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1. Decarbonising Heat is an Emergency too

The UK Government is expected to announce a policy in the next few weeks which could mean banning the sale of gas boilers from 2035. The long-awaited Heat and Buildings Strategy is expected to allow householders to install "hydrogen-ready" boilers instead. These would continue to use natural gas, at least for the time being. They would cost slightly more than a normal gas boiler and there would be a cost of around £250 to switch over to hydrogen. But hydrogen could take years before it is available, and when it is it's likely to cost around three times as much as natural gas. (1)

On the other hand, heat pumps can cost up to £10,000 to install, but hopefully costs will halve within a couple of years. At the moment it might cost slightly more to heat a well-insulated house with a heat pump, but in many cases, it can actually work out cheaper than heating a house with gas.

The third option is to install district heating networks which can use waste heat from things like industry, data centres and sewage works which is piped to homes, hospitals, schools, and offices. Using larger heat pumps warmth may also be sucked out the air rivers and the sea – and from old coalmines. The UK Government expects about a fifth of heat needed for buildings to come from district heat networks. Chris Stark from the government's advisory Climate Change Committee said "*It's really important to get district heating into the discussion. It's so appealing in population-dense cities. And it's the best answer for conservation areas, because it offers a low-carbon solution for housing where it would be difficult or expensive to upgrade the fabric of the building itself.*" (2)

Hydrogen Hype

There is a lot of hype at the moment about hydrogen which, according to Jonathon Porritt, writing in *The Guardian* is:

"*…coming from the oil and gas sector, in the hope that gullible politicians, seduced by an unattainable vision of limitless green hydrogen, will subsidise the vast investments needed to capture the emissions from gas-powered hydrogen. Their motivation couldn't be clearer: to postpone the inevitable decline of their industry*". (3)

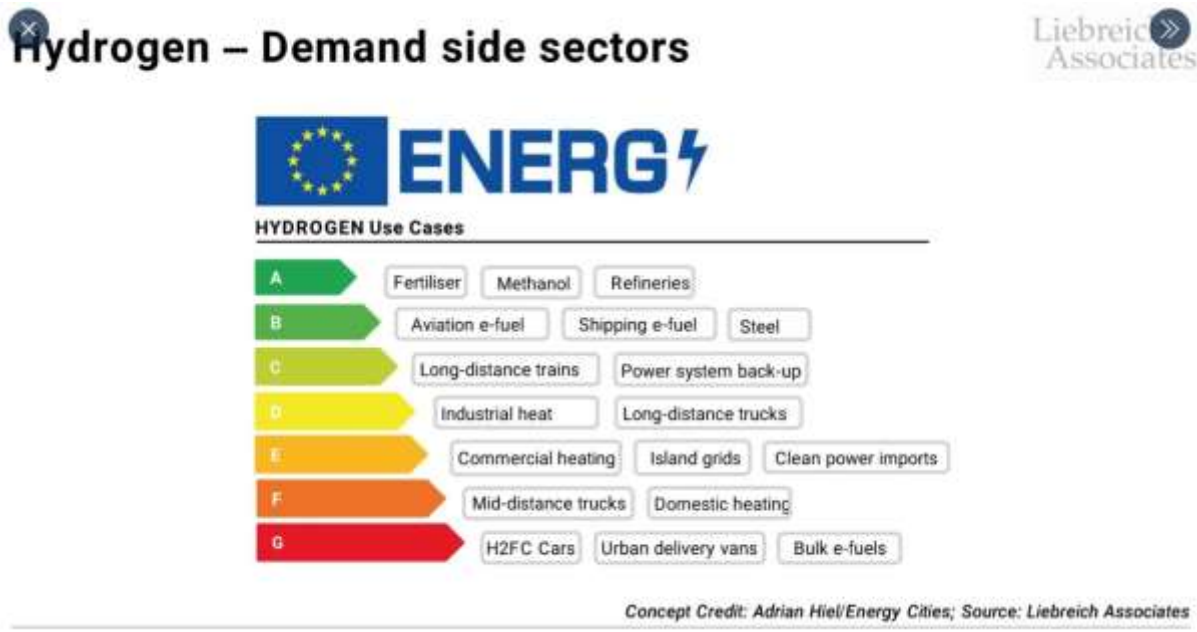
In fact, research shows heavy lobbying by the gas industry to promote hydrogen over heat pumps, with lobbying power stacked in favour of fossil fuel companies. It's no surprise then that hydrogen is high up the policy agenda. (4)

Climate think tank E3G, along with WWF, and Greenpeace have warned the government to ignore the "hype" over the use of hydrogen to provide heat. Electric heat pumps are a much better option. They urged the government to drop funding for "blue" hydrogen which depends on carbon capture and storage and risks keeping the UK hooked on fossil fuels. (5)

Professor Dave Elliott says the battle is clearly on in terms of what type of hydrogen is to be produced and stored. For example, in the UK, the HyNet North West project has been given £72 million of funding for the production of blue hydrogen from natural gas and linked carbon

capture and storage infrastructure, while ITM Power, Orsted and Siemens are working on a green hydrogen 'power to gas' project, using power from offshore wind, and there are plans to use an underground salt cavern to store it. (6)

Fossil fuel industry representatives are even suggesting that there is no need to insulate buildings, all you need to do is replace gas with hydrogen. This argument is deeply flawed and false, say Jan Rosenow from the Regulatory Assistance Project. (7) There are several reasons why using hydrogen for home heating doesn't stack up.



First, hydrogen is an expensive way of heating buildings. It's expected to cost about three times more than fossil gas (even if hydrogen is derived from fossil gas with carbon capture and storage) and twice as much as renewable heating systems. It would increase household energy bills and could push households into fuel poverty.

Tom Baxter, visiting professor of chemical engineering at Strathclyde University, says blue hydrogen will increase fuel poverty. Producing blue hydrogen carries a very poor round-trip efficiency. Natural gas is reformed to hydrogen, the resultant CO_2 emissions are captured and stored, the hydrogen is treated, compressed, stored and distributed to households where it is burned for domestic heating. This chain of delivery steps means that for every 100 kWh of natural gas used to make hydrogen around 35 kWh appears as heat in a property. The upshot is that blue hydrogen will be about 2-3 times the price of using natural gas for heating. The impact that this will have on families already in fuel poverty is obvious.

Although it might be cheaper and less disruptive to install hydrogen ready boilers compared with electrification, there will be much higher CO_2 emissions associated with blue hydrogen both from the reforming process and from the production of natural gas. Heat pump deployment can start now, hydrogen has a long lead time. Many more immediate jobs will be created with heat pump deployment. (8)

Professor David Cebon from the engineering department, Cambridge University says heating buildings with "green" hydrogen would require about six times as much electricity as a heat pump. That means six times as many wind turbines, solar panels or nuclear power stations are needed: hence six times the cost. Although a heat pump is more expensive than a hydrogen boiler, lower energy costs will pay for the investment in about six years. He says if the government wants the UK economy to perform well, it should encourage energy-efficient heat pumps and avoid wasteful hydrogen. (9)

The potential of untapped cost-effective energy efficiency improvements across Europe is still vast. The German Fraunhofer Institute estimates 25% of residential heat demand could be cut through cost-effective insulation measures alone. Cost-effective means the measures pay for themselves – they save more money than they cost to install, benefitting consumers and society. The bottom line is that using hydrogen, as a replacement for energy efficiency actions, is likely to force consumers into a more expensive way of heating and leave them with leaky and inefficient buildings. Using hydrogen as a get out of jail free card to avoid renovating buildings could lock us into an unnecessarily expensive energy future. The focus should be on insulating buildings to ensure they are as energy efficient as possible – saving consumers money and leaving green hydrogen from renewables to help decarbonise industries for which there are few other solutions.

Hydrogen delays action

The other problem is that hydrogen for home heating cannot be introduced quickly enough to tackle the climate emergency. In fact, Dr Richard Lowes, from the University of Exeter's Energy Policy Group argues that the ongoing debate over whether to go for electrification or hydrogen appears to be delaying action. Concerns have been raised that we don't yet know enough to decide between electrification or hydrogen. But this is a dangerous position when time is already tight. This is an emergency, and we need to act now. Hydrogen may play an important role in some sectors of the economy but the widespread roll out of heat pumps will offer significant strategic benefits. In any case hydrogen still needs to be tested at scale in the existing gas network. The one, early stage, in situ trial to test 100 per cent hydrogen is using new pipes. No trials are underway, meaning that the likelihood that anywhere could be converted to 100 per cent hydrogen within ten, or perhaps even 15, years is very slim. (10)

Only known, deployable technologies, i.e. energy efficiency measures, heat pumps and heat networks, are ready to go and can reduce emissions immediately. Alongside this drive, we can of course further investigate what hydrogen may be able to do and when we know more, re-evaluate the optimum pathway.

While the prime minister's target of 600,000 heat pumps a year by 2028 is encouraging, without a thorough and co-ordinated policy package it is simply empty words. There is little to no policy action at all to change the situation. The expected Heat and Buildings Strategy might partly provide this, but heat does not seem to be a policy priority. The Tony Blair Institute for Global Change describes the problem of ramping up heat pump installations from the current 30,000 a year to 600,000 as asking consumers to pay £10,000 for a device which they don't understand, which will increase their energy bill. And that's if you can find an installer to fit it. (11)

Further confirmation that using hydrogen gas as a central heating fuel for homes isn't the best idea comes from Germany's Potsdam Institute for Climate Impact Research. Researchers warn that hydrogen is too inefficient and expensive to rely on for home heating. For most sectors, including home heating and cars, it would be cheaper and greener to use electricity directly, the researchers say. That is because making hydrogen to power a car or heat a home generally requires much more electricity than simply running an electric car or heat pump. The researchers argue that hydrogen-based fuels should be prioritised for use in applications for which they are "indispensable;" those that are tough to electrify, such as long-distance aviation, shipping, feedstocks in chemical production, steel production and some industrial processes. But a full-scale supply chain for green hydrogen is not likely to be up and running for decades. Banking on it to supply cars and homes as well as other major industries such as aviation risks "locking" countries in to high carbon infrastructure (12) because equipment such as "hydrogen-ready" boilers could end up reliant on blue hydrogen and fossil gas continuing to produce carbon emissions. (13)

The research calculated that producing and burning hydrogen-based fuels in home gas boilers required six to 14 times more electricity than heat pumps providing the same warmth. This is because energy is wasted in creating the hydrogen, then the e-fuel, then in burning it. For cars, using e-fuels requires five times more electricity than is needed than for battery-powered cars.

Energy Pricing System is Counterproductive

Current energy prices, are set at levels resulting from the loading of policy costs onto electricity and the lack of a carbon price on gas (there is one on electricity), which means that the energy market is structurally imbalanced towards gas heating.

Nearly a quarter of consumers' electricity bills (23%) are made up of taxes to pay for policies, including subsidies for renewable energy and fuel vouchers for poorer households. These additional costs are acting as a major barrier to get people to switch their heating to heat pumps, at a time when gas prices are lower. Households switching to heat pumps are currently paying on average £408 more in energy bills compared to running a gas boiler.

According to *The Telegraph*, the Government will commit to removing costs from electricity in the coming years in its upcoming Heat and Buildings Strategy. It will consult on how much of the 23 per cent of policy costs will be removed from electricity, and how the £10 billion they bring in will be recouped by the Treasury. The levies could be transferred directly to gas bills, or added to general taxation, but the Government is likely to be wary of any policy that increases taxes or drives up fuel bills. Moving the costs directly from electricity to gas will make the average fuel bill for a home using a gas boiler around £70 more expensive, but would make running a heat pump £200 cheaper than a boiler.

The Heat and Buildings Strategy is also expected to include extra incentives to help with the costs of purchasing and installing a heat pump, which are around four times that of a gas boiler. The strategy is also expected to set targets for owner occupiers to improve the energy efficiency of their homes to at least EPC C level, which the government's advisers have said should be achieved by 2028. (14)

Energy Performance Certificates

Another way in which the Government is discouraging the adoption of heat pumps through the very important 'Energy Performance Certificate' (EPC) system. Incredibly, even when a property is entirely heated using 'resistance electricity, and therefore especially suitable for heat pumps, the standard advice given for energy improvements fails to mention the most important single measure which is likely to be the conversion of the heating system to a heat pump. Part of the problem is that the Government's estimates of the carbon-reducing value of heat pumps is almost a decade out of date. The system still works on carbon outputs from the electricity system of 2012. In that year the carbon footprint of a kWh of electricity was more than twice what it is now. It seems that this disparity will not be changed until at least June 2022 when the building regulations covering energy efficiency are updated. Then the software giving people advice on how to reduce the carbon footprint of their homes might be changed. If we're lucky! (15)

- Scottish Power is planning to build the largest green hydrogen production facility in the UK adjacent to its Whitelee wind farm at Eaglesham, south of Glasgow. The development there would also include a 62,000-panel solar farm and battery storage. The electrolyser, which could be ready in 2023 subject to planning permission, could produce eight tonnes of green hydrogen a day. That would be enough to fuel 550 buses travelling from Glasgow to Edinburgh and back again. The company is also involved in a project to create a hydrogen hub at the Port of Cromarty Firth in the Highlands, which may see the fuel used for transport and industrial processes such as heating up stills at whisky distilleries. (16)

- The nuclear industry is trying to jump on the hydrogen bandwagon. Nuclear provides a perfect solution for the generation of large quantities of hydrogen, according to the European nuclear trade body Foratom. The EU's hydrogen strategy says that between 2020 and 2024 the European Commission will support the installation of at least 6 GW of renewable hydrogen electrolysers, and the production of up to 1 million tonnes of renewable hydrogen. From 2025 to 2030, there needs to be at least 40 GW of renewable hydrogen electrolysers and the production of up to 10 million tonnes of renewable hydrogen in the EU. From 2030 to 2050, renewable hydrogen technologies should reach maturity and be deployed at large scale across all hard-to-decarbonise sectors, it says. Foratom questions whether, given the variable nature of renewable energy sources and the volume of installed capacity needed to provide a continuous supply of electricity to produce this hydrogen, there will be sufficient renewable electricity available to meet demand. In addition, it says this may not be the most cost-effective approach. (17)

- EDF and Rosatom have teamed up to develop low carbon hydrogen projects in Russia and Europe in order to decarbonise mobility and industrial sectors – but their labelling of H2 produced from nuclear power as 'green' is likely to cause irritation elsewhere in Europe. As part of a strategic cooperation agreement signed last month, the hydrogen is slated to be produced both from nuclear power and from methane conversion linked to carbon capture and storage (CCS) technologies. (18)

- It has also been pointed out that for industries which require high temperature heat, advanced nuclear reactor technologies could, theoretically at least, provide that heat directly, rather than converting heat to electricity and using the electricity to make hydrogen suffering thermal efficiency losses in the bargain. (19) U-battery, one of the Advanced Nuclear Technologies funded by the UK Government (see nuClear News No. 131) says its reactor is capable of providing off-grid capacity for energy intensive industries and remote locations that require both heat and power. Steve Threlfall, general manager of U-Battery, says: "*Ultimately, the culmination of hydrogen production as a value-added capability of advanced nuclear energy development would enable a direct link between nuclear and renewables.*" (20)

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2. Old nuclear grinding to a halt

In February it was reported that Centrica had suspended the sale of its nuclear business. Centrica owns a 20% interest in the UK's 8.25 GW of operational nuclear power generation fleet. In 2018 it announced it was looking for a buyer for the stake. The Company continues to look at options, but the divestment process has now been paused mainly because of the graphite cracking issue at Hunterston and Hinkley and pipe corrosion at Dungeness.

The company's nuclear output for 2020 was down 10% year on year to 9.134 TWh, while the achieved price was up 4% to £51.30/MWh. Centrica's nuclear segment made an operating loss of £17 million, down from a £17 million operating profit in 2019. A £525 million impairment charge on power assets included £481 million relating to nuclear, "*largely as a result of a reduction in price forecasts and availability issues at the Hunterston B, Dungeness B and Hinkley Point B power stations*." (1)

Dungeness

EDF Energy is reported to be exploring a range of scenarios for Dungeness B, including bringing forward its decommissioning date of 2028. The Company may decide to start defuelling the reactors seven years early unless a number of "significant and ongoing technical challenges" are overcome.

On 27 August 2018 Dungeness B shut down Reactor 22 for its planned statutory outage. On 23 September 2018 Reactor 21 was also shut down for the planned double reactor outage. Both reactors have been shut since while a multi-million-pound maintenance programme was carried out. This work was due to be completed last year but that timeline changed to August 2021 following a series of delays.

Now EDF say the ongoing challenges and risks "*make the future both difficult and uncertain*". As a result, the energy company is now exploring a range of options - including shutting the station down later this year, seven years ahead of schedule. A statement from EDF reads:

"*Dungeness B power station last generated electricity in September 2018 and is currently forecast to return to service in August 2021. The station has a number of unique, significant and ongoing technical challenges that continue to make the future both difficult and uncertain. Many of these issues can be explained by the fact that Dungeness was designed in the 1960s as a prototype and suffered from very challenging construction and commissioning delays. We expect to have the technical information required to make a decision in the next few months, as it is important we bring clarity to the more than 800 people that work at the station, and who support it from other locations, as well as to government and all those with a stake in the station's future.*"

EDF Energy said it has spent more than £100 million on the plant during its current outage. (2)

EDF's latest announcement was that Reactor 21 might restart on June 6, 2022 instead of Aug. 2 this year and Reactor 22 reactor might restart on May 27, 2022 instead of July 23 this year. (3)

Dungeness B was the first AGR to be ordered in 1965. It was expected to begin operation in 1970/1, but didn't produce commercial electricity until 1989. It is thought to have exceeded its budget by 400%. (4)

Hunterston

In April the Office for Nuclear Regulation (ONR) gave EDF permission for reactors 3 and 4 at the Hunterston to return to service for a limited period of operation after scrutiny of EDF's safety case. Operation is permitted for up to a total of 16.7 terawatt days for reactor 3 and 16.52 terawatt days for reactor 4 – approximately six month's of operation for each. This will be the final period of operation before the reactors are shut-down and the spent fuel removed. (5)

Reactor 3 has already re-started but Reactor 4 is not expected to be back on-line until 9th June. The end date for Hunterston B will be 7 January 2022 at the latest.

Hinkley Point B

On 17th March Hinkley Point B's two reactors were granted permission by ONR to restart. Reactor 4 and Reactor 3 were taken offline on 21 February and 8 June 2020, respectively, for a series of planned inspections of the graphite core. The company plans to run Hinkley's two reactors for six months, pause for further inspections and, subject to ONR approval, generate power for a second six-month period. Last November EDF announced that Hinkley Point B would operate no later than July 2022 before moving into the defuelling phase. EDF has spent £3 million over the past year upgrading the plant while detailed assessments have been completed on the graphite in the nuclear reactors. (6)

Sizewell B

EDF Energy extended the outage at Sizewell B by three months to carry out 'additional work'. The reactor went offline for planned refuelling and maintenance work on April 16, initially scheduled to end on May 29. This has been updated to 30th August following additional work required on some components identified during the shutdown. (7) This is because some steel components are wearing out more quickly than expected, forcing EDF to carry out lengthy unscheduled repairs. (8)

Plant Life Extensions

A look at the age structure of existing nuclear power plants shows the importance of analysing risks of life-time extension and long-term operation. Some of the world's oldest plants are located in Europe. Of the 141 reactors in Europe, only one reactor came into operation in the last decade, and more than 80 percent of the reactors have been running for more than 30 years. Nuclear power plants were originally designed to operate for 30 to 40 years. Thus, the operating life-time of many plants are approaching this limit, or has already exceeded it. The ageing of nuclear power plants leads to a significantly increased risk of severe accidents and radioactive releases.

A new study has analysed the risks of life-time extensions of ageing nuclear power plants. At present, life-time extensions in Europe do not have to be comprehensively relicensed according

to the state of the art in science and technology. Time limited licenses can be extended by decision of the competent authorities. However, such decisions do not meet the requirements of Nuclear Power Plant licensing procedures in regard to public participation. More often than not environmental impact assessments with public participation are not carried out. However, the situation has changed with the ruling of the European Court of Justice of 29th of July 2019 on the life-time extension of the Doel NPP (Belgium) and the new guidance under the ESPOO Convention. Accordingly, environmental impact assessments with transboundary public participation are now required for life-time extensions.

However, there are still no binding assessment standards for life-time extensions. It is still up to each regulatory authority to decide what and how to assess. In particular, the authorities are not obliged to carry out a comprehensive licensing procedure in which all safety issues are comprehensively examined according to the current state of knowledge. (9)

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3. International Energy Agency goes for net zero

The International Energy Agency (IEA) has published a landmark report that sets out for the first time its scenario for the global energy system to reach net-zero annual emissions of carbon dioxide by 2050. Significantly, the scenario would mean no new supplies of fossil fuels, with profound implications for the coal, oil and natural gas industries.

The report, Net Zero by 2050: A Roadmap for the Global Energy Sector, acknowledges that countries that have committed to achieving net-zero emissions of carbon dioxide are currently responsible for about 70 per cent of emissions. The UK is among this number and continues to support an offshore oil and gas industry. (1)

The IEA's Net-Zero Emissions by 2050 Scenario (NZE) is intended to be consistent with the objective of having a reasonable chance of limiting global warming to no more than 1.5°C by the end of this century. It concludes: "*Net zero means a huge decline in the use of fossil fuels. They fall from almost four-fifths of total energy supply today to slightly over one-fifth by 2050*." As a result, the report says there is "*no need for investment in new fossil fuel supply*". It states explicitly: "*The trajectory of oil demand in the NZE means that no exploration for new resources is required and, other than fields already approved for development, no new oil fields are necessary. However, continued investment in existing sources of oil production are [sic] needed*."

These findings send a clear signal to the fossil fuel industries that any further exploration for new reserves is likely to be a waste of money.

Associate Professor Dr Sven Teske from the Institute for Sustainable Futures at the University of Technology Sydney said: "*For the first time, the IEA clearly states that investment in fossil fuels needs to stop … It is a very significant finding. New investment in fossil fuels will end up as stranded investments. The finance industry will have to adjust their investment policies immediately*." (2)

The report calls for a "*historic surge*" in renewable energy investment, with public and private finance tripling to US$4 trillion per year by 2030. "*This will create millions of new jobs, significantly lift global economic growth, and achieve universal access to electricity and clean cooking worldwide by the end of the decade,*" the agency writes. (3)

Controversially, the IEA's net zero scenario says it relies on emerging technologies as the middle of the century approaches. "*Most of the reductions in CO2 emissions through 2030 come from technologies already on the market today. But in 2050, almost half the reductions come from technologies that are currently at the demonstration or prototype phase.*"

The IEA report says governments need to quickly increase and reprioritise their spending on research and development – as well as on demonstrating and deploying clean energy technologies – putting them at the core of energy and climate policy. Progress in the areas of

advanced batteries, electrolysers for hydrogen, and direct air capture and storage can be particularly impactful.

This was an unfortunate echo of US climate envoy John Kerry's remarks to the BBC when he said: that half of the greenhouse gas emission reductions that must be achieved by mid-century depend on technologies that don't yet exist. (4)

Sven Teske said "*I strongly disagree with that. The main technologies to decarbonise the global energy system are market-ready, and are either already cost-competitive or will be within the next five to 10 years. The IEA still relies on unproven carbon capture and storage technologies. To take CO2 out of the atmosphere is technical and economically much harder than avoiding the emission in the first place. The main technologies to decarbonise the global energy system are market ready and are either already cost competitive or will be within the next five to 10 years. They are: solar and wind technologies, battery technologies, electric mobility and various technologies to provide industrial process heat. There is no need to wait for more research, the transition to a full renewable energy supply until 2050 can start now.*"

Mark Jacobson, author of "*100% Clean Renewable Energy and Storage for Everything*" says we have 95 percent of the technologies we need today and the know-how to get the rest. No miracle technology, particularly carbon capture, direct air capture, modern bioenergy or modern nuclear power, is needed. By implementing only clean, renewable energy and storage and implementing non-energy strategies, we will address not only climate, but also the 7 million annual air pollution deaths worldwide and energy insecurity. None of the "miracle technologies" addresses all three.

Jacobson's Stanford University team and 17 other research groups have shown that we can do it with renewables alone worldwide and in the 50 United States. Such a transition reduces energy costs, and land requirements while creating jobs. The key is to deploy, deploy, deploy existing clean, renewable, safe technologies as fast as possible. (5)

Writing in the Bulletin of Atomic Scientists, John Carey agrees. He says we already have the basic technologies we need to slay the monster of climate change. Moreover, these technologies are not just affordable now, but they continue to get cheaper (and better) at a stunning pace, and new ideas are constantly emerging. In fact, humanity may look back after 20 or 50 years and wonder why we ever thought it was so hard or so expensive to move beyond the era of fossil fuels.

But we've got to act quickly. Without immediate and dramatic emissions reductions, we face an inevitable future of potentially catastrophic extreme weather—what an article in the journal Nature calls a "rapid and unstoppable" sea level rise, and many other devastating impacts. And if we delay too long, all those feedbacks could eventually push the planet towards a "hothouse Earth" scenario. Carey quotes physicist Ray Pierrehumbert who wrote about renewable technology, "*It is time to stop quivering in our boots in pointless fear of the future and just roll up our sleeves and build it.*" (6)

The IEA said nuclear would make a 'significant contribution' in its scenario. The scenario projects that the amount of energy supplied by nuclear power will increase by 40% by 2030 and

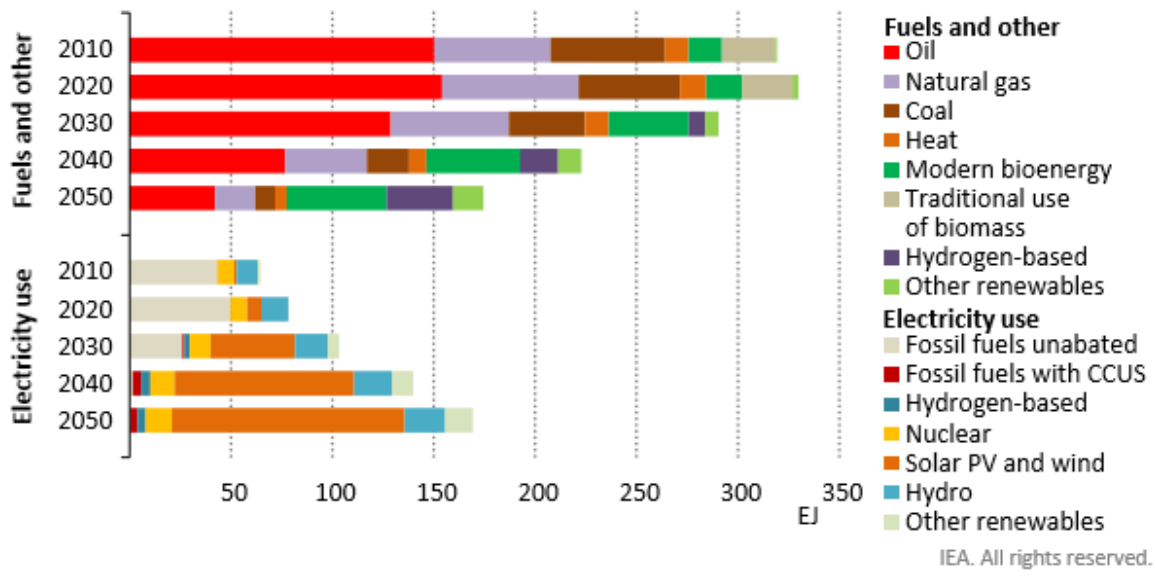
double by 2050, and that new nuclear capacity will reach 30 GW per year in the early 2030s. An important component of nuclear generation, particularly in the shorter term, will be extended operations of existing nuclear reactors, as they are "*one of the most cost-effective sources of low-carbon electricity*".

Even so, the World Nuclear Association (WNA) was not satisfied. Nuclear energy can contribute "much more", the Association said. In addition to electricity, nuclear energy can generate zero-carbon heat, thus having the potential to contribute to tackling decarbonisation far beyond electricity generation into other hard-to-abate sectors. "*This is an opportunity that the IEA's report barely touches on*." But for WNA it is not just a question of being beaten in the race to provide zero carbon energy by renewables: "*By failing to consider with adequate ambition the contribution that nuclear energy could make, the ability to deliver on the IEA's Net Zero scenario has a much higher risk of failure*," the Association said. (7)

It doesn't seem to have occurred to the WNA that it is too late for nuclear to make much of an impact by 2030. Jacobson says less helpful technologies such as nuclear "*…raise costs to consumers and society, and slow solutions to pollution and warming due to their long planning to operation times … Given the limited time and funding to solve pollution, climate and security problems, it is essential to focus on known effective solutions. Money spent on less-useful options permit more damage to occur*." (8)

As we see from the chart below from the IEA report, most of the energy would come from renewable sources, with the IEA forecasting that solar power will increase 20 times and wind power 11 times by 2050. Electricity use would also grow. Today, about 20 per cent of total energy consumption is electric. By 2050, this would rise to 50 per cent in this scenario. (9)

Figure 2.9 ▷ Global total final consumption by fuel in the NZE



The share of electricity in final energy use jumps from 20% in 2020 to 50% in 2050

Ambrose Evans-Pritchard writing in *The Telegraph* says the IEA have turned the economics of climate change upside down. Slashing CO_2 emissions and switching to renewable energy is not a 'cost' or a constraint on rising affluence: it lifts global GDP growth by 0.4pc a year over the course of this decade. World output is 4pc bigger in real terms by 2030. Net zero does not cost jobs: it replaces five million lost in oil, gas, and coal with eight times as many jobs for engineers, electrical experts, offshore operators, solar technicians, or lithium and rare earth miners, whether directly or indirectly. It does not raise energy costs: it cuts the average bill for households on heating, cooling, electricity, and car fuel from $2,800 to $2,300 a year by 2030 in advanced countries. From then on it is a canter. The energy share of disposable income halves from 4pc to 2pc by mid-century. It is tantamount to free energy. "*…if we did not have a climate crisis, we would need to invent one in order to make humanity richer, healthier, safer, more self-sufficient, and less vulnerable to hostile geopolitics*." (10)

- Is the IEA still underestimating the growth of renewable energy? In conjunction with significant global energy demand reductions from energy efficiency, behavioural change and resource efficiency, two thirds of total energy supply in 2050 comes from wind, solar, bioenergy, geothermal and hydro power in the IEA scenario. Wind and solar comprise the bulk of this. Annual additions of 630 gigawatts of solar PV and 390 gigawatts of wind by 2030, four times the levels now, are required. A report by analytics firm Ember says this entails a scaling up of wind and solar within an extremely short time frame: the IEA is expecting a rate of growth of solar deployment of 22% per year in the next decade. "But after 2030, they expect that declines to 8% a year for the next decade. And then 3% after 2040. Carbon Tracker's Kingsmill Bond told the Renew Economy website that neither of these numbers is credible. The IEA has previously faced criticism for a systemic underestimation of the deployment and costs of renewable energy, particularly solar power. (11)

- David Thorpe points out that the IEA report doesn't deal with greenhouse gas emissions from waste and agriculture/land use change. He says those advocating various means of actively removing carbon from the atmosphere as a way of compensating for our inability to cut these emissions will have to prove that the technologies they propose can step up to the mark. The verdict of Mike Childs at Friends of the Earth UK, quoted in the Financial Times. "On a list of priorities for spending money, CCS would be at the bottom," he says. He favours first massively ramping up renewables, investment in hydrogen, and improving energy efficiency. To which we can add repairing soils and ecosystems, and becoming less reliant on meat products. CCUS is analogous to treating heroin addicts with methadone. It allows addicts to function but doesn't remove the base cause of the problem, the dependency. (12)

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4. Flexibility is a “no regrets decision”

The big challenge in a future grid will be matching electricity, heat and cold and hydrogen demand with 100% renewable supplies and storage.

Now a new report from the Carbon Trust says flexibility could deliver up to £16.7 billion in savings per annum in 2050. As such investing in flexibility is a “no-regrets decision”. Flexibility can be created through a range of technologies, including battery storage, thermal storage, interconnectors and demand side response technologies across domestic, non-domestic and electric vehicle (EV) sectors. Across the different scenarios detailed in the report, up to c.48GW of flexibility from EVs, 12GW from domestic smart appliances, 11GW from non-domestic DSR, 83GW of battery storage and 900GWh of thermal storage were deployed. (1)

The report outlines how the nation’s electricity demand could treble by 2050, against a 2019 baseline, as sectors including transport and heating become increasingly electrified – and how the costs associated with this shift can be minimised. (2)

Key findings include: Embedding greater flexibility across the entire energy system will reduce the cost of achieving net zero for all consumers while assuring energy security; Investing in flexibility is a no-regrets decision as it has the potential to deliver material net savings of up to £16.7bn per annum across all scenarios analysed in 2050; A more flexible system will accelerate the benefits of decarbonisation supported by decentralisation and digitalisation; To maximise the benefits of flexibility, households and businesses should play an active role in the development and operation of the country’s future energy system as energy use for transport, heat and appliances becomes more integrated. (3)

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