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1. Hinkley decision “unlikely before the end of 2017”
2. Alternatives to Hinkley
3. 100% Renewables

1. Hinkley decision "unlikely before the end of 2017"

The final investment decision for Hinkley Point C (HPC) has been delayed yet again. It was supposed to happen before EDF's AGM on 12th May, but is now not expected to happen until September at the earliest. (1) Jean-Bernard Lévy, EDF's CEO, has bowed to pressure from unions and senior company engineers and agreed to seek a fresh opinion from the company's union-management consultative council. The consultation process will take several months. (2)

We learned last year that the French managers' union CFE-CGC, which has a seat on EDF's board, has voiced its concern about the significant financial issues raised by investing in Hinkley Point C and says such a huge commitment could put the very future of EDF as a company in danger. The Association of Employee Shareholders (EAS) - has asked for the project to be halted. (3) According to the Daily Mail EDF's works council has now voted to order an external study into Hinkley. The council said it was missing key information in order to prepare a recommendation about project. (4)

In March EDF's Finance Director, Thomas Piquemal, resigned. He was said to have been arguing that pursuing what would be the world's most expensive power project now could jeopardise the French group, which already has rising debts. (5) He wanted EDF to wait three years before making the final investment decision. (6)

Piquemal told the French Parliament in May that he unsuccessfully requested a three-year delay in the project in 2015 because the U.K. government loan guarantee to help finance the project would only be available after Flamanville is completed. "*Who would bet 60 to 70 per cent of his equity on a technology that has not yet proven that it can work and which takes ten years to build?*" Mr Piquemal asked

It could be argued that Piquemal has already achieved a delay of two out of the three years requested. Since, according to his evidence to the French Parliament he called for a three year delay in January 2015 when the expected completion date for HPC was still, 2023 which implies a construction start (first concrete) in 2017/18. In Oct 2015 EDF gave a completion date of 2025 and first concrete 2019.

But Senior Engineers are also reported to have called for a two year delay and a redesign of the EPR reactor. (7) And employee director, Christian Taxil, who is sponsored by the CFE-CGC trade union, has called for the project to be postponed. (8)

Sparks were flying at EDF's Annual General Meeting on 12th May as EDF employees were given a chance to air their views and grill the company's board, which remains divided on whether to go-ahead with HPC. In the run up to the meeting EDF announced that the contingency needs of HPC could increase the cost by about £3bn to £21bn. (9)

"*It's clear that EDF's top management and the French government are still backing the project*," Yves Marignac, director of WISE-Paris, an energy research group, said, "*but neither has the means to solve all of the problems and push it forward*." (10)

EDF has €37 billion of debt. Add to this the problems caused by the collapse of energy prices, which pushed earnings down 68% in 2015, and we are left with a company in a very precarious financial situation. EDF also needs to spend €50 billion upgrading its network of 58 ageing reactors by 2025. EDF requires a bailout so it is scrambling to sell €4 billion ($4.5 billion) of new shares and €10 billion of assets to strengthen its balance sheet. About the last thing that it needs is a new €15 billion millstone around its neck. But that is what it appears destined to get. France's Economy Minister Emmanuel Macron, is insisting that Hinkley will be approved in September. (11) The French government is planning to sell shares in some of the country's largest companies to pay for a €3bn aid package that will help EDF build Hinkley. Shares in Renault and Safran are likely to be sold this year, along with the airports in Nice and Lyon, in order to ensure that there will be no extra cost to taxpayers for the investments by the majority-state owned utility group. (12) This will all take time, as will a separate, €5 billion bailout of Areva, the bankrupt developer of the EPR technology, in which EDF is expected to participate by taking a 75 per cent stake. With French presidential elections due in a year's time, big decisions may become increasingly difficult to make, adding to the likelihood of further delay. "*They are likely to postpone the decision again*," says Yves Marignac. He believes that a final decision is unlikely before the end of 2017.

Now Greenpeace and Ecotricity have warned that the European commission needs to approve further planned support from the French state. A legal opinion given to Greenpeace by three competition barristers from Monckton Chambers says plans for state help from France's government to enable EDF to continue with the reactor scheme could break European competition rules. (13)

This means there is anywhere between 4 and 18 months to develop the argument for an alternative to building HPC.

It has been a very couple of months for the crisis-ridden project. The Stop Hinkley Campaign has listed some of the events and problems which arose between the beginning of March and mid-April here:

http://www.stophinkley.org/PressReleases/pr160415.pdf

These included, for instance Martin Young, an energy analyst at investment bank RBC Capital Markets, saying that for EDF to proceed with such a costly plan would be "*verging on insanity*". (14)

One of the highlights perhaps was a comment on DECC's five reasons why it is backing Hinkley Point C by independent energy consultant, Mike Parr. Writing in *Energy Post,* Parr called the list "*a mix of truth, unprovable assertions and omissions which could also be construed as lies*". The DECC statement assumes that the problem of intermittent generation plus storage will not be solved any time soon. He asks whether DECC has read the interview with Steven Holliday, CEO of National Grid, who said in September last year that "*the idea of large coal-fired or nuclear power stations to be used for baseload is outdated*" and we "*…have the intelligence available in the system to ensure power is consumed when it's there and not when it's not there.*" (15)

The Stop Hinkley Campaign also published five reasons for NOT backing the new nuclear reactors here: http://www.stophinkley.org/PressReleases/pr160317.pdf

On 19th April the Secretary of State for Energy and Climate Change, Amber Rudd, released a letter she had sent to MPs on the energy and climate change select committee. The committee had asked what contingency plans were in place if Hinkley is delayed or cancelled. She said: "*While we have every confidence the deal will go ahead, we have arrangements in place to ensure that any potential delay or cancellation to the project does not pose a risk to security of supply for the UK. I am clear that keeping the lights on is non-negotiable*." (16)

So the lights will not go out if Hinkley is cancelled. She also said that if Hinkley is delayed there could be a risk of the UK missing its targets to cut carbon emissions, and that alternatives could cost more but would not represent a "significant increase" in cost in the short term.

Yet a report from the government's National Infrastructure Commission in March found that "smart power – principally built around three innovations, interconnection, storage, and demand flexibility – could save consumers up to £8bn a year by 2030, help the UK meet its 2050 carbon targets, and secure the UK's energy supply for generations."

The Stop Hinkley Campaign pointed out that Ministers have been caught misrepresenting how close the solar industry is to being able to build subsidy-free projects (17) and refusing to extend the grace period for onshore wind farms with planning permission hit by the early closure of the Renewables Obligation (RO). (18) And yet we know that Hinkley Point C will cost around £99/MWh over 35 years at today's prices compared with £67/MWh currently being paid to newly installed onshore wind farms for only 15 years. (19) And solar with storage and flexibility would cost roughly half the cost of Hinkley Point C over its 35 year lifetime. (20)

Stop Hinkley Spokesperson Roy Pumfrey said:

"*This Government seems to make up whatever nonsense it feels like to support its nuclear ambitions.* (21) *Yet the reality is that scrapping Hinkley Point C and going for renewable power instead would save the UK tens of billions of pounds.* (22) *Now Rudd says Hinkley could be abandoned without risking power cuts. The answer is obvious – time the Government stopped depending on this failed French reactor for our electricity supplies and climate targets and got on with promoting renewables*."

Meanwhile, also on 19th April a group of EDF managers wrote to the Company's board of directors warning they could all face legal action if the company pushes ahead with Hinkley and this leads to the "destruction of the value" at the group, its directors could be held personally responsible. (23) And EDF's workers committee, which includes representatives from the biggest unions, voted to take legal action should the company fail to consult employees on Hinkley. (24)

This forced EDF to delay the final investment decision until at least September. The Board of Directors has agreed to undertake discussions with the company consultative council before taking a decision. (25)

Now plans for Hinkley have been thrown into yet more chaos, according to *The Times* (26) after the admission that engineers have falsified vital safety tests on parts supplied to reactors in France and possibly the UK. Power Magazine says France's nuclear sector has been rocked to its core. (27)

Stop Hinkley Spokesperson Roy Pumfrey said: "*What little credibility France's nuclear sector had left has now completely evaporated. Surely now an end to Hinkley Point C is inevitable. If the Government doesn't call a halt to this soon we will become the laughing stock of Europe.*"

A French state-owned factory - the Areva plant in Le Creusot, Burgundy - which has manufactured key components used in more than half of France's 58 nuclear reactors, may have falsified safety reports on some of those components. Unverified components may also have been installed by EDF at some of the 15 reactors it owns in Britain. The falsified documents have come to light because ASN ordered Areva to carry out an audit after it detected a "very serious anomaly" in the reactor pressure vessel at Flamanville – a nuclear plant being built in Normandy which is the same model as the ones planned for Hinkley Point C. Flamanville is currently 6 years late and around €7.2bn over budget. Another reactor under construction, which is the same design, at Olkiluoto in Finland is expected to be almost 10 years late and €5.5bn over budget. Hinkley Point C was originally expected to be generating 'in time to cook Christmas dinner in 2017'.

Stop Hinkley Spokesperson, Roy Pumfrey, said: "*As Albert Einstein is thought to have said the definition of insanity is doing the same thing over and over again and expecting different results. At the stroke of a pen David Cameron could launch projects sufficient to save or generate the same amount of electricity as Hinkley Point C which are capable of delivering long before 2025.*" (28)

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2. Alternatives to Hinkley

If there is anywhere between 4 and 18 months before a final investment decision on Hinkley is made what alternative proposals can be promoted over that time?

The Power to Transform the South-West

In April 2015, Molly Scott Cato, the Green MEP for South West England, published a study which showed how the South-west's energy needs could be met with renewable energy. (1) The report focussed on dealing with the baseload question and the economic impact of a renewable energy transition. It concluded that the South West has the renewable energy resources to meet more than 100% of its total energy needs, including replacement of liquid fuels and electrifying railways.

The South West has the potential to generate an estimated 18,935 MWe of electrical and 12,869 MWth of thermal energy. This equates to 102.6% of total future energy needs for South West assuming a 40% powering down due to energy efficiency measures by 2050. The recommendation from the study is that 12,000 MW (12GW) of energy capacity with 24,000 MWhrs of energy storage be developed in parallel with renewable energy resources. This storage would have the ability to charge and discharge twice per day providing 48,000MWhrs of daily energy from storage yielding 40% of the regions daily energy demand. In total this represents an investment of £8,780M in grid resilience and substantial future proofing from future energy price rises for the region.

Providing the South West with renewable energy and a local smart grid with energy storage and flexibility to meet spikes and drops in demand are estimated at around £60bn compared with around £82.5bn to provide all of the South West's energy needs with nuclear.

Intergenerational Foundation

More recently a report from the Intergenerational Foundation has calculated that Britain could save up to £40bn by going for renewable alternatives that would generate the equivalent power to Hinkley over the plant's planned lifetime. (2)

The report called "Toxic Time Capsule" by Andrew Simms (3) says onshore windfarms would cost £31.2bn less than Hinkley, and solar photovoltaic power £39.9bn less over 35 years to build and run. The estimate is based on both the value of subsidies paid by the taxpayer for the electricity and the cost of building the infrastructure. The analysis is based on the government's 'contracts for difference' subsidy levels for the technologies and projections by Bloomberg for how the cost of wind and solar power will fall in the future.

Five ways to power the UK without Hinkley

The think-tank E3G came up with five ways to power the UK that are far better than HPC. These were Energy efficiency; wind turbines; solar; interconnectors; storage and flexibility. (4)

- By 2030 six Hinkleys' worth of electricity could have been cut from the national demand, according to a McKinsey report for the government. (5)

- Onshore wind power is much cheaper than the heavily subsidised price Hinkley is guaranteed for over 35 years. The costs of offshore wind are also falling and likely to be below Hinkley well before 2030.
- Electricity from solar power is now also cheaper than Hinkley.
- Another third of a Hinkley has been added to the UK grid since 2010 by new cables to other European countries, where electricity is currently cheaper. New interconnectors to Norway, Denmark and France could be laid by 2025, adding another two or three Hinkleys to the grid, according to a report for the UK's National Infrastructure Commission (NIC) in February.
- Four Hinkleys' worth of electricity could be saved by 2030 by increasing the ability to store electricity, in large batteries for example, and making the grid smarter. This would also save bill payers £8bn a year.

The Baseload Myth

Commenting on the Intergenerational Foundation Report a Department of Energy and Climate Change spokesperson said: "*Nuclear can provide continuous power, irrespective of whether the wind is blowing and the sun is shining … Hinkley Point C is a good deal for consumers and, once operational will provide 60 years of secure, reliable and low-carbon electricity for the cost of 35. This will help us to keep the lights on while meeting our emissions targets in the most cost-effective way*." (6)

DECC keeps raising this same old baseload and intermittency question over and over again. (See nuClearNews No.84). DECC's argument is that despite the higher costs of electricity from Hinkley C, it is needed because cheaper forms of low carbon electricity generation are less reliable, and that other forms of baseload power (such as gas or coal) are less green.

Green Hedge

Now Green Hedge, a leading developer and operator of low carbon electricity generation and storage projects, is questioning whether it is possible to replicate the electricity generation of Hinkley Point C with a cheaper, equally low carbon combination of a) onshore wind and solar, b) energy storage and c) backup gas generation at costs that would allow their deployment today. Their analysis shows that it is indeed possible to get new reliable generation with a low carbon footprint at a substantially lower cost to consumers and deployed now rather than in the mid-2020s. (7)

Hinkley Point C requires a price guarantee from the UK government for 35 years at £100.68/MWh in today's money (£92.50/MWh in 2012 money). At the same time, the wholesale price for electricity is currently below £35/MWh. The Green Hedge analysis shows it is possible replicate the electricity generation of Hinkley Point C at a price of only £75/MWh, saving Britain's consumers £720 million per year (or £25 billion in today's money over the 35 year contract term).

Transforming weather-dependent solar and wind into a stable generator is possible because the weather variations between wind turbines and solar panels largely cancel each other out. Any

remaining variation is managed with energy storage (charging batteries when generation exceeds demand and vice versa) and with backup natural gas generators. Gas generators are the only technology emitting carbon dioxide, but as they are rarely used, the average carbon intensity is still 80 per cent lower than today's average of electricity from the grid. At a carbon intensity of only 100gCO2/kWh our "renewable Hinkley Point" would meet the UK's 2030 target already today.

Barnham Storming

Keith Barnham, Emeritus Professor of Physics at Imperial College goes one step further by proposing the use of "green gas" rather than fossil gas. He argues that the exponential rise in renewable power generation worldwide has radically changed the electricity supply scene since 2006 when Labour decided to go for new nuclear. Renewable power has made new nuclear unnecessary in the UK. He says Amber Rudd's recent statement that new nuclear is the only proven low-carbon technology that can provide continuous power is demonstrably incorrect. She appears unaware that a number of proven, low-carbon technologies are already delivering continuous power to the UK grid. DECC's own data shows that in 2014 hydropower contributed 1.7 GW to the grid. Also six bio-electricity technologies, all capable of continuous power operation, together produced 4.5 GW of electric power. That is already 6.2 GW of continuous power, nearly twice the 3.2 GW that Hinkley will struggle to produce by 2030.

Bio-electricity could provide ten times 3.2 GW before the first of the two proposed reactors at Hinkley operates. Two of these proven renewable technologies, hydropower and biomethane produced from the anaerobic digestion (AD) of farm and food waste, have the lowest carbon footprints of all forms of electricity generation. The carbon footprint of existing nuclear generators is a matter of considerable controversy in the scientific literature but is probably at least five times higher. The low carbon footprint of AD is well established. If the waste is left to rot on farms or in landfill it produces copious amounts of greenhouse gases.

In any case if renewable installations continue to expand, even at a lower rate than recent years, we won't need continuous power. Flexible, not continuous, power generation is needed to back up wind and photovoltaic (PV) power. The German Kombikraftwerk project showed how the electricity demand on a national grid like Germany, or the UK, can be supplied 24/7 all year by 80% wind and PV power. Only about 15% of flexible bio-electric power and 5% storage power back-up are needed. Many bio-electricity generators are capable of flexible operation. The government should be aiming its flexible capacity subsidies at new electricity generators fuelled by AD biomethane rather than polluting fossil fuel generators as at present. (8)

National Farmers' Union

Dr. Jonathan Scurlock, Chief Adviser, Renewable Energy and Climate Change to the National Farmers' Union commenting on Amber Rudd's statement about the need for provide continuous power, says The Energy Technologies Institute estimates there is around 4000 GW of bioenergy generation capacity already, and around 5500 MW in the pipeline.

Balancing Green Power

Professor Dave Elliott has outlined in a new book (9) the many ways available for compensating for the variability of renewables. '*Balancing green power*', produced for the Institute of Physics,

sets out to show how it is possible to balance grid systems while increasing amounts of renewable capacity are added to the system; helping to avoid wasteful curtailment of excess output and minimising the cost of grid balancing. The options include flexible generation plants, energy storage systems, smart grid demand management and super-grid imports and exports. (10)

Elliott says if the appropriate balancing systems are available it will be possible to operate a grid system reliably with large amounts of variable renewable capacity included, without a large backup from fossil fuel-fired plants. Certainly, at present levels of renewable input (up to around a 20-30% share), the existing system can cope quite happily. Gas plants are ramped up and down to balance the variations, much as they do anyway to meet the regular changes in supply and demand. No new 'back-up' plants are needed – they already exist. They just have to ramp up and down more often, adding a small cost penalty.

However, as the share of renewables rise, replacing conventional plants, unless we are prepared to keep, replace and expand these gas plants, other balancing systems will be needed. There are many possibilities. More use can be made of pumped hydro storage reservoirs and other storage options. One of the cleverest of these is Power-to-Gas conversion. Since renewable sources like wind vary, as more capacity is added to meet demand, there will be times when there is significant surplus production. Rather than dumping this excess energy very wastefully (by so called output curtailment), it can be used to produce a new fuel – hydrogen gas – by the electrolysis of water. That can be stored ready for use in a gas turbine or fuel cell to make electricity when there is a lull in renewable output and/or a demand peak. Or it can be fed direct into the gas main. Or used as vehicle fuel. So the problem of intermittency is turned into a solution – a valuable new fuel, possibly converted into methane, using carbon dioxide captured from the air or from any remaining fossil plant exhausts. The overall conversion process may not be very efficient, but the fuel input is free – it would have been wasted otherwise.

One of the biggest end-uses of energy is for heat, and that too can play a role in balancing. Combined Heat and Power (CHP) plants, feeding district heating networks and heat stores, can vary their power to heat output ratio. So if there is a surplus of renewable electricity, they can produce less power but more heat, and store it for when it is needed later. If there is a shortfall in electricity, they can increase power output, and if there is still demand for heat, draw on the store. Storing heat is much easier than storing electricity and CHP plants can and increasingly do make use of biomass, reducing net emissions substantially. Solar heat can also be fed to the network, as can heat produced using excess electricity from wind turbines.

Nuclear power plays no role in high renewables scenarios: it is too inflexible. Instead, as Elliott's new book shows, based on a range of national and global scenarios, given proper attention to balancing, flexible system development and energy saving and the use of multiple sources, renewables can supply the bulk of the energy needed in the years ahead on a reliable basis, and possibly all of it.

Get it from the Sun

Inspired by Keith Barnham, the Nuclear Free Local Authorities (NFLA) has launched a new initiative to encourage local authorities to continue the impressive and rapid deployment of renewable energy projects across the UK and Ireland in the face of subsidy cuts. (11)

Get it from the Sun (GIFTS) is a new initiative put forward by Professor Keith Barnham that aims to provide information and encourage cooperation among local authorities, town councils, charities, community energy groups, environmental NGOs and individuals working towards all-renewable electricity supplies at the local level, in spite of the extensive subsidy cuts to renewable energy by the UK Government. Renewable electricity is the quickest way to achieve the carbon reductions the government agreed at COP21. In the NFLA's view, such local initiatives can overcome government opposition.

The GIFTS initiative outlines the rapid deployment of renewable energy over the past decade, and shows that, had cuts to subsidies not been implemented, an all-renewables energy system would have been created years before new nuclear could have had any positive effect.

Despite the cuts, the GIFTS initiative also provides 6 ways to keep momentum towards deploying renewable energy solutions, centred on local authorities and community energy cooperatives. They include:

- Keep talking to investors so that renewables should remain competitive. Good Energy for example has just announced agreement on the first subsidy-free wind farm.
- Seek out new forms of finance such as crowd sourcing. Crowd sourcing will benefit from the popularity of renewables being much higher than nuclear or fracking using DECC's own figures.
- Cooperate with organisations who could be motivated by factors other than return on investment such as the devolved governments in Scotland, Wales and Northern Ireland, local authorities grouping together, eco-schools and community energy cooperatives.
- Cooperate with renewable NGOs on a campaign to increase demand for renewable power by encouraging local authorities, universities, companies and individuals to switch their electricity supplier to an all renewable electricity supply such as Ecotricity, Ovo Energy or Good Energy. (If you haven't switched yet see http://www.greenelectricity.org/)
- Local authorities and community energy groups can cooperate to encourage local farmers and food companies to send farm and food waste for anaerobic digestion (AD). If the bio-methane is used to produce electricity, or is input to the gas grid, the waste collected may count towards a local 15% bio-electricity generation.
- Local authorities and local action groups can cooperate to deny planning permission to new fossil fuel electrical generators that are supported by the government's flexible capacity subsidy. At the same time they could be encouraging new combined heat and power (CHP) electricity generation using bio-methane from AD to obtain funding from the government's flexible capacity subsidy.

Hinkley is expected to produce, at a very optimistic 90% load factor, 25TWh (billion kWh) every year. Some of the alternatives to Hinkley we have mentioned in the past include:

- Research by Forum for the Future, *Farmers Weekly* and Nottingham Trent University looked at the potential for rolling out different renewable technologies on UK farms -

principally solar and wind, and some anaerobic digestion. Their report estimates that it would be relatively simple to get 20 GW onto the grid from farm-based solar and wind by 2020. (12)

- Domestic energy efficiency alone could save 40TWh/yr by 2030 and help eliminate fuel poverty into the bargain. (13)
- There are around 100 TWh of electricity savings detailed in the McKinsey report which the Government currently has almost no plans to capture. Building fabric improvements and lighting could save almost 40TWh more than the Government is currently planning. In the industrial sector around another 15TWh could be saved by replacing motors and pumps with more efficient models. (14)
- Britain's solar industry says it could install the same capacity as Hinkley in 24 months and at comparable cost. (15)
- Offshore wind could supply up to 155TWh/yr more than planned. (16)
- Solar Farms (just on land used for biofuel) 190TWh/yr (17)
- Commercial rooftops 30TWh/yr (18)
- Domestic roofs 22 - 140TWh/yr (19)

And a few more recent ideas:

- Commercial property owners will not be able to rent out buildings that fail to achieve a minimum 'E' energy-efficiency rating as of 2018. But almost one in five commercial properties currently fall into the 'F' and 'G' categories. A guide from Love Energy Savings explains what business in rented property can be doing now: https://www.loveenergysavings.com/blog/2016/may/you-can-save-money-on-your-business-energy-bills-in-a-rented-building-heres-how/
- Danish lighting company Scotia has a new range of solar-powered streetlights that promise to turn local authorities into 'energy powerhouses' The Monopole street light collects solar energy during daylight hours and stores it in a battery for use after sundown. Not only do the lights generate enough energy to power themselves, they can also feed energy back into the local grid to turn local authorities into "energy powerhouses". If all of the UK's seven million streetlights were switched to Monopoles, it would save more than £300m in electricity costs and generate more than 4TWh of clean power per year. Some 40 per cent of this would feed back into the grid. (20)
- A major new global campaign calling on cities worldwide to switch all their street lights to LEDs by 2025 has been launched this week by The Climate Group. There is no longer any reason to delay the deployment of LED street lighting, describing it as a "no-brainer" for city authorities looking to cut emissions and save money. (21)
- A new bus shelter unveiled at Canary Wharf heralds the arrival of transparent solar panels. The solar glass will provide power for the bus shelter's smart signage with

excess power being used to run other infrastructure on the estate. The manufacturer, Polysolar said it was continuing to work with Canary Wharf and hoped to incorporate its solar cells into the facades of offices and residential developments on the site. (22)

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3. 100% Renewables

The idea that renewable energy can power the UK is an "*appalling delusion*", according to the final interview given by former chief scientific adviser, the late Professor Sir David MacKay to Mark Lynas. Prof. Sir David Mackay, who tragically died recently, strongly backed nuclear and Carbon Capture and Storage CCS over renewables, describing them as the more reliable and efficient low carbon options. (1)

Prof MacKay argued that solar, wind and biomass energy would require too much land, huge battery back-ups and cost too much to be a viable option for the UK. "*There is this appalling delusion that people have that we can take this thing that is currently producing 1% of our electricity and we can just scale it up and if there is a slight issue of it not adding up, then we can just do energy efficiency*," he said. "*Humanity really does needs to pay attention to arithmetic and the laws of physics – we need a plan that adds up*."

Quite rightly, he insisted that '*we need a plan that adds up*', so as to deliver viable, reliable energy. Perhaps he was unaware that several high renewables/non nuclear/low CCS UK scenarios have been produced which do just that, including one produced for the UK Pugwash group, using DECC's modelling system. (2)

Prof MacKay said the key for the UK was a zero-carbon solution that works in the winter, when energy demand is highest but sunshine is lowest and winds can drop for days at a time. "*The sensible thing to do for a country like the UK, I think, is to focus on CCS, which the world needs anyway, and nuclear*".

"Then if you ask what is the optimal amount of wind and solar to add in then the answer is going to be almost zero," he said. "I love wind turbines – they are the cathedrals of the modern age – but they are a waste of money if you have a low carbon solution that gets you through the winter … because when the wind blows you are going to have to either turn them down or something else down that you have already paid for like nuclear or CCS."

While advocates of renewable technologies often cite the potential for electricity storage to deal with their intermittency, Prof MacKay said that balancing wind-based power supplies would require "hundreds of flooded valleys" for hydroelectric storage. Powering the UK from solely solar and batteries would require "absurdly large" batteries, while the cost of battery technology would need to come down "by a factor of 100" for it to be a realistic option, he said. (3)

"*This does not make a great deal of* sense", said one commentator on the Guardian website. "*Yes you can attack a proposed power grid of just solar PV with battery storage as very expensive, but no sensible advocate pushes that, so it is just a straw man argument. Likewise it is naive to say that if we have enough nuclear and effective CCS then we don't need renewables - therefore renewables are a waste of money*."

"*The delivery of Nuclear is subject to significant risks in delay and cost overruns. So* ***if*** *we were confident we could build enough nuclear on time and to budget, and* ***if*** *we had an effective CCS system to deploy, then yes, renewables could be a waste of money. But putting all our eggs in the*

magical thinking basket of predictable delivery of a massive nuclear roll out and the successful development of CCS would be reckless."

"*Lots of wind power has gone up since it was decided to build Hinkley in 2007, which has displaced a lot of fossil fuel use and will continue to displace more*."

Renewable growth is continuing globally - renewable generation capacity increased world-wide by 152 GW or 8.3% during 2015, the highest annual growth rate on record. According to Bloomberg New Energy Finance's Michael Liebreich,"*in terms of renewable penetration, Europe is still the world leader. Renewable energy is likely to have provided some 30% of Germany's electricity in 2015, about 50% of Denmark's, 38% of Spain's, 33% of Italy's and nearly 25% of the UK's".* However, in terms of new renewable capacity China is clearly accelerating ahead, with big new investments: wind capacity has surpassed 148GW. And under its new 5 year plan, China aims to at least double its wind energy capacity and nearly treble its solar capacity (to 160GW), accelerating well ahead of the EU.

Many longer term scenarios suggest that renewables are likely to supply at least 50% of power, and possibly energy, globally by 2050, and perhaps, with the right support and commitment to energy saving and balancing, even up to 80% or more.

Dave Elliott's Book, Green Energy Futures argues that nuclear is unlikely to have much of a role in future, and shows that the pro- and anti-nuclear debate has absorbed too much time and energy over the years. This has been to the detriment of a more relevant, interesting and increasingly urgent debate over what sort of renewable/efficiency mix we need. Elliott explores the implications of shifting to greener, cleaner energy sources. There is a range of possible options of various types and scales: we need to choose amongst them. (4)

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