RCEA
(SUSSEX)

An Association for Retired Professional Engineers

NEWSLETTER April 2026

President's Message

Hello everyone, as this season comes to an end, welcome to the April Newsletter.

This year we have had another full season of monthly talks thanks to our ever-conscientious programme manager Mike who is already working on September onwards.

The talks have been varied, and attendance above average this year due to the number of guests attending, peaking at 47 in February.

As we now move towards the summer, our thoughts turn to visits, the only one firmed up at present is to the Brighton Engineerium in Hove on Sunday 10th May, but if anyone has ideas for others, please let myself or a committee member know.

The Coffee mornings continue each month, with folk meeting on the 3rd Thursday of the month at the Spotted Cow and the last Thursday of the month at the Swallows Return with partners, room available if you want to give it a go.

During the year I set up a WhatsApp group enabling messages to be sent out quickly to the membership should something happen like unavailability of venue or speaker.

Thankfully we have not had to do this, but if anyone, who isn't in the group wishes to join, please let me know and you can be added.

The AGM and talk will start off our new season on Tuesday September 15th and once again the usual cry goes out for new members to join the committee.

We do value the input of the membership to arrange talks and visits as new / different thoughts bring fresh ideas. So if you feel this is for you, please talk to me or anyone else on the committee for more information.

I would like to place on record, my sincere thanks to my fellow committee members for ALL their hard work and long may it continue.

All that remains is to wish you all a pleasant summer, keep your eye on emails from Mike and look forward to September when we can do it all again.

Take Care and stay safe.

George Woollard

President

April 2026

PROGRAMME OF EVENTS April 2026 – November 2026

30th April	Thursday	Coffee – with Partners at Swallow's Return
10th May	Sunday afternoon	Visit to Engineerium + talk on the History of the Brighton water supply, Hove
21st May	Thursday	Coffee – at Spotted Cow, Angmering
28th May	Thursday	Coffee – with Partners at Swallow's Return
18th June	Thursday	Coffee – at Spotted Cow, Angmering
25th June	Thursday	Coffee – with Partners at Swallow's Return
16th July	Thursday	Coffee – at Spotted Cow, Angmering
30th July	Thursday	Coffee – with Partners at Swallow's Return
20th August	Thursday	Coffee – at Spotted Cow, Angmering
27th August	Thursday	Coffee – with Partners at Swallow's Return
15th September	Tuesday	AGM & talk - North Sea Oil and a Boardwalk
17th September	Thursday	Coffee – at Spotted Cow, Angmering
24th September	Thursday	Coffee – with Partners at Swallow's Return
13th October	Tuesday	Talk - Train Tram Innovations
15th October	Thursday	Coffee – at Spotted Cow, Angmering
29th October	Thursday	Coffee – with Partners at Swallow's Return
10th November	Tuesday	Talk - Careers – choices, chances and changes
19th November	Thursday	Coffee – at Spotted Cow, Angmering
26th November	Thursday	Coffee – with Partners at Swallow's Return

All Talks and Meetings will commence at 2.30 pm and be held in the Pavilion, Field Place, Worthing, unless another venue or time is indicated. Timings for visits and outings will be as printed in the detailed description of the activity.

Coffee mornings commence at 10.30 am.

We do sometimes have to cancel/rearrange talks and visits, in which case we will inform our members of changes to our programme by email. Members can always look on our website for up-to-date details of events.

Website of the RCEA

Our website, www.rceasussex.org.uk carries the very latest information on all our events.

New Members and Speakers for Talks

The RCEA needs new members and speakers to ensure that we can continue as a thriving organisation. Please think of appropriate people you know and encourage them to come along to our talks and hopefully join the RCEA.

We also need more speakers to give talks to us at our monthly meetings on Tuesday afternoons from September to April.

We are aware that many members have the knowledge from their working careers to provide interesting talks. If you are willing to give a talk, please let us know.

The RCEA (Sussex) does not normally publish obituaries of members.

However, Ray Parsons was a 'one off'. He was our oldest member at 93 who regularly attended meetings and both types of coffee mornings. He gave several talks since joining the RCEA in 1987.

The following was posted on the Brighton Tram 53 Society Facebook page -

'Back in September I interviewed 93 year old Brightonian, Ray Parsons. Ray had some wonderful memories of the Brighton trams, he loved the illuminated ones and shared some very interesting memories of the system and what it was like to use. He was very sharp and a pleasure to speak to. I have to sadly report that he died on 16th January. It was thanks to his daughter Sally that we organised the interview. Ray, you will be missed. Guy'

Derek Webb

New Members

- Simon Norris-Jones Shoreham
- David Lemon Steyning
- John Willis Ditchling
- Nicholas Lewis Redhill
- Geoff Burchett Lancing
- Stephen Dexter Henfield

RCEA Insurance

Members need to be aware that the insurance policy that the Association holds is solely for the protection for the assets and liabilities for the Association as an entity. The policy does not provide cover for personal injury or loss to individual members. Members attend the Association's events at their own risk although under some circumstances there may be some cover from the insurance arrangements of the venue owner.

Brief Details – Talks, Visits and other activities - May to October 2026

Visit

Tuesday, 10th May 2026 - British Engineerium in Hove

Tour of the pumping station, in steam, from 2.30 to 3.15, followed by a talk in the ‘dance studio’ by John Walter on the History of the Brighton Water Supply.

The talk by John Walter will begin with a background to ever increasing need of water as population rose and technology moved forward. Brighton grew considerably in the Regency period, and later with a rail connection to London. New housing estates needed something more effectual than deeply-dug wells, hand-pumps and limited-capacity storage tanks.

The advent of the atmospheric and then steam engine was a game changer, allowing supplies to be maintained when lack of wind prevented wind-engines such as those made by engineers such as Wallis Titt, and even the French Eolienne Bollee installed in the Shermanbury monastery, working effectively. The first beam engines in our area drove water pumps in the Lewes Road Pumping Station in what is now Saunders Park. Enlarged several times, Lewes Road proved capable of supplying what was initially an intermittent service in the adjoining districts. But westward expansion of Brighton and Hove needed a new solution.

A new constant-supply water company consulted with Thomas Hawksley and then Edward Easton, and the Goldstone Pumping Station was an early result. A Woolf compound beam engine was installed in what is now Goldstone Number 1 Engine House, beginning work in 1865. The site had its own reservoir nearby, exploiting a deep-dug well with several adits to maximise water flow from the chalk aquifer. Ever growing need led to the installation of Number 2 Engine in 1875, and, elsewhere, the creation of pumping stations in Patcham, Mile Oak and Falmer by 1904.

However, eastward growth after the First World War led to supplies in places such as Balsdean and Bevendean, but these relied on electrically-driven pumps. Eventually, technology bypassed tradition, and the steam engines were decommissioned by the 1970s.

The Goldstone pump-site, driven electrically as it still is, was purchased in 1971 by leading mechanical antiques dealer Jonathan Minns and became the British Engineerium. His creation of a world-renowned museum is part of John Walter's talk, which tries to place Goldstone Pumping Station in context and, perhaps, encourage the next step!

Reports

Click on a title to go to that report.

Talk

Tuesday 9th December 2025

Weather to be or not to be

Bob Riddaway

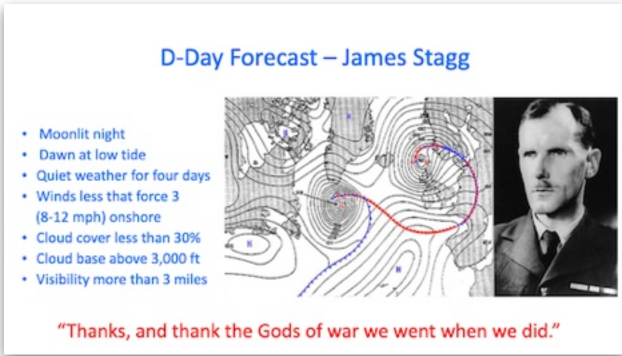
Bob has kindly supplied the slides he used for his talk. They are self-explanatory, so rather than trying to use them to produce a 'written report', they are reproduced here as shown on the day. In addition there are some extra notes below that (a) capture comments on the day and (b) draw on answers to questions.

Slides 2 & 3. The development of a telegraph network meant that it was possible to know about the weather across the UK in near real time. This led to the issuing of shipping forecasts and the publication of the first public weather forecast in The Times in August 1861. Thereafter the ability to forecast the weather was enhanced by the establishment of the International Meteorological Organisation in 1873 to facilitate the international exchange of observations. This was followed by two important scientific and technological developments: an understanding of frontal systems and the use of radiosondes to obtain observations from above the ground.

Slide 2

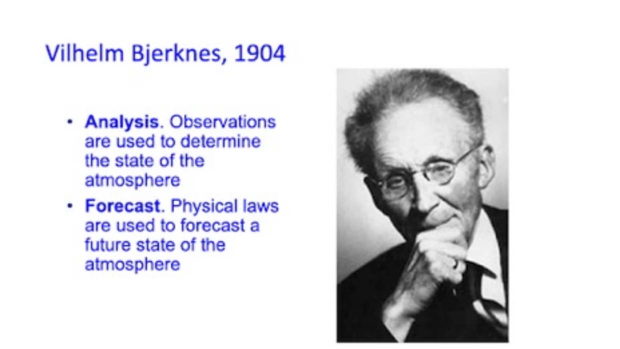
Slide 3

Slide 4. In the 1940s the forecasts were based on a careful scrutiny of observations, experience and some understanding of atmospheric processes. The D-Day forecast is perhaps the most important weather forecast ever made. Gp Capt. Stagg forecast a brief break in the weather for 6 June and on that basis General Eisenhower ordered the D-Day landings. Later Stagg sent a memo to Eisenhower explaining that if D-Day had been postponed to the next time there was the required low tide at dawn, the weather would have been dominated by the worst channel storm in 40 years and the landing would have been impossible.



Slide 4

Slides 5, 6, 7 & 8. Nowadays weather forecasting is based on Numerical Weather Prediction (NWP). This was first proposed in 1904 and later demonstrated in principle by L F Richardson using hand calculations. The first numerical forecast using a computer was made in 1950. But it was not until 1965 that the Met Office had a computer powerful enough to produce operational forecasts.



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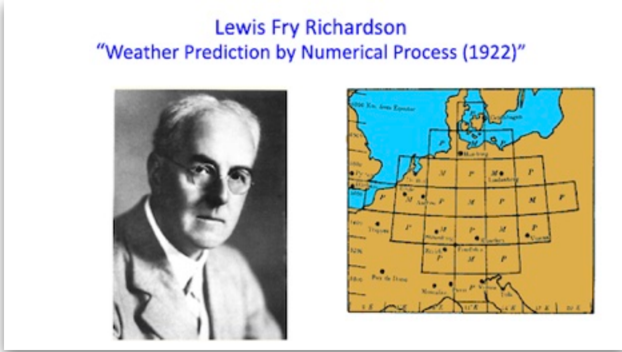
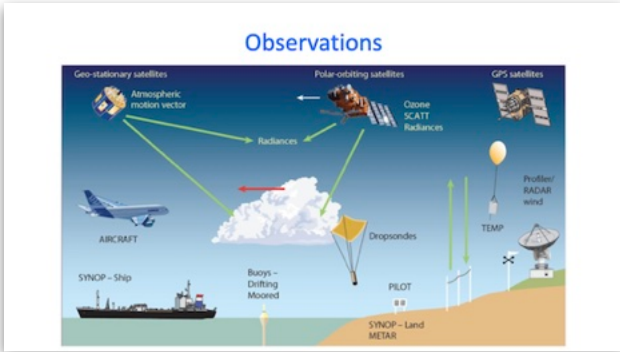


Slide 6

Slide 7

Slide 8

Slides 9, 10 & 11. Many different types of observing systems are used to provide information about the atmosphere. There are wide variations in the frequency and geographical coverage of the observations. The use of satellites has vastly increased the availability of weather information. They carry passive instruments, which measure radiation emitted naturally, and active instruments, which send out signals and measure the backscatter. The natural microwave and infrared radiation in various wavelengths provides information about temperature and humidity profiles, along with data about clouds and surface conditions.



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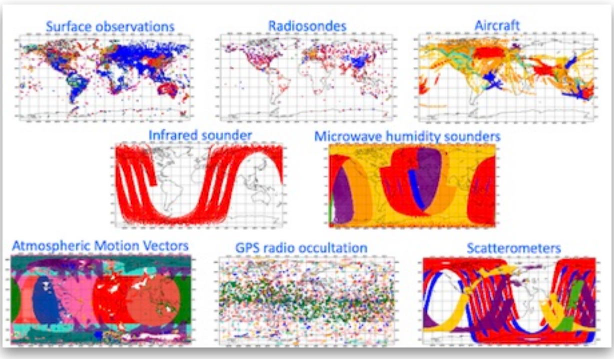

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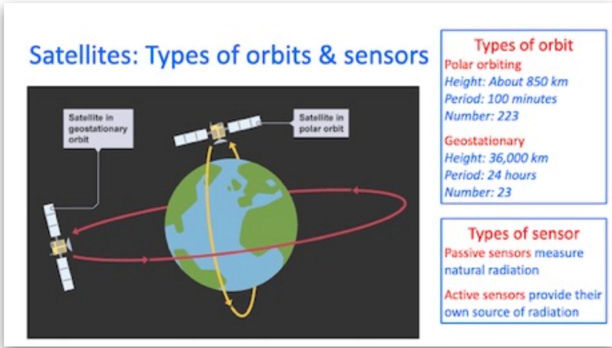
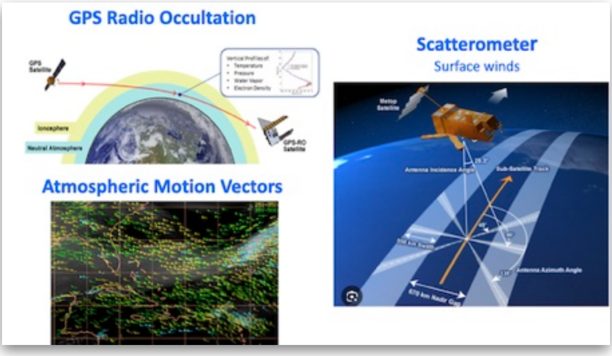


Slide 11

Slides 12 &13. Novel uses of technology have been developed to obtain weather information.

- GPS Radio Occultation (GPSRO) is a satellite remote sensing technique that uses GPS signals bent by Earth's atmosphere to profile temperature, pressure, and humidity.
- Scatterometers are radar instruments used to measure the backscatter from wind-generated ripples on the ocean surface. This provides information about wind speed and direction.
- Atmospheric Motion Vectors are winds calculated by looking at the movement of cloud tops.
- Weather radars measure the backscatter from raindrops. The bigger the backscatter the larger the raindrops. The larger the raindrops the heavier the rain.



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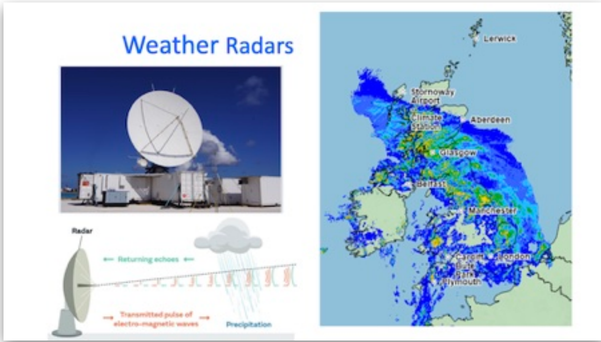
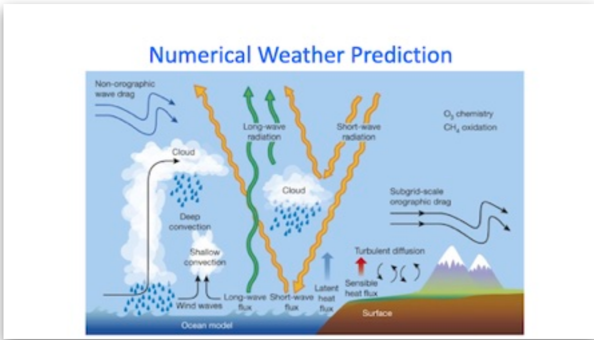


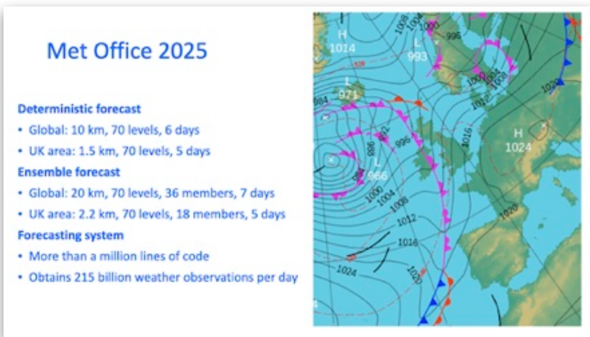
Slide 13

Slide 14. Numerical models of the atmosphere have to include a wide variety of physical processes.



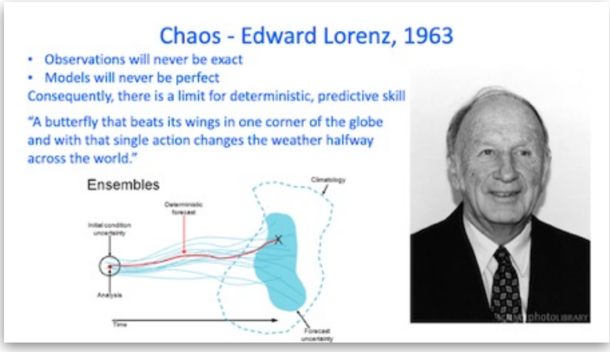
Slide 14

Slide 15, 16 & 17. Numerical models use a three-dimensional grid to specify atmospheric parameters (e.g. wind and temperature). At each grid point the physical laws (e.g. Newton's Second Law of Motion and the Second Law of Thermodynamics), along with a representation of the many physical processes, are used to calculate the rates of change of the atmospheric parameters at each grid point. These are then used to make a short forecast. For the Met Office's deterministic global model the time step is 4 minutes. New calculations of the rates of change are then made and a new 4-minute forecast is produced. For the global model this approach is used to produce a six-day forecast using a grid length of about 10 km in mid-latitudes. The Met Office also uses a limited-area model with a grid length of 1.5 km to provide detailed forecasts for the UK and the surrounding area.



Slide 15

Instead of producing one deterministic forecast, an alternative approach is to produce an ensemble of 50 forecasts with each one starting with a slightly different



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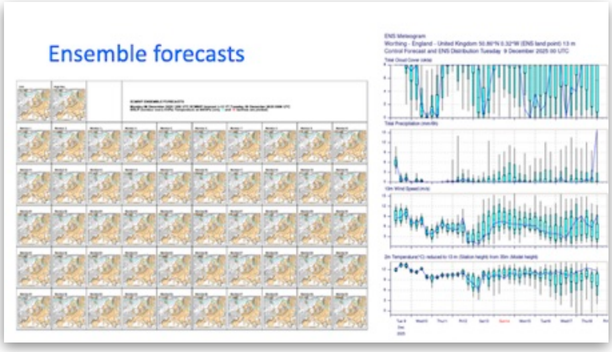
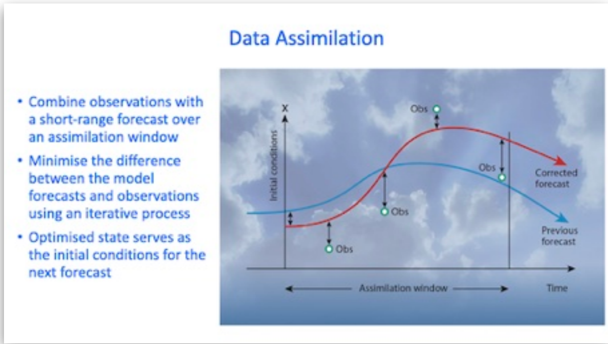


Slide 17

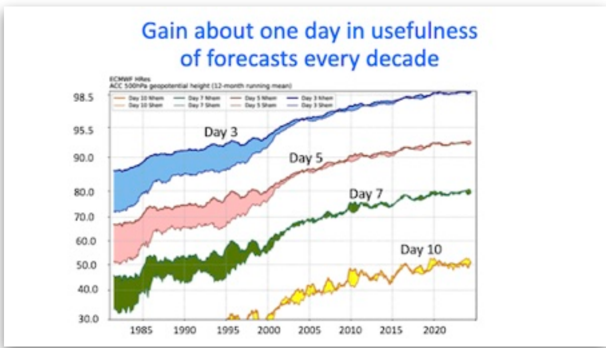
analysis that is consistent with the observations. This recognises that the exact state of the atmosphere is never known and numerical models are not perfect. The spread of the forecasts gives an indication of how much confidence can be placed on the deterministic forecast. The chaotic behaviour of non-linear systems was discovered by Ed Lorenz when trying to understand the behaviour of a simplified version of equations used in NWP.

Slide 18. Data assimilation is the process by which the many different kinds of observations are used to specify the grid-point values for the start of a numerical forecast. The basic approach is to treat the previous forecast as the first-guess for the start of the next forecast and then adjust that first-guess using the observations. Nowadays sophisticated techniques are used to assimilate observations over a 12-hour period rather than at a specific time.



Slide 18

Slides 19 & 20. The gain in 'usefulness' of forecasts over time produced by the European Centre for Medium-range Weather Forecasts (ECMWF) is depicted. The measure is the correlation between the actual anomaly (difference between the observed atmospheric state and the climatology) at a particular time and the forecast anomaly (difference between the forecast atmospheric state and the model climatology). Experience indicates that forecasts with a value of over 60% have useful skill. In broad terms, there has been gain of about one day in useful predictability every decade. It also shows that, due to the increasing amounts of satellite data that is now available, there is no longer a



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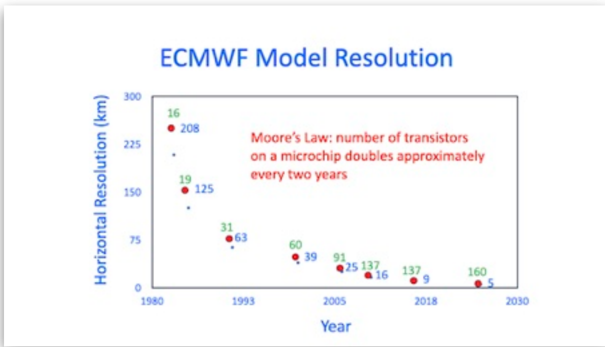
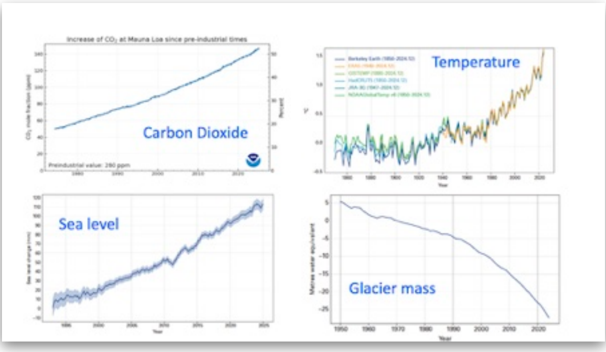


Slide 20

significant difference in the skill of the forecasts for the northern and southern hemispheres.

The main factor responsible for the increase in skill is the growth in computer power as illustrated by Moore's Law (an empirical 'law' familiar to electronic chip designers). Consequently, over time, the horizontal grid length of NWP models can be reduced and the number of vertical levels increased. For example, in 1983, the ECMWF models had a grid length of 208 km in mid-latitudes and 16 levels. By 2025 the corresponding values are 5 km and 160 levels.

Slides 21 to 24. There is plenty of evidence that climate change is taking place. As indicated by the annual reports of the Intergovernmental Panel on Climate Change, the overwhelming scientific assessment is that this change is caused by the release of increasing amounts of greenhouses gases, especially carbon dioxide associated with the burning of fossil fuels. Climate models are used to understand past changes in the climate and assess future changes in the climate based on a variety of scenarios. The climate models are similar to those used for NWP, but consider the Earth's climate system including interactions between the atmosphere, ocean, land and ice. Climate models predict significant future climate change based on various emission scenarios with impacts on temperature, sea level, ice cover and frequency of extreme weather events.



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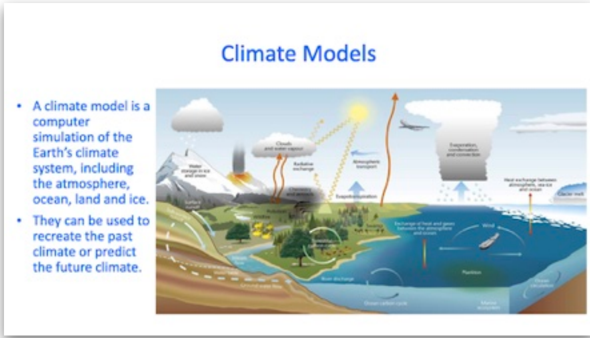

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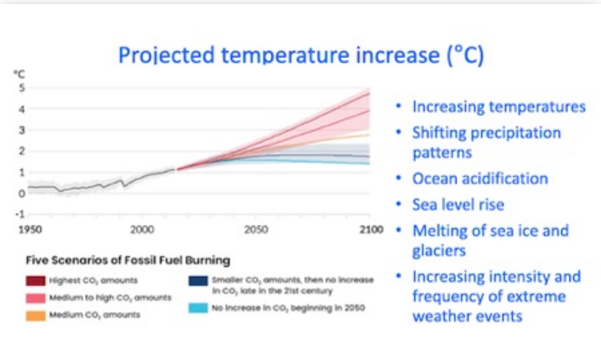

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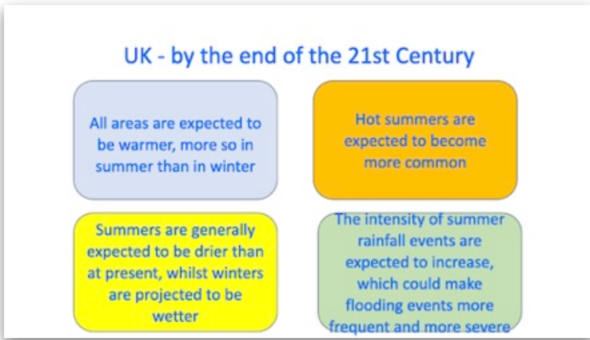


Slide 24

During the Q&A session, one of our members, Rupert Harper, commented that his uncle had taken part in the first flight over Mt Everest. During that flight they reported 'over 100mph winds over Everest'. This was probably a Himalayan jet stream, though not recognised at the time. A film of the flight, 'Wings over Everest 1934', can be found at https://www.youtube.com/watch?v=9zK4WblHxkI.

Mike Wooldridge

Talk

Tuesday 13th January 2026

The varied and successful life of a ‘failed’ engineer

Richard Sykes

The newsletter supplement (available on the RCEA website) contains a full transcript of Richard’s talk, complete with photos and diagrams. It describes his 54-year career in mechanical engineering, primarily focused on internal combustion engines, development work, consultancy and engineering leadership.

1. Early Life and Education

- Richard always wanted to be a mechanical engineer, attending Brighton Hove & Sussex Grammar School and later Brighton Technical College.
- Completed an intensive one-year A-level-equivalent course to enter engineering studies.
- Despite enjoying practical engineering, he failed his academic exams and left without formal qualifications—something he references humorously throughout his talk.

2. Ricardo (20 years): Foundation of his career

- Began at Ricardo & Co. Engineers as an engine tester, later rising through several technical roles.
- Learned extensively from experienced engineers and considered his time there “the University of Shoreham-by-Sea.”
- Shared stories about:
  - A bizarre employee who claimed implausible expertise and nearly destroyed a test bike.
  - Misguided accounting decisions that hindered efficiency.
  - Being thrust into difficult situations alone, such as troubleshooting engine issues at Ducati and Teledyne Continental Motors (including modifying engines during a worker strike).

3. Major Overseas Assignments Volvo (Gothenburg) – 2 years

- Worked on Volvo’s Light Component Prototype (LCP) car, part of a future-efficiency programme inspired by Germany’s “Auto 2000.”
- Designed engine mounts, linkages, cooling systems, and more for an experimental lightweight 3-cylinder diesel engine.
- Discovered major overstatements in performance claims from a German engine supplier (ElkoMotor).
- Developed innovative solutions for 3-cylinder torque-recoil vibration, including a contra-rotating flywheel.

4. Aston Martin Tickford (1986–1990s)

- Joined during rapid expansion and became central to engine development within a year.
- Helped build test facilities, simplify engineering workflows, and dramatically reduce development costs.
- Led or contributed to projects for:
  - Austin-Rover (extensive induction system research)
  - K-series development
  - Turbocharged Metro experiment (extreme performance, but unsafe)
  - Rover 820 Turbo (flat-torque engine development)
- Described amusing stories involving technicians, test rigs, and “Swinging Cup Holder” inventions.
- Presented work on variable-geometry induction systems at IMechE.

5. Ford Collaboration (1990s)

- Developed validation methods for Ford’s proposed Orbital two-stroke engine.
- Contributed heavily to Ford Australia’s XR6 engine, designing high-performance valvetrain components.
- Worked on a five-valve-per-cylinder Duratec V6 (“Project Eskimo”), using cost-effective methods to optimise port geometry.

6. Later Career – TWR and Cosworth / MAHLE

TWR

- Led design of a proposed engine family for Iran Khodro, centred on an advanced 1.3L 3-cylinder engine.
- Project collapsed when TWR entered financial ruin.

Cosworth Technology / MAHLE Powertrain

- Took on the unique role of Technical Specialist – Engines with no managerial burdens.
- Key contributions:
  - Downsizing Engine (1.2L 3-cyl producing up to 259 bhp in later versions).
  - Extensive CFD optimisation and structural strengthening.
  - Development of a range-extender engine for hybrid applications.
- Participated in safety analyses, including dramatic battery failure testing at MIRA.

7. Preserving Knowledge

- Spent the last decade writing comprehensive internal technical chapters covering every subsystem of an IC engine.
- Intended to prevent loss of expertise as experienced engineers retire.
- Material is stored digitally inside company networks.

8. Closing Thoughts

Richard ends with reflections on:

- The value of practical experience vs. academic qualifications.
- The importance of recording engineering knowledge.
- The possibility that future shifts back toward internal combustion may require remembering “what the grey-haired engineers used to do.”

The talk was humorous, deeply technical in places, and filled with anecdotes illustrating how engineering, people, and organisational behaviour intersect.

Summary produced by Microsoft Copilot

Talk

Tuesday 10th February 2026

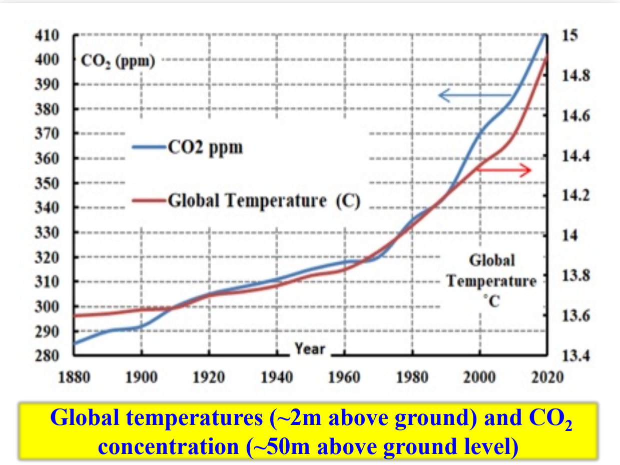
Ammonia Fuelling the Future

Jean-Pierre Pirault

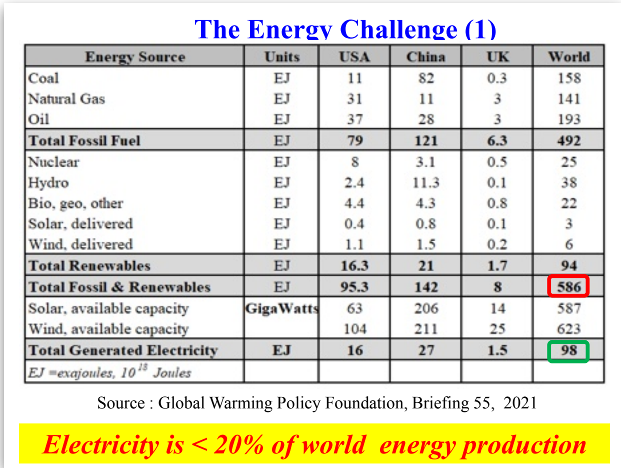
Jean-Pierre explored whether ammonia (NH_3) can serve as a viable, practical, and scalable fuel to support global moves toward Net Zero carbon emissions, particularly for sectors where electrification is either impractical or incapable of meeting operational demands. His argument unfolded across scientific, economic, geopolitical and technological domains, ultimately positioning ammonia as a near-term hydrogen vector and a realistic, carbon-neutral fuel for large engines used in maritime, off-road, agricultural, and remote-area environments.

The Global Energy and Climate Context

Jean-Pierre began by reviewing the relationship between rising CO_2 concentrations and increasing global temperatures, showing long-term data that aligns increasing atmospheric CO_2 with surface temperature rise. Although CO_2 is central to climate policy, he stresses that it represents only 20–25% of all greenhouse gases, with water vapour comprising the majority. This raises questions about how the climate system will respond once CO_2 is reduced and whether diminishing returns will arise as other greenhouse gases dominate.



Global temperatures (~2m above ground) and CO_2 concentration (~50m above ground level)


The Energy Challenge (1)

Energy Source	Units	USA	China	UK	World
Coal	EJ	11	82	0.3	158
Natural Gas	EJ	31	11	3	141
Oil	EJ	37	28	3	193
Total Fossil Fuel	EJ	**79**	**121**	**6.3**	**492**
Nuclear	EJ	8	3.1	0.5	25
Hydro	EJ	2.4	11.3	0.1	38
Bio, geo, other	EJ	4.4	4.3	0.8	22
Solar, delivered	EJ	0.4	0.8	0.1	3
Wind, delivered	EJ	1.1	1.5	0.2	6
Total Renewables	EJ	**16.3**	**21**	**1.7**	**94**
Total Fossil & Renewables	EJ	**95.3**	**142**	**8**	**586**
Solar, available capacity	GigaWatts	63	206	14	587
Wind, available capacity		104	211	25	623
Total Generated Electricity	**EJ**	**16**	**27**	**1.5**	**98**
EJ =exajoules, 10^{18} Joules					

Source : Global Warming Policy Foundation, Briefing 55, 2021

Electricity is < 20% of world energy production

He critiqued the assumption that 100% electrification is a universal solution to the climate challenge. Electrification, he argued, is technically elegant but strategically incomplete. Electricity currently supplies less than 20% of global energy demand, meaning the world would need to more than quadruple electrical generation capacity, without increasing carbon footprint, to meet global needs. The talk illustrated that many industrial, agricultural, and transport activities occur far from electrical grids or require power densities not achievable with battery systems.

The Impossibility of an All-Electric Future

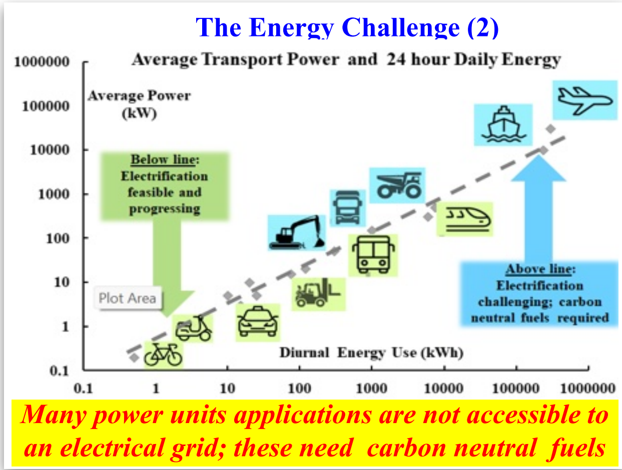
Jean-Pierre turned to the UK as a case study, demonstrating the scale of infrastructure required for an all-electric Net Zero scenario. Achieving UK Net Zero by 2050 would require over 40 new nuclear stations (≈1.5 per year) or 18,000 additional wind turbines (≈600 per year), a scale that far exceeds current construction or planning capabilities.

The material implications are equally daunting. Increasing wind turbine capacity tenfold would entail enormous increases in mining, processing and transport of steel, concrete and rare-earth materials, thereby creating a major carbon footprint just in the transition process. Jean-Pierre argued that such hidden emissions often go unnoticed in electrification narratives.

He warned that ambitious climate targets, such as limiting warming to +1.5°C, carry significant socio-economic consequences, including widening global divides, geopolitical constraints, resource inequalities and conflicts over access to energy and critical materials.

The Need for Carbon-Neutral Fuel Alternatives

Jean-Pierre pointed out that not all transportation methods lend themselves to electrification. Those applications above the line in the diagram would be difficult, if not impossible to electrify.



The talk then shifted toward developing carbon-neutral fuels that can work with existing combustion engines. Jean-Pierre listed key criteria:

- Compatibility with high excess air or high EGR (Exhaust Gas Recirculation) to control NO_x emissions.
- Feasibility of retrofitting existing engines to minimise capital cost and accelerate carbon reduction.

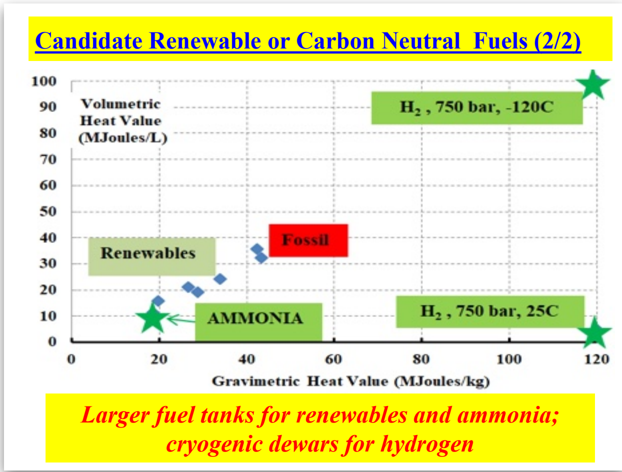
Among the candidates, such as methanol, ethanol, DME (Dimethyl ether), E-fuels and hydrogen, ammonia emerges as uniquely promising because of its storage characteristics, energy density, and global availability.

Why Ammonia? Advantages and Constraints

Candidate Renewable or Carbon Neutral Fuels (1/2)

Fuel	Formula	Type	Ignition
Gasoline	C_8H_{18}	Fossil	Spark (SI)
Diesel	$C_{12}H_{23}$ or $C_{14}H_{30}$	Fossil	Compression (CI)
Ethanol	C_2H_5OH	Renewable	SI or CI
Methanol	CH_3OH	Renewable	SI or CI
Di-methyl ether (DME)	CH_3-O-CH_3	Renewable	CI
Di-ethyl ether	CH_5-O-CH_5	Renewable	CI
Hydrogen (750bar, 25C)	H_2	Carbon free	Spark (SI)
Hydrogen (750bar, -120C)	H_2	Carbon free	Spark (SI)
Ammonia	NH_3	Carbon free	SI or CI

- For all renewable/zero carbon fuels, internal combustion engines must use high excess air and/or high exhaust gas recirculation to reduce NOx; hence highly turbocharged.
- Ideally, renewable/zero carbon fuel technology should retrofit



Production and Historical Context of Ammonia

Ammonia has been produced at scale since the early 1900s through the industrial Haber-Bosch process, revolutionising agriculture and enabling global population growth. It is widely used in fertilisers, chemicals and industrial processes, giving it deep infrastructural roots around the world. More than 200 million tonnes are produced annually, with established logistics for pressurised storage, shipping and handling.

Physical and Chemical Properties of Ammonia:

- Liquefies at ~10 bar at 25°C, similar to LPG.
- Has a density of ~610–620 kg/m³, offering useful energy per storage volume.
- Is stable and non-flammable compared to hydrocarbon fuels—but toxic.
- Has a high auto-ignition temperature and very slow flame speed, making combustion difficult in traditional engines.

These properties make ammonia safer to store and transport than hydrogen and many hydrocarbons, while offering straightforward shipboard handling.

Combustion Challenges and Engineering Solutions

Jean-Pierre explained that ammonia's slow burn rate and poor flammability necessitate ignition assistance: typically spark-ignited hydrogen or a 5–15% diesel pilot injection. Even then, combustion can be unstable, with unburned ammonia "slip" entering the exhaust stream. To resolve this, modern ammonia engines rely on Selective Catalytic Reduction (SCR) aftertreatment, which ironically uses ammonia as a reagent, making integration efficient.

The difficulty of burning ammonia is offset by its excellent logistics, energy density per storage volume and global supply chain, making it a front-runner for maritime and off-road applications.

Blue and Green Ammonia Production

As the world decarbonises, ammonia can be produced in several ways:

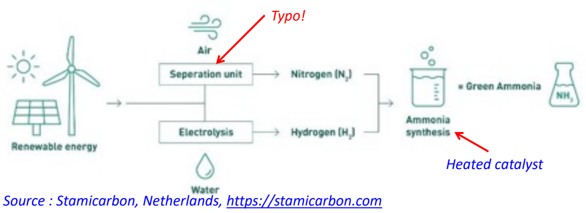
- Grey: from natural gas without carbon capture.
- Blue: natural gas + carbon capture.
- Green: electrolysis-derived hydrogen combined with nitrogen.

Jean-Pierre highlighted international developments in sun-rich regions such as Morocco, Namibia, the Gulf States, Australia and the Mediterranean, regions that can produce green ammonia at large scale for export. Although green ammonia requires substantial energy input, it represents a safe, transportable, carbon-neutral fuel that is available this decade.

"Clean" Ammonia production Characteristics

Aspect	Green Ammonia	Blue Ammonia
Hydrogen source	Water (via electrolysis)	Natural gas
Energy source	Renewable electricity	Fossil fuel
CO_2 emissions	Near-zero	Reduced, but not zero
Carbon capture	Not needed	Required (CCS)
Fossil fuel use	None	Yes
Long-term sustainability	Very high	Transitional

Green Ammonia Production



Source : Stamicarbon, Netherlands, https://stamicarbon.com

Also: Norway, https://info.topsoe.com> green-ammonia , https://yara.com>corporate-releases/green-ammonia etc

Ref: https://royalsociety.org/topics-policy/projects/low-carbon-energy-programme/green-ammonia/

Implication: high energy input...high costs...but a safe transportable fuel, available ca.2025

Current Ammonia Production Rates

- **200 million tonnes NH_3 globally annually**
- **0.5 million tonnes green NH_3 annually**
- **5 million tonnes of green and blue NH_3 annually**
- **(Ref ~4.33 billion tonnes annually petroleum products)**

Real-World Deployment: Maritime Leads the Way

Ammonia's most promising near-term use is in large maritime engines, where energy density, global logistics and safety frameworks align. Jean-Pierre noted several active developments:

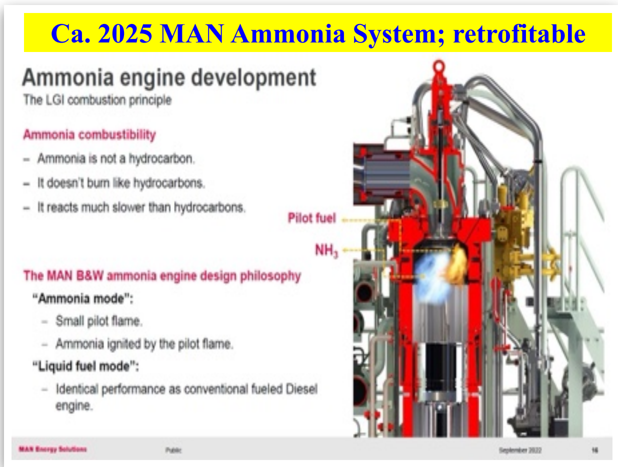
- The Fortescue Green Pioneer, which in March 2025 underwent UK Maritime & Coastguard Agency inspection in Southampton, demonstrating regulatory readiness.
- Yara Eyde and other ammonia-powered vessels now under construction, with bunkering infrastructure expanding.
- Anticipated deliveries of 40,000-tonne ammonia carriers and tugboat demonstrations in Tokyo Bay using IHI engines.
- Major engine OEMs, including WinGD, Wärtsilä, J-ENG, MAN and Bergen Engines, are developing or certifying ammonia-capable engines, with some already receiving commercial orders. WinGD alone has over 30 orders for its X-DF-A ammonia engines for bulk carriers, tankers, and LPG/NH_3 carriers.

This industrial momentum strongly suggests that ammonia engines will enter mainstream maritime use well before 2030.

Ammonia as a Hydrogen Vector

Jean-Pierre emphasised that ammonia is not just a fuel, it's a hydrogen carrier. Since hydrogen is difficult to store, transport, and manage safely at scale, ammonia offers a chemically stable, energy-dense, globally tradable way to move hydrogen around the world. Once delivered, ammonia can be burned directly or cracked back into hydrogen.

For regions with vast renewable resources, ammonia becomes a strategic export commodity, mirroring today's LNG trade.



Limitations and Appropriate Use-Cases

Despite its advantages, ammonia remains toxic and unsuitable for public-facing applications such as passenger cars or buses. Jean-Pierre argued that ammonia is best used in:

- Marine vessels
- Heavy-duty off-road equipment
- Remote power units
- Large stationary engines

These applications have robust safety management and large fuel storage volumes, making ammonia practical and economical.

Conclusions

Jean-Pierre concluded that electrification alone cannot deliver Net Zero, especially for hard-to-electrify sectors. Carbon-neutral fuels are essential and ammonia is among the most promising due to its:

- Established global production
- Mature logistics and storage systems
- Compatibility with retrofitted combustion engines
- Potential for rapid scale-up
- Role as a hydrogen vector
- Suitability for maritime and heavy-duty applications

Although ammonia is toxic and requires careful handling, it offers a near-term, technically viable, and strategically scalable means of decarbonising global transport and power units where electrification is inadequate. Jean-Pierre suggests that ammonia, particularly blue ammonia initially, followed later by green ammonia, could play a major role in the 2025–2050 decarbonisation strategy, helping bridge the gap between fossil fuels and a hydrogen-based future.

Questions

As usual, questioning was lively at the end of Jean-Pierre's talk:

- Aircraft and ammonia? Probably not. The Aircraft Industry seems to be focussed on Hydrogen, partly because it's easier to keep it cold at high altitude.
- Subsidies necessary to promote and build Ammonia fuelled vehicles and ships? No. The new regulations constraining emissions seem to be sufficient to drive Ammonia engine production.
- Where will cheap, renewable Hydrogen (necessary in the interim, for making Ammonia) come from? A likely source will be sunny countries (e.g. North Africa) using solar cells to electrolyse water.
- Are there any Ammonia fuelled gas turbines? Yes, at least one has been installed in a Power Station (in Australia??).
- How is the UK doing re Ammonia engines? Alas we are no longer an engine producing country; its all gone to the Continent, China, Japan, (and USA??).
- If alcohol based fuel is so good, are we likely to see more of it? Currently it has a ready, but limited, source in the form of waste products from the food industry (e.g. grain husks) and maybe also wood waste. But the World needs food itself as a priority crop, and hence can't devote too much land to direct fuel production.

David James (with a little help from Mike Wooldridge and Microsoft CoPilot)

Talk

Tuesday 10th March 2026

Converting a 160ton concrete WW2 petrol carrying barge into a 6 bedroom houseboat (plus some notes on the similar technology used for the WW2 Mulberry harbours)

Mike Wooldridge - Member

In Feb 1997, Mike and his wife Chris, were presented with an opportunity to buy a houseboat originally described as a 'gentleman's yacht', and its associated freehold mooring in Shoreham harbour. The yacht was beyond economic restoration. The likely auction price for the package was stated as £15k to £20k. Even with the decrepit yacht, this seemed like a good price as the mooring had the potential to accommodate a larger [house]boat and one in better condition. So, with the help of a substantial maternal loan, they purchased the package the following week. See picture 1.

Picture 1

Pictures 2 and 3 give some idea of the Riverbank. The mooring is 'dry' for some 80% of the time which makes it relatively easy to work on the mud. There are a number of interesting boats (and owners) in the community. Picture 3, a postcard of which is also available in the Tate gallery, gives some idea of what can be done in the absence of Council Planning Permission. Though, at the time of our purchase, the local Council

Picture 2

Picture 3

(ADC) said we ought to apply for same, if bringing a new boat in. But a subsequent test case ruled that boats are regarded as chattels, and hence Planning Permission is not required, though it is required for jetties and change of use of the boat relative to the conditions stated when West Sussex County Council originally sold the moorings.

Picture 4

Having bought the boat, the next job was to find a larger, 'sounder' boat for conversion to houseboat use. Mike went to the library, and studied the Yellow Pages (obsolete now?) for marine boat yards in London, Portsmouth and Southampton. After about 4 phone calls, a helpful marine surveyor said "What you want is WW2 concrete, petrol carrying barge. There's one for sale in Plymouth [actually Torpoint marina]".

So the following weekend, a trip was made to Plymouth, and picture 4 shows the aforementioned barge. Both Mike and his wife did feel slightly daunted, but being an Engineer is surely about problem solving and getting things done. So, after getting ADC planning permission, they bought the barge for £4,500 and negotiated with the Marina to keep the boat moored there a bit longer, whilst a new, more substantial jetty was constructed back in Shoreham. See pictures 5 and 6 for jetty construction shots.

Picture 5

Picture 6

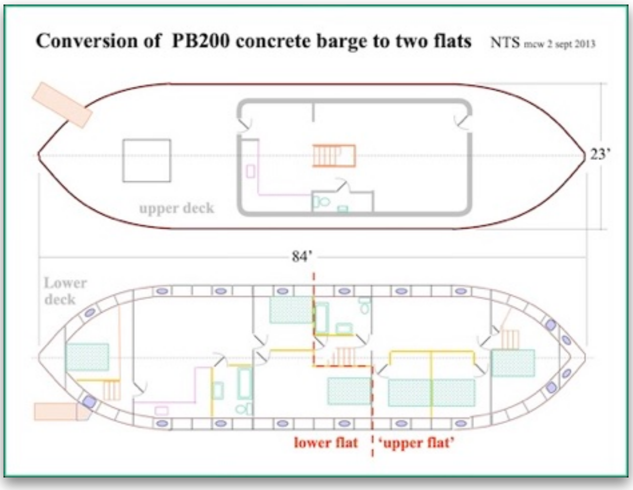
Planning then commenced for the tow. This involved a study of predicted tide heights, getting insurance cover (WSCC insisted on £1m before they'd open the Shoreham footbridge), finding a tow boat, talking to the Shoreham harbourmaster, and finding a temporary quay to moor up to before undertaking the final short tow to the Riverbank mooring itself. Picture 7 shows the hired Plymouth scallop boat (c/w 4' diameter propeller) alongside the barge which has just been tied up to the 'business' quay some 250m downstream from the footbridge. The tow took 36 hours. Note the pile of rolled 'bulb-section' steel beams on the deck. These came off a Bristol channel passenger boat being broken up in Torpoint; they were subsequently used for the new top cabin roof on the [yet to be converted] barge.

Picture 7

Picture 8 shows the barge subsequently being towed through the footbridge opening. This is the old concrete footbridge; it needed 4 or 5 council workers c/w with hammers and cold chisels to open it! No charge.

To a great sigh of relief, the barge was finally moored to its new jetty, using a 'post and collar' at the south end and stainless steel ropes passing under the barge at the north end. This configuration avoids the need for ropes from the mud to the top deck, which have to be slack enough to allow for tidal rise, thus permitting an awkward movement in settling position when it comes to accommodating gangplanks and service connections.

Picture 8



Picture 9

Picture 10

Picture 9 shows the ADC approved plans for the barge accommodation. They involve the diamond drilling of some 18 porthole/doorway openings in the hull sides, a further 3 door openings cut in the bulkhead walls, and a new top cabin built from Thermalite blocks (c/w cavity walls with foam slabs in the cavity). Picture 10 shows construction part way through, and picture 11 shows one of the home made cast concrete window frames used for the top cabin.

Picture 12 shows the diamond drilling of the hull side openings in the north (main) bedroom; the finished bedroom being

Picture 11

Picture 12

Picture 13

Picture 14

Picture 15

shown in picture 13. The next two pictures show sewerage and gas connections being made.

Picture 14 shows our home-made 7' augur, using a worm gear reduction gear box (ex scrap yard) driven by a Black and Decker drill, going through the Riverbank. This was after getting appropriate permissions from the Environment Agency for the hole, and Southern Water for the connection into the town sewer running along the bottom of the riverbank.

Picture 15 shows the DIY laying of a 63mm gas pipe along the riverbank. Transco were happy enough to supply the pipe, but did not want anything to do with the trench that had to be dug (with EA permission) along the bank.

Pictures 16 and 17 show the finished boat.

Picture 16

Picture 17

Moving on now to the WW2 Mulberry harbours, there was just time to show a few pictures relating to the concrete structures that were used, as these used the same engineers and contractors as were used for the barge construction. Actually the Mulberry project was so huge that it used most of the big UK civil engineering firms for some two years while they constructed the components. Picture 18 shows some of the 147 caissons that were cast (not all as big as the ones shown) and then used, together with block ships, to form artificial breakwaters about a mile out to sea off the Normandy coast.

Picture 18

And picture 19 show some of the 460 pontoons (aka ‘beetles’) that were constructed to support the floating roadways that conveyed vehicles from the ‘Pierheads’ (not shown) to the French coast. By the end of Mulberry B’s 10 month life some 500,000 vehicles had been unloaded!

Picture 19

Researching facts for the Mulberry harbours revealed enough material for a stand alone talk on its own; but, regrettably, there was only time to show a few minutes of this at the end of the houseboat talk.

The Mulberry structures, plus the 200 petrol carrying barges (see pictures 18 and 19), show just how useful and under-rated, concrete can be when it comes to making floating structures – especially in time of war when the more normal ‘steel’ approach is thwarted due to the high demands being made on steel elsewhere.

During questioning, Mike was asked if the mooring was freehold. He said that the County Council owned some of the bank, but the rest had been sold to the boat owners. He was also asked if the boat had originally been fitted with an engine. He said, no, it was a ‘dumb barge’. Since it is connected to mains services it is now classed as a house, rather than a ‘wasting asset’, and hence attracts Capital Gains Tax (unless, of course, it is one’s Principal Private Residence)’.

Mike Wooldridge,

Talk

Tuesday 14th April 2026

Net Zero – Challenges for the UK Power Grid

Roger Arthur CEng, MIET

Roger provided a copy of his slides, so what follows is a summary of the slides that he used and includes a glossary of terms on page 25.

1. Career Overview (Slides 2–4)

- Roger’s career includes roles as:
  - Assistant Field Tech Engineer (CEGB)
  - Commissioning Engineer (Merz & McLellan)
  - Project Engineer (Ewbank Preece)
  - Engineering Manager (NatWest)
  - Director of Engineering (Select Power Ltd)
- Project experience includes large power stations (Longannet, Dounreay), work in Malaysia, Falklands airfield infrastructure, and UK data centres.

2. Malaysian Posting and Prai Power Station Project (Slides 5–19)

- In 1975, Roger was posted to Prai Power Station in Peninsular Malaysia.
- Project: Add 3 × 120 MW oil-fired generating units to existing 3 × 30 MW.
- Involved:
  - 3-year design phase + 2 years construction/commissioning.
  - Major electrical design challenges: high fault levels, voltage regulation.
  - Large DOL boiler feed pump motors requiring tight starting constraints.
- A dramatic incident occurred where a 147 MVA generator transformer (≈106 tonnes) fell into the sea during unloading due to a crane/

barge failure. It was never recovered and had to be replaced.

3. UK Grid Discussion (Slides 20–50)

3.1 History and Governance (Slides 20–22)

- Before 1990, the CEGB managed generation and transmission with engineering accountability.
- Today, responsibilities are distributed across National Grid and six Quangos, including DESNZ and the Climate Change Committee.
- Political cycles and statutory constraints limit continuity of decision-making.

3.2 Critical Grid Stability Concepts (Slides 22–26)

Key requirements for reliable grid operation:

- Adequate MW and MVAr reserve.
- Rotational inertia to limit RoCoF.
- Fast, discriminative protection systems.
- Black start capability.
- Cost-effective operation.

Conventional synchronous generators have embedded:

- Rotational inertia,
- MW and MVAr capability,
- Support for system stability,
- Ability to help clear faults.

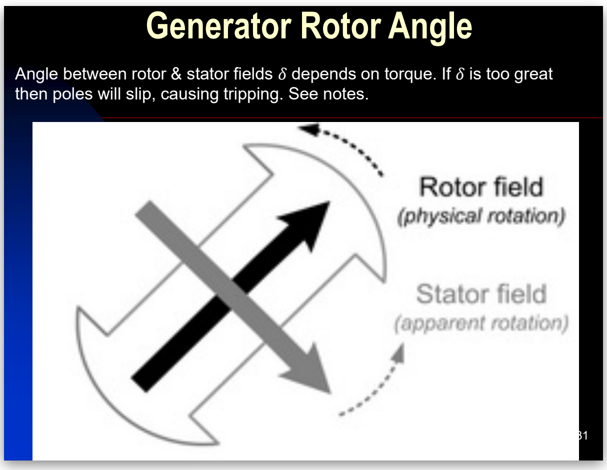
Wind/solar inverters do not inherently provide inertia or reserve power.

3.3 Decline of Conventional Reserve and Emerging Risks (Slides 23–30)

- Historically, the grid ran ≈80 GW of dispatchable generation for ≈60 GW maximum demand.
- Current and future systems rely heavily on variable renewable energy (VRE) with limited reserve.
- Issues highlighted:
  - 2019 UK blackout: insufficient spinning reserve → load shedding after ~1.3–2 GW trip events.
  - 2025 Iberian blackout: dominated by solar/wind with low inertia; over voltage tripping, caused U/F load shedding, cascade failures and wide-area collapse.

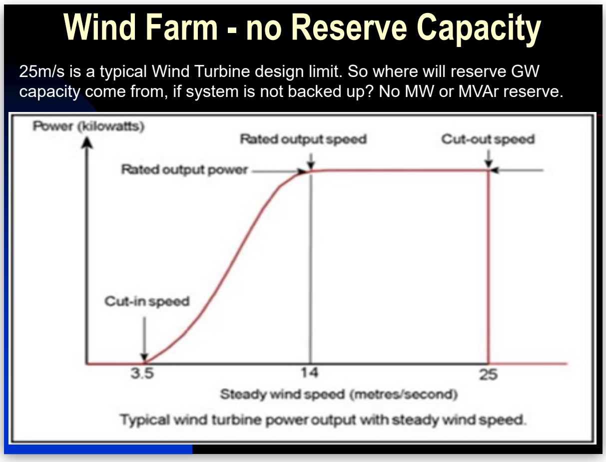
3.4 Technical Stability Factors (Slides 31–33)

- Generator rotor angle stability is critical; excess angle causes pole slipping and generator trips. It caused disconnection between Iberian and French systems.
- Synchronous condensers are being added to restore MVAr and inertia but do not provide MW backup. So MW and MVAr will have to be balanced separately.
- Inverters may trip on undervoltage due to current limits, reducing fault-ride-through capability.



3.5 Wind and Reserve Challenges (Slides 34–37)

- Wind turbines cut out at high wind speeds (>56 mph); periods of strong winds may shut down tens of gigawatts. So where will reserve GW capacity come from, if system is not backed up? No MW or MVAr spinning reserve.
- By 2035 Scotland could host ~50 GW of wind → loss of even 20–30 GW in storms must be covered.
- NESO plans rely heavily on batteries and pumped storage, but the presenter questions their adequacy.
- EVs, heat pumps, data centres and new housing will significantly increase maximum demand.



3.6 Data Centres and Storage Options (Slides 38–41)

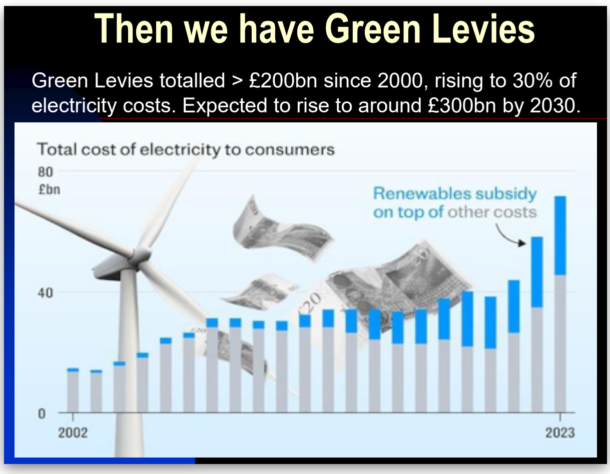
- Data centre demand may reach 10 GW by 2035.
- Energy storage options listed:
  - Grid-scale batteries,
  - Pumped hydro,
  - Gas turbines (NG or H_2),
  - Hydrogen fuel cells.
- NESO forecasts ~100 GWh of batteries (≈2 hrs at 50 GW load), but presenter doubts whether this can reliably meet peak needs or be recharged in time.

3.7 MVAr Capacity, Inverters and Grid-Forming (Slides 42–43)

- Loss of synchronous generation reduces natural MVAr reserve.
- ~30 GVA of synchronous condensers planned.
- Concerns raised about inverter capabilities:
  - How many have grid-forming functionality?
  - Can they ride through faults?
  - Can they distinguish between grid loss and short-circuit events?

3.8 Cost Considerations & Alternatives (Slides 44–48)

- Estimated capital cost of current Net Zero grid plans: £480–800 bn (excluding levies).
- Wind operation and replacement cycles are expensive; backup costs are not always included.
- Green levies have exceeded £200bn since 2000, possibly reaching £300bn by 2030.
- Alternative proposed path:
  - Expand nuclear + CCGT fleet,
  - Reduce dependence on offshore wind subsidies,
  - Restore system inertia and natural reserve capacity through dispatchable generation,
  - Focus on value-for-money and long-term stability.



3.9 Verification Questions (Slides 49–50)

Open concerns requiring further analysis:

- How many renewables can provide grid-forming capability?
- Is sufficient MW/MVAr reserve planned?
- Will embedded generation be visible to grid control systems?
- Are black-start strategies robust with high inverter penetration?
- Can 2030/2035 Net Zero timelines be realistically met?

The slide-50 summary lists 10 key conclusions, including:

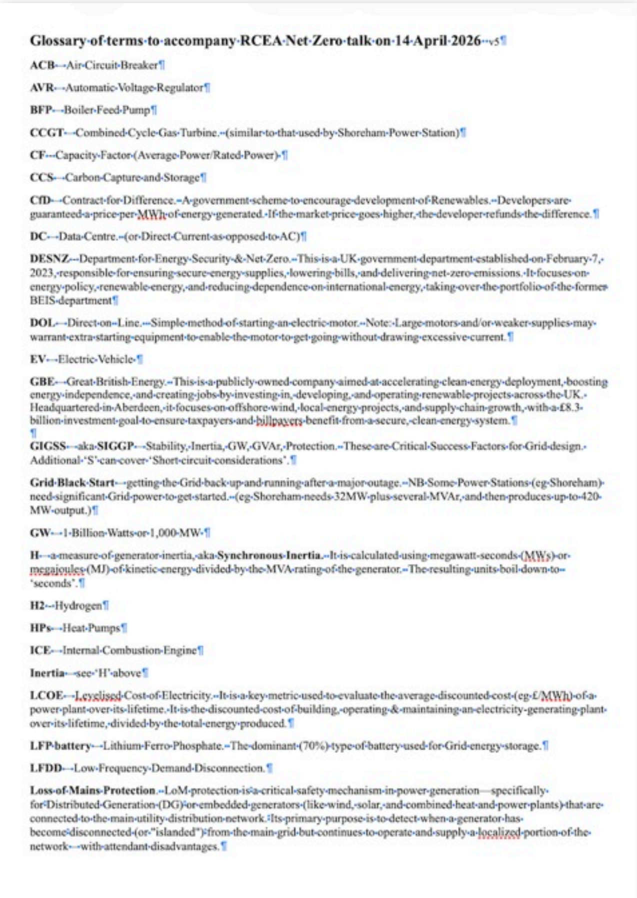
- Reserve GW capacity appears inadequate.
- Synchronous condenser modelling needed.
- Protection and black-start arrangements require verification.
- Value for money favours Gas + SMRs.
- Net-zero-2030 target should be deferred.

Roger drew attention to the ratio of solar/wind to conventional generation in Iberia, which was around 4:1 and that by 2035 the UK's will be 10:1.

We will have almost 200GW of solar & wind capacity. Not only will there be insufficient spinning reserve to cope with widespread cut out of wind turbines when wind speed rises above 56mph, but (having seen what happened in Iberia) imagine a windy sunny day in the UK with 70GW of solar and 125GW of wind belting out, with less than 40GW of consumer demand.

Roger asked, "what will there be to stop all of that embedded generation tripping out?"

He also provided the audience with a list of acronyms that are used in his slides:



Glossary of terms to accompany RCEA Net Zero talk on 14 April 2026 v5

ACB – Air Circuit Breaker

AVR – Automatic Voltage Regulator

BFP – Boiler Feed Pump

CCGT – Combined Cycle Gas Turbine. (similar to that used by Shoreham Power Station)

CF – Capacity Factor (Average Power/Rated Power)

CCS – Carbon Capture and Storage

CfD – Contract for Difference. A government scheme to encourage development of Renewables. Developers are guaranteed a price per MWh of energy generated. If the market price goes higher, the developer refunds the difference.

DC – Data Centre. (or Direct Current as opposed to AC)

DESNZ – Department for Energy Security & Net Zero. This is a UK government department established on February 7, 2023, responsible for ensuring secure energy supplies, lowering bills, and delivering net-zero emissions. It focuses on energy policy, renewable energy, and reducing dependence on international energy, taking over the portfolio of the former BEIS department

DOL – Direct on Line. Simple method of starting an electric motor. Note: Large motors and/or weaker supplies may warrant extra starting equipment to enable the motor to get going without drawing excessive current.

EV – Electric Vehicle

GBE – Great British Energy. This is a publicly owned company aimed at accelerating clean energy deployment, boosting energy independence, and creating jobs by investing in, developing, and operating renewable projects across the UK. Headquartered in Aberdeen, it focuses on offshore wind, local energy projects, and supply chain growth, with a £8.3 billion investment goal to ensure taxpayers and billpayers benefit from a secure, clean energy system.

GIGSS – aka **SIGGP** – Stability, Inertia, GW, GVAr, Protection. These are Critical Success Factors for Grid design. Additional 'S' can cover 'Short circuit considerations'.

Grid Black Start – getting the Grid back up and running after a major outage. NB Some Power Stations (eg Shoreham) need significant Grid power to get started. (eg Shoreham needs 32MW plus several MVAr, and then produces up to 420 MW output.)

GW – 1 Billion Watts or 1,000 MW

H – a measure of generator inertia, aka **Synchronous Inertia.** It is calculated using megawatt-seconds (MWs) or megajoules (MJ) of kinetic energy divided by the MVA rating of the generator. The resulting units boil down to 'seconds'.

H2 – Hydrogen

HPs – Heat Pumps

ICE – Internal Combustion Engine

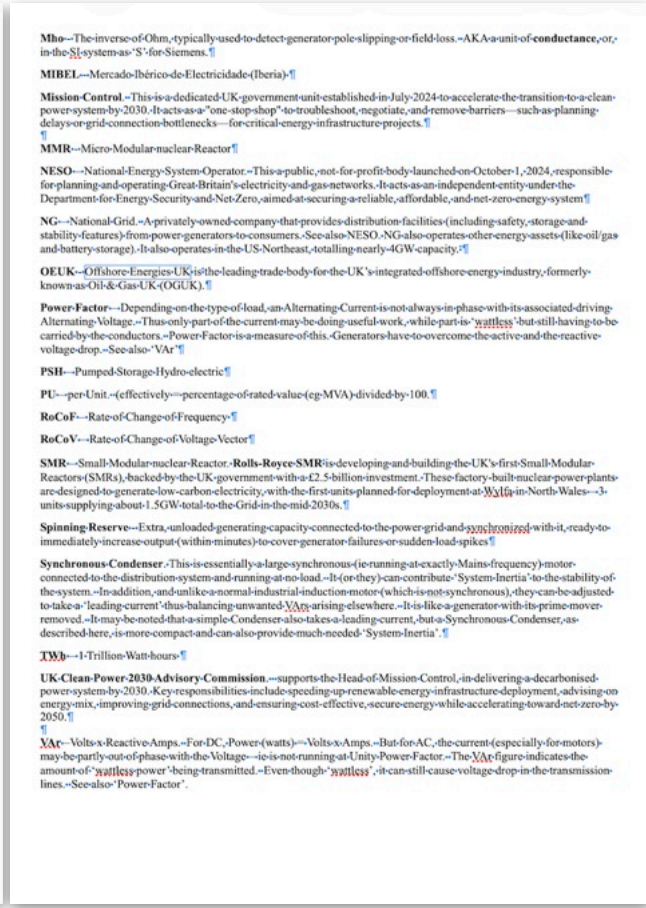
Inertia – see 'H' above

LCOE – Levelised Cost of Electricity. It is a key metric used to evaluate the average discounted cost (eg £/MWh) of a power plant over its lifetime. It is the discounted cost of building, operating & maintaining an electricity generating plant over its lifetime, divided by the total energy produced.

LFP battery – Lithium Ferro Phosphate. The dominant (70%) type of battery used for Grid energy storage.

LFDD – Low Frequency Demand Disconnection.

Loss of Mains Protection. LoM protection is a critical safety mechanism in power generation—specifically for Distributed Generation (DG) or embedded generators (like wind, solar, and combined heat and power plants) that are connected to the main utility distribution network. Its primary purpose is to detect when a generator has become disconnected (or "islanded") from the main grid but continues to operate and supply a localized portion of the network – with attendant disadvantages.



Mho – The inverse of Ohm, typically used to detect generator pole slipping or field loss. AKA a unit of **conductance**, or, in the SI system as 'S' for Siemens.

MIBEL – Mercado Ibérico de Electricidade (Iberia)

Mission Control. This is a dedicated UK government unit established in July 2024 to accelerate the transition to a clean power system by 2030. It acts as a "one-stop shop" to troubleshoot, negotiate, and remove barriers—such as planning delays or grid connection bottlenecks—for critical energy infrastructure projects.

MMR – Micro Modular nuclear Reactor

NESO – National Energy System Operator. This a public, not-for-profit body launched on October 1, 2024, responsible for planning and operating Great Britain's electricity and gas networks. It acts as an independent entity under the Department for Energy Security and Net Zero, aimed at securing a reliable, affordable, and net-zero energy system

NG – National Grid. A privately owned company that provides distribution facilities (including safety, storage and stability features) from power generators to consumers. See also NESO. NG also operates other energy assets (like oil/gas and battery storage). It also operates in the US Northeast, totalling nearly 4GW capacity.

OEUK – Offshore Energies UK is the leading trade body for the UK's integrated offshore energy industry, formerly known as Oil & Gas UK (OGUK).

Power Factor – Depending on the type of load, an Alternating Current is not always in phase with its associated driving Alternating Voltage. Thus only part of the current may be doing useful work, while part is 'wattless' but still having to be carried by the conductors. Power Factor is a measure of this. Generators have to overcome the active and the reactive voltage drop. See also 'VAr'

PSH – Pumped Storage Hydro electric

PU – per Unit. (effectively = percentage of rated value (eg MVA) divided by 100.

RoCoF – Rate of Change of Frequency

RoCoV – Rate of Change of Voltage Vector

SMR – Small Modular nuclear Reactor. **Rolls-Royce SMR** is developing and building the UK's first Small Modular Reactors (SMRs), backed by the UK government with a £2.5 billion investment. These factory-built nuclear power plants are designed to generate low-carbon electricity, with the first units planned for deployment at Wylfa in North Wales – 3 units supplying about 1.5GW total to the Grid in the mid 2030s.

Spinning Reserve – Extra, unloaded generating capacity connected to the power grid and synchronized with it, ready to immediately increase output (within minutes) to cover generator failures or sudden load spikes

Synchronous Condenser. This is essentially a large synchronous (ie running at exactly Mains frequency) motor connected to the distribution system and running at no load. It (or they) can contribute 'System Inertia' to the stability of the system. In addition, and unlike a normal industrial induction motor (which is not synchronous), they can be adjusted to take a 'leading current' thus balancing unwanted VArs arising elsewhere. It is like a generator with its prime mover removed. It may be noted that a simple Condenser also takes a leading current, but a Synchronous Condenser, as described here, is more compact and can also provide much needed 'System Inertia'.

TWh – 1 Trillion Watt hours

UK Clean Power 2030 Advisory Commission. – supports the Head of Mission Control, in delivering a decarbonised power system by 2030. Key responsibilities include speeding up renewable energy infrastructure deployment, advising on energy mix, improving grid connections, and ensuring cost-effective, secure energy while accelerating toward net zero by 2050.

VAr – Volts x Reactive Amps. For DC, Power (watts) = Volts x Amps. But for AC, the current (especially for motors) may be partly out of phase with the Voltage – ie is not running at Unity Power Factor. The VAr figure indicates the amount of 'wattless power' being transmitted. Even though 'wattless', it can still cause voltage drop in the transmission lines. See also 'Power Factor'.

Questions

At the end of Roger's talk the following questions were asked by the audience:

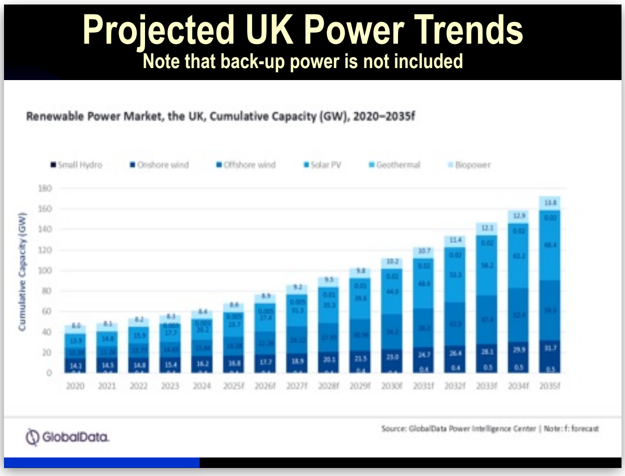
1. Can the problem of a lack of inertia be solved using batteries and some electronics? The electronics enables batteries to follow the existing frequency, but not generate it.
2. Can some turbines lead or lag the grid frequency? No, all turbines move frequency together.
3. What about solar panels? The inverter to which the panels are connected follow the grid frequency.
4. Could a solar panel be used locally without being connected to the grid, for example to heat a storage heater? Yes, although you would still need an inverter.
5. There seems to be a serious problem that politicians don't understand. Could the Professional Engineering Institutions tell them? The response from the audience was that the voters need to tell the politicians, so PEIs need to educate the voters.

The following images are a selection from Rodger's Appendix slides, providing supporting information:

NESO Plans for 2035

By 2035 Grid MD will likely have risen to around 85GW, while the despatchable power supply will be around 20GW – TWh is covered but not GW

	Grid System						
	2025				2035		
Demand	300	TWh		Demand	450	TWh	
MD	50	GW		MD	85	GW	
	Despatchable Power (GW)						
	2025				2035		
Gas	Nuclear	EU inter	Total	Gas	Nuclear	EU inter	Total
40	6.5	10	56.5	15	4.64	20	39.64
MD			45	MD			85
Spare capacity			11.5	Spare capacity (exc EU interconns)			-45



Cost of Planned Grid 2035 (ex levies)

2035 Grid based on NESO plan - ex grid upgrades & levies

Energy Source	Rating GW	Capacity Factor	Energy TWh pa	Cap per GW (£bn)	Total Cap (£bn)	Expected Life (yrs)	LCOE £ m/MWh
Wind Off - fixed	80	0.43	301	£2.5	£200	20	£90
Wind Off - float	5	0.43	19	£4.0	£20	20	£100
Wind Onshore	40	0.30	105	£1.1	£44	20	£40
Solar	70	0.10	61	£1.1	£77	30	£40
Sub totals	195		485		£341		
GTG + CCS	15	0.6	79	£6.4	£96	30	£100
Nuclear (Hinkley C)	3.2	0.9	25	£14.0	£45	60	£120
Nuclear (SMRs)	1.4	0.9	11	£4.0	£6	60	£75
Sub totals	19.6		115		£146		
Totals planned	215		600		£487		

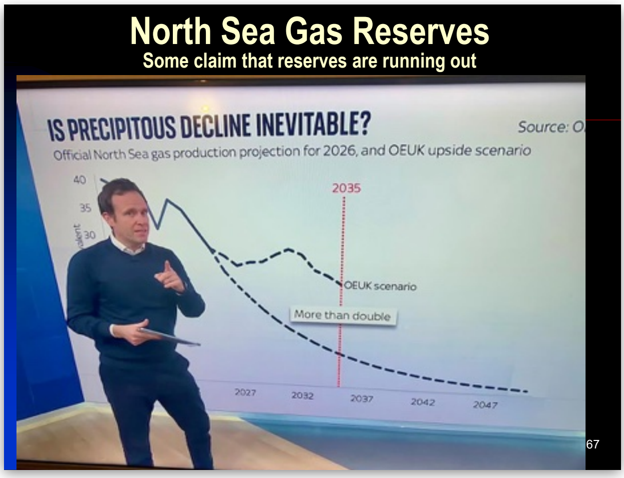
Alternative Option (ex levies)

Extra gen'r capacity: 60 GW for grid load & energy storage recharge.

Energy Source	Rating GW	Capacity Factor	Energy TWh pa	Cap per GW (£bn)	Total Cap (£bn)	Expected Life (yrs)	LCOE £/MWh
GCGTs + CCS	35	0.6	183	£6.4	£224	30	£100
Nuclear (SMRs)	25	0.9	197	£4.0	£100	60	£75
Sub totals	60		380		£324		
Grand Totals	275		980		£811		

Alternative: 450TWh & 80GW from CCGTs & SMRs

Energy Source	Rating GW	Capacity Factor	Energy TWh pa	Cap per GW (£bn)	Total Cap (£bn)	Expected Life (yrs)	LCOE £/MWh
CCGTs + CCS	50	0.60	262	£6.4	320	30	£85
Nuclear (SMRs)	30	0.90	236	£5.0	150	60	£75
Grand Totals	80		498		£470		



UK Solar Panel Output over 5 years

UK has 2nd lowest Solar CF in the world

A	B	C	D
Energy Source	Rating	Capacity	Energy out
Solar	GW	Factor	TWh pa
2021	13.80	0.100	12.1
2022	14.55	0.105	13.3
2023	16.00	0.103	14.4
2024	17.50	0.097	14.8
2025	23.00	0.090	18.0

David James (with a little help from Microsoft CoPilot)

End of Newsletter