How do we power the Northern Powerhouse

Potentia
North

A white paper from the student think-tank *Potentia North* looking at four proposed options to inform a regional energy strategy for the North

DRAFT ver5

Introduction

Government wants to create a Northern Powerhouse to better balance the UK economy. Proposals call for investment in transport, science and innovation, plus devolution of civic powers. This document poses the question: 'What if energy policy was also devolved - how would we develop a strategy that could power the Northern Powerhouse?'

In answer to that that question we have set up our own mock think tank, made up of PhD and postgraduate students from The University of Manchester, named ***Potentia North*** . This group draws on a range of expertise from across the Manchester Energy research community and, posing as an advisory group, has proposed four hypothetical scenarios for discussion which are summarised on the following page.

What is the Northern Powerhouse?

The first obvious question is what is the Northern Powerhouse? Essentially the Northern Powerhouse is a political proposal championed by Chancellor George Osborne with the aim to boost economic growth in the 'north' in a bid to rebalance the UK economy away from London and the South East. The 'north' in this context of the Northern Powerhouse is usually defined by the Core Cities of Manchester, Liverpool, Leeds and Sheffield and the proposal involves improvement to transport links, investment in science and innovation and devolution of powers in so-called City Deals.

Our scope

For the purposes of this exercise we have focused our proposals on the North-West region and to specific conurbations within this area e.g. Greater Manchester. This approach has helped set a more manageable scope for our hypothetical modelling and feasibility analysis.

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REVIEW OF OPTIONS				
	Option One	**Option Two**	**Option Three**	**Option Four**
Project Type	**Hyperlocal generation supported by smart grid** Consumers can become producers of energy by installing PV solar panels on homes Focus on Greater Manchester as pilot smart city	**Large infrastructure project to build nuclear plant** Major investment to create new nuclear power plant to supply the Northwest region To earmark Heysham, Lancs, as potential new build site	**Regional economic model to challenge big six** To set up a social enterprise to operate regionally and to undercut the big six profit-seeking suppliers	**Large scale renewable power supported by smart grid** To have an ambitious mix of renewable projects (eg wind, geothermal, biomass and tidal) Includes flagship infrastructure projects (such as tidal lagoons at key Northwest tW locations) supported with innovative storage and demand management solutions
Power potential	500,000 homes in Greater Manchester with PV would contribute 15% of local energy needs	Potential to power up to 6 million homes at the flick of a switch 1,000s of new jobs Skills and manufacturing supply chain in region	Potential to offer cheaper energy to 100,000s of homes Up to £200 off a family's energy bill	Potential to deliver 34.89 TWh (TeraWatt hour) equivalent to the Northwest's energy demand of 35TW
Selling points	Ultra-low investment because devolving infrastructure build to households People power – helping to transform behaviour and relationship with	This option is a 'powerhouse' – to potentially power many of the region's homes and business with a single project. No need for major changes in supply (eg no smart grid needed) and no need for complex and untested	Focuses on supply to market instead of generation. This scheme will generate a self-financing income stream relatively quickly compared to infrastructure projects Tangible benefits	A complex option but defines an exciting future that is 100% renewable. Elegant mix of renewable generation and smart grid systems Potential to supply all the region's energy needs

	energy as move to 'smart cities'	storage solutions	for end-users (potential voters)	
Key actions	Households need to be persuaded to install PV solar panels on own homes To persuade regional operators to develop smart grid technology To use 'smart pricing' to manage demand and adoption of PV installation	To attract major investors to build something as complex as a nuclear station To convince investors and local stakeholders of the long-term value of such a project	To persuade householders and local business to switch to a social enterprise provider To persuade agencies to work together, probably with a commercial partner/consultant	Attract billion pound investment to create renewable infrastructures (eg tidal lagoons) Develop governance between different types of supply Like Option 1, to persuade regional operators to develop smart grid technology

1: Hyperlocal model facilitated by Smart Grid technology

Introduction

In order to reach the ambitious CO_2 emission targets set out by the Climate Change Act (2008), the UK will need to dramatically change its current energy mix, replacing fossil fuel with low carbon technologies of different levels (large/medium/small/micro-scale). Placing Greater Manchester (GM) in this context, our aim is to investigate potential solutions which allow a rapid, low cost transition to a low-carbon society. We propose a hyperlocal model that encourages residents to invest in photovoltaics (PV) micro-generation facilitated by smart grid technology.

Hyperlocal model approach

The hyperlocal model approach promotes the idea that Greater Manchester could generate the electricity it requires for itself via the combination of many microscale electricity generators fitted to households and businesses. The future electricity scenario is uncertain, and a hyperlocal approach would mitigate the impact of uncertainty regarding control, supply and price of electricity imported from outside the region. It would also boost the local economy, ensuring jobs installing and maintaining the microscale energy generation network. Furthermore, it could inspire the Greater Manchester community to actively participate in the transition to a low carbon society. In principle, any microscale technology could be implemented. However, we believe that the most suitable technology at this time would be PV.

Photovoltaic scenario

A typical domestic PV panel has a power rating of 4 kW which if installed on half of all the homes in Greater Manchester would, accounting for sunlight availability, would provide approximately 15% of Greater Manchester's current electricity demand. PV is a clean, easily scalable energy source with a reasonable payback time allowing for a rapid transition to an energy mix with high proportion of renewable energy sources.

Challenges

There are two main challenges to achieving the goal of a hyperlocal model for Greater Manchester. Firstly, how to encourage residents to install PV at a rate which maximises reduction of carbon emissions, whilst not exceeding current grid capacity. Secondly, how to accommodate a large influx of micro-generators feeding into the grid. We suggest the former challenge could be met through the careful use of Feed-In Tariffs (FIT) and the latter by investing in Smart Grid technology.

Feed-in Tariffs

Feed-in Tariffs (FITs)are payments to ordinary energy users for the renewable electricity they generate. This scheme incentivises to increase the level of renewable energy in the UK. This tariff gives three financial benefits: (i) a payment for all electricity you produce, (ii) additional bonus for electricity you export into the grid, and (iii) a reduction on standard electricity bill from using the energy produced.

In the UK, FITs went live on 1st of April 2010, and, since then, a substantial amount of customers have joined the scheme. According to the Department of Energy & Climate Change (DEEC), the market has grown from virtually zero in 2010 to 5 GW solar PV capacity by August 2014, and to 8 GW by August 2015 (see Figure 1).

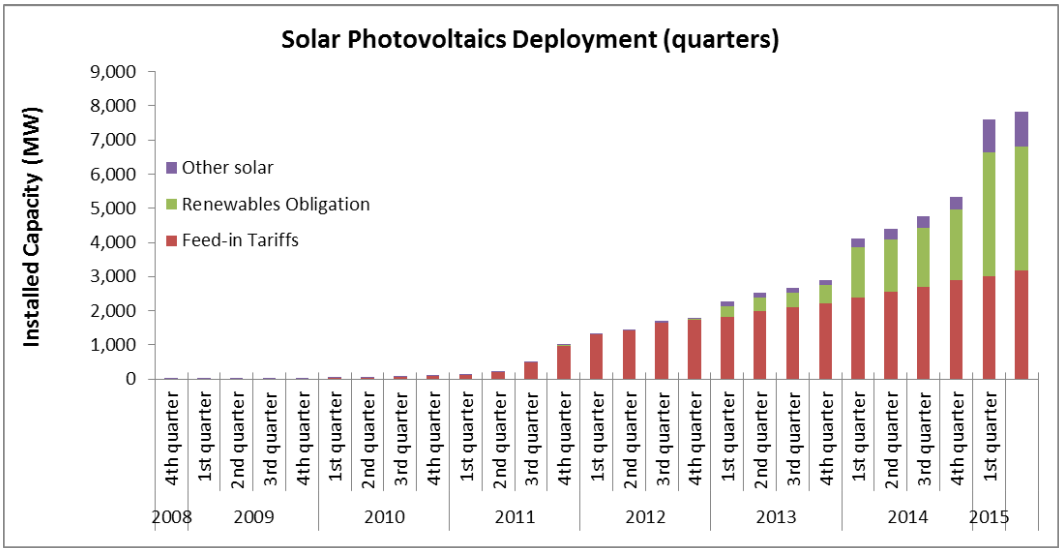


Figure 1: Solar Photovoltaics Deployment in the UK.

(Source: https://www.gov.uk/government/statistics/solar-photovoltaics-deployment)

Taking into consideration only the cumulative number of FIT installations, 99% (669,852) of the total number of solar PV installations correspond to micro-generation (<50 kW), and it represents 82% (2,452 MW) of the total solar PV capacity (Source: Performance and Impact of the Feed-in Tariff Scheme: Review of Evidence – Ref. 15D/394).

Issues of Feed-in Tariffs

In the UK, a "Consultation on a review of Feed-in Tariff Scheme" provided by DEEC demonstrates concerns about over compensation.

The over compensation scenario – which we henceforth describe as a 'BOOST' scenario – strongly encourages people to install renewable micro generators into their properties. Nonetheless, it brings several negative effects. Distribution networks were not primarily designed to allow generation close to end customers, so this reaches considerable levels this may create operational and security issues to network's operation. Furthermore, adoption of micro-generation at such high levels by end-users urge for an Electricity Market Reform.

On the other hand, the under compensation scenario – which we henceforth describe as a 'BOOM' scenario – strongly discourages people to install renewable micro generators into their properties. It may reduce the extent a region will be able to contribute to CO_2 emission targets. Furthermore, the opportunity to take advantage of the social and economic benefits created by the solar PV market can be permanently lost.

Case studies from abroad

In 2012 the Japanese government set FITs at roughly double that of the UK rate, triggering more than 1.2 million applications (a BOOST scenario), mostly for solar-power installations. As consequence, Japan's power utilities became overwhelmed and they decided to block access to the grid. Germany is experiencing a BOOST scenario as well. Unlike Japan, they were not strict. They decided to still allow new customers eligible for FITs, but, as a provisory solution, they curtailed energy that exceeds 70% of the solar PV capacity. Although this measure is needed to maintain compliance with standards, it is not desirable.

Proposed pathway – A dynamic Feed-In Tariff

As FITs are effective for its purpose, we believe that redesign some of its features to avoid BOOM/BOOST scenarios can bring several savings in money and time. Thereby we suggest a Dynamic Feed-In Tariff (DFIT) that is directly proportional to solar PV hosting capacity per feeder. This means that higher rewards would be provided to PV installations that benefit the most the system. A breakpoint, supporting the concept of hyperlocal approach, would have to be defined limiting the hosting capacity for each feeder (see Figure 2). Ultimately, distribution companies would also have to accomplish targets to improve quarterly/yearly hosting capacity based on the level of deployment and maximisation of the usage of their assets.

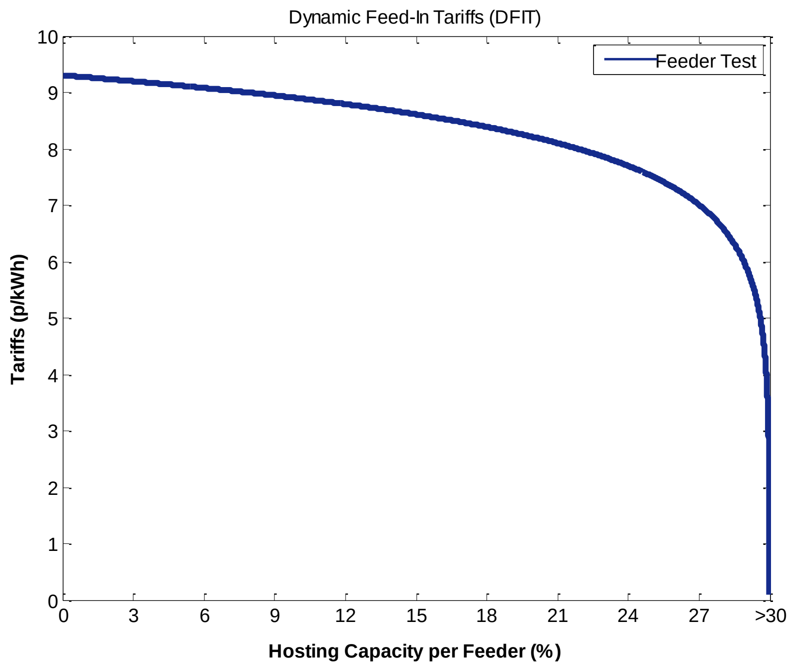


Figure 2: Dynamic Feed-In Tariffs per Feeder considering a hypothetical breakpoint of 27 % and maximum hosting capacity of 30 %.

To illustrate the proposal in other terms, consider that in the same network there are neighbours willing to join to FITs scheme at the same time, so both will have the same incentive. However, if one joins at earlier stages and the other only when the feeder already became PV-rich, then the latter will be provided with lower incentives. This would be used to encourage distributed PV uptake throughout communities and offset the cost of installation.

NATIONAL POLCY UPDATE

The Department of Energy and Climate Change (DECC) has proposed to slash the feed-in tariff – which is a payout by the Government for the energy you produce via panels – by almost 90% from January. The feed-in tariff rate dropped slightly from 12.92p/kWh to 12.47p/kWh from 1 October, 2015, but it's proposed that from January 2016 it'll drop to 1.63p/kWh. So what now pays **£435/year** would be just **£55/year** if that recommendation goes ahead.

Smart grids

The UK's electric power network, built in the first half of the 20th century initially consisted of large-scale generation units, leading to a vertical power system designed to transport energy in only one-way (generation-transmission-distribution-end customer). In the 21st century, the incorporation of generation units at numerous different levels required a big change the way the system has been operated over the years. A paradigm shift from the traditional downstream energy flow is being slowly replaced by multidirectional energy flows, raising new challenges to engineers.

"Smart grid is a concept for transforming the electric power grid by using advanced automatic control and communications techniques and other forms of information technology. It integrates innovative tools and technologies from generation, transmission and distribution all the way to consumer appliances and equipment. This concept integrates energy infrastructure, processes, devices, information and markets into a coordinated and collaborative process that allows energy to be generated, distributed and consumed more effectively and efficiently." (Source: Cecati, C.; Mokryani, Geev; Piccolo, A.; Siano, P., "An overview on the smart grid concept," in IECON 2010 - 36th Annual Conference on IEEE Industrial Electronics Society , vol., no., pp.3322-3327, 7-10 Nov. 2010).

The smart grid is the most cost-effective solution that comprises high uptakes of generation units in distribution level (it might double hosting capacity). Hence, we propose the smart grid pathway for Greater Manchester in order to maximise the usage of the current assets, i.e., capacity to accommodate new generator units into the grid deferring investments on network reinforcement and, thus, reducing costs and saving time.

Smart grid innovators

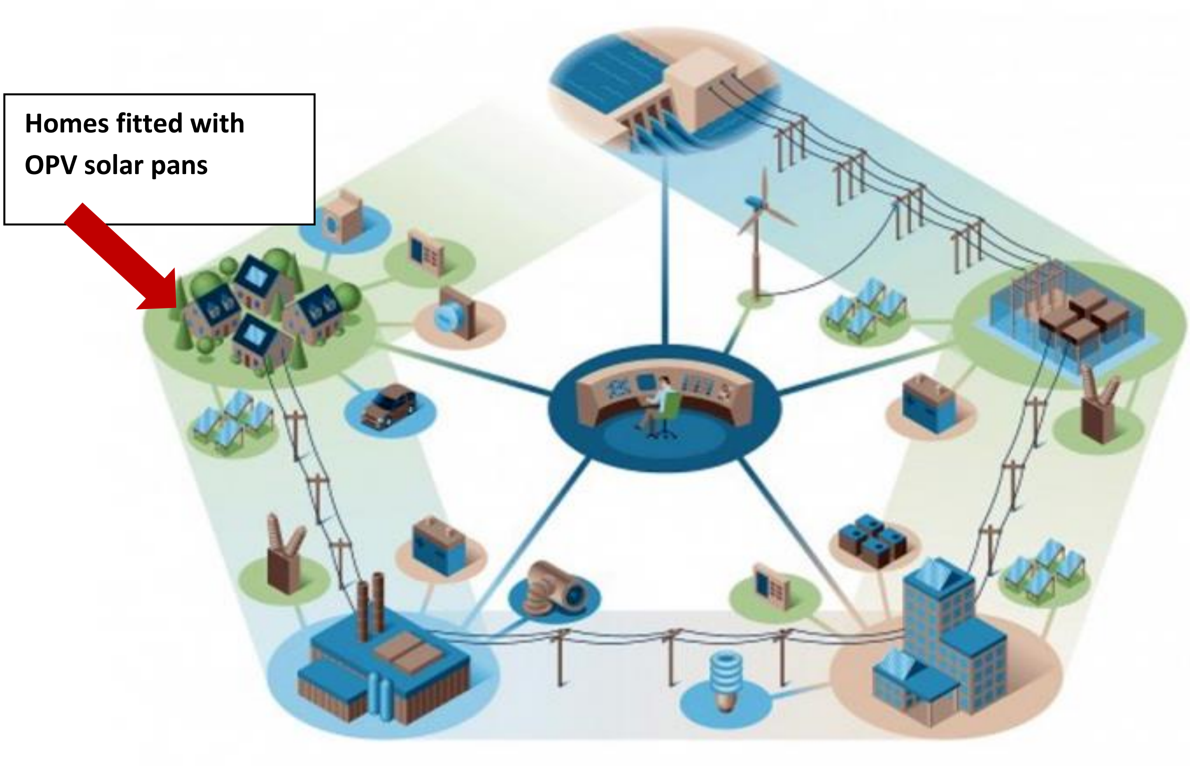
There are already a number of commercial organisations that are leading innovations in smart grid technologies and applications, for example:

- SIEMENS are interested in advance monitoring infrastructure such as smart meters
- ABB aim to provide automation to primary and secondary sub-stations
- GE Energy are looking to provide project management and implementation services.

CASE STUDY: Stockport shines

Stockport is a leader in incentivising PV take-up. The Stockport Homes Investing in Natural Energy (SHINE) is an innovative project which will see 1,200 solar installations fitted across Stockport. The first installation of solar panels was completed in August 2011 at Russell Gardens, and is just the start of a pioneering project that is one of the largest of its kind in the North West. The Feed-in Tariff (FIT) has provided an opportunity for Stockport to cut carbon emissions; tackle fuel poverty; and reinvest the FIT income back into housing stock and other low carbon projects.

An exemplification of how a smart grid organises the flow of energy



Source: Jason Munger

RECOMMENDATION 1

To deliver a low carbon energy strategy we recommend prioritising a hyperlocal model that encourages residents not only to consume energy but to install photovoltaic (PV) technology on their homes to also act as micro-power generators. This micro-generated electricity can be redistributed to local communities via a smart grid. A pathway to a hyperlocal model would include:

1) Promote the benefits uptake of PV technology by the residents of Greater Manchester with marketing campaign. Aim to persuade 500,000 householders (@ 50% Greater Manchester) to install PV solar panels.

2) 'Smart pricing' to distribute adoption behaviour: To manage this new energy supply recommend using Dynamic Feed-In Tariffs that can react appropriately to market developments in order to avoid BOOM/BOOST scenarios eg have generous tariffs in neighbourhoods with low PV adoption while offering low or zero tariffs to communities that are saturated with solar panels to deter adoption. This dynamic tariff would be managed by a local regulatory agency and offer a smarter response than national Government (which offered very generous tariffs only to universally slash them when take-up proved popular).

3) Seek commercial agreements for trials in smart grid technology in the city. Potential partners could include innovators in this area, eg Siemens, ABB and GE Energy.

We have selected Greater Manchester our pilot hyperlocal scheme. We expect this model can be adopted by other cities and communities in the Northern Powerhouse.

Lead experts: Nicholas Fowler, Fillipe Matos De Vasconcelos, Imhotep Baptiste

2) Building for the future: investing in energy infrastructure with nuclear as a priority option

Generation Infrastructure

Massive investment in supply & distribution infrastructure based around the nuclear industry for a decarbonised, secure mass energy source to cover the whole region. Skills delivered and maintained within the region and local supply chain used for manufacture of new nuclear power plant (e.g. Redcar steelworks plant under current threat of closure and switch to be used for this market).

National Policy Background

Infrastructure is seen as the critical driver for the UK economy – and in Manchester last month (Oct) the Chancellor announced the creation of the National Infrastructure Commission, an independent body to help advise and steer a non-partisan approach to implementing major investment projects. This new body will be led by Lord Adonis, who says that as well as railways and airports, energy infrastructure is also a top priority for investment.

Lord Adonis said: "Without big improvements to its transport and energy systems, Britain will grind to a halt… major infrastructure projects like Crossrail and building major new power stations span governments and parliaments. I hope it will be possible to forge a wide measure of agreement, across society and politics, on key infrastructure requirements for the next 20 to 30 years, and the assessments which have underpinned them."

And the UK does need more investment in energy infrastructure according to the **npower Future Report - 'Energy and the economy: The 2030 outlook for UK businesses'**. The report reflects upon the need for a balanced focus on economic growth and investment in the energy infrastructure to deliver a low carbon and strong UK economy. It also calls on businesses to act now to ensure they are protected for the future. The npower Future Report says a £330bn investment is needed in UK energy infrastructure by 2030.

Nuclear Energy in the UK

Currently the UK relies on nuclear power to provide 19.8% of its electricity, with a number of nuclear reactors nearing the end of their lifetime (Department of Energy & Climate Change 2014; HM Government 2013). In order to sustain the energy demands of the country as they are, investment in nuclear power is vital to the UK energy mix. Nuclear energy is a secure, affordable and low carbon energy source that is flexible; unlike low carbon renewable energy sources, nuclear power forms the ideal 'baseload' energy source to replace the heavy reliance on oil, coal and gas, where output can be managed according to demand.

New-Build Plans

The Government is backing a planned 16 Gigawatt (GW) domestic new build by 2030 constituting 11 reactors at five sites - Hinkley Point (Somerset), Sizewell (Suffolk), Wylfa (North Wales), Oldbury

(Gloucestershire) and Moorside (near Sellafield, Cumbria) (HM Government 2013). Figure 1 below demonstrates the status of the existing nuclear sites across the UK.

The proposed Moorside Nuclear Power Plant at Sellafield, West Cumbria, with 3.4 GW net output capacity, will be the UK's biggest nuclear power station, delivering enough low-carbon electricity to power approximately six million homes. The population of the Northwest is about seven million. The power project will account for 7% of the UK's electricity requirements, and will be developed by NuGeneration (NuGen), which is a joint venture between Toshiba (60%) and ENERGIE (40%). The Moorside project would be the biggest private investment in West Cumbria to date.

Another new-build close to the region is planned for Wylfa, North Wales. It will be developed by Hitachi and Horizon Nuclear Power and with an output of 2.7 GW. UK and Welsh governments are working with Hitachi and its partners to assist with an investment decision that provides the best deal for local consumers, the company and UK industry. Wylfa will represent a multibillion-pound investment in North Wales and is expected to create 1,000 permanent jobs during operation, plus many thousands of jobs during the construction period.

Heysham Power Station is a nuclear power station operated by EDF Energy located in Heysham, Lancashire. The site is divided into two separately managed stations, Heysham 1 and Heysham 2, both of the advanced gas-cooled reactor (AGR) type, with two reactors each. On 18th October 2010 the British government announced that Heysham was one of the eight sites it considered suitable for future nuclear power stations.

EDF Energy is wholly owned by the French state-owned Électricité de France. In 2009, EDF Energy took control of the UK nuclear generator, British Energy, buying share capital from the government. This made EDF Energy one of the UK's largest generators, as well as the largest distribution network operator.

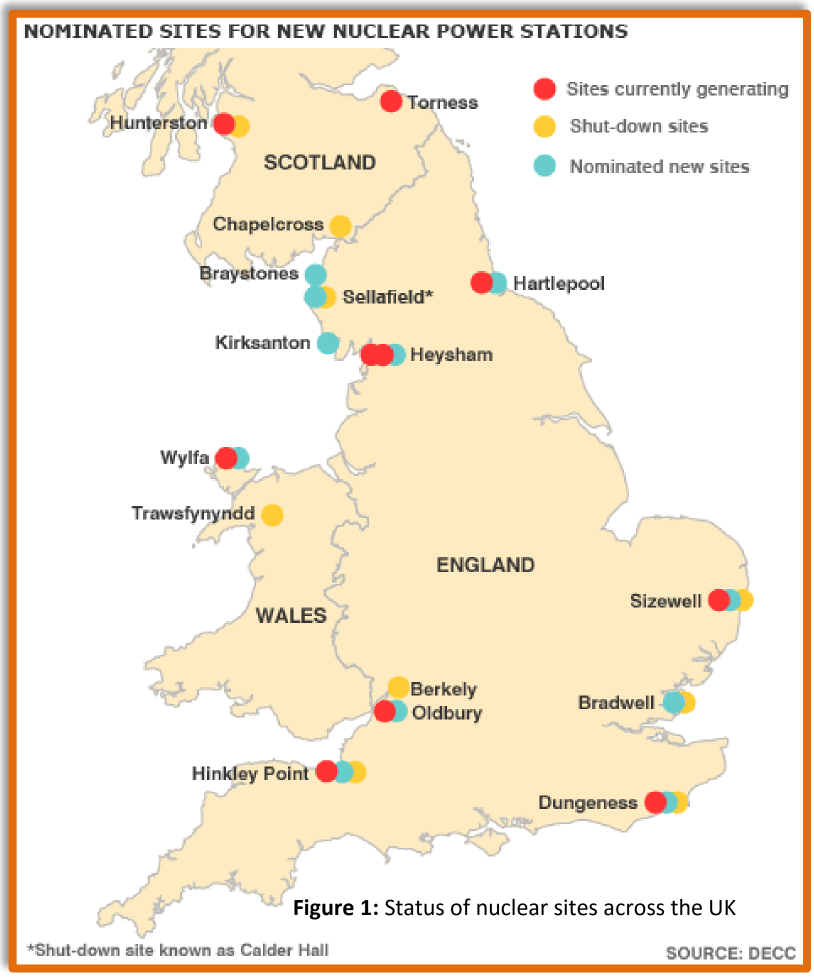


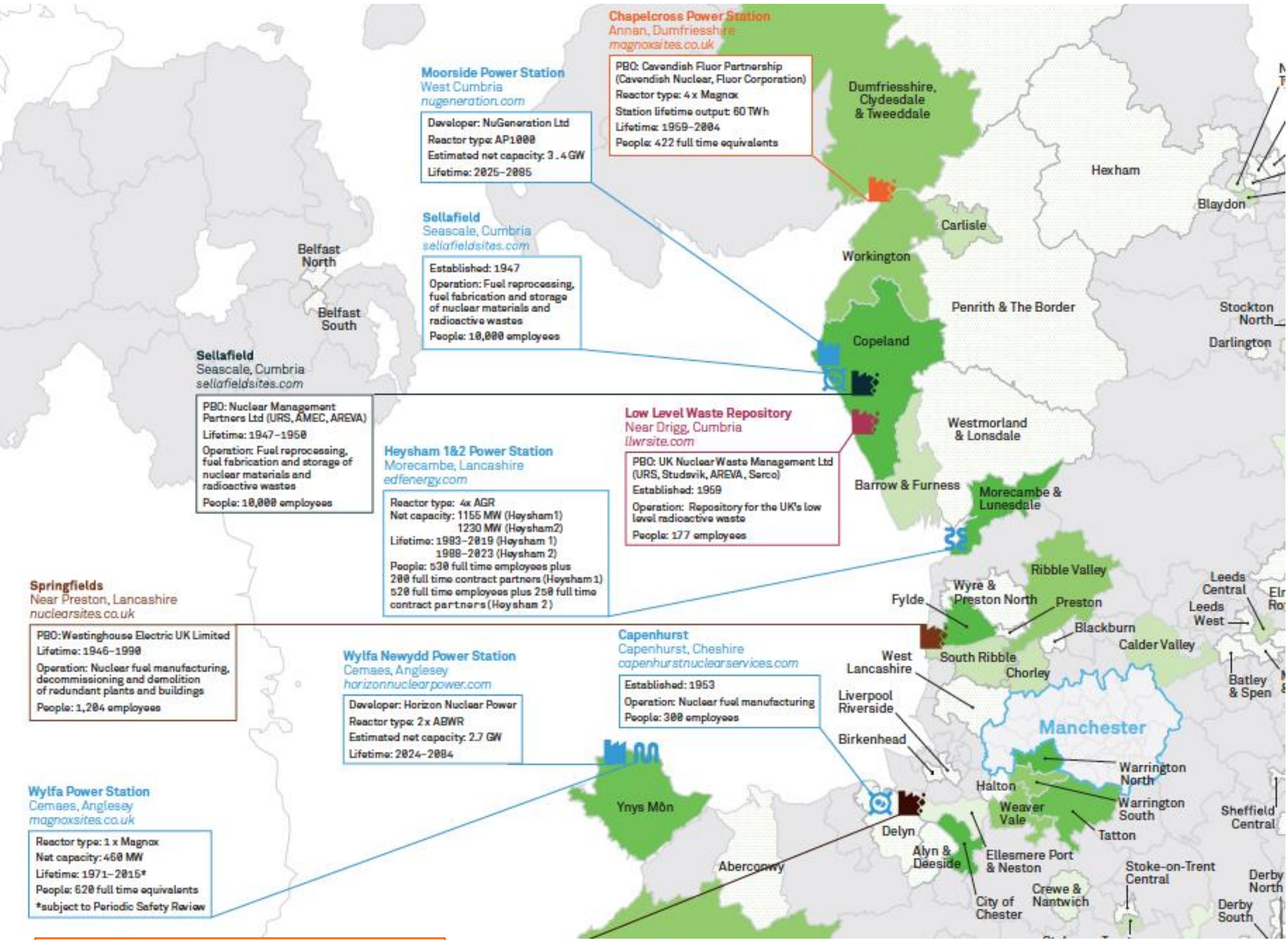
Figure 1: Status of nuclear sites across the UK

Heysham has yet to be put forward for development, but would provide the ideal new build site to allow the Northwest to achieve self-sufficient nuclear energy production as the existing reactors at Heysham are due to go offline in 2023. Due to limited available land, 1 or 2 Small Modular Reactors (SMRs) could be the new build solution for Heysham. SMRs are small and simply designed, with a high level of passive safety all of which allows lower capital costs in comparison with other reactors. SMRs also have the extra advantage of being scalable to achieve a desired power output. Westinghouse has recently proposed deployment of its SMRs in the UK, and is actively looking for investment partnerships (World Nuclear News 2015).

Existing Expertise & Infrastructure

The Northwest region is already a hub for nuclear industry expertise and R&D, with a strong history of developing, managing and supplying nuclear programmes. An £8 million joint investment from government and industry was announced in September 2014 to fund training programmes for nuclear skills, demonstrating commitment to a nuclear future (World Nuclear News 2014). This commitment helps to secure the future of existing industry infrastructure, and the associated skilled jobs. Over 80% of the work involved with new build projects could be provided by UK companies (Nuclear Industry Association 2015), with UK industry already able to offer supply chain opportunities for all stages of the nuclear fuel cycle; from conversion and enrichment, through to waste management and decommissioning.

The Northwest has more than 26,000 people currently employed by the civil nuclear industry. Figure 2 at a glance simply shows the density of nuclear employees already in the area. Developing this skilled workforce, and growing their experience and expertise with new nuclear projects will allow the region to export this expertise to both domestic and global markets. Particular export opportunities would come from regions in the infancy of their civil nuclear programmes such as South America and Africa. Due to the waste management and decommissioning challenges already experienced by the UK (mostly at Sellafield), China and India are already expressing an interest in calling upon this for advice (Department of Energy & Climate Change 2012). This demonstrates the real demand for the UK's nuclear experience, which the Northwest economy could benefit from enormously.



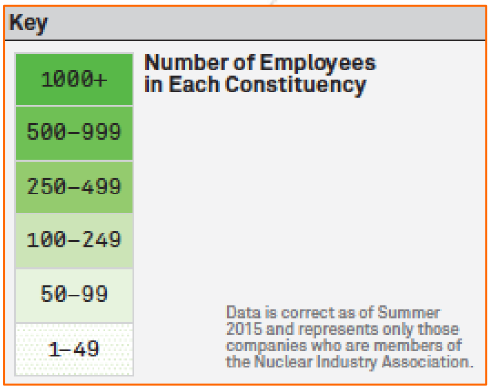


Figure 2: Job map of the UK detailing density of employees per region working in the nuclear industry

The Issue of Waste

A large concern for many concerning nuclear power is the waste, however a fleet of new power stations commissioned to replace the existing ones would only increase the UK waste inventory by 10%, with them operating over a 60-year lifespan (Nuclear Industry Association 2015). New build plants are also required to demonstrate ‘cradle to grave’ plans for the entire lifetime of a nuclear

site, and to set aside money to allow for future waste management and disposal (World Nuclear 2015). The UK government has an existing policy to deal with disposal of radioactive waste in a geological disposal facility (GDF), which is progressing towards a community-led siting process starting in 2017 (Department of Energy & Climate Change 2015).

RECOMMENDATION

This region should aim for self-sufficiency in low carbon energy though investment in nuclear power. An additional new build power plant should be commissioned in the North, with the existing nuclear site at Heysham suggested as next in line for development by EDF.

This would allow the region to continue showing leadership in civil nuclear programmes, secure existing jobs, whilst creating significant scope for expansion. The Northwest could provide world-class expertise and training, and provide consultancy services for both domestic and global nuclear programmes. Having a localised energy supply serving the region, costs will be reduced, as energy will not need to be transported far from the source.

Furthermore, investment can be attracted into the region and the local supply chain used for manufacture, which in turn will bolster the region’s economy. Development of nuclear power for the Northwest is an investment for the long-term future and success of the Northern Powerhouse.

Lead exert: Hollie Ashworth - PhD Student in Nuclear Chemistry

References

Department of Energy & Climate Change, 2015. *Implementing Geological Disposal : Annual Report*

Department of Energy & Climate Change, 2012. *The Nuclear Supply Chain Action Plan*

Department of Energy & Climate Change, 2014. *UK Energy Statistics*

HM Government, 2013. *Nuclear Industrial Strategy: The UK’s Nuclear Future*

Nuclear Industry Association, 2015. Facts and Information for Nuclear Enery. Available at: http://www.niauk.org/facts-and-information-for-nuclear-energy#achievable [Accessed October 12, 2015].

World Nuclear, 2015. The Economics of Nuclear Power. Available at: http://www.world-nuclear.org/info/Economic-Aspects/Economics-of-Nuclear-Power/ [Accessed October 13, 2015].

World Nuclear News, 2014. Funding for UK Nuclear Skills. *New Nuclear*. Available at: http://www.world-nuclear-news.org/NN-Funding-for-UK-nuclear-skills-2409144.html [Accessed October 12, 2015].

World Nuclear News, 2015. NuScale Sets its Sights on the UK. *New Nuclear*.

3 Social enterprise model: to challenge the big six and restructure the energy market

Time to disrupt the energy market

A new approach to how the energy market is structured is urgently needed if the dominance of the 'big six' suppliers is to be challenged. In recent years, householders and businesses have seen their utility bills spiral, as the profit-seeking big six have responded to supply changes in their sector. The UK's domestic energy market has also been hit with fluctuating Government policies and subsidy cutbacks.

We argue that in order to deliver better value to end-users, a 'not-for-profit' model should be introduced, allowing for the creation of social enterprises that would supply regions with their energy in a smarter way. Such social enterprises require leadership from local governments and other key social agencies, such as housing associations, because these agencies have a stake in social policy and the residents they serve. As the enterprises are non-profit, their aims would be to tackle fuel poverty, providing a fairer deal to consumers and safeguarding health and well-being. This has the potential to deliver a holistic energy policy, which when combined with health and housing policies would make a real difference to communities. This approach is being rolled out in other regions of the UK (see case studies below):

Supplier	Customers in the UK	Parent company	Parent company origin	Other divisions and branches	Rebranded
British Gas	20 million	Centrica	UK	Scottish Gas	
EDF Energy	5.7 million	EDF	France		SEEBOARD, SWEB energy & London Electricity
E.ON UK	5.3 million	E.ON	Germany		Powergen
Npower	6.5 million	RWE	Germany		Innogy, Northern Electric, Yorkshire Electricity
Scottish Power	5.2 million	Iberdrola	Spain	PPM Energy	MANWEB
SSE	9.6 million	SSE Group	UK	SSE	Scottish and Southern, Southern Electric, SWALEC & Scottish Hydro

Table 1: Profile overview - Who are the big six energy companies?

CASE STUDY ONE: EAST MIDLANDS

Nottingham City Council has set up the not-for-profit energy supply company '**Robin Hood Energy'.** The company has its own Ofgem licence and therefore does not need to "piggyback" off the big six. The company was launched in September 2015 and will buy gas and electricity in bulk on the open market from the National Grid – supplemented by energy generated from the city's incinerator, solar panels and waste food plant – which it will then sell onto its customers. What makes Robin Hood Energy different from other energy suppliers is that there are no private shareholders and no director bonuses. The money that Robin Hood Energy makes from supplying energy is used to cover their overheads and any excess cash will be invested back into the company to cover infrastructure improvements and asset expansion. The company employs around 40 staff and is the first local authority-owned energy company to run on a not-for-profit basis, since the market was nationalised in 1948- Plymouth and Bristol city councils have similar proposals.

The company offers tariffs to all regions but mainly serves residents in the Nottingham area and has tariffs specifically for customers who live in the East Midlands, *The Robin Hood Energy Nottingham* tariff. The company's best tariff could save users over £200 per year: £859 vs £1095 (big six).[1]

CASE STUDY TWO: SCOTLAND:

Founded by 35 organisations, including some of Scotland's largest housing associations and local authorities, **'Our Power Energy'** is a not-for-profit energy company. The company will enter the market at the end of 2015, as an Ofgem-licensed supplier of gas and electricity, and plans to sell cheaper heat and power to around 200,000 homes across Scotland**.** The company predicts that households will save up to 10% on their energy bills, which by 2020 could see up to £11 million in savings for households in some of the most disadvantaged communities across the country. With backing from the Scottish Government (£2.5 million) and Social Investment Scotland (£1 million) the company hope to develop renewable energy and reduce fuel poverty.[2]

RECOMMENDATION 3

To radically disrupt the existing energy market with regional intervention based around a not-for-profit energy supply company. This social enterprise would be led – and underwritten - by regional partners drawn from local governments and other social agencies, with aims to offer a fairer deal to all users by buying from the open market and selling to customers at a competitive rate because it has less commercial overheads.

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[1] Balaam, F. (2015). *Not-for-profit energy provider launches, but is Robin Hood Energy any good?*. [online] MoneySavingExpert.com. Available at: http://www.moneysavingexpert.com/news/energy/2015/09/new-not-for-profit-energy-provider-launches-but-is-robin-hood-energy-any-good [Accessed 29 Oct. 2015].

[2] Our-power.co.uk, (2015). *Our Power*. [online] Available at: http://our-power.co.uk/ [Accessed 29 Oct. 2015].

4) Large scale renewable power supported by Smart grid

Demand

The current annual electricity consumption for Northwest is about 32 TWh (TeraWatt hour) Domestic - 12 TWh and non-domestic 20 TWh [1].

The Tyndall Manchester's, RESNET project in their high electrification scenario 'TNGS' estimates about 1.5 million heat pumps to be deployed by 2050. Similarly for transport 89% of entire car fleet in Northwest will be electric by 2050. The additional demand from heat pumps will be 2.8 TWh and the transport sector will add another 15 GWh of electricity. Overall the total electricity consumption by 2050 would be about 35 TWh.

Supply

There is a large potential for renewable sources in the Northwest to provide future electricity demand from a variety of fuel sources including Onshore Wind, Offshore Wind, Geothermal, Biomass and Tidal, Wave. Due to limited solar irradiation in the Northwest, this scenario does not consider Solar and focuses on large scale renewables only.

Wind Energy

Currently there are a number of wind farms both onshore and offshore are in operation with a combined capacity of 1282 MW around Northwest. About 24% of the current electricity demand (7.75 TWh) can be provided from the wind farm projects currently considered as shown in Table 1. The projects listed do not include the 'Celtic Array' offshore wind farm which was cancelled last year due to high foundation costs which could have a potential capacity of 2.2 GW. In future such projects could be considered again when offshore technology will be improved and costs are reduced.

Table 1: Wind farms in Northwest under various statuses [2]

Wind farms statuses	**Onshore capacity in MW**	**Offshore capacity in MW**
operational	282	1000
construction	35	
approved	100	1000
Planning	115	
Total	**532**	**2000**
Capacity factor assumed	**27%**	**37%**
Energy generation in GWh	**1258**	**6482**

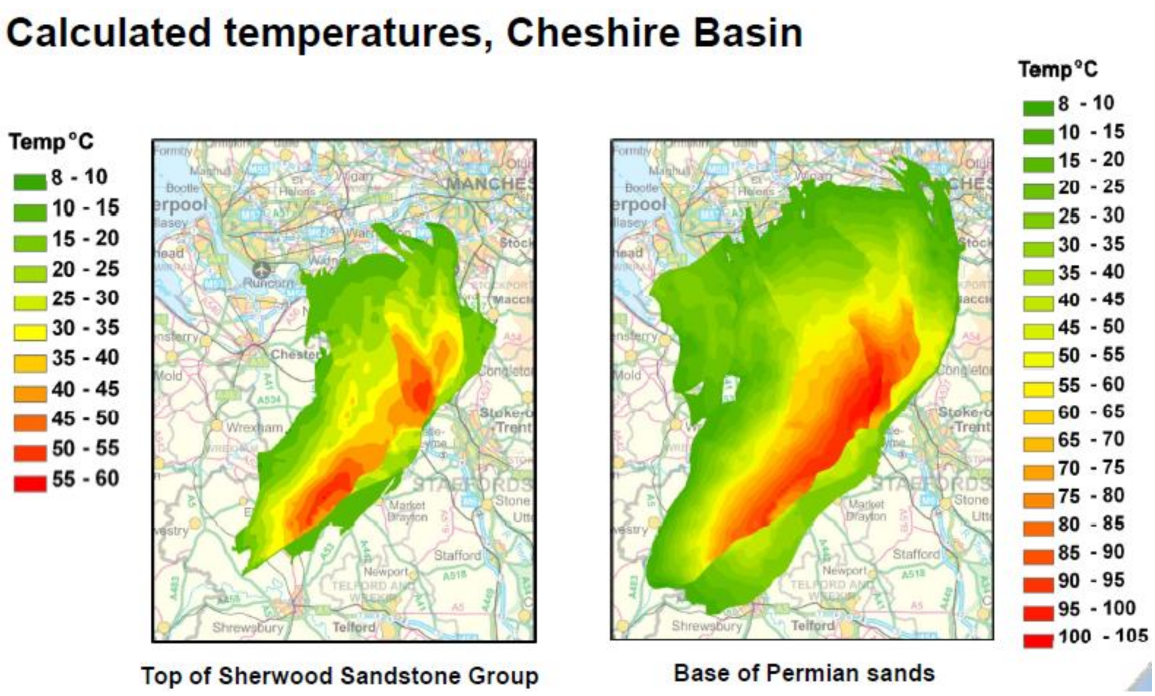
The former Northwest Regional Development Agency estimated the onshore wind resource for the Northwest to be 23 GW [3]. However, all off the resource may not be extracted and if 25% of the resource is extracted another 13.75 GW can be deployed which will provide another 13.6 TWh of electricity.

Opportunities from Wave

There is only limited potential from Wave on the Irish Sea and the sites available are of low yield sites due to blockages of wave propagation from Atlantic by Ireland. Majority of the high yield sites are on the west coast of Scotland and Cornwall. As the wave technology is still under development wide scale deployments are not expected before 2030. The PhD project from RESNET by Jaise Kuriakose estimates a maximum of 250 MW on the Irish Sea which can generate about 86 GWh annually.

Geothermal

The UK has really good potential to provide an exploitable geothermal resource at depths between 1 and 4 km. The basins of Cheshire, West Lancashire and Carlisle are suitable for geothermal heat which can be exploited through ground source heat pumps, shallow aquifers and deep saline aquifers. The British Geological Survey identified about 1600 TWh of geothermal resource in the Northwest. However only a small portion of the resource can be extracted practically and will be financially viable. Moreover, majority of the resource are suitable for only heating although combined heat and power plants (CHPs) might be technically feasible in the future.



Source: British Geological Society

Biomass

The former Northwest Regional Development Agency report [3] suggests that biomass energy can be utilized at large scale from a number of fuel supply sources. The report indicated about 1.3 GW of biomass power plants which can generate 20% of current electricity demand (6.9 TWh) assuming 60% capacity factor as shown in Table 2. The biomass power plants can be dedicated electricity power plants or CHPs. The recently announced waste wood combined heat and power (CHP) biomass plant in Widnes, Merseyside has a capacity of 20.2MWe and 7.8MWth which will be operational by end of 2016. It is anticipated that in future more CHPs will be installed due to the advantage of utilizing additional heat.

Table 2: Biomass power plants and capacity

Fuel type	**Capacity (MW)**
Energy crops	12
Plant biomass	82
Waste wood	39
Straw	11
Animal biomass	215
Organisc waste	206
Poultry litter	8
Municipal Solid Waste	210
Commercial industrial waste	135
biogas	96
Landfill gas	68
biogas	28
Co-firing	198
Total Biomass	**1308**

Opportunities for Tidal Power in Northwest UK

This region has a number of options that can be considered when looking to implement tidal technology. There are two types of Tidal power – Tidal streams and Tidal Range.

- **Stream turbines:** stream turbines operate like underwater wind turbines. With current turbine technology, in order to have significant impact, average current speeds will ideally need to be >~1.5m/s. There are no realistic sites between Mersey and Morecambe Bay.

Tidal Range

The potential tidal range sites and resource capacity for the Northwest as estimated by Burrows et al [4] are shown in table 3 with a total resource capacity of 12.9 GW which can generate 17.1 TWh. Tidal Range can be built in the form of barrages or lagoons.

Table 3: Tidal Range sites and resource capacity

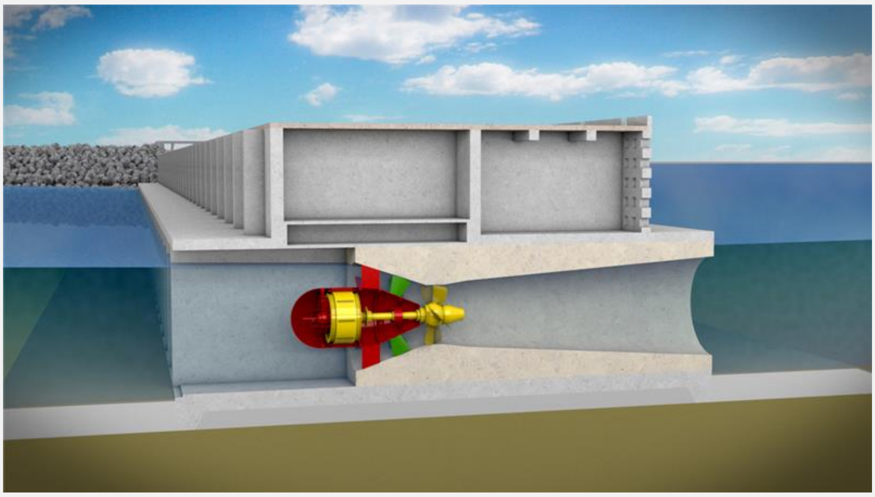
Location	Resource capacity (MW	Annual Energy (TWh)
Solway Firth	7200	9.66
Morecombe Bay	4000	5.98
Mersey	648	0.57
Dee	1050	0.89

- **Barrages**: are effectively a wall across the complete river estuary and can generate on both ebb and flood directions, current turbine technology favours ebb-only generation and some existing schemes include La Rance, France (240MW capacity) and Sihwa, South Korea (254MW). Barrages are seen as unfavorable option due to impact on river ecology - eg Severn Barrage proposals.

- **Lagoons**: this technology has been generating a lot of interest recently because its infrastructure doesn't block the whole estuary and hence less environmental impact, lower cost and construction time. An exemplar project is currently being developed at Swansea (see case below)

Since lagoons are favoured over barrages all of the resource identified won't be exploited in future. The PhD by Jaise Kuriakose estimated a maximum of 5.8 GW can be exploited in the Northwest which can generate 6.7 TWh.

CASE STUDY: Swansea Tidal Lagoon



16x20MW (6.35m diameter) Bulb turbines

120 year life span

11.5km^2 area

£1billion capital cost

5 year construction timeline

Avg. tidal range = 6.3m;

Based on our analysis *we believe annual yield for Swansea lagoon is ~ 250GWh on ebb-only or 345GWh on dual generation. This should power 100,00 homes*

Seeking strike price: £168/MWh for 35yrs

Hinkley Point C = £92.5/MWh

A study led by Poyry2014 [5] said tidal lagoon power projects could be cheaper than offshore wind and some could be cost comparable to nuclear generation. This headline statement was based on analysis of three proposed projects in the UK. The first ("Lagoon 1") is the Swansea Bay scheme. "Lagoon 2" and "Lagoon 3" are other, larger, projects at an earlier stage of development, in different parts of the UK. They are considered to be representative of a pipeline of multiple projects whose exact locations are commercially sensitive. The report says report says Lagoon 1=£168/MWh, Lagoon 2 = £130/MWh, Lagoon 3 =£92/MWh (comparable to current nuclear strike price)

(NOTE: question over the location on of the Mersey needs to be confirmed. A 4x4km lagoon will not fit into Mersey estuary easily without disturbing shipping lanes, etc, so we would likely need to be on the mouth of the river. We believe this would still generate the necessary power for our region.

KEY FACTS:

Maximum energy for ebb-only generation from a single tide cycle can be estimated as:

$E_{max}=4*\eta_{1way}*\rho*g*S*h^2$

where ρ is density of sea water, g the gravitational constant, S the area enclosed by the lagoon (assumed here constant with depth), h is the tidal amplitude (0.5*range) and η_{1way}=0.27[6].

Hence for 2 tides per day:

$P=2*\eta_{turb}*E_{max}/(24*3600)$

where η_{turb} is turbine efficiency.

POWER ANALYSIS	
Morecambe Bay Lagoon 500MW capacity Ebb-only generation. Mean h=3.07m [3] η_{1way}=0.85; Area, S=32km^2 (~5.7x5.7km) E=**665GWh/y** ~210,000 homes (using same housing energy ratio as Swansea figure)	**Mersey Lagoon** 300MW capacity Ebb-only Mean h=3.23m [3] eta_turb=0.85; Area, S=17km^2 (4.1x4.1km^2) E=**390GWh/y**
Power 210,000 homes	**Power** 123,000 **homes**
POWER POTENTIAL TOTAL:	**333,000 homes**

Managing intermittency

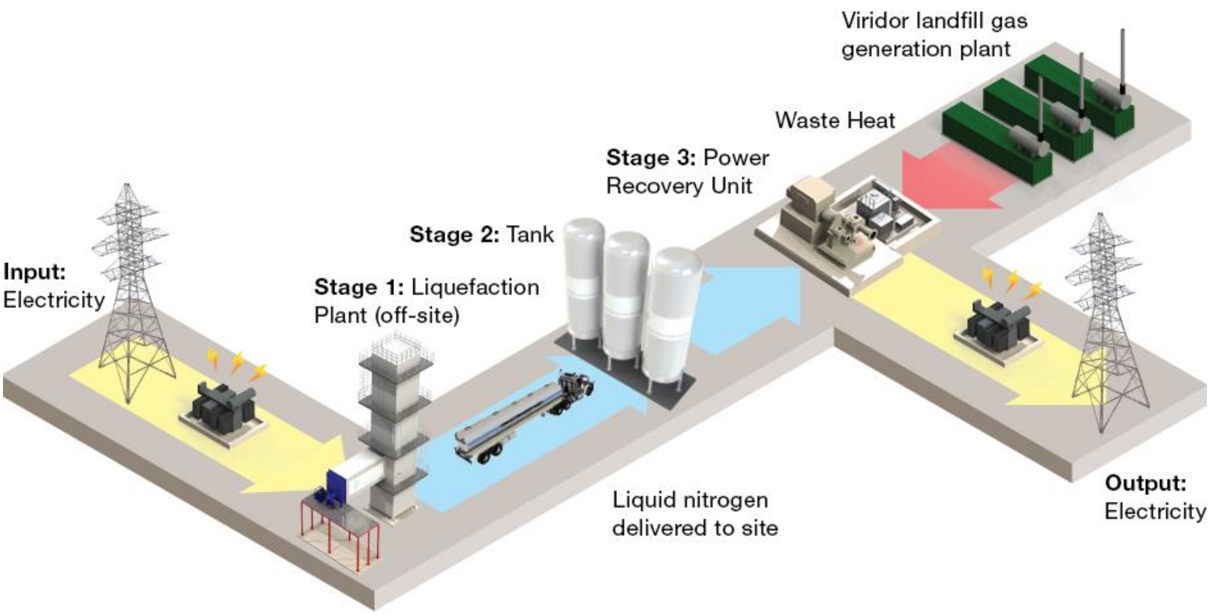
The scenario consists of a large amount of intermittent and weather dependent technologies primarily wind power. Although tidal range is variable throughout the year (daily and seasonal) it is more or less predictable. This is largely due to the relative position of the moon and sun with the earth. These variations are extremely predictable though, using something called ‘tidal constituents’ – which basically decompose the tidal cycle into a number of sine waves. Each constituent is known and summing the sine-waves back together, will give the shape of the complete tidal cycle again. Indeed the tides can be predicted years in advance using this method. The main part which is difficult to predict by this method is variation due to tidal ‘surge’, which is basically an increase in tidal height due to perhaps flood water running off land or stormy weather out in the Atlantic, driving in large swell waves, which act to increase the effective tidal depth.

The base load requirement for the Northwest can be provided by combining biomass and tidal range. The variability in generation due to changes in weather and tides means high levels of monitoring and network management systems with a ‘smarter grid’ is essential. The key smart grid technologies that could be beneficial are demand side management (DSM) and storage. DSM can be used to reduce the demand whenever there is a shortage of generation by providing tariff incentives.

There is no potential for new pumped hydro storage in Northwest. Hence the potential options for storage systems are solid state batteries (eg: Lithium-Ion) and liquid air energy storage (LAES). Batteries are useful for providing electricity for short durations such as few hours. Most promising technology is Lithium Ion and this scenario assumes grid scale battery systems similar to the one installed at Leighton Buzzard with a capacity of 6MW/10MWh.

The scenario focuses on large amount of wind power and there are periods of long spells of ‘Low’ wind speed periods. Another technology which is now getting popular is the Liquid air energy storage (LAES) which can be used to store electricity for more than a day. LAES operates by using excess electrical energy to drive an air liquefier and the liquid air is stored in an insulated tank at low pressure. When power is required, liquid air is drawn from the tank and pumped to high pressure. The application of ambient heat through heat exchanger results in a phase change of liquid air to a high pressure gas which is then used to drive a turbine and generator. The UK's first pre-commercial scale 5MW LAES plant will be operational by end of 2015 at Bury, Greater Manchester alongside a landfill gas generation site extracting the waste heat.

Lithium ion battery at Leighton Buzzard



Liquid Air Energy storage, Greater Manchester

RECOMMENDATION 4

It is anticipated that the future electricity requirement for Northwest under a high electrification of energy systems will be 35 TWh. The estimated future demand of 35 TWh can be reduced further through energy efficiency measures.

Considering the well-established renewable technologies of wind, biomass and tidal range, we recommend that a 100% of our electricity requirement can be provided from a mix renewables, as shown in the table below:

Option 4: 100% renewable power mix		
Technology	**Capacity in MW**	**Electricity (TWh)**
Wind current projects	**2532**	**7.74**
Wind future potential	**5750**	**13.6**
Biomass	**1308**	**6.87**
Tidal range	**5800**	**6.68**
Total	**15390**	**34.89**
Demand in Northwest		**35 TWh**

The intermittency from renewable can be managed by a combination of innovative storage systems and demand side management (DSM) techniques. Generation shortages during peak demand periods can be controlled through DSM, while any further generation shortages can be met by a combination of storage systems, including pioneering liquid air energy storage to renewable batteries.

Lead experts Jaise Kuriakose and David Lande-Sudall

References

[1] DECC, “Electricity: chapter 5, Digest of United Kingdom energy statistics (DUKES),” *DECC*, 2014. [Online]. Available: https://www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes. [Accessed: 31-Mar-2015].

[2] “RenewableUK | UK Wind Energy Database (UKWED).” [Online]. Available: http://www.renewableuk.com/en/renewable-energy/wind-energy/uk-wind-energy-database/. [Accessed: 19-Feb-2014].

[3] C. Fry, “Northwest renewable and low carbon energy capacity and deployment Project report,” 2010.

[4] R. Burrows, I. A. Walkington, N. C. Yates, T. S. Hedges, J. Wolf, and J. Holt, “The tidal range energy potential of the West Coast of the United Kingdom,” *Appl. Ocean Res.*, vol. 31, no. 4, pp. 229–238, Oct. 2009.

[5] P. Mohr and A. Lloyd, “LEVELISED COSTS OF POWER FROM TIDAL LAGOONS,” Oxford, 2014.