Penarth Renewable Energy Plan

A Clean Energy Future for Penarth

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1.0 FOREWORD:

A clean Energy Future for Penarth

Penarth, *a beautiful costal town, is* ***rich of renewable energy and*** *has* ***great development potentials for renewable energy****. Hence,* ***a clear energy future*** *is not just a dream for Penarth.*

Position Our Plan:

- ***As a students' assignment,*** we only have three months and we are just beginning to learn "renewable energy". Our knowledge and time is limited, but we spare no effort to read more, to learn more, and to do more, thereby making this plan better and contributing to a sustainable Penarth.
- ***As a task cooperated with GPG,*** different from traditional government plans, this is a bottom-up plan rather than a top-down plan. Hence, this plan encourage more public invovlement, and provide more information on how to realize a renewable Penarth by community themselves.

Plan Objectives:

- ***To enable Penarth's residents to understand Renewable Energy, and to encourage them to participate in renewable energy development***. Clearly, social drivers are the one of the most important aspect for a community to develop renewable energy, which has been demonstrated by many previous cases.
- ***To identify the potentials for developing renewable energy in Penarth.*** Based on a relatively comprehensive study of the possibility of every renewable energy technology in Penarth, we will identify the potential types of renewable energy and their suitable location in Penarth.
- ***To provide the guide of renewable energy development for Penarth*** which serves as a starting point when they decide to adopt renewable energy.

2.0 CONTEXT:
Why Renewable energy for Penarth?

***Thinking globally and acting locally**, it's the time for Penarth to make this change.*

2.1 WHAT Is Renewable Energy?

"…The future belongs to renewable energy…"

Brad Colllins, the executive director of the American Solar Energy Society

" Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources."

IEA (International Energy Agency), 2002

Biomass

Biomass *refers to the use of a wide variety of organic material such as wood, straw, dedicated energy crops, sewage sludge and animal litter for the generation of heat, electricity or motive power.* (Carbon Trust, 2006) Biomass can be used to produce various energy source, such as transport fuel, electricity and heating.



Tidal Power

Tidal power *is a form of hydropower that converts the energy of tides into electricity or other useful forms of power.* Although not yet widely used, tidal power has potential for future electricity generation. The Department of Trade and Industry has stated that almost 10% of the United Kingdom's electricity needs could be met by tidal power.



Solar PV

Solar Photovoltaics (PV) *is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect.* PV power generation employs solar panels composed of a number of cells containing a photovoltaic material. (Jacobson, 2009)



Solar Thermal

Solar Thermal Energy *is a technology for harnessing solar energy for thermal energy (heat).* ***Solar water heating*** systems is the most common domestic use solar thermal energy, which generate *renewable hot water* through collecting the heat from the sun by the solar panels fitted on the roof. It could be the most cost-effective and environmentally-friendly way to generate hot water for domestic use.



Geothermal Technologies

Geothermal Energy is thermal energy generated and stored in the Earth. ***Ground-source heat pumps (GSHPs)*** is one kind of widely used geothermal. GSHPs take low-level heat which occurs naturally underground and convert it to high-grade heat by using an electrically-driven or gas-powered heat pump to provide both heating and cooling . (Carbon Trust, 2006)



Wind Power

Wind power is the conversion of wind energy into a useful form of energy, such as using ***wind turbines*** to make electricity, windmills for mechanical power, windpumps for water pumping or drainage, or sails to propel ships. In the UK, wind power is the most well developed and economically viable form of renewable energy. (Carbon Trust, 2006)



2.2 WHY we need renewable energy?

*One thing is clear: **the era of easy oil is over**… **New energy** discoveries are mainly occurring in places where resources are difficult to extract, **physically, environmentally, economically, and even politically.** (Chevron, 2006, "Will you join us?" advertising campaign)*

Think Globally…

Environmentally	*Socially*	*Economically*
…Carbon Emission, Animals, Air Pollution, Temperature, Ice, Disappear, Climate Change, Polar Bears, Melt, Ecosystem, Global Warming, Urgent, Species Extinction, Human Beings, Sea Level, Rising, Global Warming, Flooding Out….	…Conflicts, Profits, Oil, Struggle, Country Equality, Interests, Natural Resources, Energy Wars, Developing Countries, Political Weapon, Peace, Harmonious, Blood, Alarming, Suffering, The Public, Campaigns…	…Fuel Prices, Energy Bill, Money, Increasing, More And More, Oil ,Gas, Exposed, World Market Fluctuations, Economic Growth, Uncertainty, Business, Cost, Barriers, Long-term, Interruptions, petrol, affordability, going up, continuous…







Act Locally…

Environmentally

Choosing renewable energy in Penarth enables us:

To reduce the consumption of fossil fuel;

To help to curb the proliferation of environmental pollution by ourselves;

To contribute to environment conservation and animal protection;

To use clean electricity /heat generated locally; and

To create a sustainable environment in Penarth and for our world.



Socially

Having renewables generated locally enables us:

To reduce energy reliance on other regions or other countries;

To be self-reliant and independent;

To ensure energy safety in our community;

To participate in the community renewable energy schemes;

To have stronger sense of community; and

To promote the social sustainability in our community.



Economically

Developing renewable energy in Penarth enables us:

To develop local green industry;

To attract more investment in Penarth;

To create a large number of local employment opportunities;

To promote sustainable economic-growth in our community;

To reduce energy bill in a long term; and

To promote the economic sustainability in our community.



2.3 Why **NOW?**

Why renewable energy now? Why not 10 years before, or 10 years after? Why it's time for renewables?

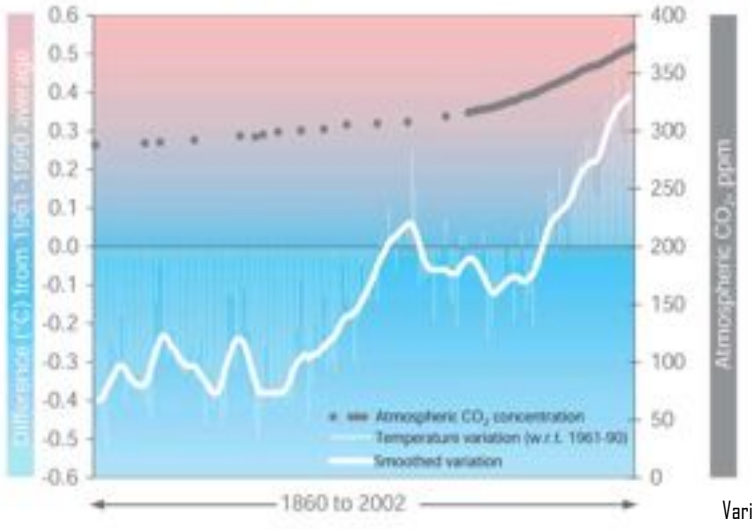


AN ENVIRONMENTAL URGENCY

The latest reports from the Nobel Prize-winning Intergovernmental Panel on Climate Change (IPCC, 2007) addressed that ***business-as-usual scenario would likely lead to about 3℃ warming by 2050***, which results in:

- *Major (20-80%) loss of Amazon rainforest;*
- *15–37% of global species to be 'committed to extinction;*
- *More than 1 billion people projected to face freshwater shortages .*
- *20 inches of sea level rise, many coastal areas are flooding out; threatening the homes of 25 million to 40 million people.*
- *2/3 of the world's polar bears could disappear*
- *increase by over 50% of forest wildfire burn area;*
- *Arctic would retain ice year-round*
- *16 million new cases of kidney stones by 2050 as a result of global warming. extreme weather causing*

Changes in our atmosphere are already underway!



"…Over the last century we have seen a rise in the atmospheric concentration of carbon dioxide from 280ppm to some 370ppm. Coincident with the rise has been an increase in global average temperature, up by nearly 1oC…." (WBCSD, 2005)

In essence, the increasing consumption of fossil fuel is the root of climate change, hence we should and must have the alternative clean energy.

How urgent is it?

Various predicted data and description are warming us how urgent it is: "Humans are messing with climate and will, sooner or later, get burned if they keep it up.'(Kerr, 2007)

When should we start to take an action?

Many scientists are more convinced than ever that immediate action is required. ***The time to start is right now!***

Variation in atmospheric CO2 and global temperature since 1860 (source: Hadley Centre, CDIAC and WBCSD)

2.3 Why **NOW?**

Why renewable energy now? Why not 10 years before, or 10 years after? Why it's time for renewables?

GREATER FINANCIAL SUPPORTS

There are increasing financial supports from government or non-government originations at different levels available for Penarth. With an ambitious aim of more than 30% of electricity, 12% of heat generated from renewables, UK government will "…provide financial support for renewable electricity and heat worth around £30 billion between now and 2020" (DECC, 2009) Meanwhile, ***in order to encourage small-scale renewable heat and electricity generation in community, more fundings from European Committee, UK national government and Wales regional government are available.*** Some of these are listed below. Furthermore, especially after 2011, the Feed-In-Tariff and Renewable-Heat-Incentives are enacted as "Clean Energy Cash-Back".



With such a great sum of financial supports, It is really a good time to start a renewable energy scheme in Penarth.

Various levels	Funding programme	Notes
EU	European Regional Development Fund (ERDF)	The funds is to strengthen economic and social cohesion, including energy efficiency and renewable energy in the EU countries.
	Intelligent Energy	Schemes of energy saving and boosting of renewable energy source in EU countries can apply for it.
	FP7	The fund's scope includes feasibility research and the implementation of renewable energy in EU.
	European Local ENergy Assistance (ELENA)	The fund is for investments in sustainable energy at local level.
	European Investment Bank (EIB)	It is used to bring forward onshore wind projects
	…	….

A List of financial supports of renewable energy available for Penarth from European committee

Various levels	Funding programme	Notes
UK	Feed-In-Tariff	From April 2010, Households, communities and small businesses investing in projects up to 5MW
	Renewable Heat Incentive (RHI)	From April 2011, for Individuals, communities and businesses generating renewable heat at all scales.
	Community Sustainable Energy Programme	The Community Sustainable Energy Programme provides funds to community-based organisations for feasibility studies and the installation of microgeneration technologies
	Enhanced Capital Allowances (ECAs)	enable a business to claim 100% first-year capital allowances on their spending on qualifying plant and machinery
	E.ON	grants of up to £30,000 for UK community energy projects
	interest-free Energy-Efficiency loans	up to £100,000 are available through the Carbon Trust for replacing or upgrading existing equipment, such as lighting, boilers or insulation.
	Lottery Funding for Bio-Energy Projects	Some £630 million a year is from The National Lottery
	ScottishPower - green energy trust	Supports renewable energy projects across the UK and aims to promote education in the community on renewable energy generation.
	Green energy fund - EDF	Funding is provided to cover the costs associated with the installation of small-scale renewable technology at community level
	...Community Action For Energy (CAfE)	CAfE is a pilot programme from the Energy Saving Trust that is designed to promote and facilitate local community-based energy projects
	....	....
Wales	Community Scale Renewable Energy Generation Programme	provide advice and grants to support the development of community-sized renewable energy schemes across Wales, through the Energy Saving Trust.
	DTI's Low Carbon Buildings Programme (LCBP)	funded by the government, provides grants for microgeneration technologies to householders, community organisations, schools, the public and not for profit sector and private businesses
	E.ON Sustainable Energy Fund	Funding for energy efficiency, micro-generation and other low carbon measures is available to community groups
	Wood energy business scheme	WEBS 2 is a new multi-million capital grant scheme for Wales. The scheme will help businesses to install wood fuel heating and Combined Heat and Power (CHP) technologie
	Environment Wales	Environment Wales offers funds to voluntary organisations and community groups which undertake projects contributing to sustainable development by helping to protect the Welsh environment.
	...	...

A List of financial supports of renewable energy available for Penarth from UK national level and Wales regional level

2.3 Why **NOW?**

Why renewable energy now? Why not 10 years before, or 10 years after? Why it's time for renewables?



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Community plans for a greener Penarth

Campaigners in Penarth are launching a number of initiatives to encourage people to shop locally and to be more environmentally aware.

Gwyrddio Penarth Greening (GPG) is launching a loyalty card scheme to encourage people to shop with retailers in the coastal town near Cardiff.

They've run a competition for school children to design a cotton shopping bag to discourage plastic bag use.

There are also plans for a garden plot share scheme and a community orchard.

A loyalty card will encourage more people to shop locally

BBC news, 9 August 2010 (source: www. bbc.co.uk)



GPG Event: the Launch of Shop in Penarth (SiP) (source: www.gpgpenarth.org.uk)

STRONGER SOCIAL DRIVERS

With the increasingly urgent situation of climate change, ***the public's awareness has been raised*** to some extent. More people have been aware of the significance of sustainability, not only to the individual, but also to our common planet.

Increasing non-profitable organizations, such as GPG (Gwyrddio Penarth Greening), have been established to push the green transfer, and also to promote their community to develop in a sustainable pattern.

Because of these community organisations, the renewable energy development in community has been largely promoted**.** By 2010, *"…community organisations in Wales are to benefit from a £15m investment in green energy technology." (BBC, 2010)* Environment Minister Jane Davidson said: "This will benefit these organizations through reduced fuel costs as well as provide the opportunity to secure a sustainable income."

Meanwhile, the push of community group as well as the successful experiences encourage more local residents. Nowadays, ***increasing people are willing to be involved with a sustainable event, and happy to create a clean future for their communities***.

GPG and the morale of local residents are crucial driving forces for renewable energy development in Penarth.

Therefore, confronted with **such an urgent environmental problems**, and with **sufficient financial supports** from governments as well as **the social drivers** from local residents, ***it is really a right time to make it happen, a renewable future for Penarth***.

3.0 INVESTIGATION:

Renewable Energy & Penarth

*In Penarth, what are the **drivers and challenges** for developing renewable energy?*

Current Energy Demand in Penarth

The energy consumption in Penarth

In order to plan the renewable energy supply for Penarth, it is essential to realize the energy demand status. For it not only provides the total amount of energy consumed in Penarth, through the analysis, the distribution of different level of average energy consumption also identify the high energy demand area.

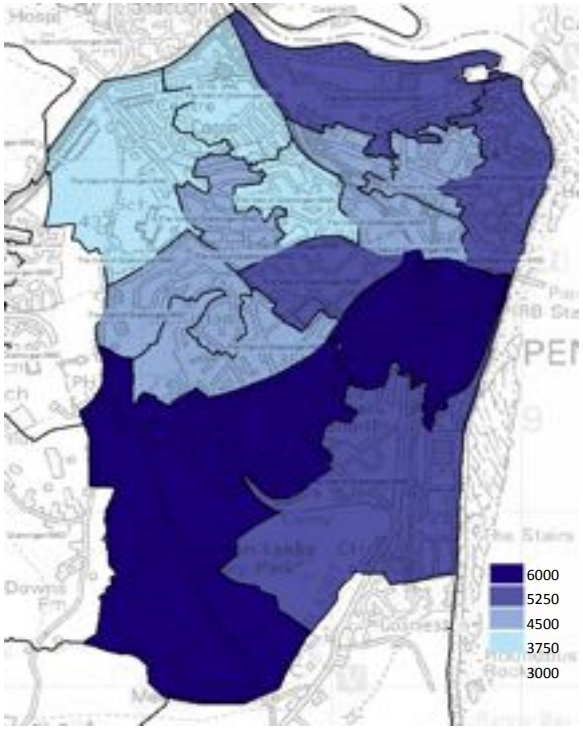
These data could be served as a benchmark for quantitative prediction and as a reference for locating the different renewable technologies.



Electricity

The electricity consumption in each Lower LSOAs is shown on the table. In 2009, the total electricity consumption was around 39GWh and the average consumption per household was 4.4MWh.

The diagram beside shows the distribution of different level of energy intensity in term of the average household electricity consumption. It shows that the households in lower Penarth possess higher electricity consumption followed by households in marina and city centre. While household in north-west Penarth consumed less electricity than others.



Electricity consumption in Penarth

	Electricity consumption (kWh/yr)*	Household**	Average consumption per household (kWh/yr)
A	3819370	776	4922
B	2318730	600	3865
C	2437613	600	4063
D	4136317	791	5229
E	2149378	606	3547
F	2185158	623	3507
G	1951539	503	3880
H	1690579	492	3436
I	2039819	515	3961
J	2326722	498	4672
K	4110854	759	5416
L	2736185	649	4216
M	3638099	638	5702
N	2971714	647	4593
Total	38512077	8697	4428

* Data source: LLOSA domestic electricity estimates 2009, DECC.

**Data source: Household Spaces and Accommodation Type, Office for National Statistics, 2001.

Current Energy Demand in Penarth

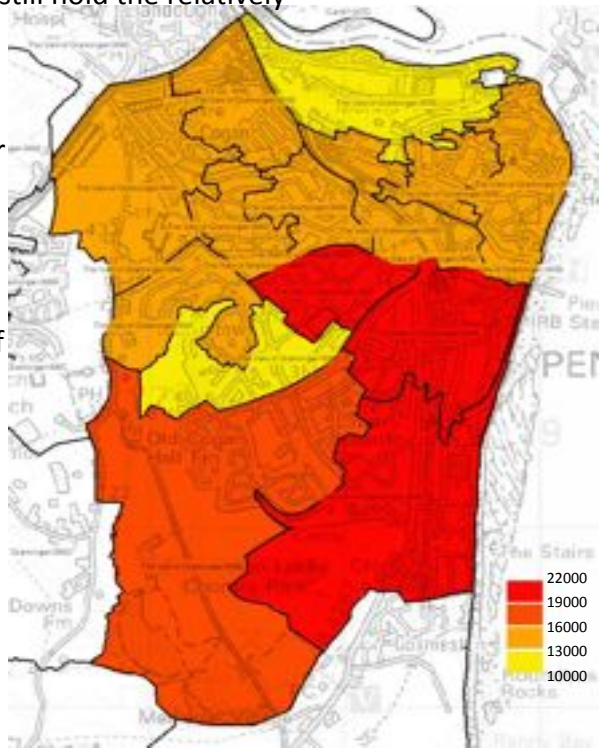
The energy consumption in Penarth

Gas

The gas consumption in each Lower LSOAs is shown on the table. In 2009, there was about 142GWh of gas had been consumed in Penarth and the average consumption per meter was 16MWh.

The diagram shows the distribution of different level of energy intensity in term of the average meter gas consumption. Drawing from this diagram, the majority of average gas consumption was focused on the range between 13-16MWh. However, household in lower Penarth still hold the relatively Higher demand than other area.





Summary

From the analysis above, the character of the energy demand in Penarth can be concluded:

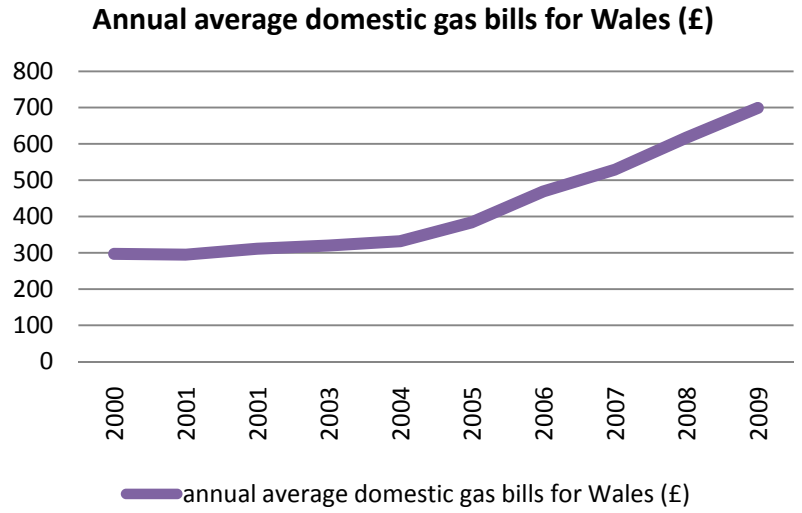
1. Gas is the major energy source for households in Penarth which consumed more the three times of the amount for electricity.
2. The households in lower Penarth possess the highest energy demand both for electricity and gas. This could be served as the reference when conducting the plan for renewable energy supply.

Gas consumption in Penarth

	Gas consumption (kWh/yr)*	Meters*	Average consumption per meter (kWh/yr)
A	7612057	518	14695
B	7959134	515	15455
C	8037215	577	13929
D	7372114	468	15752
E	7851226	603	13020
F	10168919	513	19823
G	10547056	919	11477
H	10923748	684	15970
I	10850785	720	15071
J	10125254	666	15203
K	17719588	821	21583
L	7830385	645	12140
M	10804923	635	17016
N	13988425	664	21067
Total	141790829	8948	15846

* Data source: LLSOA domestic gas estimates 2009, DECC.

Current energy supply in Penarth



The graph shows a sudden ***rise in the domestic gas bills*** around 2005 and a ***constant increase*** has been depicted since then. This indicates a need for more renewable and economically sustainable gas sources.

Assuming an annual gas consumption for an average ***Penarth dwelling as 16500 kWh the annual cost for gas varies from £578 to £825.*** (UKPower.co.uk, 2011).

HEAT:

- The majority of Penarth is ***heated by gas boiler, supplied by mains gas***.
- ***A slight proportion of modern apartment buildings*** are heated ***by electrical heaters***.
- ***Some houses*** in Penarth ***also use wood stoves***, but the ***numbers are small.***
- And there ***is no district heating currently***.

[Tim, 2011, this information is also helped by Tim (Energy efficiency group) as they did investigation of local energy consumption]

Gas being the major source of heating it is important to know that there are primarily ***5 major gas suppliers for Penarth***: British Gas, Scottish Power, E.ON, nPower and EDF including some other retail suppliers such as Good Energy and Utility Warehouse.

Of these ***only Good Energy*** providing with a tariff with ***incentive to support renewable energy generation.***

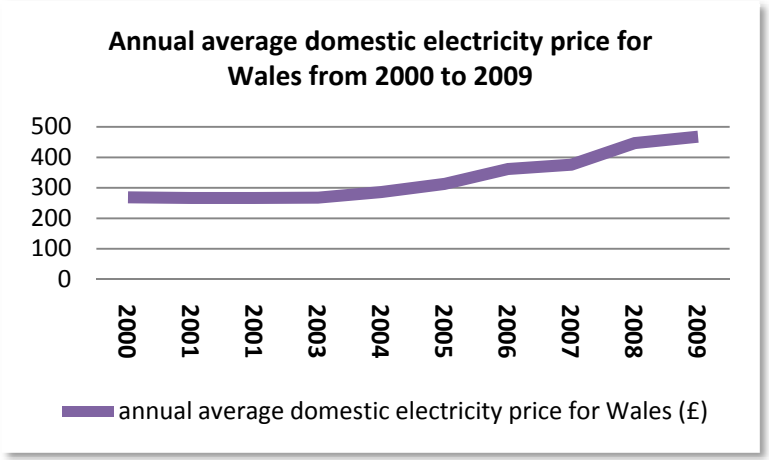
There have been evidences of rapid price hike such as The Scottish Power declared an increase in the gas prices by 2% in Nov., 2010 while Scottish and Southern Energy declared an increase in the price 9.4% around Dec., 2010. (BBC, 2010)

Current energy supply in Penarth



Lists of electricity supply companies to Penarth

Only renewable	*LO CO2 Energy; Ecotricity; Green Energy UK; Good Energy.*
Only non renewable	*EDF; Swalec*
Both	*British Gas; nPower; OVO Energy; Scottish Power; E.ON*



Source: DECC, March 2011

ELECTRICITY:

➢ ***Supply company:***

There are 6 major electricity suppliers in Penarth: British Gas, nPower, EDF Energy, Scottish Power, E.ON Energy and Scottish and Southern Energy including certain other retail electricity companies. These suppliers supply a variety of tariffs which include both renewable (supplied from sources such as CHP etc.) and non renewable electricity sources.

Electricity is generated at 3 stations located near Penarth; Combined Cycle Gas Turbine generators located in Barry and 2 coal-fired station at Uskmouth, Fifoots and Aberthaw.

Electricity price have been on ***a constant rise*** and are expected to rise in the future as can be seen in the energy price trends.

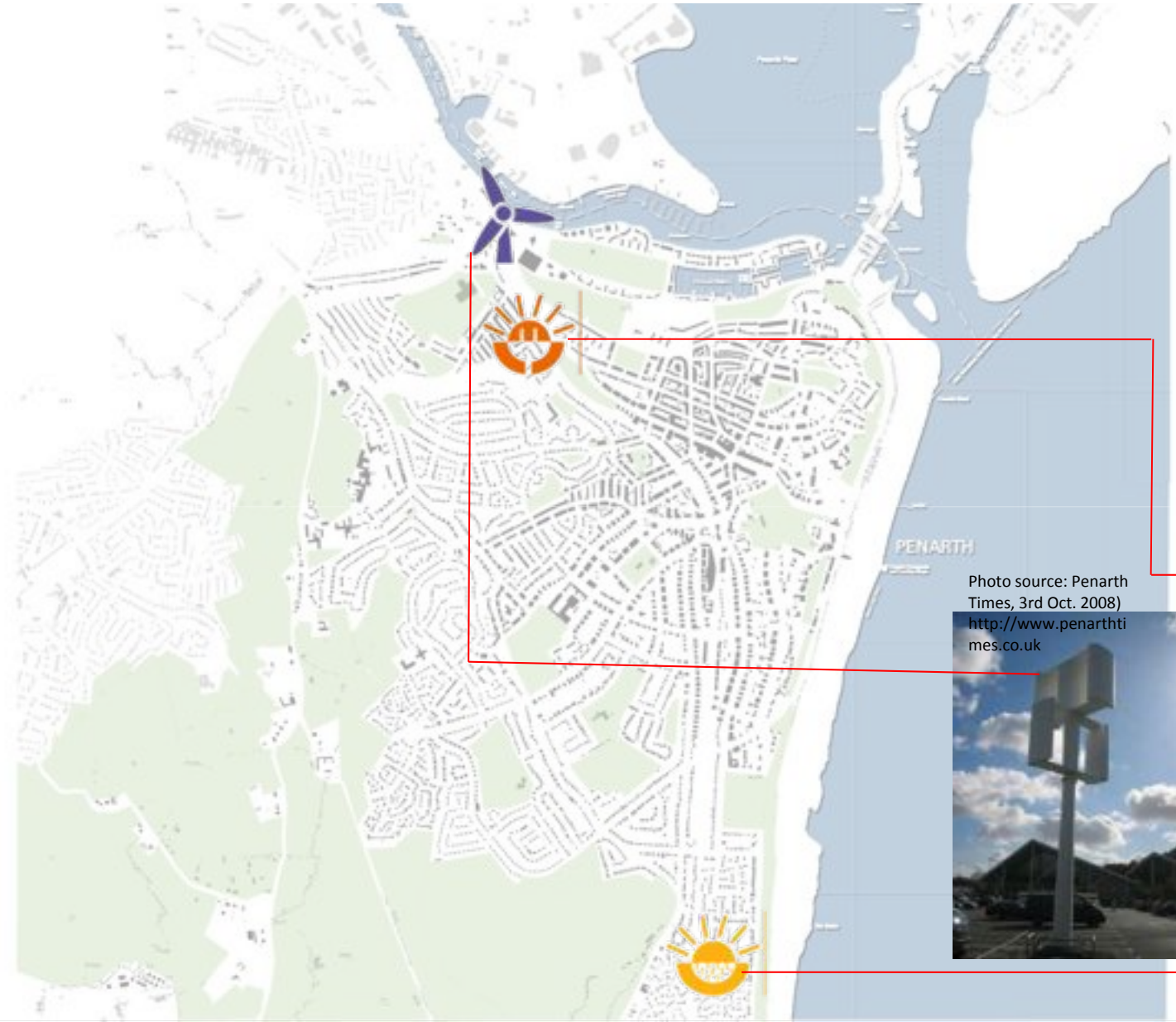
Assuming an annual energy consumption for an average ***Penarth household as 3300 kwh the annual costs for electricity vary from £360 to £526*** (UKPower.co.uk, 2011).

Hence, the long-distance transmission and electricity generated from non-renewable sources causes the increase of electricity bill. This actually demonstrates the ***necessity and potential benefits of locally renewable energy supply***.

"Changing energy prices are now becoming more and more common place but ultimately the dominant trend represents an increase. We believe at Alternative Energy UK that increasing energy costs for all will continue long into the future…" (Alternative Energy Systems (UK) Ltd., 2010)

There have been evidences of rapid price hike such as The Scottish Power declared an increase in the electricity prices by 8.9% in Nov., 2010 while British Gas increased the price of electricity by 7% around the same time. (BBC, 2010)

Existing renewable energy in Penarth



Due to the lack of Penarth's renewable energy outputs statistics, the specific proportion of renewable energy is not avialable. But, according to our preliminary survey (observations and interviews), ***the installed renewable energy systems in Penarth are very few, and the proportion of energy from renewable sources is negligible.*** *[The actual contribution of renewable resources to Wales's electricity production is 4%, and the heat from renewables in Wales is less than 0.5% and comparing this with the land area of Penarth, the percentage of renewables in Penarth is estimated to be very less.](DBERR, 2010)]*

Photo source: Penarth Times, 3rd Oct. 2008) http://www.penarthtimes.co.uk



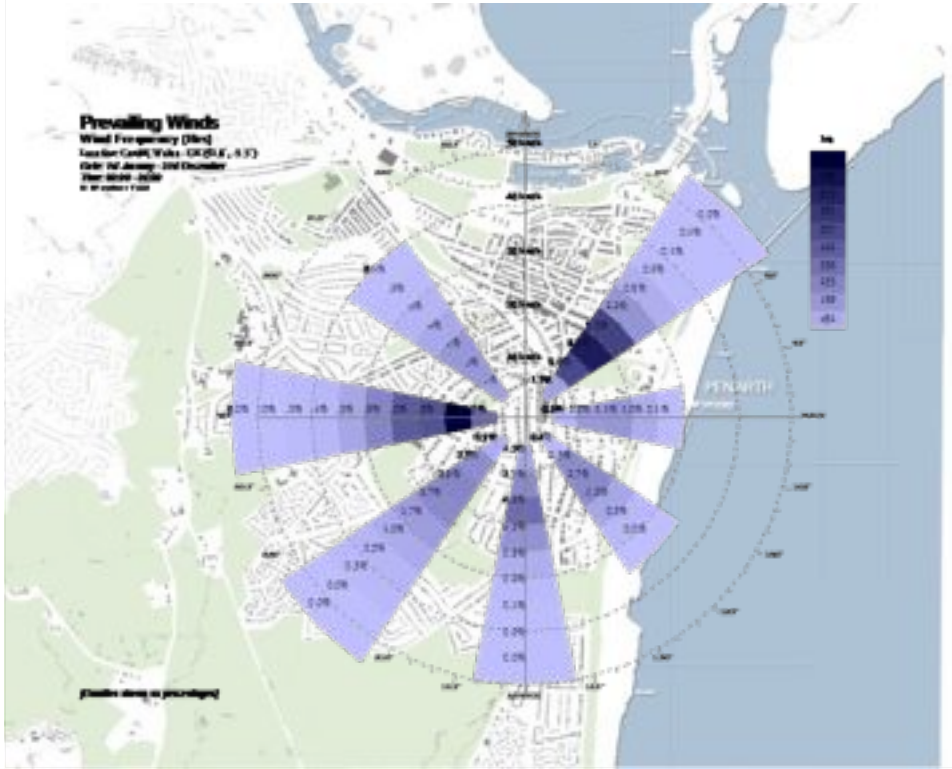


Renewable energy potential in Penarth

Penarth is rich in resources such as wind and tidal, solar radiation and has great potential for other renewable technologies such as geothermal etc.

Wind Power

The annual wind rose diagram for Penarth below shows that Penarth experiences prevailing winds throughout the year with optimum speeds which can ensure a more or less continuous electricity generation whole year round.



Tidal

The tidal range available for Penarth can be regarded as the second highest in the world as it has been mentioned that, "the Severn Estuary has the 2nd highest tidal range in the world." (White water fishing trips and charter, 2011)

Tidal range as high as 13m and high tidal velocities have been recorded.



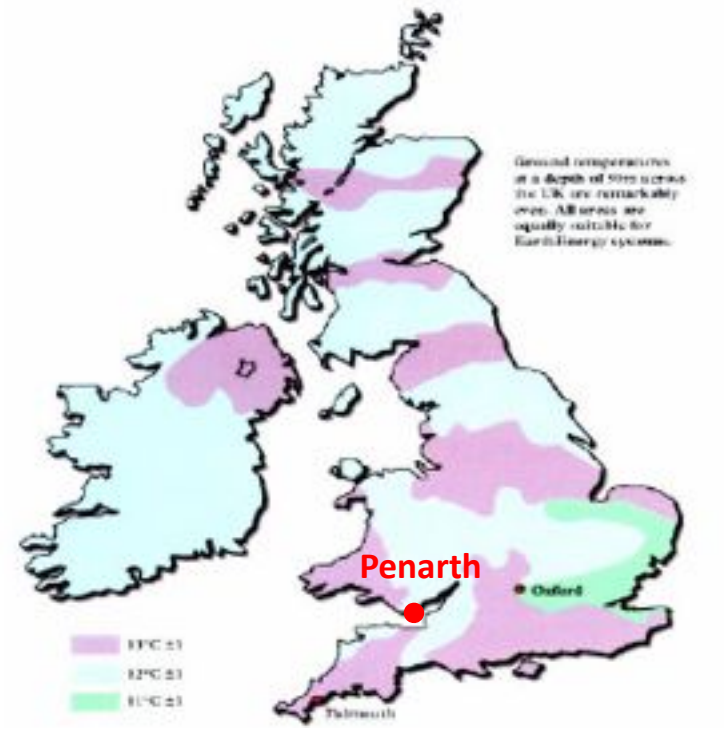
Renewable energy potential in Penarth

Penarth is rich in resources such as wind and tidal, solar radiation and has great potential for other renewable technologies such as geothermal etc.

Geothermal Technologies

Since energy obtained from geothermal resources depends on the underground temperatures the map shows that for Penarth these temperatures are approximately 12 °C to 13 °C at a depth of 50m which are quite favorable to tap geothermal energy. (Feuvre P.L. pp 70)

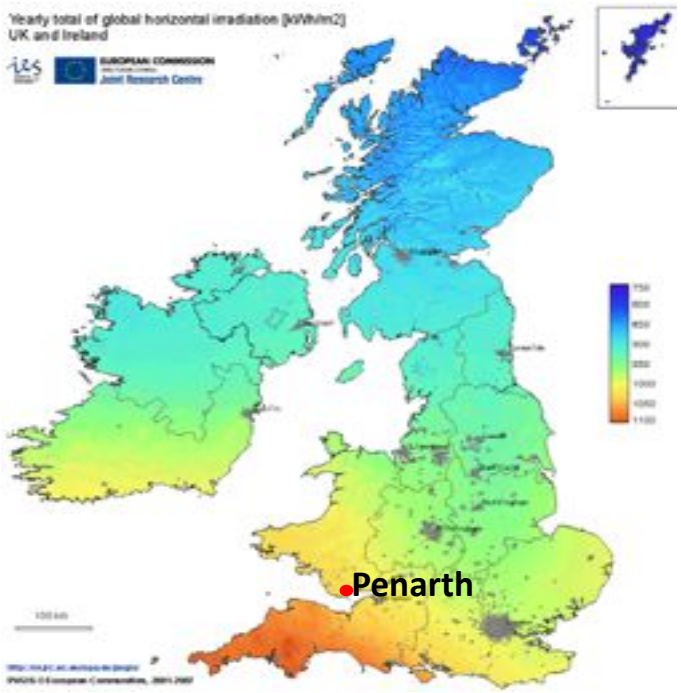
Ground Temperature in the UK at a Depth of 50M (Source: Feuvre P.L. pp 70)



Solar

The map given below gives an idea of the total global solar irradiation incident in the UK. It can be seen from the map that the amount of incident radiation for Penarth is ~1050 kWh/m² which is quite high as compared to most of the other places especially up north thereby indicating high potential foe tapping solar energy in Penarth.

The Solar Radiation in the UKPhoto source: mappery.com



3.2 Development **CONSTRAINTS** in Penarth

Why there are so few applications of renewable energy in Penarth? What constrain the development of renewable energy in Penarth?





Although ***the renewable sources are rich in Penarth***, and there is great potential for renewable energy development in Penarth, ***the current share of renewables is limited***.

Based on informal interview with local residents and preliminary survey, the development ***constraints of renewable energy in Penarth can be summarized as the following points***, some of which are also identified by Leaney et al (2001) as the major barriers for community involvement:

1) **Lack of knowledge of Renewable Energy:**
   Although many dwellers know that renewable energy benefits to our environment, most of them are still unclear about various types of renewable energy technologies, especially on the long-term advantages on different aspects and their potential limitations. Hence, a comprehensive knowledge and holistic understanding of renewable energy is crucial for them to participate in selecting a suitable renewable schemes for themselves.

2) **Uncertainty of how far can they go:**
   When asking dwellers how much proportion of energy from renewable sources do you want realize in your community. Most of their answers were *"I am not sure how far can we go, but the more, the better"*, which reflects their ambitious but also shows their uncertainty.

3) **Uncertainty of where can they adopt renewable energy:**
   Local residents can tell that wind turbines are suitable in rural areas and tidal power can be used on Penarth's shore, however, all of the understanding is general and obscure. Regarding to system's efficiency, reliability and other issues, they actually need a preliminary study on the suitable location for various renewable energy in Penarth.

4) **Uncertainty of how can they run a renewable energy project:**
   One of the major barriers for community is that they do not know how to launch a renewable energy project. What should they do step by step? For example, where can they get the financial supports, do they need a detailed feasibility survey before applying for planning permission, where should they go for consultation and so forth. All of these questions are fairly important for a successful community renewable project.

3.3 SOCIAL DRIVERS in Penarth

With the challenge ahead, we also have strong supports from the local residents. That would be precious and powerful social drivers for the development of renewable energy.







However, in spite of those potential barriers in front of them, we can still feel ***the strong confidence in a renewable future from the local residents*** in community meeting.

The public does hope a renewable future for Penarth and are more than willing to contribute to this transfer.

More importantly, ***many of them mentioned they do not think history town is a constraint for renewable energy development***, which is quiet different from what local planning officer concerns. When we inquired the possibility of renewable energy to principal planning officer for Penarth, the lady identified that the main reason why no renewable applications have been submitted is largely down to the town's conservation area status. (Andy Close, 2011)

It can be seen that ***local residents have clearly shown their positive attitude towards renewable energy, plus the push from GPG***, which will be fairly ***powerful social drivers for renewable energy development in Penarth***.



"...I do hope we can have more renewable energy supply in Penarth"

"...personally, every kind of renewable energy technology are welcome, such as PV, wind turbine, biomass...."

"... we should be open minded to those new technologies, shouldn't we?. ..only because Penarth is a historical town doesn't mean we cannot accept new things... "

"... to me, I really don't think PVs or wind turbines will cause a big visual impact, and I even feel it is ok to have PVs on church..."

"... what about tidal? Is it too expensive for Penarth? But as a coastal town, we should take the advantage of this nature resources to use the tidal power coz it is also renewable and environmentally-friendly...."

"...I would like to be involved in some renewable energy schemes in our community, it would be fantastic if we can use renewable electricity and heat generated locally..."

"... in terms of government-led and community-led projects, I prefer a community-led renewable energy system since we are able to choose the one which does suit us and benefit to us...."

Abstract of community meeting 9th April. 2009.

3.4 WHAT should we do?

Understanding the key development constraints of renewable energy in Penarth, what are the desired outcomes of this plan.

There are many barriers for community to develop renewable energy, however, actually there are more supports from local residents.

Then, **what is this plan supposed to do?**

Providing useful information on renewable energy development in Penarth and helping them over to clear away those barriers.

Hence, **the desirable outcomes of this plan** consist of:

1) A suitable Renewable Energy vision for Penarth:

Local residents are uncertain of how far can they go towards renewable energy, so a suitable vision is important for Penarth. Only having a clear target will they know where to go and how to go there.

2) Potential locational plan of renewable energy in Penarth

The potential location of various renewable energy technologies will be shown in this plan. These site selection is based on technologies' features and preliminary survey, which is to demonstrate the potential development of renewable energy for Penarth. Hence, further feasibility researches, including detailed surveys of energy load and cost-benefit appraisals, are still necessary.

3) Operational checklist of renewable energy for Penarth

One of the major barriers for community is they do not know the whole process of a renewable energy project. Hence, this report will provide a clear operational checklist. The whole process of installing a renewable energy system is explained step by step, and the consultant organisations and system installers available to Penarth are also listed.

4) Background knowledge of renewable energy

A relatively comprehensive background knowledge of various renewable energy technologies will be in the end of this report, which includes a critical evaluation of every technology. This enables residents to have a holistic understanding of various renewable energy technologies. Furthermore, some successful cases are also summarized in order to identify useful lessons for Penarth's future development.

This background knowledge is not only useful for residents to know more about renewable energy but also crucial for the renewable energy development, which has been proved in many cases. For example, Upreti & Horst (2004) explained the reason of the failed development of a biomass CHP plant in North Wiltshire that *"Lack of understanding of the long-term environmental advantages of biomass energy, general lack of knowledge of biomass technologies and misunderstandings which arose during the planning process cause the public perception of risks and mistrusts."*

Major barriers for Penarth's renewable energy development:

1) Uncertainty of how far can they go:
2) Unsureness of where can they adopt renewable energy:
3) Unsureness of how can they run a renwable energy project:
4) Lack of knowledge of Renewable Energy:



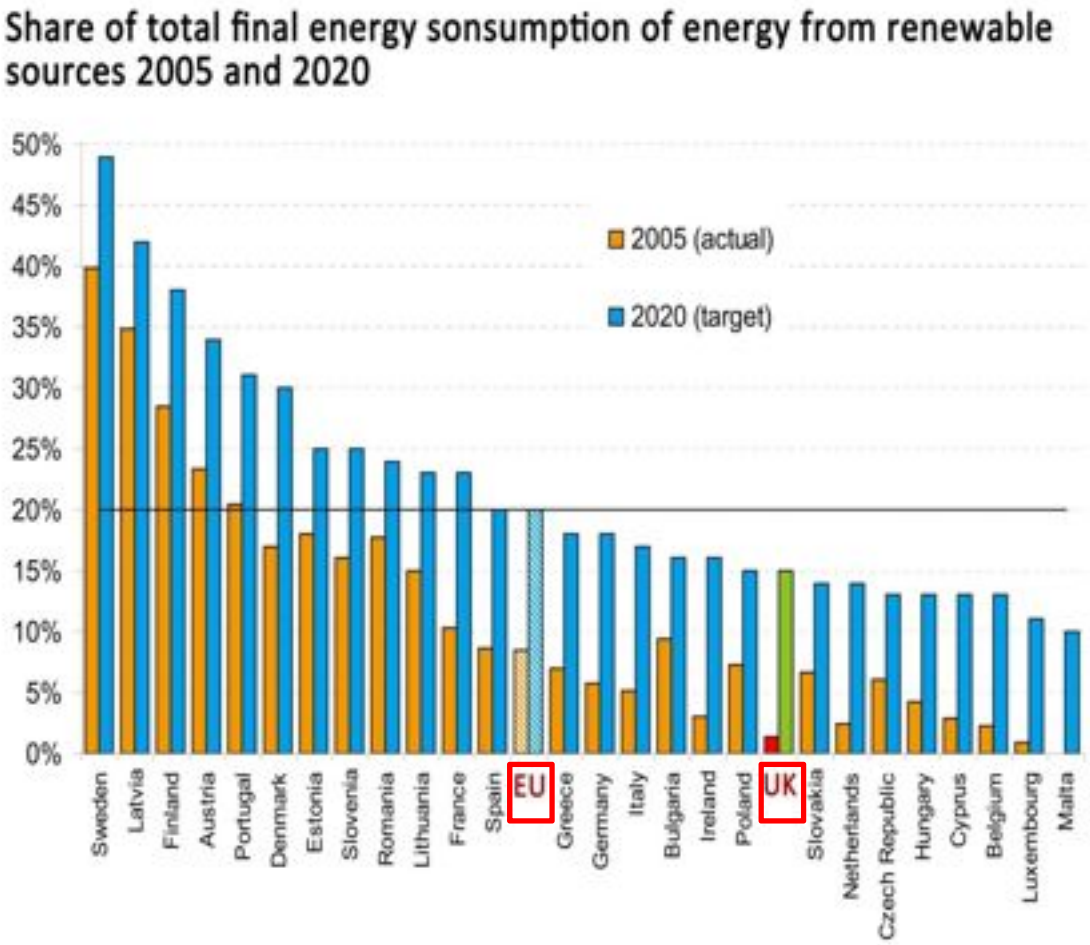
4.0 THE VISION:

A Clean Energy future for Penarth

*Setting **an ambitious but realistic vision** of renewable energy supply for Penarth*

4.1 WHICH target is suitable for Penarth?

Currently, there are various target for the renewable share, which target is suitable for Penarth?



Data Source: BERR (Department for Business Enterprise & Regulatory Reform)

Renewable energy target at different levels

Before selecting a suitable vision for Penarth, ***there are various renewable energy targets at the European, UK and Welsh levels affecting Penarth :***

➢ "…**20%** of EU energy consumption comes from renewable resources by **2020**…"

*(**EU 20-20-20 Targets**, European Union Committee, 2008)*

➢ "…**15%** of final energy consumption is from renewable sources by **2020**..."

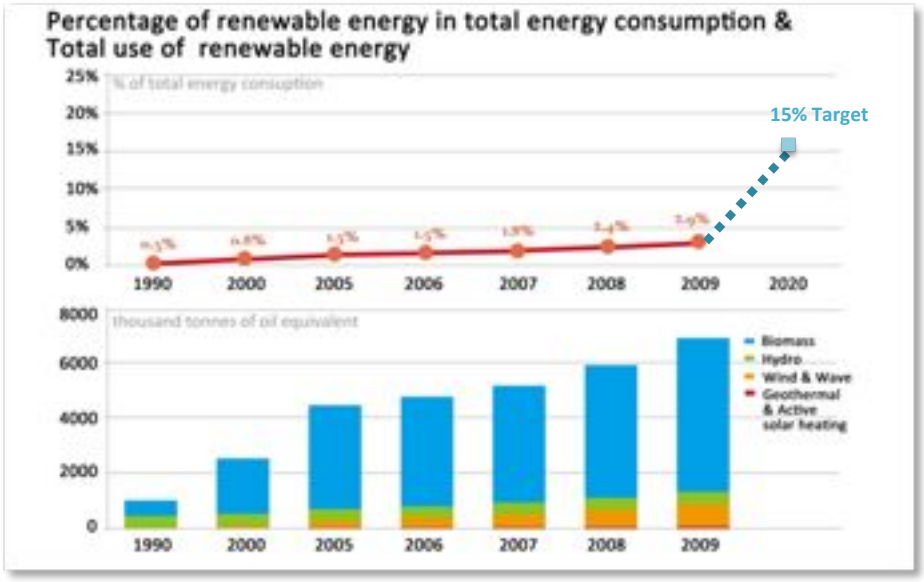
(***UK Target***, *European Union Committee, 2008*)

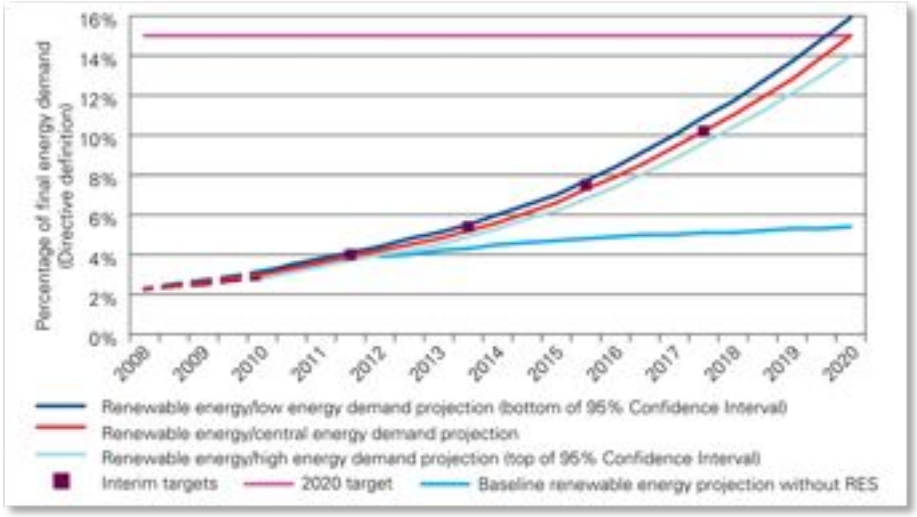
➢ "…**3% reductions** in greenhouse gas emissions **per year** in areas of devolved competence by 2011…"

(***Wales Target***, National Assembly for Wales, 2011)

4.1 WHICH target is suitable for Penarth?

Currently, there are various target for the renewable share, which target is suitable for Penarth?





Source: DECC: 2009; UK National Statistics;

UK renewable energy development

A quick review of the UK's renewable energy development in the past could show the challenges of 15% targets.

It can be seen on the left graph that ***the growth of renewable energy over the past two decades in the UK is fairly slow***. The proportion of renewables in total energy consumption (including electricity, heat and transport) had only seen a 2.6% increase between 1990 and 2009.

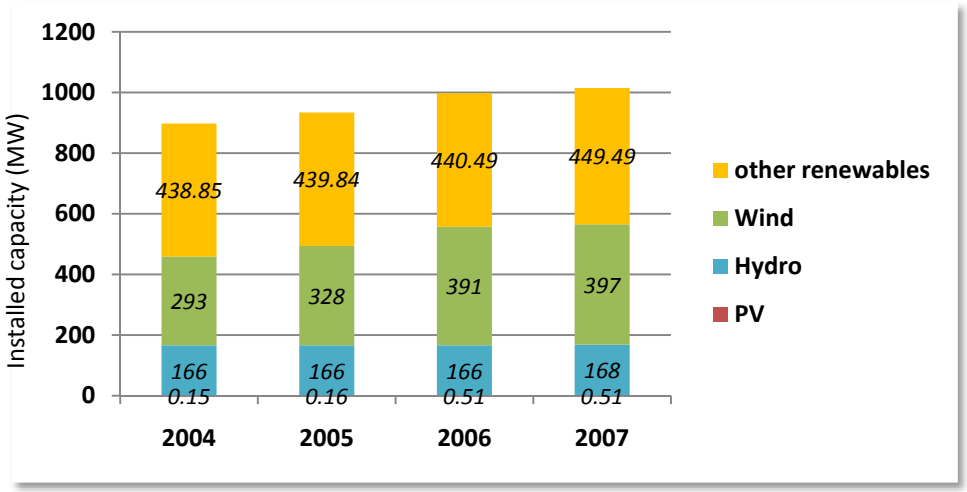
In order to meet the legally-binding target to ensure ***15% of our energy comes from renewable sources by 2020: almost a seven-fold increase*** in the share of renwables, UK government also set specific target for different sectors (DECC, 2009):

- ***More than 30% of our electricity*** generated from renewables, up from ***about 5.5% today***;
- ***12% of our heat*** generated from renewables, up from ***about 1% today***;

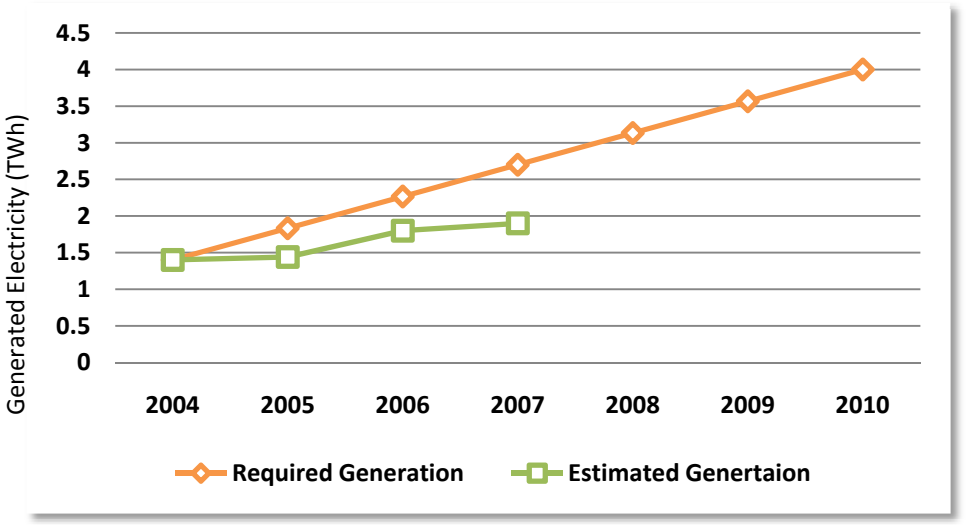
Undeniable, **it is a big challenge for the UK to achieve the Renewable Energy Target in scarcely less than a decade**. More efforts and contributions from the whole country are necessary.

4.1 WHICH target is suitable for Penarth?

Currently, there are various target for the renewable share, which target is suitable for Penarth?



Growth in installed capacity electricity generation in Wales from 2004-2007
(Source: Welsh Assembly Government, Scottish Power Manweb and Western Power Distribution



Electricity Generation from renewables in Wales , compared to the Welsh Assembly Government Target for 2010. The baseline year is 2004. (Data Source: Welsh Assembly Government, Scottish Power Manweb and Western Power Distribution, Members' Research Service)

Wales renewable energy development

In the 1990's Wales became a pioneer in renewable energy as it led the way in establishing some of the first onshore wind farms in the UK.

However, ***a poor progress of renewable energy and the development of wind farms has been made in Wales over the past two decades***.

the British Wind and Energy Association (BWEA) Cymru noted that Scotland and Northern Ireland are on course to meet targets for wind energy while Wales is expected to fall 800MW short of its own capacity goal for 2010.

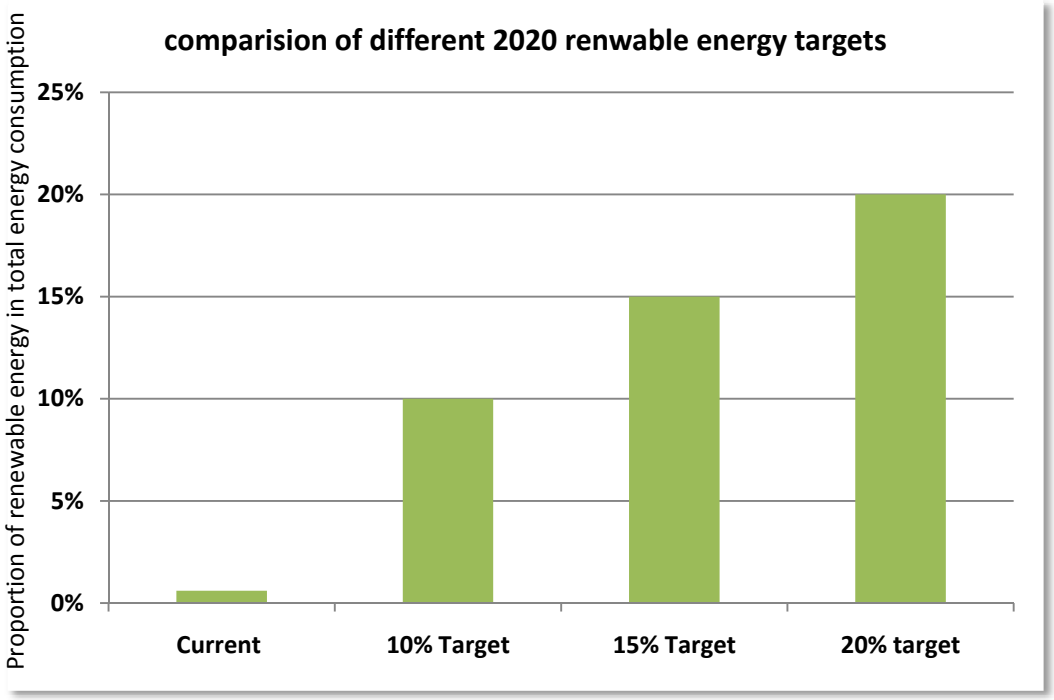
*The **actual contribution of renewable resources to Wales's electricity production is 4%,** (DBERR, 2010) which is 72% behind TAN 8 target set in 2005 (BWEA, 2010).*

In terms of renewable heat, the progresses are also very slow. Due to the lack of a distribution network and other issues, there are no Wales-specific data concerning the total consumption of renewable heat.

With the target of 7 TWh renewable electricity by 2020 (TAN8), from only about 1.5 TWh today (Welsh Assembly Government, 2008), and an 3% annual reductions in greenhouse gas emissions from 2011, ***much needs to be done if the Wales want to meet its goal of making the country self-sufficient in renewable energy***.

4.1 WHICH target is suitable for Penarth?

Currently, there are various target for the renewable share, which target is suitable for Penarth?



Penarth renewable energy

Currently, in Penarth less than 1% of energy consumption is from renewables.

Due to the town's conservation area status, there are also no specific planning on renewable energy development in Penarth.

However, in order to be a self-sufficient and self-reliant town, Penarth should also have a clear vision of renewable energy development.

Hence, ***which target is suitable target for Penarth?***

- ***Less than 10%*** *of energy from renewables by 2020*
- ***10%*** *of energy from renewables by 2020*
- ***15%*** *of energy from renewables by 2020*
- ***20%*** *of energy from renewables by 2020*
- ***More than 20%*** *by of energy from renewables 2020%*

4.2 PUBLIC CONSULTATION

We also want to hear the voices of Penarth's residents: which target do you think suitable for Penarth?



Community Meeting

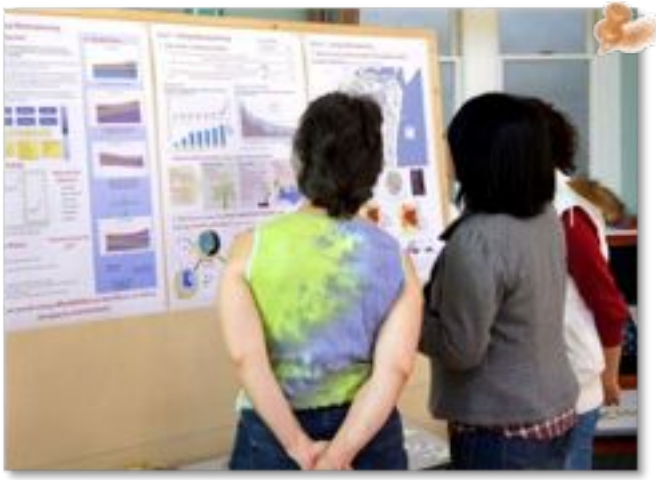
Which target do you think suitable to Penarth?

In order to set a both ambitious and realistic target, local residents' opinions are crucial because essentially the renewable energy development relies on their support and efforts.

Hence, we asked local residents to select their vision of renewable energy for Penarth:

Outcomes: To our surprise, ***70% of voters think renewable energy supply should be 20% or more than 20% by 2020.***

Limitations: The major limitation of this public consultation event ***is the number of local residents participating in this event is very few***. But the strongly positive attitude towards renewable energy can still be found in the conversation with local dwellers.



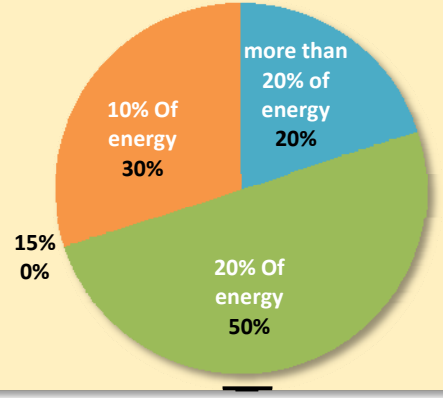
Abstract of local residents' opinions:

"... I do think we should **have a more ambitious target**, for example **50%**...at least **more than 20%**..."

"...for Penarth I think we should **set EU average target**, say **20%**..."

"...**10%** might be **realistic** for Penarth..."

Statistics: participated residents' votes



4.3 VISION Setting

Our Vision: 20% of energy consumption (electricity & heat) is from renewable sources in Penarth by 2020; 50% by 2030 and 100% by 2050 .

Penarth Renewable Energy Vision :

***20%** of energy consumption (electricity & heat) is from renewable sources **by 2020**.*

***50%** energy consumption (electricity & heat) is from renewable sources **by 2030**;*

***100%** energy consumption (electricity & heat) is from renewable sources **by 2050**.*

Firstly, the target of 20% by 2020 is based on:

1) Preliminary investigation of Potential renewable sources in Penarth;

It can be said that Penarth is rich of renewable energy sources and has great potentials to develop nearly all types of renewable energy technologies.

2) Existing targets at different levels;

According to the analysis of existing targets at different levels (EU, 20%; UK,15% and Wales, annual 3% carbon reduction), and compared the renewable targets of other EU countries, such as Sweden (50%), Finland (42%) and Austria (33%), it can be seen that 20% is a relatively practical and realistic target, rather than a mission impossible.

3) Current situation of renewable energy development both in the UK and in Wales;

The current situation of renewable energy development both in the UK and in Wales is not satisfying. In order to achieve the legally-binding target, every city or town is supposed to contribute to it.

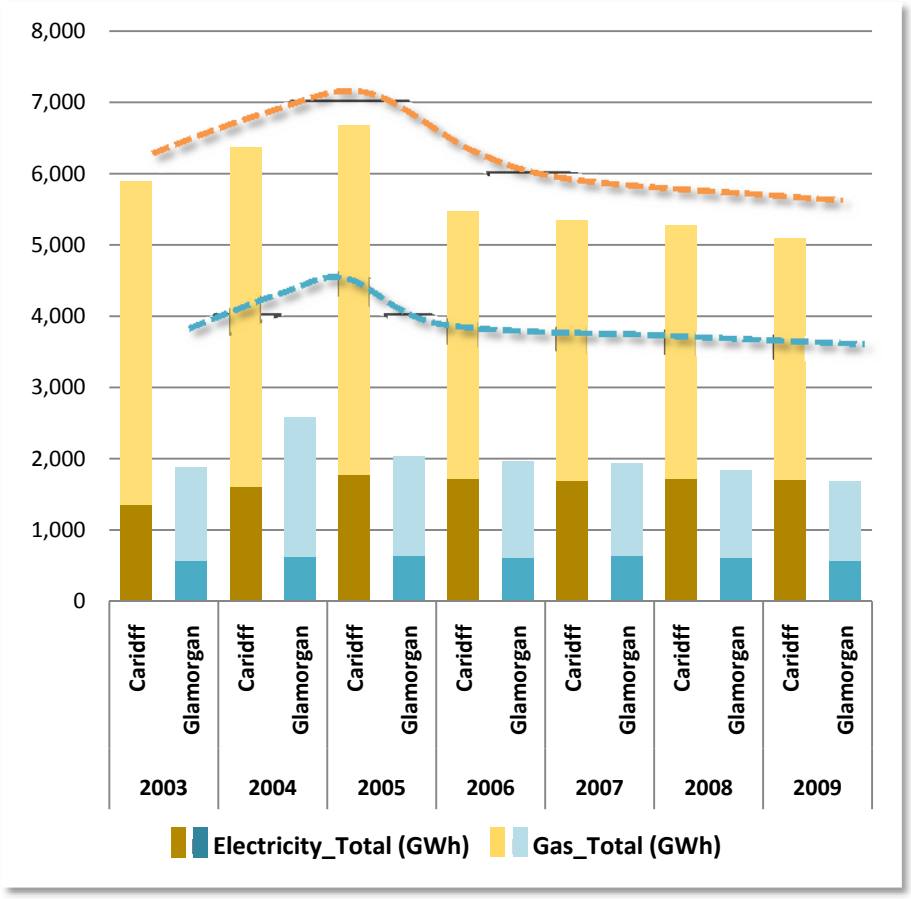
4) Public consultation in Penarth.

According to the community meeting, local residents also believe a relatively ambitious target should be set for Penarth.

Secondly, in order to see the potential of renewable energy development in Penarth, this plan will also provide a conceptual plan for 50% by 2030 and 100% by 2050.

4.3 VISION Setting

Our Vision: 20% of energy consumption (electricity & heat) is from renewable sources in Penarth by 2020; 50% by 2030 and 100% by 2050 .





Annual Energy consumption (electricity & Gas) of Cardiff & Glamorgan between 2003 and 2009

Penrth
Glamorgan
Cardiff

Specification of Renewable Energy Outputs by 2020, 2030, 2050:

In order to estimate the 20% of renewable energy supply, the energy demand should be speculated at first.

Because of the lack of long-term Penarth's statistics date, the energy consumptions of Cardiff and Vale of Glamorgan are analyzed in order to induce the trend of energy consumption in Penarth.

It can be seen that:

1) ***The general trend of energy consumption between*** *Vale of Glamorgan and Cardiff* ***is similar, and fall modestly and steadily after 2006***.

2) ***The electricity consumption nearly remains the same after 2006*** and fluctuates very slight .

3) ***The gas consumption decreases gradually after 2006.***

Energy consumption Domestic + commercial +industrial		2003	2004	2005	2006	2007	2008	2009
Electricity (GWh)	Cardiff	1358	1603	1772	1721	1697	1722	1697
	Glamorgan	568	623	646	614	635	611	572
Gas (GWh)	Cardiff	4540	4762	4908	3749	3653	3553	3391
	Glamorgan	1311	1957	1390	1356	1300	1224	1117

Total energy consumption include domestic ,commercial and industrial sectors.
Data Source: UK National Statistics

4.3 VISION Setting

Our Vision: 20% of energy consumption (electricity & heat) is from renewable sources in Penarth by 2020; 50% by 2030 and 100% by 2050 .



Current consumption per person in 2008 (left two columns), and a future consumption plan, along with a possible breakdown of fuels (right two columns)
Data source: Mackay, 2008; Welsh Assembly Government, 2010

Specification of Renewable Energy Outputs by 2020, 2030, 2050:

Furthermore, ***according to DECC (2009) and Mackay (2008)*** (see the graph below and left), based on a sustainable development scenario ***electricity consumption will remain nearly the same as that of 2008*** and ***heat consumption will decrease at a speed of about 10% per decade*** due to more efficiency (data is calculated according to the graphs).

Final energy consumption in 2008 and projected for 2020

	2008		2020	
	All Energy (TWh)	Renewable Energy (TWh)	All Energy (TWh)	Renewable Energy for 'lead scenario' (TWh)
Electricity	387	22	386	117
Heat	711	7	599	72
Transport	598	9	605	49
Total final energy consumption (EU Definition)	1695	39	1590	239

Notes

1. The heat and transport sectors exclude electricity used in these sectors which is included in the electricity sector.
2. Under the provisions of the Renewable Energy Directive, the share of renewables in the transport sector is calculated in relation to total surface transport (road and rail) only, i.e. excluding aviation and shipping, but all forms of transport can count towards the target. Using this definition, the 49 TWh renewable energy from transport represents 10%.
3. Total energy and transport consumption figures are in line with the definition agreed in the EU Directive, which caps energy consumed in aviation.
4. Totals may not sum owing to rounding.

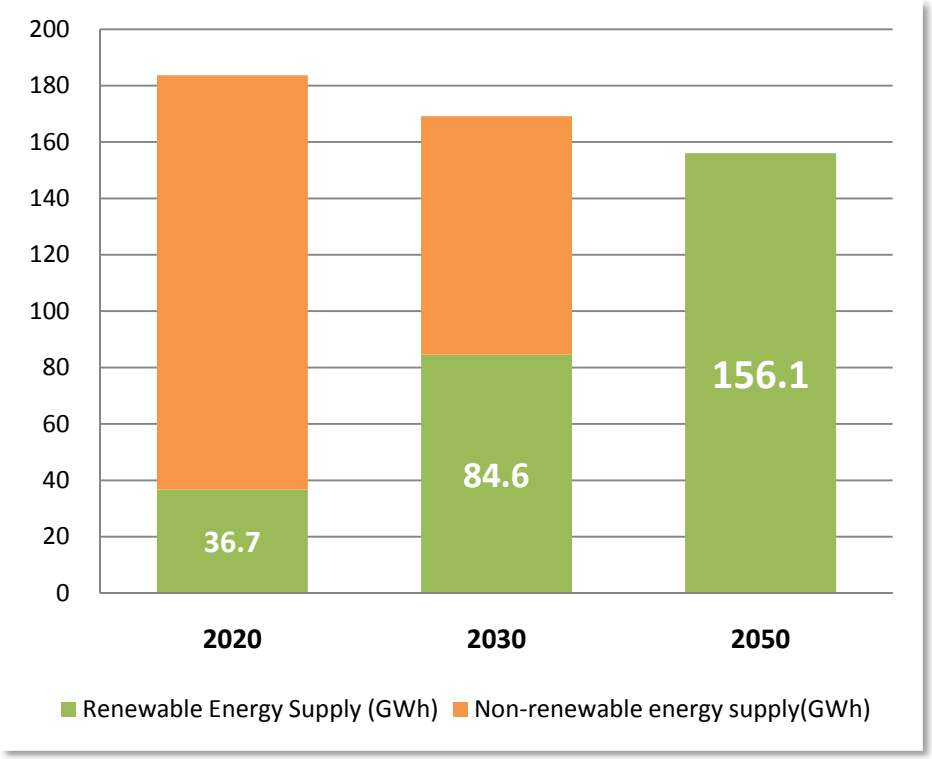
Data source: DECC, 2009

4.3 VISION Setting

Our Vision: 20% of energy consumption (electricity & heat) is from renewable sources in Penarth by 2020; 50% by 2030 and 100% by 2050 .

Specification of Renewable Energy Outputs by 2020, 2030, 2050:

Based on the analysis results of the potential energy demand trend, the **potential energy demand and the outputs of renewable energy in Penarth by 2020, 2030 and 2050** is listed in the table.



Year	2008	2020	2030	2050
Electricity (GWh)	38.3	38.3	38.3	38.3
Gas (GWh)	161.6	145.4	130.9	117.8
Total Demand (Elec+Gas) (GWh)	199.9	183.7	169.2	156.1
Renewable Targets (% of total consumption)	<1%	***20%***	***50%***	***100%***
Total Renewable Energy Supply (GWh)	<2.0	***36.7***	***84.6***	***156.1***

potential energy demand and the outputs of renewable energy in Penarth by 2020, 2030 and 2050.

4.4 What Does It **MEAN TO PENARTH?**

Our Vision: 20% of energy consumption (electricity & heat) is from renewable sources in Penarth by 2020; 50% by 2030 and 100% by 2050 .

The renewable energy supply will not only help to reduce considerable carbon emission, but also bring us remarkable social and economic benefits

Renewable Energy	*Environmentally*	*Socially*	*Economically*
2020 Penarth **7.7** GWh renwable electricity **29.0** GWh renewable heat **36.7** GWh total renewable energy	➢**10036.1 tonnes/year** Carbon Dioxide Reduction ➢20% renewable energy in buildings	➢**Some** residents participate in community renewable schemes; ➢**Beginning to be** self-reliant; ➢**Having** sense of community; ➢**Emerging** local renewable employment opportunities.	➢**Saving £ 1,291,972/year energy bill** (with potential for extra reward through Feed-in-Tariffs and/or Renewable Heat Incentives) ➢**Saving £ 150,541/year Carbon Tax** (EU Carbon tax £15/tonnes) ➢**Having** local renewable industry chain
2030 Penarth **19.1** GWh renwable electricity **65.5** GWh renewable heat **84.6** GWh total renewable energy	➢**23388.5 tonnes/year** Carbon Dioxide Reduction ➢**50%** renewable energy in buildings	➢**Many** residents participate in community renewable schemes; ➢**High-level** self-reliant; ➢**Strong** sense of community; ➢**Considerable** local renewable employment opportunities.	➢**Saving £ 5,920,675/year energy bill** (with potential for extra reward through Feed-in-Tariffs and/or Renewable Heat Incentives) ➢**Saving £ 350,828/year Carbon Tax** (EU Carbon tax £15/tonnes) ➢**Relatively sophisticate** local renewable industry chain
2050 Penarth **38.3** GWh renwable electricity **117.8** GWh renewable heat **156.1** GWh total renewable energy	➢**42713.9 tonnes/year** Carbon Dioxide Reduction ➢**100%** renewable energy in buildings	➢**A considerable number** of residents participate in community renewable schemes; ➢**complete** self-reliant; ➢**Very strong** sense of community; ➢**A large number of** local renewable employment opportunities.	➢**Saving £ 10,925,043/year energy bill** (with potential for extra reward through Feed-in-Tariffs and/or Renewable Heat Incentives) ➢**Saving £ 655,709/year Carbon Tax** (EU Carbon tax £15/tonnes) ➢**Very sophisticated** local renewable industry chain

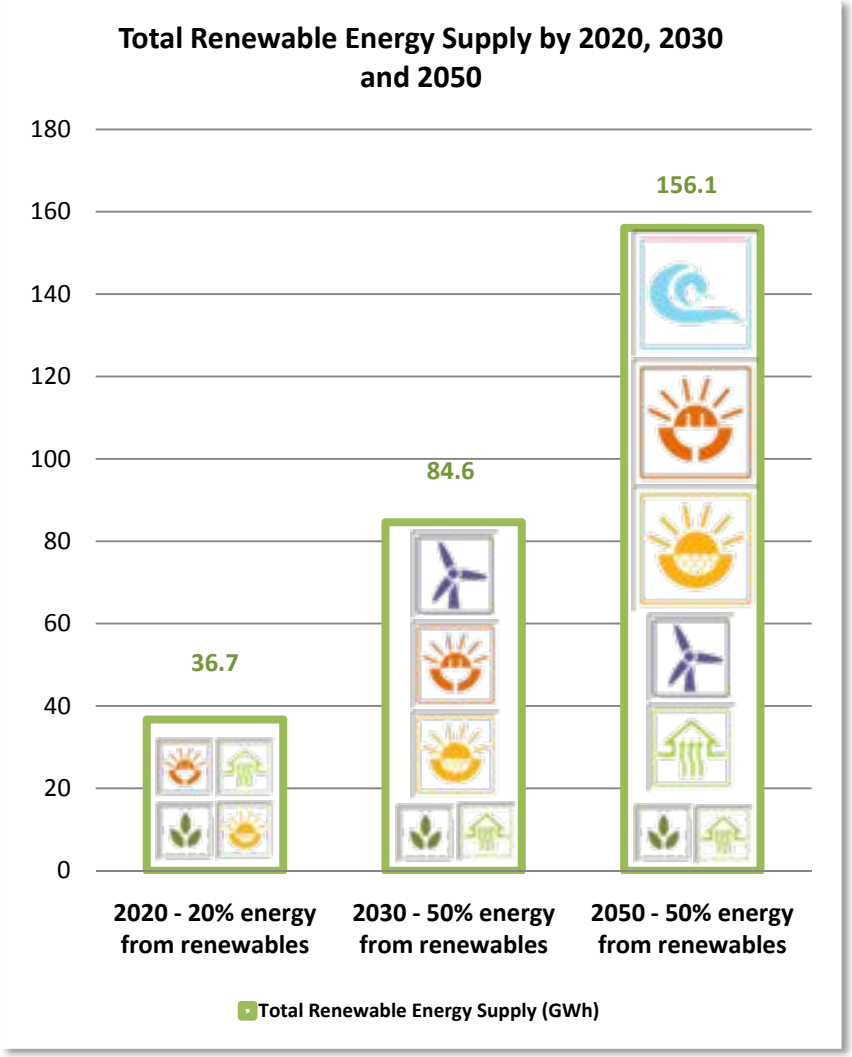
5.0 PLANNING:

How we are going to get there?

The Delivery of a clean energy future for Penarth.

5.1 WHERE to locate & WHAT renewables are for Penarth?

What types of renewable energy technologies are suitable for Penarth and where to locate them?



What types of renewable energy technologies are suitable for Penarth and where to locate them?

When answering the questions and formulating this plan, ***three key points are taken into consideration***:

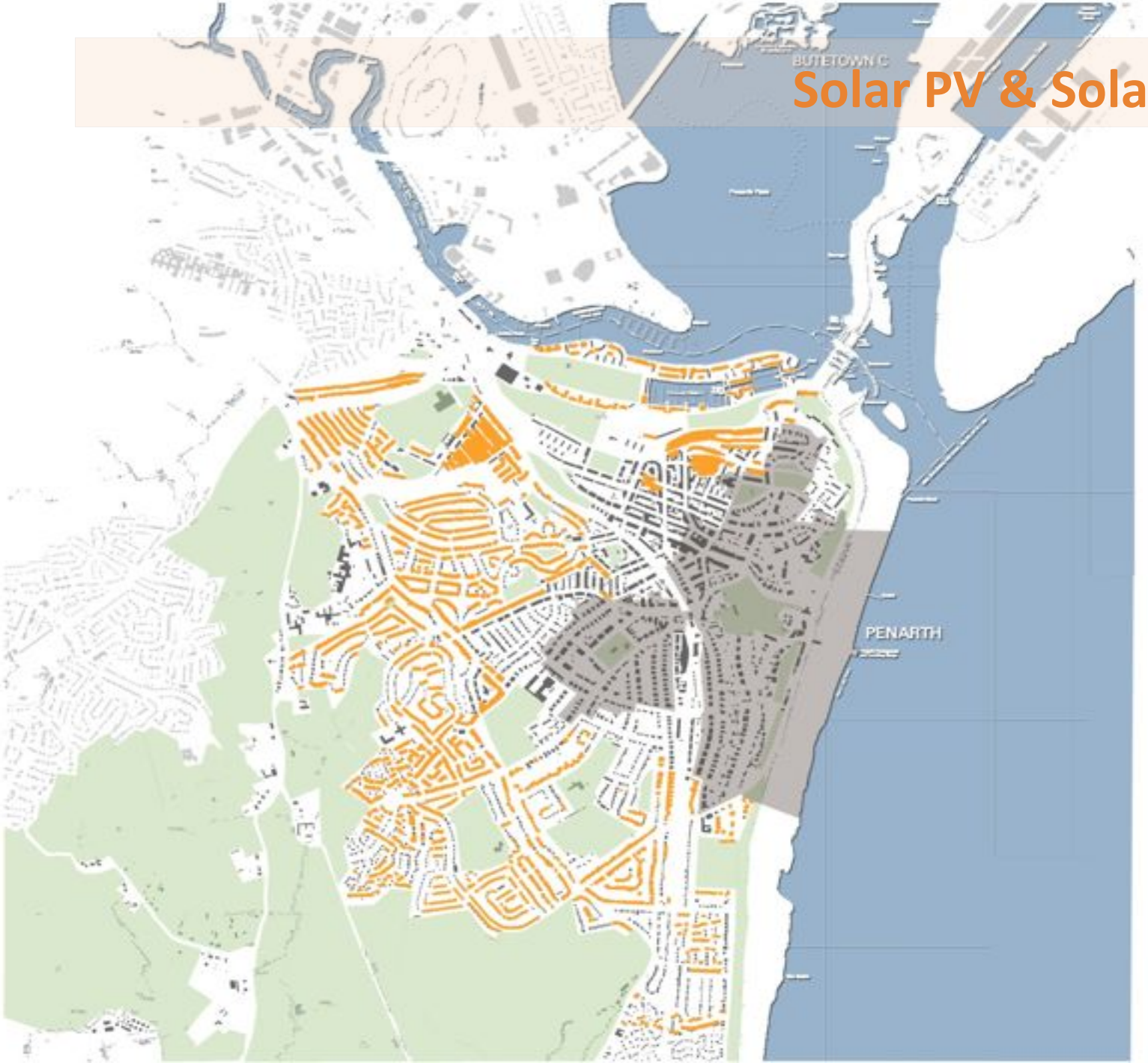
1) ***Three renewable energy visions for different stages*** (20%2020; 50% 2030: and 100% 2050);
2) ***Different features of various renewable energy technologies*** (costs, spatial requirements and so forth); and
3) ***The available sites in Penarth*** (open space, public buildings, available south-facing roofs and so forth).

Hence, this plan ***starts with the discussion of potential locations of every renewable energy technologies.*** This part includes three main points:

1) the selected ***site for renewable energy***;
2) the ***introduction and analysis of the suggested systems*** (installed capacity, potential outputs, carbon savings and so forth); and
3) some ***guidelines*** regarding to the environmental, financial and social considerations.

Then, ***the time sequences plan is formulated*** based on the locational plan for every technology, the 2020, 2030 and 2050 visions, and the feasibility according to this preliminary study.

5.1 PENARTH
Solar PV & Solar Thermal Plan



Solar PV &Solar thermal

In Penarth, ***the domestic sector contributes more than 80% of total energy consumption*** (DECC, 2010). Solar energy has been considered the ultimate source for both electricity and heat. Besides, in consideration of the required technique and cost, among all the renewable technologies, solar PV and solar thermal would be more approachable for building scale. Hence, ***the suggested development plan for solar energy application will focus on domestic houses.***

The ***development plan could be implemented in the sequence***. Start from the identified area and expand to the whole Penarth in the future.

5.1 PENARTH
Solar PV & Solar Thermal Plan

Plan sequence

This plan suggests that in the early stage, ***the houses inside the conservation area would be excluded***. The restriction for re-roofing works for existing domestic houses in the planning appraisal (Evans, 1996) might limit the installation of solar panels.

On the other hand, among all types of domestic houses in Penarth, the ***detached and semi-detached houses*** possess the advantage of ***less shading nearby and single ownership*** that might benefit and simplify the application. Then the development of the application could follow the order ***from high energy density to low energy density and expand to all domestic houses*** in Penarth in the future.

It should be mentioned that ***though this report suggests the development follow the plan sequence, it does not restrict the households outside the identified area to adopt the application in the specific period.*** In fact, as the development progressing, the rising public awareness would benefit the sound development as well.



NOW — 2020 — 2030 — 2050

1. **Detached and semi-detached houses** within in **high** energy density area.
2. **Detached and semi-detached houses** within in **medium** energy density area.
3. **Other type** of domestic houses **outside conservation area.**
4. Domestic houses within in **conservation area.**

5.2 PENARTH

Solar PV & Solar Thermal Plan

Potential energy output

The potential energy output is based on the following assumption:

1) *In priority area, 85% of the south-facing roof will install the solar energy system.*
2) *In potential area, 5% of the south-facing roof will install the solar energy system.*
3) *The assumption for application in conservation area is 10% of the south-facing roof.*
4) *The output is speculated based on 2/3 of the application for solar thermal and 1/3 for solar PV.*

System Brief

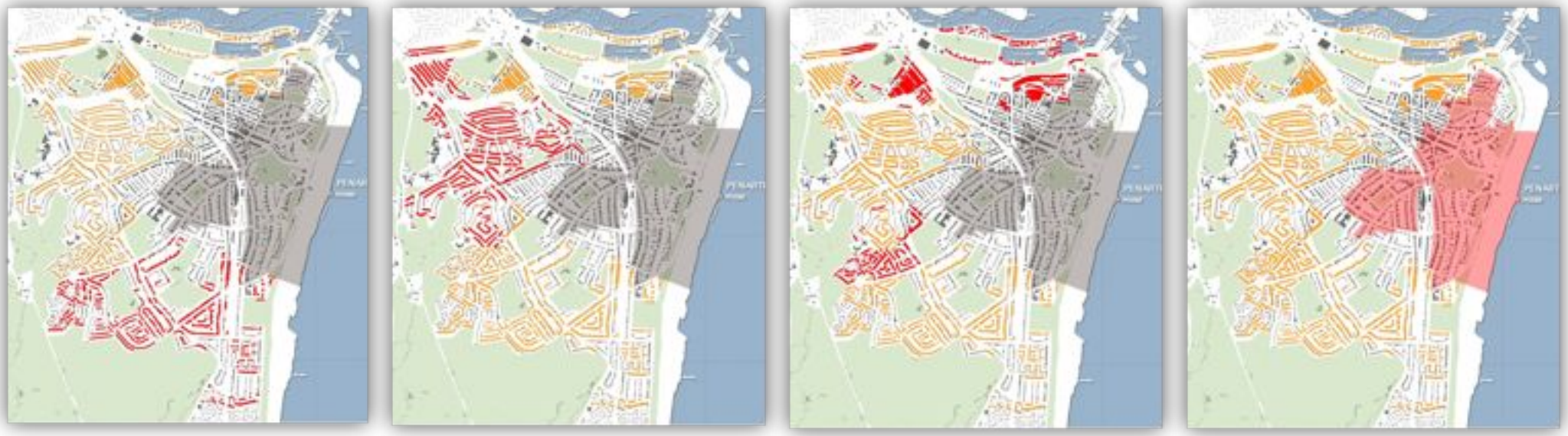
➢**Solar thermal water heater**

Potential Output:
5m²/2000kWh·yr
Cost: £4,000~5000
Carbon Saving: 860kg/year
(Source: The Solar Trade Association)

➢**Solar PV**

Potential output:
2.2kWp/15m²/1800kWh·yr
Cost: Around £12,500
Carbon Saving: 800kg/year
(Source: energy saving trust)

Priority area
Potential area



NOW

2020
Heat :1100 MWh/yr
Electricity: 500 MWh/yr
Total: 1600 MWh/yr

2030
Heat :1650 MWh/yr
Electricity: 750 MWh/yr
Total: 2400 MWh/yr

2050
Heat :1240 MWh/yr
Electricity: 560 MWh/yr
Total: 1800 MWh/yr

Heat :160 MWh/yr
Electricity: 70 MWh/yr
Total: 230 MWh/yr

PENARTH Solar System Guidelines:

The plan for solar system has the following consideration:

➢ It would be suggested that ***the application in Penarth could start from domestic houses.*** For the energy consumption status shows that domestic sector has consumed more than 80% of the total energy, besides, solar panels can be "easily incorporated into most houses" and the energy could be transformed into electricity or heat.

➢ In order to ensure the performance, ***the installed houses are suggested to possess these features***:

1. **Sufficient south-facing roof**: For ***solar PV system***, the roof ***due south*** will give the best overall annual performance and the typical installation in UK require around ***14-15m²*** roof area (Energy Saving Trust, 2011). As for ***solar thermal system***, the roof faces between ***south-east and south-west*** would be acceptable and the a ***5m²*** roof area could cover around 50-65% of water heating energy needs for a family of four (STA, 2011).

2. ***Unsheltered roof***: Any shading on the solar panel of both PV and thermal system will affect the performance. Hence, this report suggests that the application could ***initiate from the detached or semi-detached houses within the lower housing density area*** instead of crowded city centre.

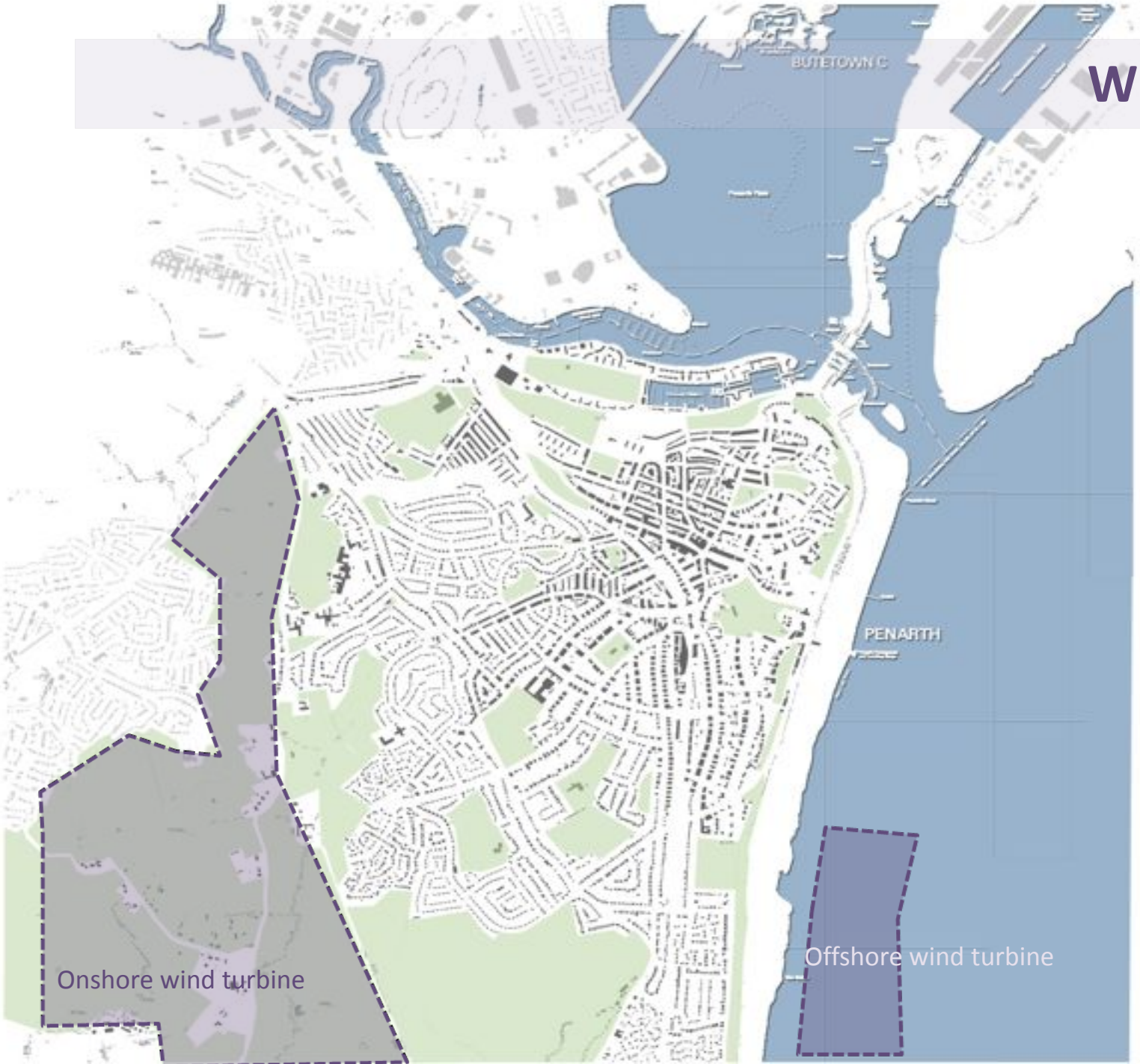
➢ With the advantage of less initial cost and the more flexibility than solar PV system, ***solar thermal system possesses the advantage to suite the majority of domestic house in Penarth***. The generated heat will also contribute to cut down the gas consumption which is as twice as the electricity consumption in Penarth.

➢ In spite of saving the consumption for fossil fuel and reducing the carbon emission, the owners could also get benefit from the UK government's renewable energy scheme. For ***owners of solar thermal system are eligible for Renewable Heat Incentive (RHI)***, and ***owners of solar PV system could get paid by exporting the generated electricity through Feed-in Tariffs (FITs)***.

➢ The array of solar panels might cause the ***visual impacts*** especially for the houses within the conservation area; hence, it will require extra permission while practicing the application.

➢ ***Choosing the local installer or supplier*** will not only benefit the local economy but reduce the energy consumption on transportation as well.

5.2 PENARTH
Wind Power Plan



Wind Power

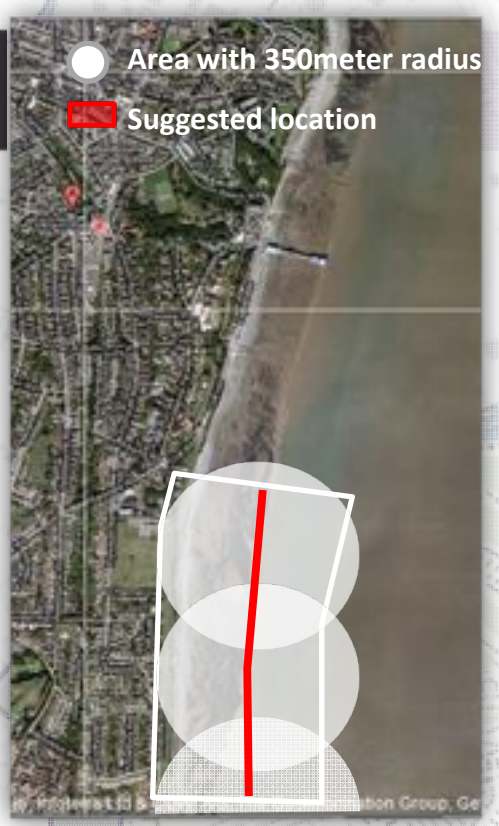
Wind turbine can be classified into two, one is the large scale including onshore and offshore wind turbine which are most implemented in rural area; and the other is micro and small scale including mast mounted and roof mounted wind turbine which are mostly implemented in exposed space in urban area or be integrated with building.

With consideration of the high housing density within in Penarth that might reduce the effective wind speed and the local opinion from community meeting in terms of visual impact and noise, the ***suggested wind power plan will be based on large scale application outside the town.***

The ***onshore wind turbine*** could be established in ***the south-west green space***, while the ***offshore wind turbine*** could situate ***along the coastal area***.

5.2 PENARTH
Wind Power Plan





Considering the noise cause by the operation of wind turbine, appropriate distance between the wind turbine and the building nearby will be require.

It has been demonstrated that the noise level can be reduced to 35-45dB within the distance of 350m. The noise level is correspond to busy road at 5km (Aus WEA).

Source/Activity	Indicative noise level dB (A)
Threshold of hearing	0
Rural night-time background	20-50
Quiet bedroom	35
Wind farm at 350m	35-45
Busy road at 5km	35-45
Car at 65 km/h at 100m	55
Busy general office	60
Conversation	60
Truck at 50km/h at 100m	65
City traffic	90
Pneumatic drill at 7m	95
Jet aircraft at 250m	105
Threshold of pain	140

Corresponding noise level. (Sources: Aus WEA)

System brief

➢**Onshore wind turbine** **(typical system)**

System capacity: 2.5MW

Potential output: 6,500Mwh/yr

Capital cost: £3,000,000-4,000,000

O&M cost: £100,000-135,000/year

Carbon Savings: 2,795,000 kg/year

(Source: Renewable UK)

➢**Offshore wind turbine** **(typical system)**

System capacity: 3 MW

Potential output: 8,000Mwh/yr

Capital cost: £6,000,000-12,000,000

O&M cost: £1,800,000 -2,100,000/year**Carbon**

Carbon Savings: 3,440,000 kg/year

(Source: Renewable UK)

Both the onshore and offshore wind turbine will require considerable cost. Therefore, it would be suggested that the application to be served as a public project. For onshore wind turbine, it could be the community-led project to engage the involvement of local residents. Besides, the profit would contribute to improve the well-being of the community afterward. As for the offshore wind turbine, so far the UK government leads the development with plans in sequence (BWEA, 2005). Possessing the geographical potential of being in coastal area for installation of offshore wind turbine, Penarth would be able to consult about the application.

PENARTH Wind Turbine Guidelines:

The plan for wind turbine has the following consideration:

➢The installation of wind turbine will require ***further study for feasibility research*** including the long-term observation of wind speed, the economic analysis regarding the cost for installation, operation and maintenance, and possible financial support, assessment for environmental impact… etc.

➢***The onshore wind turbine could be the community led project***. Several cases have been implemented successfully in UK, such as the wind turbine in The Dulas Valley. Generally speaking, the benefit for local community could from:

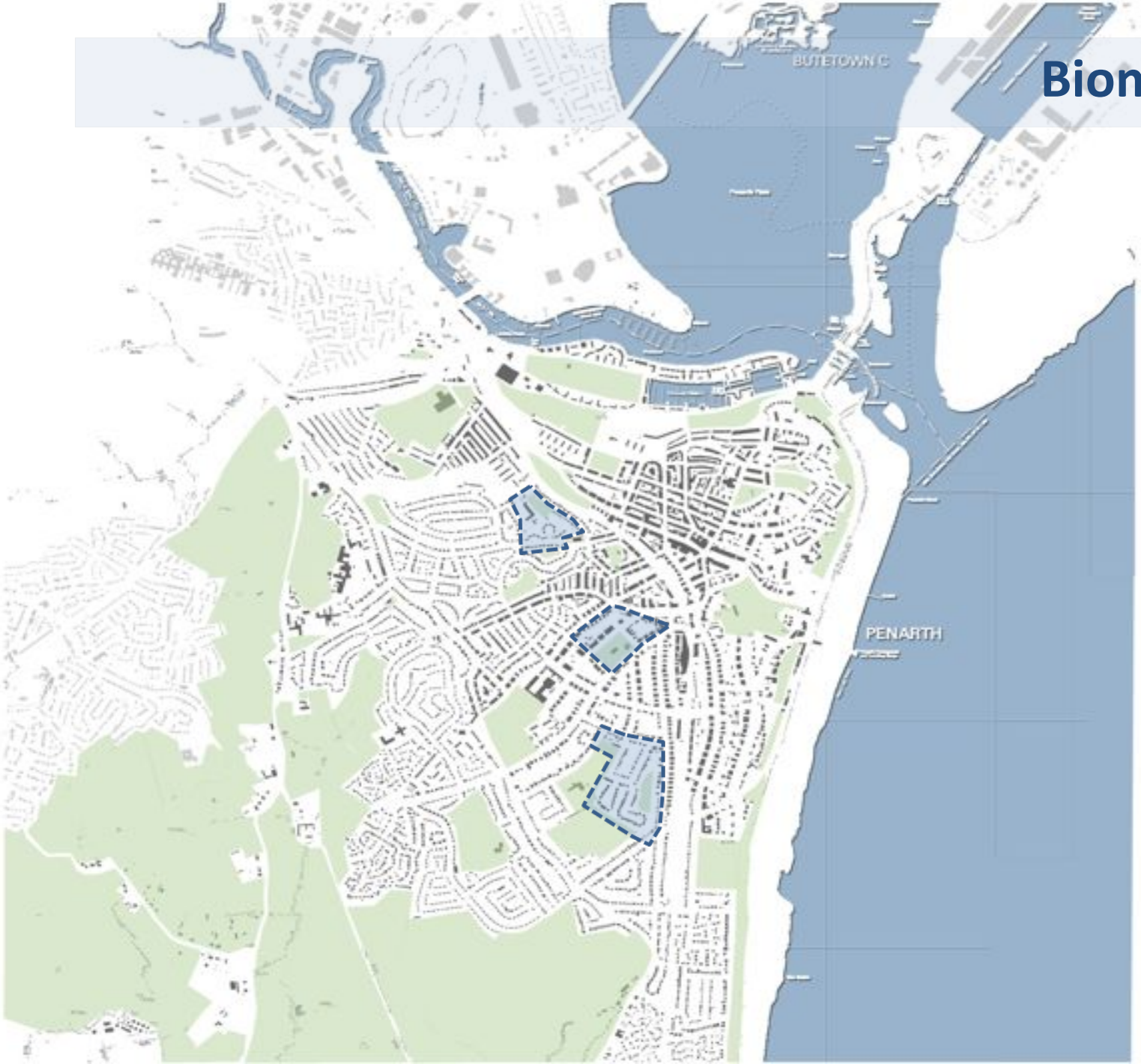
1. Enhance the local residents to get ***involved in the public affairs***.
2. ***Improve local economy*** through placing the contract of installation, operation and maintenance with local companies.
3. Get profit from generated electricity directly or from the income for selling electricity. The profit could then be used to ***improve the community well-being***.
4. Raise ***public awareness of sustainable development*** and encourage ***local responsibility***.
5. Community could search for ***grant or incentive*** to support the development.

.

➢In spite of ***the impact on psychological perceptions*** such as visual impact and noise, the ***social impact*** should be concerned as well. For the turbine site design might influence the value of houses in the housing market due to the change of local landscape (COLEBY et al., 2009).

➢ The development for offshore wind turbine is led by the UK government so far. Within the potential for located in coastal area, Penarth possesses the potential to implement the offshore wind turbine along the coastline. ***Consultation with local council will be required for further information.***

5.3 PENARTH
Biomass Power Plan



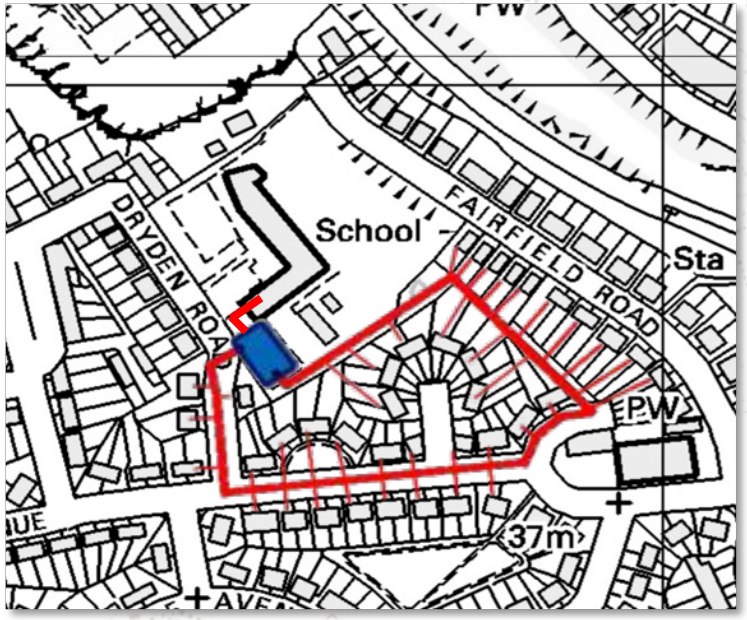
Biomass CHP

It is cost effective that biomass CHP plant is **located in big public buildings**, such as schools and community centers, **in relatively high density areas** (Energy Saving Trust, CE103), because *school has relatively steady and predicable energy demand, and relatively high density guarantee the high efficiency of network and less transmit on losses*.

Hence, in Penarth **three sites including a school/church and surrounded by dozens of houses** are suitable to be integrated biomass CHP plants . The biomass CHP plant can provide electricity to school and export extra electricity to national grid. And meanwhile it provide district heating for both school and around 30-40 houses nearby.

5.3 PENARTH
Biomass Power Plan





Biomass CHP Plant
Main pipe work
Pipe work Connecting to houses

System Brief

Capacity: 500-700KW*

Potential outputs:

Electricity: 2,000-3,000 MWh/year*

Heat: 6,000-9,000 MWh/year*

Energy distribution:

Electricity: supply Fairfield Primary School & export the extra to national grid

Heat: District heating for School 40 houses nearby.

Cost: £300,000 -400,000*

Network:

Electricity Grid: school connected on-grid system

Heating Pipework: Heat from the boilers is delivered to the school, and the houses via plastic pipes buried one metre below the ground and located along the roads for ease of access. It also ensures that it is easy for houses wishing to join the scheme in the future to do so. The pipes are then connected to each building's central heating network via a heating interface unit.

Carbon Savings:

more than 1,000,000-1,500,000 kg/year**

*Data source: System capacity, energy outputs and cost are deduced from Western Development Commission, 2008; Renewable Energy Association 2010; Energy Saving Trust, 2004; Combined Heat and Power Association, 2010 ; **Carbon emission is calculated based on SAP 2005.

PENARTH Biomass System Guidelines:

The plan of biomass plant has the following consideration:

➢In this plan ***biomass CHP system is selected*** because some successful practices demonstrates that "…it is a cost-effective system for community…" (Energy Saving Trust, 2003). This system can both supply both renewable electricity and provide community heating. And the energy outputs is more efficient. However, ***one issue about CHP system is the yearly demand of heating***. If the heating period is short, it will affect the system efficiency. Therefore, specific feasibility appraisal about the heating demand of the selected areas are significant. Based on this appraisal, which type of Biomass system, biomass CHP plants or biomass boilers only for district heating, can be specific compared.

➢***The project can be run sequentially*** in accordance with the involvement of nearby dwellers. The system and the main pipe can be built at the beginning and The pipes connected to each building can be built as long as the occupants want to join. The possibility for the expansion of supply areas could also be provided. This will both benefit to the economic efficiency and provide more opportunities for further development.

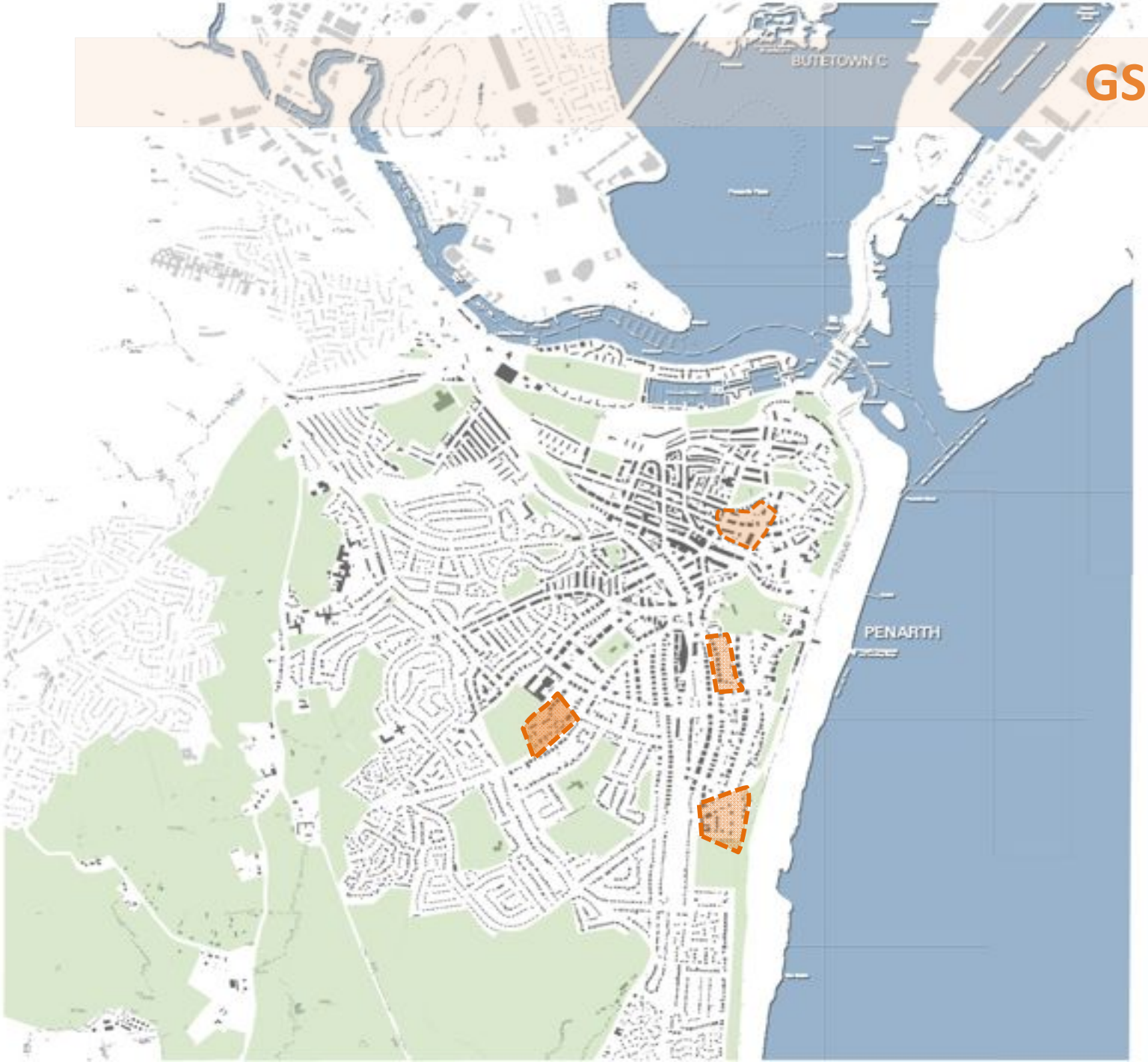
➢Before starting Biomass project, it is necessary to ***popularize the knowledge and benefits of Biomass Plant in Penarth***, thereby enabling local dwellers to have a holistic understanding of biomass project both environmentally and economically. Because the failed development of biomass plant in in North Wiltshire demonstrates that "…the lack of understanding of the long-term environmental advantages of biomass energy, general lack of knowledge of biomass technologies and misunderstandings which arose during the planning process cause the public perception of risks and mistrusts…" (Upreti & Horst, 2004)

➢ ***Bill Contract can also be adopted when encouraging local dwellers to join this scheme.*** The successful practices of Llanwddyn (Montgomeryshire, Wales) can be learnt (see chapter 5.3.4 biomass). Before starting the scheme, an fiscal appraisal need to be done to estimate the heat price and electricity price both for school and residences. This price enable customers to compare the benefit. And also an agreed price before the implementation is necessary to maintain this scheme.

➢ Furthermore, ***the locations of wood-chips' /wood-pellets' suppliers are supposed to be within 25miles*** (DEFRA, 2007). Some available suppliers to Penarth have been listed in below. The nearest one is exactly 25miles away, and there are not many suppliers within 15 miles. However, as the development of biomass plant some local supplier will be fostered, which as a result promote local industry and economic growth.

➢ For long term sustainability of a community heating project it is important that ***fuel prices are guaranteed by contract with suppliers for fixed periods***. Because this could guarantee a steady cost and heat price for customers.

5.4 PENARTH
GSHP Power Plan



Ground-Source Heat Pump

GSHPs can be of basically 3 types: vertical borehole, horizontal and slinky. Vertical boreholes do not require large ground space to lay the pipes but instead involves deep bore holes in the ground with depth varying from 15m to 180m depending upon the ground conditions and the capacity of the GSHP. Therefore **vertical boreholes tend to be expensive**.

Therefore in case the funds are not available, **site which has open space available to accommodate pipes for a horizontal or slinky system has been selected**.

Also **high density dwelling** units such as flats and approximately 20-40 adjoining houses to further avoid long pipe lengths. However on a large scale horizontal might have to be supported by vertical pipes

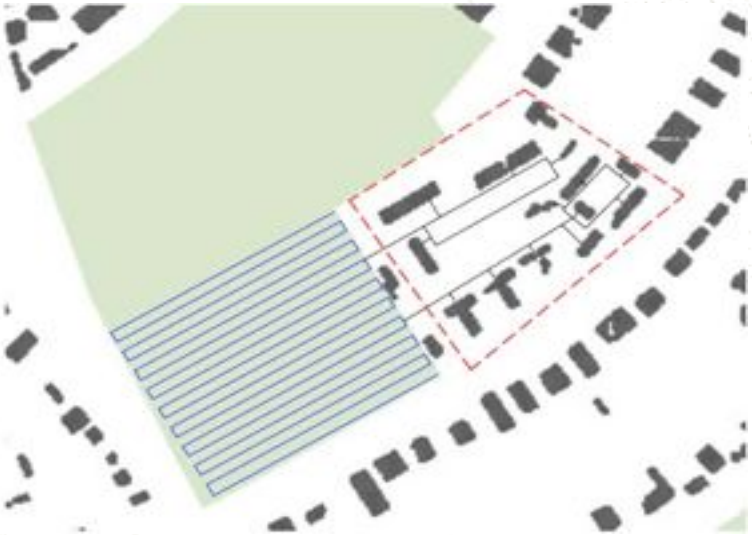
5.4 PENARTH
GSHP Power Plan











Secondary pipes

Main horizontal pipe layout

System Brief

Capacity: 200-250 KW

Potential outputs:

Heat: **1700-2100 MWh/year;**

Assuming annual household energy consumption is 23MWh and heating constitutes 80% of this (source: Nicole, 2011)

Approximate cost:

Heat pump installation: £5,500

Ducting with piping: : £430,000

Total: **: £ 435,500**

Energy distribution:

It has been assumed that the flats considered for the calculation of the capacity of each **individual system** have an average of approximately 70 households. Therefore calculations have been done for these ***70 households plus 20-40 adjoining houses***. Four separate units of capacity approximately 63 KW each can be installed along with a total pipe length of approximately 4 km for a horizontal heat exchanger in trenches about 0.5 to 1.0m deep. (as per rules of thumb, from Rawling R. and Doherty P., et al)

Carbon savings:

731,000- 903,000 kg CO2 /year (Assuming carbon emissions from conventional electricity approx. 0.43 kg CO2/kWh (Entec UK Ltd. May,2007) and system being run on a clean energy source)

PENARTH GSHP System Guidelines:

The plan of GSHP has the following consideration:

➢The ***efficiency and carbon savings achieved by the GSHP system depend on type of source used to drive the system***, for example the efficiency of GSHPs run on conventional electricity is 120-160% and CO2 emissions are 0.27- 0.2 kg CO2./ kWh heat whereas when driven by cleaner electricity the efficiency increases to 300-400% with almost nil carbon emissions. (GreenSpec 2010)

➢ ***One limitation with installing GSHPs in existing buildings*** is that since it supplies **low grade heat** at temperatures of approximately 30-45°C and therefore care must be taken that the building is **properly insulated** to benefit from the GSHP. This has been a major barrier in the adoption of GSHPs in the UK market as mentioned by Feuvre P. L., September 2007. An insight on the quality of insulation in new and old domestic buildings in Penarth has been given by one of the other groups in our class.

➢Installation of a GSHP has high capital cost therefore the ***technology must be promoted before hand and introduces to the community*** so that they are aware of its economic, environmental and social benefits. Past experiences in the UK have not shown growth in the adoption o f these technologies due to lack of awareness amongst the general public as well as the investors. If people are not aware of this the market will become restricted to only a few environmentally conscious ones

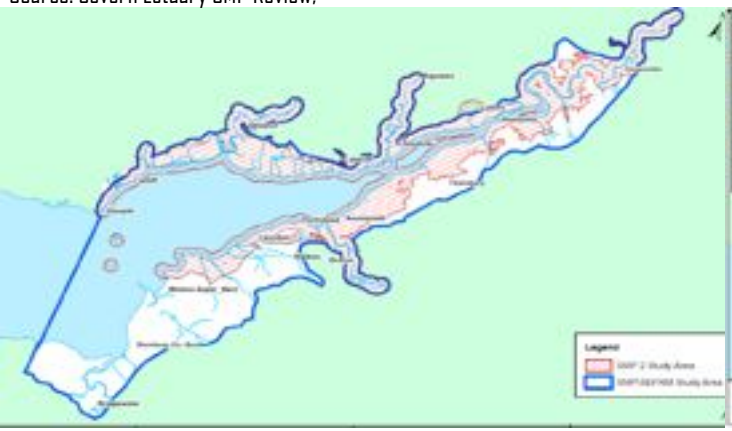
➢ ***The scheme proposed in this report is purely based on rules of thumb*** therefore a horizontal pipe layout that has been suggested might turn out to be not suitable for the site and a vertical borehole might be required therefore a prior feasibility analysis by professional consultants is essential. Also a prior check for the existing services under the ground should be made before starting the installation

➢Care should also be taken to ***make the public aware of the market trends*** in the sense that the CoP generally quoted by the manufacturers is higher than the actual performance.

➢ ***Some of the selected proposals lie in the conservation area*** but The Legislative Act, 1990 *"requires that any alterations of the fabric [of buildings in the conservation area] …should be 'justified' and the impact of the proposed be assessed in terms of character and appearance."* This essentially means to be able to retain the façade of the buildings facing the street, Victorian features such as sash window and doors and the street furniture and paving etc. and ***GSHP installation would not affect these characteristics***. (Helene, 2011 and Evans J.M.,1996)

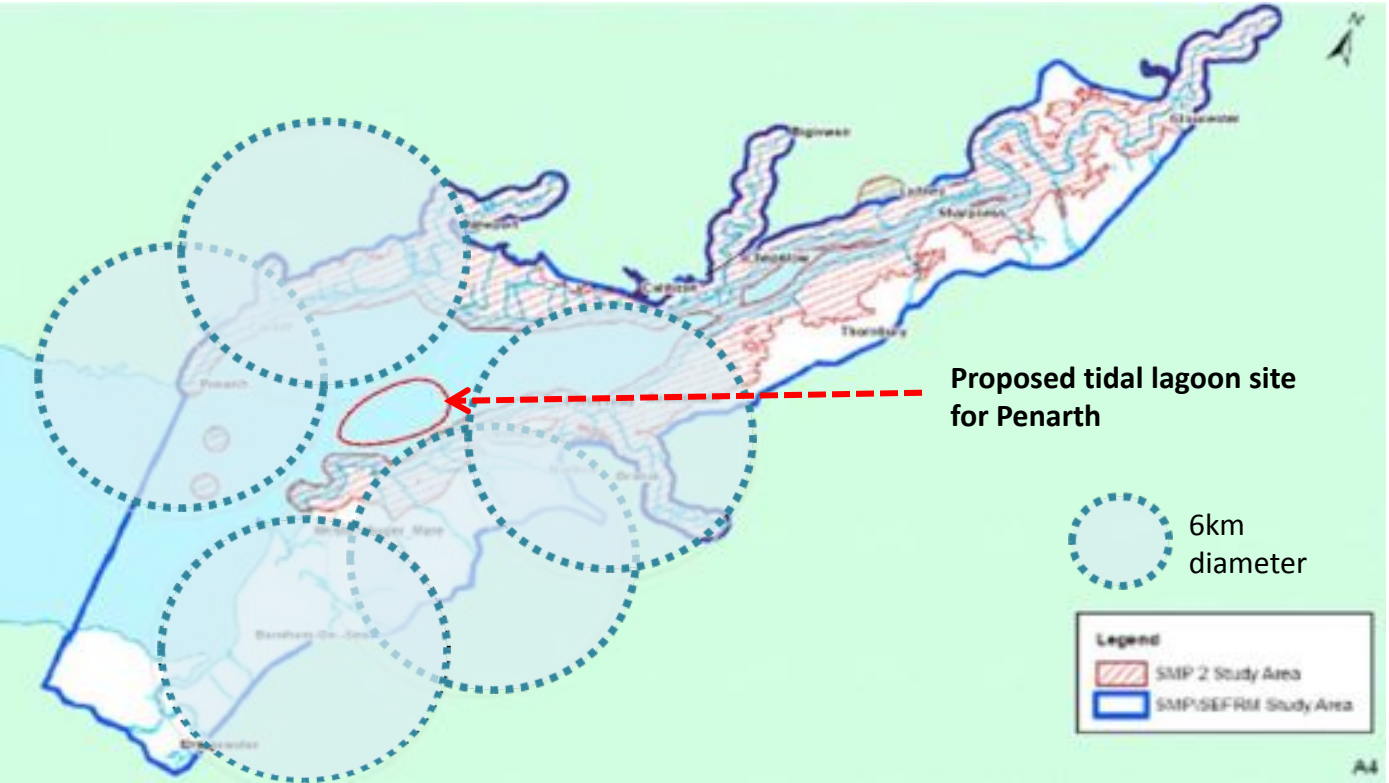
5.5 PENARTH
Tidal Power Plan

Source: Severn Estuary SMP Review,



Source: Severn Estuary Partnership, 2002-09, Theme Review





Tidal Power

Of the three types of tidal power- tidal barrage, tidal lagoon and tidal stream, a tidal lagoon has been proposed for Penarth in this report. This is mainly because this proposal is focused on Penarth and the cost and scale of tidal barrage has been generally studied more comparison to tidal lagoon whereas although ***there is tremendous potential for tidal stream*** as well but this technology is in a nascent stage and ***there is not enough data*** to base an academic study. (Sustainable Development Commission, October 2007) Also *the data provided for this technology is very basic as actual calculations are out of the scope at this level*.

Criteria for Selection of Site

1) Conservation areas

Area under the SMP2 (Severn Estuary Shoreline Management Plan) consists of a number of sites with "***nature and conservation designations". "****The SMP2 covers The SMP2 covers the coastline from Haw Bridge near Gloucester, to Lavernock Point on the Welsh coast, and to Anchor Head, north of Weston Bay, on the English coast"* (Severn Estuary Partnership, 2002-09)

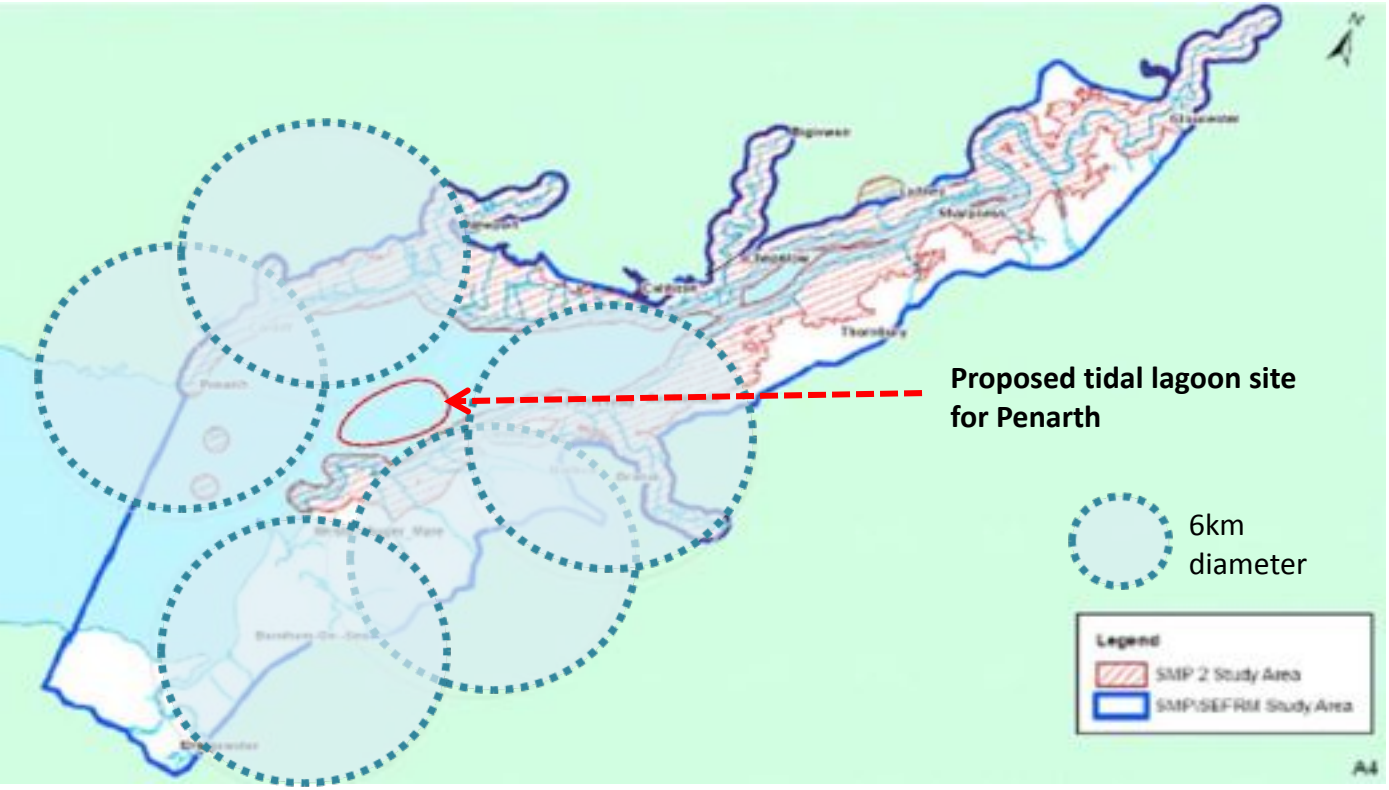
5.5 PENARTH Tidal Power Plan

*Since **there is no actual live case study for a tidal lagoon plant the estimates for this proposal for Penarth are derived from the proposed Swansea Tidal Lagoon project** which has a basin area of approximately 5km² (AEA Energy & Environment, October 2007) which is similar what has been estimated to be available for Penarth in this report. The approximate area of the site marked above is 6.5 km²*


Source: Google Earth


Source: WelshIcons.org.uk


Source: bbc.co.uk



Of this the Penarth shoreline comprises of about 88 hectares of coast within 1km SMP buffer zone. (Severn Estuary Partnership, 2002-09, Theme Review)

2) Visual Impact

From ***the case study on the Liverpool Bay Tidal Energy*** tidal lagoon it has been studied that the *lagoon has the visible part only 3m above high water level* ***and*** *has a visual impact from a distance of 6 km*. Therefore taking that as an approximate standard the ***site has been chosen at a distance of 6 km from the shore.***

System Brief

Capacity: 50 MW

Potential outputs:

Electricity**: 103 GWh/year**

Approximate cost:

Approximately £187.5 million with unit rate of electricity equal to 8.7p/ kWh at 3.5% discount rate and 18.39 p/ kWh at 8% discount rate.

Carbon savings:

5332000 tonnes of CO2 over an estimated life time of 125-130 years with a carbon payback period of approximately 9-12 years

Source: Crown, 2006, Tidal Lagoon Power Generation Scheme in Swansea Bay

Source: Atkins, 2009, Severn Estuary Shoreline Management Plan Review (SMP2)



Newport and the River Usk
The River Usk is bound by extensively developed land and open spaces with flood protection.
Much of the city is in a flood risk zone and protected extensively by flood defences.



Chepstow and the River Wye
The River Wye valley is designated as an Area of Outstanding Natural Beauty and includes an array of Sites of Special Scientific Interest.

Gwent Levels
The Gwent Levels is an extensive area of low lying land with nationwide significance for its wildlife and archaeology. There are numerous sites with in the Gwent Levels recognised as Sites of Special Scientific Interest.

Cardiff
Substantial industrial development and Cardiff Bay Barrage, alongside international and national statutory conservation designations and sites of histbric interest creates a complex coastal zone to sustainably manage. Cardiff Flats to the east of the port is undergoing significant rates of erosion.



Penarth
Weathering and erosion of the cliff faces both north and south of Penarth is of concern due to the threat to residential properties. Risk of flooding to commercial properties and infrastructure on Penarth Esplanade is also an

Gloucester
Extensive areas of low lying land either sid of the Severn Estuary at Gloucester are protected by defences.

Beachley to Sharpness
Agricultural grounds and small settlements are protected by a system of flood embankments.



The Severn Crossings
Here the estuary is constricted between the promontories of Sudbrook and Redwick / New Passage, and Beachley and Aus The land on either side of the river is low lying, leading to defence management issues and flood risk.

Bristol and the River Avon
Substantial industrial developments and the port of Bristol are located on the River Avon, a tributary of the Severn Estuary. Additionally, the critical infrastructure and residential developments at Bristol are key features considered by the SMP2.

Portishead and Clevedon
Agricultural land and residential units are well protected by the hard rock geology erosion resistant cliffs.



PENARTH Tidal System Guidelines:

The plan of GSHP has the following consideration:

➢ ***The turbines can be connected to the national grid*** via subsea cables to a suitable substation (nearest substation can be Aberthaw, Barry and Uskmouth). The cables could also be connected to the nearest landfall and then a new link connecting to the nearest suitable substation.

➢It should be noted that ***the values given are just basic guidelines*** and the actual calculation of these is a very lengthy process and involves 1 to 2 years

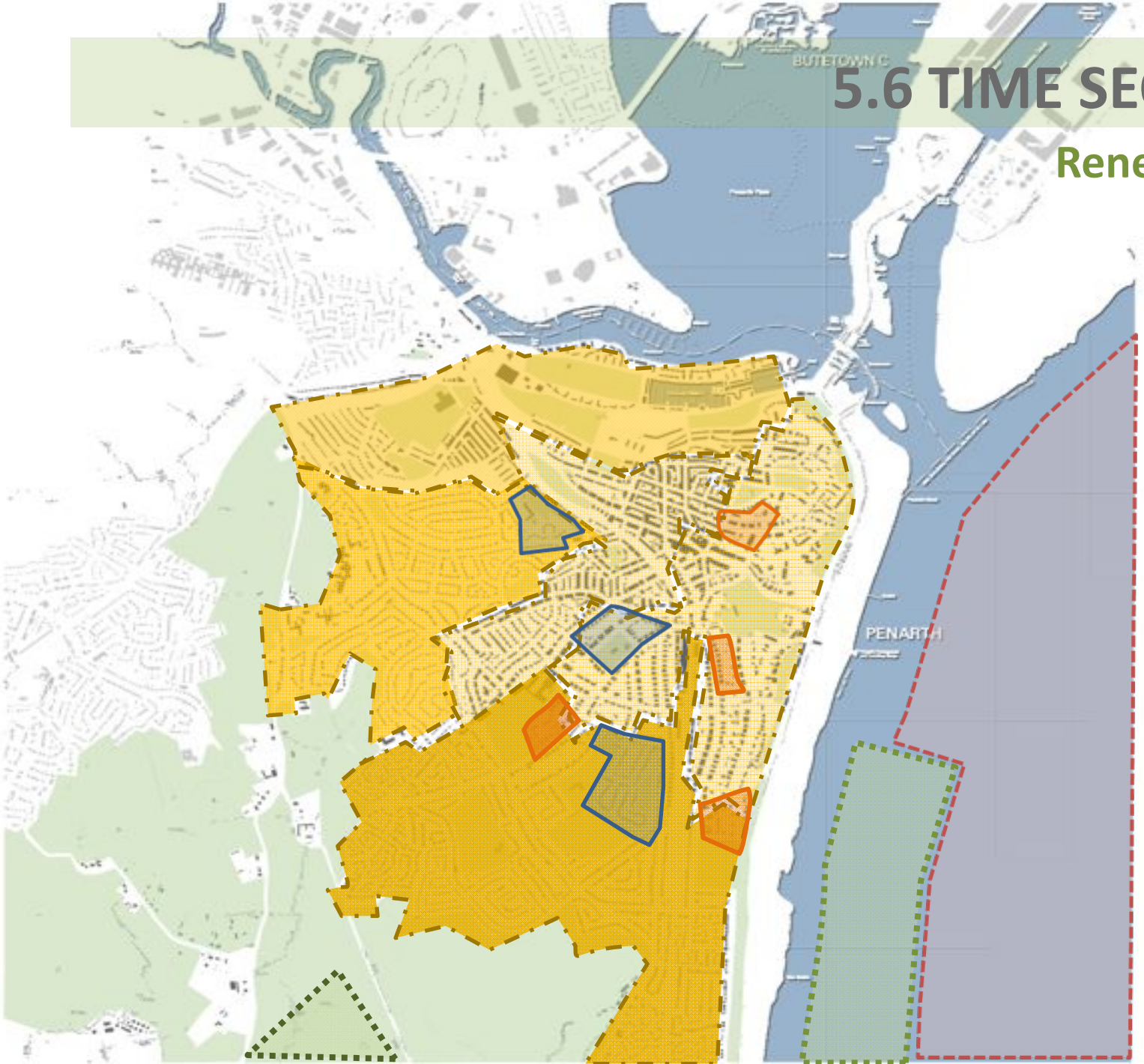
➢A ***detailed decommissioning Programme shall be required*** in order to gain permission for the project. The Crown Estate requires a decommissioning proposal which an incorporate a funding source such as a *bond.* (AEA Energy & Environment, October 2007)

➢A ***strategic Environmental Assessment*** is recommended by DEFRA and WAG to consider alternative options as a part of the tidal project before its implementation (Sustainable Development Commission, October 2007)

➢ ***The scheme can incorporate community involvement/ ownership*** and it is being looked into actively in north Wales. This can be done by informing the public about the social and environmental impacts of the scheme and most importantly the *"visual and landscape impacts at a local level"* (Sustainable Development Commission, October 2007) This can be done by presenting ***sophisticated computer simulated pictures of the scheme as it would look after implementation***.

5.6 TIME SEQUENCE PLAN

Renewable Energy Plan



Based on the locational plan of each type of renewable energy technology, the left graph illustrate all the sites.

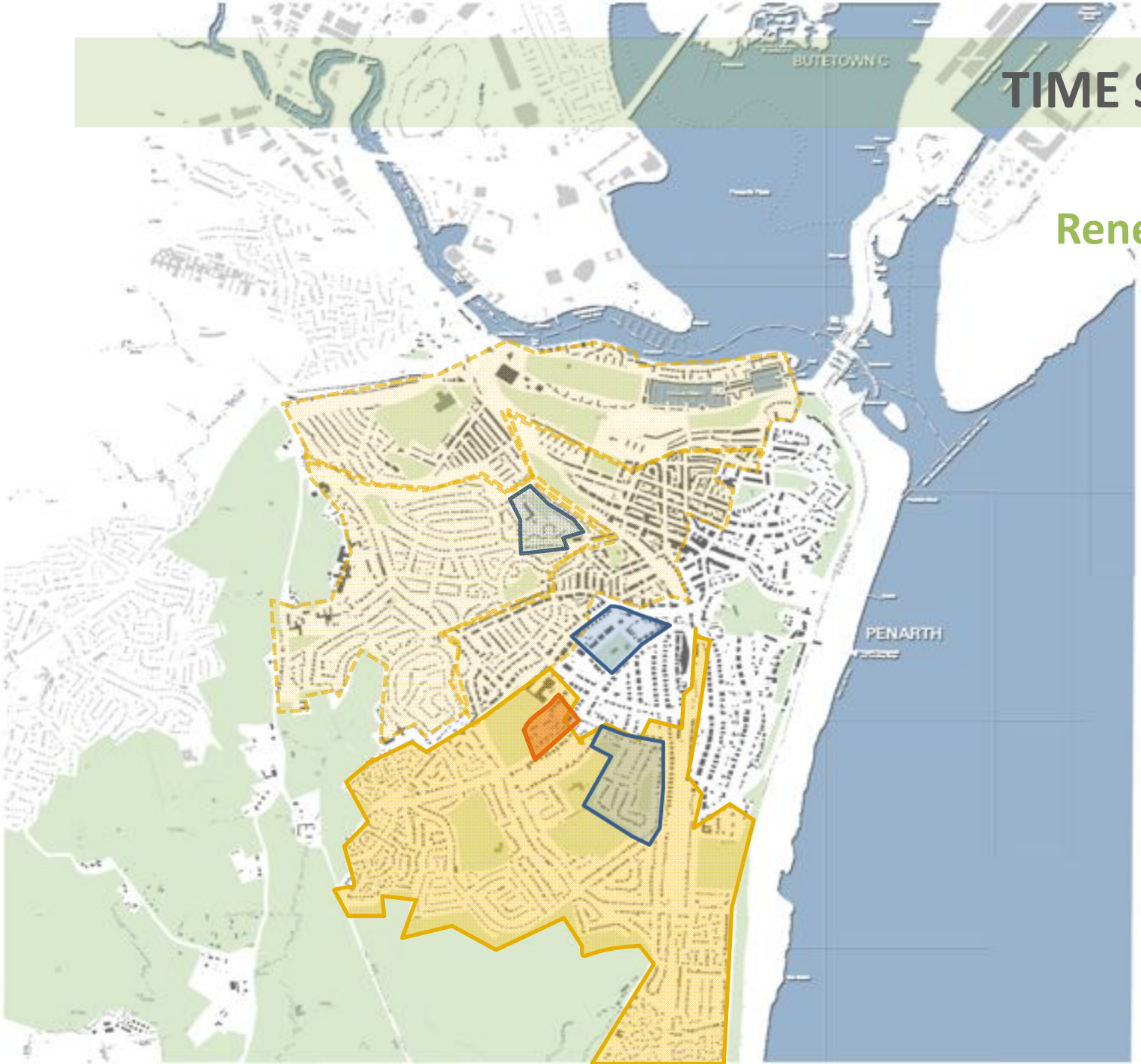
Legend

- Suggested GSHP Sites
- Suggested Biomass Sites
- Suggested on-shore Wind Turbine Sites
- Suggested off-shore Wind Turbine Sites
- Suggested Tidal Power Site
- First priority area of Solar PVs/ thermal
- Second priority area of Solar PVs/ thermal
- Third priority area of Solar PVs/ thermal
- Forth priority area of Solar PV/ thermal

TIME SEQUENCE PLAN

Penarth 2020

Renewable Energy Plan



*In this plan, there will be **20% of energy (electricity & heat) from renewable sources by 2020**.*

*T**hree biomass CHP plants, one Ground-Source Heat Pump** and the **priority area for Solar PVs/thermal** are planed to be implemented in this phase.*

Legend

- Suggested GSHP Sites
- Suggested Biomass Sites
- Priority area of Solar PVs/ thermal
- Other areas of Solar PVs/ thermals

Types of Renewables	Potential Annual outputs per system* (MWh/year)	Installed number	Total outputs* (MWh/year)	Total Potential Cost* (£)	Total Potential Carbon Savings (tonnes/year)
Biomass CHP	11,000	3	33,000	1,050,000	3,600
GSHPs	2,100	1	2,100	450,000	800
Solar PVs	1.8	280	500	3,475,000	200
Solar Thermal	2.0	550	1,100	2,475,000	500
NEWLY INSTALLED RENEWABLE ENERGY by 2020			36,700	7,450,000	5100
2020 TARGET			36,700	-	-

*The potential outputs of every renewable energy system is appraised based on preliminary study, and it might vary after further feasibility researches. The potential costs of every system are estimated based on the current market, it will decrease as the renewable energy market develops

PHASE 1: A Starting Stage

1) **Technically:** Compared with wind power or tidal power systems which need long-term feasibility researches and public consultations, ***Biomass CHPs/ boilers, Ground-Source Heat Pumps, and Solar PV/thermals*** *do* ***not require long-term feasibility research. Besides, t***hose technologies also do not have much spatial requirements. They can be integrated with buildings and relatively small scale.

2) **Economically:** Compared with other renewable energy technologies, the capital cost of ***biomass CHP system are relatively cheaper***. Furthermore, currently ***there are more grants*** both in Wales and at the national level available to Penarth, plus the Renewable Heat Incentives and Feed-In-Tariff, it would be ***more cost-effective to install Biomass***. Hence, the three sites of biomass CHPs are suggested to launched in the first phase.

3) **Socially:** This is a starting stage of renewable energy development, hence small-scale renewable energy systems are planned to implemented firstly since they are ***relatively easy to be owned or implemented by community***. The ***campaigns and publicity of renewable energy*** are significant in this stage.

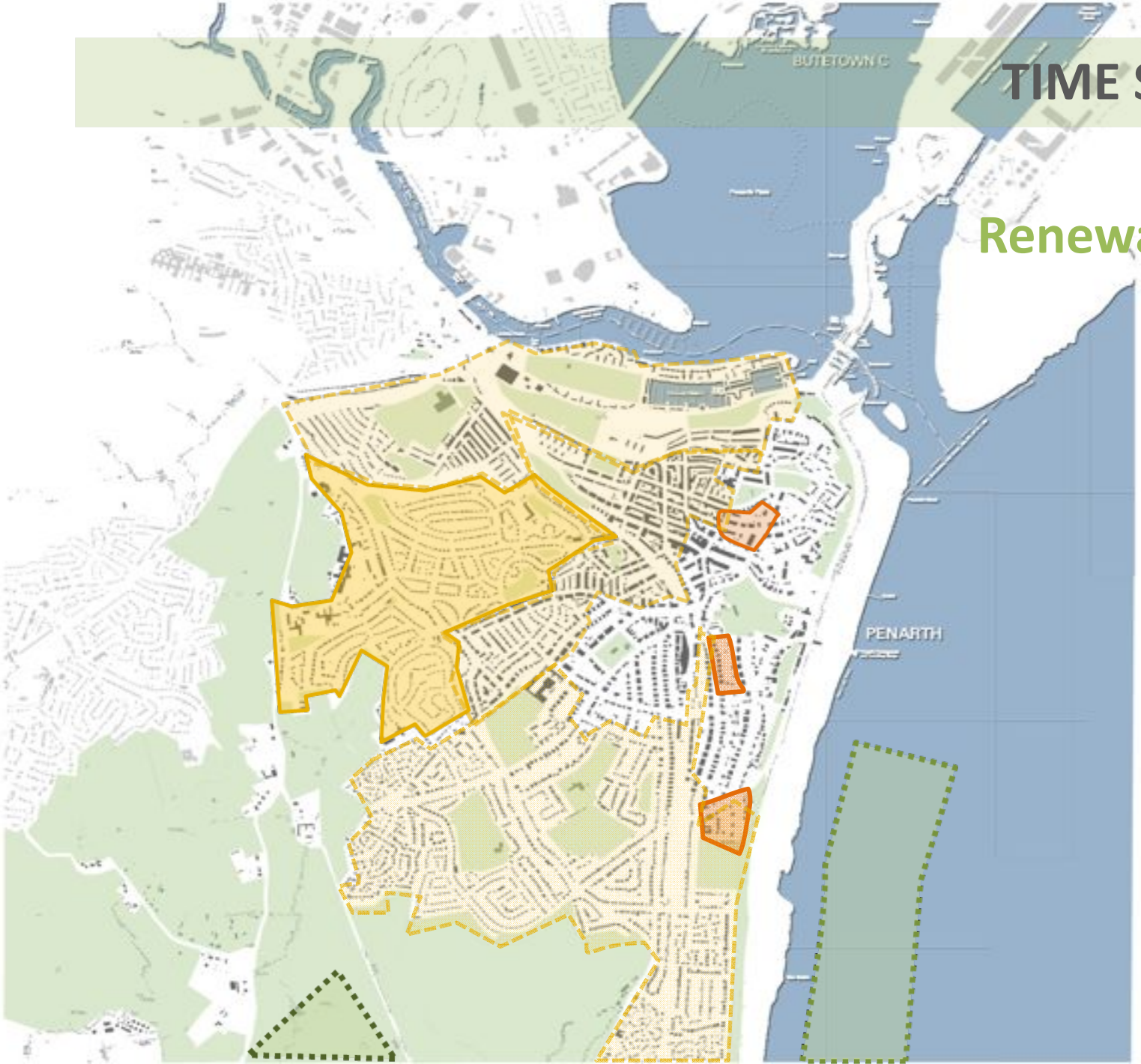
TIME SEQUENCE PLAN

Penarth 2030

Renewable Energy Plan

*In this plan, there will be **50% of energy (electricity & heat) from renewable sources by 2030**.*

*They are **three Ground-Source Heat Pump, two on-shore wind turbines, a set of off-shore wind turbines,** and **the priority area for Solar PVs/thermals**.*



Legend

- Suggested GSHP Sites
- Suggested on-shore Wind Turbine Sites
- Suggested off-shore Wind Turbine Sites
- Priority area of Solar PVs/ thermal
- Other areas of Solar PV/ thermal

Penarth 2030 Renewable Energy Plan

Types of Renewables	Potential Annual outputs per system* (MWh/year)	Installed number	Total outputs (MWh/year)	Total Potential Cost* (£)	Total Potential Carbon Savings (tonnes/year)
GSHP	2,100	3	6,300	1,350,000	2,400
On-shore Wind Turbine	6,500	2	13,000	7,000,000	5,590
off-shore Wind Turbine	8,000	4 (a set)	24,000	30,000,000	10,320
Solar PV	1.8	420	750	5,250,000	350
Solar Thermal	2.0	820	1,650	3,690,000	700
NEWLY INSTALLED RENEWABLE ENERGY			**47,900**	**47,290,000**	**19,360**
PHASE 1 (2020) INSTALLED RENEWABLE ENERGY			*36,700*	*-*	*5,100*
TOTAL RENEWABLE ENERGY by 2030			**84,600**	**-**	**24,460**
2030 TARGET			**84,600**	**-**	**-**

*The potential outputs of every renewable energy system is appraised based on preliminary study, and it might vary after further feasibility researches. The potential costs of every system are estimated based on the current market, it will decrease as the renewable energy market develops

PHASE 2: An Upgrading Stage

1) **Technically:** The Renewable energy development in phase1 will **have fostered a sophisticated renewable energy market** in Penarth, both renewable demand and renewable industry market. This period, from now to 2030, are long enough to complete the feasibility and efficiency researches of wind turbines. Hence**, both on-shore and off-shores wind turbines are planned to be implemented in this phase**.

2) **Economically:** *The potential cost of wind turbines in the table above is estimated based on the current market (2010), so it looks relatively higher. However,* ***the capital costs will decrease*** *with the time because,* generally speaking, the cost will ***decrease considerably*** as the ***wind turbine's market develops*** in the next 20 years.

3) **Socially:** Currently, some issues about wind turbines are **visual impact and noise**. The noise from wind turbines can *be minimized by suitable site selection*, and the idea of visual impact will be gradually changed as the advantages of renewable energy turn more obvious and significant. With the development of renewable energy for about two decades, *increasing local residents will* ***have deeper understanding*** *and* ***higher degree of recognition of*** *renewable energy .*

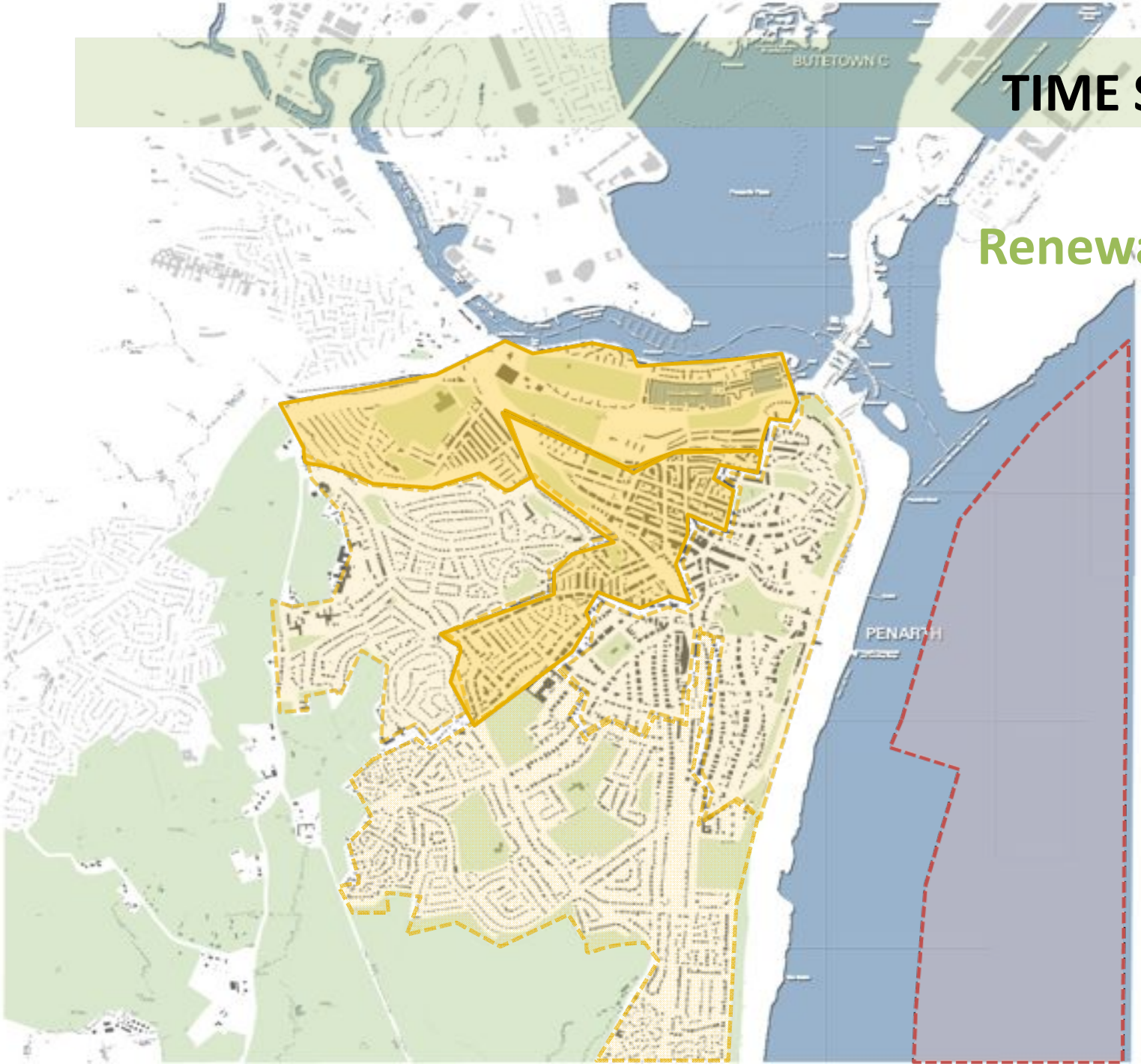
TIME SEQUENCE PLAN

Penarth 2050

Renewable Energy Plan

*In this plan, there will be **100% of energy (electricity & heat) from renewable sources by 2050**.*

*They are **a tidal power system, the priority area for Solar PVs/thermals.***



Legend

- Suggested Tidal Power Site
- Priority area of Solar PV/ thermal
- Other areas of Solar PV/ thermal

Types of Renewables			Total outputs * (MWh/year)	Total Potential Cost* (£)	Total Potential Carbon Savings (tonnes/year)
Tidal Power			103,000	About 190,000,000	5,332,000
Types of Renewables	**Potential Annual outputs per system* (MWh/year)**	**Installed number**	**Total outputs (MWh/year)**	**Total Potential Cost* (£)**	**Total Potential Carbon Savings (tonnes/year)**
Solar PV	1.8	310	560	3,875,000	250
Solar Thermal	2.0	620	1,240	2,790,000	500
NEWLY INSTALLED RENEWABLE ENERGY			**104,800**	**196,665,000**	**5,332,750**
PHASE 1 (2020) INSTALLED RENEWABLE ENERGY			*36,700*	-	*5,100*
PHASE 2 (2030) INSTALLED RENEWABLE ENERGY			**47,900**	-	**19,360**
TOTAL RENEWABLE ENERGY by 2050			**189,400**	-	**5,357,210**
2050 TARGET			**156.100**	-	-

*The potential outputs of every renewable energy system is appraised based on preliminary study, and it might vary after further feasibility researches. The potential costs of every system are estimated based on the current market, it will decrease as the renewable energy market develops

PHASE 2: An Self-Sufficient Stage

1) **Technically:** The majority potential capacities of other renewable energy technologies have already have been implemented, in order to achieve the target of ***100% locally renewable energy supply***, tidal system which has greater energy outputs is planned to be implemented in this stage. At that time, relevant ***feasibility researches*** will be completed and the ***tidal technology*** will be more sophisticated. also have made a great development, so at that stage, it might be possible to install the tidal system.

2) **Economically:** The ***cost of tidal system*** is fairly high according to current data (2010), so ***it will be a government-led or business-led project.*** Besides, The energy outputs will not only supply locally but also export to national grid, so the ***economic benefits*** from energy generation will also be considerable. furthermore, in order to optimize the efficiency, the tidal system will probably be ***a regional project,*** which will also help to share the capital cost.

3) **Socially:** As the tidal power system is installed in Penarth's coast or near Penarth's coast, Penarth will achieve 100% renewable energy. At that time, ***Penarth will be completely self-sufficient and self-reliant***. Furthermore, ***the majority of Penarth's residents might have be involved into one or two community renewable energy schemes***. People living in Penarth will ***have strong sense of community***. Besides, because of renewable energy development ***more green employment opportunities*** are available.

6.0 IMPLEMENTATION:

HOW to operate a Renewable Project in Penarth?

6.0 HOW to operate a Renewable Project in Penarth?

How to start a renewable energy project? Who will probably be involved in ? Where is the specialists, installers and suppliers?

- ***What to do step by step?***
- ***Who will be involved in various stages?***
- ***Where are the specialists, installers and suppliers located in and near Penarth?***
- ***Which kinds of grants or initiatives can Penarth apply for regarding to different technologies?***

These are probably the most common questions puzzled local residents when starting a renewable energy system in Penarth.

Hence, we also explore the useful information regarding to these four questions.

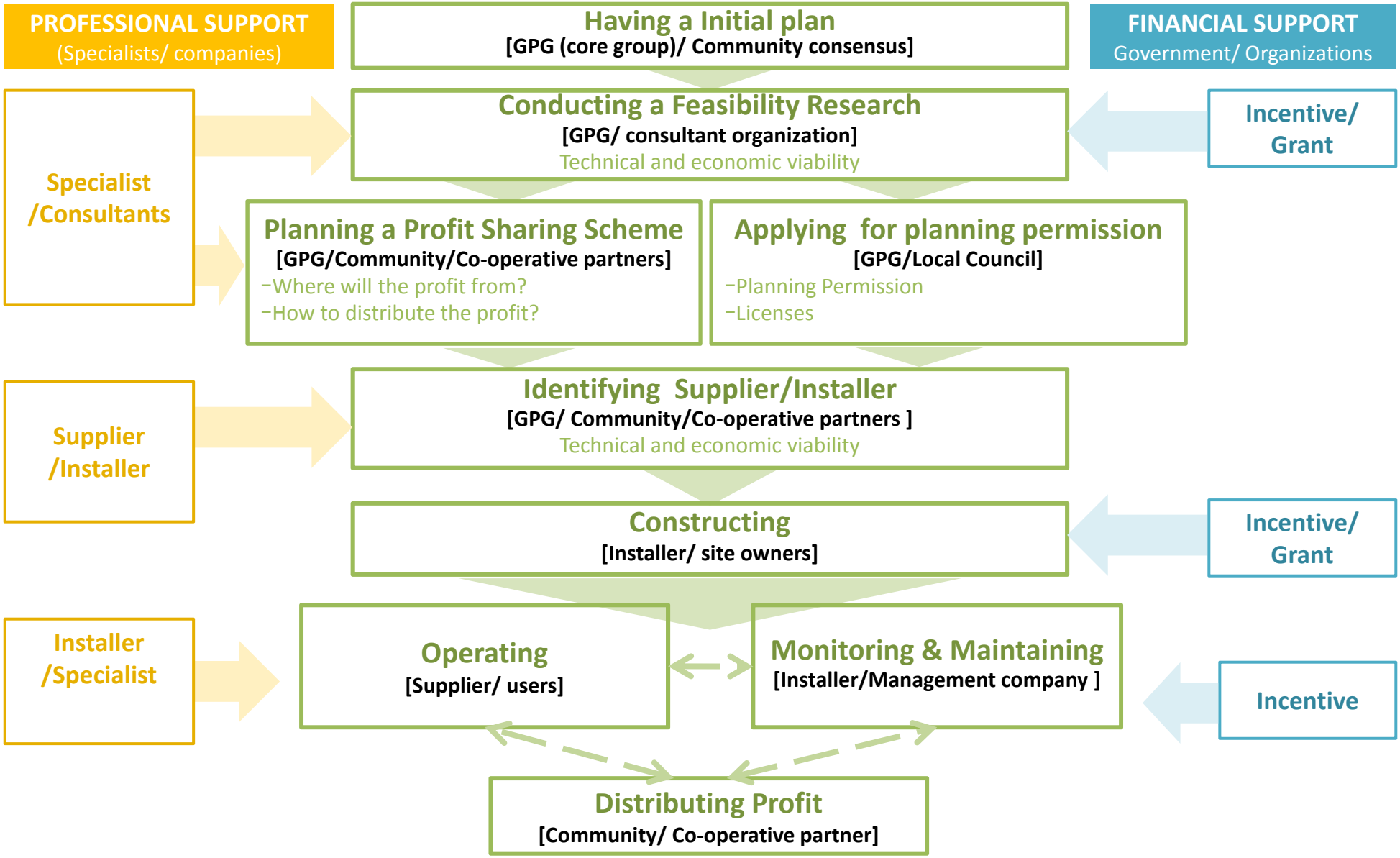
Firstly, the ***general procedure of a renewable energy system***, from feasibility researching to operating and maintaining, ***are shown in a flowchart***.

Secondly***, the professional support*** (including consultants, manufacturers and installers) ***and the available financial supports*** (including grants and initiatives) are ***listed for every technologies***.

Furthermore, there are various types of operational pattern of renewable energy projects, government-led, business-led or community-led. As a bottom-up plan, we assume the projects will be **COMMUNITY-LED PROGRAMs, and GPG will be a core group to push these projects.**

6.1 General Operational Flowchart for Community-led program

How to operate a Community-led renewable energy program?



SOLAR PVs/THERMAL System

PROFESSIONAL SUPPORT
(Specialists/ companies)

Specialist/Consultants:
1. *Energy saving trust*
2. *The Solar Trade Association*
3. *Renewable Energy Association*
4. *The microgeneration certification scheme*

Installer-solar PVs
1. *Williams PM Electrical Limited*
2. *PV Solar Solutions Ltd*
3. *Solar Total Limited*
4. *CAG Energy Limited*
5. *New Way Solar Energy Ltd*
6. *AP Electrical & Renewable Energy Ltd*

Installers_ Solar Thermal
1. Williams PM Electrical Limited
2. Gas Care Wales Ltd
3. Heatforce (Wales) Ltd
4. Inspect
5. John West (Contractors) Limited
6. Colin Laver Heating Ltd

Having a Initial plan
[GPG (core group)/ Community consensus]

Conducting a Feasibility Research
[GPG/ consultant organization]

Planning a Profit Sharing Scheme
[GPG/Community/Co-operative partners]

Applying for planning permission
[GPG/Local Council]

Identifying Supplier/Installer
[GPG/ Community/Co-operative partners]

Constructing
[Installer/ site owners]

Operating
[Supplier/ users]

Monitoring & Maintaining
[Installer/Management company]

Distributing Profit
[Community/ Co-operative partner]

FINANCIAL SUPPORT
Government/ Organizations

Incentive:
1. Feed-in tariffs (FITs)
2. Renewable Heat Incentive (RHI)

A Checklist of SOLAR PVs/THERMAL professional supports

Consultant

Company/ organisation name	location	website
Energy saving trust	Cardiff, CF10 4DQ	http://www.energysavingtrust.org.uk/
The Solar Trade Association	London, SE1 8RT	http://www.solar-trade.org.uk/
Renewable Energy Association	London, SE1 8RT	http://www.r-e-a.net/
The microgeneration certification scheme	-	http://www.microgenerationcertification.org/

Installers_ Solar PV

Company/ organisation name-	location	website
Williams PM Electrical Limited	Cardiff, CF11 8JQ	www.williamspm.com
PV Solar Solutions Ltd	CARDIFF, CF10 5EQ	www.pvsolar.eu
Solar Total Limited	CARDIFF, CF24 5GT	www.solartotal.com
CAG Energy Limited	CARDIFF, CF24 2NP	www.cagenergy.co.uk
New Way Solar Energy Ltd	Vale of Glamorgan, CF63 1EP	-
AP Electrical & Renewable Energy Ltd	CARDIFF, CF14 6JW	-

Installers_ Solar Thermal

Company/ organisation name	location	website
Williams PM Electrical Limited	Cardiff, CF11 8JQ	www.williamspm.com
Gas Care Wales Ltd	Cardiff, CF11 8AA	-
Heatforce (Wales) Ltd	South Glamorgan, CF14 5GP	www.heatforce.co.uk
Inspect	CARDIFF, CF14 6RG	www.inspect.uk.com
John West (Contractors) Limited	North Somerset, BS22 8NA	www.johnwestcontractors.co.uk
Colin Laver Heating Ltd	Mid Glamorgan, CF37 1BW	-

6.2 Useful Information for Implementation

WIND TURBINES System

PROFESSIONAL SUPPORT
(Specialists/ companies)

Specialist/Consultants:
1. *Community Windpower*
2. *Energy4all*
3. *RenewableUK*
4. *Wind Prospect*
5. *Egnisco Solutions Ltd*
6. *Pbe Bioenergy*
7. *Windpower Monthly*

Installer:
1. *Wind Prospect*
2. *Clipper Windpower*
3. *The MKW Group*
4. *Nordex UK Ltd.*
5. *REpower UK*
6. *Siemens Industrial Turbomachinery Ltd.*
7. *Vestas Celtic*

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[GPG/Community/Co-operative partners]

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[GPG/ Community/Co-operative partners]

Constructing
[Installer/ site owners]

Operating
[Supplier/ users]

Monitoring & Maintaining
[Installer/Management company]

Distributing Profit
[Community/ Co-operative partner]

FINANCIAL SUPPORT
Government/ Organizations

Incentive/ Grant:
1. *Community Sustainable Energy Programme*
2. *European Regional Development Fund (ERDF)*

Incentive/ Grant:
1. *Triodos Renewables from Triodos Bank*
2. *Energy4All*
3. *The Ventus Funds by Climate Change Capital Limited*

Incentive
1. *Feed-in tariffs (FITs)*

A Checklist of WIND TURBINES professional supports

Consultant

Company/ organisation name	location	website
Community Windpower	Cheshire, WA6 6XU	http://www.communitywindpower.co.uk/index.asp
Energy4all	Cumbria, LA14 2PN	http://www.energy4all.co.uk/home.asp
RenewableUK	South Glamorgan CF11 9HA	http://www.bwea.com/index.html
Wind Prospect	Bristol, BS8 1HG	http://www.windprospect.com/
Egnisco Solutions Ltd	Powys, SY22 6HT	http://www.egnisco.com/index.html
Pbe Bioenergy	Pembrokeshire SA62 6RQ	http://www.pbe.org.uk/
Windpower Monthly		http://www.windpowermonthly.com/go/contactus/

Installers

Company/ organisation name	location	website
Wind Prospect	Bristol, BS8 1HG	http://www.windprospect.com/
Clipper Windpower	London, NW10 7DG	http://www.clipperwind.com/aboutus.html
The MKW Group	Tyne & Wear, NE40 3EX	http://www.mkw.co.uk/index.php
Nordex UK Ltd.	Didsbury, M20 2DX	http://www.nordex-online.com/en
REpower UK	Edinburgh, EH1 3EG	http://www.repower-uk.co.uk/index.php?id=2
Siemens Industrial Turbomachinery Ltd.	Lincolnshire, Lincoln	http://www.siemens.com/entry/cc/en/
Vestas Celtic	Warrington, WA3 6XG	http://www.vestas.com/en/

6.2 Useful Information for Implementation

BIOMASS System

PROFESSIONAL SUPPORT
(Specialists/ companies)

Specialist/Consultants:
1. *Sustainable Energy Ltd*
2. *Organic Energy (UK) Limited*
3. *Good Life*
4. *Dulas Ltd.*
5. *Egnisco Solutions Ltd*
6. */Pbe Bioenergy*

Installer
1. *Eco Angus Ltd*
2. *Solid Fuel Services Ltd*
3. *Thermal Earth Ltd*
4. *VITAL Energi*
5. *R&S Biomass Equipment*

Supplier
1. *Ty Nant Timber*
2. *Cardiff Technoscapes*
3. *PLB Ecowood*
4. *The Firewood Company*
5. *FLS Treecare*
6. *Anstee Firewood*
7. *Pathfinder Renewable Energy*

Having a Initial plan
[GPG (core group)/ Community consensus]

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[GPG/ consultant organization]

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[GPG/Community/Co-operative partners]

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[GPG/Local Council]

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[GPG/ Community/Co-operative partners]

Constructing
[Installer/ site owners]

Operating
[Supplier/ users]

Monitoring & Maintaining
[Installer/Management company]

Distributing Profit
[Community/ Co-operative partner]

FINANCIAL SUPPORT
Government/ Organizations

Incentive/ Grant
1. Ynni'r Fro Grant funding (Up to £30,000 is available to fund early stage activities)
2. 100% interest free loans of £3k - £100k (Carbon trust)

Incentive/ Grant
1. Wood Energy Business Scheme – WEBS2 (run by Forestry Commission Wales)
2. Ynni'r Fro Grant funding
3. Enhanced Capital Allowances (ECAs) (run by Carbon Trust)
4. Big Lottery Fund

Incentive
1. Renewable Heat Incentives
2. Feed-In-Tariff

A Checklist of BIOMASS professional supports

Consultant

Company/ organisation name	location	website
Sustainable Energy Ltd	Cardiff, CF24 2SA	http://www.sustainable-energy.co.uk/
Organic Energy (UK) Limited	(Powys, SY21 7AZ)	http://www.organicenergy.co.uk/
Good Life Incorporated	Pembrokeshire, SA69 9HL	http://www.goodlifeincorporated.com/
Dulas Ltd.	Powys, SY20 8AX	http://www.dulas.org.uk/
Egnisco Solutions Ltd	Powys, SY22 6HT	http://www.egnisco.com/index.html
Pbe Bioenergy	Pembrokeshire SA62 6RQ	http://www.pbe.org.uk/

Installers

Company/ organisation name	location	website
Eco Angus Ltd	Somerset, BS40 5SA	http://www.ecoangus.co.uk/
Solid Fuel Services Ltd	Carmarthenshire, SA18 2ET	http://www.solidfuelservices.co.uk/
Thermal Earth Ltd	Ammanford, SA18 3SJ	http://www.thermal-earth.uk.com
VITAL Energi	Lancashire BB1 2LD	http://www.vitalenergi.co.uk/Index.aspx
R&S Biomass Equipment Ltd.	Newtownstewart, BT784ED	http://www.rsbiomass.com/index.html

Wood-chips & pellets suppliers

Company/ organisation name	Location	Distances from Penarth	website
Ty Nant Timber	Cardiff, CF14 5HP	6.9 miles away	http://www.firewoodman.co.uk
Cardiff Technoscapes	Cardiff, CF3 2AZ	8.2miles away	http://www.treetechno.co.uk/#
PLB Ecowood	Stable Cottage, Penmain Farm, CF71 7LT	10 miles	http://www.firewoodfuels.co.uk/
The Firewood Company	owbridge, CF71 7FF	12.4 miles	http://www.firewoodcompany.co.uk/
FLS Treecare	Abercarn, NP11 4SQ	15 miles	http://www.flstreecare.co.uk/
Anstee Firewood	Bridgend, Vale of Glamorgan, CF35 5DA	15.4 miles	http://www.anstee-firewood.co.uk/
Pathfinder Renewable Energy	Monmouthshire, NP15 1NZ	18.9 miles	http://www.pathfinderrenewableenergy.co.uk/

6.2 Useful Information for Implementation

GSHP system

PROFESSIONAL SUPPORT
(Specialists/ companies)

Specialist/Consultants:
1. *Groenholland UK Ltd*
2. *GECCO2 Limited*
3. *Cool Planet*
4. *Earth Energy Ltd*

Manufacturer
1. *Grant Engineering (UK) Ltd*
2. *Thermal Earth Ltd Dimplex*
3. *Viessmann Limited*
4. *DanfossRandall Ltd.*
5. *ICS Heat Pumps*

Supplier
1. *Azure Natural Energy Systems*
2. *Energy Heat Pumps*
3. *Ground Source Green Energy*
4. *Jawad Aurakzai*
5. *Loopmaster (Europe) Ltd.*
6. *GECCO2 Limited*
7. *ICS Heat Pumps*

Having a Initial plan
[GPG (core group)/ Community consensus]

Conducting a Feasibility Research
[GPG/ consultant organization]

Planning a Profit Sharing Scheme
[GPG/Community/Co-operative partners]

Applying for planning permission
[GPG/Local Council]

Identifying Supplier/Installer
[GPG/ Community/Co-operative partners]

Constructing
[Installer/ site owners]

Operating
[Supplier/ users]

Monitoring & Maintaining
[Installer/Management company]

Distributing Profit
[Community/ Co-operative partner]

FINANCIAL SUPPORT
Government/ Organizations

Incentive/ Grant
1. Government organizations such as DECC, WAG

Incentive/ Grant
1. Low carbon Building Programme Phase II from DTI
2. Lottery funded Community Sustainable Energy Programme
3. Carbon Trust - Energy Efficiency Loans
4. The Enchanced Capital

Incentive
1. Renewable Heat Incentives
2. Low carbon Building Programme Phase II

A Checklist of GSHP professional supports

Specialists

Company/ organisation name	Location	Distance from Penarth	website
Groenholland UK Ltd	Hampshire PO9 1BD	161 miles	http://www.groenholland.com/nl
GECCO$_2$ Limited	Northwich, Cheshire, CW8 1AQ	182 miles	http://www.gecco2.com/contact-us.aspx
Cool Planet (Part of British Gas	Higham Ferrers NN10 8DN	182 miles	http://www.cool-planet.co.uk/
Earth Energy Ltd	Falmouth, TR11 4SZ	213 miles	http://www.earthenergy.co.uk/contactus.asp

Technical consultants

Company/ organisation name	Location	Distance from Penarth	website
WSP Environment and Energy	Cardiff, CF3 0LW	12.7 miles	http://www.wspenvironmental.com/home
GASTEC at CRE Ltd	Gloucestershire, GL52 7RZ	76.9miles	http://www.gastecuk.com/
EA Technology Group	Chester,CH1 6ES	210 miles	http://www.eatechnology.com

Manufacturer

Company/ organisation name	Location	Distance from Penarth	website
Grant Engineering (UK) Ltd,	Wiltshire, SN10 2EU	78.2 miles	http://www.grantuk.com
Thermal Earth Ltd Dimplex – a division of the GDC Group	Southampton**,** SO30 2DF	145 miles	http://www.dimplex.co.uk/index.htm /
Viessmann Limited	**Telford,TF1 7YP**	150 miles	http://www.viessmann.co.uk/en
Danfoss Randall Ltd.	Bedford, MK42 9ER	193 miles	http://www.danfoss.com/United_Kingdom
ICS Heat Pumps	**Blackpool**,**FY4 2RP**	238 miles	http://www.icsheatpumps.co.uk/

Accredited Installers

Company/ organisation name	Location	Distance from Penarth	website
Azure Natural Energy Systems	Shrewsbury, SY5 8NY	87.8 miles	http://www.azure-systems.co.uk/
Energy Heat Pumps	Oxon OX29 4TH	106 miles	http://www.iceenergy.co.uk/home-page-_5/
Ground Source Green Energy	Warwickshire, CV358DS	128 miles	tim_inglefield@hotmail.co.uk
Jawad Aurakzai	West Drayton, UB79JF	141 miles	jaurakzai@yahoo.com
Loopmaster (Europe) Ltd.	Nuneaton, Warwickshire, CV11 4BH	142 miles	www.loopmastereurope.co.uk
GECCO$_2$ Limited	Northwich, Cheshire, CW8 1AQ	182 miles	http://www.gecco2.com/contact-us.aspx
ICS Heat Pumps	**Blackpool,FY4 2RP**	238 miles	http://www.icsheatpumps.co.uk/

6.2 Useful Information for Implementation

TIDAL System

PROFESSIONAL SUPPORT
(Specialists/ companies)

Specialist/Consultants:
1. Marine Current Turbines Ltd
2. IT Power
3. Wind Prospect Ltd
4. C-Wave Ltd

Manufacturer
1. Marine Current Turbines

Installer/ Equipment Supplier
1. Marine Current Turbines
2. Swan Turbines
3. C-Wave Ltd

Operators
1. Marine Current Turbines
2. South West England Wave Hub Project
3. Pulse Generation

Having a Initial plan
[GPG (core group)/ Community consensus]

Conducting a Feasibility Research
[GPG/ consultant organization]

Planning a Profit Sharing Scheme
[GPG/Community/Co-operative partners]

Applying for planning permission
[GPG/Local Council]

Identifying Supplier/Installer
[GPG/ Community/Co-operative partners]

Constructing
[Installer/ site owners]

Operating
[Supplier/ users]

Monitoring & Maintaining
[Installer/Management company]

Distributing Profit
[Community/ Co-operative partner]

FINANCIAL SUPPORT
Government/ Organizations

Incentive/ Grant
1. Government organizations
2. European Union, WAG
3. Technology Programme
4. Competitions to develop demonstration projects
5. WAG/DEFRA/SWRDA

Incentive/ Grant
1. Renewable Obligations
2. Marine Renewable Deployment Fund (MRDF)
3. EU Structural Funds
4. Tax funded/ Govt.-backed bonds
5. Bonds issue/ large institutional financer
6. ESCOs

Incentive
1. Tax funded
2. Long-term low-carbon electricity contracts

A Checklist of TIDAL professional supports

Specialists/ Designers/ Consultants

Company/ organisation name	Location	Distance from Penarth	website
Marine Current Turbines Ltd	Bristol, BS34 8PD	43.9 miles	http://www.marineturbines.com
IT Power	Bristol, BS1 5QT	47.3 miles	http://www.itpower.co.uk/Home
Wind Prospect Ltd	Bristol, BS8 1HG	47.7 miles	http://www.windprospect.com
C-Wave Ltd	University of Southampton, Highfield, SO17 1BJ	84.5 miles	http://www.emec.org.uk

Manufacturer

Company/ organisation name	Location	Distance from Penarth	website
Marine Current Turbines Ltd	Bristol, BS34 8PD	43.9 miles	http://www.marineturbines.com

Turbine Installers/ Equipment Suppliers

Company/ organisation name	Location	Distance from Penarth	website
Swan Turbines	Singleton Park, Swansea SA2 8PP	45.4 miles	http://www.swanturbines.co.uk/home.htm
C-Wave Ltd	University of Southampton, Highfield, SO17 1BJ	84.5 miles	http://www.emec.org.uk

Operators

Company/ organisation name	Location	Distance from Penarth	website
Marine Current Turbines Ltd	Bristol, BS34 8PD	43.9 miles	http://www.marineturbines.com
South West England Wave Hub Project	Plymouth, PL4 0RA	153 miles	http://www.wavehub.co.uk/
Pulse Generation	Hull, HU5 3HX	257 miles	http://www.pulsegeneration.co.uk

7.0 FURTHER UNDERSTANDING:

Renewable Energy Technologies

Penarth, *a beautiful costal town, is* ***rich of renewable energy and*** *has* ***great development potentials for renewable energy****. Hence,* ***a clear energy future*** *is not a dream for Penarth.*

7.0 A FURTHER UNDERSTANDING of Renewable Energy

A holistic understanding of renewable energy, including technologies, long-term advantages, possible outcomes as well as potential issues, is crucial for the public. Because that helps them to have enough background knowledge, and be able to participate in projects and choose suitable technologies for themselves.

Hence, some useful information, including the characteristics, the advantages and potential barriers of these technologies, are analyzed in this part, which could provide a relatively comprehensive introduction of various renewable energy technologies. As introducing the technologies, the suitability to Penarth is also analyzed, which to some extent also explain the reasons we choose these technologies and systems in this Renewable Energy Plan for Penarth.

Some selected cases are explained for every renewable energy technology in order to demonstrate their implementation in practice. Also, some useful lessons which can be learnt for Penarth are summarized with an aim to promote the development of renewable energy in Penarth.

7.1 Solar Electricity (Photovoltaic)

"When electricity rather than heat is required, PV is a robust, flexible, scaleable technology which can provide energy for both houses and other buildings." *Solar Trade Association*

What is Solar Photovoltaic?

Solar has been taken as an abundant, free and clean energy resource which provide energy in the form of light and warmth. *Energy from the sun can be used to generate electricity through a PV system. Solar PV systems convert the sun's rays directly into electricity through the use of solar cells.* (Solar Trade Association).

The solar cells are normally packaged together into panels. For building-integrated system, the solar panels are generally placed on roof; while commercial scale solar PV arrays are grouped into arrays and mounted on freestanding racks(Welsh Assembly Government, 2011).



Source: solar-trade.org.uk



Source: powerofsolarenergy.com

System types

The majority of PV cell are made from silicon-based materials and can be classified into crystalline silicon cells and thin film cells. Generally speaking, crystalline silicon cells have higher efficiency for converting solar energy to electricity than film cells while the cost for production is relatively higher. Among them, monocrystalline silicon cells possess the highest conversion efficiency of 15-18%.

The solar PV system can be integrated with building in several ways, including (Pennycook, 2008):

- *Sloping and flat roofs*
- *Building façades*
- *Glass roof structures*
- *Solar shading devices.*

Integrating the PV panels into the building fabric can reduce the cost for mounting the panels on a frame, and retrofit work will be required such as replacing roof tiles with conventional components .



Source: homemadeenergyreview.com



Source: BSRIA

7.1 Solar Electricity (Photovoltaic)

"When electricity rather than heat is required, PV is a robust, flexible, scaleable technology which can provide energy for both houses and other buildings." *Solar Trade Association*

What is Solar Photovoltaic?

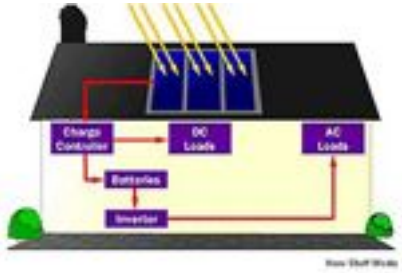
There are two main types of PV systems: grid-connected and standalone (Pennycook, 2008).

Buildings with the grid-connected system are able to use the generated electricity when in need while excess electricity could be exported to the grid and get profit through the Fit-in Tariff (FITs).

Stand alone systems used for domestic and industrial applications in which a household or company is able to produce its own electricity and its yield can be matched to its demand (The Solar Trade Association, 2011). This type of system will require batteries for storage electricity while not in use. Hence, it will be suitable for houses or buildings which are inconvenient or expensive to connect to the grid.



Source: energysavingtrust.org.uk



Source: solarcellcentral.com

Performance

The orientation and the shading nearby should be consider when placing the solar panels.

Generally speaking, the orientation would be ideally due south and tilted by the angle between 30° and 50° from the horizontal to give the best overall annual performance(Energy Saving Trust, 2011). Though PV systems can perform at any orientation, however, the output will be reduced when facing the other orientations.

Shading will affect the performance of PV panels. Since the modules are all connected, one single modules being shaded will affect the whole performance as well. Therefore, the location should avoid tall buildings or trees nearby.

Solar PV systems can still work on cloud days but will only generate one third of the energy in sunny days (Energy Saving Trust, 2011).

In UK, with reasonable tilt, orientation and system efficiency, a PV array will generate approximately 750kWh per year per kWp (peak) installed or 100kWh per m^2 annual (Pennycook, 2008).

The size of a solar PV panel is around 1m x 1.5m. A 2.2kWp system which comprises of 12 panels taking up an area of 15m2 will generate 1800kWp annul and cover around 45% of the average home use (Energy Saving Trust, 2011).

7.1 Solar Electricity (Photovoltaic)

"When electricity rather than heat is required, PV is a robust, flexible, scaleable technology which can provide energy for both houses and other buildings." *Solar Trade Association*

Why Solar Photovoltaic?

The advantage for using solar PV systems could be:

Cut your electricity bills and carbon footprint

Since the sunlight is free, once the system has been installed, the electricity bill could be reduced effectively. A typical domestic solar PV system can support around 40% of the electricity for household use in one year(Energy Saving Trust, 2011).

The electricity could be generate in a way which is green, zero carbon emission and without pollutants through solar PV systems. It has been demonstrated that a typical PV system could save around 1000kg of CO_2 per year (Energy Saving Trust, 2011). Considering the lifespan of solar PV system, around 25,000kg of carbon emission would be saved over its life time.

Get profit through selling surplus electricity back to the grid

For grid-connected system, the generated electricity can both support the need or be exported to the grid depending on the usage at the time. For domestic buildings, if the system is generating more electricity than need or during the time with low demand, the owners can get profit through selling electricity back to the grid.

In UK, the Feed-in Tariffs (FITs) scheme is suitable for solar electricity. The scheme guarantees both a minimum payment for all electricity generated by the system and additional payment for exported electricity. The payment mainly depends on the system size and the installation time and with the guarantee of 25 years.

The current tariff for domestic buildings is shown below:

Technology scale	Current tariff level (p/kWh)	Tariff lifetime (years)
≦ 4kW (on existing building)	41.3	25
≦ 4kW (new building home)	36.1	25

Source: energysavingtrust.org.uk

Beside the generation tariff above, the owners will be paid 3p/kWh for every exported electricity. Moreover, around 12.5p/kWh of electricity bill could be saved by use the generated electricity on-site(Energy Saving Trust, 2011).

Store excess electricity for use while need

For stand alone systems which are not connected to the national grid, the excess electricity can be saved in batteries to ensure the supply when there is not enough daylight or when the electricity demand is higher than the generation amount.

Low maintenance will be required during lifetime

Solar PV systems require very little maintenance if designed well. The main point for maintenance is to keep the panels clean and make sure they are not overshadowed by surroundings.

7.1 Solar Electricity (Photovoltaic)

"When electricity rather than heat is required, PV is a robust, flexible, scaleable technology which can provide energy for both houses and other buildings." *Solar Trade Association*

Potential barriers

There are still some potential barriers need to be considered when adopting solar PV systems:

High initial installation cost

Generally speaking, the installation cost for solar PV system is around £5,800 per kWp. As for a typical 2.2kWp system for domestic hoses, the cost will be around £12,500(Energy Saving Trust, 2011). This is relatively higher than other micro-scale electricity generation. However, comparing the possible benefit during the operation including the profit from FITs and the cut in electricity bill, solar PV systems could still possess its advantage to be the alternative of electricity resource.

Visual impact from the PV arrays

PV arrays do have some visual impact on the environment. Since the panels will be clearly visible to neighbors, and may be regarded as either attractive or unattractive depends on individual aesthetic taste (Boyle, 1996). In high housing density area, the sun glare reflected by the panel might also cause the visual discomfort.



(Source: Clean Technica)

Planning permission might be required

Most of application of solar PV systems will not need planning permission below the size regulated by local council. However, according to The Town and Country of Wales, the following condition of development will require the planning permission (Welsh Assembly Government, 2011):

- *The solar PV or solar thermal equipment would protrude more than 200mmbeyond the plane of the wall or the roof slope when measured from the perpendicular with the external surface of the wall or roof slope.*
- *It would result in the highest part of the solar PV or solar thermal equipment being higher than the highest part of the roof (excluding any chimney).*
- *In the case of land within a conservation area or which is a World Heritage Site, the solar PV or solar thermal equipment would be installed –*
  - *On a wall forming the principal or side elevation of the dwelling house and would be visible from a highway, or*
  - *On a wall of a building within the cartilage of the dwelling house and would be visible from a highway, or*
  - *The solar PV or solar thermal equipment would be installed on a building within the cartilage of a dwelling house if the dwelling house is a listed building.*

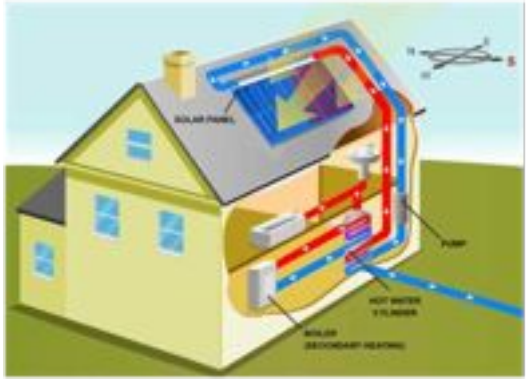
1.2 Solar Water Heating

Solar water heating is a well known renewable energy technology in the UK. It can be used to provide hot water at temperatures of between 55 and 65ºC. *Energy Saving Trust*

What is Solar Water Heating?

By collecting the heat from solar radiation, solar water heating systems produce renewable hot water for domestic use. The heat is collected by solar collectors which are usually placed on the roof of a building. A back-up system such as a conventional boiler or immersion heater would be required to heat the water further or provide hot water when solar energy is unavailable.

Though the performance would depends on the weather condition and the best performance usually happens in the summer months when home heating is unnecessary, a well designed solar thermal system could still meet 50-60% of demand during May-September (Welsh Assembly Government, 2011).



(Source: energy saving trust)

System types

A solar thermal system usually contains the solar panels sited on a south-facing roof, free of shade, tilted at an angle between 20 and 50 degree, and a back-up system such as boiler and a storage cylinder (The Solar Trade Association, 2011).

There are three main types of solar heating collector that are suitable for mounting on buildings. These are: (Energy Saving Trust, 2006)

Flat-plate collectors

> *A sheet of black metal that absorbs the sun's energy encases the collector system. Water is fed through the system in pipes which conduct the heat to the water.*

Evacuated tubes

> *A series of parallel glass heat tubes grouped together. Each tube contains an absorber tube. Sunlight passing through the outer glass tube heats the absorber tube contained within it, and in doing so, the heat is transferred to water flowing through the tube.*

Solar matting

> *A range of extruded hollow sections of flexible black material that can be used for solar collection. Water passes through the hollow tubes, absorbing the heat from the sun.*

Performance

An adequately designed solar water heating system can provide at least 40-60% of the domestic hot water requirement per year. The saved energy could reduce around 400kg of carbon dioxide annual (The Renewable Energy Centre, 2011).

1.2 Solar Water Heating

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Why Solar Water Heating?

Hot water throughout the year

An adequately designed solar water heating system can provide at least 40-60% of the domestic hot water requirement per year. The saved energy could reduce around 400kg of carbon dioxide annual (The Renewable Energy Centre, 2011). Though requiring further heating with a boiler, especially during winter season, solar water heaters can supply hot water all year round.

Cut fossil fuel bills and carbon footprint

The solar water heating system can provide around one third of domestic hot water needs. That will not cut the bill for fossil fuel but also reduce the carbon dioxide emission.

It has been estimated that applying the solar water heating system to a three bedroom, semidetached home, the saving in terms of cost and carbon emission are shown below.

Fuel Displaced	£ Saving per year	CO2 saving per year
Gas	£50	260kg
Electricity	£85	580kg
Oil	£50	320kg
Solid	£65	530kg

Source: energysavingtrust.org.uk

Financial support from Renewable Heat Incentive (RHI)

The UK government provides the financial support for solar water heating system through RHI policy. The eligible installation should be below 200kWth capacity and be MCS, or equivalent certificated. The support duration for solar water heating system is 20 years (DECC, 2011).

Moderate installation cost and low maintenance

Typically, solar water heating systems installed into existing households are priced in the region of £4,000, though this will depend on the size and type of collector and storage system (The Solar Trade Association, 2011). Comparing the installation cost for solar PV system, it is quite moderate and will be suitable even for domestic houses.

The cost for maintenance is relatively low and little maintenance will be required. The key point is to keep the solar panels clean and avoid the shading falling on. A thorough check by an accredited installer every 3-5 years will ensure a better performance (Energy Saving Trust, 2009).

1.2 Solar Water Heating

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Potential barriers

Planning permission might be required

Like the application of solar PV systems, concerning the effect due to the visual impact, it may require planning permission before installing the solar water heating system.

The Town and Country of Wales has regulated the following condition of development to apply for the planning permission before installation (Welsh Assembly Government, 2011):

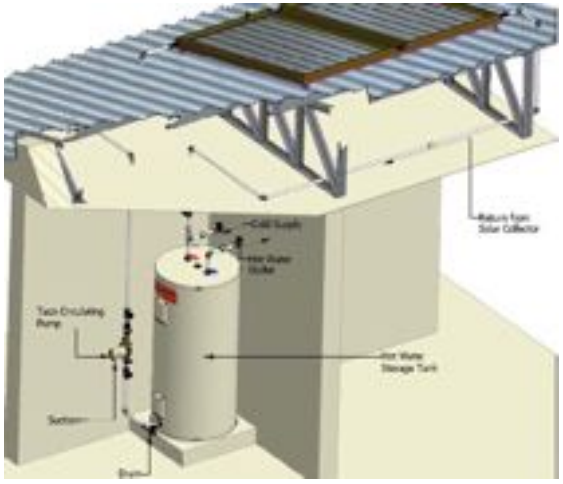
- *The solar PV or solar thermal equipment would protrude more than 200mmbeyond the plane of the wall or the roof slope when measured from the perpendicular with the external surface of the wall or roof slope.*
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  - *On a wall of a building within the cartilage of the dwelling house and would be visible from a highway, or*
  - *The solar PV or solar thermal equipment would be installed on a building within the cartilage of a dwelling house if the dwelling house is a listed building.*

Extra space for a larger water cylinder

The sizing of the cylinder should be closely linked to the area of collectors on the roof, ranging between 25–75 litres per m^2 of collector area (The Solar Trade Association, 2011). For a typical solar water heating system with $5m^2$ of solar panels, it will require around 300 litres of water cylinder which will require a corresponding size of space.

The existing boiler should be compatible with solar water heater

Most conventional boiler and hot water cylinder systems are compatible with solar water heating (Energy Saving Trust, 2009). Therefore, if the existing boiler is a combination boiler without a hot water tank, then the solar water heating system may not be compatible and extra cost for additional tank or boiler replacement.



(Source: Amici Water Systems)

References & Bibliography:

Boyle, G., 1996. *Renewable Energy*. Oxford: The Open University.
DECC, 2011. *Renewable Heat Incentive*. London: DECC.
Energy Saving Trust, 2006. *Renewable energy sources*. London: Queen's Printer and Controller of HMSO.
Energy Saving Trust, 2009. *Solar thermal hot water*. [Online] Available at: http://www.lowcarbonbuildings.org/Microgeneration-Technologies/Solar-thermal-hot-water [Accessed May 2011].
Energy Saving Trust, 2011. *Solar electricity*. [Online] Available at: http://www.energysavingtrust.org.uk/Generate-your-own-energy/Solar-electricity [Accessed March 2011].
Home Made Energy, 2009. *Build Your Own PV Solar Panels*. [Online] Available at: http://www.homemadeenergyreview.com/blog/build-pv-solar-panels/ [Accessed May 2011].
Pennycook, K., 2008. *The Illustrated Guide to Renewable Technologies*. Berkshire: BSRIA.
The Renewable Energy Centre, 2011. *Solar Heating*. [Online] Available at: http://www.therenewableenergycentre.co.uk/solar-heating/ [Accessed May 2011].
The Solar Trade Association, 2011. *PV Systems*. [Online] Available at: http://www.solar-trade.org.uk/solarHeating/pvSystems.cfm [Accessed May 2011].
The Solar Trade Association, 2011. *Solar Heating (hot water)*. [Online] Available at: http://www.solar-trade.org.uk/solarHeating/solarHeating.cfm [Accessed May 2011].
Welsh Assembly Government, 2011. *Planning Implications of Renewable and Low Carbon Energy*. Cardiff: Welsh Assembly Government.

7.3 Wind Power

In the UK, wind power is the most well developed and economically viable form of renewable energy. Wind turbines produce electricity by capturing the natural power of the wind to drive a generator. *Energy Saving Trust*

What is Wind Power?

Wind energy has been considered as one of the clean energy resources. I*n the UK, 40% of all the wind energy in Europe blows over the UK* (Energy Saving Trust, 2009), making it an ideal country for adopting wind energy. However, the statistics identified that only 0.5% of the electricity demand is generated by wind power currently in the UK and showed the largely untapped condition (Energy Saving Trust, 2009).

By converting the Kinetic energy from the wind into mechanical energy, wind turbines drive the generator to convert wind energy into electricity (The Renewable Energy Centre, 2011). Possessing the sufficient wind energy, wind turbines have the potential to generate substantial electricity without producing harmful pollutions and considerable CO_2 emission which have been served as the major problem of most conventional forms of electricity generation.

"*Wind power is proportional to the cube of the wind's speed*", therefore, even minor increases in wind speed will result in considerable changes in potential output (Energy Saving Trust, 2009). For wind generation, the suggested average wind speed will be no less than 5m/s. Moreover, considering the shelter from existing buildings or trees might decrease the efficient wind speed, an open and exposed site would be more suitable.



Wind resources[1] at 50 metres above ground level for five different topographic conditions

	Sheltered terrain[2]		Open plain[3]		At a sea coast[4]		Open sea[5]		Hills and ridges[6]	
	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}
	> 6.0	> 250	> 7.5	> 500	> 8.5	> 700	> 9.0	> 800	> 11.5	> 1800
	5.0-6.0	150-250	6.5-7.5	300-500	7.0-8.5	400-700	8.0-9.0	600-800	10.0-11.5	1200-1800
	4.5-5.0	100-150	5.5-6.5	200-300	6.0-7.0	250-400	7.0-8.0	400-600	8.5-10.0	700-1200
	3.5-4.5	50-100	4.5-5.5	100-200	5.0-6.0	150-250	5.5-7.0	200-400	7.0- 8.5	400- 700
	< 3.5	< 50	< 4.5	< 100	< 5.0	< 150	< 5.5	< 200	< 7.0	< 400

Source: European Wind Atlas, 1998

7.3 Wind Power

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What is Wind Power?

System types

Wind turbines can be categorized into two types including free-standing and building-mounted versions (Energy Saving Trust, 2006).

Building-mounted wind turbines are usually installed on the roof of a building and mainly for micro or small-scale application. The size for building-mounted wind turbines are often are around 1kW to 2kW in size (Energy Saving Trust, 2009).

The free-standing wind turbines are available in a large range of size. Generally speaking, the large scale wind turbines (1-2 MW) are used in wind farm development. They can be single installation or group on exposed sites with sufficient space. The capacity for small scale wind turbines are usually less than 1MW and will be more suitable for on-site applications (Energy Saving Trust, 2006).

The generated electricity from both type of wind turbine can provide power to an existing building or be exported to the national grid. For most wind farms which are located in more remote areas, the generation will directly supply to the national grids (Welsh Assembly Government, 2011).

(Source: The Saint)

Besides the on-shore application illustrated above, offshore wind turbines development has been set to increase steadily. The UK possesses a substantial proportion of the total European offshore wind resource in Britain's waters. It has been estimated that the potential generation could reach 1,000 terawatt hours (TWh) per year is equivalent to several times of the total electricity consumption in the UK. With the *favorable combination of wind resource, strong offshore regime and the extension of relevant legislation*, the UK has been identified as the best market for offshore wind turbine development in the world (BWEA, 2005).



(Source: Wind Turbine Zone)

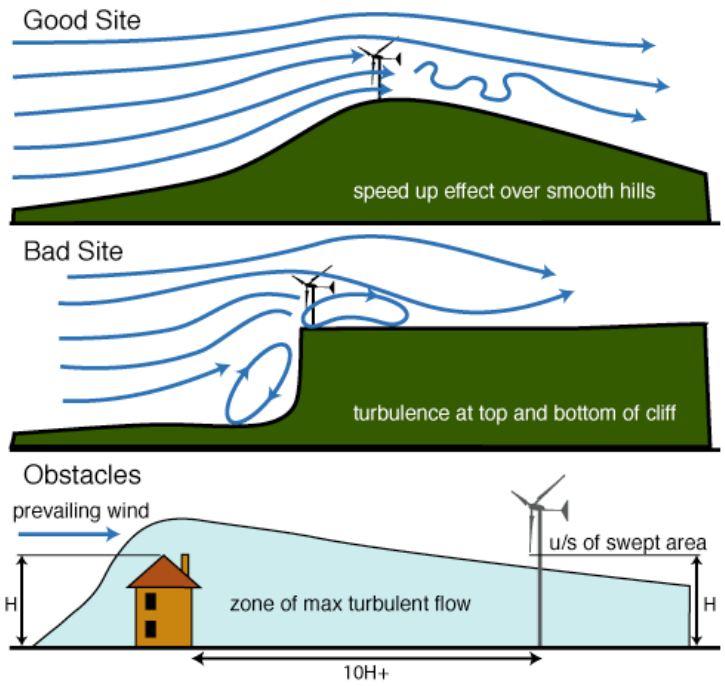
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What is Wind Power?

Site suitability

The wind condition of the site is important for wind turbine application. Therefore, it is necessary to obtain the relevant information. A preliminary estimate of annual wind speed for exposed sites is available from the DTI wind speed database (http://www.bwea.com/noabl/) (Energy Saving Trust, 2006). However, to ensure the actual efficiency, a further measurement for site wind condition will be required.



locate the turbine away from the turbulence caused by obstacles

Source: greenspec.co.uk

Performance

Performance

The following factors could affect the performance of wind turbines:

- Wind speed
  "The power available from the wind is a function of the cube of the wind speed." (Boyle, 1996) That means slight increase of the wind speed might increase the potential output significantly. For example, with a 20% of increase in wind speed, the generation will become almost double of the original amount.
- Height
  "Wind increases in speed with height because of the reduced drag of the land." (Boyle, 1996) Without the resistance from the drag of the land, the efficient wind speed can be improved. Studies show that 10% of the wind speed increases as doubling the height and raises 34% of the power output.
- Size of the rotor
  The power output will increase with a larger rotor. Since *the output is related to the square of the rotor diameter*, doubling the diameter will result in four times of the electricity generation.

7.3 Wind Power

In the UK, wind power is the most well developed and economically viable form of renewable energy. Wind turbines produce electricity by capturing the natural power of the wind to drive a generator. *Energy Saving Trust*

Why Wind Power?

UK possess 40% of Europe's total wind energy

The best wind resources including onshore and offshore locations have made the UK become very attractive location for wind developments. The “practical” potential output of onshore wind resources has been estimated to be 50,000 GWh and around 100,000 GWh for offshore windturbine (Sustainable Development Commission, 2005).

Wind electricity is renewable and nearly zero-carbon emission

Wind electricity is renewable and nearly zero-carbon emission. There is no carbon dioxide, acid rain, smog or radioactive pollutants involved in the generation of electricity by wind. Through adopting wind power as the energy resource, it can reduce dependency on conventional fossil fuel and nuclear fuels (Boyle, 1996).

Economical benefit includes lower fuel bills and earn Feed-in Tariffs

When adopting the wind power as the alternative resource of electricity, the generation will not only supply the need but also cut the bills. As for surplus electricity, it can be exported to the grid and the owners would be paid according to the FITs scheme. One thing need to be emphasized is that the systems and the installer must both be MCS certified to be eligible for FITs (Energy Saving Trust, 2009).

Potential barriers

High installation cost

Comparing with other type of renewable energy applications, the installation cost is relatively higher. For micro or small-scale application, a typical 2.5kW wind turbine will cost around £ 15,000 and a 6kW system requires around £ 23,500 to install (Energy Saving Trust, 2009). Besides, extra cost might be required for the relevant research or measurement t o ensure the efficiency.

As for large scale application, the installation cost for a onshore wind turbine ranges from £ 1,300/kW to £ 1,600/kW. For a typical 2.5 MW wind turbine, the installation cost will be around 3 million pounds (Renewable UK, 2010). The fee for offshore wind turbine is even higher and the cost is from £2,000/kW to £4,000/kW. One typical 3 MW wind turbine will require 6-12 million pounds (Renewable UK, 2010).

Regular maintenances are required to keep the efficiency

In order to ensure the efficiency, regular scheduled maintenance will be required. The maintenance will also help to exert the lifespan of wind turbines to operate for 20 years or more. Besides, an annual check by a professional installer is recommended.

The user should keep contact with the installer for professional consultation would be essential for wind turbine system during the operation (Energy Saving Trust, 2009).

7.3 Wind Power

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Potential barriers

Possible environmental impacts such as noise, electromagnetic interference, and visual impact should be concerned

There are two main sources of wind turbine noise, one is mechanical noise from the mechanical or electrical equipment, and the other is aerodynamic noise from the interaction of the airflow with the blades. The main noise problem will be the mechanical noise. In order to reduce the impact on residents nearby, adequate distance and some implements would be required such as special quieter gears or acoustic enclosures (Boyle, 1996).

Electromagnetic interference would happen when the location of wind turbines are between radio, television or microwave transmitters and receivers. This may result in the received signal to be distorted significantly. To minimize the influence, consulting for further information about the radio service and the service within a sensitive radius is crucial (Boyle, 1996).

The installation of wind turbines will somehow change the landscape in certain extent. However, the visual perception is regarded to be attractive or unattractive is depend on individual aesthetics. Though planning policies has been revised to encourage the installation of renewable technologies, as for the installation of wind turbine, it is still required to apply for planning permission. Therefore, consulting the local council about the installation plan would be suggested (Energy Saving Trust, 2009).

Case study

Community-owned Wind Turbine in The Dulas Valley



(Source: Centre for Alterative Technology)

Background

AS the UK's first wind turbine owned and developed by the community, this project runs the program by selling the electricity generated by the 75 kW wind turbine to both the local company and the local grid. The dividends not only bring the financial profit but also become the found for energy efficient measures for the community.

7.3 Wind Power

In the UK, wind power is the most well developed and economically viable form of renewable energy. Wind turbines produce electricity by capturing the natural power of the wind to drive a generator. *Energy Saving Trust*

Case study

Community-owned Wind Turbine in The Dulas Valley

Development

This project is not only community-owned but community also leads the development. Starting from the advice of two local professionals, the public meeting assembled the interested community members to form the Dulas Valley

Community Wind Partnership (DVCWP) to mainly lead this project. The objective of this project is strongly supported by the local people to make the development locally- local people develop and get profit from wind power. As a cooperative party, the Centre for Alternative Technology (CAT) enthusiastically got involved and provided a secure recipient for the generate electricity which is extremely beneficial for this project.

Cost

The capital cost was £81,175 and the annual operation cost was £2,318. Lots of funding supported this project. The founding was from ERDF funding, the Energy Saving Trust and the Baywind Co-operative and covered around 80% of the cost. The rest was self-funded by local residents.

Performance

The primary goal of this project is to reduce the carbon emission within the local community. In spite of the annual generated electricity for 160MWh from the installed wind turbine, a proportion of income from selling the electricity has been used to form The Energy Conservation fund to further promote the installation of energy efficient measure. The implement also contributed to save 784MWh annual.

The total carbon emission reduction is estimated to be 415 tonnes per year.

Feedback

To summaries, the local benefits from this project are as followed:

- Stimulate local economy through placing the construction and O & M contracts with local companies.
- Encourage local people getting involved in the community development.
- Besides providing the electricity generation, the wind turbine is served as a educational demonstration of renewable technology for both local residents and visitors.
- Around 30% of the annual project profit will go into a community energy fund to promote the use of energy efficiency measures and further the carbon reduction objective.

7.3 Wind Power

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Lesson for Penarth

Financial support

The initial cost for the installation of wind turbines is considerable high especially for medium or large scale of wind turbines. However, the community could get financial support from the government and relevant organizations. The financial support could cover the cost for the initial research of site assessment, the construction cost and even O & M cost which help to ease the financial burden for the local community.

Besides, through profit sharing scheme or spontaneous funding raising to be self-support by local residents. This will also encourage the involvement of local people.

Stimulate local economy

Through placing the relevant contracts within the development with local companies, the local economy would be stimulated.

Another advantage of choosing local companies is the reduction of carbon emission during the transport. For on-site construction, the transport for displacing the material and equipment will be frequently. Comparing the un-local companies, local companies possess the advantage to cut the unnecessary energy consumption and carbon emission during the process of transport.

Diversified development

Through different type of profit sharing scheme, the development of renewable energy technology could further the local benefit.

Take the Dulas Valley case for example. The income from selling the generated electricity from wind turbine had been taken to form the Energy Conservation fund which contributed to other carbon reduction scheme. The statistics shows that the benefit from adopting the energy efficient measurement which was promoted by the Energy Conservation fund was more the profit from wind turbine.

Moreover, the running model will support to further enhance the well-being of local community and lead to a sustainable development.

Therefore, combing the renewable technologies with other energy efficient strategies will help to create an integrated and replicable energy plan to reduce carbon emission.



(Source: The Saint)

References & Bibliography:

Boyle, G., 1996. *Renewable Energy*. Oxford: The Open University.
BWEA, 2005. *BWEA Briefing Sheet-Offshore Wind*. London: BWEA.
Energy Saving Trust, 2004. *WIND ENERGY CASE STUDY*. London: Energy Saving Trust.
Energy Saving Trust, 2006. *Renewable energy sources*. London: Queen's Printer and Controller of HMSO.
Energy Saving Trust, 2009. *Wind turbines*. [Online] Available at: http://www.energysavingtrust.org.uk/Generate-your-own-energy/Wind-Turbines [Accessed May 2011].
Leaney, V. et al., n.d. Empowering the Community. In *the 2001 BWEA Conference*. London BWEA.
Renewable UK, 2010. *Wind Energy Generation Costs*. London: RenewableUK.
Risø National Laboratory, 1989. *European Wind Atlas*. Roskilde: Risø National Laboratory.
Sustainable Development Commission, 2005. *Wind Power in The UK*. London: Sustainable Development Commission.
The Renewable Energy Centre, 2011. *Wind Power*. [Online] Available at: http://www.therenewableenergycentre.co.uk/wind-power/ [Accessed May 2011].
Welsh Assembly Government, 2011. *Planning Implications of Renewable and Low Carbon Energy*. Cardiff: Welsh Assembly Government.

7.4 Biomass

"In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material." *Biomass Energy Centre*

What is Biomass?

Biomass refers to the use of a wide variety of organic material such as wood, straw, dedicated energy crops, sewage sludge and animal litter for the generation of heat, electricity or motive power. (Carbon Trust, 2006) Biomass can be used to produce various energy source, such as transport fuel, electricity and heating. In this plan, it only focus on the generation of electricity and heat.

Biomass as a solar energy store:

It can be viewed as a form of stored solar energy. Because the sun's energy is captured and stored via the process of photosynthesis in growing of plants. And then this energy is released by processes of conversion such as combustion or fermentation and distillation. Hence, Biomass is a renewable energy source because its supplies are not limited. We can always grow trees and crops, and waste will always exist.

A Low carbon fuel source:

Biomass is a low carbon fuel source because the carbon dioxide released when biomass is converted for energy purposes, such as combustion or fermentation, is largely offset by that absorbed by the organic material during its growth. With the appropriate management this can be recaptured with new growth.

Biomass Sources

There are four types of biomass: wood and agricultural products, solid waste, landfill gas and biogas, and alcohol fuel. (DEFRA, 2007) Wood, such as logs, chips, bark, and sawdust, accounts for about 53 percent of biomass energy. The majority of small-sized biomass plant use wood pellets or wood chips . Agricultural waste products like fruit pits and corncobs can also used to generate electricity.

Burning trash turns waste into a usable form of energy, but not all garbage is biomass. And making electricity from garbage costs more than making it from coal and other energy sources. The main advantage of burning solid waste is that it reduces the amount of garbage dumped in landfills by 60 to 90 percent, which in turn reduces the cost of landfill disposal. Landfill gas is the methane gas produced as the waste decays. But the process is slow and the cost of collection is much higher than natural gas prices. Alcohol gas, such as Ethanol, can be as a vehicle fuel.

With the aim to supply electricity and heating in Penarth's community scale, the main biomass sources are wood-chips or wood-pellets.







Source: newenergyworldnetwork.com

7.4 Biomass

"In the context of biomass for energy this is often used to mean plant based material, but biomass can equally apply to both animal and vegetable derived material." *Biomass Energy Centre*

What is Biomass?

Biomass System:

There are two types of Biomass system suitable for Penarth renewable energy plan at community level:

Biomass heating system: Combusting biomass fuels such as wood, straw or energy crops (for example, willow coppice or specific types of grasses) to raise heat or steam for space or process heating is one of the most cost-effective applications for biomass from a cost-of-carbon point of view at the present time. Biomass heating plant can come in a wide range of sizes from a few kWs to many MW of heat. (Carbon Trust, 2006)

Biomass CHP plant: Biomass CHP (combined heat and power) system can provide both electricity and heat with high efficiency by organic plant. It, using renewable sources and recovery of wasted heat, delivers an environmentally friendly, operationally efficient and cost-effective solution.

Performance:

In terms of Biomass CHP plants, "… new biomass CHP plant designs using MSW are expected to reach 28%-30% electrical efficiency, and above 85%-90% overall efficiency in CHP mode if good matching is achieved between heat production and demand... "(IEA Energy Technology Essentials – Biomass for Power Generation and CHP, 2007), and report from carbon trust (2006) shows "…For each MW of electrical generation around 3MW of heat will be produced..." and "Biomass CHP Market Potential in the Western Region" did by WDC (2008) claims that "…biomass CHP units typically have a power to heat ratio of 1:4…" Hence, generally speaking, the production of heat and electricity from a biomass CHP system is around 2:1 to 4:1.

Biomass boilers has high thermal efficiency which is greater than 85%. (Forestry Commission England, 2008) Besides, the moisture of biomass fuel, especially to wood chips and wood pellets, affects the system efficiency.

Site Suitability & Space Requirement

When selecting a suitable location for a biomass boiler or biomass CHP plant, a reliable and accessible source's supplier should be taken into consideration. The guidelines given by the Department for Food and Rural Affairs (DEFRA, 2007) suggest that *the crops should be grown within 10miles of smaller installations and 25 miles of larger units.*

If biomass is installed in existing public building, adequate space is necessary to accommodate fuel storage and delivery. For example, a 20kW thermal boiler typically consumes 0.6m3 of wood chip daily in winter, and the volume of one tonne of dried wood is about 6m3 (Carbon Trust, 2006). Biomass boiler is suitable to be located on the ground floor or in basement to be convenient for fuel transport. The biomass boiler itself will be larger than an oil or gas-fired boiler and boiler-houses for CHP plant will be larger to accommodate the additional generation equipment. Generally speaking, a biomass CHP with 500KW-800KW capacity requires a 4-8 m2 room and about another4-8m2 for fuel storage. (Carbon Trust, 2006)



7.4 Biomass

"…biomass is an important tool for tackling climate change, as well as offering new commercial opportunities…"

DEFRA; DTI; Department for Transport. 2007. UK Biomass Strategy

Why Biomass?

Why should we choose biomass as a energy source? There are a range of advantages of biomass.

A Low carbon fuel source:

Biomass is renewable and theoretically a carbon-neutral fuel source because the carbon dioxide released when biomass is converted for energy purposes, such as combustion or fermentation, is largely offset by that absorbed by the organic material during its growth. With the appropriate management this can be recaptured with new growth. However, this balance is sensitive to the carbon intensity used in the production, supply and transport of biomass, which will be discussed next.

Besides, the embodied carbon emission from production of biomass boilers should also be taken into account. Jungmeier, G. et al (1998) investigated the carbon emission of A 1.3 MWel biomass CHP plant located in Reuthe (Vorarlberg, Austria) from a life cycle perspective, the results show that "…particularly in the year of construction, CO2 emissions account for about 70% of the total, the 20 years of operation and the year of dismantling together for 30%..." but the entire carbon emission in a life cycle is can roughly offset by the growing process of organic material.





Turning waste into energy

Biomass energy can be recovered from waste. Potential sources include biomass wastes such as food and wood together with mixed waste streams which have a biomass fraction e.g. waste derived fuels or residual post recycling waste.

Besides, many suppliers of wood chips and wood pellets are also the timber company or furniture facture. They recycle the wood waste, such as dry sawdust and offcuts, and treat them into wood chips or pellets for biomass fuel. There are 35,000 tonnes wood waste every year in the UK, accounting for one third of current

Production (DECC, 2010). Hence, biomass can make full use of the waste and turn them into precious energy. And greater use of these biomass sources will reduce dependence on landfill and associated greenhouse gas emissions.



Photo Source: Flexenergy.net

7.4 Biomass

"…biomass is an important tool for tackling climate change, as well as offering new commercial opportunities…"
DEFRA; DTI; Department for Transport. 2007. UK Biomass Strategy

Why Biomass?

Efficient system for district heating

Community (or district) heating involves the use of a central boiler plant (or other heat sources) to heat a number of buildings or dwellings through a network of well-insulated underground pipes. Community heating schemes come in all shapes and sizes, from single blocks of flats to schemes serving city neighbourhoods. By using a central boiler plant, community heating systems can benefit from competitive fuel purchasing and can utilise alternative energy sources such as CHP or renewables, including geothermal. (Carbon Trust, 2004)

Because of high Thermal efficiency, greater than 85%, biomass boilers or biomass CHP plants are very suitable as community heating system. And many successful cases demonstrate the advantages. For example, Bernotat, K. et al (2004) study small-scale biomass CHPs in Sweden and the Baltic States, and proved that "…biomass, especially pellets fired small-scale cogeneration in combination with local heating network…is efficient"





Dunbury School – Pellets are blown into a sack silo (left door) and these are transported to the boiler room (right door) by a suction system. Source: Crops for Energy & Center for Sustainable Energy, 2010

Controllability & reliability

There is an increased demand for power and this means that people need a source of energy that can be relied upon.

Different from other renewable technologies, such as solar PV and wind turbine, biomass boilers are more reliable and controllable. Because the plant materials and animal matter that are use to produce it are in constant supply. Besides, biomass technology is flexible and scalable. The capacity can be designed according to local energy load, from a single boiler to a power station.

Flexible to integrate with CHP plant

Biomass technologies is easy to integrated with CHP Plant. As what has been mentioned a lot above, biomass CHP has a high efficiency.

Combined Heat and Power (CHP) is the combined production of heat and power in a single process. Typically, in conventional electricity generation, over 60% of the input energy is lost to the atmosphere as waste heat, while the remaining 40% is transformed into electricity. (Western Development Commission, 2008) CHP systems channel this extra heat to useful purposes so that usable heat and electricity are generated in a single process. Hence, the efficiency of CHP can be 85-90%. (OECD/IEA 2007)

7.4 Biomass

"…one promising option of clean energy has proved to be biomass. However, there are some biomass disadvantages as a source of energy…"
DFID (Development for International Development)

Potential Barriers

Biomass is showing great promise as a source of energy to replace fossil fuels being consumed in today's world. However, there are also some limitations when choosing it.

The balance of carbon neutral

As what has been identified, biomass is regarded as a renewable and carbon-neutral energy sources, however other energy inputs may affect this carbon balance, for example the production, the transport and storage of biomass.

Pretreatment of wood to reach the standard for biomass boilers consumes energy. Besides, energy plant are relatively bulky so it will be costly, and more importantly, results in more carbon emission if the biomass plant need to be transport over large distance.

Hence, reasonable selection of biomass fuel suppliers is important regarding to the energy consumption and carbon emission during manufacturing and transporting. It is best to choose the suppliers recycling waste sawdust or offcuts and their locations need to be within 25miles.

A slight air pollution

Undeniable, just the combustion process of every materials, biomass boilers also releases carbon monoxide, nitrogen oxides, particulates, volatile organic compounds, and other pollutants into the atmosphere.

However, some practical experiences and researches (Carbon Trust, 2006; DECC, 2008) show the pollution and influences to the area nearby can be minimized as the system is well designed. According to the review of implementation cases (Bernotat & Sandberg, 2004; Wahlund, et. al. 2002), most dwellers using biomass district heating system, are satisfied with its performance rather than complain its air pollutions.

Renewability

Though biomass is a renewable resource, some concerns are how quickly it can be replaced. If people harvest trees for use as fuel or to convert into other forms of fuel, those trees will take many years to replace with more trees of equal size. This means that we must focus our efforts on using plants, grains, and other forms of biomass that can be replaced quickly and inexpensively.

Some research has showed if we choose fast growing energy plant, like willow, poplar and fast growing tree as biomass fuel, it is practicable. (National Energy Foundation, 2010)





Photo Source: Clean Energy Source

7.4 Biomass

"…one promising option of clean energy has proved to be biomass. However, there are some biomass disadvantages as a source of energy…"
DFID (Development for International Development)

Potential Barriers

Cost

As compared to fossil fuels, biomass energy is quite expensive. This is primarily because a lot of research still remains to be done, methods of extraction have to be refined, and biological matter for the biomass has to be consolidated. As progression is made in these areas, the cost of biomass energy will automatically come down.

Maintenance and management

In order to keep the system work efficiently and continuously, the biomass systems should be checked and reviewed regularly. So a local and reliable biomass fuel supply chain needs to be in place in order to ensure successful operation. Security of supply would also be an ongoing issue.

Efficiency

Some other concerns on biomass are "…Combustion of biomass as a fuel also consumes it at a much faster rate than it can be replaced. This means that biomass is, in and of itself, not a very efficient source of energy…." (Biomass Net, 2010)

This does mean, though, that biomass has the disadvantage. Because biomass boilers in small scale do not have high efficiency, especially household biomass boiler, less than 1KW capacity. To biomass boilers least on a small scale, more energy must be added to produce a viable fuel and that the amount of energy yielded by that fuel is not equal to the energy that went into making it. The only way to overcome this disadvantage is to work on a relatively large scale that the energy added works on a larger quantity of biomass at the same time, yielding more usable fuel and energy.

Hence, for Penarth biomass boilers or biomass CHP plant providing community heating and electricity to about 40-50 or more buildings are more efficient.

As a source of clean energy, biomass technology need to be further advanced to overcome these disadvantages. And increasingly studies are ongoing to determine what forms of biomass will yield the greatest amount of energy and be quickly renewable.

Hence, as planning and designing a biomass system in Penarth, some issues, like suppliers' location, energy efficiency and distribution patterns, are supposed to be sophisticatedly considered.





Photo Source: Biomechanism.com

7.4 Biomass

"… This case study demonstrates the potential of biomass as an energy source for community heating …"

Carbon Trust, CE91,2004a

Cast Study

Biomass Community Heating, Llanwddyn , Montgomeryshire, Wales *(Carbon Trust, 2004a)*

Background

Llanwddyn is a small community in forested Vyrnwy valley in Montgomeryshire, Wales. The majority of land, forest and approximately half of the houses in the valley are currently owned by Severn Trent Water. The remainder of the 42 houses that make up the community are in private ownership. The houses, which were built in the 1950's, are situated around a school and a community centre. It is not on the gas network and heating systems in the houses include open coal fires, electric storage heating and oil systems.

In 2000, Vyrnwy Forum, a local community group, commissioned Powys Energy Agency to investigate options for boosting the local economy, to be based on the plentiful local wood resources.

Cost and Grants

The total project cost was £375,000. Due to the location and perceived benefits of the scheme, several avenues of grant funding were available and it was able to attract 100% grant funding. The specific shares of grants can be found in table.

Implementation

Under a design and build contract the ESCO constructed a dedicated boiler house and designed and installed the heat system. In October 2003, a 600kW wood-chip boiler was installed, linked to a smaller backup oil-fired boiler rated at 315kW. The boilers were sized to meet the full load of the school, the community



Birdview & Location of Llanwddyn

Source: Carbon Trust, 2004a

Grant/ Loan/ Contribution	Amount	Source
Grant	£114,200 (30.5% capital costs)	European Regional Development Fund
Grant	£163.200 (43.5% capital costs)	Local Regeneration Fund (Welsh Assembly Government via Powys County Council)
Grant	£ 47,459 (12.5% capital costs)	Community Energy programme capital costs boilers, site preparation and design
Grant	£50,000 (13% capital costs)	Welsh Development Agency

7.4 Biomass

"… This case study demonstrates the potential of biomass as an energy source for community heating …"

Carbon Trust, CE91,2004a

Cast Study

Biomass Community Heating, Llanwddyn , Montgomeryshire, Wales

centre and all 42 dwellings in the immediate vicinity, should they all wish to join.

Heat from the boilers is delivered to the school, community centre and the houses via the heat network. The contract specified that at least 60% of the wood-chip fuel for the boiler would be sourced within a 15 mile radius of Llanwddyn. For the first year of operation Forestry Commission Wales have supplied and delivered 200 tonnes of small round wood to the fuel storage facility at no cost.

Benefits

This project helps to reduce amounts of carbon emission. The installation of wood-fuel heating for the school, community centre and the outlying houses is predicted to save 1,805 tonnes of CO2 over the next five years.

This project also demonstrate the considerable savings of energy bills for both school and houses. Based on this projection, the agreed heat price for domestic customers was 2.65p/kWh. The heat for the community centre and school is charged at 2.45p/kWh. This charge covers all fuel, operation and maintenance costs. It is estimated that the school and community centre will save £750 per year compared to previous consumption patterns. The present domestic average heating cost is around £450 per year. Annual savings for domestic consumers are predicted to range from £20 for oil fired heating, to £210 for off-peak electricity.

The regular demand for wood-chips promote local industry and create new employment opportunities. Production of wood-fuel retains money spent on energy within the local economy. This project also helps to attract more local investment. Besides, as a remote community, this project also helps to make good use of the locational advantages and create important employment opportunities in fuel processing and transport.

There are also some other potential benefit for local community. The regular fuel supply required for a local wood-chip boiler provides an outlet for low-grade timber. This can enhance the return from woodland management and yield a host of sporting, amenity and ecological benefits.





Photo Source: Dulas Ltd

7.4 Biomass

"… This case study demonstrates the potential of biomass as an energy source for community heating …"

Carbon Trust, CE91,2004a

Cast Study

Biomass Community Heating, Llanwddyn , Montgomeryshire, Wales

Lessons learnt for Penarth

This project is a successful practices of biomass community heating. Hence, there are some useful experiences can be learnt for Penarth:

The drivers of local organization: In this case, Vyrnwy Forum, as a local community group, play an important role in initiating the project. They asked consultant agency to investigate the options and system design. Hence, GPG, as a community group is also significant to push the development of renewable energy in Penarth.

Sufficient Community consultation: Before design the system, Powys Energy Agency, the organization who did the feasibility study detailed survey the willingness of local dwellers. They held a number of public meetings, produced articles for the local press and carried out two questionnaires, in order to ensured that the local community were thoroughly consulted. The objective was to gauge local interest and identify and address any of the residents' concerns. The questionnaires achieved a 50% response rate. Therefore, like what has been emphasized above, Community consultation and awareness raising are essential to the development of a successful wood-based community heating scheme. This is fairly important lessons for Penarth's development of biomass community heating in the future.

Capital grant funding: this project got 100% funds of its capital cost from government or Non-Governmental Organizations (NGO). Currently, in order to reduce carbon emission and promote renewable energy, there are many grants and funds available in EU, UK national, welsh and local governments or NGOs.

The pattern of community heating: The schools or community centers, generally have continuous heating demand, and there are some space for biomass boiler and fuel storage in school. So if it is surrounded by a cluster of houses. This group of buildings can be supplied by biomass community heating system. The practices of this case is proved to be relatively successful. But more detailed survey of the energy load profile and heating demand are crucial for sizing the system.



Photo Source: Wood Fuel Wales

7.4 Biomass

"… This case study demonstrates the potential of biomass as an energy source for community heating …"

Carbon Trust, CE91,2004a

Cast Study

Biomass Community Heating, Llanwddyn , Montgomeryshire, Wales

Lessons learnt fro Penarth

Energy Service Company: Powys County Council invited Energy Service Companies (ESCOs) to submit bids to design, build and operate the wood-fuelled district heating system. A condition of the capital grant funding was that the infrastructure, including boiler, heat and distribution network, domestic interfaces and fuel storage shed, must be owned by a public sector organisation. The infrastructure will remain the property of Powys County Council, who would then lease the infrastructure to the successful ESCO. In order to have the capital grant funding, the system in Penarth will probably also need to run by ESCOs.

Step by step development: The project provides options for local dwellers to join this scheme gradually. The design and construction of pipe work ensure that it is easy for houses wishing to join in the future. Some houses have not yet connected. Therefore, given that the full anticipated load is not yet operational. Because this is not ideal, the wood-fuel boiler has been turned off until the entire network is connected. The back-up oil fired boiler is being used instead. When the houses come on-line this will extend the heating load and increase the peak load, enabling better use of the wood-chip boiler. Hence, if a Biomass community heating project will also run in Penarth. This step by step development way is also a good option since it not only ensure the residents' right to choose but also enhance the economic benefits.

Guaranteed price by contract: In this case, the heat price for customers and the fuel price from wood-chips supplier are guaranteed by contract. Firstly, For long term sustainability of a community heating project it is important that fuel prices are guaranteed by contract for fixed periods. Secondly, based on the fuel prices and maintenance cost, the heating price can be estimated. Then the agreed heating price is important to dwellers to compare the benefits.



Photo Source: Dulas Ltd

References & Bibliography:

Anon., n.d. *Renewable Energy Association*. [Online] Available at: http://www.r-e-a.net/ [Accessed 12 March 2011].

Bernotat, K. & Sandberg, T., 2004. Biomass fired small-scale CHP in Sweden and the Baltic States:a case study on the potential of clustered dwellings. *Biomass and Bioenergy*, 27, p.521–530.

Brammer, J.G. & Bridgwater, A.V., 2002. *Biomass and Bioenergy*, 22, p.271–281.

Carbon Trust, 2006. *Renewable energy sources: Opportunities for businesses*.

CHPA, 2010. *Integrated Energy: The role of CHP and district heating in our energy future*.

Combined Heat and Power Association(CHPA), 2010. *Integrated Energy: the Role of CHP and District heating in our energy future*.

Creative Environmental Networks, BioRegional and SEWF, 2009. *Biomass for London:Wood Fuel Guide*.

Crops for Energy; the Centre for Sustainable Energy, 2009. *Technical study: Woodfuel supply and demand in Dorset* .

DEFRA, DTI, Department of Transport, 2007. *UK Biomass Strategy*.

Energy Saving Trust, Aberdeen City Council, 2003. *Aberdeen City Council:a case study of community heating*.

Energy Saving Trust, 2004a. *Rural biomass community heating: A case study*.

Energy Saving Trust, 2004b. *Community heating: a guide*.

Eriksson, O., Finnveden, G., Ekvall, T. & Bjo¨rklund, A., 2007. Life cycle assessment of fuels for district heating: A comparison of waste incineration, biomass- and natural gas combustion. *Energy Policy* , 35, p.1346–1362.

Groscurth, H.M. & et.al., 2000. Total costs and benefits of biomass in selected regions of the European Union. *Energy*, 25, p.1081–1095.

JUNGMEIER, G., RESCH, G. & SPITZER, J., 1998. ENVIRONMENTAL BURDENS OVER THE ENTIRE LIFE CYCLE OF A BIOMASS CHP PLANT. *Biomass and Bioenergy*, 15, p.311–323.

Rentizelas, A.A., Tolis, A.J. & Tatsiopoulos, I.P., 2009. Logistics issues of biomass: The storage problem and the multi-biomass supply chain. *Renewable and Sustainable Energy Reviews*, 13, p.887–894.

Savola, T. & Fogelholm, C.J., 2006. Increased power to heat ratio of small scale CHP plants using biomass fuels and natural gas. *Energy Conversion and Management*, 47, p.3105–3118.

Southwest Woodland Renaissance; Forestry Comssion England, 2010. *A guide to small-scale wood fuel (biomass) heating systems*.

U. S. Environmental Protection Agency, 2007. *Biomass Combined Heat and Power Catalog of Technologies*.

University of Surry; Imperial College of London , 2010. *Building a roadmap for heat2050 scenarios and heat delivery in the UK*.

Upham, P. & Shackley, S., 2006. The case of a proposed 21.5 MWe biomass gasifier in Winkleigh, Devon: Implications for governance of renewable energy planning. *Energy Policy*, 34, p.2161–2172.

Wahlund, B., Yan, J. & Westermark, M., 2002. A total energy system of fuel upgrading by drying biomass feedstock for cogeneration: a case study of Skellefte bioenergy combine. *Biomass and Bioenergy*, 23, pp.271-81.

Wahlund, B., Yan, J. & Westermark, M., 2004. Increasing biomass utilisation in energy systems: A comparative study of CO 2 reduction and cost for di$erent bioenergy processing options. *Biomass and Bioenergy*, 26, p.531–544.

Weighell, T., 2011. *The global land use impact of the United Kingdom's biomass consumption*. Joint Nature Conservation Committee.

Western Development Commission, 2008. *Biomass CHP Market Potential in the Western Regional:an assessment*.

7.5 Ground-source Heat Pumps

"…46% of the suns energy is absorbed by the Earth… [Ground Source Heat Pumps] use this abundant energy to heat or cool a building…"

- Minister of Natural Resources Canada 2001 - 2005

What are Ground Source Heat Pumps?

Ground source heat pumps utilize the energy stored in the earths crust to heat or cool a building. (Minister of Natural Resources Canada 2001 – 2005). They tap the natural heat occurring at very high temperatures from *"shallow ground, hot springs or aquifers (water-bearing rocks), rock deep below the Earth's surface, and magma."* (Carbon Trust, 2011, Geothermal) However in practice only a small percentage (less than 3%) of the energy is utilized from the earths core. Heat pumps make use of the fact that there is an average increase in the ground temperature at the rate of 1.5 - 4.5 °C per 100m depth "or an average energy flow of 60mW/m²"(Rawling R., pp-3).

GSHPs in the UK

For the UK the average temperature increases at the rate of approx. 2.6°C per 100m with mean observed equilibrium temperatures for UK at a depth of 100m approximately 12 °C ± 1.6 °C (NERC, 2010)

A Low carbon fuel principle

Principally GSHPs use the same process as used in refrigeration i.e. *"naturally occurring underground low-level heat is converted to high-grade heat using an **electrically driven or gas powered heat pump.** Water [or refrigerant] is re- circulated in a closed loop underground and delivered to the heat pump which is usually located inside the building".* (Carbon Trust, 2011)

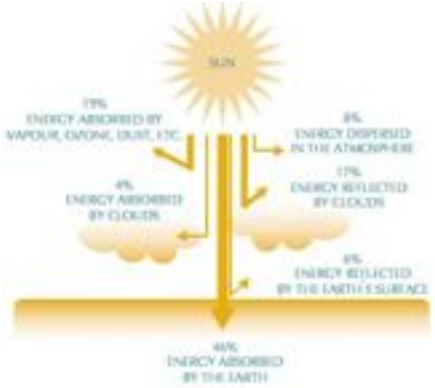
Thus depending on the type of source used to run the heat pump the carbon savings for the heat pump can be determined. For example for a GSHP run on solar PVs the carbon emission would be less than that run on fossil fuels such as coal or gas.

Performance

The energy efficiency of a heat pump can be measured as a ratio of the heat output to the total electricity input known as the CoP.

$$CoP = \frac{\text{Heat Output } (kW_{th})}{\text{Electricity Input } (kW_{el})}$$

COP is measured is measured for a certain set of conditions and as per British Standards values for an air temperature of 2°C and a source temperature of 35 °C are usually mentioned by the manufacturers. (Rawlings R., pp- 31)



Source: Minister of Natural Resources Canada 2001 - 2005



Source: Earthenergy

7.5 Ground-source Heat Pumps

" Essentially heat pumps take up heat at a certain temperature and release it at a higher temperature…by means of ground collectors (coils) in which heat exchange fluid circulates and transfers heat via a heat exchanger to the heat pump." *- Dr. Hard K., Fabre Maunsell*

What are Ground Source Heat Pumps?

A typical CoP for GSHPs is 3-4 which means that GSHPs are "*300-400% efficient in terms of its use of electricity.*" (Ground Source Heat Pump Association) "*Heat pumps are cover a wide range of capacities, from a few kW to many hundreds of kW machines that heat or cool large, multi-storey buildings.*" (Queen's Printer and Controller of HMSO , Aug 2010)

Components and types

Heat pumps comprise of three basic components: "*a ground loop, the heat pump itself, and a heat distribution system.*" (Ground Source Heat Pump Association)

Ground Loop: A ground loop consists of pipes laid under ground in either a "*horizontal trench or a vertical borehole*." When laid in a horizontal trench there can be two further types of layouts: horizontal or spiral (slinky). Horizontal trenches usually have a depth of 1.5 to 2m and the depth recommended for trenches in Europe is 0.5 to 1.0m (Ground Source Heat Pump Association and Rawling R.) Although horizontal trenches require large quantities of land it is more expensive to lay pipes in vertical boreholes.

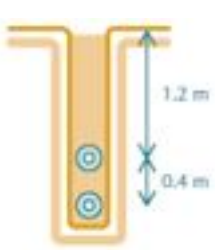
It should also be noted for horizontal trenches that since trenching costs more than laying of pipes it is more economical to have systems with multiple pipes in one trench.

A maximum of 6 pipes per trench can be used to increase the heat exchange per meter length of the trench. To avoid interference a minimum separation of 0.3m between the pipes is recommended.

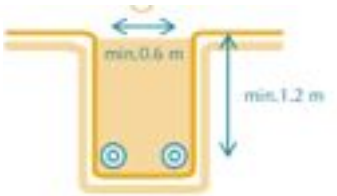
However the efficiency of vertical boreholes is greater than horizontal trenches as vertical boreholes make use of the high temperatures found in the earth's crust at depths of 15 to 150m. *For vertical boreholes a smaller number of deeper boreholes is more preferable economically*. (Ground Source Heat Pump Association and Rawlings R.)

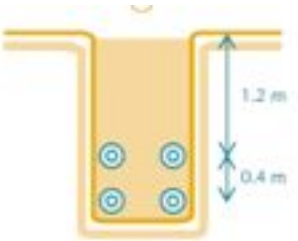
The heat distribution system for GSHP can either be via radiators or under floor heating.
However wherever possible under floor heating should be preferred since GSHPs supply low grade heating as its efficiency decreases when used with systems such as radiators which deliver heat at higher temperatures.





Vertical ground loop configurations;





Horizontal ground loop configurations

Pictures source: Minister of Natural Resources Canada 2001 – 2005

7.5 Ground-source Heat Pumps

What are Ground Source Heat Pumps?

Space Requirements

Although the space requirements for GSHPs depends on the thermal properties of ground and the surface area of the ground collectors the estimated space required can be given using some rules of thumb given in the table below. Usually a single heat pump is sufficient for a house or a small office, however multiple heat pumps with a common building loop are required for large scale buildings.

Cost

Due to the high capital costs involved GSHPs are generally designed for partial heating loads with some other additional supplementary heating system. Rules of thumb for cost at year 2004 rates are given in the table shown alongside.

Considerations

Since GSHP ground loos are difficult to access once installed these should be laid with precision in the first place i.e. *with high material quality and workmanship.* A list of accredited installers for GSHPs closest to Penarth has been provided in this report.

'Rule of thumb' data for **length** of ground coil	
Estimates of ground heat exchanger lengths	
Slinkies	40-90 m/kW
Horizontal	5-35 m/kW
Vertical	20-50 m/kW

Source: Doherty P., et al.

Why GSHPs?

Cost savings

Operation costs for GSHP heating are less as compared to oil, LPG and electric storage heaters. A typical CoP for Ground Source Heat Pumps available in the market is 3.2 i.e. for an electrical input of 1kWh a heating output of 3.2 kWh can be expected.

The average approximate heating requirement for a Penarth household is 50 kWh/ day and the cost of 1kWh electricity varies from approximately 9.7p/ kWh to 14.2p/kWh and the average approximate cost for gas is 6.914p/kWh(UK Power Limited 2001 – 2011)).

This gives an average electricity demand of 15.625 kWh daily for heating, costing approximately 51.563 p to 221.87 p. Whereas the cost for heating using a gas based boiler comes out to be approximately 345.7p. Thus it can be seen that GSHP have the potential for saving about 123.83p to 293.537p daily or £452 to £ 1071 annually.

'Rule of thumb' data

Estimates of GSHP cost	
Heat pump unit	£200–300 per kW
Bore-holes (open loop)	£1500–2000 (single well) £2000–3000 (pair)
Bore-holes (closed loop)	£140 per kW
O&M costs	Approx. 30% less than conventional heating systems
Payback period	2–6 years (based on the difference in installation costs between a high efficiency gas boiler and a GSHP system)
Estimates of GSHP cost/emission	
CO_2 emissions	Approx. 40% reduction to that of conventional heating/cooling systems

Heat exchanger lengths are defined as tube lengths and depend on soil/geological conditions.

Source: Doherty P., et al.

7.5 Ground-source Heat Pumps

Why GSHPs?

Low carbon emissions:

Since GSHPs use electricity or some other source to run the compressor to convert low grade ground heat to high grade heat it uses less heat to give high thermal output i.e. *"it draws free energy from the ground to actually produce more energy than it consumes"*. (Minister of Natural Resources Canada 2001 - 2005) For example for a ground source heat pump with a CoP of 4 the system will produce 1kWh of heat using only 0.25kWh of electricity. And taking average carbon emissions from electricity as 0.422 kgCO2 / kWh the carbon emissions are reduced to 1/4th as compared to electric heating i.e. emissions from heat pump would be 0.106 kgCO2/ kWh

Comparison of carbons emissions of GSHPs has been given in the table below

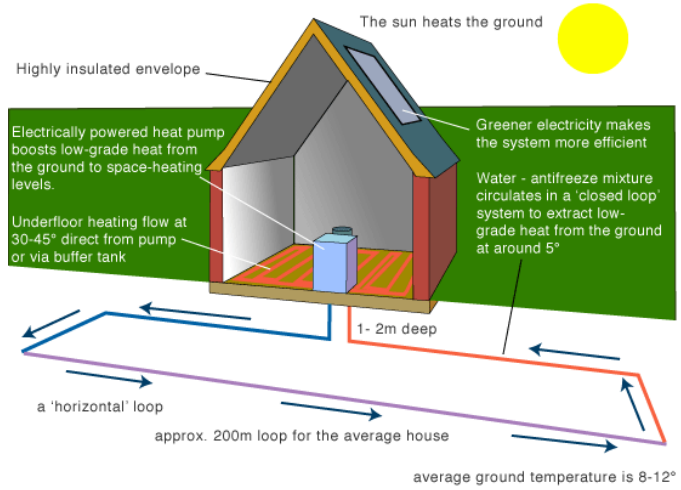
System	Primary energy efficiency (%)	CO2 Emissions (kg CO2/ kWh heat)
Oil fired boiler	60-65	0.45 - 0.48
Gas fired boiler	70-80	0.26 – 0.31
Condensing gas boiler + low temp. system	~ 100	0.21
Electrical heating	36	0.9
Conventional electricity + GSHP	120-160	0.27-0.2
Green electricity + GSHP	300-400	~ 0

Source: GreenSpec 2010

Visual impacts: Once the GSHP is installed there are no external fans or radiators visible. Also the space required for mechanical room space housing the heat pump is reduced by about 50 – 801% as compared to other technologies. (International Ground Source Heat Pump Association, 2010)

Operation: Very quiet in operation and requires negligible maintenance.

Can be used for heating and cooling: GSHPs can provide cooling for the buildings on the same principles as that for heating. These are capable of reducing the energy consumption by 30-70% during the heating season and 20-50% during the cooling season. (Minister of Natural Resources Canada 2001 – 2005)



Source: GreenSpec 2010

7.5 Ground-source Heat Pumps

Why GSHPs?

GSHPs in commercial buildings

As opposed to the common views about GSHPs, these can be prove to be efficient on a large scale for commercial buildings as well. There are examples of successful GSHPs on large scale, for e.g. the largest GSHP installation till 2005 located in *"Louisville (KY), USA [has been running successfully since 15 years and]… provides heating and cooling for 600 rooms, 100 apartments, and 89,000 square meters of office space, representing a total area of 161,650 m²".* This system have enabled energy savings of approximately 47%. (Minister of Natural Resources Canada 2001 – 2005) These can be particularly beneficial when included in the design considerations for in new buildings since these can provide free building spaces since these are smaller in size than conventional heating and cooling systems and dispense with large supply ducts, rooftop cooling towers and chimneys.

These can be beneficial for buildings having simultaneous heating and cooling demands. For e.g. in commercial or office buildings where probably the core of the building has cooling demands while the perimeter has heating demands.

Therefore the scope of installing GSHPs in Penarth is beyond what has been described in this report. GSHPs can prove to be beneficial when planned in future commercial and institutional buildings as well and also looking the current status climate change there are studies going on point out the need for cooling requirements in buildings in the UK.







Picture source: Minister of Natural Resources Canada 2001 – 2005, Earth Energy Ltd., Mitsubishi Electric Corporation, 2011

7.5 Ground-source Heat Pumps

"As systems become more popular the purchase price will reduce, and as designs become more proven the systems will become more efficient."
- NHBC Foundation, Oct 2007

Potential Barriers

GSHPs seem to be a promising renewable technology however there are some limitations to related to it.

Retrofitting

Retrofitting GSHPs in existing buildings can be problematic since these provide low grade heating these are better suited for new and better insulated buildings. Also these are more efficient with under floor heating thereby requiring retrofitting the existing flooring. The installation of GSHP to replace existing wet central heating systems would require major renovations.

High capital costs

Studies conducted to study the market of GSHPs in the UK using questionnaires have suggested that the high capital costs involved act as key barriers in the adoption of the technology. (Le Feuvre, P. and Kummert, M., 2008). High costs of trenching and piping increase the capital investment for ground source heat pumps, resulting in these systems to be designed to meet partial heat loads with supplementary secondary heating systems. (Rawlings R.)
However with the government increasing grants on renewable energy technologies it is expected that the technology is bound to rise. About 500 to 700 GSHPs are expected to be installed in the UK every year which is likely to increase the probability of government grants thus facilitating ease of installation. (NHBC Foundation, Oct 2007)

Lack of development of the technology

The UK industry till date has been dominated by the well established gas/ oil based boilers and radiator heating systems. There are no set guidelines established by the industry for the design and installation of GSHP systems thereby making it the responsibility of the designers and installers to set their own criteria making it difficult to assess the efficiency of the systems against set standards. (NHBC Foundation, Oct 2007)
A lack of experienced installers has been a major barrier in the success of the technology however this scenario is changing as a number of accredited installers can be seen in the UK now



Photo Source: icax.co.uk



Photo Source: The Low Carbon Economy Ltd., 2006-11

7.5 Ground-source Heat Pumps

"An understandable consumer worry is 'who puts it right if it goes wrong in five years' time?' "

- NHBC Foundation, Oct 2007

Potential Barriers

Maintenance

Although these systems require little maintenance, it can be a problem when required because of the underground buried ground loops.
Therefore it is advisable for owners to sign a "post installation services agreements" with the installers to save the trouble involved in maintenance and cots-breakdown. (NHBC Foundation, Oct 2007)

Environmental Impact

GSHPs can pose a barrier where ground water is used as a part of the system and then returned to the ground. This might require the approval of the Environmental Agency as it might be considered as a potential source for ground water pollution.

Availability of fossil fuel

UK has been very self sufficient in the past in the availability of fossil fuels for heating and electricity. It has been described as *"an island of coal, sitting on a bubble of gas, surrounded by a sea of oil*" The low gas prices have also limited the adoption of GSHPs in the UK market. UK has a vast network of natural gas distribution supplying approximately 75% of UK dwellings and most cities. (Feuvre P.L., 2007)

Past Reputation

Due to lack of adoption of the technology in the past most of the systems installed in the UK were overdesigned thereby increasing the cost of the system. Also care should be taken that the heat used from the ground during the heating season should be replenished during the cooling season to avoid the system from becoming unsustainable as this could result in the system working harder to maintain the required temperatures and consuming more energy in the process.

Therefore a careful design is necessary for the efficient operation of the system



Photo Source: geotekheating.com



Photo Source: isoenergy.co.uk

7.5 Ground-source Heat Pumps

Cast Study

Penwith Housing Association, Cornwall, UK. ManagEnergy.net

Background

This case study has been chosen to demonstrate the application of GSHP in existing residences on a community scale. The project consisted of installing ground source heat pumps in existing social housing homes. It was the first in the UK to retrofit GSHPs in existing structures and provided heating and hot water for 14 1960's bungalows via vertical borehole heat pumps and was completed in the year 2004. It was carried out by the *"Penwith Housing Association in conjunction with GeoScience, the utility company Powergen, the local authority Penwith District Council, and the Cornwall Sustainable Energy Partnership".*

The main objective to carry out this project was to demonstrate the potential to retrofit GSHP in existing buildings in rural areas without a mains gas supply.

Cost and Grants

The project was provided with 100% grants fro m various schemes and agencies:
The total cost od the project was £ **204,300**
Fundings provided by Clear Sky Program £ **89,450** (45%)
Grants provided by Penarth District Council £ **32,450** (15%)
Grants provided by Penarth Housing Association £ **82,400** (40%)

Implementation

The project involved installing a separate 3.5 kW capacity vertical bore GSHP for each of the houses to allow installation in a small garden space. The system was *"housed in a plastic enclosure outside the houses"* to cause minimum interference. It consisted to 70m long ground loop pipes with anti freeze mixtures running as refrigerant.
Simultaneous with the design of the system tenders were opened and separate contractors for ground work/ drilling and plumbing were appointed to carry out drilling/ groundwork and to install the heat pumps systems. Following the appointment the work commenced in January 2004 until June 2004. Technical support and heat pumps were supplied by Powegen and earth energy consultation was provided by GeoScience..





Source: penwithha.org.uk

Cast Study

Penwith Housing Association, Cornwall, UK. ManagEnergy.net

During the implementation process it was noticed that while the process of installing the plumbing system to suit the GSHP was quite similar to conventional systems the problem lied in employing a drilling contractor. So although the project was installed successfully the method of procurement remains questionable. Thus to overcome this barrier it would probably be beneficial to appoint an installer who would install the heat pump along with the groundwork.

Benefits

One of the main reasons to retrofit the homes to provide heating via GSHPs was to provide ***the elderly residents with the ease of operation and maintenance*** since these practically do no require much maintenance and are not complicated to operate and have a very quite operation.

The project has received many awards for its use of GSHPs such as the South West Green Energy Award, (Best Community Project 2004) and the 2004 National Home Improvement Council Award for 'Innovative Approaches to Central Heating and Domestic Hot Water Installations and the Building & Engineer Awards 'Energy Efficient Project of the Year.' Therefore the ***project has acted as an example to encourage other social housing landlords to install GSHP systems and also these awards have helped to promote the system and raise awareness amongst the public.***

Carbon emissions reduction. The project is estimated to give high carbon and fuel cost reductions. A comparison of the emissions from GSHPs and other conventional methods has been done for the project which estimates reductions from about 150 $kgCO2/ m^2$ p.a. from coal to about 16 $kgCO2/ m^2$ p.a. from installed heat pumps.



Heat Pump external enclosure



Photo Source: Energy Saving Trust, May 2005

Cast Study

Penwith Housing Association, Cornwall, UK. ManagEnergy.net

Lessons learnt for Penarth

The project is a successful example of implementation of community ground source heat pump systems and there are some points from which Penarth can benefit.

The main barrier overcome by this project is not technical but cultural. This has proved to be successful in removing the apprehension of the residents of this community as well as the neighbouring housing communities which have also adopted this system. Till this project there had been no practical experience of drilling boreholes in such close proximity of the existing residences but various community meetings resulted in the residents willing to experience this as is visible in their comments: *"…There is only small disruption to the gardens during the work. We have had the dust and dust- now we will have clean air."*

Also the capability of the technology to deliver reliable heating had not been tested before. And since this project a lot of UKs social housing projects have taken up similar projects installing GSHPs in existing residential dwellings.

The project had been implemented after consultation with the residents. They had been provided with the options of either a geothermal or oil. They opted for geothermal. Hence the success of the project largely depends on the level of satisfaction of the users and to ensure this it is very important to consider their opinions before actual implementation. The satisfaction of the residents is evident in their comments:

"For too many years we have endured the problem associated with solid fuel heating- the dust, ashes, getting the coal in etc. So we are very much looking forward to geothermal heating. The obvious benefits of cleanliness, it being so eco-friendly, lack of pollution…together with low running costs will be greatly appreciated by us pensioners" - Richard Fishers, Resident

(Stephens D., Penwith Housing Association)



Photo Source:
ManagEnergy.net

Cast Study

Penwith Housing Association, Cornwall, UK. ManagEnergy.net

Lessons learnt for Penarth

Step by step development:. The Penwith housing association now has another 23 housed which have installed GSHPs. Therefore as has been the case in this project the installations can first be made in the residences of the more willing dwellers and then this can act as an inspiration for others to join in.

In this case a separate heat pump had been provided for each residence but for Penarth for a more large scale installation 4 – 5 heat pumps can be installed which can serve a total of 130 – 150 houses as has been done in some other community scale GSHP installations.

Radiators instead of under floor heating. Contrary to the common belief that GSHPs only work well with under floor heating, the project has been running successfully with the use of radiators as well. Using radiators for existing houses is easier since this reduces the cost and hassle of retrofitting the flooring.

However it should be noted that the efficiency of the system does decrease with radiators.

Refurbishment funds. Since GSHPs have a higher efficiency when installed in well insulated buildings, a refurbishment program was also carried out for the buildings prior to installation sponsored by the Penwith Housing Association itself. This program included *"cavity wall insulation, loft insulation and upvc double glazing in order to reduce the heat demand of the properties."* (Energy Saving Trust, May 2005)





Photo Source:
ManagEnergy.net

References & Bibliography:

Minister of Natural Resources Canada 2001 – 2005, GROUND-SOURCE HEAT PUMP PROJECT ANALYSIS CHAPTER; [online] available at www.retscreen.net/download.php/ang/479/0/Textbook_GSHP.pdf [accessed 30th May 2011]

Carbon Trust, 2011, Geothermal; [online] available at http://www.carbontrust.co.uk/emerging-technologies/technology-directory/pages/geothermal.aspx [accessed 30th May 2011]

Dr. Hard K., Fabre Maunsell, Building Regs, Planning and Ground Source Heat Pumps; [online] available at http://www.gshp.org.uk/documents/GSHPsKevinHard20June06REVISED.pdf [accessed 30th May 2011]

UK Power Limited 2001 – 2011; [online] available at http://www.ukpower.co.uk/home_energy/compare/electricity/W5HQ7NWY/ [accessed 30th May 2011]

Queen's Printer and Controller of HMSO , Aug 2010, Carbon Trust, Renewable Energy Sources; [online] available at http://www.carbontrust.co.uk/publications/pages/publicationdetail.aspx?id=CTG011[accessed 30th May 2011]

Earth Energy; Reliable, Sustainable, Affordable, Available, Renewable Ground Source, Brighter People, Cleaner Future, Renewable Ground Source Heating & Cooling; [online] available at http://www.earthenergy.co.uk/downloads/EarthEnergy_Brochure_Jan2010.pdf [Accessed: 03, March, 2011]

Ground Source Heat Pump Association, Ground Source Heat Pumps – An Introduction; [online] available at http://www.gshp.org.uk/documents/GSHPIntroduction_000.pdf [Accessed: 03, March, 2011]

GreenSpec 2010, GreenSpec 2010; [online] available at http://www.greenspec.co.uk/ground-source-heat-pumps.php [Accessed: 30th May, 2011]

International Ground Source Heat Pump Association, 2010, Commercial; [online] available at http://www.igshpa.okstate.edu/geothermal/commercial.htm [Accessed: 30th May, 2011]

Mitsubishi Electric Corporation, 2011, **COMMERCIAL HEATING - Ground Source Heat Pumps;** [online] available at http://commercialheating.mitsubishielectric.co.uk/the_range/ground_source_heat_pumps [Accessed: 30th May, 2011]

Le Feuvre, P. and Kummert, M., 2008, **Ground source heat pumps in the UK - market status and evaluation;** [online] available at http://en.scientificcommons.org/44242758 [Accessed: 30th May, 2011]

NHBC Foundation, Oct 2007, Ground source heat pump systems: Benefits, drivers and barriers in residential developments; [online] available at http://www.nhbcfoundation.org/LinkClick.aspx?fileticket=FzCSHGAGTaw%3D&tabid=339&mid=774&language=en-US [Accessed: 30th May, 2011]

Feuvre P.L., 2007, An Investigation into Ground Source Heat Pump Technology, its UK Market and Best Practice in System Design; [online] available at http://www.esru.strath.ac.uk/Documents/MSc_2007/Le_Feuvre.pdf [Accessed: 30th May, 2011]

Stephens D., Penwith Housing Association; [online] available at http://www.completingtheloop.org.uk/downloads/SHAOpenDay_PenwithHA_FULL_VERSION.pdf [Accessed: 30th May, 2011]

Energy Saving Trust, May 2005, Breaking New Ground, Promoting the Use of Ground Source Heat Pumps in Social Housing; [online] available at http://www.completingtheloop.org.uk/downloads/BNG_case_study_final.pdf [Accessed: 30th May, 2011]

Rawlings R., BSRIA TN 18/99; *Ground Source Heat Pumps- A Technology Review; pp.1-61*

7.6 Hydropower

"Hydropower is the energy we make with moving water…"

What is Hydropower?

Hydroelectric power is a renewable form of generating electricity. *"It exploits the gravitational force of falling water, converting it into mechanical power via a turbine which produces electricity by driving a generator."* (Carbon Trust, 2011) Hydropower is generally associated with large scale projects however small scale hydropower projects to provide electricity for industrial and commercial purposes are also feasible. Generally it can be said that hydropower plants with capacity less than 100kW are small scale and more than 100kW are large scale. (Queen's Printer and Controller of HMSO, Nov. 2006)

The basic requirements:

The amount of energy available from a hydroelectric power plant depends on the "head" available. This "head" is the *"difference in height in the water source and the point where it flows through the turbine."* Generally the higher the head available the lower is the cost per unit of electricity. (Carbon Trust, 2011)

A Low carbon technique:

Hydropower can be regarded as carbon neutral in the sense that no fuel is burnt in the production of electricity. Electricity is generated by allowing water stored at a height to fall on the turbine under gravity. There are no direct CO2 emissions from hydropower.

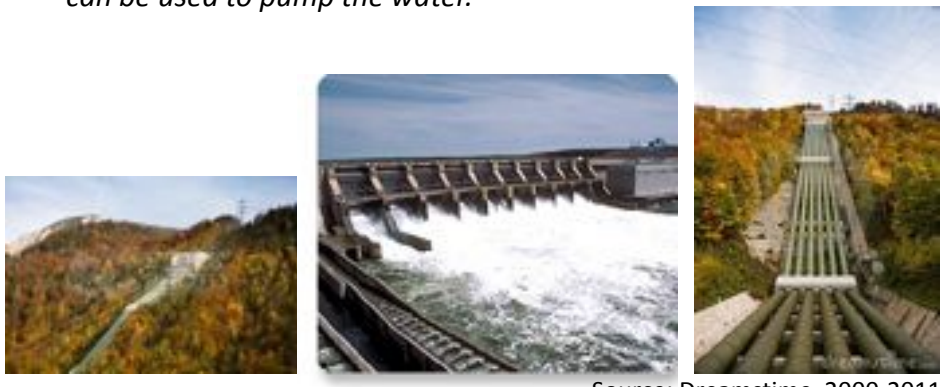
Types of Hydropower

There can be two types of hydroelectric power plants based on the type of water source available. One is a "run-of-river" hydroelectric power plant which does not require a reservoir for water catchment and uses the *"natural flow of rivers with a consistent steady flow rate"* (Carbon Trust, 2011)

The other type requires an appropriate *"rainfall catchment area, a water intake placed above a weir or behind a dam and a sufficient drop (head) between inlet and outlet"*. This water is then used to run a turbine by transporting it via a pipe line or a channel on the turbines and then it is allowed to return to its natural course via the turbine outlet..

However if a sufficient head is not available naturally electricity can also be generated on a commercial scale by allowing water to flow between 2 reservoirs located at different heights. Such a scheme is not essentially carbon neutral as energy (electricity) is consumed in pumping the water to the higher reservoir but is very useful in increasing the overall efficiency of the plant (OECD/IEA, 2010). Such a scheme is beneficial in case when the water is stored up the hill during low electricity demands and then used to generate hydroelectricity during peak demand periods.

This type of a plant can be used in Penarth where no natural drop in the level of water is available and "cleaner" sources of electricity can be used to pump the water.



Source: Dreamstime, 2000-2011

7.6 Hydropower

"A modern hydro turbine generator can convert over 90% of the energy in the available water into electricity. This is more efficient than any other form of generation." *British Hydropower Association*

What is Hydropower?

Performance

Considering modern hydropower plants , *"a modern hydro turbine generator can convert over 90% of the energy in the available water into electricity."* (British Hydropower Association). The power generated by a hydropower plant is dependent on the head available (H) and the rate at which the volume of water passes per second over the turbine (Q). It is the product of Q and H, for example assuming 70% efficient system, the mechanical power (P) produced by the plant can be given by the following formula: (The British Hydropower Association, Jan, 2005)

P (kW) = 7 x Q (m3/s) x H (m)

Cost of installation for a low head system (head height < 4m) is approximately *"£5,000 to £8,000 per kW of capacity installed."* and that of a high head (4-20m) system is approximately *" £4,000 to £7,000 per kW of capacity."* (Local Government Improvement and Development 2001-2010)

Site Suitability & Space Requirement

Hydropower project is feasible where there is flow of water available from a higher to a lower level. "*This may occur where a stream runs down a hillside, or a river passes over a waterfall or man-made weir, or where a reservoir discharges water back into the main river*." (The British Hydropower Association, Jan, 2005) Primary factor is the elevation available for the pipeline from the water intake to the powerhouse. This height is essential to deliver the necessary pressure at the bottom of the pipeline to drive the turbine in the powerhouse. (Haven F., 2008)

Why Hydropower?

The advantages of using hydropower as an energy source…

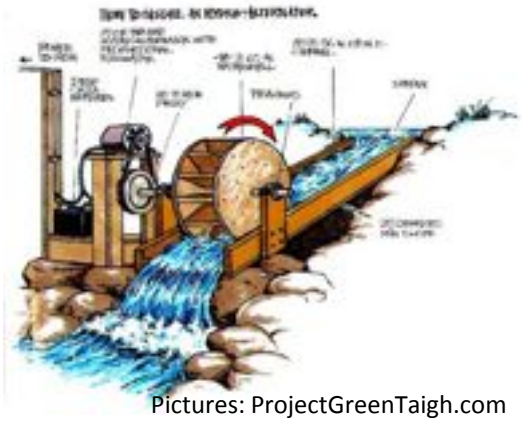
Maintenance and service cost

Although the capital cost for these systems is fairly high these have low maintenance and servicing costs which generally does not exceed 1-2% of the capital cost. (The British Hydropower Association, Jan, 2005)

Most of the hydropower plants have a reasonably long life of about 50 to 100 years which can compensate for the high upfront cost for the plant.

A small scale hydropower plant will have a respectable payback time owing to its long life and low maintenance and servicing costs. For example , say a small hydropower plant with a capacity of 8kW, assuming to be to be producing electricity 50% of the year would generate 35040 kWh/ year which is approximately equal to the energy consumption of 5 British semi detached houses. An approximate payback time for this system shall be 7 years.





Pictures: ProjectGreenTaigh.com

7.6 Hydropower

"Hydropower is a reliable and proven technology and it is increasingly attractive to local communities, organisations and individuals..."
Environment Agency 2011

Why Hydropower?

This can be demonstrated with the help of the following assumptions and calculations: the capital cost of this system shall be approximately £63,000; *"the annual FITs income (assuming installation before April 2012) guaranteed for 20 years)"* shall sum up to £8,500 which has been derived from the assumption that *"9.9p [is] for every kWh generated and 5p for every kWh exported to grid (assuming 90 per cent is exported to the grid and 10 per cent is used onsite)"; "Annual savings from not using grid electricity, assuming 14p/kWh"* would sum up to £500; "*An annual net income from the plant would be £9,000".* Therefore a net payback period would come out to be 7 years. (Local Government Improvement and Development 2001-2010)

Flexibility

"Hydropower plants can be designed to provide for peak or base demand loads or for both." These are flexible in the sense that they have a storage capacity as well as the capability to respond quickly to "fluctuating" load demands "*and to match supply from less flexible electricity sources and variable renewable sources*." (OECD/IEA, 2010)

Pumped storage plants which have been suggested earlier in this report for Penarth have been identified as *"the largest and most cost effective form of electric energy storage at present."* (OECD/IEA, 2010)

Economy

It has been observed that large scale hydropower plants often also serve as tourist spots and the reservoir for storing water in case of large scale projects can be used for leisure activities such as water sports etc. thereby generating additional revenue.

A community owned hydropower plant can help to reduce the energy costs for the residents and help generate income via FITS. (Local Government Improvement and Development 2001-2010)

Predictability and reliability

This technology can be regarded as more reliable than some of the other renewable technologies such as PVS etc. since the *"outputs change gradually from day-to-day, as opposed to hour-by-hour."* (Local Government Improvement and Development 2001-2010)

Also since the amount of energy generated is directly proportional to the amount of rainfall, the peak power generated corresponds to peak demand season i.e. during the winters when the levels of rainfall tend to increase in Penath.



Pictures: http://bluelivingideas.com

7.6 Hydropower

Potential Barriers

Although hydropower can be regarded as a low carbon energy generation technology there are certain social, economic and ecological issues related to its implementation.

Capital cost

The capital costs for hydropower is very high as compared to other renewable technologies such as biomass and wind etc. The cost of construction for a new plant in OECD countries as mentioned by IEA, OECD, 2010 (International Energy Agency) is approximately 1.2 million to 2.5 million GBP for a plant with capacity less than 10 MW. Such projects are generally not feasible without 100% grants from the government. A feed-in-tariff for **hydropower projects** with capacity up to 5MW had been introduced in 2009, however with the change of the government a "Comprehensive Spending Review" was launched in October 2010 to enable savings in FITs. Although it had been predicted that due to the "reasonable evidence based tariffs" offered by hydropower it should not suffer much, the banks have taken precautionary actions by holding loans for implementation of new projects until April 2012 making the industry stagnant. (Esha, Stream Map) However in another report published by DECC and WSA, October 2010, *"England and Wales Hydropower Resource Assessment",* it has been stated that many studies carried out in the past did not take into account green incentives such as Climate Change Levy and Renewable Obligations in the feasibility studies since these incentives were yet to be introduced and thus with the advancement in the technology and new renewable incentives projects which were rejected say 20 years ago might be feasible now.

Hydropower plants also involve *"high taxes contractual expenses."* (Union of the Electricity Industry - EURELECTRIC, 2000)



Pictures: http://images.businessweek.com/



Pictures: http://www.proactiveinvestors.co.uk



Pictures: http://www.energy4me.org

7.6 Hydropower

"Hydropower schemes can have complicated impacts, including changing river flows... To ensure the environment and river life are protected, a range of permissions covering abstraction, fish movement… are required from Environment Agency Wales" *Environment Agency 2011*

Potential Barriers

Certain social issues

There are certain social issues related to the implementation of hydropower plants such as visual impact, noise problems for neighbouring residents, disturbance during construction phase, and conservation of historic buildings etc.

Environmental issues

There have been some arguments regarding the environmental impacts of a hydropower plant. The energy produced is considered to be carbon neutral but there has been opposition that these schemes require water to be stored in reservoirs and *"by flooding landscapes and forests a lot of plants die."* The decomposition of organic matter releases CO2 and methane. Thus a full life cycle assessment of the project prior to its implementation needs to be carried out to measure the net carbon emissions from the plant. Also : Hydropower plants on rivers having migratory fish like Salmon and Trout require special considerations.

Hydropower plants in Penarth would require to obtain planning permission from the local planning authority to ensure the acceptability of the site and design of the plant from the "The Environment Agency". (The British Hydropower Association, Jan, 2005)

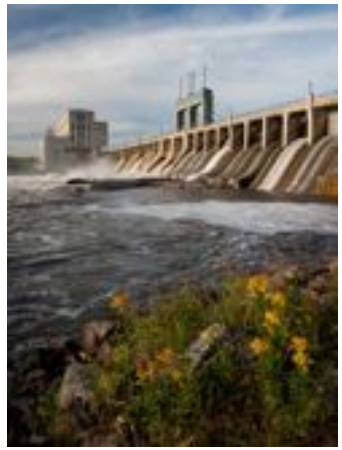
Planning a hydropower plant in Penarth would require careful consideration of the water head available, the space for reservoir, the effect on the aquatic life which is very site specific. Also since the capital cost would be high it is likely that public and government participation would be required.

In addition to this all environmental and social impacts need to be considered prior to the implementation of the project in the planning stage to "avoid, mitigate, or compensate for impacts" (OECD/IEA, 2010)



Pictures: renewbl.com





Pictures: powersolarsystem.com Pictures: http://www.eere.energy.gov/

7.6 Hydropower

"There is a great deal of community pride in the scheme, and not just among our own shareholders."

Richard Body, Director at Torr Hydro, May 2010

Cast Study

Torrs Hydro, New Mills, Derbyshire (Environment Agency, October 2010)

Background

It is a community owned hydropower project and the scheme had been proposed by Water Power Enterprises Community Interest Company (h2oPE). This scheme has been developed with the aim utilising a share of the revenue generated for regenerating the community, *"improve the environmental sustainability of the New Mills area, and to promote community development…The scheme is located on an* ***existing weir*** *of* ***Torr Mills****".* (Environment Agency, October 2010) The project has been located at the junction of the River Goyt and the River Sett in New Mills, Derbyshire." The Mill was constructed in the year 1790 and then destroyed in a fire in the year 1912. The scheme has been producing electricity since September 2008.

Performance and supply

Average power generated annually is approximately 240,000 kWh by a "*63kW [capacity] Archimedes screw turbine*". All the power generated is sold to an electricity supplier through a "*Power Purchase Agreement"* who then sells it to the Co-operative group. This electricity is then supplied to a nearby Co-operative Food Store

"This [240,000 kWh] is the equivalent of the annual electricity consumption of around 50 typical British homes …"

Cost

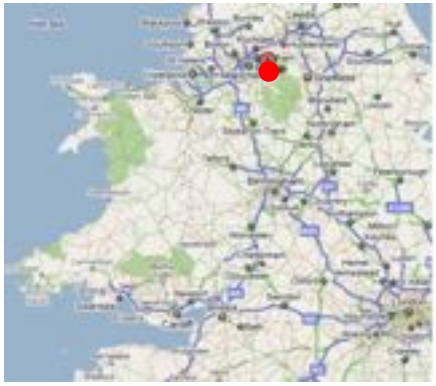
Total cost of the project is £330,000 of which £125,000 (approximately 38%) have been invested by 230 members of an "*Industrial and Provident Society*" formed by the local community. Approximately a total of £165,000 was provided by grants available from the East Midlands Development Agency, the Cooperative Fund and the Sustainable Development Fund

A bank loan of £70,000 had also been taken. (Local Government Improvement and Development 2001-2010)

"(*This scheme does not include profits from FITs as it was completed before FITs started)".*



Source: Local Government Improvement and Development 2001-2010



Source: **Environment Agency, October 2010**

7.6 Hydropower

"There is a great deal of community pride in the scheme, and not just among our own shareholders."

Richard Body, Director at Torr Hydro, May 2010

Cast Study

Torrs Hydro, New Mills, Derbyshire

Preserving the heritage

The development has been constructed on a historical site and has used some of the original stones from the mill pit thereby preserving the "Post Industrial" set up of the site. The scheme also incorporates a fish pass funded by the Environment Agency.

Benefits

This project helps to reduce amounts of carbon emission. The installation of the hydropower for the Co-operative food store is predicted to save "*over 150 tonnes of CO2 emissions compared to conventional electricity generation"* (Environment Agency, October 2010)

Profits. The system on an average produces *"60-70 per cent of the Co-op supermarket's electricity needs over a 24-hour period, and also collects excess to sell back to the grid during the night when the Co-op is shut."* It is estimated that the scheme will bring about financial profits of approximately £2,000 to £3,000 / year by selling the electricity generated back to the grid, and once the loan is paid off this profit shall increase to £10,000 which the community plans to use for *"insulation of community buildings, regeneration work, environmental education or energy saving initiatives, etc."* (Local Government Improvement and Development 2001-2010)

Benefits for local community. The scheme has also benefitted the local economy as the place has now become a tourist spot. There are open days for visitors, school trips and private tours for groups interested in developing their own hydroelectric scheme.



1 - River Goyt; 2 - River Sett; 3 - Torr Weir; 4 - Headrace (water intake); 5 - Powerhouse; 6 - Fish Pass; 7 - Reverse Archiemedes Screw Turbine a.k.a Archie; 8 - Tailrace (water outlet); 9 - Leaping Salmon Carving; 10 - Ruins of Torr Mill; 11 - Torr Bridge.
Source: Peak Digital Limited 2009

Photo Source: Peak Digital Limited 2009

7.6 Hydropower

"There is a great deal of community pride in the scheme, and not just among our own shareholders."

Richard Body, Director at Torr Hydro, May 2010

Cast Study

Torrs Hydro, New Mills, Derbyshire

Lessons learnt for Penarth

The project contains certain useful experiences from which some lessons can be gained for Penarth:

Motivating the investors: As it was difficult to initially motivate to investors to buy shares in the project the Industrial and Provident Society, THNM decided to bring in PR professionals to promote the scheme. Thus the scheme was published in newspapers and also advertised on national BBC television and radio. In addition to this there were planned tours of the site in order to show the potential shareholders what was planned and also there was a detailed website for the scheme.

Thus while planning a hydropower plant for Penarth the scheme should be properly promoted and well explained to the community and other potential stakeholders.

Pattern of supply: The electricity generated by the project has been supplied to a local Co-operative food store with surplus being sold to the grid. However the total amount generated is sufficient to supply 50 British Detached houses. Therefore it can be seen that a hydropower plant does not always have to a large scale and can b designed to supply a few number of houses/ buildings with less capital cost provided the required resources are available.

"Community share issues can provide a source of capital where grants or loans are not available." *-Richard Body*

Tax reduction: This scheme had been proposed by Water Power Enterprises Community Interest Company, h2oPE and h2oPE have on their behalf applied to the HM Revenues and Customs for a reduction in tax to be paid by a shareholder in this scheme. h20PE have requested *"that if a member purchases shares over the value of £500, then the member will be eligible for Enterprise Investment Scheme tax relief. Under this scheme, shares must be held for 3 years and 20% of the value of the investment can be used as an 'income tax reducer' in the year that the shares are purchased."* (Torrs Hydro New Mills Ltd (THNM), Nov. 2007)

Therefore in the case of Penarth GPG can perform the role of h2oPE and explore the scope for the reduction of tax for local stakeholders in the scheme.



Photo Source: www.derbyshire-peakdistrict.co.uk





Photo Source: Peak Digital Limited 2009

References & Bibliography:

Minister of Natural Resources Canada 2001 – 2005; [online] available at http://www.carbontrust.co.uk/emerging-technologies/technology-directory/Pages/hydroelectric.aspx [accessed 20th May 2011]

Queen's Printer and Controller of HMSO, Nov. 2006, Renewable energy sources, Opportunities for businesses, Technology Overview, Carbon Trust; [online] available at http://www.carbontrust.co.uk/publications/pages/publicationdetail.aspx?id=CTV010 [accessed 21st May, 2011]

Dreamstime, 2000-2011; [online] available at http://www.dreamstime.com/stock-photos-pumped-storage-hydropower-plant-image15561273 [accessed 21st May, 2011]

British Hydropower Association, Hydro Facts; ; [online] available at http://www.british-hydro.org/hydro_facts.html [accessed 21st May, 2011]

The British Hydropower Association, Jan, 2005, A GUIDE TO UK MINI-HYDRO DEVELOPMENTS; [online] available at http://www.british-hydro.org/mini-hydro/download.pdf [accessed 22nd May, 2011]

OECD/IEA, 2010, Renewable Energy Essentials: http://www.iea.org/papers/2010/Hydropower_Essentials.pdfhttp://www.british-hydro.org/mini-hydro/download.pdf [accessed 22nd May, 2011]

Esha (European Small Hydropower Association), Stream Map, Mapping the way forward for the hydro sector in the European Union; [online] available at http://www.streammap.esha.be/20.0.html [accessed 22nd May, 2011]

DECC, WSA, October 2010, England and Wales Hydropower Resource Assessment; [online] available at http://www.british-hydro.org/UK%20Hydro%20Resource/England%20and%20Wales%20Resource%20Study%20Oct%202010.pdf [accessed 22nd May, 2011]

Union of the Electricity Industry - EURELECTRIC, 2000, Hydro Power and Other Renewable Energies Study Committee; [online] available at http://www.google.co.uk/#sclient=psy&hl=en&site=&source=hp&q=Hydro+Power+and+Other+Renewable+Energies+Study+Committee&aq=f&aqi=&aql=&oq=&pbx=1&bav=on.2,or.r_gc.r_pw.&fp=597de7160f1b3af4 [accessed 22nd May, 2011]

Local Government Improvement and Development 2001-2010, Hydropower cost and funding; [online] available at http://www.idea.gov.uk/idk/core/page.do?pageId=25454511 [accessed 24th May, 2011]

Richard Body, A Director at Torr Hydro, May 2010, Stepping up to Enterprise; [online] available at http://www.steppinguptoenterprise.org.uk/assets/Torrs%20Hydro%20FINAL.pdf [accessed 24th May, 2011]

Torrs Hydro New Mills Ltd (THNM), Nov. 2007; [online] available at http://casestudies.inforse.org/sites/default/files/torrs_hydro_new_mills_prospectus.pdf [accessed 24th May, 2011]

7.1 Tidal

"The majority of the tidal range resource in the UK is found in the Mersey and Severn Estuaries, with the Severn Estuary alone accounting for 90% of the UK tidal range resource" - Entec UK Ltd. May,2007

What is Tidal Power?

Tidal energy is a type of marine energy generating as a result of the *movement of water due to gravitational pull of the moon and the sun.* (Carbon Trust, Marine, 2011)

Tidal resource in Wales. Wales has a tremendous potential for marine power generation because of its tidal power resources such as 13.5m tidal ranges and high velocities (of the order of 8 knots) and strong and consistent winds. (Masters I., LCRI) It has been estimated that **tidal stream** can generate 5% of UKs electricity demands and another 5% demands can be met by **tidal range** projects (Crown, 2008). The **tidal range** for Wales is supposed to be the second highest in the world as it has been mentioned that, "the Severn Estuary has the 2nd highest tidal range in the world." (White water fishing trips and charter, 2011)

Types of Tidal

Tidal energy can further be classified in two categories: ***Tidal Stream and Tidal Range***. Tidal stream is generated as a result *of "large bodies of water moving around the ocean due to the gravitational pull of the sun and the moon." W*ater in tidal stream attains its energy by acceleration caused due to passing through *"restrictions such as channels between islands…"* etc. *."* This tidal stream energy is converted to usable form with the help of underwater turbines. (Carbon Trust, Marine, 2011)

Tidal Range derives energy from the *"rise and fall of tides in estuaries and bays"* (Carbon Trust, Marine, 2011) Electricity is generated by collecting *"large volumes of water on a high tide…[and passing it] through a low head turbine once a height difference is created on either side of impoundment…"* (Sustainable Development Commission, October 2007)

Tidal Stream technology is still in a nascent stage but certain projects such as "EoN/Lunar tidal stream and Wave Dragon wave-power projects" near Pembrokeshire are under development. This technology is estimated to be operational on a large scale by 2020. (Crown, 2008)

However due to limited time and scope more focus will be laid on Tidal Barrage Technology in this report.

Tidal barrage



Tidal lagoon



Off-shore tidal lagoon



Photo Source: Aqua-RET

7.7 Tidal

What is Tidal?

Basic Requirements and suitability for Penarth

The implementation of a tidal barrage project either *"involves building a dam across an estuary with a high tidal range"* known as a tidal barrage *or constructing an "impoundment against the banks of a tidal estuary or a basin in shallow water areas"* known as a tidal lagoon. There are also off-shore tidal lagoons consisting of artificial impoundment on *"tidal flats in high tidal range areas" (*Aqua-RET)

The capital cost for construction of a tidal barrage project have been studied to be higher than that for a tidal lagoon project due to the construction of longer barriers or dams required in a tidal barrage. However the energy produced in case of a tidal lagoon is less than that for a barrage. Therefore for Penarth if we consider the production of energy at a town level a tidal lagoon seems to be a more viable option.

However there is a lot of uncertainty regarding the estimated costs of a tidal lagoon project as demonstrated in the SDC report, the cost for Swansea Bay tidal lagoon project varies immensely in the estimates presented by the developer, Tidal Electric Ltd. (£81.5m) and a DTI Commissioned Review (£225m).
Also due to the lack of implementation of tidal lagoons all over the world there is less scope for new and innovative techniques to be used and thus this reduces the scope for financial incentives involved which are mainly "justified on the on the basis of innovation and long-term cost reductions." thereby requiring major Government, public sector and community involvement in the project for financial support. (Sustainable Development Commission, October 2007)

***Implementing tidal project as a public sector project*:**
Implementing a tidal project as public sector would allow the use of low discount rates (around 2%) on the basis of the long term public benefits that could be gained from the project. *"This is supported by the Stern Review, which recommended that a very low discount rate be used when evaluating long-term climate change mitigation measures to take account of the intergenerational benefits."* (Sustainable Development Commission, October 2007) *Thus this can act as an encouraging tool to involve the people of Penarth*.

It has been mentioned in SDP, Oct. 2007 report that its is completely justified that at least one tidal lagoon should be constructed in the UK as a demonstration project and the Crown Estate (owner of the sea bed around UK) provides demonstration leases for low carbon projects up to 10MW installed capacity for wave and tidal projects anywhere in the UK.
(MacKay D., June 2010)



Tidal Range Resource Site

Source: McCall R. et al, May 2007

7.1 Tidal

"Tidal power can create considerable job opportunities during construction, and some permanent long-term employment from associated regional economic development" - DECC

Why Tidal?

Why should we choose tidal as a energy source? Benefits of using a tidal power plant:

Transport links

Construction of a tidal barrage opens up the opportunities for new transport links- *"either road or rail – running on top of the barrage and thus gaining additional value from the structure."* Such a proposal was raised in one of the public engagement programmes held by the SDC regarding Severn Barrage and there was a strong public interest in this scheme. (Sustainable Development Commission, October 2007)

Carbon savings

The reduction in CO2 from tidal technologies depends on the type of conventional technology it has replaced. The standard emissions *"from the current UK generation mix is 0.43kg of carbon dioxide per kWh of electricity delivered to the consumer."* Taking the long life time of tidal technologies into account these can allow for large amounts of carbon savings. It has been studied that the CO2 emissions payback period for tidal barrage schemes is approximately 36 months and that for tidal lagoon schemes is 12 months (Entec UK Ltd. May,2007) The table given alongside gives an approximate estimate of the carbon savings possible by implementing different types of tidal projects.

Long life

The expected life of most of the tidal projects is 120 years, however a project can very well continue to produce electricity even after the expected design life provided the *"structural integrity of the project is maintained and if siltation did not significantly impair operational efficiency."* This statement can be supported with the help of a live example- the La Rance tidal barrage in France is still operating in a good condition even after about 45 years of construction.(Sustainable Development Commission, October 2007)

Employment opportunities and economy

The implementation of tidal project would open up opportunities for new jobs especially during the construction phase. Of all the jobs offered about 20-40% are expected to be taken up by the locals. (Crown, OCTOBER 2010)

Source: Entec UK Ltd. May,2007

7.1 Tidal

"The UK has an abundance of wave and tidal resource on its doorstep. With the right support, the marine energy industry can play a pivotal role in achieving our renewable energy targets in 2020 and beyond" - Oliver Wragg, Wave and Tidal Development Manger at RenewableUK

Why Tidal?

There is also likely to be an increase in the economy since it is expected that the barrage in itself would act as a tourist place. The estimated increase in tourism due to a Severn Barrage is about 5-20%. Crown, OCTOBER 2010)

Amount of electricity produced

Tidal electricity can play a vital role in achieving the "…3% reductions in greenhouse gas emissions per year [target]in areas of devolved competence by 2011…" set by the National Assembly for Wales 2010 or the targets preferred by the local people of Penarth (data gathered from one of our community meetings) as are mentioned in this report. (20% renewable energy consumption by 2020, 30% by 2030 and 100% by 2050). The amount of electricity produced by tidal energy as compared to an equivalent capacity of any other renewable energy technology is much greater. For example the installed capacity and average annual energy output for some of the proposed tidal projects in UK are as follows:

Proposed project	Installed capacity (MW)	Annual energy output (GWh/ year)
Mersey Barrage	700	1450
Loughor Barrage	5	15.1
Duddon Barrage	100	212
Wyre Barrage	63.6	133

Source: Sustainable Development Commission, October 2007

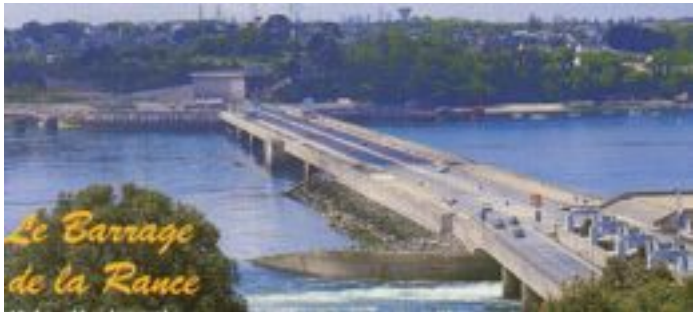


Photo Source: pteratunes.org.uk



Photo Source: windenergyplanning.com



Photo Source: bleedingcool.com

7.7 Tidal

"Estuaries are important to migratory species of fish, many of which are the foundation for commercial fisheries. Barrages could act as barriers to migration." - DECC

Potential Barriers

Tidal power seems to be a promising technology especially in Wales but there are certain barriers associated with this technology which have restricted its development.

High capital cost

This is one of the major barriers in the adoption of tidal power. There have been studies on various tidal projects since years but most of them have failed to be implemented due to very high capital costs. For e.g. studies on the feasibility of a tidal barrage project on the Severn Estuary have been carried out since 1920s. In spite of this no proposal has ever been implemented due to high capital cost of construction of barrage and more recently due to environmental impacts as well. This barrier accompanied with the long construction periods and "*risk of cost overruns*" has further limited the adoption of tidal projects in the private sector. *(Sustainable Development Commission, October 2007)*

However as mentioned in the SDC, Oct 2007 report, this situation seems to be changing for the better owing to the increase in awareness amongst the public about climate change, energy security and the potential of tidal projects to save carbon emissions.

Funding

Due to the high capital cost involved it is not feasible to implement a tidal project solely by private funding. it is generally not feasible without government funding which becomes difficult to obtain due high risk factor and lack of live projects to analyze the success

Decommissioning

The decommissioning of these projects can often turn out to be highly cost intensive, costing approximately as much as the capital cost of the project. Therefore it is advisable to consider a source for the funding for decommissioning in the planning period of the project. (Craig J et al.,Oct. 2007)

Flood risks

Tidal power involves storing water in embankments before producing electricity thereby raising the mean water levels. This increase the time the land might take to drain the water, and also the risk of erosion, increasing the potential for flooding.
Therefore while designing a project for Penarth it is essential to include the expenses involved in implementing *"mitigation methods to maintain existing protection levels for land on both sides of the estuary"* in the capital cost of the project. (Crown, OCTOBER 2010)



Photo Source: Clean Energy Source

7.7 Tidal

"Changing tidal flows by damming a bay or estuary could have an impact on aquatic and shoreline ecosystems – and on shipping navigation and recreation." - DECC

Environmental concern

This is another major barrier to the adoption of the technology. Estuaries are generally home to a variety of species of aquatic plants and animals. In addition estuaries with a high tidal range house even more unique species since a very few species are capable of surviving the harsh conditions. Thus tidal projects can have a significant impact on the local ecology. (Sustainable Development Commission, October 2007) Tidal projects are known to disrupt the aquatic life not just in the construction phase but also during the operation phase by affecting the ecosystem- these projects decrease the turbidity of the water allowing sunlight to pass through which in turn supports the growth of phytoplankton thereby changing the ecosystem chain. (EfficientGreenPower.com, 2011) There are arguments that the environmental impact of tidal lagoons is somewhat less than that of tidal barrages such that depending upon the position and size of the lagoon, the fish and navigation pass might be affected to a lesser degree. (Sustainable Development Commission, October 2007

Intermittent source of electricity

Since it is dependent on the rise and fall of tides it is an intermittent source of electricity, though it is completely predictable in nature. Therefore tidal projects have a low load factor (estimated approximately 22.5-30%) as compared to other thermal generation technologies such as from coal, gas and nuclear, which have an approximate load capacity of 80-90%. However this low load factor is not much of a problem as it is compensated via the cost of electricity output. (Sustainable Development Commission, October 2007)

Impact on navigation

Construction of a tidal barrage can have considerable impact on navigation as it would create a physical barrier to the passage of ships. This would require the implementation of lock(s) to allow for the ship to pass from one level of water to another thereby causing a delay in the movement of ships or limiting the number of allowed to pass. Here also care must be taken while designing the lock so as to allow for future when ships carrying much larger containers might also have pass through.



Photo Source: Canadian Nuclear Association, 2010



Photo Source: Theecologist.org

Cast Study

Liverpool Bay Tidal Energy Lagoon- *Proposed Project* (Craig J et al, Sustainable Development Commission, October 2007)

Background

Due to the lack of an existing small to medium scale tidal project (which might just increase the possibility of a tidal lagoon project to be taken up by the Government as a demonstration project) (Sustainable Development Commission, October 2007) a proposed tidal lagoon project studied by AEA Energy & Environment has been selected as a case study. This study has been taken up in the SDP owing to arguments such that tidal lagoon energy can lagoons might prove to be more cost expensive and less environmentally damaging in comparison to tidal barrages. (Craig J et al.)

The project is has a ***capacity of 340 MW*** with an ***annual energy output of 938 GWh*** proposed off shore tidal lagoon scheme within an area of 60 sq km *"impounded by 34km of embankment …"* The embankment has been proposed to be made up of *"sand-filled geotextile bags"* stacked step-by-step on top of each other. It has been suggested that the scheme shall have a total of 20 turbine with a capacity of 17 MW each. (Craig J et al.)

Cost

Total estimated cost of the project is about £663 million (2006 prices) including the cost for construction of power house, embankment, turbine generators, labour costs, cable connection and project management, feasibility, planning and approval costs. The estimated construction period for the project has been estimated to be 4 years with one year for preconstruction with operation and maintenance cost assumed to be 0.5% of the capital cost. (Craig J et al.)



Area proposed for tidal lagoon in Liverpool bay

Source: Craig J et al, Sustainable Development Commission, October 2007

Cast Study

Liverpool Bay Tidal Energy Lagoon- *Proposed Project* (Craig J et al, Sustainable Development Commission, October 2007)

Visual Impact

The scheme being off shore is expected not to have a very dominant visual impact. The structure shall become evident from a distance of approximately 6km. This impact shall be more prominent during a low tide but since the maximum visible portion is only about 3m above the high water this shall seem like an *"off shore reef or an island from the shore"*

Benefits

Unit cost of electricity. The unit cost for generation of electricity turns out to be 3.11p/ kWh at a discount rate of 3.5%. Further the unit cost of electricity has been estimated with a range of discount rates shown in the table alongside. This rate is quite less as compared to the current average electricity price for Penarth which is approximately 12.6 p/ kWh (Energyhelpline.com)

Access to ports like Cardiff and Bristol. The implementation of a tidal lagoon system in Penarth would not provide a huge obstruction to access ports such as Cardiff, Bristol and Barry as compared to a tidal barrage project.

Long life. The project has an estimated life of 120 years with a complete turbine replacement every 40 years. This life time is very long as compared to other renewable technologies. Also the maintenance and operation costs are very less (0.5% of capital cost).

A low carbon option. The savings assumed for this project are approximately 0.43 kg CO2 per kWh of electricity produced. With this assumption the estimated carbon savings of technical life of 120 years for the project are calculated to be 48,410,914 tonnes of CO2. This gives a maximum carbon payback period of about 8 months thereby demonstrating huge amounts of savings.

Employment Opportunities. The project is expected to employ between 2000 to 1200 people for its implementation during the peak construction phase. But being a large off shore structure it is not expected to encourage local employment but is expected to benefit the neighbouring commercial port facilities such as Mostyn, Rhyl, and Connah's Quay that are closest



Picture source: bbc.co.uk.

Table 4.4 Unit cost of generation for the Liverpool Bay tidal-energy lagoon

Discount rate	3.5	8	10	15
Liverpool Bay unit cost (340MW Evans et al) p/kWh	3.11	6.80	8.64	13.75

Source: Craig J et al.

Cast Study

Liverpool Bay Tidal Energy Lagoon- *Proposed Project* (Craig J et al, Sustainable Development Commission, October 2007)

Lessons learnt for Penarth

Although the project has not actually been implemented there are some things that can be gained from what is proposed and calculated for the project with respect to Penarth:

Carbon savings as a driver for implementation: The project shows tremendous estimated total carbon savings over its life time of 120 years. This is far more than most of the other renewable technologies as can be seen in this report. This estimate can be calculated for the project proposed for Penarth and used as a driver for the promotion of the project.

Financial Incentive: Although the estimated capital cost for the project is high the cost of power per unit of electricity which has been calculated is very less. This can be a motivating factor for a project keeping in mind the increasing electricity prices. Also the kWh of energy produced for the capacity of the plant is very high.

Decommissioning: Although detailed decommissioning for the project has not been proposed but the report on Liverpool Bay Tidal Energy Lagoon suggests that this can be a very cost intensive process and the cost of decommissioning can turn out to be equivalent to the capital cost of the project.

It shall be beneficial for a project to identify the various steps involved in the decommissioning of the project such as removal of mechanical and electrical components, in-situ deconstruction of concrete caissons and removal of broken concrete etc. As has been mentioned in the report a full environmental impact assessment would be necessary.

Therefore it is beneficial to prepare a decommissioning report for the project to analyze the need for accruing a bond for the life of the scheme to fund the decommissioning.



Photo Source:
2011 garden-route

References & Bibliography:

Carbon Trust, Marine, 2011; [online] available at http://www.carbontrust.co.uk/emerging-technologies/technology-directory/marine/pages/marine.aspx [accessed 22nd May, 2011]

Sustainable Development Commission, October 2007, Turning the Tide, Tidal Power in UK; [online] available at http://www.sd-commission.org.uk/publications.php?id=607 [accessed 22nd May, 2011]

Aqua-RET, Tidal Impoundment, Technology Types, [online] available at http://aquaret.com/index.php?option=com_content&view=article&id=56&Itemid=206&lang=en [accessed 22nd May, 2011]

McCall R. et al, May 2007, SUSTAINABLE DEVELOPMENT COMMISSION, UK TIDAL RESOURCE REVIEW; [online] available at http://www.sd-commission.org.uk/index.php [accessed 22nd May, 2011]

Craig J et al, Sustainable Development Commission, October 2007, Sustainable Development Commission, Research Report 5, Case Studies; [online] available at http://www.sd-commission.org.uk/publications/downloads/TidalPowerUK5-UK_case_studies.pdf [accessed 22nd May, 2011]

MacKay D., June 2010, A Case Study and Update on The Crown Estate Wave & Tidal Programme, The Crown Estate; [online] available at http://www.r-e-a.net/document-library/events/rea-events-2010/Duncan%20Mackay%20Crown%20Estate.pdf [accessed 22nd May, 2011]

Masters I., LCRI, Low carbon energy generation, storage and distribution; [online] available at http://www.lcri.org.uk/th1-research-pri-3.html [accessed 21st May, 2011]

2011 garden-route, [online] available at http://garden-route.iblog.co.za/2007/06/14/knysna-bollard-bay/accessed 27thMay, 2011]

Crown, 2008, Renewable Energy Route Map for Wales consultation on way forward to a leaner, greener and cleaner Wales [online] available at http://www.caerphilly.gov.uk/pdf/Environment_Planning/LDP-Examination-Documents/W55-Renewable-Energy-Route-Map-for-Wales.pdf [accessed 19th May, 2011]

White water fishing trips and charter, 2011, Bristol Channel Tides; [online] available at http://www.whitewatercharters.co.uk/bristol-channel-tides.htm [accessed 19th May, 2011]

EfficientGreenPower.com, 2011, Tidal Energy Generation; [online] available at http://www.efficientgreenpower.com/tidal-energy.cfm [accessed 29th May, 2011]

Entec UK Ltd. May,2007, Tidal Power in the UK Research Report 2 -Tidal technologies overview; [online] available at http://www.sd-commission.org.uk/file_download.php?target=/publications/downloads/TidalPowerUK2-Tidal_technologies_overview.pdf [accessed 29th May, 2011]

Crown, OCTOBER 2010, SEVERN TIDAL POWER, Feasibility Study Conclusions and Summary Report; [online] available at http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/severn-tp/621-severn-tidal-power-feasibility-study-conclusions-a.pdf [accessed 29th May, 2011]

8.0 CONCLUSION:

The End but also a beginning…

Penarth *is in rich of renewable energy source – Wind, Tidal and Solar, and promising potential for development of renewable energy – plenty of open space and strong social supports.*

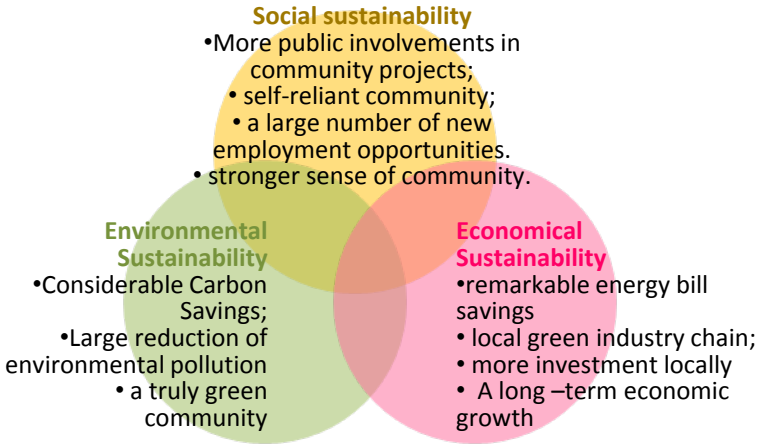
To CONCLUDE: the End but also a beginning…

On the one hand, Penarth Renewable Energy Plan is completed

The desirable outcomes are delivered with a aim to achieve the plan objectives.

1. ***The renewable energy vision is set according to relatively reliable investigation****. Firstly, the* ***2020 vision is set based on the survey*** *of existing legally-biding renewable energy vision and current development situation at different level EU, UK and in Wales which will affect Penarth. Secondly, in order to* ***demonstrate the maximumly potential*** *development of renewable energy in Penarth,* ***2030 Vision and 2050 Vision are set*** *relatively high.*
2. ***The locational plan consists of two parts: the potential locations*** *for each renewable energy technology and* ***the time sequence plan*** *regarding to 2020's, 2030's and 2050's visions.* ***Guidelines*** *regarding to* ***environment, social and economic issues*** *for every selected renewable energy system are formulated so as to* ***deliver a holistically sustainable plan****.*
3. ***A general operational flowchart is based on a community-led programme****, thereby enabling it to be useful to GPG.* ***A detailed checklists*** *for every technology, including the financial supports and professional support available to Penarth, are delivered to help GPG and residents to start a project more easily.*
4. ***A relatively comprehensive background knowledge*** *of various renewable energy technologies are also provided in this report. The characteristics, long-term advantages and potential limitations of each technology are summarized with an aim to enable local residents to have* ***a holistic understanding of renewable energy, not only from three-dimensional perspectives but also on the positive and potential negative aspects****.*

A holistic sustainability is maximumly delivered in this plan:



Desirable outcomes of this plan:

1) *A suitable Renewable Energy vision for Penarth;*
2) *Potential locational plan of renewable energy in Penarth;*
3) *Operational checklist of renewable energy for Penarth; and*
4) *Background knowledge of renewable energy.*

Plan Objectives:

1) *To enable Penarth's residents to understand Renewable Energy, and encourage more public involvements in Penarth renewable energy schemes;*
2) *To identify the potentials for renewable energy development in Penarth.; and*
3) *To provide the guide of renewable energy development for Penarth.*

TO CONCLUDE: the End but also a beginning…

On the other hand, the renewable energy development in Penarth is just starting.

***Some potential limitations of this plan be done in the future*:**

1) To conclude we shall say that ***this report is a macro-level energy masterplan for Penarth.*** The report is more focused on demonstrating the potential for various renewable energy technologies in Penarth including their social, economic and environmental impacts on the town as a whole as well as the community rather than providing a detailed feasibility analysis for the technologies. It should be noted that as and when the residents of Penarth decide to implement one or more of the technologies mentioned in the project this report shall give them a basic introduction to the technology, information about the various steps involved in the implementation and a list of the related specialists, suppliers and manufacturers etc. nearest to Penarth. To summarize the report shall provide the residents with a flowchart of all the steps involved and the stages where fundings would be required and potential sources for funds while implementing a renewable energy project in Penarth.

It should also be noted that ***a further detailed feasibility study on the technology would need to be conducted by specialists before actual implementation.*** Also the potential for renewable energy is in Penarth is not limited to the technologies presented in the report and other options should also be considered.

2) The ***objective of this project was to encourage public consultation*** and consider this as a key deciding factor in the implementation of a project. This was attempted by holding public meeting to educated them about the technologies and to gain their opinions on what they thought were the possible constraints. The report is more oriented. towards the cultural issues such as the apprehensions of public towards the acceptance of technologies etc. Throughout the report case studies have been presented to emphasis the role of community in the success of a project. ***However one limitation*** in this regard was ***the limited number of people*** who attended the community meetings therefore the opinions of the majority could not be included.

3) The report is a bottom up plan and primarily ***focuses on community led programs rather than government or business led programs***. This is because this work is being done in conjunction with the ***GPG which a community based group*** working at a local level with the residents of Penarth. ***However this does not rule out the scope for government and business led programs*** and these should also be considered and studied when considering implementation.

4) Lastly the ***financial appraisal provided for various technologies has been derived from suitable case studies or is based on the current market scenario***. This is definitely bound to change as the renewable energy technology develops and the popularity increases. The prices of the technologies such as hydro, tidal and solar which are still new in the market and are still developing stages are expected to decrease with the increase in popularity and development in their fields.

References & Bibliography

AEA Energy & Environment, 2007. *Research Report 4 - Severn non-barrage options*. [Online] Available at: http://www.sd-commission.org.uk/publications/downloads/TidalPowerUK4-Severn_non-barrage_options.pdf [Accessed 25 May 2011].

Anon., n.d. *Renewable Energy Association*. [Online] Available at: http://www.r-e-a.net/ [Accessed 12 March 2011].

Asefa, S., 2005. *The Economics of Sustainable Development*. W.E.Upjohn Institute of Employment Research.

Atkins, 2009. *Severn Estuary SMP Review, Appendix I – Part A – Strategic Environmental Assessment*. [Online] Available at: http://www.severnestuary.net/secg/docs/public%20consultation/dec10/Appendix%20I_PART%20A_SEA_FINAL_Dec2010.pdf [Accessed 25 May 2011].

Atkins, 2009. *Theme Review*. [Online] Available at: http://www.severnestuary.net/secg/docs/6.1.pdf [Accessed 25 May 2011].

Barn , G., 2010. *UK Renewable Energy Pricing Analysis*. [Online] Available at: www.fimltd.co.uk [Accessed 8 May 2011].

Boyle, G., 2004. *Renewable Energy: Power for a Sustainable Future*. 2nd ed. Oxford: Oxford University Press.

BWEA, 2005. *Offshore Wind*. London: BWEA.

Carbon Trust, 2006. *Policy frameworks for renewables:Analysis on policy frameworks to drive future investment in near and long-term renewable power in the UK*.

Carbon Trust, 2011. *Feed-in tariffs:Policy and Markets Guide*.

Cato, M.S., 2009. *Green Economic: an Introduction to Theory, Policy and Practices*. London: Earthscan.

Chiras, D., 2006. *The Homeowner's Guide to Renewable Energy*. Canada: New Spciety Publishers.

COLEBY, A.M., MILLER, D.R. & ASPINALL, P.A., 2009. Public Attitudes and Participation in Wind Turbine Development. *Journal of Environmental Assessment Policy and Management*, March. pp.69-95.

Combined Heat and Power Association(CHPA), 2010. *Integrated Energy: the Role of CHP and District heating in our energy future*.

Crown, 2006. *Tidal Lagoon Power Generation Scheme in Swansea Bay*. [Online] Available at: http://www.inference.phy.cam.ac.uk/sustainable/refs/tide/file30617.pdf [Accessed 25 May 2011].

Daly, H.E., 1988. In Economics, Growth and Sustainable Environmen. In O. Collard, D.W. Pearce & D. Ulp, eds. *On sustainable development and National Accounts*. New York: St.Martin'.

Daniels, K. & Hammann, R.E., 2009. *Energy Design for Tomorrow*. London: Stuttgart.

DECC, 2009. *UK renewable energy strategy*.

DECC, 2010. *LLSOA electricity and gas: 2008 (experimental)*. [Online] Available at: http://www.decc.gov.uk/en/content/cms/statistics/regional/mlsoa_llsoa/llsoa_2008/llsoa_2008.aspx [Accessed May 2011].

Eicker, U., 2001. *Solar Technologies for Buildings*. Chichester: John Wiley & Sons Ltd.

Elliott, D., 1997. *Energy, Society and Environment*. London: Routledge.

Energy Saving Trust, 2003. *Aberdeen City Council: a case study of community heating*.

Energy Saving Trust, 2004. *Rural biomass community heating: A case study*.

Energy Saving Trust, 2011. *Solar electricity*. [Online] Available at: http://www.energysavingtrust.org.uk/Generate-your-own-energy/Solar-electricity [Accessed May 2011].

European Commission, 2007. *EU LOCAL ENERGY ACTION:Good practices 2007*.

Evans, J.M., 1996. *The Penarth Appraisal*. Barry: Planning and environmental service.

Farmer, J., 1999. *Green Shift*. Second Edition ed. Oxford: Architectual Press.

Goodland, R., 1995. *the conception of Envrionemtnal sustainability*. Washinton DC: The World Bank Environment Department.

GreenSpec 2010, 2010. *Ground Source Heat Pumps (GSHP)*. [Online] Available at: http://www.greenspec.co.uk/ground-source-heat-pumps.php [Accessed 25 May 2011].

References & Bibliography

Grubb, M., 1995. *Renewable Energy Strategies for Europe*. London: Earthscan.

Harvey, D.L.D., 2010. *Carbon-Free Energy Supply: Energy and the New Reality 2*. London: Earthscan.

Helene, 2011. *Sustainability in Context, Energy & Buildings Group, Conservation*. ART431:Sustainable Design Practice, pp.71.

IEA Renewable Energy Working Party, 2002. *Renewable Energy. into the mainstream*.

IPCC, WMO and UNEP, 2011. *The IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*.

J.M., E., 1996. *The Penarth Appraisal*.

Jacobson, M.Z., 2009. *Review of Solutions to Global Warming, Air Pollution, and Energy Security*. [Online] Available at: www.stanford.edu/group/efmh/jacobson/0810EnergySeminar.pdf [Accessed 10 May 2011].

Kerr, R.A., 2007. GLOBAL WARMING:How Urgent Is Climate Change? *Science*, 318 (5854), pp.1230-31.

Komor, P., 2004. *Renewable Energy Policy*. Lincoln: iUniverse Inc.

L., F.P., 2007. *, An Investigation into Ground Source Heat Pump Technology, its UK Market and Best Practice in System Design'*. [Online] Available at: http://www.esru.strath.ac.uk/Documents/MSc_2007/Le_Feuvre.pdf [Accessed 25 May 2011].

Lerch, D., 2007. *Post Carbon Cities: Planning for Energy and Climate Uncertainty*. California: Sebastopol.

Linde´n, A.L.e.a., 2006. Efficient and inefficient aspects of residential energy behaviour: What are the policy instruments for change? *Energy Policy*, 34, pp. 1918-1927.

Mackay, D.J.C., 2008. *Sustainable Energy: without the hot air*. UIT Cambridge.

Markvart, T. & Castaner, L., 2002. *Practical Handbook of Photovotaics Fundamentals and Applications*. Oxford: Elsevier.

Matlary, J.H., 1997. *Energy policy in the European Union*. New York: St. Martin's Press.

McMichael, A.J., Woodruff, R.E. & Hal, S., 2006. Climate change and human health: present and future risks. *Lancet* , 367, pp.859-69.

Mitchell, C., 1995. The renewables NFFO: a review. *Energy Policy*, 12(23), pp.1077-91.

Mitchell, C. & Connor, P., 2004. Renewable energy policy in the UK 1990-2003. *Energy Policy*, 32, pp.1935-47.

National Assembly for Wales, 2008. *Renewable Energy in Wales*.

North Wiltshire District Council-NWDC, 2000. *Letter issued by the Head of Development Control*. North Wiltshire District.

Owebs, S., 1986. *Energy, Planning and Urban Form*. London: Pion.

Pennycook, K., 2008. *The illustrated Guide to Renewable Technologies*. BSRIA BG I/2008.

Peuser, F.A., Remmers, K.-H. & Schnauss, M., 2002. *Solar thermal Systems*. Berilin: Solarpraxis.

Prasas, D. & Snow, M., 2005. *Design with Solar Power: a Source Book for Building-integrated Photovoltaics (BiPV)*. Londong: Eanhscan.

Ramaswamy, S. & Sathis, G.K., 2009. *Energy, Environment and Sustainable Development*. New Delhi: Regal Publication.

Renewable UK, 2010. *Onshore Wind*. [Online] Available at: http://www.bwea.com/onshore/index.html [Accessed May 2011].

Renewable UK, 2011. *RENEWABLEUK CYMRU MANIFESTO: Policy actions for wind, wave and tidal England and Wales.*

Roberts, S. & Guareinto, N., 2009. *Building Integrated Photovoltaics: A Handbook*. Germany: Birkhauser Verlag AG.

Severn Estuary Partnership, 2009. *Shoreline Management Plan Flyer*. [Online] Available at: http://www.severnestuary.net/secg/docs/Summary%20SMP2%202%20Page_final.pdf [Accessed 25 May 2011].

STA, 2011. *Solar heating (hot water)*. [Online] Available at: http://www.solar-trade.org.uk/solarHeating/solarHeating.cfm [Accessed May 2011].

The Economist, 2011. *Climate change in black and white*. [Online] Available at: http://www.economist.com/ [Accessed 17th Feb 2011].

the World Commission of Environment and Development, 1987. *Our Common Future*.

References & Bibliography

Trilemma UK, University of Cambrideg and REDPOINT, 2008. *Implementation of EU 2020 Renewable Target in the UK Electricity Sector: Renewable Support Schemes*.

Upreti, B. & Horst, D.v.d., 2002. *Public perception on biomass energy in the UK: results from 7ve case studies in England and Wales. A CES Working paper: Centre for Environmental Strategy*. Guildford: University of Surrey.

Welsh Assembly Government, 2008. *Renewable Energy Route Map for Wales: consultation on way forward to a leaner, greener and cleaner Wales*.

Welsh Assembly Government, 2010. *A Low Carbon Revolution: The Welsh Assembly Government Energy Policy Statement*.

Welsh Assembly Government, 2011. *Planning policy Wales*.

Welsh Assembly Government, 2011. *Practice Guideline: Planning Implications of Renewable and Low Carbon Energy*.

Western Development Commission, 2008. *Biomass CHP Market Potential in the Western Regional:an assessment*.

Williams, E.D., 2007. *Sustainable Design: Ecology, Architecture and Planning*. New Jersey: John Wiley & Sons.

World Business Concil for Sustainable Development, 2009. *Facts & Trends to* 2050: Energy & climate change.

BBC, 2010, Scottish Power increases gas and electricity prices; [online] available at http://www.bbc.co.uk/news/uk-scotland-11798209 [accessed 2nd June, 2011]

DECC, March 2011, QUARTERLY ENERGY PRICES; [online] available at http://www.decc.gov.uk/assets/decc/Statistics/publications/prices/1492-qepmar11.pdf[accessed 2nd June, 2011]

Alternative Energy Systems (UK) Ltd., 2010, Alternative energy UK; [online] available at http://www.altenergyuk.com/domestic-gas-and-electricity-price-increases.asp [accessed 2nd June, 2011]

United Kingdom Solar Radiation Map; [online] available at http://mappery.com/United-Kingdom-Solar-Radiation-Map [accessed 2nd June, 2011]

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