Institute of Physics

Energy Management Group

Summer Newsletter

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Energy Management Group Newsletter

Contents

1. Introduction

Welcome to the summer edition of the Energy Management Group's newsletter. If you have any comments, please contact the editor of this edition, Peter Gill (gill.pf@virgin.net) As always we would like to encourage contributions to the next newsletter from our group members. The deadline for the autumn edition contributions is end of August and should be sent to the editor Terri Jackson (jacksont@utvinternet.com).

If you would prefer to receive most future Energy Management Group newsletters in electronic form please e-mail Yasmin Andrew (yasmin.andrew@jet.uk). Please note that the Group is required to send at least one Newsletter per year to each Member in hard copy.

2. Bursaries

Subject to the availability of funds, Energy Management Group members can apply for bursaries of up to £250 to contribute towards the cost of attending energy related seminars or conferences including EMG events. To apply for a bursary please contact Yasmin Andrew (yasmin.andrew@jet.uk), detailing the event you wish to attend, costs for which you are seeking support and reason for application (e.g. priority may be given to those not in employment or for whom travel costs are a particular obstacle for certain events).

3. Energy Management Group Events Summer 2006

Thursday 1st June – Severn Tidal Barrage - is the Tide Turning?
Evening lecture by David Kerr, Chief Design Engineer, Sir Robert McAlpine Engineering Company.
Further information is available at http://groups.iop.org/EG/02/10/021005a_e.html
As this lecture predates the distribution of this Newsletter post event reviews or comments may be posted on the web site or included in the next newsletter.

Tuesday 13th June – Practical Options for a Nuclear Renaissance.
Joint all day meeting with IChemE organised by EMG to be held at IOP HQ. This meeting will address the practical and technical options available to us for nuclear new build and facilities for continuing a nuclear power programme. We are looking at the entire life-cycle: from mining to decommissioning and waste disposal. We are making a modest charge for Members of £25 but this includes all refreshments including lunch. The full programme and online registration details are available on the following web page: http://conferences.iop.org/nucren/.

Date to be decided – An EMG Visit to BedZED Low-energy, Live-work Development (www.bedzed.org.uk).
The visit is being arranged by Alan Morton (alan.morton@nesta.org). He will shortly be circulating details by e-mail of this rearranged event.

Date to be decided – The Future of Fossil Fuels. This all day meeting is being arranged by your Committee to be held at IOP HQ on the same day as our AGM. If you would like to suggest possible speakers for this event please contact a Committee Member (a list appears at the end of this Newsletter)

4. Other forthcoming Energy Events

23rd World Gas Conference, June 5-9, Amsterdam, Netherlands www.eurocongres.com

Caspian Oil & Gas Azerbaijan, June 6-9, Baku, Azerbaijan
www.ite-exhibitions.com

Fuel, Emissions and the Environment – Sustaining the Future, 7 June. Contact the Society of Operations Engineers Tel: +44 (0) 20 7630 1111

International Gas Distribution and Utilisation Expo & Conference - IGE 2006, June 27-30, Kuala Lumpur, Malaysia.
www.ambexpo.com

Fuel Cells, 29 June at the Energy Institute. Contact London and Home Counties Branch Chair Gopal Srinivasan Tel: +44 (0) 1372 752353
E-mail: gopal.srinivasan@atkinsglobal.com

5. Energy News Items

The following news extracts were provided by Terri Jackson (jacksont@utvinternet.com)

Australian Uranium Bonanza

China has just signed an agreement to buy thousands of tonnes of uranium ore from Australia reported to be worth £40 billion! This will be used to power the 28 new nuclear reactors China hopes to have operating by 2020. India will have 24 new nuclear reactors built in the coming decade. China has not signed the non-proliferation treaty. The Australian government has said that China has undertaken only to use the uranium for nuclear power. Dozens of small uranium prospectors in anticipation of the nuclear revival have recently floated on the Australian stock market. Their share prices have soared. Two of the worlds largest uranium mining companies the Australian BHP Billiton which owns the vast Olympic dam mine in South Australia with the worlds largest untapped reserves, and Rio Tinto the British company which through its subsidiary Energy Resources Australia is Australia`s largest exporter of uranium. (report Sunday Times 23 April 2006).

New company headed by former Shell chairman to exploit new source of power. North sea gas geo-pressure.

A new company CO2 is working with national grid to exploit the North sea gas pressure to generate electricity. The technology is based on the high pressure that natural gas has when it emerges from the North Sea. This pressure is then usually released before the gas is pumped round the country. The new company 20C chaired by Lord Oxburgh the former Shell chairman would use the pressure that is wasted to drive turbines and generate electricity, electricity that would have no CO2 pollution.

Alberta Oil Sands Conference

A breakthrough energy technology was announced at the hydrogen conference in Alberta Canada earlier this year. On 13 February Syngas International revealed a new technique for refining oil sands into oil using hydrogen enrichment. Shell Oil Canada was among the many top oil companies present for this advance in petroleum technology. It takes two tonnes of oil sands to create one barrel of oil and each barrel of oil needs 3 to 4 kilograms of hydrogen to refine it to synthetic light crude suitable for refineries**.** Alberta contain the largest known reserves of oil sands in the world.

Russian Siberian oil & gas reserves being tapped by Shell at Sakhalin Island.

Shell are building two 800km pipelines with an estimated investment of £12billion. When finished this shell sakhalin development will deliver 150 000 barrels of oil a day and 9.6million tonnes of LNG a year or 7.5% of currenr LNG global demand a year. Shell and its minority partners Japanese Mitsui and Mitsubishi have rights to 4 billion barrels of the islands 45 billion oil and gas reserves in the block known as sakhalin 11. It is Shells biggest single project and the largest direct foreign investment in Russia. Exports should start in 2008. (Tracy Boles Sunday Times 12 March 2006.) Add to this the development of the Canadain oil sands in Alberta, mentioned above, and the arguments of the prophets of doom that predict the world is running out of oil begin to look a bit thin.

6. Report on EMG's Events

Nuclear Power - the energy balance?
Monday 9th March 2006

Jan Willem Storm van Leeuwen gave a talk on the costs, constraints on uranium supply and technological shortcomings for implementation of nuclear power. He referred to results from life cycle analyses (LCA) that give insights into fundamentals of the uranium fuel cycle. Van Leeuwen claimed to use only data produced by the nuclear industry itself. He demonstrated that for uranium ore concentrations below a certain level the overall energy balance is adverse i.e. more (probably fossil fuel derived) energy is required to beneficiate, concentrate, transport, fabricate, construct, dispose of waste etc. than is produced during nuclear reactor life. This of course must be true at some ore concentration level. However the concentration levels at which this occurs has been the subject of some controversy. In the first piece below by our ex-Chair, Terri Jackson challenges van Leeuwen's conclusions. This is followed by a summary by Simon Roberts of three rebuttal articles submitted to us later by van Leeuwen. To consider the matter yourselves please note that a transcript of the lecture is available on our website (http://groups.iop.org/EG/)

Should anyone wish to have copies of the three articles provide by van Leeuwen in full please let me know and I will e-mail them to you. Ed.

Letter from Terri Jackson (jacksont@utvinternet.com)

Dear Editor,

Contrary to the opinion given by Storm van Leeuwen at the recent meeting of the Energy Management Group that there is only enough uranium left to fuel the current generation of nuclear reactors the figures from the OECD and the UN International atomic energy agency show that in 2001 the sources of known economically recoverable uranium amounted to 3,107,000 tonnes. This is an accumulation of all the resources from all the uranium producing countries including Australia, Canada, Kazakhstan and South Africa. Given that the current rate of use of uranium is about 70 000 tonnes per year(figures from the WNA) and allowing for some reprocessing that means that currently known resources are enough to last for about 45 years even when used in conventional reactors with no breeding. This is a higher level of assured resources than for most minerals and even without breeding would easily be enough to fuel another generation of nuclear reactors. The same sources put highly probable deposits of uranium as around 12 million tonnes. The Inspector at the Hinkley point inquiry Michael Barnes QC concluded there is plenty of uranium to fuel a nuclear power programme for many years to come. An energy analysis by the Swedish state power board Vattenfall based on their Forsmark nuclear station over a projected 40 year lifetime has found that the energy input to the Forsmark plant is only 1.35% of the lifetime output! (nuclear issues).

Even with higher uranium prices the price of uranium generated electricity would only increase marginally as fuel cost only contributes about 18% to the price of nuclear electricity compared to 60% for gas fired electricity. France which is nearly all nuclear has the cheapest electricity in Europe. Plutonium and uranium are recovered by reprocessing at Sellafield and La hague and the uranium recovered joins new uranium in fuel fabrication and the plutonium can be used to a limited degree in MOX fuel in existing reactors. Also the breeder programme will increase the productive use of uranium by 60 fold. In addition enriched weapons

grade uranium is now availanble from the decommissioning of nuclear warheads and will become increasingly available as existing nuclear warheads are decommissioned. the equivalent of more than 9000 nuclear warheads have altready been converted to fuel for nuclear reactors. Russia has already sent 22 tonnes of weapons grade uranium to the US for downblending. (nuclear issues). Regarding the use of lower grade ores Dr van Leeuwen omits to mention that the energy intensity of uranium is 20000 times that of coal so even if there is a doubling in the energy use in extraction and reprocessing it will have little impact on CO2 emissions for the whole of the nuclear cycle. Dr van Leeuwen's position simply does not stand up to scrutiny.

Simon Robert's Precis of response articles provided by Storm van Leeuwen (simon.roberts@arup.com) (storm@ceedata.nl; www.stormsmith.nl)

Van Leeuwen's provide three articles addressing some of the points raised by Terri Jackson. More details can be found on the EMG web site together with a transcript of the talk itself.

Vattenfall AB, a Swedish utility, has published an EPD (Environmental Product Declaration) which is often quoted. However this EPD is not a full energy analysis, as confirmed by Birgit Bodlund of Vattenfall, but is made to comply with certain Swedish regulations. For instance, the EPD report states that some data on processes needed to fabricate nuclear fuel from uranium is missing. Also, figures of some processes not yet in existence (e.g. deep repository) are not included.

What is called a 'breeder' is not just a reactor type or a stand-alone system but a complex cycle. Its comprises three components: the breeder reactor, a reprocessing plant and a fuel fabrication plant (see talk transcript for more details). All three have to operate flawlessly and continuously and have to be fine-tuned to each other. If one component fails, the whole breeding system fails.

In fact, none of the three components have ever demonstrated operation as required, let alone the three components together as one integrated continuously operating system. Fifty years of intensive research in seven countries (USA, UK, France, Germany, the former Soviet Union, Japan and India), with investments of tens, if not hundreds of billions, of dollars, so far have failed to demonstrate that the breeder cycle is technically feasible. Only the Russian reactor is operating, but it never bred, and it has a history of large and serious accidents.

Regarding future costs of uranium fuel, consideration of the energy costs of extraction gives greater insight than monetary costs in today's climate. The principal use of uranium is ultimately to deliver energy. More precisely, the energy costs of all processes within the nuclear industry must first be subtracted so that it is net energy provided to the rest of the economy. Storm showed data in his talk that as grades of uranium ore decline, energy (from fossil sources) needed to extract each tonne of "yellow cake" uranium oxide increases, a well known concept to chemists. Below grades of 0.01%, the energy for extraction becomes so high that it dominates over all other processes driving the net energy to zero. There may be vast quantities of uranium in rocks but when the grade is too low, its pointless to extract for energy generation.

7.1 Contributed Articles

Observations on the UKERC Report on 'The Costs and Impacts of Intermittency'

By *Professor Michael Laughton, FREng*. (michael.laughton1@btinternet.com)

Editor's note: *See also by the same author "Power Supply Security with Intermittent Sources – Conventional Plant Capacity Requirements" Platts Power in Europe Issue 480 10 Oct. 2005.*

Commenting on the UKERC Report,, Energy Minister Malcolm Wicks said: *"Our target is to have 10% of the UK's electricity produced from renewable sources by 2010 and a significant proportion of that will come from wind power. Suggestions that it is excessively expensive, or that traditional power stations are needed to back-up the energy produced by all our wind farms, are just two of the myths that have been peddled by their opponents. The UK Energy Research Centre's study demonstrates that these claims have been exaggerated. I welcome the report's contribution to the debate."*

The problem is that according to studies by the National Grid and others traditional power stations will be needed for reliable electricity supply with sufficient capacity to meet peak power demand much as at present, so unfortunately the Minister's reference to the absence of need of conventional plant to back up wind energy has lead to some misunderstanding.

With or without wind generation in the electricity system, security of power supply is governed by the probability of the available plant being able to meet power demand at all times, especially at or near peak periods. Wind generation on its own cannot provide a reliable supply of power. When backed up if necessary by appropriate levels of reserve plant, however, it can provide an annual energy supply within desired levels of probability. The latter result is the essential conclusion of the UKERC Report and in previous studies listed. Unfortunately ensuring the reliability of annual energy supplies and ensuring the reliability of daily power supplies are two very different problems. They are often confused as being the same problem by those not in the field; thus the Report is in danger of being misinterpreted and so misreported.

By way of illustration, if 25,000 MW (25GW) of wind capacity were to be added to the electricity supply system only 5GW of conventional plant capacity could be retired. This result is contained in extensive studies made by the National Grid, ILEX Consultants and others. The relatively small capacity credit of wind generation in Britain is governed by existing security of supply standards (loss of load probability, or LOLP levels), where in general the capacity credit is of the of the order of the square root of the GW of wind installed.

With a 30% annual load factor this 25GW of wind capacity would generate annually the same energy on average as 7.5GW of conventional thermal plant capacity. If 7.5GW of conventional plant were to be closed as a result of this loss of market, however, then an additional 2.5GW of reserve capacity would have to be added back into the system in order to maintain power supply security standards (LOLP) by ensuring that only a net amount of 5GW of dispatchable capacity were removed. It is the cost of this extra reserve plant plus extra annual balancing costs

that are quoted as the additional costs arising from the intermittency, or variability, of wind. These are small relatively, or even zero, depending on the wind annual load factor and penetration of the market.

Other additional costs from transmission reinforcement and additional distribution costs are omitted. From the ILEX Report to the DTI in 2002 on *"Quantifying the System Costs of Additional Renewables in 2020"* (the SCAR Report) these costs for a 20% penetration of wind are seen to add a further 50% to the total. A further omission is the extra cost of the impact of the cycling wind power output on the operation and eventual replacement of the other retained conventional stations. If open cycle gas turbines (OCGT) were to replace some combined cycle gas turbine plant, the extra operating and reserve plant costs per OCGT MWh generated would then be pushed up towards those quoted in the Royal Academy of Engineering report of 2004 on *"The cost of generating electricity"*, which were partly based on such considerations. These matters, however, were considered to be outside of the remit of the UKERC Report.

Editor's Note: *I was told of a programme aired on Channel 4 that I had missed. James Harrison, ex President of the Energy Institute was kind enough to put me in touch with David White who has provided two inputs. The first is a report on the Channel 4 programme and the second a report on the paper submitted by EDF to the Energy Review.*

EDF Announcements on Nuclear Energy

By David White (IChemE) (enconsult@blueyonder.co.uk)

On Channel 4 News Thursday night (13th May 2006), there was a 7 minute slot devoted to EDF's submission today on the Energy Review. They are proposing 10 new advanced design nuclear plants at no cost to the UK tax payer. Their assessment is that other energy costs have rise to make nuclear the least cost option.

The report was accessible as a replay on channel 4.com News. It caught the Sustainable Energy Commission off guard and their only response was that we have to see the outcome of the review. The reporter picked up the point about the backlog of nuclear waste and its processing cost. Fortunately, Malcolm Wicks accepts that existing wastes are a totally separate issue from the much smaller level of waste that would emerge from a new nuclear programme.

It will be interesting to see whether the government will find comfort in EDF's offer.

I also noted that neither the BBC nor the Telegraph picked up the EDF statement but over the weekend, they have played up the Tim Yeo report on the Environmental Committee report advocating gas fired stations and revisited the Sustainability Commission report to say nuclear was not necessary.

I attended a meeting of the Parliamentary Group for Energy Studies to hear EDF presenting a summary of their submission to the DTI for the Energy Review. The full text of the EDF submission runs to 110 pages and I imagine it will be on the DTI website shortly.

I made a quick follow-up phone call to EDF in order to try to reconcile the submission with the EDF's proposal made on TV. The presentation made no

mention of an offer to build but simply a case for energy diversity with replacement of existing as a minimum in any energy policy. I discovered that the Energy Review submission was prepared by EDF Energy based in London while the offer made on TV was introduced by the CEO of the parent company - EDF France who own and operate the nuclear technology.

Parliamentary Group for Energy Studies – 19 April 2006

Speaker – Vincent de Rivaz – Chief Executive – EDF Energy

The theme of the presentation was "Can the market deliver nuclear as part of a diverse energy mix?"

The paper addressed the UK and was based on EDF's submission to the Energy Review which had been published the previous week. (I have a hard copy of their submission from the meeting but is should be on the DTI website). He believes the UK has a unique opportunity to shape energy policy and reduce CO_2 emissions through the broadest possible portfolio of inputs. Their estimate is that if nothing is done in the immediate future, the UK could face a shortfall of 34GW of generating capacity by 2015. A gap will develop between demand and supply if decisions are not taken quickly because of the impact of the LCP Directive on the coal stations and the decommissioning of nuclear.

The gap must be filled but what type of technology can provide it while reducing CO_2 but with security assured via diversified sources? Coal with CO_2 capture and storage would be a priority for the power sector because of the availability and need to use coal globally. Renewables will have a role but it is imperative to have a realistic view of what can be achieved in the time frame and the intermittency of some sources. EDF sees the sea e.g. tidal flow as a more secure resource than wind and in their written submission, they explain why they envisage a limit of 15% max of renewables in the UK.

They see no alternative to nuclear if carbon reduction is to take place. The UK needs to replace existing as a minimum and their analysis of CO_2 emissions from a nuclear system is just 22 gm/kWh versus 385 gm/kWh for gas and over 800 for coal. They emphasised that new nuclear is cost competitive, reliable and with minimum waste volume. New technology produces just 10% of the early designs. Waste is now manageable most probably in deep underground stores. They believe they can be built quickly. A state-of-the-art plant can now be physically built in 54 months and even allowing 5 years for permitting and licences, some plant could be built before 2015 if a swift decision were to emerge from the Energy Review. The reinforced the need to use a single design and repeat than try to build a series of one-of-a-kind as the UK did first time round.

There is clearly a need to carry the public with any such decision but their 40 years of experience and an excellent track record on safety gives them confidence that this could be achieved.

In his closing remarks, Mr de Rivas stressed than no forms of technology should be excluded at this stage. All were necessary in their own way and that micro-generation would play a part as well. Nevertheless, if UK industry is to remain viable, electricity prices must remain competitive by European standards and

absorbing high cost renewables could damage industrial users. He pleaded for a level playing field and stated the need for a value to be placed on carbon to justify the investment in cost effective technologies. The European Carbon Trading Scheme could be a suitable mechanism if used properly and guaranteed for many years. However, at present he sees it a means for siphoning money out of the UK to Accession Countries to buy their credits from industrial closures.

EDF has a London Office in Grosvenor Place, Victoria. I spoke to their Director of Communications briefly and will cross-check the Channel 4 Report. They did not say at the PGES meeting that they had made an offer to build 10 GW of nuclear for us but hinted that they were only to willing to cooperate with the UK government to help fill the 2015 capacity gap.

Hubbert's 1956 paper, Nuclear Energy and Fossil Fuels

By John Busby (johnbusbyltd@hotmail.com)

Fossil fuels production

Hubbert was a geologist working for Shell when he noticed that the rate of oil production from an individual well tended to follow a 'bell' shape curve. Following the well's initiation, there was a growth in production to a peak, followed by a decline. He argued that the aggregate of the production from past, present and future wells would mean that the overall indigenous US oil production would follow a similar curve to that of an individual well. In 1956, Hubbert predicted that the lower-48 states US oil production would peak in 1970 and then decline. This has since proved to have been fulfilled.

His report, **Nuclear Energy and the Fossil Fuels**, can be downloaded from

http://www.hubbertpeak.com/hubbert/1956/1956.pdf

North Sea oil production has broadly followed a Hubbert curve with a rise followed by two successive peaks and is now in decline. The production of North Sea natural gas has passed its peak and is also in decline. The outstanding dilemma for the world is "If and when oil, gas and coal production peaks occur, will the aggregate of these mean that global fossil fuel production will follow a Hubbert curve and if so when will this peak?"

Colin Campbell's Association for the Study of Peak Oil and Gas (ASPO) calculates that regular oil is on peak, with the overall oil peak delayed to 2010 by including heavy, deepwater, polar oil and natural gas liquids. The overall oil and gas peak will take place around 2015. For access to the monthly ASPO newsletters, see http://www.peakoil.ie

Not all energy consultants accept that fossil fuel production will peak in the near future and some argue that improved technologies will allow currently uneconomic and inaccessible reserves to be exploited far into the foreseeable future. However, the major energy companies now predominantly invest in the acquisition of minor companies which have already made discoveries or in joint ventures with others having access to reserves, examples being BP with TNK for oil and Shell in Sakhalin for gas, both jointly with Russian enterprises. Exxon/Mobil claims that its production has more than been covered by additional reserves, but examination of

its annual report shows that its 'booked' oil reserves are down, the increase being in its gas reserves, based on its agreements with Qatar.

Thus the investment policies of the major energy companies - in contrast to their public pronouncements - show their lack of confidence in new discoveries. Profits resulting from high oil prices are being returned to shareholders, rather than being devoted to exploration and new field development.

As far as fossil fuels is concerned it can reasonably be expected that Hubbert has been proved right. The next ten years or so will establish if and when his predictions in the case of oil and gas will mature as airways and roads begin to empty. Does this mean that "Hubbert's peak" has universal application and will eventually apply to uranium?

Gold

See http://www.gold.org/value/markets/supply_demand/mine_production.html

The World Gold Council's plot of global annual mine production indicates that Hubbert's curve can be applied to other minerals. Gold is mined from ever decreasing ore grades, with ore grades in underground operations at 8 to 10 parts per million, while open pits tend to be employed for the lower grades of 3 to 4 parts per million. The world average production cost in 2004 was $11,000/kg.

In spite of an escalating price, gold production passed its Hubbert peak in 2001.

Open pit mining involves the use of huge excavating machinery and as the price of diesel has doubled over the ensuing year, gold production costs in 2005 must have risen considerably, continuing the downward trend.

Uranium

Metals have their own intrinsic value and oil, gas and coal provide sources for chemical manufacture as well as energy, but discounting nuclear weapons, uranium is only of use as a source of energy. So the cost of extraction has to be measured in the primary energy units consumed over the entire nuclear fuel cycle and compared with the secondary energy units obtained as electrical energy.

However a rough analysis in monetary terms is illuminating. The present cost of uranium is US$100/kg, which with the price of electricity at say £25/MWh and 0.024751 tonnes uranium burned per GWhe, the uranium cost/MWh is £1.44/MWhe, or around 6% of the electricity price. However, if the uranium had to be mined from an ore of 10 ppm at the 2004 gold production cost of $11,000/kg, it would cost 6 times the electricity price.

MIT (See http://web.mit.edu/nuclear_power/) argues that as the price of uranium rises, it becomes economic to mine the lower ores and as progressively lower ores are considered, the size of the reserves increases exponentially. Unfortunately this analysis is flawed, because the energy costs to extract the uranium from the lower ore grades also rise exponentially. As the input energy approaches and then exceeds the output energy from the overall nuclear fuel cycle, nuclear power is non-viable.

Proponents make reference to the composite price index of mineral commodities which has decreased over the last century, even as consumption increased, due to advances in technology. However, the said advances have required increasing

energy inputs and were achieved in an era of cheap and plentiful oil and corresponding low energy costs.

The demand for uranium has been met from two sources. Primary mining contributes only 60% of the demand, the deficit coming from the so-called secondary sources of ex-weapons highly enriched uranium, re-worked mine tailings and inventories. Supplies from the dwindling secondary sources have held the price down until recently, when a realisation of an impending crisis struck home. So the timing of a global uranium production peak is difficult to predict. However, the production cycles of uranium mines in Canada exhibit individual Hubbert curves. (See plots in http://www.after-oil.co.uk/nuclear.htm) From the opening of a mine, production rises rapidly, platforms and then declines. To maintain steady production a succession of new mines needs to be procured. There therefore seems no reason why global uranium production should not eventually follow a Hubbert curve, being the aggregate of the individual mine production curves.

Although Canada is the major production provider, reserves in Australia are claimed to be the largest. However, the Australian mines are characterised by low grade ores and because the diesel power needed is at the expense of net imported crude oil, there is no guarantee that the next project, the Olympic Dam expansion as an open pit, will go ahead. It is currently the subject of a feasibility study.

Hubbert and Nuclear Power

Hubbert ended his 1956 paper with an examination of “Energy from Nuclear Sources”. He saw the era of fossil fuels as “an ephemeral event in the span of recorded history” and concluded that “There is promise … that we may at last have found an energy supply adequate for our needs for at least the next few centuries of the *foreseeable future*”. (My italics)

He saw that the “objections to the sole use of U-235 are its scarcity and the large amounts of energy required to separate it from U-238”, attaching great importance to the possibility of converting U-238 and Th-232 (thorium) into fissionable materials by means of the breeder reaction. He then assumed that breeding will become the standard practice within a comparatively near future.

Hubbert considered the significance of high and low uranium ore grades and assessed the quantity of recoverable deposits in the USA. Based on this assessment he postulated that uranium supply will follow a Hubbert curve, i.e., its production will rise to a peak around now and then decline. Nuclear power would be sustained only by breeder reactors.

In 1956, Calder Hall, the world’s first nuclear power plant was commissioned. The issues considered by Hubbert in his seminal paper remain with us today. Without a commercially available breeder reactor, nuclear power has no future. Even James Lovelock sees nuclear fission only as “a medicine that keeps the lights … burning … until fusion … and renewable energy are available.” (the revenge of Gaia, p11)

A study of the uranium production statistics, shows that was Hubbert was right about a uranium production peak, but his long-term vision was thwarted by a failure to develop a breeder reactor. Lovelock’s nuclear contingency will fail because of a simple lack of supply to meet demand. The breeder reactor failed because its high

temperature operation required an impractical heat transfer system, while both breeder and fusion rely on non-existent heat-resistant materials.

Both are a diversionary waste of capital resources, needed to engender a society embracing an energy-lean lifestyle, based on around a quarter of that we consume now. In 1956 Hubbert reckoned that the entire US primary energy requirements of 12.51×10^{12} kWh (45 EJ) could be met by burning 553 tonnes of U-235 occurring in 79,000 tonnes of natural uranium. However, nuclear power provides secondary electrical energy and some U-235 is lost in the enrichment tails, so in practice around 300,000 tonnes of natural uranium would have been required to match the primary energy consumption at that time.

In 2005, the USA consumed over 22,000 tonnes of natural uranium, just for its nuclear electricity, while for all its electricity it would have required 98,000 tonnes. For its primary energy requirements of 28×10^{12} kWh (98 EJ) it would have needed 700,000 tonnes to generate the equivalent in electricity. Had it been possible in 2005 to substitute hydrogen from electrolysis and liquefaction for liquid transport fuels, a further 100,000 tonnes of uranium would have been required. In 2004, indigenous USA mining produced 835 tonnes of natural uranium, less than 4% of its demand.

Hubbert's vision of sustainable energy depended on "properly developed breeder reactors" becoming "standard practice within the comparatively near future".

Various Meetings

Editors Note: *I have attended a number of meetings that remain unreported in our Newsletter. However as we have a wealth of other contributions this time I shall simply give you references to where reports of some of these events are available on the web.*

A Nuclear Waste Management Workshop held at the Geological Society by the Royal Society of Chemistry
http://www.rsc.org/ScienceAndTechnology/Events/MaterialsNuclearWasteManagementWorkshop.asp

Energy 2100 Conference held at the DTI Conference Centre by The Royal Academy of Engineering
http://www.raeng.org.uk/policy/reports/default.htm

Energy Policy 2020+ Meeting our Energy Challenge held at Central Hall, Westminster by the Energy Institute and the Parliamentary Group for Energy Studies

www.pges.org.uk; www.energyinst.org.uk

8. Useful Energy Web-sites

This time we have broken from tradition and would like readers to submit useful energy related web-sites that they have discovered. Please provide a short write-up and give the site URL. Suggestions should be sent to Terri Jackson (jacksont@utvinternet.com) who will be editing the next (Autumn) Newsletter.

9. Group Committee and IOP HQ Contacts

This newsletter is produced by the Energy Management Group of the Institute of Physics, a professional group comprising members with interests in all aspects of energy use, energy policy, power generation and energy technologies. Further information can be obtained from the Group Committee and the IOP Science Support Officer.

We would like to welcome our new Committee Member Rebecca Holyhead.

Officers

Group Chair: Peter Gill (gill.pf@virgin.net)

Group Hon. Secretary: Yasmin Andrew (yasmin.Andrew@jet.uk)

Other Committee Members

Webmaster: Simon Roberts (simon.roberts@arup.com)

Industry & GCC committee representative: Terri Jackson (jacksont@utvinternet.com)

Education representative: Richard Bloodworth (richard.bloodworth@ntlworld.com)

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IOP HQ

Science Support Officer: Sarah Verth (sarah.verth@iop.org)

Contributions to the EMG newsletter are warmly invited from all group members. In particular if you would like your company or research institute to feature in the snapshot section, please draft a short description and send it by e-mail for inclusion.