PV cells, and has its European module assembly plant in Wrexham. While much of the value added in the cells is linked to raw materials, the assembly function does add some value in the region. Moreover, a number of other firms have sought to develop solar power technology in Wales such as ICP Solar and G24 (Cardiff). While developments in the latter firms are linked to smaller scale devices the presence of these investments signals an emerging supply side in terms of skills. Second, installation of solar/PV devices in arrays does not typically involve specialised capital equipment or very specific construction skills which means that assembly of arrays would provide opportunities for local contractors.

Table 5.2 showed the expected distribution of the person years of employment across different sectors of the Welsh economy. Nearly two-thirds of the employment effects are anticipated to be linked to manufacturing, but with rather less activity supported in construction compared to other electricity generation technologies.

The nature of the power generation process in solar arrays means a relatively low estimate of FTE employment supported in Wales through the operational phase. This was estimated in Table 5.3 at 0.4 FTE jobs per installed MW, meaning that a 30MW scheme might support around 12 FTE jobs in Wales per annum. Employment here is potentially supported through inspection, routine maintenance and replacement, security and payments in terms of rents and rates.

5.3.10 Anaerobic digestion (AD)

Table 5.1 revealed that AD is something of an outlier in terms of estimated person years associated with construction and development. The comparison with other technologies may not be reasonable here because AD plants are smaller scale and fulfil a different role with respect to plant covered in the remainder of the table. It is estimated that AD could be connected with around 45 person years of employment in Wales per installed MW. Given the expected size of a facility would be around

3.0MW then this would translate into around 136 person years of employment through the development and construction phase. During the research we were unable to source any reliable information on which to base estimates of employment through the operations stage of such facilities.

5.4 Conclusions

It is important to recognise that the employment reported in Section 5 of the report is that estimated to be supported in Wales through construction and development, and then operational phases of different technologies. Care needs to be taken in using these estimates particularly given limits on knowledge on spending and local sourcing characteristics of newer generation technologies. Furthermore, job estimates should not be used in isolation when considering the implications of the growth or contraction of sectors. For example, employment estimates do not illuminate the quality of employment being provided, or the externalities connected to selected power generation technologies. We return to these issues in the conclusions in Section 7 of this report.

6. Skills analysis

6.1 Introduction

This chapter provides a high level assessment of the skills context facing the main energy generating technologies in Wales. In doing so, the chapter:

- Assesses the demand for and supply of relevant skills within Wales,
- Subject to the availability of evidence, identifies key skills shortages and gaps and how these are likely to evolve in the future,
- Explores the adequacy of current learning and skills provision / intervention.

The chapter places more focus on the skills needs of the renewable elements of the energy sector. However, we note that the skills issues considered are potentially relevant for more conventional generation technologies such as coal and gas. In what follows the main emphasis is on:

- Onshore wind
- Offshore wind
- Marine Energy
- Nuclear
- Bioenergy (incorporating biomass, AD, landfill gas and sewage sludge etc).

The chapter draws upon a mixture of desk based research and consultation with key industry stakeholder (a full list of consultees is provided in Appendix C). The rest of this chapter is structured as follows:

- Demand and Supply of Skills ςOverarching Considerations
- Wales Renewable Energy Sector ςOverarching Skills Demand Context
- Wales Energy Technologies ςSkills Overview.

<u>We note here that EU Skills during 2013 will be publishing additional Welsh research that addresses specific skills needs in the energy industry.</u>

6.2 Overarching Factors in Local Skill Demand and Supply

The development of new electricity generating capacity will create additional demands for particular skill-sets at a local level. However, the scale and nature of this demand, and the manner in which these needs are met by local workers, is not straightforward. Whilst the development and long term operation of these facilities can provide large numbers of employment opportunities, it is not uncommon for these opportunities to be limited for local/regional communities.

The key factors which influence the need for labour and skills vary for the development and construction and operational and maintenance phases of activity. This is outlined below.

6.2.1 Development and Construction Jobs and Skills

The key factors which influence the need for labour and skills associated with the development and construction phase and the scope to source these from the local labour market include on the demand side:

- The scale and nature of the development, including the specialist nature of the construction and manufacturing inputs.
- The extent to which manufacturing, construction and assembly occurs on- or off-site.
- The duration of the construction period.
- The procurement process, including the origin of the prime contractors and key sub-contractors.

On the supply side key factors include:

- The location of the development site and the character of the local economy, including its key sectors, and the associated labour market.
- The degree to which proactive action is taken by the developer, prime contractors, local agencies and colleges to engage with the local supply chain and local workforce.

In what follows we consider these issues in more detail.

The requirement for workers is heavily shaped by the size of the scheme. Larger schemes will have a greater capital cost and typically require more labour input on or close to the construction-site. For these schemes, the size of the total expenditure injection and therefore potential economic impact will be greater. For example, the new build nuclear scheme proposed at Wylfa B on Anglesey will, by its sheer scale, provide some excellent opportunities for employment and training for local workers and young apprentices.

Likewise, developments with longer durations usually provide a greater opportunity for higher levels of local sourcing of workers and skills. The main reason for this is that longer durations make it more cost effective for overseas and some UK based contractors to recruit and train local workers, as opposed to bearing the costs of relocating their workers on a short term or more prolonged basis.

Clearly there are also a series of connections between skills supply/demand and the economic base. The ability of a local area to benefit from the contracts on offer in the construction phase depends on the capacity of the supply side. Local economies with a sufficient presence of suitable firms in construction and manufacturing have a greater chance of being able to participate in the supply chain and hence provide workers and skills. For example, the use of local labour for the construction of the Cefn Croes Wind Farm (a relatively large 59MW onshore scheme) was limited due to its rural location and the lack of suitable contractors and workers. However, the more rural parts of Wales will often be well placed to supply some types of goods and services, due to a local supply and skills base. Examples include aggregates, non-specialist civils, forestry and landscaping.

A further relevant factor is the extent to which external suppliers and contractors which are based on or close to a site, bring their workforces with them or recruit locally. This is typically driven by three factors:

- The duration of the construction activity on-site.
- The degree of specialism in the skills required on-site and the manner in which these vary during the construction phases.
- The density and nature of the labour market for these skills.

As our review in Section 3 suggested, the development of new energy generating facilities does require very specialist skills that are not always available in local markets in Wales. However, many of the civil engineering, general construction and plant operators, manufacture of metal fixings, electrical engineering, and general marine skills are available.

Nonetheless the nature of the labour market and the associated availability of these skills varies from location to location within Wales. There is a reasonably strong presence of consultancy, civil and electrical engineering firms and their workforces located in South East Wales in particular, as well as some other clusters in North East Wales and South West Wales (e.g. the Port Talbot and Swansea areas). There is also a strong presence of maritime and related engineering skills at various locations around the Welsh coast.

Again the earlier review in Section 3 shows that it is not uncommon for much of the on-site employment during construction to be filled by workers from other parts of the UK or Europe. The origin of the contractors and the nature of the work mean that there can be limited opportunities currently to recruit locally, even if the skills were available locally. Whilst Wales undoubtedly has strength in some aspects of the supply chain, these firms are often not located in the areas in which the new developments are located. It is unlikely however, that the more specialist skills will become readily available, unless the scale of on-going development activity leads to supply chains developing within Wales.

A lot of additional electricity generation capacity is due to be developed over the next decade and much of this is already in the planning system. Although not all of the schemes may be built, the capacity which does come forward could provide major opportunities for both local firms and workers. However, the scope for these firms and their workforces to benefit could be constrained by a lack of suitable skills in sufficient volume and in the right places.

Where skills are currently in short supply, this can be countered through appropriate efforts to upskill workers, given sufficient time to plan and certainty over the investment plans from developers. This underlines the importance of local businesses being made aware of future opportunities and being assisted to access them. Businesses often report a lack of awareness and insufficient lead-in time to respond appropriately as key barriers to entering the supply chain, recruiting workers and developing skills.

Even if many of the factors set out above are favourable, ultimately the approach to procurement followed by the developer can be the key factor in shaping the level of local employment that is ultimately secured. Moreover, the actions taken by the developer can themselves shape some of these other factors.

Whilst in some cases Welsh firms lack the scale and track record necessary to compete for the prime and first tier contracts, the developer can influence the main contractor to maximise use of local suppliers and hence workers.

6.2.2 Operations and Maintenance Jobs and Skills

The factors which influence the scope to source workers and skills from the local economy in the operational and maintenance (O&M) phase are similar to the supply side factors noted above. On the demand side the specific factors include:

- The scale of the O&M workforce required and the extent to which it is on or off-site.
- The nature of the skills required and the extent to which these are highly specialist.
- The placing of long term maintenance contracts with the main providers of equipment and the geographical origin of these providers.

Again scale is a factor in so far as it influences the degree to which there is a need for on-site operational staff. Whilst staff posts associated with core management functions are to some extent fixed, other elements vary with the size of the facility, including the level of maintenance work required. Section 2 of this report showed that renewables facilities often have limited and difficult to identify on-site employment, with the maintenance requirements being met by a mobile workforce.

The more specialist maintenance services (e.g. for turbines and switch gear) are provided under contract by the suppliers of the equipment. These firms are typically non UK-based firms and do not necessarily require on-site staff. The extent to which local firms and workers are able to benefit from this woNJ ǃ Ř Ŝ LJ Ŝ ƴ Ř ă ƽ ƴ ű K Ŝ ō Ͱ ƚ Ͱ ƴ Ŏ Ŝ ō Ŝ ű ǿ Ŝ Ŝ ƴ ű K Ŝ Y Ͱ ƴdz
and their use of their own workers.

Where operators choose to deliver maintenance in-house, the opportunity to recruit locally partly depends on the nature of the facility and whether the operator has a portfolio of similar facilities. Larger operators with a portfolio of facilities in Wales may choose to centralise their approach to operations and maintenance of these facilities, sharing responsibility across a mobile workforce staff. For example, specialist maintenance services for coal, gas and nuclear power stations tend to be provided by a specialist team of analysts, operators and engineers who are often based outside of

Wales. However, RWE npower renewables maintenance staff for its onshore wind farms in Wales are based at their offices in Mid Wales, from where they travel to the firms various sites across Wales.

6.3 Wales Renewable Energy Sector ςOverarching Skills Demand Context

This section provides a broad introduction to the overarching skills demands of the energy sector.

The commentary is based on evidence from EU Skills (the sector skills council for Energy and Utilities) and UKCES, and as such, largely focuses upon the Operation and Maintenance elements of the broadly defined Energy and Utilities sector. Consideration is given to the other phases of activity (e.g. R&D; Planning and Development; and Construction and Installation) later in this section, when focus is placed upon the individual generating technologies.

Number and Location of Jobs: The Sector Skills Insight report for Energy (UKCES) suggests that a broadly defined energy sector (including extraction, generation, transmission and distribution, but excluding retail) currently employs around 16,000. These are spread across numerous generating technologies, which are considered in detail later in this section. These jobs are located throughout Wales. Different energy technologies have different locational characteristics ςfor example, onshore wind activity is often located in rural areas and nuclear activity in peripheral rural areas, whilst other activities such as bioenergy (e.g. energy from waste) may be located in more urban locations.

Type of Jobs and Skills Requirements: EU Skills reports that overall, the workforce employed within the broadly defined energy sector in Wales is similar in occupational structure to that of the whole Wales workforce. Despite this, there are some substantial industry variations:

- The power industry employs relatively more professional, associate professionals, skilled trades and sales and customer service occupations. Only 14% of the power industry workforce is employed in operative and elementary occupations (compared to 26% of the entire Wales workforce).
- More than one-fifth of the gas (transmission & distribution) workforce is employed in a skilled trade ςmore than seven percentage points above the Wales and sector averages. Just 9% of the workforce is employed in elementary and operative occupations; reflecting the generally skilled nature of the activities being undertaken.

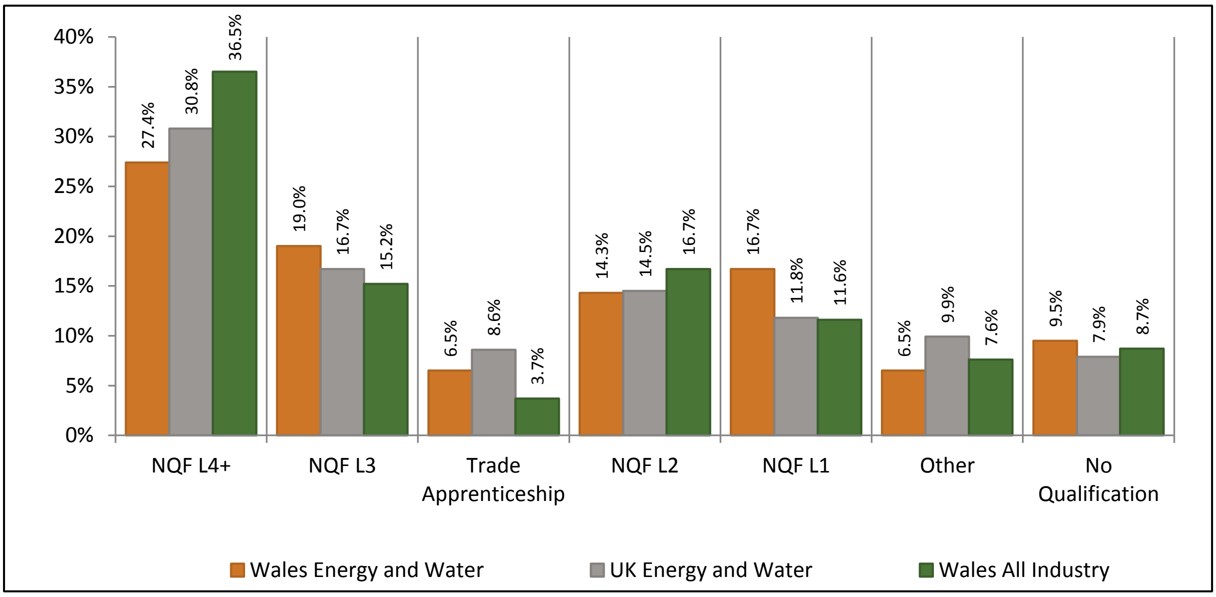
As this suggests, the skills requirements of the sector are varied. Figure 6.1 highlights that:

- Around 27% of all Energy and Utilities jobs in Wales are occupied by workers with NVQ 4+ qualifications (i.e. degree level or higher) ςa lower proportion than in the Energy and Water sector in the UK and across all sectors in Wales.
- Around a third of jobs are occupied by workers with NVQ Level 2 or 3, a much higher proportion than across all sectors in Wales.

A higher proportion of jobs (7%) are occupied by workers with Trade Apprenticeships than across all sectors in Wales, although the proportion is lower than is seen in the Energy and Water sector across the UK.

! NJ 2 dz ƴ Ř ŀ ű Ŝ ƴ ű Ƙ 2 Ŧ Ƨ 2 ō ă ŀ NJ Ŝ 2 Ŏ Ǫ slightly higher ō è ǿ 2 NJ ʅ proportion than across all sectors in Wales.

Figure 6.1 Highest qualification held by workforce, 2010



Source: Wales Sector Skills Assessment 2010, EU Skills.

Anticipated Future Changes in Labour Demand: Projections regarding the likely level of growth of the energy sector vary significantly. Sector Skills Insight for Energy[5] forecasts that at a UK level of employment across the broadly defined Energy and Water sector[6] will expand by around 4% between 2010 and 2020. These levels reflect anticipated growth across a number of generating technologies ǫincluding Onshore and Offshore wind, Marine and Nuclear. The spatial implications of this are considered later in this section.

Anticipated Future Changes in Skills Demand: Growth is likely to be spread across a broader ǫand more sophisticated ǫrange of energy technologies than has previously been the case. This is projected to impact significantly upon the demand for skills from the sector. As the industry evolves with the development of new generating technologies, the skills and competences required are expected to change, with expectations of higher level skills requirements and less reliance on manual entry level roles. This reflects numerous factors including the demand for high-level skills in research and development and broader-based business skills to exploit and commercialise innovation. UKCES make the following workforce skills projections:

[5] Sector Skills Insight for Energy (2011), UKCES
[6] ! Ǝ ŀ ƛ ƴ Σ ű Ƙ Ŝ ά Ŝ ƴ Ŝ NJ Ǝ è ă Ŝ Ŏ ű 2 NJ ɛ ƛ ă Ř Ŝ Ŧ ƛ ƴ Ŝ Ř ō NJ 2 ŀ Ř ƭ è ŀ ă Ŝ ƴ, electricity ŀ ă ă ƛ ƴ Ǝ Ƴ ƛ ƴ and utilities

The proportion of workers with a Level 4 qualification in the sector will double (an increase from 15 per cent in 2000 to 28 per cent in 2020, a faster rate of increase than across the whole economy).

The proportion of workers with mid-level qualifications in the sector will remain relatively unchanged.

The proportion of people without any qualifications in the sector will fall by a half (from a current estimate of 14% to less than 10% in 2020).

The report highlights an increased need for both generic competences and specific skill requirements including adaptability and transferability skills (for new technologies and processes), environmental and sustainability awareness, systems and risk analysis skills, entrepreneurial, innovation (to identify opportunities and create new strategies), communication and negotiation skills, marketing, consulting, networking, IT and language skills.

In addition to the net expansion of the sector workforce, UKCES also note that there will be strong replacement demand ςa need to replace retirees and people who leave the sector. UKCES project that this will affect the sector more than the rest of the UK economy, as the sector is currently characterised by a relatively older workforce.

6.4 Wales Energy Technologies ςSkills Overview

Building upon the overarching context above, this section focuses in more detail on the skills issues facing individual generating technologies in Wales. In considering the demand for workers, the analysis focuses both upon net demand (i.e. whether size of the overall workforce is increasing or decreasing) and replacement demand (i.e. arising mainly from retirements but also people leaving the sector for other reasons).

6.4.1 Onshore wind

Research by Regeneris and Cardiff University (2013a) has suggested that reaching a target of 2GW of installed capacity by 2024 could create 2,300 FTE jobs in the onshore sector in Wales. This is expected to be spread across the various phases of activity as follows:

Planning, Development and Construction ςthe research estimated that up to 1,600 jobs could be created in Wales in the period to 2024. Given the nature of the supply chains (and sub-contracting), it is likely that this demand would be across Wales (rather than constrained by the location of specific sites).

Operations and Maintenance ςover three quarters of all first round expenditure is expected to be retained in Wales. Based upon this, the Regeneris research projects the creation of around 700 jobs in Wales in the period to 2024. These jobs are likely to be more locationally specific than those in the Planning, Development and Construction stage, more closely correlating with the location of clusters of onshore wind sites.

In terms of skills broad occupations types, Renewable UK report that around 63% of the onshore wind workforce is employed in managerial, professional and associate professional occupations (typically seen to require degree level qualifications), compared to 40% across the economy as a whole. STEM skills are particularly important, reflecting the number of engineering occupations required. Table 6.1 shows results from research by the Renewable Energy Association[7] on specific occupations needed by the industry.

Table 6.1 Onshore wind sector ςJobs Types

Design and development	Design engineer; Lawyer; Project manager; Financial planner; Economists; Electrical systems designer; Physics engineer; Environmental engineer; Environmental consultant; Meteorologist; Programmers and modellers; Aeronautical engineer; Communications expert
Manufacture	Electrical engineer; Welder; Metal worker; Machinist; Skilled assembler; Test technician; Quality controller; Chemical engineer; Materials engineer; Mechanical engineer; Semi and non-skilled workers
Construction and Installation	Planning and environmental consultants; Project management and construction workers; Electrical engineer; Power generation engineer; Project manager; Turbine specialist engineer; Tower erector; Crane operator; Health and safety manager
Operations and maintenance	Electrical engineer; Power generation engineer; Energy traders.

Source: Renewable Energy Association, Made in Britain, Jobs Turnover and policy framework

Set against this demand profile, research by Renewable UK[8] found that in 2010-11, 23% of UK onshore wind employers had hard to fill vacancies, with around half of these in managerial/professional occupations. The majority of employers report that skills shortage is the reason for these vacancies. However, in absolute terms, these numbers are not large ςin 2010 there were estimated to be 200 hard to fill vacancies in the sector across the UK.

In Wales, consultation with stakeholders has suggested that the supply of skills is not currently a constraining factor in the onshore wind sector. However, the projected scale of future development may present a challenge in terms of the supply of skills ςparticularly if numerous proposed developments come forward within similar timescales.

In summary there are a number of considerations in relation to the future supply of skills for onshore wind in Wales:

Future spatial demand for onshore wind labour in Wales will to a large extent reflect the distribution of expenditure described above. The nature of expenditure and activity in the Planning, Development and Construction stages means that labour demand is less spatially defined than is likely to be the case under the Operation and Maintenance stage

[7] REA (2012) Renewable Energy: Made in Britain, Jobs Turnover and policy framework by technology 2012 assessment
[8] Working for a Green Britain (2011), Renewable UK

(where employment is likely to be required on a more permanent basis either on-site or centrally with access to numerous sites).

Recruitment in the onshore wind sector in Wales mirrors that seen across other sectors ς businesses will recruit locally if they have access to skilled, qualified and experienced individuals[9], and will also invest in training people provided they are confident that local providers can meet their needs.

Despite this, it is worth bearing in mind that in some cases, Operation and Maintenance may be included as part of the Development and Construction contracts. In these cases, the contractors responsible for Development and Construction will also be responsible for on-going operation. This will vary on a project by project basis, but will impact upon the extent to which a demand for local labour is generated.

Higher level STEM skills are of critical importance to the skills needs of the sector. As discussed in the previous section, whilst the supply of STEM skills has been cited as an issue in recent years, there is evidence[10] that the supply of these skills is increasing, including in Wales. However, the onshore wind sector faces a challenge in attracting these workers, in the face of strong completion for skills from other sectors.

There is a risk that delays in the planning process, could result in numerous proposed developments (both offshore and onshore) coming forward within similar timescales. This may have implications in terms of the ability of the local supply chains (e.g. limited capacity within local component manufacturers) and local labour markets to take full advantage of the opportunity.

Reflecting this, consultees emphasised that the key to ensuring future skills supply in Wales is appropriate and responsive planning and collaboration between employers, sector organisations and providers. This is already in evidence in Wales, as highlighted below.

There are increasing levels of skills provision focusing specifically on the onshore wind sector. Increasingly there is collaboration between providers and employers in the sector, reflecting a growing appreciation of the need to work collaboratively to address future skills constraints.

Reflecting the complexities of the labour markets discussed above, it is relevant to consider both local provision (where jobs can be supplied locally within Wales) and UK-wide provision (the elements of the labour market which are national or international, such as the supply of higher level or more specialist skills).

Provision of relevance includes:

[9] Working for a Green Britain 2 (2011)., Renewable UK

[10] Sector Skills Insight Energy (2011), UK Commission for Employment and Skills

- Lŷ ²ŀƒŜăΣ / marine and built environment centre has a new wind turbine training centre at Rhos-on-Sea campus providing relevant qualifications up to Foundation degree level.
- Coleg Llandrillo has also worked with RWE npower and Vattenfall to design apprenticeship programmes ς6 apprenticeships have been offered, 3 in mid-Wales and 3 in North Wales.
- ISOFab a mechanical engineering contractor and Vattenfall are delivering a 3 year apprenticeship scheme training 4 apprentices as wind turbine technicians for Pen y Cymoedd near Neath.
- A number of Foundation Degrees have been developed by EU Skills in Partnership with providers and employers. Those of particular relevance include Foundation Degrees in Renewable Energy Engineering, Power Generation and Distribution, Renewable Energy technologies and Electrical Power Engineering.
- EU Skills and City & Guilds are working with industry to develop electrical engineering, wind turbine operation and maintenance qualifications and an apprenticeships framework.
- In Wales, EU Skills (working with RenewableUK) has developed a bespoke Modern Apprenticeship in Wind Turbine Operations and Maintenance.
- At Blyth in Northumberland there is a wind turbine training tower and the UK Centre for Wind Technician Skills is currently in development at the site.

Despite this, Renewable UK[11] also highlight the importance of the provision of industry specific ά űNJŀ ŷă ƛ ű ƛ ƻ ŷ űNJŀ ƛ ŷ ƛ ŷ Ǝ έ ƛ ŷ ű Ķ Ŝ Ŧ ƻNJƴ ƻ Ŧ ă which Σ ǿ ŜNJ is essential for the sector Ωsuccess. Renewable UK note that this type of training is reported by ƛ ŷ Řdz ă űNJè Ƴ Ŝ Ƴ ō ŜNJ ă ű ƻ ō Ŝ ƒ ƻ ǿ ŀ ŷ Ř ƛ ŷ ƛ ŷ ŀ Ř Ŝ ǉdz ŀ ű Ŝ ă dz Lƴ ō ƻ ű ű ƒ Ŝ ŷ Ŝ Ŏ Ɩ ƛ ŷ Ŝ ƳLJ ƒ ƻ è Ŝ Ŝ This suggests that industry should strengthen its messaging to potential training providers.

6.4.2 Offshore Wind

The total offshore generating capacity in UK waters is currently around 8 terawatt-hours (TWh) of electricity annually. Strong growth in the sector is projected. Industry projections see a total of around 8GW of capacity installed by 2016 and around 18GW installed by 2020, by which point offshore wind could ă dzLJLJ ƒ è ō Ŝ ű ǿ Ŝ Ŝ ŷ м ŷ ŀ ŷ Ř н л LJŜNJ ǑŜ ŷ ű ƻ Ŧ ű Ķ

Wales has played an important role in the development of the UK offshore wind sector. This is currently focused around North Wales, with the main sites including North Hoyle and Rhyl Flats. There is also a strong pipeline of projects including Gwynt-y-Mor (576MW; expected to be operational by 2014) and Rhiannon (2.2GW; in the planning and consenting process). Renewable UK estimate that FTE employment in offshore wind across the UK currently stands at around 3,100. Reflecting the technical complexities of offshore wind, around 40% of employment is in construction and installation. Although design and m ŀ ŷdz Ŧ ŀ Ǒ űdzNJƛ ŷ Ǝ Ω ă ă Ķ ŀNJŜ ƻ Ŧ Ŝ

[11] Working for a Green Britain 2 (2011), Renewable UK

relatively low (7%) as many turbines are still imported, this is expected to grow in the future. Around 17% of jobs are in operations and maintenance.

Table 6.2: Offshore Wind Estimated UK Employment, 2011

	Number of Jobs	Proportion
Planning and Development	470	15%
Design and Manufacturing	220	7%
Construction and Installation	1,270	41%
Operations and Maintenance	530	17%
Support Services / other	620	20%
Total	**3,100**	**100%**

Source: Working for a Green Britain 2, 2011

Reflecting the strong growth projections for the sector, the number of jobs supported by the sector and hence skills demands are projected to increase strongly over the next decade. Renewable UK suggest that direct employment could increase to around 30,000 jobs under a medium growth scenario.

As with the onshore wind sector, the spatial demand for labour will depend on the extent to which expenditure is retained locally ςand this will vary on a project by project basis. However, figures included within the Gwynt y Mor environmental impact statement show that 66% of the contract value for development and construction would be spent within the UK and 9% locally (North Wales, Cheshire and Merseyside).

Reflecting the marine element (and associated health and safety issues), the skills needs of the sector are typically higher than for the onshore sector. Renewable UK report that around 47% of the offshore wind workforce is employed in managerial, professional and associate professional occupations (typically seen to require degree level qualifications), compared to 40% across the economy as a whole. STEM skills are particularly important, reflecting the number of engineering occupations required. Despite this, there is also a greater demand for technical skills / people working in skilled trades than is the case with onshore wind.

Research by the Renewable Energy Association[12] reported in Table 6.3 shows the specific occupations required in offshore wind.

[12] REA (2012) Renewable Energy: Made in Britain, Jobs Turnover and policy framework by technology 2012 assessment

Table 6.3 Offshore wind sector ςJobs Types

Design and development	Design and development: Planner; Lawyer; Financial planner; Economist; Electrical systems designer; Physical engineer; Project manager; environmental engineer; Meteorologist; Programmer and modeller; Aeronautical engineer; Communications expert.
Manufacture	Design engineer; Electrical engineer; Welder; Metal worker; Machinist; Skilled assembler; Semi and non-skilled worker; Test technician; Chemical engineer; Materials engineer; Mechanical engineer; Quality assurance.
Construction and Installation	Planning and environmental consultant; Underwater diver; Project management and construction worker; Marine Engineer; Electrical engineer; Power generation engineer; Turbine specialist engineer; Tower erector; Crane operator; Health and safety manager; Specialist shipping and port personnel.
Operations and maintenance	Electrical engineer; Sea and air transport personnel; Power generation engineer; Energy trader

Source: Renewable Energy Association, Made in Britain, Jobs Turnover and policy framework

Research by Renewable UK suggests that there are more hard to fill vacancies in offshore wind than in onshore wind ςin 2010-11 26% of UK offshore wind employers had hard to fill vacancies (numbering 140 in total), 68% of which were in managerial/professional occupations. The majority of these were reported to be due to skills issues. Skills shortages exist for electrical, electronic, structural, aeronautical and power engineers (especially highly qualified and experienced) with marine knowledge to work offshore. Challenges are exacerbated by the stiff competition for workers in the relevant technical and commercial disciplines from other industries especially the high paying oil and gas industries.

However, as with onshore wind, consultees suggest that the supply of skills / labour is currently not constraining the development of the offshore wind sector. This partly reflects the relatively large labour markets over which the sector exerts an influence but also the broader spatial factors at play ςoffshore sites can theoretically be approached from a large segment of coast and hence have access to a larger pool of labour than might be the case for onshore wind.

A number of important sources of labour are likely to emerge:

New graduates / labour market entrants ςThe industry recruits graduates studying courses in renewables, geology and marine technology as well as more general STEM disciplines such as engineering and maths. Vocational skills are also important.

From other established offshore sectors - transferable skill sets and sector aptitude from oil and petro-chemical industries mean workers in these declining industries could provide a source of labour. Retraining of workers who have lost jobs in heavy manufacturing may also contribute to the metal workers and welders requirements.

The skills shortages reported by Renewable UK are expected to persist at the UK level, particularly for project managers, technicians, maintenance workers and health and safety specialists. Key factors influencing these issues are thought to include: an ageing workforce and smaller cohort of young people entering labour market; oil and gas offering higher salaries; lack of STEM graduates; sector attractiveness issues and increasing competition from other sectors.

As with onshore wind, there are increasing levels of skills provision focusing specifically on the offshore wind sector, built upon collaboration between providers and employers in the sector. Again, provision across the UK as a whole is relevant here ςparticularly where focusing on higher level skills (and a typically more mobile workforce). Provision of relevance includes:

Renewable UK accredited courses in health and safety (Marine Survival Training, working and rescue from height).

Foundation degrees developed by EU Skills such as the Foundation Degree in Sub-Sea Engineering.

MSc Marine Renewable Energy at University of Plymouth and at Heriot-Watt University, MSc Offshore Renewable Energy at University of Strathclyde.

Offshore Marine Academy was established in 2010 and is run by Offshore Marine Management as a response to the skills shortage. It offers training in marine, supervision, survey, health and safety and security.

The upskilling of the existing workforce is also seen as critical to the future development of the sector. However, given the lengthy lead times to competence, it is crucial that employers and industry bodies take a proactive approach to marine investment to avoid skills gaps further down the line.

6.4.3. Marine (Tidal and Wave)

Technologies generating renewable energy from wave and tidal sources are at a nascent stage but are thought to have great potential in the UK. Renewable UK state that current capacity is modest at 9MW, but that the industry is on track to deliver 120 MW of capacity by 2020. The Welsh Government suggested that Wales has potential for up to 4GW of marine generating capacity by 2025, which would increase to over 10GW should the proposed Severn Estuary scheme come forward. Pembrokeshire has been identified as a hub for marine renewables, as reflected by the establishment of Marine Energy Pembrokeshire to promote the opportunities.

Reflecting the nascent state of the technology, employment is currently relatively limited. UK-wide in 2011 the marine renewables sector employed around 800 people. However, should the growth potential of the sector be achieved, there is potential for significant employment generation. wŜyƒŜøŀōŧŜ ¦Y ăŜű ƨdzű ŧƨø ŀyŘ KⱥƎK ƎNJƨøűK ăŎŜyŀNJ employment across the UK could number between 5,000 and 9,400 by 2021. There is currently no research on the number of these jobs which are likely to be created in Wales.

The nascent nature of marine resource means that most of the employment is based on pilot plants rather than fully commercial plants. This affects the current split of jobs ςa quarter of current jobs are in design and manufacture, a third are in support services and R&D, 16% in construction and installation and around 10% in operations & maintenance[13].

Table 6.4 Marine Renewables Current Employment, 2011

	Number of Jobs FTEs	Proportion
Planning and Development	140	17%
Design and Manufacturing	210	26%
Construction and Installation	140	17%
Operations and Maintenance	70	9%
Support Services / other	260	32%
Total	**800**	**100%**

Source: Working for a Green Britain 2, 2011

Research undertaken by Regeneris and Cardiff University (2013b) regarding the likely economic impact of the marine renewable sector in Wales in the future suggests that there is likely to be considerable leakage of expenditure away from Wales. This reflects the presence elsewhere of relatively well developed specialisms in the marine sector, including in Scotland and Germany.

According to Renewable UK current skills levels in the technology are high. In the wave and tidal sector, 79% of the workforce is estimated to be employed in managerial, professional and associated professional occupations, compared to 40% across the economy as a whole. This will partly reflect that a lot of the current activity is in R&D.

The activities associated with the marine renewable sector are similar in some respects to those in offshore wind. Research by the Renewable Energy Association[14] suggests that specific occupations include those listed in Table 6.5.

Table 6.5 Marine sector ςJobs Types

Planning and development	Environmental and planning consultant; Marine biologist; Marine surveyor; Subsea engineer
Design and manufacture	Design engineer; Electrical systems designer; Project manager; Environmental engineer; Environmental consultant; Oceanographer; Programmer and modeler; fluid dynamics specialist; Communications and control engineer; Electrical engineer; Power generation engineer; Marine engineer; Electrical engineer; Welder; Metal worker; Machinist; Skilled assembler; Test technician; Materials & Mechanical engineer.
Construction and Installation	Planning and environmental consultants; Project management and construction workers; Marine Engineer; Electrical engineer; Power generation engineer; Quantity surveyor; Turbine specialist engineer; Health and safety manager; Specialist shipping and port personnel; Divers; Controls engineer; Project manager; Marine installation crew; Health and safety manager
Support services and other	Device maintenance crew; Electrical engineer; Marine engineer; Power generation engineer; Energy sales people; Divers

Source: Renewable Energy Association, Made in Britain, Jobs Turnover and policy framework

[13] Working for a Green Britain 2 (2011), Renewable UK
[14] REA (2012) Renewable Energy: Made in Britain, Jobs Turnover and policy framework by technology 2012 assessment

Consultations with stakeholders have suggested that skills shortages are not currently acting as a constraint on the development of the sector. The current context of relatively small operators means that skills demands are low (typically 1-2 people) and skills of this scale can typically be resourced from other industries.

Despite this, Renewable UK found that in 2010-11, 37% of UK marine energy employers had hard to fill vacancies ςa relatively high proportion. Over two thirds of these hard to fill vacancies were in managerial/professional occupations. Vacancies were also mainly in specialist skills that are not directly transferable, such as hydrodynamic modelling, aerodynamic mechanical engineering, hydrographic surveying, environmental consultancy, subsea design, ornithology and ecology. There is a shortage of graduates specialising in these disciplines generally in the UK and there is difficulty attracting experienced personnel from other sectors due to competition with more established industries.

Looking ahead, as discussed above, the leakage of expenditure away from Wales will effectively limit the scale of demand for skills within Wales. However, developers, where possible, will be looking to source expertise and services locally to support their projects. Vital skills in the oil and gas sector could be translated to the marine renewables industry. Wales can also look to build upon its strong manufacturing and engineering tradition to secure new manufacturing jobs. The research and collaboration of Welsh Universities and industry is also a strength on which to build, as evidenced by the Marine Energy Research Group and the SEACAMS project (see below).

The highly skilled nature of the marine and tidal sector means that NVQ Level 4+ provision will play an important role in sector development. The challenges regarding the demand for and supply of STEM skills have been covered previously, but it is worth stressing the challenges regarding increasing competition for STEM skills across the economy. Reflecting this, upskilling and reskilling existing workers with transferable skills is also likely to be crucial to the development of the marine sector. Again EU Skills are seeking to promote the skills needs of the sector and ensure that appropriate conversations are taking place between employers and providers to meet future needs.

Aside from mainstream provision, there are also number of wider projects being delivered in Wales which could play a role going forward in skills provision for the Marine sector:

- The Marine Energy Research Group at Swansea University provides research on environmental and engineering aspects and involves academic, industrial, governmental and environmental groups located along the Welsh coast.
- The SEACAMS project ςa collaborative project between Bangor, Swansea and Aberystwyth Universities. It aims to integrate research and business opportunities in the marine sector in Wales and aims to promote economic activity, growth of SMEs, innovation, generate commercial opportunities and create jobs.

6.4.4. Nuclear

Future skills demands in nuclear are largely linked to whether Wylfa B is developed. If Wylfa B goes ahead, it is projected that the site could generate a 60 year demand for employees. Wales has 11% (1,400) of the civil nuclear workforce in the UK ς1,000 in direct employment and with the immediate supply chain accounting for the remainder[15]. Without new nuclear provision, Cogent estimate that nuclear employment levels in Wales will decline to minimal levels post 2017.

The likely employment needs of Wylfa B are uncertain, but estimates suggest that there would be up to 6,000 construction jobs at peak, and 1,000 operational jobs when completed. Cogent project that this will broadly equate to a demand for around 32,000 person years of employment (taking into account the duration of the construction period).

Of current jobs at Wylfa, around 78% are at a technical or associated professional level (NVQ Level 3+). A broad range of activities and occupations are required, covering project management, safety case authority, high intensity welding, design engineering, geotechnical, control and instrumentation, planning and estimation activities.

If Wylfa B goes ahead, future skills needs are likely to be similar to those in the established nuclear sector. Cogent project that there will be strong demand for STEM graduate skills, totalling 140 per graduates annum over a ten year period and demand for around 250 apprentices per annum.

Despite the long timescales involved in delivery it is important to note that there will be a demand for skills from early on in the development process, with the future workforce ramping up (gaining critical experience and training) over several years prior to generation commencing.

The development and construction supply chains are likely to be national and international, with implications for the extent to which the local labour markets will have a role to play. In an ideal scenario, there would be managed transition of the current workforce of Wylfa to Wylfa B. making full use of the experience and expertise developed over the past decades. However, the likely time-lag between the cessation of generation at Wylfa and the completion of Wylfa B means that many of the existing skills are likely to be lost (either through displacement to other industries or retirement). Half of the current workforce is expected to retire by 2025 ςthis is especially acute at the professional and management levels where two-thirds are expected to be lost.

As such, it is likely that the majority of the supply of skills for long term demand will come from young people currently in education or training. Reflecting this, Cogent notes that the main gaps within the nuclear workforce are likely to be in terms of project management and adequate capability and experience of the sector.

[15] Cogent (2011) Future Skills Needs for the Nuclear Industry in North Wales (Wylfa and Trawsfynydd)

Whilst the numbers of new entrants required represents a considerable challenge for the sector, there is general confidence amongst stakeholders regarding the ability of the local labour markets to provide the skills required. The main concern amongst stakeholders lies with the current lack of clarity in the overall nature and timescales of proposed development. Until more clarity is provided regarding the timescales for construction, it is not possible for sector organisations to start working with local employers (both Hitachi and supply chain employers) or providers to plan in detail for and start to respond to skills needs.

As above, large scale targeted intervention in Wales will not be possible until there is greater certainty regarding the nature and timescales of Wylfa B delivery. Despite this, there are numerous existing frameworks and interventions in place with the objective of matching skills supply to demand from the nuclear sector. Interventions of particular relevance include:

- The National Skills Academy for Nuclear – an employer led membership organisation established to ensure that the UK Nuclear Industry and its supply chain has the skilled, competent and safe workforce it needs to deal with the current and future UK nuclear programme. There are five Welsh employers that are member of the National Skills Academy for Nuclear (over 100 across the whole of the UK).
- Cogent and the National Skills Academy for Nuclear have responsibility for the development of standards and qualifications for the industry, including the Nuclear Skills Passport. In the past, training by employers has often been delivered (in partnership with local providers) with an eye on short term targets. Thus training provided by one employer is not necessarily recognised across the industry. To remedy this, the Nuclear Skills Passport includes a facility for new entrants from other sectors to top-up their original sector competencies with nuclear awareness, behaviours and cultures. It is already designated as desirable for Supply Chain Contracts by the utility and vendor companies in the first wave of new nuclear. Workforce qualifications and training that are under development include a Certificate of Nuclear Professionalism, a Foundation Degree for the Nuclear industry, and standards and training modules that are accredited and recorded through the Nuclear Skills Passport .
- Coleg Menai is the Wales hub for the NSA-nuclear and has constructed a new Energy Skills Centre to be the centre of training for the nuclear industry. The college has already established strong links with Horizon, with monthly meetings convened. The college has also established linkages with Bridgewater College (located near Hinkley Point) for learning and best practice purposes. The College also has linkages with the Nuclear Decommissioning Authority and together they have located heavy machinery on college land near Llangefni for training.
- Currently, Coleg Menai is delivering more general courses in Business Administration, Warehousing and Engineering. This partly reflects the current lack of certainty over timescales for Wylfa B. However, the college will deliver a work-based Foundation Degree for the Nuclear Industry, as part of the HEFCE Working Higher project.

In response to the perceived risk of taking on apprentices for small businesses, Coleg
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funded to take the risk away from small organisations.

At a national level last year The Nuclear Graduate Scheme (rotational placements) has 30-60 vacancies and over 3000 applicants.

More general higher education provision is also highly important. Cogent notes that while much of the skilled supply from universities will sit across science and engineering, there will be a need for a number of specialisms for nuclear. Four universities within the UK collectively offer 11
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Cumbria) and Working Higher (a HEFCE initiative involving Cogent) will provide dedicated workforce development programmes.

6.4.5 Bioenergy

Bioenergy incorporates a number of generating technologies including landfill gas, sewage sludge digestion, municipal solid waste combustion, animal biomass, anaerobic digestion and plant biomass. Data from DECC suggests that across the UK, bioenergy provided a total of 1,100 MW generating capacity. In Wales landfill gas, sewage gas and other bioenergy renewable sources generated 443GW hours of electricity in 2011[16].

The Renewable Energy Association[17] states that biomass utilisation including biomass power, AD, CHP and biofuels is the third largest renewable energy sector in Wales, employing 970 people in 2010-11. Whilst these jobs are located across Wales, generating sites are typically located in more urban areas than is the case with some of the other renewable energy technologies. This reflects the need for access to population / road networks for fuel needs.

There is potential for employment in the sector to grow. If the UK achieves the levels predicted in the Renewable Roadmap the bioenergy sector (biomass electricity, heat and anaerobic digestion) could employ 35,000 (low scenario) to 50,000 (high scenario) by 2020[18].

Reflecting the broad range of technologies included here, the occupations profiles is varied. The Renewable Energy Association[19] notes that roles in engineering, design, construction will be particularly important. Specific occupational needs are revealed in Table 6.6.

[16] Welsh Government (2013) Energy Generation and Consumption for Wales, 2011, Statistical Bulletin.
[17] REA (2012) Renewable Energy: Made in Britain, Jobs Turnover and policy framework by technology 2012 assessment
[18] NNFCC (2012) *UK jobs in the bioenergy sectors by 2020*
[19] REA (2012) Renewable Energy: Made in Britain, Jobs Turnover and policy framework by technology 2012 assessment

Table 6.6 Bioenergy sector ςJobs Types

Design and development	Design engineer; Project manager; Materials engineer; Electrical systems designer; Mechanical engineer; Environmental engineer; Environmental consultant; Fuel handling systems designer.
Design and manufacture	Design engineer; Project manager; Welder; Labourer; Sheet metal worker; Chemist; Electrical engineer, Mechanical engineer.
Construction and Installation	Planning consultant; Rigger; Environmental consultant; Project management and construction workers; Electrical engineer; Power generation engineer; Health and safety manager; Pipefitter; Welder; Electrician.
Support services and other	Agricultural specialist; Microbiologist; Biochemist; Fuel sourcing manager and negotiator; Electrical engineer; Power generation engineer; Energy trader; Boiler engineer; Welder; Electrician; Service engineer; Electrical/ electronic technician; Plant operator; Mechanic; Fuel and ash supervisor; Labourer; Maintenance manager.
Note: There are numerous technologies within bio-energy and occupational demands will vary across these. However, the above presents some of the main occupations required	

Source: Renewable Energy Association, Made in Britain, Jobs Turnover and policy framework

Generally speaking, the supply of labour is likely to emerge from a number of sources:

Existing energy sector workforce ςthere are some instances where existing power generating sites will be converted to bioenergy sites. In these instances, the sector will be able to build upon the existing workforce, with upskilling where necessary to operate the new technology.

New entrants ςas with other energy generating technologies, new entrants will be required with requisite skills, as and when new opportunities emerge.

Whilst the literature does not provide much detail on the current supply of skills for the Bioenergy sector in Wales, the Bioenergy Action Plan for Wales[20], notes the presence of skills shortages in forest management and the need to respond to these.

There are a number of interventions aimed at skills development for the Bioenergy sector. These include:

Wood Energy Business Scheme ςrun by the Forestry Commission Wales and funded by the European Union and Welsh Government. This scheme supports the training of staff in areas of expertise relating to installation of wood fuel heating systems and the development of a wood fuel supply chain.

A Centre for Excellence for Anaerobic Digestion was established in 2008. This is based in the Sustainable Environment Research Centre at the University of Glamorgan and is funded by the European Union, the Welsh Government and the University of Glamorgan. The Centre provides a wide range of technical and non-technical support to AD and Biogas stakeholders, with the aim of driving forward the development of the sector.

British Gas Training Centre ςThe British Gas Green Skills Training Centre in Tredegar opened in 2010. The centre aims to train over 1,300 people each year, including local long term unemployed people. They will get the chance to learn how to install equipment such as solar

[20] Welsh Government (2010) Bioenergy Action Plan for Wales Progress Report

panels, hi-tech smart metres, biomass boilers and combined heat and power boilers in purpose built training bungalows.

As with other technologies, the sector will also depend upon the supply of STEM skills from higher education providers. There are a number of courses nationally which focus on Bioenergy including Bioenergy and Environmental Change (MSc Managing the Environment) at Aberystwyth University, MSc Sustainable Bioenergy at University of Nottingham, MSc Renewable Bioenergy at Abertay University, Dundee.

6.5 Summary and Conclusions

Whilst there are numerous gaps in the research base (particularly regarding the skills context facing some of the more nascent energy technologies such as Bioenergy), the review and consultations have highlighted a number of messages which are summarised below.

First, overarching skills challenges exist across the energy sector in Wales. These include:

- Lower than average skills levels within the resident workforce, with a higher than average proportion of residents with no qualifications and a lower than average proportion with degree level qualifications, which represents a lost opportunity for Wales.
- As is the case across the UK, the supply of higher level STEM skills remains a challenge. Whilst the supply of STEM graduates has been increasing, there is increasing competition for these skills throughout the economy.

However, despite these overarching challenges (and a number of more specific challenges facing the individual technologies), the supply of skills does not currently appear to be constraining the development of the main energy technologies in Wales.

Whilst this will partly reflect the fact that the level of employment supported by these energy technologies in Wales is still relatively low, it may also reflect the proactive approach being taken to low carbon skills training provision within Wales. Recent years have seen increasing levels of collaboration between industry employers, representative organisations, government and providers and there is evidence that this is bearing results in terms of the breadth and relevance of targeted provision on offer, and the flow of apprentices and STEM qualified graduates. This provides a strong base upon which to build in the future.

Strong growth is projected across many of the renewables sectors in Wales over the next two decades. If realised, these growth projections will result in a significant increase in the demand for labour and skills in Wales.

Consultation with stakeholders has suggested that the Welsh labour market is capable of responding adequately to these increasing demands and that given appropriate planning, the labour market can be positioned to act as a catalyst for the growth of the technologies rather than as a constraint. However, there are a number of core challenges to overcome:

- Uncertainty about labour and skills requirements. Whilst strong growth is projected across many of the energy technologies, in many cases this is dependent upon numerous unknowns and uncertainties.
- Detailed skills planning and provision cannot take place until concrete timescales emerge for new nuclear.
- The onshore wind sector is projected to grow strongly. However, growth is dependent upon planning challenges being overcome. There is a risk that these challenges could ǑNJŜ ŀ ű Ŝ Ψ ōdz ƴ Ǒ K ʎ ƴ ∃ Ω ʎ ƴ ű K Ŝ Ř Ŝ Ǿ Ŝ ƭ ƻ LJ Ƴ Ŝ ƴ ű LJ ʎ LJ Ŝ ƭ ʎ meet demand once the pipeline comes forward.
- Strong growth is projected in nascent technologies such as Marine and Tidal. However, given that these technologies remain at the pre-commercialisation stage, there is significant uncertainty about the future scale of skills demand.

Furthermore the spatial demand for labour in Wales varies significantly according to energy technology and phase of activity. The growth energy technologies have very different spatial characteristics. Onshore wind sites are typically rural, offshore sites rely on port locations, whilst nuclear is located in peripheral rural areas. These varied spatial patterns differ from the more established energy technologies (e.g. coal). Furthermore, coupled with this new geography, the more specialised the activity required, then the more likely it is that the expenditure will leak away from the local economy (lessoning demand for local labour). This is particularly the case for design and manufacture and development and construction activities which often rely on established supply chains which are relatively mobile in nature.

Whilst skills needs vary from one energy technology to the next, a general trend is expected of increasing demand for higher level skills. This partly reflects the increasing levels of sophistication associated with the emerging energy technologies. As such, the existing challenges associated with the supply of higher level STEM skills are expected to intensify in the future.

Skills planning will play a large role in responding to these challenges. As discussed above, there is a strong base to build upon in this respect ҁin recent years, strong relationships have been forged between the sector skills councils, the large employers and providers, resulting in the establishment of National Skills Academies, bespoke further and higher education courses and Apprenticeships.

It is also important that these relationships also extend where possible to include smaller employers to ensure an all-encompassing approach to skills supply right through the supply chain. This is particularly key in the more nascent technologies which are characterised by the presence of smaller operators.

6.5.2. Energy Technology Specific Summary

Whilst there are numerous gaps in the evidence base, the review of the individual energy technologies has highlighted a number of broad messages regarding the main trends in the demand for and supply of labour. These are summarised in Table 6.7.

Table 6.7 Energy Technologies ςSkills Demands and Challenges in Summary

	Background	Current and Future Labour Demand	Demand for Skills	Skills Issues / Challenges
Onshore wind	. NJ ƛ ǘ ŀ ƛ ȝ Ω mature renewable energy technology Over 200 generating sites in Wales, generating around 0.4GW Located in largely rural parts of Wales	Currently around 6,000 Jobs across the UK ς Around 50% in Development and Planning Around 16% in Construction and Installation Around 25% in Operation and Maintenance Sector growth projected ςup to 2,300 jobs in Wales to 2025.	Skills needs vary by activity phase: Development and Planning ςoccupations inc. professional services. A large proportion of these jobs can be delivered by Welsh firms. Construction and installation ςoccupations including manufacture of structures and electronics, and construction activities. Typically mobile workforce with greater expenditure leakage outside of Wales. Operation and Maintenance ςthese jobs will be more site specific (whether located on-site or centrally with access to several sites) Activities including Civil Engineering, Environmental services and Management.	Consultation with stakeholders has suggested that the supply of skills is not currently acting as a constraining factor in the onshore wind sector in Wales. Despite this, challenges include competition from other sectors for highly skilled workers and ensuring local supply of skills to ensure employment opportunities are maximised for local people. Whilst the Wales labour market should be able to respond to future demand, there may be significant challenges should numerous proposed developments bunch together.
Offshore wind	Numerous offshore sites in Wales, with current capacity of around 600MW Significant future growth anticipated, with strong pipeline of projects Largely focused in North Wales, but developments also planned in South Wales (e.g. Atlantic Array)	Current UK-wide employment of around 4,000, future estimated growth to 30,000 by 2021 (medium growth scenario). Of this, Around 7% in Design and Manufacturing Around 40% in construction and Installation Around 17% in operation and maintenance.	Skills needs vary by activity phase: Construction and installation ςtypically broader and more highly skilled occupational demands than onshore wind, reflecting the marine element. Typically mobile workforce with high expenditure leakage outside of Wales (and hence lower local labour demands). Operation and Maintenance ςagain, more specialised requirements than onshore wind reflecting marine elements. Higher demand for local labour, but largely dependent upon developer decisions with regards to access port.	As with onshore wind, consultees suggest that the supply of skills / labour is currently not constraining the development of the offshore wind sector. This reflects the relatively large labour markets over which the sector exerts an influence. Offshore sites can often be accessed from numerous ports and hence have access to a larger pool of labour than might be the case for onshore wind.

Marine	The technology is at a relatively nascent stage, with current UK generating capacity modest at 9MW Strong growth projected ς 120MW capacity projected by 2020 The first tidal device in Wales is due for deployment in 2013	Reflecting nascent state, only around 900 people currently employed UK wide Projected growth of between 5,000 and 9,400 by 2021.	Skills needs vary by activity phase: Construction and installation ςbroad and more highly skills occupational demands, reflecting the marine element. Typically mobile workforce with high (two thirds) expenditure leakage outside of Wales (and hence lower local labour demands). Operation and Maintenance ςagain, more specialised requirements than other technologies, reflecting marine elements. High expenditure leakage projected from Wales impacting on scale of demand for labour.	Consultations have suggested that skills shortages are not currently acting as a constraint on sector development. The current context of relatively small operators means that skills demands are low and skills of this scale can typically be resourced from other industries. Looking ahead, the leakage of expenditure will effectively limit the scale of demand for skills within Wales. However, a number of strengths on which Wales can look to build including the research and collaboration of Welsh Universities and industry.
Nuclear	Future nuclear in Wales depends upon the development of Wylfa B on Anglesey	Currently around 1,000 employed in Wales nuclear industry (mainly O&M reflecting current nuclear cycle) Wylfa B could support up to 6,000 development and construction jobs at peak (32,000 person years of employment over construction) and around 1, 000 O&M jobs	Skills needs vary by activity phase: Development and Construction ςbroad range of activities from planning, to highly specialised manufacture of components to construction. A large proportion of expenditure likely to be lost to Wales; some role for Wales / local companies in less specialised elements of on-site construction. Operation and Maintenance ςthese jobs will be more site specific with local labour market demands. Broad range of occupations including management, health and safety, engineering, and control and instrumentation. Specialised skills, with majority at technical or associate professional levels.	Main challenges is the uncertainty with current timescales for Wylfa B Some labour supply for O&M is likely to come through managed transition from current Wylfa site. However, time-lag means that Wylfa B will rely upon a largely new and (currently) inexperienced workforce. Reflecting this, workforce recruitment and training will begin well in advance of O&M commencing to generate requisite experience and expertise. Relationship already in place between Horizon and Coleg Menai (local FE provider) to start to plan for future skills needs.

Bioenergy	Covers a range of technologies including Landfill Gas, Sewerage Sludge, Anaerobic Digestion and Biomass Current UK capacity of 1.1GW; strong growth expected Sites spread more broadly across Wales than other technologies	Strong employment growth projected across the UK ς between 35,000 and 50,000 jobs by 2020	Development and construction ςreliant on general construction, civil engineering skills, along with more specialist skills relating to the generating equipment. Much of the generating equipment is likely to be manufactured overseas. O&M ςrelatively low density labour demand with typically lower skills demands than other technologies. Demand for labour in transit activities (moving waste to plant and around plant). More specialist skills likely to be outsourced.	Limited evidence base on the supply of skills for this technology. However, reflecting the lower levels of specialism and skill required, both in construction and O&M, jobs are likely to be accessible to many in the Welsh labour market.

7. Conclusions

7.1 Caveats

This report marks the first attempt in Wales to consistently analyse the employment effects associated with different electricity generation technologies through development and construction, and the operational phases. The research is complicated by a number of factors that need to be reflected on by users of the findings. These factors include:

Considerable uncertainty regarding the nature of future spending on renewables, and then with additional uncertainty on the extent to which the regional supply chain can meet the needs of developers. The modelling framework employed in this report, to a large extent, uses as a base current industrial structure. In the future entirely new industries might come to Wales to meet the needs of developers or existing firms might succeed in diversifying to meet these same needs.

The report, in gaining a comparative perspective, examines better established technologies where cost drivers are well understood, together with emerging technologies which are at advanced prototype stages and are not yet commercially viable or tested operationally over long periods.

Some reluctance among the major developers to share details of construction and operational spending because of issues surrounding commercial confidentiality.

Our analysis is necessarily developed on a series of assumptions regarding the levels of activity and household income that might be supported in Wales through different phases of power station development. With this in mind one-off decisions by developers and/or managing contractors during build phases could have marked effects on the levels of local/regional employment supported. For example, in offshore wind the choice of gateway port (i.e. within or outside of Wales) would have marked effects on employment supported both during operational and construction phases. Similarly, in onshore and offshore wind even decisions on whether towers are purchased within or outside of Wales could have marked local employment effects.

It is also important to understand the drivers of regional employment effects per MW of installed capacity. High employment effects in relative terms might be connected to relatively high levels of capital spending or might reflect inefficiencies in nascent technologies. It is unlikely that any future interventions planned by Welsh Government and others could heavily influence employment effects per MW of installed capacity. A wider set
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of jobs supported over the life cycle might be the same technologies that are associated with higher levels of environmental externalities. In consequence estimates of employment connected to technologies can only be one variable considered in informing interventions.

7.2 Conclusions

The changing energy mix in Wales will reduce the easily Ψ ƛ Ř Ŝ ƴ ű ƛ Ŧ ƛ ŀ ō ƒ Ŝ Ω ƴdzƳ ō ŜNJă **employed in electricity generation**. The current pattern identified in Section 4 of the report is direct employment focused in a small number of sites. The rundown of coal-fired capacity together with uncertainty on the progression of nuclear will see much of future employment more spread out, more mobile and more difficult to identify within the electricity standard industrial classification ςfor example, much employment will be in construction and engineering companies and trades. Given these changes it becomes far more important to look at the entire employment supported by, regional operational spending rather than attempting to differentiate in detail the difficult dividing line between direct and indirect employment in what are increasingly extremely capital intensive operations.

Lƴ űKŜ ¦Y ŀ ∃NJŜŀű ŘŜŀ **ther wind or marine is focused in the** ΨŎ ŀ LJ ŀ Ŏ ƛ ű è **periphery. While this already poses problems in terms of grid connections, there are also a series of development opportunities**. Bristow et al. (2013) show that the geography of UK renewables could provide opportunities for improving the resilience of more disadvantaged UK communities partly through supply chain effects during development and operational phases but also through the benefit provisions that developers make for communities. In the context of Wales more peripheral rural and coastal areas may not, without assistance, have the capacity to engage with development projects to maximise local returns.

It is difficult to escape from the opportunities lost in Wales due to the absence of capacity in terms of the high value added elements surrounding device manufacture, and the absence of large scale developers with integrated bases of operation in the region. Permeating much of the analysis in Section 5 are assumptions reflecting that major decisions on capital investment are made elsewhere, developers are typically based elsewhere, managing contractors are based elsewhere, and then the risks and rewards of new infrastructure development are in large measure internalised elsewhere. In part this state of affairs in Wales reflects decisions made in newly privatised utilities nearly two decades ago (Gripaios and Munday, 1998, 2000) which saw the hollowing out of regional utility employment. Then one context of the employment effects reported (and then resulting gross value added effects) for electricity generation is a Ψbranch plantΩtype economy, and a linked low skills equilibrium. Such an economy which will find it difficult to capitalise on future opportunities in renewables, in spite of being adjacent to one of the highest quality natural resources in Western Europe.

A further set of conclusions relate to the skills analysis. Whilst there are numerous gaps in the research base (particularly regarding the skills context facing some of the more nascent energy technologies), the report finds that:

The supply of skills does not appear to be constraining the development of the energy technologies in Wales. This partly reflects that the level of employment supported by these energy technologies in Wales is still relatively low, and may also reflect the proactive approach being taken to low carbon skills training provision within Wales.

If realised, projected growth across many of the renewables sectors in Wales could result in a significant increase in the demand for labour and skills. The regional labour market can be positioned to act as a catalyst for the growth of the technologies rather than as a constraint.

There are a number of core challenges to overcome including uncertainty about labour and skills requirements in the face of developmental uncertainty, particularly in nuclear and on/offshore wind, and with other (marine and tidal) technologies at the pre-commercialisation stage. There are also a series of spatial and temporal challenges ςthe spatial demand for labour in Wales varies significantly according to energy technology and phase of activity.

Whilst skills needs vary from one energy technology to the next, a general trend is expected of increasing demand for higher level skills. This partly reflects the increasing levels of sophistication associated with the emerging energy technologies. As such, the existing challenges associated with the supply of higher level STEM skills are expected to intensify in the future. Skills planning will play a large role in responding to these challenges. There is a strong base to build upon in this respect ςin recent years, strong relationships have been forged between the sector skills councils, the large employers and providers, resulting in the establishment of National Skills Academies, bespoke FE and HE courses and Apprenticeships. It is also important that these relationships also extend where possible to include smaller employers to ensure an all-encompassing approach to skills supply right through the value chain. This is particularly key in the more nascent technologies which are characterised by the presence of smaller operators

7.3 Recommendations and Implications for Welsh Government Policy

Some recommendations that follow from our employment effects analysis:

There are significant uncertainties involved in assessing the jobs impact of electricity generation (quite apart from methodological and modelling issues). For many important elements, developers either do not yet know, or are unwilling to say.

The Welsh Government should thus exercise caution in using any prior assessment of jobs connected to the construction and development phases of large scale new power infrastructure to drive policy especially when originating from parties with a vested interest. Our review suggests on-site employment estimates made in advance are rarely followed up by a later analysis of out-turn, and without due consideration of balance between local, Welsh and travelling workers from the rest of the UK and overseas;

As with any economic impact assessment assumptions on local sourcing have effects on the estimates made. Targeted Welsh Government interventions in terms of improving supply chain performance (information provision; supplier diversification and new inward investment) could lever welcome employment returns;

Further research is merited to investigate how multinational managing contractors involved in power infrastructure and other major projects in Wales actually go about the task of selecting tier 1 and particularly tier 2 suppliers and subcontractors. In particularly here whether there are path dependencies in the selection process that could be changed by better information on the regional supply side, or by other Welsh Government interventions.

This report has focussed on the regional employment impacts of electricity generation in Wales. There are a number of key themes that arise from the work (and from associated projects and literature) that are perhaps not directly policy-relevant for Welsh Government in the short term, but might inform longer-term policy in this area. We summarise these below.

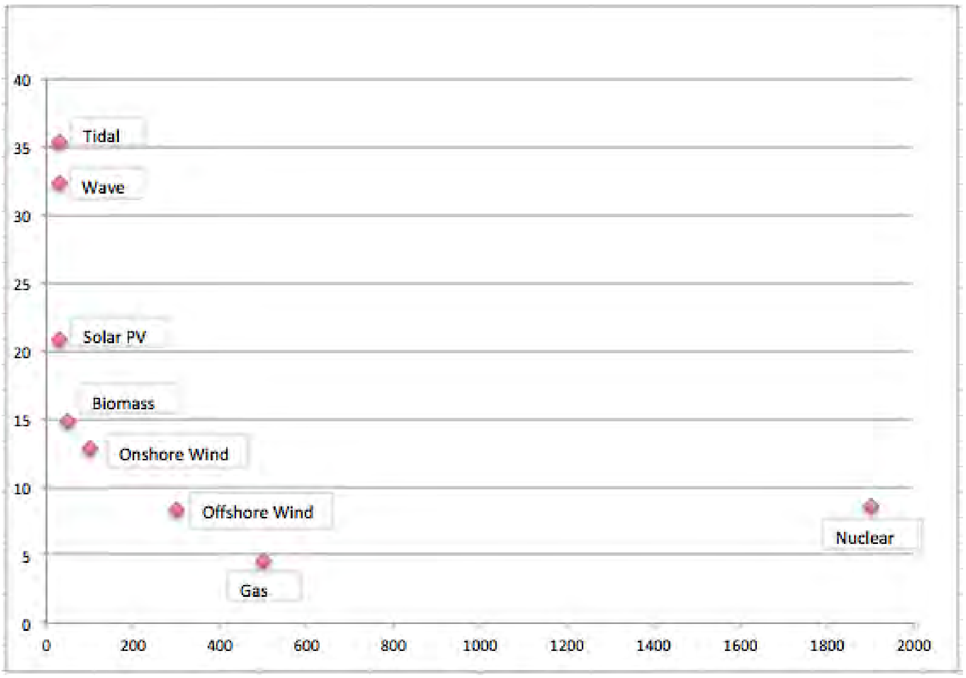
[ǀ NJ∃ Ŝ centralised power is easiest, but Ɣ ǀ è ɣ ƻ ű ō Ŝ Ψ ō Ŝ ă ű Ω

As Figure 7.1 shows, there is a trade off between large-site, centralised and often more established technologies; and novel (renewable) and more diffuse technologies in terms of employment generated per MW installed. With some caveats, the latter have higher employment impacts per MW but with these likely to be spread across a number of sites as technologies move to scale.

Clearly, from a pure regional-employment perspective large centralised development has a number of planning, electrical-technical and potentially public acceptance benefits. Nuclear, in particular will have significant and visible employment effects at a site already prepared, and where public and political opinion is arguably benign (certainly relative to electricity developments elsewhere in Wales).

Clearly, however, such development has indirect costs. There is virtually no opportunity for Welsh- (indeed perhaps UK) based companies to engage in technological development, or to constitute a ō Ŝ ǀ Ŏ Ķ Ķ Ŝ ǀ Ř ΨŘ NJ ƻ ǿ ƛ ɚ dz Ŏ ƭ Ŝ NJ ƻ dz ɣ Ɣ ǀ è Ŏ NJ ƻ ǿ Ř ƻ dz ű ƻ ű Ķ Ŝ NJ ű Ŝ Ŏ Ķ Welsh level). Additionally the very ease of such big developments close to existing large transformers may arguably slow the development of more diffuse technologies, and the grid to support them. This may, in time be seen as a lost opportunity.

Figure 7.1 Jobs per MW (development) and Likely Facility Size (horizontal axis; MW)



There is a tension between economic impact and viable power generation

Examination of Section 5 shows that the best performers in terms of regional employment generation are the novel technologies of wave and tidal stream. Even though we have moderated the cost assumptions associated with these technologies consistent with a 30MW array in each case, they are still by far the most expensive to install per MW ςdouble the cost of any other reported technology.

It is this cost which to a large degree drives regional economic impact in both development and operational phases. Novel technologies will not be viable (in the absence of technology specific subsidy) unless they can be made whole-cost competitive with competing generation technologies, whether fossil or nuclear. As cost per kWh diminishes, so will regional economic impact. Given the ʆ ŀ ű dzNJŜ ƹ Ŧ ădzLJLJƹNJű ƛ ʆ Ǝ ŀ Ŏ ű ƛ Ø ƛ ű ƛ Ŝ ă Ʃ Ř Ŝ Ø Ŝ ƒ ƹ LJŜNJă ŀ ʆ Ř between generating types, one might expect regional economic impact to be reasonably convergent between technologies over time, and with the overall trend of impact (per MW) downward as cost savings are made, and the balance shifts from installation to maintenance.

Ownership matters more than technology

Following the above, it is probably the case that technology type is far from the biggest driver of regional economic impact. What is notable is that regional impacts largely come as returns to labour (directly or in subcontractors) rather than returns to capital employed or land/sea owned. There are of course exceptions ςMabey Bridge for example, or the monies paid to Natural Resources Wales for onshore wind leases. Leases for offshore wind are paid to the Crown Estates Trust with hence no *direct* benefit to the devolved region, and the same is true of ongoing payments for grid connections.

For very capital intense developments, and particularly where fuel is not a large relevant cost, returns to capital are likely to significantly outweigh returns to labour. We are not privy of course to the extent of these returns. To provide an example of this, we can take the Gwynt-y-Mor offshore wind farm as an example: this large development, developing from Figure 5.4, might provide the equivalent of 800 FTEs per annum across Wales in the first ten years of operation (and with construction and employment rolled in to this). During this time, even at current wholesale electricity prices, the farm might generate £1bn of sales - £1.25m for every job it generates here.

Another example relates to the small community-owned wind farm on Gigha in Scotland. Taking advantage of electricity subsidy from sales brings that community the equivalent of £100,000 per MW installed annually. In Wales, the best expectation for onshore wind is for around £5,000 per MW installed in Community Benefit payments annually.

Employment impacts: welcome but modest

Clearly, here the majority of the economic benefit (rather than economic impact) of electricity generation is, in the UK at least, in the form of privatised returns to capital with this then serving to repay initial investments and generate profits for generating companies. Under this paradigm, economic and employment benefits from electricity generation are likely to be modest but welcome. For example, the roll out of a significant 1GW of power generation might generate annual employment in the order of 0.05% - 0.15% of Welsh total annual employment, dependent on technology and supply chain take up.

Given the lack of other economic benefits evidenced so far from large electricity investments in Wales, across fossil and renewable technologies, it is very unlikely that development of this sector will be in any way transformational for the Welsh economy without a parallel transformation in underlying economic and proprietary relationships.

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Appendix A: Consultation topic guides- Industry

1. Work Phase 5ȥIndustry

Introduction

1.1 The purpose of Work Phase 5 is to supplement our knowledge gathered in the previous phases, but with a focus on:

1) Those technologies for which insufficient information was gathered through the WP4 survey of developers and operators;

2) The established technologies where we have difficulty determining future economic impacts based on existing capacity (nuclear,);

3) The nascent technologies for which future development profiles are uncertain (tidal, wave, solar photovoltaic) or smaller scale commercialised technologies (eg landfill and sewage gas).

1.2 The focus of the consultations will be upon the development and operational implications of these technologies. As such, the consultations will be undertaken with a mix of industry bodies, developers and operators, new technology developers and researchers, and potentially sector and specific technology experts in universities.

1.3 We do not propose to cover wave and tidal technologies as these will be covered by the Welsh Government commissioned marine energy economic Study.

Topics

1.4 A single topic list is set out below which is aimed primarily at consultees in category (3) above. For categories (1) and (2), the WP4 questionnaire should be used to guide the consultations.

Background

What is the nature of your involvement in the research, development and operation of energy generation within Wales? Distinguish between different generating technologies, if relevant.

What are your priorities for R&D and the development and operation of generating capacity over the next three years? If relevant, distinguish between Wales and elsewhere.

If appropriate, what is the estimated capital investment that your company has made in the research, development and operation of energy generation in Wales over the last and next three years?

On the basis of these initial questions, clearly establish with the consultee which e generating technologies the discussion will focus on.

Available Energy Resources

For the technologies with which you are most familiar, what do you think is the scale of the resource which could be commercially exploited within Wales?

To what extent is there a need for Government assistance to facilitate the exploitation of these resources? What do you think is the most appropriate forms and scales of support necessary?

Stages of Development

Focus on the emerging generating technologies with which the consultee has a g knowledge.

At what stage of development is the energy technology in terms of its exploitation in Wales. Please distinguish between the following stages and the extent to which these are occurring within or outwith Wales:

ü Research and development

ü Pre-commercialisation testing and piloting

ü Early commercialisation and roll-out

ü Full market exploitation.

Who are the main organisations involved in R&D, development of new capacity and operation within Wales?

What factors are likely to encourage or discourage the pace of pre-commercial development of these technologies in Wales? These factors could include: R&D facilities, expertise and financial support; access to early stage and corporate finance; land use planning regimes; access to suitable suppliers and skill sets; access to grid infrastructure; etc.

What factors are likely to encourage or discourage the roll-out of significant capacity for these technologies in Wales? These factors could include: R&D facilities, expertise and financial support; access to early stage and corporate finance; land use planning regimes; access to suitable suppliers and skill sets; access to grid infrastructure; etc.

Research and Development

Focus on potential new generating technologies in the R&D stage. Cover all technolo with which the consultee has a good knowledge.

What is the focus of R&D activity, in terms of different generating approaches, the specific technologies being utilised and the developers/champions of the technology? To what extent is this activity occurring within, facilitated by or supported through organisations based in Wales?

What is the likelihood of these technologies being commercialised in due course within Wales? What are the strengths and weaknesses of these different technologies in terms of their potential for successful commercialisation?

Given the nature of the supply side in Wales and supply chains, to what extent could suppliers within Wales capture the opportunities around the future commercialisation of these technologies?

Development and Construction

For existing generating facilities which have been developed on a commercial basis in Wales. If no commercial facilities are currently in existence in Wales, there may be scope to expl Ŏ Ƃ ƴ ă dz ƒ ű Ŝ Ŝ ă Ω Ŝ Ȅ LJŜNJ ƛ Ŝ ƴ Ŏ Ŝ Ŧ NJ Ƃ Ƴ Ŝ ƒ ă Ŝ ǿ K ŜNJŜ Ȼ

Cover all technologies for which the consultee has a good knowledge.

What is the typical size (MWs) of new generating facilities?

What are the factors which determine the scale of development (availability and access to energy resource, the nature of generating capacity, land use and environmental planning issues, energy economies, etc)?

What is the indicative total cost of the (notional) facility (including all relevant development, construction and commissioning costs)? *Please consider these co on a per MW basis if this is easier.*

What is the typical construction duration for a facility of this size?

What is the typical direct construction workforce for a facility of this size? Can you indicate how this varies through the construction phase?

What are the main development and construction cost components and broadly what proportion of total costs do these represent?

To what extent are you able to source the range of goods and services, at the right cost and quality, used in the development and construction of this generating capacity from suppliers based in Wales? Are there any particular suppliers based in Wales which are worthy of note?

Can you give examples of goods and services that had to be sourced outside Wales because of cost or quality?

Are there are particular opportunities to grow the supply chain within Wales? Are there any particular factors which constrain these opportunities within Wales?

Operation and Maintenance

For existing generating facilities operating on a commercial basis in Wales. If no commercia Ŧ Ɩ Ŏ ƛ ƒ ƛ ű ƛ Ŝ ă Ɩ NJ Ŝ Ŏ dzNJNJ Ŝ ƴ ű ƒ ѐ ƛ ƴ Ŝ Ȅ ƛ ă ű Ŝ ƴ Ŏ Ŝ experiences from elsewhere.

Cover all technologies for which the consultee has a good knowledge

What is the indicative direct FTE employment level and cost per MW? Are these jobs located at or near the generating facilities? What is the typical occupations and skill level (i.e. NVQ equivalent level)?

What is the indicative value of bought in goods and services associated with the operation of the generating facilities? If possible, provide on a cost per MW basis? What are the main expenditure groups?

To what extent are you able to source the range of goods and services, at the right cost and quality, used in the operation of the generating facilities from suppliers based in Wales? Are there any particular suppliers based in Wales which are worthy of note?

Are there are particular opportunities to grow the supply chain within Wales? Are there any particular factors which constrain these opportunities within Wales?

Thank the consultee for their time and cooperation.

Appendix B Skills consultation topic guide

1. Work Phase 7 – Skills

Introduction

Work Phase 7 is a high level assessment of the skills issues facing a number of generating technologies in Wales. As such it will examine the demand and supply of relevant skills within Wales, key gaps and the adequacy of learning and skills provision. Reflecting the potential for supply side constraints to be in part skills related, the analysis will also consider the extent to which a lack of key skills might restrict supply chains within Wales.

Topic Guide

Ask the following set of questions for the generating technology with which the cons well acquainted.

If the consultee has responsibilities relating to the energy sector in Wales as a whole policy or strategy leads in Welsh Government) rather than any one specific technolo questioning will need to be tailored to reflect this.

Background

Could you please outline the roles of your organisation in energy policy, the development and operation of particular types of generating capacity, or other aspects of the energy sector?

Specifically, what role does your organisation have in analysing, planning and delivering the skill needs of energy generating technologies?

What are your specific roles and responsibilities?

[in light of these responses, tailor the questions below to the specific generating technolog with which the consultee is most familiar (probably just one technology in most instances) o seek an overview of the energy generating sector as a whole]

Skill Needs of Generating Technologies

What aspects of the R&D, development, and operation and maintenance activity for this generating technology (and the associated supply chain) typically occurs in Wales?

Are there any strategic assessments of the skill needs of the generating technology in Wales (or elsewhere in the UK)? [*if there is, ask for a copy or a link to the resea*

How does the industry within Wales plan and communicate its skills needs?

[Note: the information requested in the next question may be difficult to capture th these consultations but may be available from existing published sources. Only ask the

Given the presence of these activities in Wales, what is the typical occupational mix and qualification levels required in the various lifecycle stages?

Pre-commercialisation R&D activity

Planning and development

Manufacture, assembly, construction and the associated supply chains

Operation and maintenance and associated supply chain.

If relevant, how does this requirement vary according to the scale and specific technology utilised in the facility (eg the type of turbine technology)?

Meeting Current Skill Needs in Wales

To what extent are the skills needed in R&D, construction or O&M for the generating technology available within Wales (in terms of both the quantity and quality of supply) K I ƍ ǿ Ř ƍ Ŝ ă ű K ƛ ă Ǿ ŀ NJ è ō Ŝ ű ǿ Ŝ Ŝ ƴ ² ŀ areas?

Are there are any significant skill shortages or gaps currently in Wales, either related to R&D, construction or O&M? If yes, what are these and what are the main reasons for these?

Do developers and operators experience any particular skills issues in specific locations within Wales at which they operate?

Are there are any significant skill shortages or gaps within the supply chains serving the development and operation of the generating technology? If yes, what are these and what are the main reasons? Do these skill issues limit the extent of the supply chain within Wales?

To what extent is there training provision tailored to or of relevance to the needs of R&D, construction or O&M for this generating technology in Wales? Explore types and levels of courses, locations, indicative volumes, funding, types of participants, etc.

Have there been any particular initiatives, led by government, industry or other stakeholders, to address these skill issues? How successful have these been to date and what evidence is there to demonstrate this?

Are there any local initiatives focused on the recruitment and training of residents from communities in close proximity to the generating facilities? If yes, what has been the nature of these and how successful have they been?

Skill Needs over the Next Decade

How do you expect the capacity in Wales to change for the technology over the next decade? What are the key factors which will promote or constrain this?

Is there any additional **R&D capacity and skills** which will be required to facilitate this growth? How are these additional skill requirements likely to be met? Do you anticipate key skill shortages or gaps across Wales or in specific geographical locations? What are these and how can these issues be overcome?

What is the indicative scale of employment, occupational mix and skill levels that will be required to successfully meet the **planning, manufacture and construction** of this additional capacity? How are these additional employment and skill requirements likely to be met? Do you anticipate key skill shortages or gaps across Wales or in specific geographical locations? What are these and how can these issues be overcome?

What is the indicative scale of employment, occupational mix and skill levels that will be required to successfully meet **on-going operation and maintenance** of this additional capacity? How are these additional employment and skill requirements likely to be met? Do you anticipate key skill shortages or gaps across Wales or in specific geographical locations? What are these and how can these issues be overcome?

To what extent can current training provision and related training infrastructure meet the future skills needs of this additional generating technology? (in terms of facilities, scale, location, content, level and type of learning provision)

If this provision and the related infrastructure needs to be enhanced to better meet future skill needs in Wales, what actions are required to achieve this? Consider the planning and communication of skill requirements, the promotion of job and training opportunities, the stimulation of demand, the funding and delivery of training courses or related infrastructure, etc. What is the role of industry, government and other stakeholders?

Appendix C Selected organisations contacted in connection with this research

Bangor University
Biffa
Centre for Alternative Technology
Cogent Sector Skills
Coleg Menai
Dwr Cymru Welsh Water
Dulas Wind
EDF Energy
Energy and Utility Sector Skills
Horizon Nuclear Power
Kelda Services
Low Carbon Research Institute (Cardiff University)
National Nuclear Skills Academy
Pembrokeshire College
Renewable UK Cymru
RWE n power (Pembroke Dock)
South West Wales Procurement Hub
Scottish and Southern Energy
Summit Skills
Swansea University
Welsh Centre for Excellence Anaerobic Digestion, University of Glamorgan
Welsh Government (Waste and Resource Efficiency Division)

Appendix D: Welsh Input-Output Tables in Outline

(http://business.cf.ac.uk/sites/default/files/IO_2007_Final_30_6.pdf)

The analysis of indirect and induced effects in this report has made use of economic data contained within the Welsh Input-Output Tables. The Welsh Input-output project as a whole has been in progress since 1993. Tables have been published for each of the years 1994 to 1996, and for 2000, 2003 and 2007. The 2003 Tables were supported by the Welsh Development Agency and Cardiff Business School, and their development and construction undertaken by members of the Welsh Economy Research Unit at Cardiff Business School. The construction of the 2007 tables was supported by Environment Agency Wales.

The Welsh Input-Output tables reveal the different industries that make up the Welsh economy, and show how they fit together in terms of their sales and purchasing patterns. Each industry in Wales relies to a greater or lesser extent on local, regional, national and then international markets. Each industry also uses labour inputs, and imports goods and services. The Input-Output tables then allow comparisons between industries in terms of their pattern of resource use, and the sectoral and geographical destinations of their outputs, including the level of export activity.

The Tables can be used to identify sectors which are important to the local economy by virtue of their spending, employment, exports, or local linkages and consequent economic activity supported directly and indirectly in the Welsh economy. Then the Input-Output framework should also be seen as a detailed statement of account, with tables allowing reconciliation of the supply of, and demand for, goods and services in Wales.

In this report the framework of the Input-Output tables were used, for example, to generate multiplier impacts for construction activity linked to power station development. For example, an increase in demand for the goods produced by the construction sector in Wales, would lead to an increase in the spending of the construction sector (direct effect). However, as the industry increases its spending, their suppliers in Wales will also have an increase in demands for their goods, and then also the suppliers to the suppliers experience extra demands, and so on (indirect effects). The shock of the increase in final demand ripples through the Welsh supply chain. Moreover, as a result of these supply chain effects, the level of income in the economy will increase, and a portion of this income will be spent on Welsh goods and services leading to further increases demand. This is termed an induced income effect. The ratio of the direct, indirect and induced income effect to the direct effect is termed a multiplier. Multipliers can also be derived with regards to employment effects. Our employment effects estimates in this report derive from the 2007 Input-Output tables; while these tables are now dated the multiplier values for large sectors of the Welsh economy do not tend to change markedly over these time periods.

Appendix E Indicative Sources

Sector	Examples of sources
Solar PV	Industry consultation. Sector review in section 2 of report. Feasibility studies
Tidal	For sources see Regeneris and Cardiff University (2013b)
Wave	For sources see Regeneris and Cardiff University (2013b)
Nuclear	Input-Output Tables for Wales; Industry consultation. Hinkley Point C Development Consent Order Application, Economic Strategy (October 2011); Hinkley Point C Futures, Education, Skills and Jobs; http://www.edfenergy.com/about-us/energy-generation/new-nuclear/hinkley-point-c/documents/Nuclear_Baseline_Hinkley_Point_C_(Part_A).pdf Benefits from Infrastructure Investment: A case study in Nuclear energy An IPPR Trading Ltd report for EDF energy (June 2012) Glasson J (2005) Better monitoring for better impact management: the local socio-economic impacts of constructing Sizewell B nuclear power station in Impact Assessment and Project Appraisal Volume 23, Issue 3, 2005 http://www.tandfonline.com/doi/pdf/10.3152/147154605781765535
AD	http://www.thebioenergysite.com/articles/1143/ad-infrastructure-in-the-uk A Review of Anaerobic Digestion Plants on UK Farms - Barriers, Benefits and Case Studies http://www.rase.org.uk/what-we-do/core-purpose-agricultural-work/ad-full-report.pdf http://www.aberdeenshire.gov.uk/support/agriculture/jim_booth_study_report.pdf
Gas CCGT	Input-Output Tables for Wales; Industry consultation. Baglan Bay Power Station,http://site.ge-energy.com/about/press/en/articles/baglan_bay_article.pdf http://www.edfenergy.com/about-us/energy-generation/thermal-power-generation/west-burton-combined-cycle-gas-turbine.shtml UK Engineering Construction Industry Sector Profiles 2013 http://www.ecitb.org.uk/custom/ecitb/docManager/documents/Industry%20Sector%20Profiles%20Issue%204%20(2013).pdf Drakelow Combine Cycle Gas Turbine Power Station Extension, Derbyshire. Environmental Statement April 2009 E.On Engineering http://www.eon-uk.com/downloads/Drakelow_CCGT_Extension_Environmental_Statement_April_2009.pdf
Biomass	Map of Waste plants (various planning stages) http://www.wtert.co.uk/content/documents/UK_Map2.pdf http://pressreleases.eon-uk.com/blogs/eonukpressreleases/archive/2011/11/14/1759.aspx E.ON announces construction plans for biomass energy plant in Sheffield (E.ON UK Press Releases, 14 November 2011) Newport Docks Bulk Drying, Pelleting and Combined Heat and Power Facility (non-technical summary) http://www.newport.gov.uk/stellent/groups/public/documents/planningdocument/cont550693.pdf http://www.bbc.co.uk/news/uk-wales-north-west-wales-15179120 Proposed New Renewable Energy Plant at Blackburn Meadows Sheffield http://www.eon-uk.com/4_EON_BBM_Renewable_Energy_Plant_ES_Appendix_A_-_Scoping_Statement.pdf
Onshore/Off-shore wind Wind	Economic Opportunities for Wales from Onshore Wind Development Renewables UK, Previous analyses of economic impacts of offshore arrays, and prior economic analysis of supply side for offshore wind.
Coal	Input-Output Tables for Wales

Appendix F: Review of employment effects associated with different energy technologies.

F.1 Introduction

This Appendix examines existing evidence of the employment effects connected with the construction and operation of power stations using different technologies. There are some nascent technologies where limited review material was available on employment effects. The expected potential connected with nascent technologies was examined through a series of consultations which fed into the analysis in Section 5 of this report. We examine each energy generation technology in turn.

F.2 Coal Fired Generation

The World Resources Institute identified 1,200 coal plants across 59 countries in planning (with 75% of these in China and India). Commercial literature on coal generation shows a preoccupation with Ψ ăNJ ĞŎ ĩ Ŝ ű ƛ ƴ Ǝ Ω Ŏ ƶ ƴ ă ű NJdzŎ ű ƛ ƶ ƴ Ŏ ƶ ă ű ă -capture technology ƚ ŀ Ŏ ĩ ƶ Ŧ (Synapse Energy Technology, 2008).[21]

It was not possible to identify significant literature on coal power generation employment effects in the UK (although some information is available for Wales on employment effects connected with older coal fired assets ͼsee Section 4). Little new coal fired capacity is coming on line presently, with the growth of gas fired capacity uppermost. In terms of build and the structure of construction activity/requirements there is some expectation that employment effects might be similar to gas (see below). Analysis for Wales of existing coal fired capacity would suggest around 0.2 direct jobs (FTE) per MW of installed capacity (see Section 4 Table 4.5).

A review of recent projects in the US (see for example, Leatherman and Goldman, 2012) reveals typical plant construction taking up to four years and capital costs of around $2bn per GW of installed capacity. For example, Leatherman and Goldman (2010) cite construction of a 0.9GW facility in Kansas expected to employ a construction workforce of 1,900 at peak (around 6,000 person job years, compared to around 90 permanent jobs when a plant becomes operational). During each year of operation, the facility was expected to generate nearly $350 million in overall economic activity, more than 260 permanent jobs throughout Kansas and pay $17 million in labour income, and almost $200 million in total income. Combined annual state and local tax revenue was estimated to grow by over $41 million. The analysis suggested an employment multiplier (reflecting indirect and induced effects) of around 3.4. Put another way an estimated 0.1 direct jobs per MW of installed capacity.

[21] http://schlissel-technical.com/docs/reports_35.pdf

F.3 Gas Power Generation (Combined Cycle Gas Turbine Technology)

Compared to coal there have been a much larger number of recent planning applications and permissions for CCGT power stations, sometimes built adjacent to existing coal-fired sites in decommissioning phases. Clearly the activity supported in the construction phase might be lessened where facilities are placed close to existing power generation infrastructure and grid connections.

Once again there is limited information that actually tracks development and construction employment through time. Moreover, our review shows that quoted evidence of employment effects through construction tend to round up to the nearest thousand at peak activity and with very few analyses citing equivalent job years through stages of the development process. This is a real problem because site employment can vary daily by many hundreds. Our conclusion is that construction impacts are commonly overstated ex ante, and with very little research undertaken ex post to verify claims and estimate equivalent job years. We highlight two cases from outside of Wales, and then evidence from recent Welsh developments.

The West Burton CCGT 1.3GW[22] plant is situated on the west bank of the River Trent near an established power complex. The power station was commissioned in 2011, with an expected life of 25-30 years. Total capital investment is an estimated £450m. The construction phase is stated to have employed an average 1,000 people, but with operational employment expected of around 40-50 skilled operators, and operational and maintenance costs of approximately £15m annually.

In terms of an ongoing development Drakelow E CCGT Derbyshire[23] is a proposed extension of a facility expected to begin operation during 2013. The proposed development consists of three gas-fired CCGT generating units each of around 440MW (electrical) output and comprising a gas turbine (GT), a generator, a heat recovery steam generator (HRSG) and a steam turbine, plus associated auxiliary plant. On-site construction activities will include the creation of working areas, foundation piling for main unit plus further foundations for buildings, services, and roads, structural steel frameworks, mechanical plant. Cranes and mobile plant will be used for on-site assembly of tanks, pipe work and storage vessels. Also required will be the installation of electrical cables, equipment, and control and instrumentation systems. During the peak of construction activities it is forecast that around 800 construction workers will be required at the site. Construction including the commissioning period will take place over approximately 3 years.

There has been a swathe of Welsh developments in terms of new gas capacity. Planning permission for Baglan Bay Power Station[24] was granted to the US firm General Electric in 1999, and with the construction phase beginning in October 2000 and being completed in September 2003 at a capital

[22] See http://www.edfenergy.com/about-us/energy-generation/thermal-power-generation/west-burton-combined-cycle-gas-turbine.shtml
http://www.kier.co.uk/construction/projects_details.asp?p=598&co=92&x=1

[23] http://www.eon-uk.com/downloads/Drakelow_CCGT_Environmental_Statement.pdf
[24] http://www.power-technology.com/projects/baglan/

cost of £300m. The 525MW output gas turbine was manufactured in the USA and shipped to Baglan Bay in December 2000. The Baglan project was welcomed by the local authorities for the amount of regeneration and employment it brought to the area. While around 1,000 workers were cited as being employed during the construction phase, it was estimated that over 600 mechanical and electrical construction jobs were filled by local workers, with around 40 people when fully operational.[25]

Construction on the DONG 0.85GW Severn Power plant at Newport[26] began in March 2008 with an expected 30 month construction period and 4 month commissioning phase. At September 2009 there were estimated to be 500 people employed on the site. There was some concern raised locally with regard to the high proportions of workers from outside of the UK working on the development. At September 2009 it was estimated that 50% of those employed in the construction process were either British or Irish. By December 2009 it was believed that construction employment peaked on the site at around 1,200 people. The project was completed in November 2010. Operational employment is around 40 people, with many of these being employees of Siemens who have the contract to maintain the turbines. The DONG case illustrates a generic issue surrounding large capital projects in Wales. Fundamentally as soon as developers begin to talk in terms of thousands of jobs being supported in construction, it is necessary to question which households finally benefit. Commonly used construction multipliers within basic regional economic models may not adequately account for the high import propensity on labour inputs into the construction process of major plant.

The most recent gas fired power station opening is the £1bn 2.2GW Pembroke Dock facility of RWE npower. The construction process was estimated to employ around 2,000 at peak (much of this being employment managed by Alstom, the builder of the station). This contrasts with an estimated 100 people on the ground during normal operations. However, added to this would be employment supported during routine maintenance. It was estimated that an 8 week outage on a turbine could see 100-200 people on-site. RWE npower sought to engage as many local firms and subcontractors as possible during operations largely because of the advantages of having people close to site in case of problems. While the main maintenance contract is let to Alstom, RWE estimates around £10m in operational spending per annum and with a maintenance budget of around £10m. Both these items exclude gas purchases with power stations typically operating as cost centres.

The pattern in CCGT through operational phases is an on-site team responsible for routine maintenance, with contractors brought in for specialist services, major plant inspections and overhauls. Direct employment supported by CCGT is then quite small during normal operations. For example, six Centrica UK gas fired stations ranging in capacity from 230MW to 895MW employ between 31 and 42 people in each case.[27] Very often the maintenance

[25] http://article.wn.com/view/2010/04/06/Baglan_power_station_may_bring_1000_construction_jobs/

[26] http://www.power-technology.com/projects/uskmouth/
[27] http://www.centrica.com/index.asp?pageid=924

contract on recent new build stays with the turbine manufacturer, whereas older stations will more widely tender the turbine maintenance after a set period. Portfolio engineering teams manage major overhauls and review technical issues.

F.4 Nuclear Power Generation

Nuclear generation more than any other technology seems to be connected to some of the most optimistic estimates on employment supported through the development phase. Once again our review reveals rough estimates of peak manpower, partly informing accommodation strategies and various investments in accommodation compounds and associated planning applications. There tends to be less consideration of equivalent job years, and with much of the economic analysis undertaken *ex ante* and with limited *ex post* evaluation of the employment out-turn. Moreover, the direct employment connected to future nuclear generation is of particular interest in the Welsh case as, in terms of direct employment in Welsh power generation, further development of Wylfa will mean that nuclear takes up a larger proportion of Welsh direct employment in power generation following the expected run down of coal fired capacity.

We select a series of cases to provide background for employment analysis by providing estimates of:

- direct employment requirements by skill type and typical local labour market capacities for such skills,
- employment multipliers for an existing UK nuclear power station, and
- a realistic cost-base for a contemporary development,
- some prior estimates of economic effects connected to operation of nuclear facilities
- a summary of expectations surrounding development of Wylfa B.

Glasson and Chadwick (1995) examined the local (county level) socio-economic effects associated with Sizewell B between 1988 to 1995. Interestingly, this work focussed on the construction phase, comparing the local predicted socio-economic effects of Sizewell B construction presented at the public inquiry with out-turns. It reported the direct employment supported in construction and whether this was local or non-local, during mid-years of the development programme. They estimate that the total workforce rose from 883 (64% assessed as local people) in Year 1 to 4,638 (45% local) by year 5. The falling local share connected to a shift to more skilled professional and mechanical /electrical engineering jobs and away from civil engineering, as the construction progressed. The skills breakdown (at end 1991) showed that 49% of total workforce was local, with some variation in terms of type of contractor. 61% of civil engineering activities were sourced locally compared to 38% of mechanical and electrical activities, and 33% of project management. Meanwhile, 96% of site services and security was sourced locally. Maintaining relatively high levels of local recruitment was underpinned by employment and training initiatives. The total cost of the project was over £2 billion. The study picked up some displacement of employees from local firms.

However, while Sizewell B had a large in-migrant workforce of between 2,000 to 3,000 workers over 3 years, they occupied bed and breakfasts, camping sites and in a purpose built hostel on-site.

In an earlier study Glasson et al. (1988) undertook an analysis of employment effects for Hinkley Point (north Somerset).They showed that a 7-8 year construction phase with peak employment on-site at 3,500 in the fourth year. It was estimated that 47-48% of the peak construction employment came from within a commuter distance of 35-40 miles, involving around 1,650 jobs. The capital cost of the power station was then estimated to be £1.15bn (CEGB evidence Sizewell B Public Enquiry[28]). Glasson et al. expected little of this would be spent in the local economy. The study assembled estimates of average salaries and wages for each type of construction operative, and their numbers over the life of the project which yielded an annual wage injection into the local economy ranging from £2.5m at the start to £49m at the peak. Main contracts were let to major specialist national Ŧ ƛ NJ Ƴ ă Σ ǿ ƛ ű K ŧ Ŝ ă ă Ŝ NJ Ŏ ƻ ƴ ű NJ ŀ Ŏ ű ă ŧ Ŝ ű ƻ dz ű ƻ ƴ ű K Ŝ ō ŀ ă ƛ
and contractor market. It was observed that the client CEGB gave consideration to local firms if they were competitive. However, the local industrial base, being relatively poorly developed, was not able to supply the specialist requirements. There was an assumption, therefore, that contractor expenditure on goods and services in the locality was very low at around 1% of construction costs.

Glasson et al. (1988) reported six types of employment effect with a high and low estimate for each as follows:

Table F.1 Estimated Multiplier Values

	Low Estimate	High Estimate
In-migrants (with family) Earnings	1.3	1.51
Unaccompanied In-Ƴ ƛ ∃NJ ŀ ƴ ű ă Ω Ŝ ŀ NJ	1.05	1.11
Non-local/non-ƛ Ƴ Ƴ ƛ ∃NJ ŀ ƴ ű ă Ω Ŝ ŀ NJ	1.02	1.06
Local employees Earnings	1.09	1.19
Power Station expenditure (non-labour)	1.09	1.19
Induced Investment	1.09	1.19

Source: Glasson et al., 1988

The proposed Hinkley Point C development provides some further inference about possible effects surrounding the Horizon investment on Anglesey. Infrastructure Planning Commission (2012) identified a number of likely on-site developments which are useful to repeat here in identifying potential types of expenditure (local and non-local) which might be connected to future nuclear development. These include offices, workshops, storage buildings and transport infrastructure and car parks; a sea wall along the frontage of the site for coastal protection; interim spent fuel storage facilities; interim radioactive waste storage facilities; cooling water tunnels (two intakes and one outfall) and associated infrastructure; a temporary aggregates jetty for bulk aggregate delivery; temporary accommodation for construction workers; spoil disposal/landscape integration; and

[28] CEGB (1982) *Sizewell 'B' Power Station Public Inquiry: CEGB Proof of Evidence* cited in Glasson et al 1988.

transmission infrastructure from the generating station to a proposed National Grid sub-station. Among the off-site developments was a bypass around the village of Cannington; accommodation facilities for construction workers (campuses); park and ride facilities; freight consolidation/storage facilities; refurbishment of Combwich Wharf and a heavy loads berthing facility; temporary lay down and storage facilities on land adjacent to Combwich Wharf; road improvements; and spoil disposal/landscape integration.

EDF (2012)[29] estimates that the total workforce for Hinkley Point C would be expected to peak at 5,600 in 2016. The language used in the document reflects its advocacy nature so, for example, it ă ű ŀ ű Ŝ ă T Ψ ƻ Ø Ŝ NJ ű K Ŝ Ŝ ŋ ű ƛ NJ Ŝ Ŏ ƻ ŋ a 25,000 individual posts LJ K ŀ ă Ŝ ƛ ű (person years) ŏ ƛ ſ ſ ō Ŝ i.e. an average of 2,800 over the nine year construction period. At the construction peak it is estimated that 1,400 Somerset residents will be provided with work. The LJNJ ƻ ∃ NJ ŀ Ƴ Ƴ Ŝ ŏ ŀ ă LJNJ Ŝ Ř ƛ Ŏ ű Ŝ Ř ű ƻ ΨLJNJ ƻ Ø ƛ Ř Ŝ мпрƳ LJ Ŝ NJ è Ŝ year of co ŋ ă ű NJdz Ŏ ű ƛ ƻ ŋ ă dz Locally in Somerset. It was also noted that there would be benefits to the tourism sector derived from demand for accommodation during off-peak and shoulder seasons. It is unclear on whether displacement issues were considered.

Given levels of overall construction spend are one driver of local benefits there has long been concern about under-estimates in nuclear build. Most recently Harris *et al* (2012) reported cost estimates for nuclear power in the UK and concluded that the UK Government tends to use too low estimates of cost escalation based on international cases from France and the USA. Two new reactors at the Hinkley C site, on this basis would cost around £4,885/kW rather than the current estimate of £3,742/kW. The paper considered a 6 year construction phase estimate as being 2 years shorter than the current global average (with the longer time being linked to new reactor technologies and regulatory requirements). 8 years is considered a more realistic baseline.

Set beside significant employment effects in construction, nuclear generation also supports significant employment during normal operations. For example estimates from DECC (cited in EDF Energy, 2012) on the overall employment in the nuclear sector in the ¦ Ƴ ă K ƻ ŏ ă ά ΦΦΦ ű K ŀ ű 44,000 people currently employed in the British nuclear industry. This includes 24,000 who are employed directly (with 12,000 in decommissioning, 7,500 in electricity generation and 4,500 in fuel processing) and 20,000 with con ű NJ ŀ Ŏ ű Ŝ Ř ƛ ŋ Ř ƛ NJ Ŝ Ŏ ű Ƨ ƻ ō. ă ƛ ŋ ű K Ŝ ŏ ƛ Ř Ŝ NJ

The relatively strong employment effects connected with nuclear generation are well known. For Ŝ Ѐ ŀ ƳLJ ſ Ŝ Σ [Ŝ ŏ ƛ ă όмфус ύ Ŝ Ѐ ŀ Ƴ ƛ ŋ Ŝ Ř ű K Ŝ Ŝ ƳLJ ſ ƻ è Ƴ Ŝ ŋ ű Ŝ operation in order to predict the impact of closure and decommissioning. Material supply to the site was seen as predominantly originating from outside the region, so impacts focussed on employee wage spending in the locality (induced impacts). Salaries paid to station staff (£7m in 1984) and CEGB purchases of goods and services (locally very small and amounting to £50,000 in 1984) were analysed with the marginal propensity to consume locally being calculated from a worker

[29] See also Hinkley Point C Development Consent Order Application, Economic Strategy (October 2011).

questionnaire. A multiplier (of 1.5 which was seen as relatively high due to the remote physical and cultural nature of area where most day-to-day requirements are met by the locality) was then used to estimate the total injection to the local economy. This was calculated as £7.25m per annum in 1984. Lewis (1986) estimated that direct employment at the site of 522 supported around a further 400 jobs locally.

EDF Energy (2011) reported economic effects associated with the operation of its 1.2GW nuclear power station at Torness in Scotland. This study used an input-output model framework, with data based on official and plant data to calculate the indirect and induced output and employment. Estimates on the socio-economic impact were that: the site contributes £56 million to GDP (made up of £35 million direct, £18 million indirect, and £3 million induced). The site contributed nearly £33 million in income into the local economy, representing nearly 4 per cent of all economic output in the East Lothian region. Within this framework direct employment of 545 people, supported another 756 jobs through spending and wage effects (i.e. employment multiplier taking account of indirect and induced effects of around 2.4).

The report showed that EDF Energy Torness had over 450 suppliers, but the top 20 accounted for nearly 70% of all expenditures in 2008 and 2009. Heavy engineering, construction and manufacturing firms accounted for the bulk of purchases. The supplier expenditure excluded nuclear fuel costs and contribution to the nuclear liability fund (NLF) as these were procured centrally.

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occurred every 18 months. In 2009 around £15m spent on outage-related activities accounting for nearly 27% of total expenditure of goods and services. Overall annual expenditure increased by 55% between non-outage year (2008) and an outage year (2009). Annualising for outage expenditure indicates that total expenditure on goods and services was more or less shared between Scottish and the rest of the UK-based suppliers. In non-outage year (2008), suppliers in Scotland accounted for 77% of total expenditure on goods and services. This dropped to 32% in an outage year (2009) as suppliers in the rest of the UK accounted for 68% of total expenditure.

EDF Energy (2012) also published estimates of the economic impact of an investment of £10bn over the life cycle of the Hinkley Point C site. Here it was estimated that £40million annually would be added to the local economy during the sixty years that the plant would be operational.

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operational jobs, which would persist for at least 60 years (700 full-time directly employed staff and 200 contract staff) with a temporary workforce of 1,000 during the periodic one month outage
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ű KNJƾdz∃K űKŜ dzăŜ ƾŦ ŧƾŎŀŧ ădzLJLJŧƛŜNJ ŦƛNJƳă ŀƴŘ ŧƾŎ

F.4.1 Wylfa/Horizon[30]

Wylfa is now owned by Hitachi, having been sold by EON and RWE in 2012 in the wake of the Fukishima accident. Current plans being worked up for Wylfa are for 2-3 Advanced Boiling Water Reactors (ABWRs) ςa new type of reactor for the UK. Current timescales for delivery are currently uncertain ɸprojections suggest that the site would not be operational until the mid-2020s at the earliest. Were Wylfa B to go ahead, it is projected that the site could generate as much as 3.0GW and create a 60 year demand for employees. It is anticipated that development will require a £8bn investment ςalthough no detail is currently available around how this expenditure will break down, and high level estimates suggest that there would be up to 6,000 construction jobs at peak. The development and construction supply chains are likely to be national and international in nature, and the manufacturing of components is likely to take place on an international scale, with a limited role anticipated for north Wales companies. Reflecting the specialist nature of the technologies likely to be involved (a new type of nuclear reactor to the UK) many of the main reactor components are likely to be built outside the UK. Some components could be provided by some of the major UK manufacturers, such as Babcock International and Rolls Royce.

Construction activity is also likely to be national and international in nature. For example it is expected that the owner of the technology (General Electric Hitachi Nuclear) will have its own existing supply chains which it is likely to utilise for the more specialist elements of construction (i.e. relating to the reactors). The large scale of the construction process will mean that construction expertise from large scale national infrastructure projects (e.g. the Olympics and other nuclear projects) is expected to be utilised. Despite this, there is expected to be a role for more local suppliers, particularly around more general civil engineering and construction (earthworks etc).

The current high level estimate suggests that once operational, Wylfa B will directly support around 1,000 jobs. There are no current details on how these will break down, but these are likely to be similar to those currently seen on nuclear sites ςa large number of highly skilled (and specialised) occupations, along with more technical jobs. In terms of operation and maintenance, skills supply is likely to be much more local, than that in the development and construction stages, typically coming from North Wales (Technical Level 2/3 skills), or a wider catchment (typically national) for higher level skills.

F.5 Biomass

Much of the employment analysis of biomass generation considers employment supported through the whole life cycle i.e. jobs supported in growing the biomass, and with research also focusing on issues of dѦ ăLJ f Ꮀ Ŏ Ŝ Y Ŝ ƴ ǔ Ѧ Ɍ Ŝ Ɍ Ѧ ƴŎNJŜ Ꮀ ă Ŝ ă Ѧ ƴ Ŧ ƻ ƻ Ř Ŏ ƻ ă ǔ ă Ꮀ ƴ
fuel. In the specific context of Wales biomass generation at large scale would require significant imports because of the size of the domestic forestry resource. In this review the focus is more on

[30] This section is informed in part by a consultation with the developers. See Appendix D

examples of employment supported in development and operation of biomass facilities of different scales. Here there is some reliance on estimated effects with a series of biomass projects in the planning system. Notwithstanding in the case of biomass direct employment supported on-sites is increased by the materials handling needs in similarity to coal. One of the reasons frequently cited for encouraging deployment of bio-energy systems in general is their job creation effect, particularly in rural areas with high levels of unemployment or depopulation trends.

For example, RES is planning to develop a 100MW renewable energy project fuelled by wood-based biomass, working closely with the Port of Blyth. The North Blyth Biomass Project will use between 500-900,000 tonnes per year of biomass fuel (dependent upon calorific value). The construction period is an estimated 30 months, with the construction workforce expected to peak at approximately 300 people. An operational workforce of about 40 to 50 is anticipated.[31]

There have been several cases where conventional coal-fired stations have been converted to biomass. For example, the RWE npower Tilbury B power station is being converted to run on 100% biomass (wood pellets) fuel largely imported. RWE npower reveal that much of the work revolved around modifications and upgrades to existing plant to accommodate different means of materials handling. Construction comprised work packages including fuel storage and materials handling, flue gas clean up equipment, cooling water systems, station drainage, combustion system modifications, chimney stacks, a new dust separator and dust storage facilities. The main construction works are expected to last 17 months (over 2013-2014). Material will include construction equipment, bulk civil engineering materials including ready mix concrete, consumables, steel and cladding. Specialist construction equipment will include cranes, heavy lift equipment, mobile elevating work platforms, HGVs, excavators, welding machines, and winches. Manpower will include engineering and office staff as well as construction operatives and site services and support workers, excluding existing RWE npower Tilbury B Power Station staff. Around 1,000 workers are expected to be employed at the site at peak, and with the modifications expected to sustain operational employment at previous levels.

Forth Energy plans (still in planning at Spring 2013) a new 100 MW £360m biomass facility at Port of Dundee with an estimated three year build. Construction is estimated to involve 300 jobs on-site, peaking at 500 (converting to 900 person years for the construction period with 10 person years of employment the equivalent of one FTE job which then equates to approximately 90 FTE jobs). Forth Energy assumed a high level of local sourcing (80%) based on the experience and history of heavy engineering and technology, together with the pool of available and experienced construction labour in the area, and with only 10% leakage at the Scotland level; these being specialist construction workers. The consultants estimated further indirect and induced employment of 49 FTE jobs, representing a total estimated net additional local employment equal to 139 FTE jobs, and 156 FTE jobs at a Scotland level. They expected a significant proportion of the value within the

[31] See www.northblythproject.co.uk. North Blythe Project is currently in the final stages of planning see also http://infrastructure.planningportal.gov.uk/projects/north-east/port-blyth-new-biomass-plant/

manufactured items making up the plant would be spent outside Scotland but that a significant element would be sourced locally including the site clearance and preparation, foundations and ground works, utilities and electrical cabling, transport, port activities, security, and craneage elements of the construction process.[32]

Thornley et al. (2008) consider 22 different types of biomass plant, with direct operations staff numbers ranging from 0.4 to 25 FTEs. Direct employment in this study comprises direct plant jobs, FTE agricultural jobs for crop growth and transport jobs supported. This research highlighted how significant the employment impact of bio-energy plants can be with 25MWe plants typically creating jobs of the order of 4000 person years (approximately 75% of which are within the operational and maintenance phase). This would be equivalent to around 160 FTE positions supported over the lifetime of the biomass plant- much larger than the 20 or so people who would be directly employed at the power generation facility.

F.6 On and Offshore Wind Power Generation

The material reviewed on the economic impacts of on and offshore wind reveals that economic effects are multi-faceted and variable. Project level impacts depend on available resources and the ability of local businesses to participate in wind energy projects as well as the preferences of [illegible] ed the numbers employed in the sector [illegible] across Europe, and revealed a clear relationship between installed capacity and number of jobs. However, it concluded that the use of a single job/MW ratio was not feasible, due to differences in export/import capacity when comparing different countries. This study also concluded with respect to operation and maintenance activities that there existed a scarcity of workforce able to undertake specialist roles (project managers, engineers and operations and maintenance technicians), requiring a series of educational, mobility and dissemination measures to be put into practice.

Research reveals that in general for wind generation the bulk of the employment effects are highly concentrated around turbine and component manufacture, rather than in installation, operations and maintenance (see for example Table F.2 below).

There have been a series of academic papers seeking to examine the economic effects of onshore wind in the UK. Given that parallel research by Regeneris and Cardiff University (2013a) has recently reported on the economic effects associated with onshore wind the reader is directed to this study and its findings (see Regeneris and Cardiff University, 2013a). In similarity to many other power generation technologies the UK academic evidence covering the economic effects of onshore wind contrasts the identifiable levels of employment supported during development and planning phases of onshore wind with problems of actually identifying local employment supported during the

[32] http://www.forthenergy.co.uk/pdf/biomass-project-update-dundee/02%20ES%20Volume%202%20-%20Main%20text/Chapter%2016%20-%20Socio-economics%20-%20FORTH%20ENERGY.pdf

operational phase. Indeed, Regeneris and Cardiff University (2013a) in their analysis of onshore wind in Wales, reveal an estimated £1.25m per MW spend (£2012) during construction, development and planning, to around £39,000 per MW of spend during annual operation of which around 25% are employment costs. The study then estimates that between 2005-11 onshore wind in Wales supported an average of 335 FTE jobs per year through construction, development and planning alone (including jobs supported directly, and jobs created through indirect and induced effects). The limited employment opportunities available during the operational phases of on-shore wind have been cited as one of the reasons for the growth in community benefit provisions linked to recent schemes across the UK, and growing debate on the use of rental payments for the publicly owned land on which some larger wind farms reside (see Munday et al., 2011; Joseph Rowntree Foundation, 2012; Callaghan et al., 2013).

Table F.2 Direct and Indirect employment in wind energy in the EU in 2007 by type of company

	Share of direct employment (%)	Direct Employment
Wind turbine (WT) manufacturing	37	40,183
Component manufacture	22	23,892
Wind farm development	16	17,376
Installation, operation and maintenance	11	11,946
IPP/utilities	9	9774
Consultants	3	3258
R&D/universities	1	1086
Financial	0.3	326
Others	0.7	760
Total	100.0	108,600

Source: Bilgili *et al.* 2011

Following from the above an important issue is whether the employment effects connected to offshore wind development might be materially different due to scale and access issues during normal operations and maintenance (see Joseph Rowntree Foundation, 2012), notwithstanding that the high value components connected to offshore wind development are unlikely to be produced in proximity to generation-sites. For example, in contrast to onshore wind developments estimates of the cost of offshore maintenance activities have a large spread and are uncertain. This links to issues around access to high rise turbines, including availability of specific vessels and cranes, limiting operational conditions and the need for suitable weather. Other factors[33] include availability of trained personnel. Key issues seem to include more regular failures of small mechanical and electrical items. In these circumstances facilitating technicians out to sites for frequent minor repairs is a main concern. In this contex ű ƛ ű ƛ ă ō Ŝ ƚ ƛ ŜǾŜ Ř ű K ŀ ű ű K Ŝ Ψ ϩ NJŘ ŜNJΩ
operational and maintenance could be anywhere between £50,000 and £100,000 per turbine, depending on a range of factors including location, machine size and how well the maintenance is

[33] Issues picked up by Colin Morgan, of wind energy consultancy, Garrad-Hasson.

organised. It will typically require at least twice what it costs to keep equivalent onshore plant and machinery working and in good repair.

Table F.3 Average investment costs per MW related to offshore wind farms in Horns Rev and Nysted (Holland)

	Investments 1000 є κ а ²	Share %
Turbines ex works, including transport and erection	815	49
Transformer station and main cable to coast	270	16
Internal grid between turbines	85	5
Foundations	350	21
Design and project management	100	6
Environmental analysis	50	3
Miscellaneous	10	<1
Total	**1680**	**100**

Source: Bilgili *et al* (2011) http://www.sciencedirect.com/science/article/pii/S1364032110003758

Something of the relatively higher employment prospects connected to offshore wind during operations and maintenance was picked up in a report by Oxford Economics (2010), which highlighted the importance of technicians for the operations and maintenance of offshore turbines. It estimated that 40 per cent of all people employed in the operation and maintenance of offshore
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addition to possessing a technical background, technicians must be multi-disciplined and flexible, be
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Economics, 2010, p.19). The report estimated that, assuming 14GW of generating capacity by 2020 in the UK, the offshore wind energy sector would support 4,600 jobs in operation and maintenance with a further 1,100 jobs in the supply chain, and an additional 1,000 jobs from the spending of those employed directly in operations and maintenance.

Cambridge Econometrics (2011) provided an overview of current employment in the renewable energy sector and growth between 2007 and 2010. The report estimated the number of FTEs working directly in UK offshore wind energy sector at approximately 3,100 (planning and development 15%; design and manufacture 7%; construction and installation 41%, and operations and maintenance was estimated to have around 17% of the total) Ф ₵ K ⅄ ă Ψ ō Ⱶ ƭ Ⱶ ʎ Ŏ Ŝ Ω ƻ Ŧ Ŝ
within the sector was said to reflect its current stage of development and the relative position of the UK in the global value chain. The report suggested that this balance may not be a good guide to the future scale and make-up of the sector in the coming decades, in particular with regard to the growth of manufacturing jobs producing components for wind schemes.

Once again a key issue in UK material is that most reports are ex ante and produced in support of planning applications, but with limited ex post analysis of employment claims. Indeed it would seem to be very difficult to track employment associated with the operations and maintenance of onshore and offshore schemes with projects offering strong economies of scale. This noted the material below provides a brief review of the commercial documents relating to a sample of planned/operational UK of Ŧ ă Ʀ ƨ NJ Ŝ ǿ ƛ ƴ Ř ŀ NJNJ ŀ è ă ƛ ƴ ƨ NJ Ř Ŝ NJ ű ƨ ∃ ŀ ƛ ƴ ƛ patterns and employment during the construction phase.

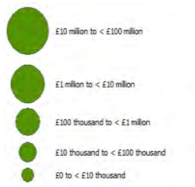
Gwynt y Môr[34] represents an estimated є н ō ƛ investment comprising 160 turbines and is being built by RWE npower Renewables in Liverpool Bay. Expected installed capacity on completion at end 2014 is 576MW. In the environmental impact statement for the project (and based on evidence from previous offshore wind farm construction projects), it was anticipated that 66% of the total Gwynt y Môr contract value could be spent in the UK. 9% of the total contract was expected to be sourced Ψ ƒ ƨ Ŏ ŀ ƒ ƒ è Ω Σ Ŧ NJ ƨ Ƴ ǿ ƛ ű Ʀ ƛ ƴ ű Ʀ Ŝ b ƨ NJ ű Ʀ ² ŀ ƒ Ŝ ă Σ a Ŝ NJ ă Ŝ è ă ƛ to directly support around 1,330 permanent full-time equivalent jobs during the construction phase. Indirect and induced effects were assessed as providing additional employment on top of direct employment, with direct and induced effects supporting 1,180 jobs in the UK, including around 140 in the local regions. It was thought at the planning stage that a total of around 90 full-time permanent workers would be employed locally in the operation and maintenance of the project. This was expected to include maintenance technicians, offshore supervisory/engineering staff, offshore technical staff, shore-based managerial and clerical staff and crew for the maintenance vessels. In addition, further indirect employment was expected to be created during the operational phase so that, in total, it was estimated that around 124 full-time equivalent jobs could be supported in the UK during the operational phase, with a significant number located in regions proximate to the facility.

The Robin Rigg[35] offshore windfarm, constructed on the Solway Firth sandbanks was completed in 2010 by E.ON. It comprises 60 x 3MW Vesta turbines. BVG Associates analysed the economic value of the development. Their report refers to previous work undertaken on Scroby Sands where the UK content was 48%, and quote UK content levels of 10% and 20% for London Array and Thanet Arrays respectively. The Robin Rigg research examined all the contracts awarded, and eschewed the assumption that components and services procured by Tier 1 suppliers were sourced according to the location of the contracting company, but rather identified UK contracting value (if more than 1% of the capital value). The research provides an interesting blue print for subsequent work on value chains. In summary, the total project value was £381m (£2.1m per MW). Of this 37% was turbine manufacture, 36% installation, 22% plant manufacture, and 5% project management (overall typical). 5% of the value went to the North West region, 11% to Scotland, 21% to rest of UK (37% total UK) and with 0.2% going to the immediate locality of Dumfries and Galloway (D&G). Figure 2.1 below shows the distribution of this *headline* 37% of spend. Hence, very little of the business was won by local or regional companies. Local supply was in the form of small value contracts, such as those for land leasing and land agreements fees. After drilling down through the supply chain the final estimate for UK content of the capital expenditure was 32% (4% North West of which 1.4%

[34] http://www.rwe.com/web/cms/mediablob/en/1269360/data/1202906/1/rwe-innogy/sites/wind-offshore/under-construction/gwynt-y-mr/English.pdf
[35] http://www.eon-uk.com/E.ON_Robin_Rigg_UK_content_report_October_2011.pdf

Cumbria), 8% Scotland of which 0.2% Dumfries and Galloway). UK was held to be strong on offshore operations in installation and commissioning (foundations and cables), grid connection and in providing infrastructure for the on-shore base. Turbines were imported. Low value projects were sourced in Cumbria. Port of Mostyn was used as one of the construction ports.

Figure F.1 Location of UK suppliers contracted by E.ON Climate & Renewables according to contract value (Robin Rigg offshore wind farm)



Source: http://www.eon-uk.com/E.ON_Robin_Rigg_UK_content_report_October_2011.pdf

F.6 Hydro Generation

Hydropower in the UK is mainly represented by large-scale storage or dam-based sites, built in the first part of the last century. In the review it was difficult to gain estimates of employment connected to construction of large sites because of the age of many of the assets. Data on operational and maintenance employment costs and levels are also scarce. Moreover, recent hydro developments in Wales tend to be small-scale (less than 5MW) schemes. For Wales the expectation is that most large scale projects will already have been undertaken, and with future scope focused on small scale projects. For example, Moon (2013) shows that in Rhondda Cynon Taff there is potential for around 30 micro-hydro schemes and with estimated capital costs of around £200,000, and with outputs varying from around 40-260kwh.

Some inference on employment impacts connected to modern schemes at scale can be derived from North America where hydro generation is very significant in some states. For example, the U.S. Bureau of Economic Analysis (BEA) has data[36] which was used to estimate the associated indirect and induced multipliers for direct jobs in this energy sector per MW. This literature did not

[36] http://www.hydroworld.com/articles/hr/print/volume-29/issue-7/articles/study-hydropower-potential-could-create-14-million-jobs.html

differentiate between construction and operations and maintenance, and estimated direct jobs ranging from 5 to 6 FTE *per MW*for mature inland hydropower technologies. Newer technologies and smaller systems tend to need more FTEs per MW as one might expect, lessening as they undergo efficiency improvements/cost reductions with maturity and with larger systems having economies of scale.

F.7 Landfill gas & Anaerobic digestion

Landfill sites can release methane as a natural by-product from decomposition of solid waste. Its collection is low-technology consisting of wells which channel the methane to a central point where it is treated and then fed to an internal combustion engine/turbine for the production of electricity. Research material on landfill and sewage gas facilities rarely mentions any employment impacts, concentrating instead on the reduction in greenhouse gas emissions from clean energy production. This would seemingly indicate that employment numbers involved are not substantial. Indeed academic literature on landfill and sewage gas tends to major on the technological and chemical side. Economic benefits are described in terms of energy benefits and/or toxicity reduction. In our NJŜǾƛŜǿ ǿŜ Ŧƛ ƴŘ ŦŜǿ Ŏƪŀƛ Yă NJŜ Ǝ ŀNJŘƛ ƴƎ ŜYLJƪ ƻè YŜ ƴű proposals.

Estimating employment connected to landfill gas is made difficult partly because of some uncertainty on the number of operational landfill sites, and then how many produce gas. According to OFGEM[37] there were 377 landfill sites generating electricity from gas in 2008. This same source showed BIFFA to have 24 sites generating 49,954 kilowatts of energy. Once again there is limited evidence of significant employment effects directly connected to operation of landfill gas. For example according to the BIFFA annual 2011 report[38], the number of people employed in its Landfill Division is identified as 213 (out of a total employment of 6,140), and clearly only a proportion of these would be at sites generating electricity. Few UK operators separately identify the landfill component in their company reports. However, Infinis[39] state that they operate 123 landfill sites which generate electricity (i.e. 343MW of capacity which they argue is 40% of the UK electricity generation from landfill in the UK. Total employment across the whole organisation is only 386 (in 2012) and of these only 264 are operational staffs.

In Wales the operational employment potential of landfill gas in Wales is exemplified in the case of the BIFFA Trecatti site near Merthyr Tydfil. Here there are five methane gas burners on-site and estimated installed capacity is 5.3MW. The site employs two people to run the machines. Here wells are sunk across the site and they are connected to the gas burners. A flare is used to create a vacuum which drives the gas to the turbines. When these sinks no longer yield they are moved

[37] Landfill OFgem Accreditation doc (as at May 2008)
http://www.ofgem.gov.uk/Sustainability/Environment/RenewablStat/Documents1/Accreditation_OVER50kw.xls

[38] BIFFA Annual Report 2011 http://www.biffa.co.uk/assets/files/corporate-info/BGL%202011%20Accounts%20signed.zip%20file.pdf
[39] Infinis company report see http://www.infinis.com/assets/downloads/INF_AR2012_DPS.pdf

around the site. A specialist UK contractor that travels around the UK comes in to relocate devices around the site.

In the case of Anaerobic Digestion this tends to be a broad term for the capture of gases from anaerobic processes which can be used as energy. The term therefore covers farm based digesters, sewage sludge digestion (captures gas which runs an engine which then produces electricity to run the plant) and plants using non-sewage waste biological matter - food waste, abattoir waste, etc.). In the case of AD and sewage sludge plants there are difficulties estimating direct employment effects. Bioenergy identifies 214 anaerobic digestion facilities in the UK linked to a total installed generating capacity of over 170MW of electricity (baseline established in September 2011). Employment that can be directly linked to energy production on small farm sites is small and on larger sites employment would likely be indirects, created through the supply chain when plant etc needs servicing. Something of the expected employment effects of larger plants can be inferred from recent investments. For example, the £8M 1.4MW Emerald Biogas[40] anaerobic digestion (AD) facility in County Durham which will convert 50,000 tonnes of food waste annually into electricity will create just eight new jobs. Much of this employment connects through to materials handling i.e. removing plastic, glass and metal, pasteurising the waste to meet stringent regulations, before transferring it to large digestion tanks.

Much of the Welsh activity in terms of sewage sludge occurs under the auspices of Dwr Cymru Welsh Water which has 13 (sewage sludge) sites in Wales. Eleven of these are small handling less than 5,000 dry tonnes per annum, with one handling between 5,000-10,000 and another 10,000 to 20,000 dtpa. Dwr Cymru estimate that they will produce 47GWh (estimated to equate to a notional 5.36MW of installed capacity) from anaerobic digestion in 2013/14 across 11 of their sites. However, ŀ ƒ ŀ ǋ Ǝ Ŝ ǋ ʏ ǆ ʏ ō Ŝ ǋ ƻ Ŧ ǿ ŀ ă ű Ŝ ǿ ŀ ű Ŝ ǋ Ǉ ƒ ŀ ʏ ű ă Ψ Ŧ Ŝ Ŝ Ř Ω ű Ķ Ŝ using an internal fleet of tankers for moving sludge around. Just two of the eleven sites account for о л D ² K ŀ ʏ Ř ǆ ă Ŝ Ψ ŀ Ř Ǿ ŀ ʏ Ŏ Ŝ Ř Ω ŀ ʏ ŀ Ŝ ǋ hydrolysis). These Ǝ Ŝ ă ű ƛ ƻ ʏ ó ŀ facilities have a team of 22 full time equivalent jobs connected covering different aspects of sludge management and energy production (including elements of electrical and mechanical maintenance as well as operating the machinery). At other smaller sites it is estimates that the extra work for digestion and CHP would be measured in part of a person ς perhaps only exceeding 1 at the two largest of the remaining sites. A very approximate benchmark would be around 0.5 FTE for every GWh on energy produced, but noting that if more conventional digestion processes were used with no high pressure / steam equipment, that numbers employed would be lower. One observation here is that the job count in AD (and energy from waste ς see below) tends to be higher than in wind for example, but possibly features a lower skill base.

[40] http://www.emeraldbiogas.com/news-item/items/project-well-underway-at-emerald-biogas-for-new-green-energy-plant

F.8 Energy from waste

Apart from the biological processes already described, energy can be derived from waste through thermal (either incineration or advanced thermal) processes. Advanced thermal processes can be divided into Gasification, Pyrolysis and Plasma Arc. Incineration creates energy directly from the combustion process whereas more advanced techniques convert the waste into products from which energy can be generated.

A DEFRA report (2007)[41] identified 19 Municipal Solid Waste (MSW) incineration plants in the UK, with the first established on the Isles of Scilly in 1987 (this having no energy recovery). The total energy recovery summed to 295.5MW (linked to 3.317m tonnes of waste per annum). The same report stated that operational employment for an incineration plant of 50,000tpa capacity would be 2-6 workers per shift and with a three shift system, to allow for 24-hour operations.

[illegible][42] [illegible] that these are going through the planning process (and subject to the objections raised by the Network) .

Using DEFRA MW figures, we can estimate that the 31 plants, the waste capacity of which sums to approximately 7.05m tpa, and assuming little change to technology gives a total energy capacity of around 650MW. Then using the DEFRA employment figures on the most up to date (estimated) plant numbers and waste capacity (and excluding outage supplier employment) we can infer a total employment of 1,680. Using the same inferences, the 114 potential sites could be linked to a further 5000 FTEs.

The employment linked to the capital costs of construction are more difficult to estimate. Furthermore, construction times can be very protracted; a result of strong opposition and multiple appeals. For example, Cory Environmental's Riverside Resource Recovery plant situated on the River Thames in Belvedere, Bexley, with a waste capacity of 585,000 tpa and energy generation capability of 72MW, was handed over to Cory in Autumn 2011 but was conceived 17 years earlier. Actual construction time was 3-4 years at a cost of £410m.

According to the Network source (above) there is only one waste incinerator in Wales (which is included in the above estimations) at Crymlyn Burrows in Swansea (owned by Neath Port Talbot Recycling Ltd and NPTC) with a waste capacity of 166,000 tpa. This was reportedly recently shut down because of high dioxin emissions.

[41] DEFRA 2007 Municipal solid waste
http://archive.defra.gov.uk/environment/waste/residual/newtech/documents/mbt.pdf

[42] http://ukwin.org.uk/

There are, however, six in various stages of planning and development. Viridor (Trident Park, Cardiff) provides a good exemplar of projects in development. Viridor sees strong growth potential in the Energy from Waste sector. The company also has a strong pipeline of projects and is looking to increase generating capacity to 300MW by 2017 (3-4% of the UKs renewable supply). The company estimates it will be making capital investment worth £1 billion 2007-2017. Viridor Ώfirst Energy from Waste scheme in Wales[43] is currently under construction. It is the first Combined Heat and Power waste to energy facility in Wales and is designed to treat residual household waste (and some waste collected from local businesses), with distribution via a heat network system. Once operational, the scheme will have a waste treatment capacity of 350,000 tonnes a year and electricity generating capacity of 28MW. Completion is currently anticipated in 2014/15. The scheme represents an £185 million investment. It is anticipated that the construction will support 300 construction jobs at peak. Given that the facility involves advanced technology, it is anticipated that specialist construction skills will be required, along with more general civil and construction skills. Once operational, the plant is estimated to require 50 employees (this is taken to include employees in the supply chain delivering waste etc). In general, those employed are expected to be highly skilled and specialised in the operation of the facility. These jobs will demand a range of technical skills, but with a particular demand for engineering type jobs.[44]

Other schemes in development include:

Deeside Industrial Estate (North Wales Residual Treatment Project) 150,000 tpa (by 2017)
Barry Dock by Biogen/Energos ς80,000 tpa
Hirwaun Industrial Estate owned by Enviroactive Ltd and Marlborough Developments ς 250,000 tpa
Newport Docks by Biogen/Energos ς120,000tpa
Swansea by Clean Power Ltd and Network Rail. 100,000tpa and 6MW

Were all these plants to come on-line it is unlikely that operational employment would exceed 100-120 full time equivalents.

F.9 Solar Photo Voltaic Power

The term solar power covers a number of different technologies. Concentrating solar thermal power LJ f ŀ ү ű ă LJNJϨ ŘdzŎ Ŝ Ŝ f ŜŎ űNJƛ Ŏ ƛ ű è ű ĸNJϨdzᴲ ĸ Ŏ ĸ ŀ ү ᴲ ƛ ү ᴲ ű ĸ Ŝ different mirror or lens configurations. Solar thermal systems (trough, dish-Stirling, power tower) transfer heat to a turbine or engine for power generation. Concentrating photovoltaic (CPV) plants provide power by focusing solar radiation onto a photovoltaic (PV) module, which converts the radiation directly to electricity. The latter is a focus of activity in Wales.

[43] SLR (2010) Energy from Waste and Recycling Facility, Trident Park, Cardiff, Volume 4 Non-technical Summary for Viridor, January 2010.
[44] Consultation with Viridor, Cardiff by research team ςsee Appendix D

Sharp at Wrexham currently employs around 500 people making Solar Crystalline Photovoltaic Modules. Manufacturing capacity has been established at 600MW / year, producing around 2.5 million modules per year. Activity includes some R & D on new modules and improved efficiencies to meet global demand, particularly for Europe and Japan, and is supported with a laboratory based in Oxford. Sharp[45] believe the scale of the resource which could be commercially exploited within Wales would link to an estimated 750MW / year manufacturing capacity, involving 2000 workers in the whole supply chain. While Sharp is the main Solar PV company in Wales in manufacturing, there are a broad range of range of installers and project / energy companies who are also integral to the industry. Sharp believe there are real challenges for suppliers within Wales to capture the opportunities around the future commercialisation of these technologies, with the strength of the supply chain is in the Far-East. The high volume expectation restricts the choice of supplier ς limited supply capacity of components in Wales.

Assessing the direct employment effects associated with the operation of solar power plants is difficult because, in the UK case at least, much of the capacity is small scale on domestic and commercial properties. Moreover, employment associated with these technologies is almost entirely focused in the supply chain rather than operations. For example, at October 2011 the UK Renewable Energy Association estimated that there were 4,000 solar industry registered companies, and that these would support 7,000 solar jobs by April 2012. The Solar Trade Association (STA) is quoted as ăűŀűƛʏ∃ άyЛ ƨŦ űKŜ ſƨźƛƨʏăʏXΦăƨĿNJNJŀNJŜŘdzʏŜăʏăʏŘ pЛ ƨŦ űKŜ Ŏƨăű ƨŦ ŀʏ ƛʏăűŀſſŀűƛƨʏΦ ¢KŜ ƨűKŜNJ pЛ simply adding together employment in solar installation companies provides an inaccurate estimate of employment linked to solar technologies because often companies undertake a multitude of activities which include solar panel installation.[46]

The concentration of employment in the supply chain is also evidenced by recent investment decisions by panel makers. For example, Sunsolar (at Oldbury, West Midlands) is setting up a manufacturing plant capable of producing 65MW of PV solar panels per year. The site is due to be up and running by May 2013. The capital automated machinery used is of Swiss/German Technology, capable of producing 60/72 cell panels with which the company hopes to be able to directly compete with any imported panel. Around 600 jobs are expected at the new £10million facility.[47]

Notwithstanding the above there are questions on the ădzăűŀƛʏŀōƛſƛűè ƨŦ ŜYLJſƨèY ăŜŎűƨNJ Kƨǿ ŜØŜNJ ŘŜŦƛʏŜŘΦ Wƨōă Ŏŀʏ ōŜ ădzōƧŜŎű űƨ subsidies and then falling production costs. For example, reported employment increases in the sector in the first half of 2011 were attributed to generous feed in tariffs which were then reduced causing a fall in the number of solar panel installations resulting from the lower private return.

[45] Consultation with Sharp, Wrexham by research team.
[46] http://www.solarpowerportal.co.uk/news/real_facts_over_25000_uk_jobs_have_been_created_under_the_uk_fits_5478

[47] http://www.solarpowerportal.co.uk/news/plans_emerge_for_uk_based_solar_module_manufacturing_facility_5478

From our review we found very few examples of the costs associated with installing and operating larger solar arrays. Some inference on costs is available from the case of St. Modwen, which was granted permission to build a 5MW array of solar panels at an old BP Chemicals works site in Port Talbot. The project is expected to cost £15 million. A feasibility study undertaken by Virtus (2011) for this project found that 92% of the capital cost was in terms of supply of panels and installation, with the balance being grid connections, security fencing and lighting, consulting and design fees. This feasibility work reveals the smaller employment connected to operations. It was estimated that total operational costs per annum would be in the order of £136,000 (around £27,000 per installed MW), made up of grid charges (9%), security (11%), rates (12%), insurance (29%) and with the balance (39%) being the maintenance contract. This reveals the limited employment opportunities during the operational phase with the maintenance element including an element of warranty and visual inspection of units. Fundamentally units involve few moving parts, and with no employment involved in any materials handling as in some other generation technologies.

Research from the United States into facilities that work by concentrating solar power (CSP) reveals larger employment impacts. For example, one study estimated a 100MW parabolic trough plant with 6 hours of storage could support directly and indirectly around 94 permanent operations and maintenance jobs. However, facilities of this scale and type are not feasible in Wales.

F.10 Review of treatment of electricity production in Input-Output Tables[48]

As well as reviewing studies of employment effects connected to electricity generation technologies, a second part of the review sought to examine the treatment of electricity generation in input-output tables. The context for this was that the total employment effects of different electricity production technologies in Wales (see later) would be undertaken using input-output tables as a means of better understanding the indirect and induced employment effects connected to different electricity production technologies. A core objective here was to gain insights into the operational technical coefficients of different technologies. Input-Output frameworks from 20 countries were examined. Furthermore a review was undertaken of academic materials which had sought to disaggregate electricity production activity.

From the review of different input-output frameworks it was clear that there was limited disaggregation of energy production within the national Input Output tables surveyed. For example, the majority of tables follow the UK pattern where Input-Output tables (2005 product by product analytical tables from the ONS[49]) aggregate electricity, production and distribution together.

Table F.4 illustrates the problem showing highlights from the UK (2005) and Scottish (2007) analytical product by product tables.

[48] Appendix D provides a brief review of the purpose of input-output tables.
[49] See for UK 2005 analytical tables; http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-237341

Table F.4 Electricity production and distribution UK (2005) and Scotland (2007): Components of basic output

Purchases from	UK	Scotland
Coal	341	72
Oil and Gas Ext	6,870	342
Coke, Petrol, Nuclear Fuel	625	112
Electricity production and distn	8,198	1,664
Gas distn	1,817	349
Other purchases	3,872	363
Imports	1,816	1,023
Total Consumption	**23,539**	**3,925**
Taxes on products	675	130
Gross value added	8,196	1,331
Output at basic prices	**32,409**	**5,386**

Source: ONS and Scottish Executive.

The aggregated sector electricity production and distribution not only bundles different technologies together but also comprises distribution and transmission of electricity (for example, including the activities of National Grid). This creates a series of problems as the drivers of indirect and induced employment effects are the different technical coefficients associated with different electricity generation technologies. For example, the Scottish Input-Output framework permits an estimate to be made of the employment effects connected with an increase of £1m in final demand for the products of the electricity production and distribution sector but this is an average for a huge sector. Furthermore, of interest in this report is how the purchasing patterns and import propensities of different electricity production technologies vary, as this together with differences in earnings, drives some of the indirect employment effect connected with the technology.

Furthermore, the aggregation of electricity production and distribution means that purchases from own sector make up a large proportion of output. For example, in the UK case electricity production and distribution purchases £8bn from itself in the UK 2005 Input-Output tables (see Table 2.4).

Attempts have been made to disaggregate different energy production technologies within input-output frameworks and these confirm important differences in the make-up of sectors and employment effects. For example, Winning (2013) disaggregates different generation technologies within the Scottish Input-Output tables and with Table 2.5 providing estimates of components of costs of different technologies. Marked here are differences in local purchasing propensities across technologies in Scotland (revealed in the intermediate purchases row of Table 2.5), together with differences in employment costs as a percentage of total costs.

Table F.5 Components of Costs for Disaggregated Electricity Sectors in Scotland (2004) from Winning (2013)

	Elec Supply	Gen - Nuclear	Gen - Coal	Gen - Gas + Oil	Gen Hydro	Gen Biomass	Gen-Wind	Gen-Wind Offshore	Gen - Other	Gen - Marine/ solar
Intermed Purchases	69%	29%	49%	77%	28%	53%	61%	60%	32%	61%
Imports	5%	5%	5%	5%	0%	0%	5%	5%	5%	5%
Taxes	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Employees	7%	7%	9%	8%	38%	54%	23%	33%	54%	38%
Gross Op Surplus	15%	57%	34%	8%	32%	-9%	9%	0%	7%	-6%

Source: Winning (2013)

Related attempts have been made in Wales in connection with the 2007 Input-Output tables (see Section 4 of this report). These attempts at disaggregation confirm the dangers of using an aggregated electricity production and distribution sector to draw inference on the employment and value added effects associated with changes in the electricity production mix going forward. Where disaggregation has happened in generation technologies it has tended to be ad hoc and incomparable between nations.

Table F.6 Examples of academic research seeking to disaggregate electricity production

Source	Country	Method	IO Year	Class of Model
Dejuan, Oscar; Zafrilla, Jorge (2010)	Spain	Construction of a new "Energy input-output" has 18 industries. Each of them are identified with the homogeneous commodity it produces. Energy source are linked to the commodities Petrol, Gas, Electricity, Coal	2005	Applied General Equilibrium Structural Decomposition Analysis
Lindner, Legault, Guan (2011)	China	Disaggregation of the existing Chinese Electricity sector. 5 new sectors are constructed, Power plants, Electricity Generation by Fuel	2006	Environmental Economic Life Cycle Analysis
Cruz (2002)	Portugal	The electricity sector is disaggregated into 3 fossil fuel electricity generation, hydroelectricity generation and electricity distribution	1992	Environmental Economic Life Cycle Analysis
Marriott (2007)	USA	Disaggregation into fuel types but limited by both distribution and generation	1997	Three-dimensional Input Output

The review suggests that existing input-output frameworks provide little by means of benchmarks for this research. A related issue is that selected input-output frameworks include some elements of the supply chain within a defined electricity sector. For example, coal mining output supported included in an electricity production vector.

A final problem here is that input-output frameworks poorly represent nascent technologies. Input-Output tables at their best give a static representation of an economy at a point in time. For example, activities related to solar PV and wave power/tidal stream that are in the early stages of experimentation or commercialisation might not be adequately picked up in the official surveys used to develop input-output frameworks.