A global energy assessment – in the wake of the latest UN Sustainable Development Goals

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UN new Sustainable Development Goal No. 7:
ENSURE ACCESS TO AFFORDABLE, RELIABLE, SUSTAINABLE and MODERN ENERGY FOR ALL

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services.

7.2 By 2030, increase substantially the shar of renewable energy in the global energy mix.

7.3 By 2030, double the global rate of improvement in energy efficiency.

7. a By 2030, enhance international cooperation to facilitate access to clean energy research & technology, including renewable energy, energy efficiency and advanced and cleaner fossil fuel technology, and promote investment in energy infrastructure & clean energy technology.

7. b By 2030, expand infrastructure and upgrade technology for supplying modern & sustainable energy services for all in developing countries, in particular least developed countries & small island developing States.

Other new UN SD goals relevant to energy supply & use:

1. By 2030, eradicate extreme poverty for all people everywhere ….Ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.
2. By 2030, end hunger and ensure access by all people … to safe, nutritious and sufficient food all year round … equal access to land … double agricultural productivity and income of small-scale farmers … implement agricultural practices that help maintain ecosystems … progressively improve land and soil quality … ensure proper functioning of food commodity markets in order to help limit extreme food price volatility.
8. Endeavour to decouple economic growth from environmental degradation.
11. Make cities & human settlements inclusive, safe, resilient, & sustainable … by 2030, ensure access for all to affordable housing & enhance inclusive & sustainable urbanization …

12 – 14: By 2030 achieve sustainable consumption & production patterns; take action to combat climate change & its impacts; conserve & sustainably use the oceans, seas & marine resources for sustainable development.

The promotion of worthy but unrealistic goals within the timeframes indicated, and perhaps even longer-term.

- The first serious reference to the significance of energy came in the Brundtland Commission's Report : "The period ahead must be regarded as transitional from an era in which energy has been used in an unsustainable manner…" (1987).
- The nearest the 1992 Rio Earth Summit got was in Chapter 9: "Protection of the Atmosphere": "Energy is essential to economic and social development and improved quality of life. Much of the world's energy, however, is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to increase substantially."
- The word "energy" did not appear at all in the Millennium Declaration of 2000.
- The UNDP/World Energy Council 508-page "World Energy Assessment", 2000, was largely ignored amidst conflict between UNDESA and UNDP.
- The Rio+20 Report of June, 2012, made some amends although social, poverty and gender issues were again dominant. In a document stretching to 126 pages, energy was allocated one page, and climatic change rather less. The critical role that energy plays in the development process was recognized, as access to sustainable modern energy services contributes to poverty eradication, saves lives, improves health & helps provide for basic human needs. Committed to facilitate support for access to these services by 1.4 billion people worldwide who are currently without them.

Barriers to achievement of sustainable development goals and most specific energy-related targets:

1. Population growth, where it is most likely to occur, pressures for movement, and risks of conflict. Risks of potential catastrophes – man-made or natural.
2. Numbers of people currently without access to modern energy services, and challenges to meeting the needs of 1.2 billion more people by 2030, 2.5 billion more people by 2050, and 4 billion more people by 2100 – to a total of over 11.2 billion (UN: "World Population Prospects: The 2015 Revision").
3. The World's current heavy reliance on fossil fuels – for primary energy supply, electricity generation, and transportation – and associated risks.
4. Concerns about availability of conventional oil resources & recent E&P cutbacks.
5. The slow growth of the contribution of 'modern' renewable resource availability.
6. The particular challenges for wind energy and solar – intermittency, current lack of storage, need for back-up, scarce material (9 listed by US DOE 2011) requirements.
7. The profound challenges for 'modern' biomass and biofuels.
8. The likely limits on CCS (Carbon Capture and Storage).
9. Political uncertainties over some CSP (Concentrated Solar Power) locations.
10. Fundamental constraints on 'modern' renewable energy – relatively low power densities, and EROIs (Energy Return on Energy Invested).
11. Fears concerning nuclear power – though it emits little CO2 & post-Fukushima counter-intuitive panic has had some strange results (e.g. in Germany).
12. Limitations on energy efficiency – the 'rebound' effect or Jevons 'paradox'.

HUMAN POPULATION ISSUES

- The UN median population projection is for world population to grow from 7.35 billion in 2015 to 8.5 billion in 2030, 9.275 billion in 2050, & 11.2 billion in 2100.
- Of the 1.2 billion increase between 2015 & 2030, 500 million is expected to occur in Africa (to bring the total there to 1.68 billion), 530 million in Asia (to a total of just over 4.9 billion), Europe's population is projected to decline before 2030, Latin America & North America to increase 90 million & 40 million, respectively.
- By 2050 Africa's population is projected to have increased by 1.3 billion, & Asia's by 900 million from 2015 levels.
- By 2100 Africa's population is projected to be 3.2.billion above 2015 levels, Asia's up 500 million, Latin America up 90 million, North America up 140 million, & Oceania up 30 million.
- Most of the population growth is projected to occur in areas where already there live 2.8 billion people reliant on traditional forms of biomass for cooking, and 1.4 billion are without electricity.

IMPLICATIONS & SOME BROADER ISSUES

1. Pressures to leave most poverty-stricken, unstable, undemocratic and corrupt areas: "The history of human existence could almost be written around the history of population movement." ["Living in One World", World Energy Council).
2. The turbulence caused by Sunni/Shia rivalries and Daesh.
3. Challenges to US hegemony from China and a "renascent" Soviet Union – but how well are the BRICs faring?
4. Pressures on natural resources – food, potable water, minerals, metals, ecosystems.
5. Threats to more comfortable lifestyles, challenges of those who seek higher material standard of living, and the "paradoxes" which exist. General diet, health and lifestyle issues: is a large-scale shift to 'Voluntary Simplicity' feasible?
6. Rapidly rising urban populations – now 55% of the World's population is urbanised, and this is projected to rise to 66% by 2050 and to 80% by 2100 – with challenges for infrastructure, access to food and water, and many other supplies.
7. Concentrated populations may expose more people to pandemics, epidemics, and natural catastrophes.
8. Important urban/rural links may become fractured.
9. Prospects for climatic change, the potential consequences if significant warming occurs: the need for sound 'precautionary' measures & investments in the face of complexity and uncertainty.

LACK OF ACCESS TO MODERN ENERGY SERVICES

Of the 2.8 billion people currently reliant on traditional biomass for cooking:

- **750 million are in sub-Saharan Africa.**
- **1.95 billion in Asia – of which under 400 million are in China, over 850 million are in India, and nearly 700 million elsewhere in Asia.**
- **85 million are in Latin America.**

Of the 1.4 billion people who are currently without access to electricity:

- **nearly 600 million are in sub-Saharan Africa.**
- **800 million in Asia – of which 400 million are in India, and nearly 400 million elsewhere in Asia, but only 10 million are estimated to be in China.**

Thus: nearly 75% of sub-Saharan Africa's population reliant on traditional biomass for cooking are rural dwellers; nearly 90% of India's; and nearly 85% of the rest of Asia's (excluding China).

For those without access to electricity, rural dwellers account for 80% in sub-Saharan Africa; 94% in India; and nearly 85% elsewhere in Asia (excluding China).

It has been estimated that it would cost US$700 billion (at 2009 prices) between 2010 and 2030 simply to maintain the 2.8 billion figure of those reliant on traditional biomass for cooking, and to reduce by 200 million those without access to electricity. Of the 1.2 billion still without electricity in 2030 54% would be in sub-Saharan Africa.

The World continues to rely heavily on fossil fuels:

1. Around 80% of the world's current primary energy supply comes from fossil fuels.
2. Some 90% of the World's transportation is fuelled by oil products.
3. Coal accounts for about 29% of the World's total primary energy supply.
4. Oil accounts for about 31% of the World's total primary energy supply.
5. Natural gas accounts for about 21% of the World's total primary energy supply.
6. The IEA in 2014 estimated that total annual World subsidies to the fossil fuels, at the latest count, were US$ 548 billion, of which $120 billion went to the electricity sector.
7. Nuclear now provides under 5% of the World's total primary energy supply, a figure which has steadily fallen in recent years.
8. Traditional biomass still provides about 8% of the World's primary energy supply.
9. All 'new' renewables provide under 4% of total World primary energy supplies. However, hydro - although its contribution to primary energy supplies is trivial – can provide around 16% of the World's electricity supplies (though varying).
10. Realistic assessments are required, e.g.: Denmark claimed that wind provided about 40% of its electricity in 2014, yet only 5% of its energy production comes from wind & coal still accounts for more electricity than wind. [WWI & IEA]

Questions raised about the availability of fossil fuel resources

- Exploitable coal resources are currently plentiful, but concerns about carbon and methane emissions are a strong impediment, although China greatly increased its coal usage over the past 15 years, and India intends to continue to do so.
- Although CCS (Carbon Capture & Storage) is believed in some quarters to offer a lifeline to continued fossil fuel usage, and storage in depleted oil and gas wells, etc., appears feasible, yet severe warnings have gone out about the potential and ecological risks of CO2 storage in the deep ocean. [IPCC Special Report, 2005]
- Manipulation of "proved" conventional oil reserves figures by several OPEC-member States since 1984, and inclusion of Venezuelan heavy and Canadian tar sands, mean that actual proved conventional oil reserves are likely to be about half those stated in standard publications. Although the 'peak oil' hypothesis is currently off the front pages, it is likely to re-emerge.
- Recent oil and gas E&P cutbacks are also likely to have medium term impact.
- US shale gas and oil fracking has provided a short/medium-term lifeline, and helped to reduce oil prices, most US formations have shown early declines.
- Energy supply security concerns (due to deliberate disruptions, lack of gas storage, premature closure of coal & gas plants, high costs of bringing on new generation capacity, power cuts, "luck" runs out) persist.

CHALLENGES FOR 'NEW' RENEWABLE ENERGY

- Starting from a low position in terms of % contribution to energy supplies – natural gas also exhibited slower entry than coal or oil before it.
- The intermittency of wind and solar – and waste of resources where poorly located.
- The need for back-up from traditional sources of supply.
- The need for large-scale storage, and fast – even pumped storage has been slow to take off.
- Wind and solar energy equipment rely on some rare earth metals.
- 'Modern' biomass and biofuels pose a severe threat to food and water availability and food prices (the US bid for biofuel expansion is widely blamed for the food price riots in 47 countries and the "Arab Spring"), on ecosystems and natural habitats and species (e.g. the exploitation of Indonesian palm oil for burning in electricity generating plants; slippage of burning of US wood wastes to tree felling).
- Threats to birds coming from wind energy, estuarine barrages, and some CSP (Concentrated Solar Power) plants, and threats to some other species – bats, seals, and some fish.
- Political uncertainties – such as in North Africa, where under the DESERTEC proposal many CSP plants had been envisaged.
- Visual intrusion and sleep/health impacts of aerodynamic modulation from wind turbines – concerns which vary from country to country.

SOME UNLIKELY CLAIMS

- Renewable energy can supply 100% of the world's energy needs by 2030 – 2050 – etc. (Jackson & Delucchi, WWF, and others).
- The UK's Renewable Energy Obligation "is not a subsidy". (Chairman of UK wind energy industry association).
- Citing of UK wind energy operators' capacity factors achieved by their developments is "bizarre pseudo-science" and "absolute nonsense" (CEO of UK wind energy industry association).
- The UK is the windiest country in Europe (no, Scotland probably is, England and Wales are definitely not).
- UK wind energy developments typically achieve a capacity factor of 30% (DECC, Office of the Prime Minister). Misleading – onshore annual average 2010-15 26%.
- Denmark produces 39% of its energy from wind (no, that figure for electricity only, is for the occasional very windy month), their wind energy provides about 5% of their energy, coal still

  accounts for more electricity generation than wind, surplus wind generation has to be exported to Norway, Sweden, Germany (can be 140% of requirements) often at a loss.
- Despite being informed that the burning of palm oil (developer's preferred feedstock) in proposed electricity generators is environmentally hostile (exploitation of Indonesian palm oil on average emits 33 tons of CO_2 for every 1 ton of palm oil produced, destroys tropical forest and habitats – e.g. of the orangutan – before transport overseas) UK Planning Inspectors have dismissed such concerns & declared palm oil "a renewable source of energy".

SOME UNCOMFORTABLE FACTS

1. In the UK wind energy capacity figures achieved in recent quarters have been as low as 14% and 17%. With offshore wind energy capacity figures mostly about 20 percentage points higher than those onshore we need to know onshore data in much finer detail – DECC are "thinking about it."
2. Even in relatively windy Scotland there have been recent quarters when onshore wind energy capacity figures have been as low as 16%, 18%, and 19%.
3. There have been recent months when UK wind energy output was less than 10% of capacity for up to 138 hours, and less than 5% for up to 71.5 hours.
4. The UK wind energy industry claimed that 10% of UK electricity would come from wind energy by 2010. The actual figure has risen from 3.05% in 2011 to 7.2% in 2014.
5. In March, 2013, Siemens published a study which concluded: "The crux lies in the choice of location. If installations were built at the sites in Europe that offer the highest power yields, some EUR 45 billion of investment in renewables could be saved by 2030."
6. Wind energy provided 8.6% of Germany's electricity in 2014, solar 5.5% (after EUR 60 billion of subsidies over the years). Electricity prices in Germany and Denmark in 2014 were double those of Sweden & Italy, four times those of the USA, France, Austria, and the UK.

SOME INPUT FROM THE USA

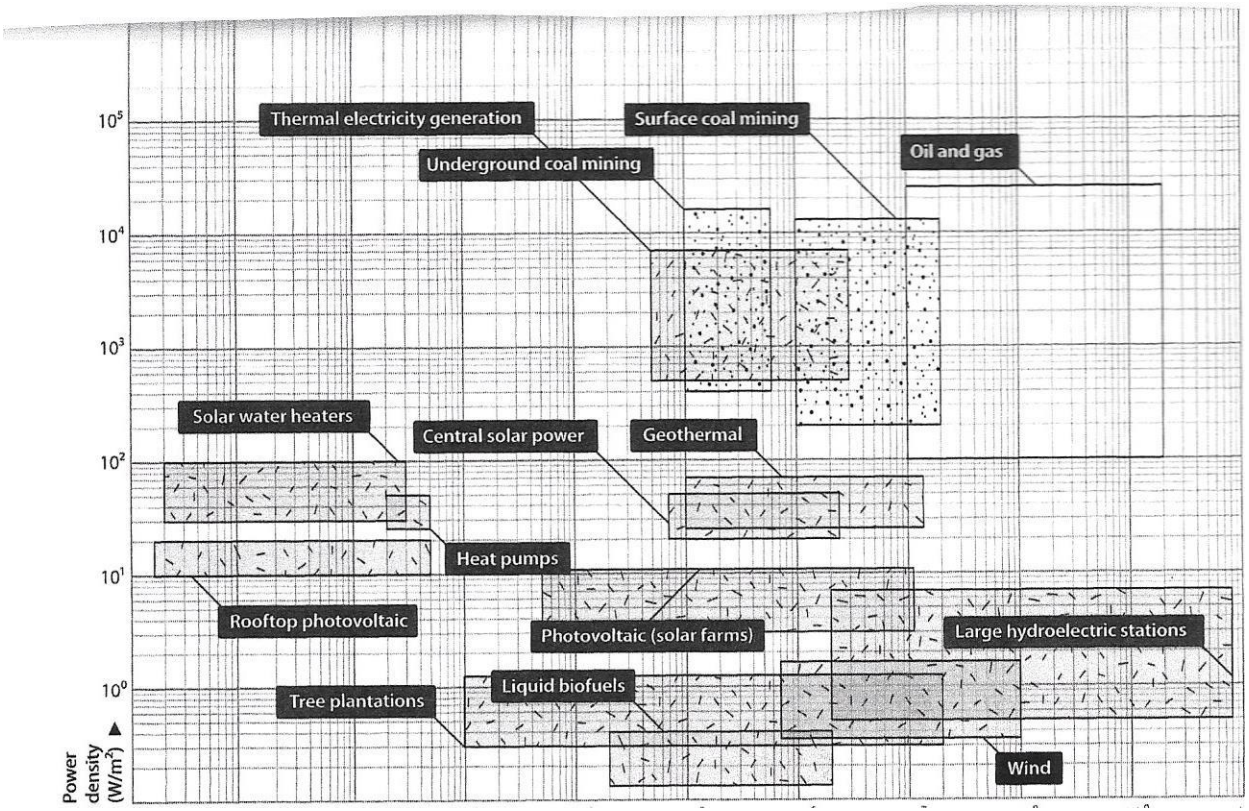
- Wind turbines originally designed for lower wind speed sites have rapidly gained market share. Why? Because, apart from N.W. Texas the overwhelming majority of wind energy developments have taken place outside the relatively windy Interior. Therefore: "The build-out of wind power projects in lower-quality wind resource areas is a key reason why overall average capacity factors have not increased for projects installed in recent years." (Wiser & Bolinger, LBNL, 2015). [It's called the 'Pickenham effect' in UK.] Whereas in the USA the Interior band from Montana & North Dakota to Colorado is the windiest, Germany's inner Lander are the least windy and produce the lowest capacity factors.
- Rooftop solar PV remains uncompetitive without subsidies in the lower 48 States, only in Hawaii can it produce electricity at a levelised cost equivalent to the retail electricity rate. (Shelly Hagerman, et al., Carnegie Mellon).
- The drive for biofuels in the USA caused 37% of the US corn harvest (13% of global production) in 2014 to be used for ethanol. Biodiesel production has required about 50% from soybean oil (15% of the US harvest). These forces have increased world food prices substantially – by in excess of 20%. The FAO attributed much of the cause of the 40% rise in food prices in 2007 and further rises in 2008 to US biofuels policy. The policy was also blamed for food price riots in up to 47 countries, and the "Arab Spring". (Int'l Food Policy Research Inst. etc.)

TWO FUNDAMENTAL CONCEPTS:

There are two fundamental concepts lying behind the provision and use of energy services:

1. **Power density – density is a concept important to populations, land (sometimes space) use, provisions, services and energy. For energy the concept is energy flux per unit of the Earth's surface expressed in Watts per square metre. As will be seen in the next slide coal, oil, gas and thermal electricity generation have higher power densities than biomass/biofuels, wind, solar PV and most hydro schemes. For more detail see: Vaclav Smil: "Power Density: A Key to Understanding Energy Sources and Uses", 2015. MIT Press. (The next two slides are copied from this book).**
2. **EROI (Energy Return on Energy Invested) – a concept as old as when human beings existed by hunting and foraging, and of increasing importance as the Industrial Revolution led to coal, then oil, gas, and 'new' renewables exploitation. Once again, with nuclear at the top, followed by hydro, coal and CCGT these have higher EROIs than CSP, wind, biomass, or solar PV. EROI buffered takes account of estimated storage requirements. [See D. Weissbach et al., *Energy* 2013, 52, 210-221; C. Hall et al., *Energy Policy* 2014, 64, 141-152; M. Jefferson, *Energy Policy* 2015, 804-811.]**

Both concepts serve to underline the challenges facing human society and renewable energy.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Central solar power
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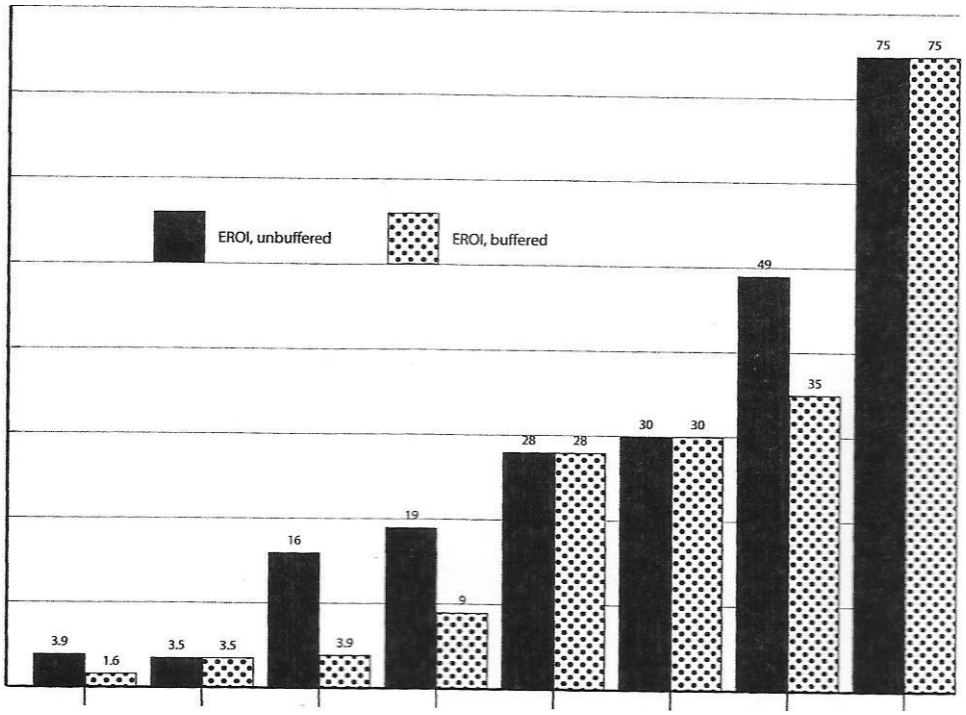
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TWO REMAINING CONCERNS COVERED HERE:

- **Human-induced near surface climatic change has been high on many international, national and personal agendas for the past 30 years. Given all the complexities and uncertainties surrounding this subject, it is disappointing how polarised the debate has become, how often information has been manipulated or ignored to mislead or exaggerate, and how often vested interests have climbed on bandwagons to pursue their own agendas. Given the complexities and uncertainties, the rational way forward is by sound policies, measures, and investments to mitigate and/or adapt to concerns and evidence. In doing so, the importance of natural variation, from solar variation downwards, should be taken fully into account. It should be noted that the latest IPCC Assessment found that, of 114 climate models they considered relevant, 111 showed a greater warming trend than observations, and that there was medium confidence the changes that had taken place were due to natural internal climate variability.**
- **With the expansion of the human population, the stresses on ecosystems, food and potable water availability, and energy supply and services, much will depend on whether lifestyles, diets, health and co-operation will shift dramatically. It is 80 years since Richard Gregg wrote about "The Value of Voluntary Simplicity" and 40 years since the Stanford Research Institute went about promoting it. Will it – given human nature, can it – ever happen? Is the Jevons' "paradox" somehow going to wither away?**

“Those who foretell the future lie, even when they tell the truth.”
An old proverb much quoted in Shell’s scenario team in the 1970s.

“All thoughtful men agree that the present aspect of society is portentous of great changes. The only question is whether they will be for the better or the worse. Those who believe in man’s essential nobleness lean to the former view, those who believe in his essential baseness to the latter.”

Edward Bellamy: “Looking Backward”, 1887.

Thank you for listening. On the UN Sustainable Development Goals, for a start, I’m a Pessimist!