Cynulliad Cenedlaethol Cymru Pwyllgor Amgylchedd a Chynaliadwyedd	National Assembly for Wales Environment and Sustainability Committee
Dyfodol Ynni Craffach i Gymru?	A Smarter Energy Future for Wales?
Ymateb gan Yr athro Gareth Wyn Jones (Saesneg yn unig)	Response from Professor Gareth Wyn Jones
SEFW 20	SEFW 20

Cynulliad Cenedlaethol Cymru National Assembly for Wales

Economic and Social Policy and Energy

1. **Summary:**

    1.1. Affordable, flexible, portable, reliable energy supplies have been at the heart of western and global economic development and Wales' historic contribution to it. Similarly, affordable, flexible and reliable, **"low carbon"** energy must be central to Wales' economic rejuvenation.

    1.2. This short paper makes the case for maximising the exploitation of our small scale [i.e. below 50MW and within Welsh Government (WG) competence], dispersed, renewable energy resources through a large number of community, local or individual schemes so as to promote local work creation, maximise local profits and multipliers and increase Wales' resilience to future energy price increases and global shocks.

    1.3. Wales' small-scale energy resources could amount to at least 5TWh of electricity and 10 TWh of heat. These will need to be supported and complemented by large scale, conventional, 'commercial' schemes, which should also, dominantly, if possible exclusively, be exploiting renewable resources e.g. tidal flow, tidal polders and off shore wind. But the former have a significant developmental and social potential.

    1.4. The total renewable energy potential of Wales and adjacent inshore waters has not been formally assessed. In 1.8 below I list possible sources. There is an urgent need to add quantitative estimates of the physical potential of each followed by a cost benefit analysis. It is not clear what proportion of the 2011 annual demand of 98 TWh in all categories of energy [space heating, transport, industry, home etc.], of which I7 TWh is electricity, can be met from renewable sources and or/ be saved by better management.

    [NB. There was a substantial decline in total energy demand between 2006 and 2011 from ~126 TWh to ~98TWh. Due in part to the economic depression)

    1.4.1. Within this 'demand' there remains significant room for energy saving by better management, improved spacial planning, improved space insulation etc. and technological innovations. A >20% increase energy-use efficiency should be possible.

    1.4.2. But in the case of electricity, this will be off-set by **increased** demand due to the increased electrification of transport (cars and trains) and the use of air and ground source heat pumps for space heat.

    1.4.3. These technologies while increase electricity use *per se* offer major saving in the total energy use budget [see Mackay, Without-the-hot-air: e.g.[a] EV cars 15-20 kWh per 100km cf. 70 - 100 kWh per 100 km for standard petrol car; [b] ground source heat pumps are <5 times as energy efficient as direct use of an electric fire].

1.4.4. The % of energy as electricity will increase even if the total energy chain is reduced and decarbonised and a target demand of 25 to 30TWh of electricity, much of which could be supplied form renewable sources by 2030, seems not unreasonable.

1.4.5. A massive annual increase in demand from energy-dependent economic growth would of course undermine these figures (a 2% annual growth doubles demand in 35 years).

1.4.6. Logically, the decoupling of economic activity/growth and wellbeing from incremental increases in energy use must be a major strategic WG objective. Cf. Denmark

1.4.7. These data do not include embedded energy and GHGs in imported goods, freight from outside Wales and air flights etc.

1.5. Wales' household energy use in 2006 amounted to ~27 TWh per annum approximately 20TWh used for space heating (85% gas and some oil) and 6.3TWh of electricity. By a strategic combination of local energy generation, improved energy use efficiency and management and heat pumps, this may well be satisfied from renewable locally-controlled sources.

1.6. A strategy based on realising the economic advantages of energy saving combined with local, dispersed, energy generation is advocated so as to change both the public perceptions and the local economic returns. Anecdotal evidence suggests that household renewable energy generation has a powerful influence on efficient energy use at a household level. The general public are largely unaware of the size and complexity of the issues, tend to NIMBYism and perhaps can only become aware if the problems are personalised i.e. how would you and your community meet your own energy demands?

1.7. This document is based on semi-quantitative estimates. A major recommendation is for WG to undertake a comprehensive analysis that would include an analysis of the costs and the economic returns, jobs created and retained, energy generated and saved, carbon saved and its value under various credible scenarios.

1.8. Sources of renewable energy which require assessment include: Wind - terrestrial and off-shore; Water – micro and meso hydro electricity [river flow and small dams], hydro electric potential of exiting dams and of pressure reduction values in water grid; Sun - solar photovoltaic, direct solar heating; Biomass – wood fuel, other biomass source including clippings; Sea/tidal - tidal lagoons, tidal flow turbines, wave energy; Wastes - anaerobic digestion of wastes [animal slurry and manure and human food wastes, methane from ruminants; Geothermal – hot rocks; Ground source heat pump; Air – air source heat pumps; Waste incineration.

1.9. In Section 8 a number of WG interventions are proposed which could immediately move this strategy forward at little or no cost.

2. **Rationale**

2.1. The costs of hydro-carbon fuels are projected to rise. The International Energy Agency (IEA), World Energy Outlook 2012 forecasts that global energy demand will grow by over a third in the period to 2035: the main increase in demand will be in China, India and the Middle East. This will be mirrored in prices. In the UK, central estimates of crude oil prices are projected to rise by 18% by 2030. The US/Canada shale gas and oil is contributing significantly to the market although it is unlikely that it will be replicated in Wales, UK or Europe for geological, social and political reasons [see New Scientist, 10th Aug 2013]. However there are doubts whether the extravagant claims made for cheap unconventional hydrocarbon sources in North America will be realised, but nonetheless, the expansion of these gas resources is influencing energy costs in the USA and already leading to diversion of some coal from US to Europe for power generation. Even so, in the US coal use is more than keeping pace with gas. While gas produces less CO_2 per kWh of energy, a number of studies suggest that 'fracked gas' will reduce net CO_2e emission little.

2.2. Wales has a high proportion of poor households; people on long-term sickness benefit, unemployed or in low wage employment. Fuel poverty is a significant issue for many Welsh families living in poorly heated and inadequately ventilated homes. In 2008 some 1/3 of million homes in Wales were recorded as in fuel poverty. Many Welsh communities, consequently, are very vulnerable to medium and long-term increases in energy prices as well as to annual and short-term price fluctuations. WG Energy Statistics show that average gas consumption per consumer was 13,600kWh, and average electricity consumption per household was 3,850kWh in 2011. (Equiv. Ofgen numbers- 16,500 and 3,500 kWh respectively.)

2.3. Wales has high % of over 65s living on small pensions vulnerable to cold and less likely to have access to private transport.

2.4. In dispersed rural communities, general energy costs are very significant. The 2008 Living in Wales Poverty survey estimated that around a fifth of households depend on a main heating fuel other than gas; these will be dominantly rural. Many 'off-the-gas network' households rely on fuel oil and/or coal or some wood for heating. Heating oil prices rose by 22% in 2011 compared with 2010, showing the vulnerability of these households to high and variable home heating costs and also transportation costs. Associated loneliness, depression and ill health are significant problems.

The related excess mortality is estimated to be over 1,000 annually *in Wales.*

2.5. Wales has an aged housing stock with a large % of dwellings with energy inefficient, solid brick or stonewalls. In the characteristically wet climate of western Wales (most of the Objective 1 region), cavity wall insulation is not recommended and consequently more innovative but expensive insulation measures are required. These physical factors increase fuel bills, make energy saving more difficult and foster ill health.

2.6. The total energy cost to Wales is in £billions. Based on the average consumptions figures above, Welsh households spend on average ~£1,300 per annum on energy, with space heating typically the heaviest item. With 1.3 million households [2011 census], this implies a cost of ~£1.7 billion, in this sector alone. The total energy cost must be of the order of £8 -10 Billion.

2.7. Climate change, caused mainly by CO_2 emissions from hydrocarbon combustion, poses a major threat to all countries and communities, but especially to poor ones. As recognised by the CIA as well as the UN, it is a threat to the existing, globalised socio-economic order as well as creating specific threats to global food and water supplies and costs and to communities due to extreme weather events e.g. flooding as well as general social unrest and forced migration.

2.8. Major increases in the exploitation on hydro-carbon fossil fuels are incompatible with avoiding catastrophic climate change. The broad issue of anthropogenic climate change has been widely discussed and will not be pursued in the paper.

2.9. The need for affordable, low-carbon energy is driven by geo-physical reality as well as national economic and social concerns. It is reflected the WG, UK and EU policies to cut total greenhouse gas emissions by 80% by 2050. But WG implementation has been sluggish.

2.10. However the existing market place protects the interests of the large energy companies better than those of small consumers. There is an obvious danger that poor Welsh communities will be faced with ever increasing costs imposed by companies over which they and WG have no control.

3. Wales' Current Energy Mix

3.1. Wales has a complex and changing energy-demand profile, comprising electrical energy (~20 %), space heating, fuel for transportation and fuels for a variety of industrial requirements. These are currently supplied by coal, natural gas and nuclear fission with a small contribution from renewable sources. These profiles are analysed in more detail in Annex 1, which also includes the energy flow diagrams produced for WG in 2006/7.

3.2 Welsh Government Statistical Bulletin on Energy Generation and Consumption, 2011 gives a more recent but less detailed picture. Prior to 2008, electricity production was about 35TWh but dropped to 27.3TWh in 2011. Renewable electricity generation has increased from 1.37TWh in 2007 to 2.16TWh in 2011. Gas is the main fuel for electricity generation (10.7TWh in 2011), with coal and nuclear making significant contributions – around 5-6TWh.

3.3 Wales' total energy consumption is 98TWh in 2010, composed of 1.7TWh from coal, 8.96TWh from manufactured fuels, 42.8TWh from petroleum products, 26.5TWh from gas, 15.8TWh from electricity and 2.1TWh from bioenergy and waste. Industry and commerce is the largest consumer sector (47TWh), the domestic sector consumes 27TWh, and the transport sector consumes 23TWh.

3.4 The ways in which electricity is consumed and generated are important in considering at low carbon renewable sources. Of the 27.3TWh generated in 2011, the main destinations of the electricity were

- 4.27TWh was used in generation and for pumped storage,
- 3.65TWh was exported to England
- 1.47TWh was lost in transmission and distribution.
- 17.91TWh was consumed (cf. 2010 consumption figure of 15.8TWh in Para 3.3)
- 2.16TWh was generated by renewables, comprising 1.45TWh from wind, wave and solar, 0.44TWh from thermal mainly, and 0.27TWh from hydro.

3.5 No single energy source will support each of the energy demands, although it is noteworthy that Scotland generated 13.79TWh from renewables – mainly hydro and wind/solar/wave in 2011 (DECC DUKES 2012). A similar position in Wales would mean that we would be well on our way to meeting our electricity consumption from renewable sources.

3.6 The situation is made more complex by the need to **match electricity generation and consumption instantaneously**, not just on an annual basis. Apart from tidal and biomass sources, renewable energy sources are not predictable, and therefore requires some back-up either from storage systems, such as pumped storage schemes, or rapidly activated energy systems such as gas [CO_2 producing spinning reserve]. Consequently the nature, cost and reliability of the each energy source and its relation to the relevant demand must be considered. If Wales can develop a mix of low-carbon, low-cost energy sources to meet demands, it will go a very long way to ensuring a successful sustainable economy into the future and would address many of the social and environmental issues noted in para. 2.1 to 2.10. Some renewable sources are likely to have complementary generation profiles and, as discussed a length by Mackay [Without the Hot Air], a number of options exist and can be developed to regulate and even out both supply and demand. Electricity demand is already variable on a daily and annual basis. This demand profile is well characterised and managed but is not geared to the supply profile of renewables.

3.7 The conventional approach to **electricity** generation and distribution has been, from the days of the CEGB, to build a small number of large generating units, connected by the High Voltage grid from which radiate out the supply, at successively lower voltages, to the myriad customers. This approach means individual and communities are tied into the large companies and, despite the political doctrine of 'choice', have in practice very limited options. The centralised system also leads to annual distribution and transmission losses which were are about 1.45TWh in Wales in 2011.

3.8 The centralised approach is relatively easily managed, favours the large energy companies **but**, equally important, distances people from the reality of the economic and environmental issues we face - – whilst ensuring that they bear the costs. For example, it is reported that, at proposed Hinckley C Nuclear Power station, EDF are seeking a 35 year post start-up agreement at ~£90 per MWh, compared with current wholesale price of £45 per MWh, in order to recoup their investment, reported as £14billion [The Times]. The cost of the Severn Barrage is/was reported at £25B to produce 16.5 TWh annually and would [have] require[d] similar guarantees to raise the required investment. This approach will not encourage individuals, households and small companies to engage directly with their energy supply nor with energy saving, other than by imposed energy poverty.

3.9 Similarly, gas and oil supplied for space heating, transport etc. are controlled by a small number of international companies. Formal Welsh Government responsibility is limited in this area and to energy from installed capacity sources of 50MW and below. It has little leverage in some areas but the alternative approach outlined here would align with its current authority.

4. The Dispersed, Renewable Source Approach

This can be seen as complementary to the standard centralised model, but until continuity of supply can be ensured, cannot replace it.

4.1. The approach is predicated on exploiting the range of renewable energy sources within Wales and its adjacent seas **and** promoting their local and/or community ownership. The various resources are exemplified below [4.5]. Their development would create **many thousands** of small schemes dispersed throughout Wales [e.g. from 3kW roof PVs installations to >50MW hydro or wind schemes], owned locally by individuals and/or communities. Their installation would favour small local contractors. They would have short lead-in times compared with the macro schemes such as Wylfa B and would disperse economic activity throughout the country and promote social inclusion. In conjunction with our HE/research sector, the policy should lead to the development of new exportable, low-carbon, small scales technologies, suitable for the developing world.

4.2. Such a policy has significant implications for both National Grid and even more, for the local networks, run by the two 'Welsh DNOs' and WG involvement with these bodies. This is expanded upon below under **Section 7 Issues**.

4.3. The evidence clearly shows that energy saving through better energy management, use of low energy goods and greatly improved insulation etc. is the most effective way of achieving the economic, social and environmental objectives of WG. However the evidence also suggests that improved awareness and important psychological changes, whereby energy is seen as a social/community responsibility, are enhanced by local dispersed generation i.e. a potential win-win.

4.4. A dispersed, communal strategy could buffer the people, especially the vulnerable, from rising energy costs as they would be part-owners of the asset and/or recipient of favourable local tariffs.

4.5. There is a range of potential dispersed renewable energy sources that can supply electricity, heat and small volumes of gas. As noted, electricity demand will reflect **both** decreased demand due improved efficiency and demand management **and** increased demand from electrification of transport e.g. electric cars and use of ground and air source heat pumps.

4.6 Current Welsh electricity demand is ~ 17TWh per annum. To a first approximation, a saving of 20 to 30 % would partly off-set any increased demand due to adoptions of electric vehicles. [See Examples 6. – for the massive decreases achieved by National Trust Wales]. N.B. electrically propelled vehicles require less than a quarter as much energy per unit distance as petrol/diesel vehicles [see Mackay].

4.7 A range of renewable energy sources is available, should be deployed and **must** be part of comprehensive strategy. **Heat sources** include fuel wood, other biomass, direct solar, ground and air source heat pumps (which requires electricity and are only valuable in well insulated homes), biogas from anaerobic digesters, potentially renewable electricity in tandem with excellent insulation, CHP, H_2 from renewable sources. **Electricity sources** include wind, PVs, small and medium hydro, hydro from existing dams, tidal flow, tidal polders, tidal barrages, wave energy.

5. Crucial questions:

- How much of the required, low-carbon, renewable energy can come from dispersed sources within Wales and how much must be produced by large commercial initiatives or imported? [see Mackay "Without the hot air" for detailed analysis at UK level and potential European-wide solutions]. A primary need is to define what is technically possible, and what might be acceptable to society – as MacKay has done.
- How can the economic and social advantages of energy efficiency be realised widely?
- What will be the scale of capital investments required and how can they be realised? How much work will be created? What are the estimated local multipliers?
- What will be the returns on that investment?
- What are the significant blockages to realising this potential?

It is not possible to answer the above questions definitively but below, examples are enumerated which suggest that the potential is sufficiently large to make a material difference to the Welsh economy, and that they could improve local resilience, help achieve climate change emissions targets and address the triple bottom lines of sustainable development. Copies of correspondence with WG are appended as Annex 2.

6. Examples:

There will be a need to prioritise the resources in terms of reliability of supply, and costs/access to technology. Clearly PV and on-shore wind are already the relatively cost-effective with a declining need for subsidy. The same is true for home grown wood biomass for heating. Imported biomass for electricity production is much suspect. Anaerobic and waste incineration and small scale hydro can give good returns on investment. Off-shore wind has a large capital outlay but a large potential. Wave and tidal polders and flow are at a proof of concept stage but the latter are very attractive as they are predicable and Wales enjoys high and rapid tides. Whilst not discussed in any detail in this paper energy saving must be a major priority.

6.1. Currently Wales has some 23,000 home PV installations [WWF Jan. 2013] and a few large PV farms. The distribution is patchy and does not correspond to the light/irradiance potential, which is highest near the coast and, fortuitously, closely follows Wales' population distribution pattern. A modest national installation target of 150,000 [~10% of households], (small 3 to 4 kW roof units at a 10% load factor} would produce 3,000 x 150,000 = 450GWh of electricity. With some large installation on the west coast and the new materials e.g. from Corus/Tata Steel, clothing industrial and farm sheds, a putative target of 1TWh annually by 2025 seems feasible. Currently PVs cost ~£1,500 per installed kW down to £1,000 for large schemes producing ~900 kWh per kW annual production with life expectancy of over 20 years. In USA PV electricity is reported to be down to ~50 cents per installed W and is claimed to be cheaper than gas and wind.

6.2. WG policy is for Wales' woodlands to increase to 400,000ha by 2040. This forest of mixed hardwood and conifers should produce a sustainable annual increment of ~ 1Mtonne which, when dry, would produce 3.7 TWh (based on 60% to 30% reduction of moisture content on drying and energy content of 4.6MWh per dried tonne) of direct heat on burning as well as income employment and additional cash if carbon is fully priced.

6.3. National Trust in Wales has achieved cost effective, energy saving of over 40% in its pre 2012 property portfolio.

6.4. The hydro-electric scheme at Hafod y Llan has 640 kW capacity and will generate ~ 1.5 GWh. The scheme is costing £1.8m (funded at 5% interest) and is expected to pay for itself in 7 years by producing some 1.5 GWh per year and over £1/4M per year, with low maintenance costs, assuming 12p per kWh. There is little doubt that Wales being wet and hilly could support perhaps 50 to 100 schemes in the range 500 to 1000kW and several hundred micro hydro schemes of 20 to 50 kW. The potential is of the order of 0.5 TWh. See also Green Valleys Initiative.

6.5 ETSU [2009] reported a potential of 27 to 63 MW in meso hydro electrical schemes in upland Wales – equiv. at 50% load factor t0 ~0.25 TWh.

6.6. Estimates are required on generation potential of exiting dams

6.7. Anaerobic digestion/farm biogas.

6.8. Community Wind Power See Neil Lewis Menter Cwm Gwendraeth

6.9. Solar heating [Mackay 1.3 kWh per m^2 - 2.5 m^2 would provide an average house with most of it hot water]

6.10. Ground and air source heat pumps [some water heat sources e.g Plas Newydd on Menai]

6.11. Large scale projects with lower but not negligible community potential

6.12. Tidal flow

6.13. Tidal lagoons. The proposed tidal lagoon in Swansea Bay is forecast to produce a reliable electricity output of 0.4TWh annually. Successful exploitation could lead to a larger scheme at Colwyn on the North Wales coast. The financial model is based on community investment and local benefits which include low electricity tariffs.

6.14. Off shore wind. Mackay suggests that for shallow off-shore, the UK area is 40,000km^2 with power output of 120GW. Ten per cent of this operating at 40% load factor would produce 42TWh annually but creates strong public reaction

6.15. Wave??

6.16. Other??

As an individual I do not have the resources or capacity to undertake a full survey of resources — it is vital that detail work is undertaken immediately.

7. Issues:

7.1. There is no comprehensive survey of Wales' physical renewable energy potential.
7.2. No clear strategic priority integrating matters of importance [a] work creation, [b] energy poverty etc. [c] carbon reduction targets [d] urban and rural generation has been developed.
7.3. DNO connection/ fees, additional pylons/ transformers/ links to National Grid. Smart control systems for control of local and national electricity systems will be essential
7.4. Cost benefits taking into account energy saving/engagement/ dispersal of assets and wealth/ psychology.
7.5. Intermittence - energy storage must be addressed.
7.6. Backup by conventional energy sources

8. Immediate no/low cost Interventions.

Aspects the Welsh Government should address now

8.1 Planning system still is still a piecemeal. Individual planning officers not trained in renewables and interpreting policy which results in long time periods and uncertain outcomes from authority to authority. Advise for developers specifically ecological, aesthetic and archaeological is often contradictory (plenty of examples)

8.2 One size fits all approach in development process inadequate. This approach is having a disproportionally and high economic impact on micro and peco sector. An area where there is a current small expansion in Wales with small manufacturers and developers but the statutory process for a £40k hydro is exactly the same as a £1.4m scheme. Wales have the potential to be market leaders but are held back in our own country (much easier in Scotland on sub 50kw)

8.3. Using existing legislation such as the 'licence lite' mechanism Wales could break new ground in energy trading between small generators and communities / fuel poor individuals. It needs a whole country approach to add value to the energy we generate and retain more of the benefit at a user level. The National Trust are currently working with others to develop a 'Sleeving' mechanism to do just this. But there is so much more opportunity in Wales

8.4. The changes in NRW are having a very immediate and negative impact on renewable energy sector in across Wales. W G need to address this quickly in terms of clarifying roles and responsibilities, ensuring greater clarification on economic development role for the new body and establishing a quality management process in NRW service delivery

8.5. The Electricity Grid in Wales is very patchy in terms of capacity and quality. The WG has a n important role to play in assisting where it can with levers such as RDP resources to target capacity issues blocking renewable energy generation in large areas of Wales. WG has a role to play with the two District Network Operators who are developing multiple billion pound local grid overhauls. Value could be added in considering local generation in the roll-out plans. A more immediate role for Welsh Government is to engage with the DNO's to improve quality of service to developers. This includes timely responses and work. Consistent advise and costs across the two DNO's. Encourage the DNO's to have a more active role in realising the economic potential in local renewable energy generation

8.6 The WG role in education and training of renewable energy is to be applauded. This is laying the foundation for the development of renewable energy generation. But if the patchy and sometimes contradictory approaches highlighted above continue, Wales will not be a good place to grow companies, manufacturing and sustainable energy

Summary of potential, costs and impacts

Annex 1

An array of data suggest that perhaps up to 30% of electricity and other energy sources could be saved by better management and insulation.

A useful format for addressing the issues is to consider major 4 areas:
[1] Electricity – generation, distribution and use
[2] Space heating - household, office and commercial
[3] Transport – cars, buses, trains.
[4] Industrial demand.

In each of these sectors increasing energy use efficiency and minimising current waste and future increase in demand by good design and regulation must be prioritised. A 30% saving is equivalent to ~30TWh, equivalent to the outputs of four Wylfa A or four Aberthaw power stations. For comparison the projected Hinckley C nuclear power station is anticipated to have a 3.2 GW capacity at a cost of >£14billion, and produce at a load factor of say 80%.

[1] <u>Electricity</u> - Current use of ~17TWh can be reduced by better efficiency [minus 20% = 3.4TWh] but electricity usage will increase because of the electrification of transport and space heating by ground and air source heat pumps. (Electric cars use some 15kWh per 100km compared with an average conventional car using 68kWh per 100km; see Mackay). Therefore 100% electrified cars should reduce energy demand by x 4, although at a significant capital cost. Based on an estimate that cars use about 2/3rd of the transport energy, then the energy for the car sector would reduce transport sector energy

of 23TWh by perhaps 11TWh. Taking into account, crudely, these changes then it can be suggested that electrical supply should rise by about 4TWh for cars to about 21TWh. The demand impact of heat pumps etc. is factored into earlier estimates.

(Note that an installed capacity of 1GW would, with a 100% load factor, produce 8.7TWh per year so equal to an installed capacity of > 3 to maybe 10 GW depending on the ave. 70% load factor =. *Not sure what the point is here.*

[2] Space heating – if it is assumed that 37kWh/day is required for all heating (see Mackay p 53), with 3 million population we use 40.5TWh annually. Insulation should decrease requirement by 30% [-12TWh]. Better insulation opens the way for efficient heat pumps. As discussed below, other options include local community-based heat schemes and wood fuel and renewable gas from anaerobic digesters. A rough and conservative estimate suggests that 400,000ha of woodland as is WG policy by 2030 should produce sustainably 1million cu. meters per year of timber which, dried, would equate to 3.7TWh. All new build should be near carbon zero.

[3] Transport – Current use about 23TWh in 2010. As indicated above for electricity use for cars, energy use could be reduced by 11TWh by [a] a 20 year programme to bring EVs and H_2 vehicle and engines, the latter generated by renewable energy. Even with grid electricity for charging electric cars, the effective emissions are about 100 g CO_2/km, and with decarbonisation of electricity generation, the emissions would be even less. [b] This should be combined with a clear Spatial Plan to reduce commuting, encouragement for children to walk or cycle to school, and increased use of video link/ teleconferencing and more local supply chains etc.

[4] Industrial demand – Current (2010) use is recorded as 47TWh. There are fiscal pressures to reduce energy costs but this remains a very difficult area. Refinery energy use would drop with decarbonisation of energy. It seem likely that carbon capture as currently being piloted in Norway will be essential for some major industrial processes such as refineries and steel works

Re-energising Wales

- In 25 years the World and Wales must re-configure and re-engineer its energy supplies to a zero carbon format.

- There are no simple or cheap solutions; every possible energy source has its own advantages and disadvantages.

- However, as Wales has substantial and varied *per capita* on- and off-shore renewable energy resources, this global challenge offers us the potential to re-energise our economy, much as coal energised Victorian Wales when "Coal was King", Cardiff its Queen and Rhondda its workhorse!

- WG figures show we use, internally, ~100 TWh of energy annually in all forms of which only about 20% is as electricity: these figures does not including embedded energy in our imports, most travel and much food etc. Assuming an average of 10p per KWh this equates to an annual outlay of £1Obillion. (TWh = 10^{12} or a million-million Watt hours)

- Our use of energy is profligate (equivalent to 4 one-bar electric fires burning continuously day in day out to sustain for each of us).

- The major priority must be to increase energy use efficiency and reduce our total national energy use to ~60-65 TWh a year without increasing imported embedded energy!

- This requires much better space insulation (stronger new build regs. and retro-fitting to existing building including ~1.2m homes), rapid move to x3 more energy-efficient electric vehicles (EVs), adoption of ground- and air-source heat pumps in well-insulated buildings, adoption of energy efficient lighting and other goods, integrated, efficient, electrified, or possibly H_2 fuel-cell based, public transport and railways e.g. Cardiff-Valleys Metro, encourage walking and cycling especially to school, much improved spacial planning to minimise commuting etc.

- Several EU countries have ambitious energy saving targets; so should Wales.
- Of the ~60-65 TWh of energy required in 2035 a large proportion, perhaps up to 40TWh, will be as electricity and the remainder mainly heat.

- The basic question is therefore reframed as:- **over 20 years can Wales pursue a economically viable strategy for a ~35% decrease in energy use and the generation of ~40 TWh of zero-carbon renewable energy and ~20TWh of heat energy?** (NB. The food chain will use up all our residual carbon/Green House Gas allowance).

- The available data suggest strongly the answer is **yes** and consequently there is no compelling case for massive public investment in high-risk nuclear electricity and/or fracking etc.

- In this forum it is not possible to consider the options in any detail. M**y main recommendation, which I hope will be endorsed and pursued by this conference, is that the IWA should urgently seek the resources to set up a small task force of independent experts covering all the relevant physical, technical, engineering, economic and social aspects to assess the potential and come up with a detailed, costed, timed plan.**

- Since the renewal resources are varied, dispersed and locality-dependent, they offer great scope for community and personal enterprises throughout Wales that will yield local economic gains.

- Thousands of dispersed generating units also require the development of smart, local, nested grids and re-assessment of the approach of and to the DNOs. In Germany there is a move to the municipalisation of the local grids. This should be explored.

- While some of the renewable energy resource e.g. the large marine tidal lagoons demand on large infrastructure projects, there is merit in developing thousands of small schemes throughout Wales i.e. an emphasis on dispersed community and individual generation. This required a reappraisal of planning obstruction and guidance cf. Scotland. Local energy schemes offer the prospect of long term fiscal flows into communities and catalysing local enterprises as well as job creation.

- The approach is very different to the classical "CEGB model" of centralised generation, dispersal, control and ownership which means a decadal transfer of profits abroad and bleeds resources from communities. The dispersed model also implies a shift in the relationship between people and energy and much greater individual and local responsibility.

- In summary: the re-energising strategy has four components: [a] an integrated effort to save energy and lower energy demand, which will also improving life styles, and health etc.,

[b] the promotion of renewable energy resources, especially but exclusively, dispersed locally-owned generation,

[c] local, nested smart grids and

[d] development of electricity storage capacity in batteries, pump storage and maybe, in time as hydrogen storage for fuel cells.

- This 20-year strategy is potentially transformative for Wales, economically, socially and environmentally, and will create a large number of jobs in urban and rural areas and a much more resilient, self-reliant and dynamic society for the low carbon age.

- Through personal engagement, hopefully people must be encouraged to be more aware of the options open to them, if catastrophic social and environmental changes are to be avoided, and that constructive solutions are available.

- Just as the City of London and south-east England exploit their comparative advantages of financial muscle, political power and geographic location, we in Wales must leverage our own comparative advantages. One of these is our range of renewable energy resources.

Appendix: Sources of renewable energy etc:

A. Electricity:

Wind: Off shore wind turbines
Terrestrial wind turbines
Solar: Photo-voltaics
Biomass: (Undesirable as it's much more efficient to burn directly for heat -conversion to electricity incurs >60% loss)
Hydro electricity: Small sale hydro
Retrofit existing large reservoirs
Small new reservoirs
Pump storage – no net gain but to store surpluses
Marine: Tidal lagoons - depend on tidal rise and fall
Tidal flow - essential water mills
Wave energy?
Geothermal: [improbable in Wales]

B. Heat:
Biomass; sustainable local wood
Ground, air and water source heat pumps: use electricity by 3 fold increase in efficiency.
Methane from AD plants:
Solar heating: mainly water

C. Electricity storage

Pump storage as in Dinorwig and Ffestiniog
Local battery storage.
Use of the batteries of Electric vehicles (EV's) as storage systems.