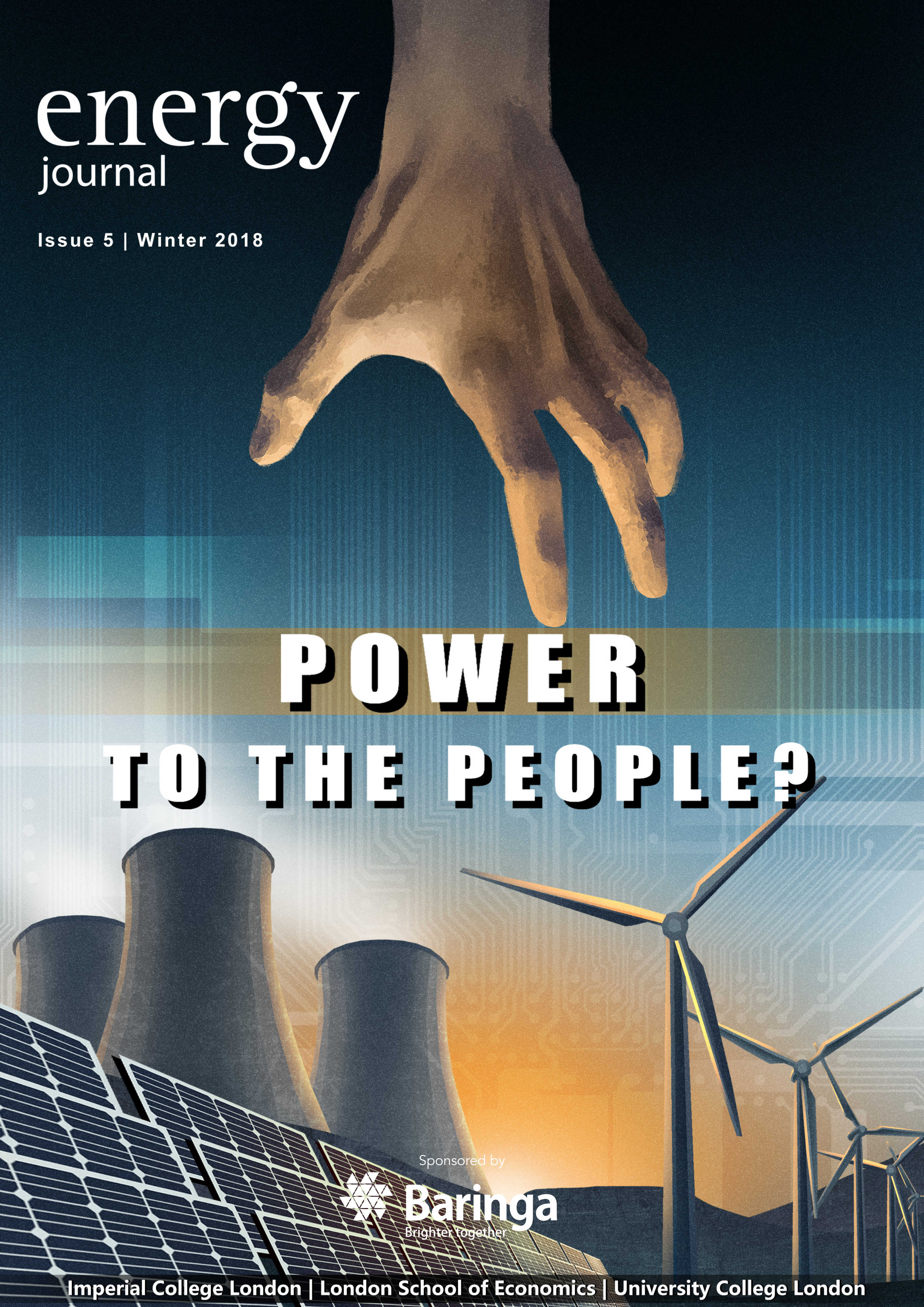
energy
journal

Issue 5 | Winter 2018



POWER TO THE PEOPLE?

Sponsored by
Baringa
Brighter together

Imperial College London | London School of Economics | University College London

Baringa
Brighter together

Summer Internship 2019

Are you looking for an interesting, intellectually stimulating internship with a management consultancy? In a company that values its culture as highly as the work it does? In a business where the people are always put first? With colleagues you value and trust? We can provide you with all of that and more.

Baringa Partners is an independent business and technology consultancy, working across Energy, Financial Services, Consumer Products & Retail and Telecoms, Media & Technology

We help businesses run more efficiently, reach new markets and navigate industry shifts. We use industry insights, pragmatism and original thought to help each client transform their business

Baringa Partners was recently voted the No.1 Management Consultancy in the UK 'Energy, Utilities and Environment' Sector by clients in Financial Times 2018 poll.

We are also delighted to be ranked the second Best Workplace in Large Workplaces for businesses with 500+ employees by Great Place to Work ® UK. This is the 12th consecutive year we have been recognised for our positive, innovative and stimulating company culture.

What we're looking for

Our eight-week summer internship programme will give you a first-hand view of life in an award-winning management consultancy firm. You will gain an understanding of the consulting business model as well as valuable experience on aspects of the consulting project lifecycle, business analysis and client engagement techniques.

Following our induction training course you will join one of our current assignments working on a real client project as a valued member of the team. We will provide you with a 'buddy' from the business unit you're working for to ensure you have a friendly face to ask questions of during your time with us.

How to apply

Further details on the programme and how to apply can be found at: http://bit.ly/2A1jk86

Application deadline: 6th January 2019

"The best thing about my internship at Baringa was the level of support offered throughout – both from my project team and the wider internship team. There is a huge focus on the personal development of each intern, with constant constructive feedback and a solid support network. The culture at Baringa really is extraordinary; everyone is approachable, no matter what grade, which creates a really welcoming atmosphere. The socials are not only great fun but a testament to how people-focused Baringa is and the encouragement towards a healthy work-life balance. Working on interesting projects with some of the brightest minds in the industry, and having a fun time along the way, is a pretty winning combination.

Martha Samano, Analyst - Energy (Summer Intern 2017)

energy
journal

Editor in Chief	**Kathryn Jaitly**
Executive Publisher	**Irene Escobar Castells**
Director of Content Creation ICL	**Humera Ansari**
Director of Content Creation LSE	**Matt Piggins**
Director of Content Creation UCL	**Ayobami Adeyemo**
Director of Graphic Design	**Hongyi Wan**
Assistant Director of Online Content	**Maria Wood**
Director of Online Content	**Ayrton Bourn**
Director of Video Content	**Gabriel Yoong**
Director of Social Media	**Mike Steventon**
Assistant Director of Social Media	**Sarah Patterson**
Director of Chinese Relations	**Sophie Wei**
Assistant Director of Chinese Relations	**Emily Lui**
Director of External Relations	**Muhammad Waabis**

Authors

Fatemeh Alemi, Joana Barragan, Maddie Cole, Harry Collini, Annabelle De-Bigaul, Sachin Gulati, Adriaan Hilbers, Rhea Iai, Sharada Joshi, Maximillan Maier, Dimitris Mavrokapnidis, Shayan Moghaddam, Sofia Russi, Kirin Tantinon, James Warren Johnson, Mingchuan Zheng

About

The Energy Journal is a biannual publication focused on current energy affairs. It is a collaboration between LSE, Imperial and UCL students, making it the largest student-for-student energy magazine in print. We're working to create a high-quality Journal whilst creating a community of like-minded people.

Want to get involved? Email us at energyjournalonline@outlook.com, or find us on social media.

"It is this balance between the democratic will of the people and everything else – our innovations, our technology, and the businesses that create them – that makes this topic so interesting."

Editor in Chief Kathryn Jaitly

Dear Reader,

Thanks for picking us up. Without your support, we wouldn't have made it to where we are now. We have released five issues, seen across three major university campuses across London. We have built a website, various platforms and a Journal that is worth reading. This is amazing, and things are only looking better for us. We have been nominated for the Bright Network Society of the Year Innovation Award – a massive achievement for us. We're thankful that you've been on this journey with us.

So much has changed since the creation of the Journal. This is a really interesting time in the energy world – our politics is volatile, and our planet's ecosystem is fragile. The release of the IPCC Report should be a massive red flag to us all. Our planet is not coping and we are in serious danger of destroying our futures. We know this, yet it can sometimes seem like our actions are futile. It is this balance between the democratic will of the people and everything else – our innovations, our technology, and the businesses that create them – that makes this topic so interesting.

Have a great Christmas, and see you next year!

Kathryn Jaitly,
Editor-in-Chief.

01

News in Brief

"I would encourage you: be informed. Knowledge is power."

Matt Bevin

Fracking has officially started in Blackpool. The first shale gas from the site was detected just two weeks into operations – **"evidence of potential"** in the site. However, drilling caused many minor earthquakes. Considering the UK's stringent regulations for **earthquakes** created by drilling, this may have caused Cuadrilla to stop operations regularly to the cost of approximately **£94,000 per day**.

Elon Musk has experienced a few interesting months. Following his **accusations of paedophilia** against Vernon Unsworth, the British diver who took part in the Thai Boys' Rescue, he took to Twitter again to claim the **company was going private** – a fraudulent act if true. This, in addition to **missed Tesla production targets** and him **smoking weed** on the Joe Rogan Podcast, led to a lack of confidence in his public image and therefore his resignation from his role as Chairman of Tesla. He **remains CEO**.

The **UK Labour Party** pledged in its manifesto that it would run the country's power supply on **80% solar, wind and nuclear** by 2030. While the Labour Party touted this at their Conference, the reality is that most of the new zero carbon energy will come from nuclear generation, meaning new nuclear sites will need to be built to make these plans feasible.

SSE and **Npower's** planned merger may be delayed due to the UK Government's plans to put a **price cap** on energy bills for consumers. The companies still plan on moving forward with the merger, but analysts expect delays as new terms are brought to the table by both companies. The merger would decrease the "Big Six" energy retailers to the "**Big Six**"; it was approved by competition watchdogs in October.

Vivergo Fuels, one of two UK-based wheat-to-ethanol plants, is planned to shut down for good. Managing Director Mark Chesworth stated the proposed cessation was due to the Government's **refusal to back E10**, a proposal to include 10% bioethanol in unleaded petrol. The temporary closure of Ensus, the other major UK bioethanol plant, by CropEnergies in November will not help pessimism about reaching the UK Government **target of 10% decrease in transport emissions by 2020.**

The IPCC released a special report detailing the impacts of **global warming of 1.5°C** above pre-industrial levels. Their report indicated that global greenhouse gas emissions need to be cut **45% by 2030** in order to keep warming below the 1.5°C threshold. To reach this target will require strong use of renewables/nuclear, with a strong possibility of **Carbon Capture Storage** (CCS) being needed to avoid long-term threats.

The European Court of Justice ruled that the **UK's capacity market constitutes illegal state aid** to fossil fuel producers. The **£1bn market** will be put on hold until the UK can obtain permission to resume payments from the European Commission. The capacity market **compensates baseload generation facilities** for their availability, attempting to ensure the proper provision of electric generation when intermittent sources are unavailable.

Toshiba has liquidated **NuGen**, its nuclear construction subsidiary in the UK. This was tied to plans to withdraw from the planned **Moorside** site. According to press releases, the decision was purely **commercial** but brings into question viability of new-build nuclear reactors in the UK.

The **Trump administration** has tabled a plan to **bailout failing coal and nuclear generation** in the United States. The plan, originally presented as a Notice of Proposed Rule Making at the United States Federal Energy Regulatory Commission (FERC), would have provided selected coal and nuclear plants the **cost-recovery rate for their facilities.** FERC rejected the original proposal, but a leaked memo indicated the Department of Energy was considering moving forward with the bailout under the **auspices of national security.**

In June, the **Indian government increased its target of renewable energy generation** to 227 GW by March 2022. Amidst falling prices of solar and wind energy worldwide, India's targets are estimated to **require an investment of $50bn**. The new goal would make India the **third largest market for renewable energy** in terms of capacity—behind only the United States and China.

Bloomberg New Energy Finance (BNEF) projects that multicrystalline solar module prices **will fall 34% in 2018.** BNEF estimated that this decline will be the **largest a single year since 2011,** when prices fell by 40%. The decline is **driven by oversupply**, caused in large part by a reduction of feed-in-tariff prices and a cap on new project development in China.

02

Focus: Power to the People?

A power shift? The digital transformation in the oil industry

Sharada Joshi. Imperial College London
sharada.joshi17@imperial.ac.uk

Once upon a time, around thirty years ago, the oil industry was at the forefront of technological innovation, pushing boundaries with creations born out of necessity, such as digital well logs, electrical submersible pumps and 3D seismic imaging tools, which use sound waves to create a 3D image of geological formations. In years following, the focus shifted. As oil prices skyrocketed in 2011, the aim became maximizing production and, in relative terms, technology took a backseat. However, with oil prices currently at $72/barrel, the narrative has shifted again. The players in this tumultuous market have started looking to new technologies, driven by the need to become more efficient in order to remain profitable. But as companies embark on this digital transformation, a natural question emerges: How will this affect the people working there? Is power being transferred from the people to the latest technology?

An example of the industry's latest endeavour to embrace technology is BP's partnership with Beyond Limits, an American artificial intelligence company based in Los Angeles. The aim is to utilise cognitive artificial intelligence (AI), a system that uses models to simulate human reasoning when faced with complex problems by 'learning' how geologists and petroleum engineers think; it then mimics their approach when faced with challenges. The benefits are huge – AI can catalogue unused ideas from discussions between engineers, it can bring up relevant suggestions when a problem needs to be solved quickly, and, because it has been trained by experts (who will at some point retire), it can digitally store their knowledge and expertise for the benefit of future generations. Does this mean that fewer engineers will be needed in the upstream sector in the future? According to the Journal of Petroleum Technology, "many analysts do not see the mass replacement of human engineering talent on the immediate horizon." This perhaps implies that although the transfer of power from people to

> *"But as companies embark on this digital transformation, a natural question emerges: Is power being transferred from the people to the latest technology?"*

technology is not happening right now, it will inevitably become the reality of the future. Figure 1 shows that post-oil price collapse, the number of oil rigs have increased substantially again, a trend not entirely echoed by industry employment figures. Meanwhile, the production figures show a near-steady increase. Thus, a conclusion that one can perhaps draw from this is that digital transformation has already had some impact in terms of productivity and efficiency on the oil industry; clearly, higher production levels are being achieved by a smaller workforce. But the CEO of Beyond Limits puts forward a different perspective: "We are creating a collaboration between man and machine", he says, "to amplify human talent". Perhaps one could then view this shift not as power to the people, but as the sharing of power between people and technology.

Anadarko is another company undergoing a technological transformation; it now employs almost 20 data scientists in its Advanced Analytics and Emerging Technologies group. Other members include geoscience and engineering experts. The advantage of such a collaboration is immediately obvious – it increases knowledge across all disciplines and promotes creativity. The team aims to test new concepts and accelerate technological development to enhance "competitive advantage in the exploration and production space". An example of such a

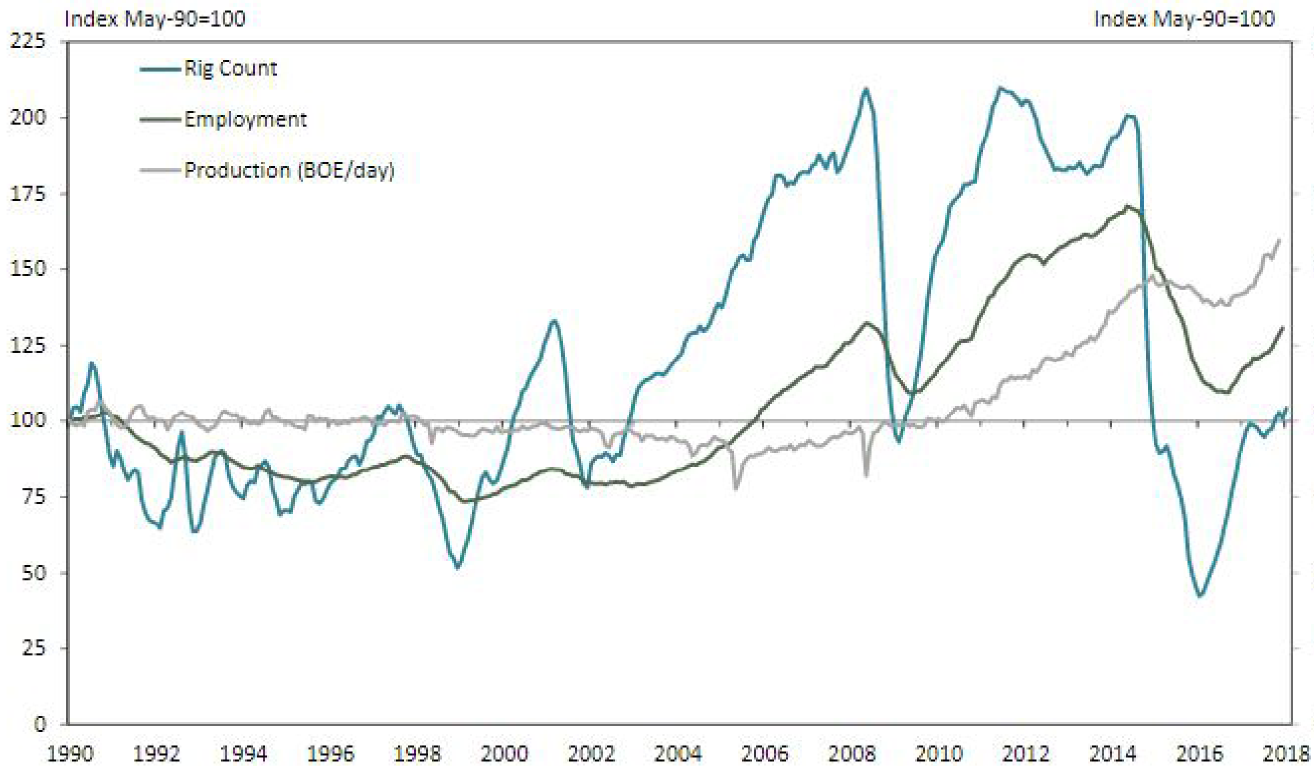


Figure 1. Trend in industry employment and rig count in the USA (Source: kansascityfed)

project is the integrated production surveillance and optimisation platform, IPSO. IPSO, which breaks down and filters data like pressure and temperature changes in wells into digestible and easy-to-monitor bits, was an unprecedented success when it was deployed for use in the Gulf of Mexico; it was fully operational 97% of the time in the first 6 months. To continue such breakthroughs, more data scientists are needed, yet the Journal of Petroleum Technology comments that "the upstream industry has openly acknowledged in recent years that it is not the most attractive sector for data scientists". Thus, it seems that emerging technologies can play a role in encouraging such recruitment and multidisciplinary teamwork, a sure sign that power still remains with the people.

Another major driving force for these investments in technology is safety. An article in Chemical Report reads: "Artificial intelligence can eliminate the health and safety concerns by helping the operators to control critical tasks through automated systems without the need for human presence". Obviously, getting people off platforms has many more benefits than just eliminating health and safety concerns; labour costs are drastically reduced and other costs such as helicopter use are eliminated. Technologies have been rolled out to combat these 'inefficiencies'. The Iron Roughneck connects drill pipe segments, a dangerous and repetitive task previously done by hand. Drones can collect data in five days; it takes rope-access technicians about eight weeks to undertake the same amount of work. So, what happens to the workers when these powers are transferred from people to automation? It's estimated that automated drilling rigs could reduce the workforce on a rig by up to 40% in the future. But Chris Robart, Ambyint's president of US Operations takes on a different view: "We are freeing up individuals to go do other things, like think about new technology, troubleshoot failed equipment, deal with workovers, or new well designs." Clearly, these new tasks require a completely different skillset to the labour-intensive jobs that AI and automation are replacing.

From Iron Roughnecks to drones to the applications of AI, the oil industry has certainly embraced this era of technology, focusing on increasing efficiency and improving safety. This additional power to technology though, comes with additional costs to the people of the workforce. For the foreseeable future at least, oil rigs will not all become fully automated. But we are witnessing the birth of shared power, as machines become increasingly better at tasks humans were employed to do. Where this power shift leads the oil industry, only time will tell.

Asset Stranding in the Energy Sector: Between Coal and a Hard Place

James Warren Johnson. London School of Economics
J.W.Johnson@lse.ac.uk

> *"In order to increase support for a 2°C threshold, policy makers will need to account for the negative socio-economic impacts of transitioning towards a low-carbon economy."*

The Intergovernmental Panel on Climate Change (IPCC) refers to the adoption of a 1.5°C threshold as a matter of life or death for many. However, limiting the rise in average global temperatures to below even 2°C, as per the Paris Agreement, is going to require significant reductions in fossil fuel use. The prospects for coal, the most polluting fossil fuel, are bleak. According to an analysis by McGlade and Ekin (2015), just over 80% of global coal reserves must be left in the ground to keep warming below the 2°C target.

Thus, if national pledges under the Paris Agreement are taken seriously, then the entire coal value chain (figure 1) faces material risks that will negatively impact its future prospects. Although the entire value chain for coal may face disruptions of some sort during this transitional phase, the socio-economic implications for the extraction and generation components remain most sensitive to the risks of asset stranding. This is mainly due to the large capital expenditure requiring stable revenue streams over lengthy time horizons.

Transitional risk factors include changes in policy, technology and sentiment resulting in large-scale disruptions in the economy. Techno-economic paradigm (TEP) shifts have occurred before, and often result in negative socio-economic impacts for various stakeholders. Perez (2002) refers to five such TEPs: the Industrial Revolution; the Age of Steam and Railways; the Age of Steel, Electricity and Heavy Engineering; the Age of Oil, the Automobile, and Mass Production; and currently, the Age of Information and Telecommunications (Caldecott, 2018:5).

Each TEP results in new sectors replacing traditional ones. For instance, the Industrial Revolution ushered in the mechanisation of cotton production making India's cottage textile industry redundant. More recently, the Age of Information and Telecommunication made analogue communication such as typewriters and telegraphs obsolete. For each transition, there are winners and losers. In order to increase support for a 2°C threshold, policy makers will need to account for the negative socio-economic impacts of transitioning towards a low-carbon economy.

According to BP's Statistical Review of World Energy report (2018), although coal consumption increased by 1% in 2017 for the first time in four years, its share of 27.7% in primary energy heralds its lowest point since 2004. When it came to power generation, renewables took the lead accounting for almost half (49%) of the growth, with coal coming in at a close second (44%). Also, almost all the growth in power generation (94%) came from emerging economies, reiterating the importance of developing countries in the transition towards a global low-carbon economy.

The discourse around 'stranded assets' began to gain traction in the early 2010s, as stakeholders started to evaluate the threat of assets becoming stranded in response to the physical and transitional risks associated with climate change. Figure 2 provides a brief overview of the typology of these risks. Although definitions of stranded assets vary across disciplines, the definition by Caldecott et al. (2013) aptly describes them as "assets that have suffered from unanticipated

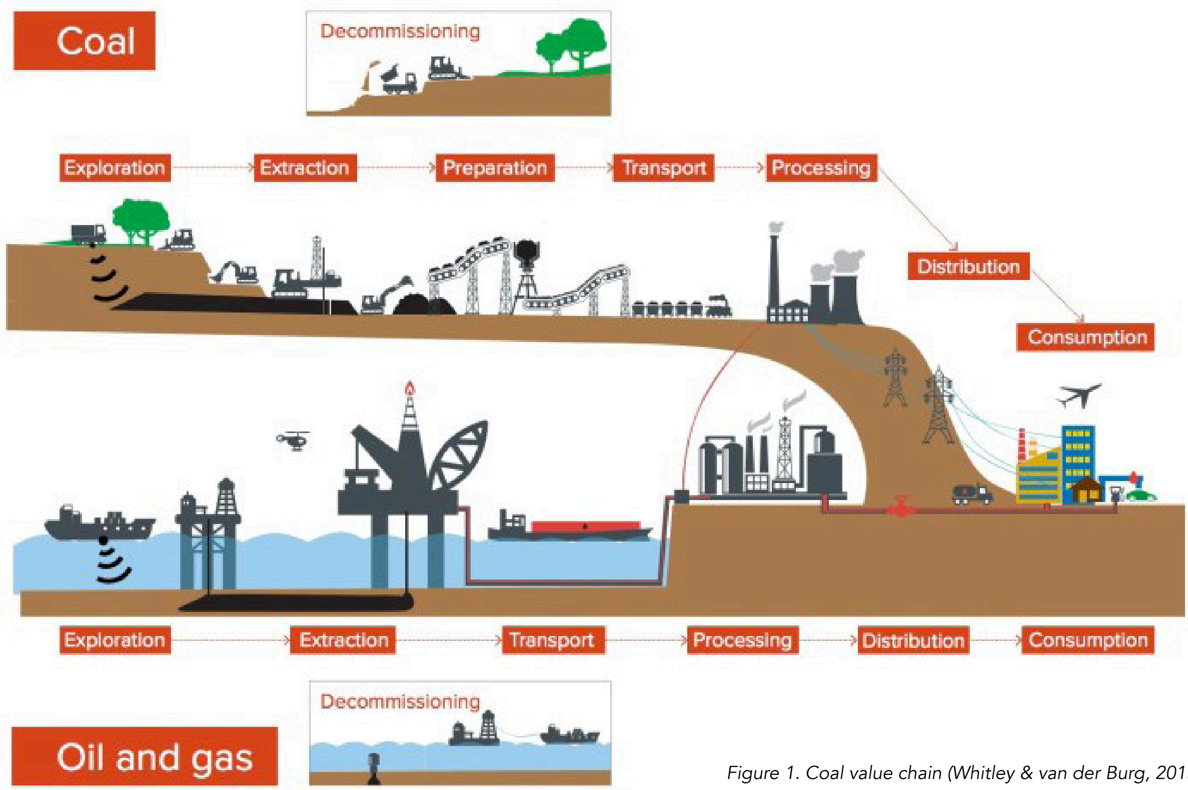


Figure 1. Coal value chain (Whitley & van der Burg, 2015)

or premature write-downs, devaluations, or conversion to liabilities" (Caldecott, Howarth, et al. 2013:5). Caldecott (2018) points out that the transition towards a more sustainable economy can prove unattractive to policy makers when confronted with the implications of value destruction (e.g. job losses, infrastructural write-offs, etc.). For example, the Australian government rejected calls from UN scientists for the phasing out of coal by 2050, stating that it would be "irresponsible" to comply with the recommendation by the United Nation's IPCC to stop using coal to generate electricity. Such a statement is hardly surprising given that coal, Australia's largest export, provides over two-thirds of its electricity. This highlights just one example of the difficulty in persuading policy makers to embrace the transition to a low-carbon economy.

In Germany, twenty thousand miners recently marched through Bergheim demanding protection for their jobs as the coal commission met to draw up a plan to phase out coal-fired power generation. In March of 2017, hundreds of coal haulage trucks descended on South Africa's capital city of Pretoria to protest against the government's plans to close down coal-fired power stations. In March 2018, when the South African authorities sought to finalize contracts to source renewable energy from twenty-seven Independent Power Producers (IPP), the National Union of Metalworkers (NUMSA) rushed to court to block the decision based on concerns around the negative socio-economic impacts.

With an abundance of local coal reserves, South Africa illustrates the difficulties emerging economies face in replacing coal. Although the latest 2018 Integrated Resource Plan retains coal as the dominant source of energy by 2030, emphasis has been place on the inclusion of gas and renewables to meet increased demand. According to the country's Energy Minister Jeff Radebe, "It is evident that close to 75% of the current Eskom coal fleet would have reached end-of-life by 2040." Radebe reiterated that the uptake of renewables was not the cause for job losses in the coal sector, but rather due to the fact that mines were reaching the end of their productive life.

Despite reluctance from certain stakeholders, the construction of thermal coal power plants is in decline. Added to this, these power stations are being retired at an accelerating rate. In the United States alone, 2018 will see a record-breaking twenty coal-fired plants expected to close by year-end. According to Global Coal Plant Tracker, at current rates global coal capacity should

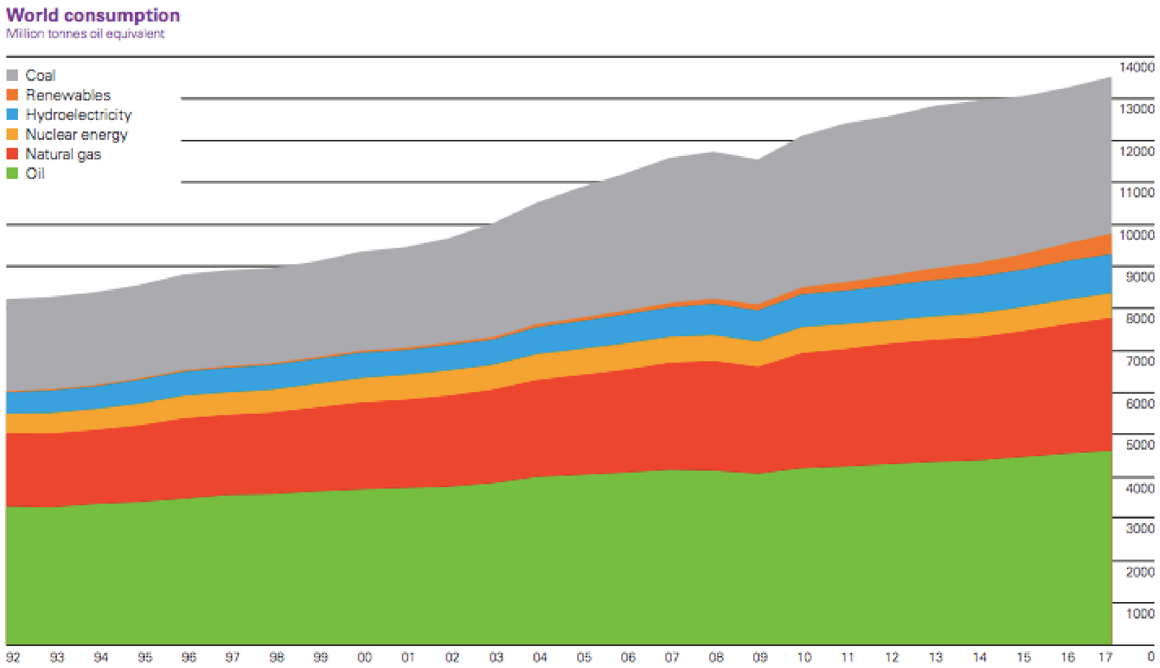


Figure 2. Global primary energy consumption (BP, 2018:10)

peak by 2022. Much of this decline is a consequence of large funders backing away from investing in coal as they try to burnish their environmental credentials. There now exists empirical evidence showing how investors are incorporating the long-term impact of climate change policies on market conditions when evaluating investment decisions (Tulloch et al., 2017).

Power generation assets generally become uneconomical when i) the market price for electricity remains below the marginal cost of generation over the long-term or, ii) generation assets are forced to reduce output by regulators. Carbon taxes form just one example of the various carbon pricing mechanisms being implemented by policymakers around the world (see figure 3). Although the direct impacts of stranded generation assets will be borne primarily by the utility and utility's investors, the indirect negative socio-economic implications can be significant if not handled correctly.

Potential socio-economic consequences include large-scale direct and indirect job losses in the coal mining, and coal-powered generation sectors. Further, any potential increase in electricity prices can increase social marginalisation while negatively impacting those sectors of the economy reliant on stable, low-cost electricity. South Africa, one of the most disparate countries in the world and heavily reliant on coal for its electricity generation, has recently implemented a carbon tax despite having electricity prices increase by around 350% over the last decade. Unfortunately, marginalised members of society are usually impacted the most by these inflationary pressures.

Given the idiosyncratic nature of the risks associated with asset stranding, there is no single method with which to mitigate the negative socio-economic impacts involved. Each asset class will, depending on its unique regulatory and economic environment, inevitably face its own set of opportunities, risks and challenges. There is no hiding from the fact that the energy sector needs to drastically reduce its reliance on fossil fuels in order to mitigate the impact of anthropogenic climate change. Given the rapidly declining cost of renewables, amongst other factors, evidence suggests that this will happen with or without policy intervention. The question is, who will be the winners and who will be the losers?

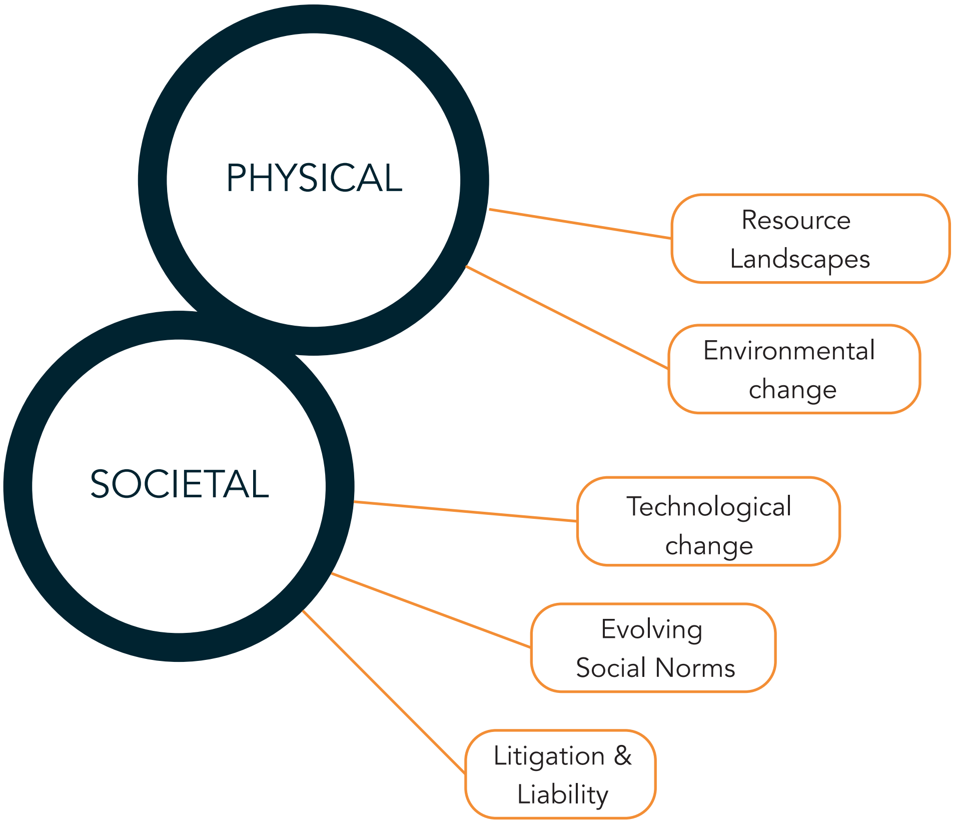


Figure 3. Typology of environment-related risks (Caldecott, Howarth and McSharry, 2013)

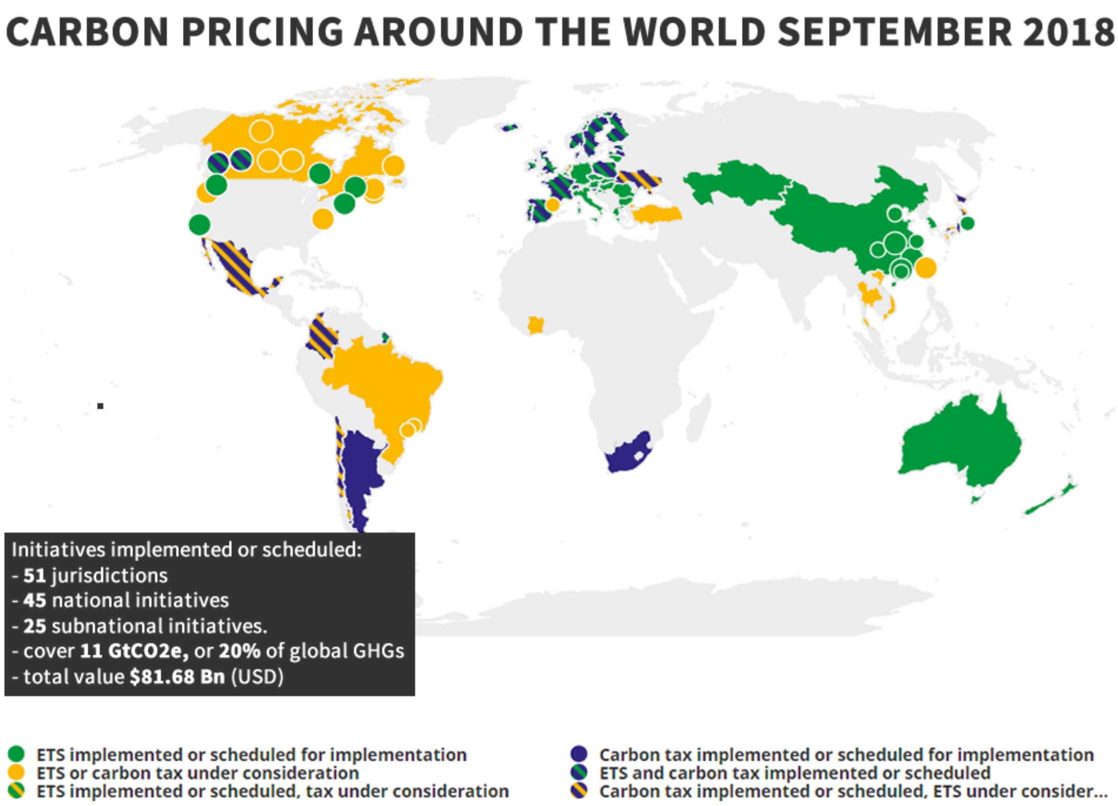


Figure 4. Carbon Pricing Dashboard at the World Bank

Food Waste as Biofuels

Fatemeh Alemi. Imperial College London
f.alemi17@imperial.ac.uk

"Biodiesel is able to reduce greenhouse gas emissions by 45% compared to diesel sourced from crude oil."

The Oil Shortage Crisis of the 1970s was caused by a heavy reliance on imported energy. It demonstrates the importance of finding alternative energy sources to achieve national energy independence and security. The US Energy Independence Security Act of 2007 is one of many responses to move forward towards greater energy independence. It established a mandatory renewable fuel standard where by 2022 the transportation fuel sold in the US was to include 36 billion gallons of renewable fuels such as cellulosic biofuels, starting from a set standard of nine billion gallons in 2008 (Bagheri, Espi, Teresa, & Cacho, 2016). The UK followed suit with the Renewable Transport Fuel Obligation (RTFO) in 2008 as an incentive to encourage the use of biofuels as a more sustainable and greener alternative. In 2015 the UK had a biofuel capacity of producing 1500 million litres annually since the first plant opened in 2005 (Transport, 2013). In 2018 legislation took effect to revise the RTFO to enforce further legislations for additional use of biofuels. Now businesses that supply greater than 450,000 litres of road transport or non-road mobile machinery fuel must report their supply to ensure that a percentage includes renewable and sustainable fuel sources, including biofuels. The use of biofuels is attractive as it provides a means to import less energy as a nation, but also it is driven by the notion that biofuels emit reduced greenhouse gases compared to their gasoline and petrol counterpart. For example, biodiesel is able to reduce greenhouse gas emissions by 41% compared to diesel sourced from crude oil (Hill, Nelson, Tilman, Polasky, & Douglas, 2006).

Waste to Energy (WtE) systems involve the conversion of organic waste such as wastewater sludge, livestock waste, municipal solid waste and agricultural waste for energy production. Biofuels are fuels in liquid or gaseous forms and can be derived from biological processes like fermentation. The production of biofuels is a WtE approach focusing on using biomass; biomass is organic material that is obtainable from a renewable or reoccurring method and therefore can be sourced from plant material, feedstock, crops and forestry. (Skaggs, Coleman, Seiple, & Milbrandt, 2018). This can be achieved through various conversion processes such as (i) thermal processes (combustion, gasification and pyrolysis) and (ii) biochemical processes (microbial digestion and fermentation to ethanol and methane).

Food waste contains carbohydrates, fats and lipids, proteins, phosphates, vitamins and minerals - all which can be converted for biofuel production. Carbohydrates such as starch and cellulose can be converted to bioethanol through alcoholic fermentation and distillation processes (biochemical conversion), or a wet milling process that helps further separate and extract the sugars needed for bioethanol synthesis, the most widely used liquid biofuel (Balat, 2007). Lipids from vegetable oils and fats (methyl esters) are used to produce biodiesel via transesterification with the use of an alkoxide catalyst; also non-catalytic transesterfication can be achieved using a supercritical fluid (Demirbas, 2007). Examples of natural sources are provided in Figure 1.

Food waste for biofuels has received a fair amount of interest, as food waste is often a zero value resource that is thrown away in vast quantities without further use. Food waste disposed in landfills causes a rise in methane emissions, risk of leaching and produces a bad odour in the vicinity; the landfills also take up space and therefore are expensive. The Organisation of Petroleum Exporting Countries (OPEC) estimates that oil and gas will still make up over 52% of the global energy use in 2040 (James Griffin, 2017) which means more can still be done to improve the incorporation of renewable energy, and potentially the use of food waste. Indeed according to the Food and Agricultural Organization of the United Nations, about 1.3 billion tonnes of food waste is discarded globally, with fruits and vegetables having the highest wastage rates. Ideally these can be sourced and re-used for biofuel production from biological processes that also consume CO2 and reduce greenhouse gases in return. This is different to gasoline and diesel, which are refined from petroleum (Gustavsson et al., 2011).

Biofuels can be used as transportation fuels and are generally blended with petroleum-based fuels. Presently nearly all gasoline in the world is used as E10, a 10% bioethanol blend which can be functional in modern cars and is currently used in the US, Canada, Australasia and Europe. The UK however does not offer E10 and continues to offer E5 standard unleaded petrol; nevertheless, the Department of Transport is looking into how it can be introduced with a conference that took place in July 2018 discussing the continual supply of E5 alongside debating the best strategy for widespread introduction of E10 (Agency, 2018). E10 offers reduced harmful emissions of components such as carcinogens of butadiene and benzene, and it allows nations to hit their renewable energy goals and targets. Engine modification is needed to use higher blends of bioethanol, such as E85, which is 51-83% ethanol; this can reduce the net emissions of greenhouse gases up to 37% (Demirbas, 2007). Additionally, biodiesel can be used in diesel engines with little to no modifications. Pure biodiesel is a non-toxic and a biodegradable fuel that produces lower levels of air pollutants compared to petroleum-based diesel fuel.

Alternatively, lignocellulosic biomass can be converted into biooil or biocrude, a dark brown fuel that can be a total or partial substitute for petroleum. The advantage is that it offers fuel oils a source for aromatics or phenols. Pyrolysis or 'cracking' is a thermochemical process, that produces biooil from biomass. However, biooils are not available commercially in fuel stations because they exhibit poor fuel properties and are corrosive. Another option is biogas, produced when organic matter biodegrades under anaerobic conditions. It is commonly prepared from animal manure using anaerobic digesters, consisting of up to 55 – 75% pure methane, but can be produced from nutrient rich sources such as vegetables. State-of-the-art systems report generating biogas that is more than 95% pure methane (California Energy Commission, 2003). Another opportunity is hydrogen that can also be produced from biomass and is useful for internal combustion engines; it can be produced

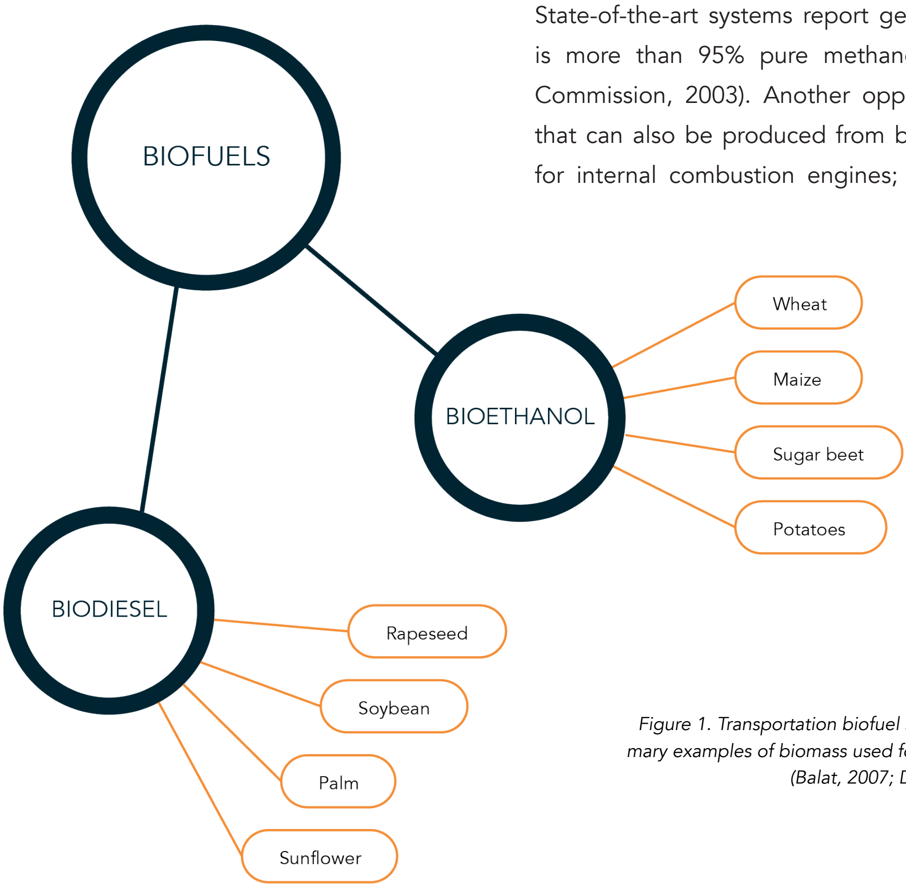


Figure 1. Transportation biofuel sources with primary examples of biomass used for its production (Balat, 2007; Demirbas, 2007).

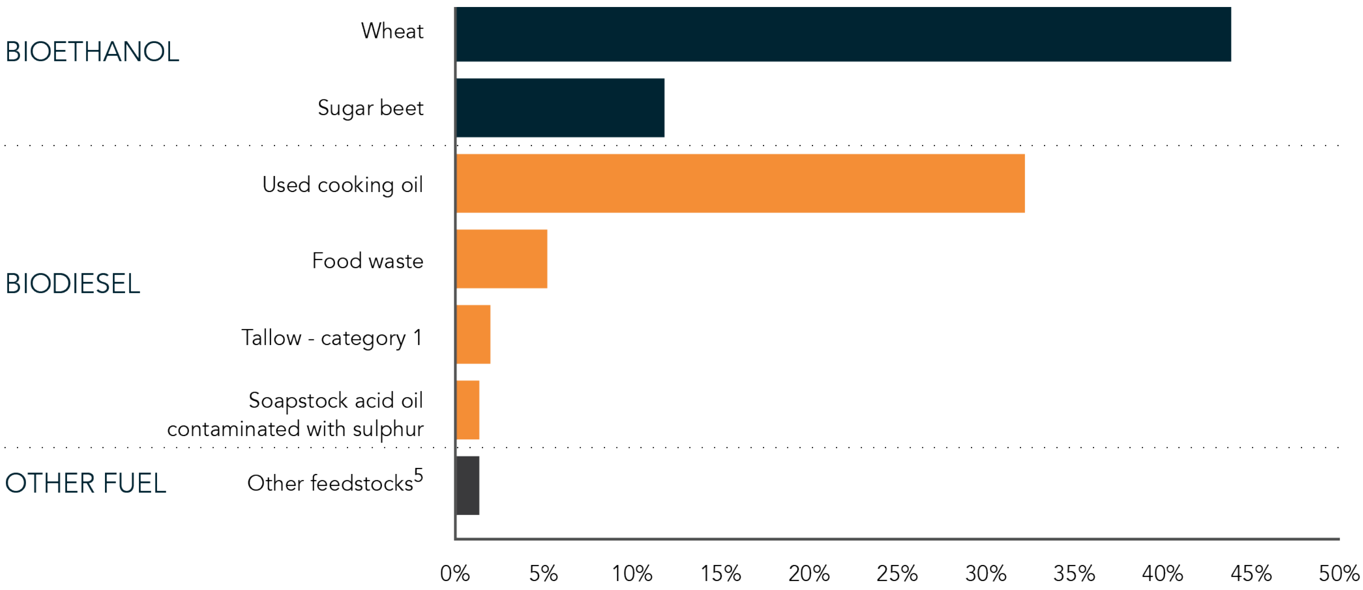


Figure 2. The main UK origin of biofuel feedstocks between 15th April 2017 to 31st December 2018 (Department of Tranport, 2018).

5. Includes **bio petro** (used cooking oil), **biodiesel** (brown grease, crude glycerine and sewage system FOG), **biomethane** (sewage sludge), **off-road biodiesel** (food waste, oilseed rape and used cooking oil) and **diesel with bio origin** (used cooking oil).

from anaerobic digestion, fermentation, high-pressure conversion, pyrolysis and metabolic processes from biomass. The prospect and possibilities for using food waste is vast with a great deal of leeway for further improvements and optimisation as newer technologies and research is performed.

However, there is a growing concern for the food vs fuel debate, especially after the 2007-2008 Global Food Crisis that caused food shortages and price increases. Some argued that a contributor to the crisis was the rise in the use of food and food crops for biofuel generation. Presently, a proportion of biofuels are produced from edible feedstocks and contribute around 80–90% to the total cost of biofuels. There are various cases where natural land and rainforests have been eradicated and converted for biofuel production, such as the Brazilian Amazon for soybean bio-diesel, Brazilian Cerrado for soybean biodiesel and sugarcane bioethanol, Malaysian tropical rainforest for palm biodiesel and US grassland for corn bioethanol (Fargione, Hill, Tilman, Polasky, & Hawthorne, 2008). However, the main UK origin of biofuel feedstock between 2017 and 2018 was found to be wheat and not food waste, as shown in Figure 2. It is important to recognise the key ethical and economic benefits of using food waste, which is regularly discarded, instead of producing edible crops for use as a fuel source; this is key to diminishing the food vs. fuels concern and alleviating the fear of another global food crisis.

Non-government organizations, food industries, expert scientists and the government should shine a light on the value of food waste and its advantageous use in biofuel production. The recycling of food waste is not optimised due to a lack of awareness and poor legislation. Taxes have a significant impact on the cost of biofuel, therefore duty reductions are required to make biofuel cheaper and more easily accessible. Generally, food waste is mixed with other municipal solid wastes such as plastics, bottles, batteries and appliances. A separation strategy is crucial in extracting the food waste from non-biological waste for maximised utilisation and the reduction of waste in landfills. This also falls to us as individuals to inform and eradicate the 'throw-away' culture in order to recycle food (Karmee, Sze, & Lin, 2014).

Overall, biofuels are increasingly recognised as an attractive alternative fuel, largely as transportation fuels. This includes the increase in interest for widespread introduction of E10 petrol in the UK in the near future due to the environmental benefits that biofuels offer in reducing greenhouse emissions. Further support and a clear strategy by various organisations, mainly the government is needed to bring awareness in the use of food waste for biofuel production with masses of food being thrown away without any further use every year.

Why are Renewables Difficult?

Adriaan Hilbers. Imperial College London
a.hilbers17@imperial.ac.uk

> *"With renewables, the single biggest difficulty is that production levels can't be controlled."*

In the face of climate change, considerable efforts are being undertaken to reduce carbon emissions. One of the most promising pathways to sustainability is to decarbonise electricity and electrify other sources of emissions such as transport and heating. Renewable technologies such as wind, solar and hydropower (emitting no greenhouse gases) have been around for years, but a combination of factors means most countries still generate the vast majority of their electricity from fossil fuels. Some of these relate to climate science denial or an unwillingness to adapt energy systems. However, weather-dependent renewables introduce another important challenge for power systems. This article hopes to give the reader a sense of why renewables are "difficult", and how the world can keep the lights on in the future in a cheap, secure, and sustainable way.

Power systems: supply & demand

Until recently, the primary reason for the slow uptake of renewables was economics. It was impossible to build wind turbines and solar panels cheaply enough to compete with fossil fuel technologies, which had become highly cost effective after more than 100 years of use. While there was some effort, governments were not willing to spend billions on subsidising renewables when electricity could be generated cheaply in other ways. Mark Rutte, the Dutch prime minister, frequently claimed in debates between 2010 and 2014 that "windmills are only powered by subsidy" (Mommers, 2016). However, as time passed, improved manufacturing methods, economies of scale and increased competition have sent prices plummeting. The price of solar panels has decreased by a factor of 100 in the last 40 years, and generation through many renewables is now cheaper than fossil fuels (Shahan, 2018).

To understand why societies aren't rapidly going 100% renewable, an understanding of power systems (the industries, infrastructures and markets based around electricity) is needed. At their core, power systems are supply & demand problems: industries and consumers use electricity provided by generators. Their main distinguishing feature is that there is virtually no means of storing electricity at large scale (with the notable exception of hydropower). Supply & demand must continuously be matched exactly, and this makes managing the grid both complicated and essential. Usually, some independent party, called a system operator, is issued this task.

Historically, most electricity was generated by fossil fuel plants. Fuel (e.g. coal or gas) was burnt at different rates to meet demand. This is more difficult than it sounds since considerable flexibility is required. For example, the UK's system operator had to deal with a massive demand spike just after the royal wedding, as millions turned on their kettles at the same time (National Grid, 2018). Another example is shown in Figure 1. With renewables, the single biggest difficulty is that production levels can't be controlled. Since it's not always windy or sunny, maintaining the supply and demand balance is more difficult. In most countries, this is not yet a problem since renewable capacity is small and their output never exceeds demand. Renewables

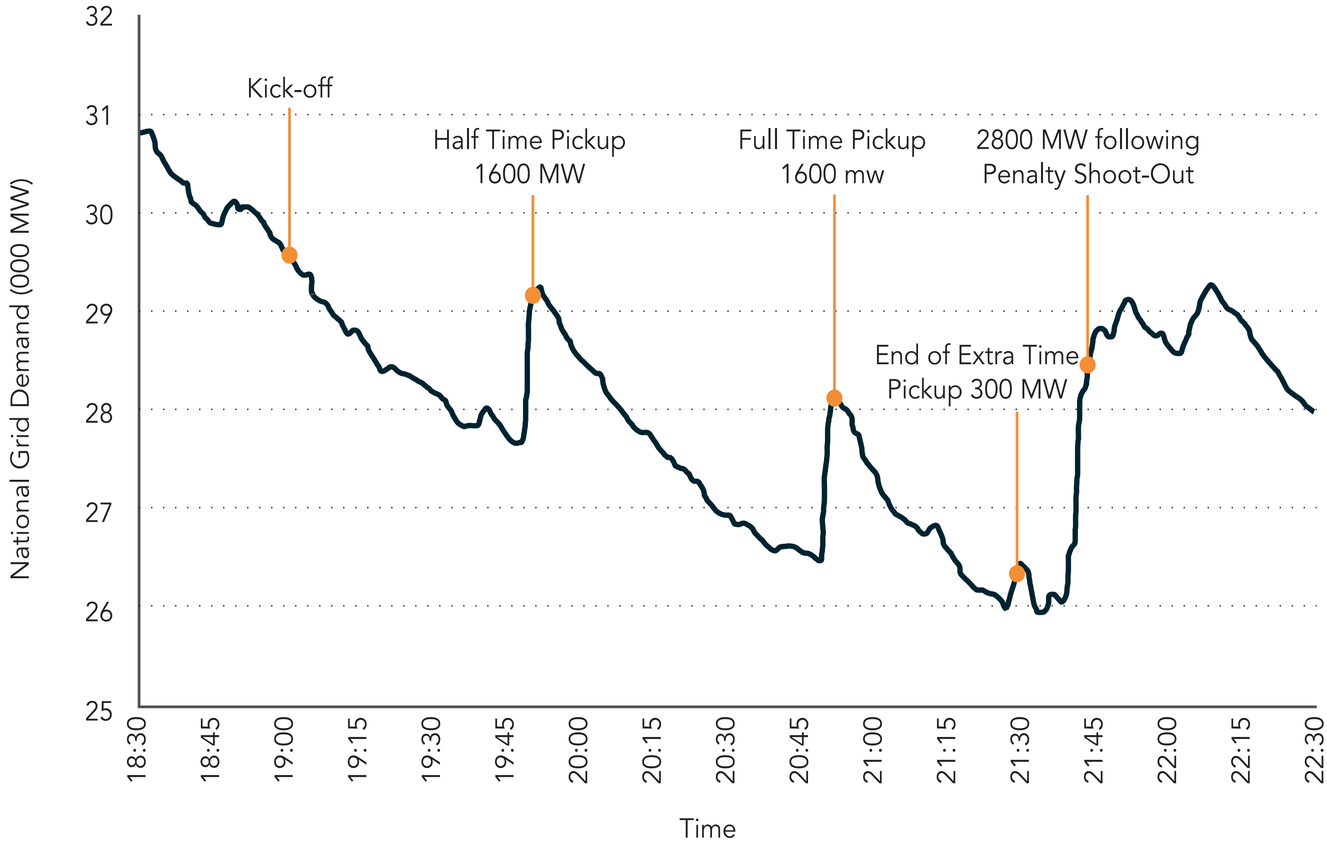


Figure 1. Total UK electricity demand during the 1990 World Cup semi-final against Germany, with spikes at times that viewers turned on their kettles en masse. System operators had to rapidly adjust supply to ensure the lights stayed on. Source: National Grid

produce whatever electricity they can, and the rest is picked up by conventional generation such as coal or gas. Two complications warrant mentioning.

Firstly, the required flexibility increases. Generation must be able to ramp up quickly enough to meet a simultaneous demand spike and drop in wind levels. In May 2018, the Dutch grid was unable to respond quickly enough to an unexpected drop in windspeeds and required emergency imports from Belgium (Koster, 2018). Secondly, the advent of renewables changes the economics of power markets. Power plants have a particular business model: build an expensive facility and pay off the investment using the proceeds from the sale of electricity. For this to work, electricity prices need to be high for a large proportion of time. This is no longer the case when renewables are added to the grid: at times of high wind or sun, they produce electricity virtually free, pricing out conventional generation. Investing in a conventional power plant or keeping an old one open may no longer be economical. As a consequence, there is insufficient conventional capacity left when renewable output is low. To counteract this effect, some countries host capacity auctions in which they subsidise producers to meet demand when necessary (Department for Business, Energy & Industrial Strategy). This economic situation applies to renewables as well: as more wind is added to the grid, electricity prices bottom out at windy times, "cannibalising" the potential profits.

Two additional complications, which will not be discussed at length here, are the issues of transporting electricity from windy areas to demand centres, and frequency stability through inertia. In Germany and Ireland, these issues have already led to multiple occurrences of wind curtailment, in which wind farm owners are paid to turn off their turbines.

Making renewables work

The issues of flexibility and supply security intensify with increasing renewable penetration. There are a number of ways in which highly renewable systems can be made to work, falling broadly into two categories.

The first is storage. Excess electricity production on windy or sunny days can be stored and used in times when renewable output is low. Besides adding to supply security, this enhances the economic picture since storage owners buy up electricity when price is low and sell it when high, evening out price differences. At present, technology (e.g. battery) prices have to drop significantly before grid-scale storage is economically viable (with the exception of hydropower). This typically involves a dam being built in a river, creating an elevation

difference on either side. Water is allowed to flow down and power a turbine (generating electricity). Generation levels can be controlled by adjusting the flow level, and there is a natural storage function: when demand is low, water is allowed to accumulate, "charging" the lake naturally. A difficulty is that hydropower requires mountainous and rainy terrain and is hence limited to particular regions.

A second solution is interconnecting countries and allowing them to share electricity. Calm periods in London and Scotland may overlap considerably but it may be windy in Germany or Spain. Transporting electricity could help alleviate supply insecurity. The UK currently has interconnections with France, the Netherlands and Ireland, and more are in the pipeline (Ofgem, 2018), eventually becoming the European Supergrid, where electricity can be transported across Europe to balance out regional renewable supply peaks and troughs.

The prospect of combining hydropower and interconnections between countries is tempting. For example, countries with lots of wind but little storage capacity (e.g. Germany or Denmark) can "use Norway as a battery" by exporting excess wind power to Norway in windy periods. The Norwegians use this power and allow their dams to accumulate water. In calm spells, the hydropower generation levels are increased and excess electricity is exported back the other way. Such a scenario requires significant increases in Norwegian hydropower infrastructure, interconnection lines and international co-operation.

Another option is using the storage potential from batteries in electric cars. Electric car uptake will lead to demand spikes when users return from work and plug them in to charge. Owners could get the option of cheaper electricity if it means the car's battery is not immediately charged, or even emptied, during demand spikes and recharged when demand is lower.

A new (uncertain) era of electricity

Current power systems are not yet ready for renewables to be the primary source of electricity. However, under the immediacy of the climate change threat, business-as-usual is not an option. A total energy revolution is required. Presently, the most realistic short and medium-term solution is the use of renewables. Making highly renewable electricity work without sacrificing energy affordability or supply security is a significant challenge, and one of the few things energy researchers agree on is that the power system of the future will be very different.

Net Metering: What Comes Next?

Madison Cole. London School of Economics
M.Cole2@lse.ac.uk

As solar energy makes new inroads in the United States, electricity regulatory structures have been bent and stretched to accommodate its growth. Over the past few years, distributed solar in particular has gone through a growth spurt, forcing regulators to reconsider the laws that define the relationship between producer and consumer. The debate that has emerged has roiled the industry and could come to define a new era of distributed generation (DG) policy in the U.S.

The debate revolves around net energy metering (also referred to as NEM or simply net metering), a billing mechanism that allows customers who generate their own electricity and are connected to the grid to pay for their net energy usage. For instance, when a home- or business-owner's solar panels produce more energy than can be consumed on site, their energy meter runs backward, and the excess energy is fed back to the grid. Owners of distributed generation systems therefore pay and receive the same price for every unit of electricity purchased from and exported to the grid. This is known as the retail rate [1]. Given the intermittent nature of solar energy production, the ability to sell excess energy back to the gird is an important determinant in the economic viability of distributed solar.

Despite the theoretical simplicity of NEM, there is quite a bit of variability between current policies. First approved by the Arizona Corporate Commission in 1981, net metering is now legal in 44 states plus the District of Columbia[2]. These policies vary between states, and states' individual programmes have evolved over time. Specifics regarding billing, crediting and banking of credits differ between states and localities. However, one overriding feature of these programmes is that they are capped. Of the 45 jurisdictions where net metering is allowed, 57% restrict capacity and an additional 7% trigger a policy review when solar penetration reaches a certain threshold [3].

The reasoning for these constraints on capacity is at the heart of the net metering controversy. Proponents of net metering argue that solar customers, who pay the retail rate for energy they draw from the grid, should be compensated for energy they produce at the same rate. Critics argue that the retail rate is artificially high; that because the utility can produce energy more cheaply than by buying it from customers, it should not be compelled to buy energy back at a price designed to account for transmission, distribution and administration costs. They see this price as a solar subsidy, the burden of which they say is borne by the rest of the customer base (which is called "cost-shifting")&.However, it is widely agreed that cost-shifting is at least negligible when feed-in is sufficiently low[6]. Therefore, most regulators have agreed to allow net metering below certain thresholds—hence the widespread programme caps.

> *"The challenge becomes crafting a successor tariff that encourages the use and development of new storage technologies, benefits the grid, compensates solar customers fairly and does not impose costs on non-solar customers."*

The process by which lawmakers and regulators determine programme caps is not entirely clear[9]. A report prepared by the National Renewable Energy Laboratory found that policymakers take state and local energy policy goals, rate impacts, grid impacts and existing federal policies into account. But according to a whitepaper by EQ, most net metering

caps are the arbitrary result of negotiations rather than "principled analysis" [3,9]. These arbitrarily set caps have been drifting upward as installed capacity grows and expectations are adjusted. According to NREL, early net metering programmes were capped at 1% or less of peak demand; today many are at or above 5%. As of 2014, 15 states had increased their net metering restrictions, and several of these made multiple adjustments.

This upward drift in programme caps doesn't always proceed smoothly, especially now that net metering has begun to elicit such strong opinions. Changing net metering policy and regulatory structure can produce widespread confusion and stall investment[9]. In South Carolina, the Duke Energy service region reached the state's 2% net metering cap this July. As the region hurtled toward the cap over the summer, several bills were introduced to raise or lift it. However, none made it to the governor's desk before the end of the legislative session, causing anxiety among solar installers in particular (Duke has agreed to a temporary extension while an agreement is reached)[10,11]. In Massachusetts, a Solar Energy Industries Association study found that the state's net metering cap stalled $78 million worth of investment as companies put projects on hold in the face of regulatory uncertainty[12]. In 2015, Nevada regulators ended net metering in the state, forcing SolarCity and Vivint to close their operations. This set off a years-long debate over solar tariff structure[13].

So, what does the future of distributed solar look like? As the grid's share of distributed solar capacity grows, two problems begin to emerge that have significant implications for net metering. First, the potential of cost-shifting to non-solar customers (whether founded or not) remains a concern for many stakeholders. Second, eventually installed capacity may reach levels at which experts believe it no longer benefits the grid. Specifically, this occurs when "the system can no longer benefit from new daytime generation" [14]. It is at this point that solar-plus-storage becomes much more valuable than solar-only systems. Storage technology allows DG customers to store energy produced when the sun is shining during the day and feed it back into the grid at night when it is needed. Net metering wasn't designed to incentivize storage systems. When solar capacity reaches the point at which it no longer benefits the grid (generally agreed to be around 5-10% of peak demand) regulators begin considering "successor tariffs," or billing arrangements to succeed net metering[15]. Even in solar-friendly states like California and Hawaii (13 states in all), public utility commissions and solar advocates are beginning to move away from net metering toward alternative rate designs designed to usher in a new phase in solar energy [16].

In most cases, this involves setting new compensation rates, usually between the utility's avoided cost (marginal cost) and the retail rate[17]. Many successor tariffs employ time-of-use (TOU) rates, which price power according to when demand is highest[17]. TOU

> *"Policymakers can save themselves headaches by both locking in sufficiently high net metering caps and engaging stakeholders in discussions on successor tariff schemes as early as possible."*

rates can shift demand to off-peak hours. Additionally, they can encourage the adoption of solar-plus-storage systems by incentivizing DG customers to sell excess energy back to the grid when it will receive the best price and is of highest value to the electric system[17].

The challenge becomes crafting a successor tariff that encourages the use and development of new storage technologies, benefits the grid, compensates solar customers fairly and does not impose costs on non-solar customers[18]. What is more, regulators must weigh stakeholders' valuations of solar (VoS, or Value of Solar rate) and find a balance between granularity and flexibility [17].

There are two other alternatives to net metering[17]. The first is net billing. It is very similar to net metering, but with a more complex compensation rate and without the ability to bank credits for future consumption[17]. The more precisely the rate is calculated, the more efficient the mechanism becomes. But this raises administrative costs and complexity. New York's Reforming the Energy Vision (REV) includes transitioning from net metering to a Value of Distributed Energy Resource (VDER) tariff, which is an example of a net billing scheme[20].

The second is a buy-all, sell-all arrangement (or BASA in industry parlance). Under this agreement, the DG customer sells all of the energy they produce and is billed for all of the energy they consume at a fixed rate (although this can be dynamic). BASA has the benefit of being comparatively simple and flexible[17]. Hawaii, where the transition from net metering began in 2015, is applying BASA. So far, it seems to be successful in incentivizing adoption of storage systems [17]. Arizona's new rates are also based on a BASA structure [17]. Similarly, feed-in tariffs (FiTs) are somewhat of a hybrid between net billing and BASA schemes and can closely resemble either depending on the context [19]. FITs are common around the world and are features of some of the most successful solar markets (e.g., Germany).

An important consideration for most U.S. states is when to begin the transition from net metering to a successor tariff. If they wait too long, as Hawaii and California arguably did, stakeholders could waste valuable time arguing over a policy they've already outgrown. On the other hand, Michigan ended net metering far too early, when the state's installed capacity was less than 1%. The state's solar industry is now reportedly "frozen"[17]. In what seems to be the most reasonable approach, Indiana and Illinois lawmakers have locked in their net metering policies until they reach certain rates of penetration (1.5% and 5% respectively) and are discussing successor tariff policies in the meantime[17]. For most states, where solar penetration remains below the 5-10% range, net metering is still a fitting policy. It benefits the grid as well as DG customers. But policymakers can save themselves headaches by both locking in sufficiently high net metering caps and engaging stakeholders in discussions on successor tariff schemes as early as possible.

Over the past few years, several states have begun the shift from net metering to alternative metering and billing arrangements. While 2015 and 2016 were marked by research and review in a number of states, several began transitioning to their own successor tariff agreements in 2017 and 2018[21]. It is too soon to understand the impacts of these new regulatory arrangements, but in the future, it will become increasingly important to watch states like Hawaii and California closely. If the goal of distributed energy generation is to help create a sustainable, resilient and equitable grid, stakeholders should be open to applying lessons learned from states on the forefront of distributed solar.

Lessons from Community Choice Aggregation (CCA) Programs in California

Sofia Russi. London School of Economics
s.russi@lse.ac.uk

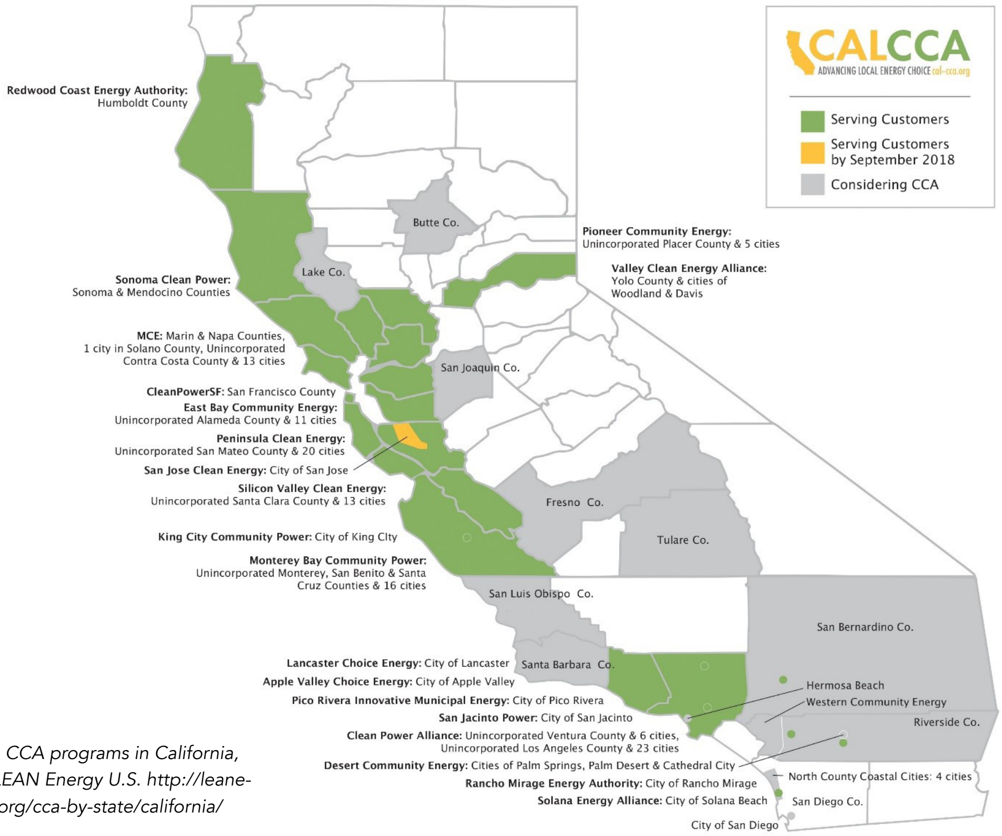


Figure 1. CCA programs in California, source: LEAN Energy U.S. http://leanenergyus.org/cca-by-state/california/

The emergence of Community Choice Aggregation (CCA) power purchase agreements in California indicates disruptive consequences for both Investor Owned Utilities (IOUs) and customers. It also poses new challenges to grid reliability [1]. Initially implemented to create competition within the State's regulated electricity monopolies, CCAs aim to make community energy procurement cheaper, cleaner and more transparent through a democratic decision-making process. By enabling municipalities to act as load serving entities, the programs aim to achieve energy independence, price stability, increased procurement of renewable energy, and boosts to local employment [2]. Although the number of CCAs is on the rise, with 20 schemes in place as of 2018 and six more to launch in 2019-2020 (Figure 1), some fundamental questions remain unanswered.

The California Public Utility Commission (CPUC) is currently debating crucial policy decisions that will shape the future of CCAs and traditional utilities. Utilities are often locked into power purchase contracts signed in the last decade that were intended to serve large customer bases. CCAs erode an IOUs' customer base by signing newer contracts at lower prices and drawing customers away from traditional utilities. Subsequently, the costs incurred by IOUs to procure generation and distribute electricity are being shared by a shrinking customer base, increasing IOU customer's electricity costs. As a result, CCA mechanisms raise concerns over cost-shifting decisions relating to pre-existing power purchase contracts. The central question then is how to even out costs and responsibilities between key stakeholders including utilities, utilities' customers and CCA customers to address the issues created by cost-shifting.

Traditionally, utilities sign 'bundled' power purchase agreements that reflect the costs of generating electricity and maintaining transmission and delivery services. CCAs replace bundled contracts with 'unbundled' contracts where municipalities purchase electricity from either local generators or through the energy market and IOUs operate distribution and delivery lines services, splitting the costs between CCA and IOUs'. Through this mechanism, CCAs achieve the intended goal of disrupting the vertically-integrated business model of IOUs, creating competition and encouraging utilities to adopt more competitive portfolios comprised of a greater share of renewables at lower prices. However, these mechanisms imply significant financial decisions for utilities as the customer base shrinks, and as policymakers debate compensation agreements to even out projected losses between parties.

Power to the people?

CCAs operate state-wide as not-for-profit agencies, directly involving community members in the decision-making process through community advisory committees that are included in the debate between stakeholders and CCA boards. Through the involvement of community representatives, CCAs can give communities a choice over the quality of their electric generation. The authority to establish CCAs in California was specified in the Assembly Bill 117 in 2002. The bill's goal was to disrupt the vertically-integrated monopoly historically held by IOUs and incentivise the procurement of renewable energy to comply with the California Renewable Portfolio Standards. A pilot study on 12 communities in California estimated that CCA customers could save 1-10% on the energy bill with an ambitious share of 40% renewable energy in their portfolio, exceeding the state-mandated 20% requirement [2].

To incentivise the procurement of renewable energy, CCA programs generally offer both a default electricity offering, with 35% to 55% of electricity generated by renewable sources, and a 100% renewable energy offering. Portfolio variations are included to accommodate the needs of different demographics, because some CCA customers are willing to pay higher rates for a greater share of renewable energy. Furthermore, the not-for-profit nature of CCA programs allows municipalities to reinvest excess revenues into the local economy through renewable energy projects. By incentivizing local energy generation, CCAs aim to increase community resilience to catastrophic events, and reduce the electric system's reliance on long transmission lines. Additionally, communities have access to competitive electricity prices under CCA programs despite the generally higher cost of renewables. As of 2018, CCA customers saved more than $89.7 million combined on their energy bills compared to IOU customers, according to a California Community Choice Association (CalCCA) report[4]. Lastly, CCAs aim to boost local job creation through investment in local generation resources. One example is the 10.5-megawatt MCE Solar One project developed by Marin Clean Energy (MCE), California's first CCA established in 2010. The project supported 341 local jobs and mandated that at least half of the workforce be comprised of residents from the local community, traditionally affected by high unemployment rates [6].

Price Charge Indifference Adjustments: fair share, or Catch-22?

The energy market in California is traditionally dominated by three IOUs, namely PG&E, Southern California Edison and San Diego Gas & Electric (SDG&E) controlling about 60% of load distribution in the State. These utilities' investors might have reason to be worried about the systematic loss of customers to CCAs, since CCAs are operated as opt-out programs. As municipalities across the State establish their own CCAs, all residents in a given jurisdiction join the CCA by default and can choose to opt-out at any time. Indicative of this trend is SDG&E's Vice President of Energy Supply's remark that, "67% of the load of SDG&E is looking at CCAs. All three IOUs could see up to 80% of the load departing across California"[5] As of January 2017, the 'departing load' customers for PG&E represented almost 28% of the customer base [7]. If customers leave IOUs at this rate, the IOUs may need to substantially change their operations strategies to remain competitive despite a decrease in revenues that does not correspond to a decrease in operations costs. California law is in place to protect utilities' operations in view of past contributions to the energy market. In fact,

the California Public Utilities Commission recognizes that low renewable energy generation prices—which equally benefit CCAs and utilities' customers—are the product of utilities' long-term investments to comply with the Renewable Portfolio Standards. The CPUC decided that such retroactive costs must be included in CCAs' considerations, and State law is in place to regulate cost-shifting decisions for IOUs and CCA customers. The Public Utility Code Sections 366.1 and 366.2 mandate that sunk costs incurred by IOUs to serve departing customers travel with the customer. California law requires departing customers to compensate utilities for any loss incurred by pre-existing power purchase agreements, a fee known as Price Charge Indifference Adjustment (PCIA). The PCIA is essentially an exit fee that is billed to CCA customers over time, wherein a customer leaving an IOU is required to pay their utility for the generation the utility previously acquired to serve the customer. However, CPUC is still debating to what extent customers should be mandated to compensate utilities for retroactive costs.

The current logic is that CCA customers are mandated to pay where the costs are unavoidable and attributable to the customers' departure (Public Utilities Code Section 366.2(f)(2) and California Public Utilities Commission (2004) Decision 04-12-046). However, this poses a series of legitimacy questions since CPUC has so far considered all costs incurred by IOUs as unavoidable. CCA advocates are encouraging IOUs to incorporate projected loss of customers to CCA in their business decisions, a move that could reduce overall expenditures for CCA customers. Although the California Public Utilities Commission has not yet reached a final decision on Price Charge Indifferent Adjustment structuring, PCIA are currently calculated based on market value and charged to customers per kWh, meaning that PCIA fees can fluctuate year by year depending on market value. The fee is calculated periodically, typically twice a year, and it is included in CCA customers' electricity bill.

Moving forward with CCA

One key issue with PCIA charges is that they are difficult to communicate to customers, who might notice significant variations in the electricity bill. A recent report by the UCLA Luskin School of Innovation found that PCIA represented about 5% of CCA customers' electricity bill in 2015 and up to 10% in 2016[8]. As the projected costs of renewable energy generation indicate further reductions in the future, the PCIA fee is set to cover ever-larger shares of the electricity bill and it is uncertain how it will affect CCA customers retention rates. CCAs should deploy appropriate communication capacity to ensure customer retention until the California Public Utilities Commission clearly stipulates burdens and responsibilities among CCA and IOU customers. However, due to the novelty of the projects, it is still uncertain what the future of both CCAs and investor-owned utilities in California will look like.

Although the core strength of CCAs lies in their ability to shake up the energy market and facilitate the achievement of the California Renewable Portfolio Standards, it is first necessary to untangle the debate surrounding Price Charge Indifference Adjustment to ensure that costs and responsibilities are equally distributed between CCA and IOU customers. Failure to do so might dampen the projected benefits for local communities and unfairly place the burden on customers who live outside the jurisdiction of CCAs.

How Carbon Management and Embodied Energy Influence Infrastructure

Rhea Iai. University College London
rhea.iai.17@ucl.ac.uk

Infrastructure is responsible for the growth and development of employment and quality of life in expanding markets and economies. There are plans for a £500 billion investment in construction for UK infrastructures from 2016 to 2030, with a predicted UK GDP increase of £1.3 billion for every £1 billion investment (UK Green Building Council 2017). However, the construction and operation processes in emerging infrastructure account for approximately 70% of global emissions (Saha 2018). Carbon is a growing concern, prompting measures to reduce these emissions and maintain an appropriate carbon footprint in all sectors of infrastructure. Estimation of embodied energy is vital in regulating the carbon footprint of a project.

The Dictionary of Energy defines embodied energy as "the sum of the energy requirements associated, directly or indirectly, with the delivery of a good of service" (Cleveland & Morris 2009). However, depending on the lifetime of the building considered, embodied energy can alternatively be distinguished as "cradle-to-gate", "cradle-to-site" and "cradle-to-grave" (Densely Tingley & Davinson 2011). A cradle-to-gate approach refers solely to the energy required to assemble the final product. A cradle-to-site enquiry focuses on each individual component and the energy required for the raw material to be extracted, processed, assembled and transported without considering operation and maintenance. This is useful when comparing the individual building components. A cradle-to-grave study, typically known as the life cycle embodied energy, explores embodied energy that has been consumed throughout the lifetime of a building without accounting for operational energy required to allow the building to serve its purpose. This is further divided into three stages encompassing the beginning, middle and end of its lifetime, known as the initial embodied energy, recurring embodied energy and demolition energy respectively (Yohanis & Norton 2002). Although this is more difficult to estimate, it is often useful when comparing the entirety of the building. The measure of embodied carbon includes subtleties such as the seclusion of carbon within materials used for building, such as timber; the emission of carbon dioxide during the production of materials through chemical reactions

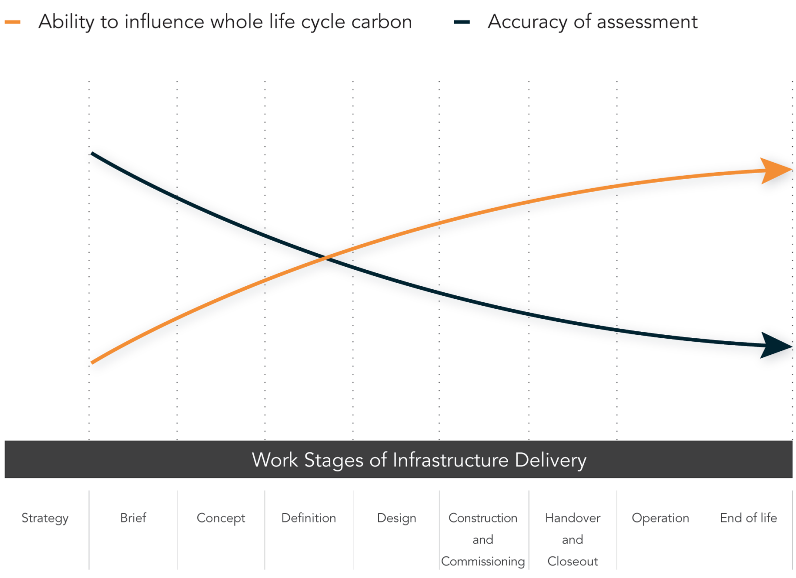


Figure 1. "Ability to influence carbon reduction across infrastructure life cycle" (PAS, 2016)

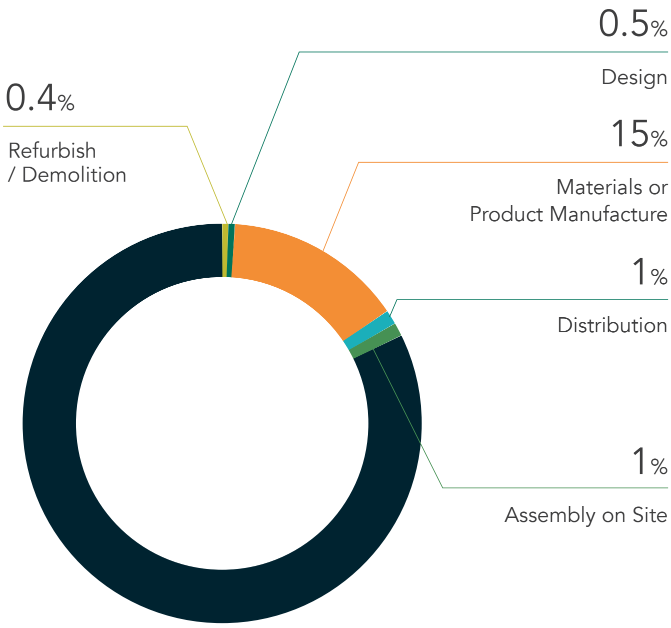


Figure 2. "Broad areas of a building's life cycle" (McAlinden 2018)

such as in cement; and the interaction of materials in the building with the environment during its lifetime such as concrete carbonation.

Globally, operational energy used in buildings accounts for 30% of carbon dioxide emissions related to energy consumption and 33% of the total final energy demand (Koezjakov et al. 2018). Legal obligations to reduce emissions in the United Kingdom have been established by the UK Building Regulations, with a primary focus on operational energy (Densley, Tingley & Davinson 2011). The lack of legislative attention on embodied energy often results in its unforeseen increase. Many European countries appear to have an increasing number of energy-efficient buildings, however, it is evident that carbon savings of life-time cost and total impact from the renovation and renewal of buildings can easily be neglected (Koezjakov et al. 2018). The trade-off between operational energy and embodied energy in buildings proves that it is vital to maintain and standardize the embodied energy of a project in order to reduce its net carbon cost.

In a study conducted by Reddy and Jagadish in India, it was found that using low-energy materials and construction techniques in residential buildings resulted in a reduction of 30–40% in embodied energy (Reddy & Jagadish 2003). Another study demonstrated that embodied energy contributes immensely to total energy use in the life cycle of low-energy buildings, contributing up to 46%. (Takano et al. 2015). It is important to note that the proportion of initial embodied carbon against operating energy varies between buildings for residential and commercial purposes, and larger constructions such as bridges and stadia. Thus, in large energy-demanding builds, building materials can often exceed initial embodied energy due to controls over ventilation and lighting, hence proving that the cradle-to-grave evaluation can be critical.

The construction industry is the largest consumer of natural resources within the country and accounts for 10% of carbon emissions in the UK (ENVEST 2010). Thus, civil engineers have a major role in regulating materials used in the process of construction by observing life cycles of buildings. The IGT report provides an estimate of the total carbon dioxide emissions produced and its relation to processes of construction. This study is intended to estimate the extent to which the construction industry "has the ability to influence" carbon dioxide emissions and does not account for emissions directly caused by the construction industry (Crown 2010).

According to the IStructE, advances to reduce embodied energy of buildings include better specification and sourcing of construction materials, designs suitable for material optimisation, adaptable designs for future use, designs for easy deconstruction and reuse, and minimisation of waste which accounts for 22% of all construction embodied energy (Jones & Hammond 2008). Thus, application of sustainable approaches in early design stages allows the evaluation of design plans for intended materials and systems, providing a considerable overview of the optimal point in the trade-off between operational and embodied energy. Building Information Modelling (BIM) can be used with respect to early design stages to predict and assess operational energy through energy performance simulation. Oftentimes, embodied energy assessments are executed subsequent to the final detailed design through Life Cycle Assessment (LCA) of the project, resulting in less capacity for negotiation. To overcome this, a BIM-based model can help monitor the life cycle energy of a building whilst accounting for the trade-off (Shadram et al. 2017). It is important to understand that the focus of designers and regulators should divert from the zero-operational emissions concept to one that envisions the reduction of whole life embodied energy and thus, carbon emissions. This concept should be further embraced beyond a national level, such as exploring the relation of UK trade flows to embodied energy.

03

Opinion

Lancashire Said 'NO!', so Why Did Westminster Say Yes?

Harry Collini. Imperial College London
harry.collini13@imperial.ac.uk

"The High Court decision to allow fracking to continue in Lancashire has now been made but the restrictions and regulations imposed on Cuadrilla's activities suggest that the UK government has listened to the locals' concerns and are committed to making sure fracking is done properly."

Fracking. No matter what your background is you are likely to have heard about it, the arguments for and against it, and you have probably got an opinion on it. Fracking, or hydraulic fracturing, is a process which extracts natural gas and oil trapped in tight, compacted shale rocks deep underground by pumping in high pressure fluids to create fractures in the rock, allowing the oil and gas to flow out. Fracking is one of the most controversial industrial processes of the last decade or so, with proponents arguing it is an important process needed to meet future demands and opponents suggesting the process causes gas leaks, unnatural earthquakes and tremors, and toxic chemical contamination of ground and drinking water. The key arguments around fracking were summarised in a previous article in the 3rd edition of the 'Energy Journal' published earlier this year.

Fracking in the UK has been a hotly debated issue over the last few years. The very first exploration wells were drilled by the private company called Cuadrilla in Lancashire in 2011, but drilling was stopped after tremors measuring 2.3 on the Richter scale were detected. Since then there has been a lengthy legal battle from local residents aiming to prevent Cuadrilla from further exploration, including a 2015 report by Lancashire County Council which recommended that planning permission for the fracking site be refused [1]. Additionally, several environmental campaign groups, media outlets and senior MPs, including Labour leader Jeremy Corbyn, have all spoken out against fracking and called for bans against the process [2]. However, in October 2018, the UK High Court rejected the block on Cuadrilla's fracking activities, paving the way for the company to continue exploration and begin extraction tests at their Preston Road site near Blackpool. Why, despite all the negative press and local resistance, would the UK courts and governments give Cuadrilla approval to begin fracking operations and essentially open up the UK for other 'frackers' to explore?

Likely reasons behind this decision can be traced back to the USA, the largest producer of shale gas in the world. In the last decade (the period termed the 'shale boom') the amount of natural gas produced from fractured shale reservoirs has increased seven-fold, as can be seen in Fig 1. This has significantly contributed to an increase in US natural gas production of almost 50% and a two-fold increase in crude oil production, resulting in an 80% reduction in net imports of crude oil & petroleum products [3]. Over the same period, the price of natural gas has remained reasonably constant each year despite inflation and GDP growth, largely due to this surging domestic gas production (Fig. 1). In 2018 alone, British Gas announced twice that they would increase UK consumer gas prices due to increases in wholesale demands, a 4% increase equivalent to approximately £44/yr per household [4]. During the current period of increasing tensions in international politics, and the tendency of moving towards more nationalist parties and policies, the energy security and independence the US has achieved is highly desirable

https://www.thetimes.co.uk/article/cuadrilla-presses-the-button-on-a-shale-gas-revolution-2kdctdc0s

to insulate domestic economies from external policies and threats to their energy supply. The British Geological Survey has estimated that the Bowland Shale, where Cuadrilla have started exploration, contains 1329 trillion cubic feet of gas reserves [5]. In 2013, Prime Minister David Cameron stated that if 10% of this could be extracted, it could meet UK gas demands for 50 years. However, it is important to note that the exact amount that is extractable is unknown without drilling exploration wells and conducting flow rate tests [6]. Oil and gas production from the traditional offshore reservoirs in the North Sea is in serious decline and it appears as though fracking has the potential to provide a significant portion of the UK's energy demands and could even turn the UK into an energy exporter for the first time since 2005, if significant enough [7] [8]. Energy prices and demand are commonly discussed political issues and the national benefits shale gas may provide are clear motivators for the UK government to approve and encourage further testing of fracking, regardless of local opinion.

The UK government is further motivated to increase natural gas production in order to meet its climate change targets. The ultimate goal is to reduce carbon emissions primarily by meeting energy demand using renewable or low carbon sources. However, it will take time to implement these sources into the current energy framework due to existing issues surrounding energy storage and battery technology, along with the need for investment and new infrastructure. BP's Energy Outlook 2018 predicts that carbon emissions will peak around 2025, but that only 25% of primary energy consumption will come from non-fossil fuel based sources in 2040 [9]. Part of the UK's low carbon energy plan relies on natural gas power generation being an intermediate 'bridging' step in the shift away from traditional fossil-fuel based electricity production as natural gas produces less carbon dioxide per megawatt than coal or oil, thereby offering a "greener" alternative [9] [10]. Modern combined cycle gas turbines (CCGT), which convert natural gas to electricity, are amongst the highest efficiency power generation processes currently available, typically over 60% [11]. CCGT are also able to rapidly ramp up and down production levels faster than other power plants in order to meet fluctuations in energy demand when renewables fall short [7]. Due to these advantages, natural gas demand is expected to grow more than other fossil fuel sources in the near-term (1.6% p.a. compared with 0.5% p.a. and 0% p.a. for oil and coal, respectively [9]). Thus future investment into natural gas production, including fracking, is favoured over traditional oil fields and coal mines to meet energy demand and climate change targets concurrently.

Common arguments against fracking often focus on induced earthquakes and groundwater and drinking water contamination from chemicals used in fracking fluids. Plenty of anecdotes and news stories from local residents near fracking sites in the US can be found by a quick search online. Videos showing taps igniting from natural gas present in the drinking water, or earthquake damage to property have gone viral and are often used as examples of the dangers of fracking, but these are sternly refuted by the fracking companies. Naturally, these anecdotes have caused huge concern amongst local residents in the UK and form the basis of their protests, along with concerns regarding air pollution

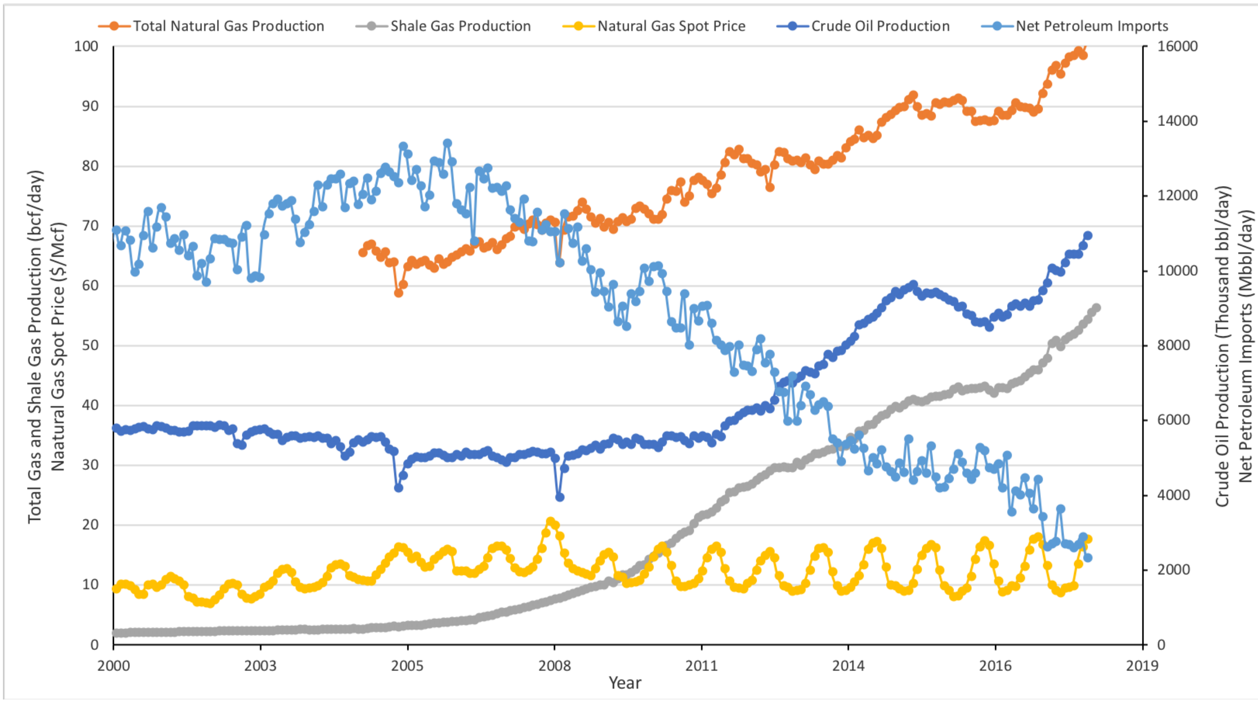


Figure 1. Data Obtained from EIA

and greenhouse gas emissions. However, the report by Lancashire County Council that recommended refusal of planning permission for Cuadrilla's fracking site did so because of concerns over local noise pollution [1]. The environmental risks, induced earth tremors, air quality concerns and other commonly argued issues were assessed by specialist consultants and government departments and were concluded to be of 'low risk if properly regulated' and could be controlled and monitored. Nonetheless, due to the locals' concerns, protests and the significant negative press coverage received regarding the courts' decision, stringent regulations and scrutiny have been placed on Cuadrilla's activities. This is to ensure that they are using the best industrial practices and they obtain high quality data and information about the risks posed by fracking in order to better assess its impact on the environment. One example of this is the imposed 'traffic light' system which monitors seismic activity and requires Cuadrilla to halt operations for 18 hours if a red light caused by a measurement of 0.5 on the Richter scale is triggered. This value is well below the limit at which tremors are detectable at the surface and is far more conservative than in other countries, such as Canada and the US, which allow tremors of greater than 2 before operations have to be stopped. Additionally, to minimise the impact on local drinking water supplies, the initially proposed water consumption was reduced by 165,000L/day, by requiring Cuadrilla to reuse flowback water and reduce the number of fracking stages, whilst carefully removing and properly treating production wastewater [1].

The High Court decision to allow fracking to continue in Lancashire has now been made but the restrictions and regulations imposed on Cuadrilla's activities suggest that the UK government has listened to the locals' concerns and are committed to making sure fracking is done properly. All industrial processes pose potential risks if they are poorly executed and the evidence and analysis by various government departments suggest fracking is no different. The potentially huge economic benefits will always drive the government and private companies to want to utilise natural resources and those companies are certainly eager to capitalise on this potential, evidenced by the more than £60 million that has already been invested into the Cuadrilla project [12]. The exact impact fracking will have on natural gas production or the environment are unknown until exploration wells have been drilled and flow tests have been performed. Cuadrilla's activities will certainly be scrutinised in the coming months and hopefully this scrutiny will help to avoid repeats of incidents such as those seen in the US. Testing will also provide important data for companies, governments and regulators to assess the potential for safe fracking in the UK, potentially revolutionising the UK's energy landscape.

How can people take steps to reduce carbon emissions and implement renew-ables when governments are too busy squabbling?

Sachin Gulati. Imperial College London
sachin.gulati15@imperial.ac.uk

Global temperatures will rise to 3°C above pre-in¬dustrial levels if drastic changes are not made to current investment pathways and energy production methods (Leslie, 2018). The outcome of this would be devastating to both the environment and civili¬sation; even the current target of a rise below 2°C – set out in the Paris agreement – is a far from ideal scenario (Leslie, 2018). One would expect possible impacts such as increased frequency of droughts and floods, diminished food supply and ocean acidifica¬tion (IPCC, 2013) would spur governments to work together to find and fund solutions, but unfortunately one would be wrong.

Across the world, governments have proven that they are unable to work together, with the wealthiest and worst offenders in terms of emissions perhaps doing the least. The USA notoriously left the Paris agreement, an action all the more costly due to the fact they are one of the largest global producers of carbon dioxide (CO2) per capita, sitting at a spectac¬ular 16.44 tonnes per capita. One of the key reasons for continued increase in emissions is that developing countries are increasing emissions in order to increase growth. It is imperative developed nations help them to grow in a cleaner fashion to avoid a world full of countries emitting at the same rate as the likes of Qatar and Canada (Ritchie and Roser, 2017) (Saran, 2018). Figure 1 illustrates that most countries do not have a particularly high CO2 production per capita. However, as these countries strive to improve their standards of living, the cheapest way to do so is by using fossil fuels unless developed nations assist. Again, we see little effort on the part of governments to take an active role in emission reduction, citing economics as the main reason. It has been left to the people to research solutions and fund them, and to make them economically attractive for policymakers to then make use of them (Butler, 2018).

A report by the United Nations Environment Pro¬gramme (UNEP) discusses how financial institutions are tackling climate change and how they can continue to do so. For example, longer term investment funds such as pensions are being put towards low carbon and energy efficiency projects. Due to their length, pension funds are more able to deal with intermittent fluctuations in value without needing to sell and this consistency is what long-term projects require to come to completion. There is also a growing green bond market, another vital factor in ensuring low carbon projects get the time they need. Billions are being invested into developing countries so that they can develop sustainably with less reliance on fossil fuels (UNEP, 2014).

The finance sector will continue to prove vital and as it continues to grow, it needs to ensure the developing culture of sustainability and emphasis on green proj¬ects is not lost. New employees straight from univer¬sity need to have this impressed upon them. In 2012, it was estimated the value of all assets in the financial sector totalled US$225 trillion and the ability to shift these assets from a high carbon to a low carbon econ¬omy will prove vital in reducing emissions, with a par¬ticular emphasis on renewable energy. Figure 2 below shows how the finance sector can move investment to a low carbon economy without disrupting existing high carbon assets. Dividends and interest harvested from both pathways should be reinvested

" One of the key reasons for continued increase in emissions is that developing countries are increasing emissions in order to increase growth. "

solely into the low carbon pathway, encompassing assets such as renewable energy sources and emerging sustainability projects.

There are many worthy projects for investment in the field of sustainability research, some still fledgling and others waiting for investment to be put in place on a global scale. For example, a technology, stored in con¬struction materials, has been designed to capture car¬bon dioxide from the air, designed by physicist Peter Fiekowsky (Holden, 2018). Rapid progress has been made in the last decade, with the technology initially seen as prohibitively expensive, it now is estimated to cost $100 to $200 per ton of carbon. This technology still requires investment, perhaps even from govern¬ments. Even if it never becomes profitable, it high¬lights the impact a single project can make.

The two winners of the Nobel Prize for Economics this

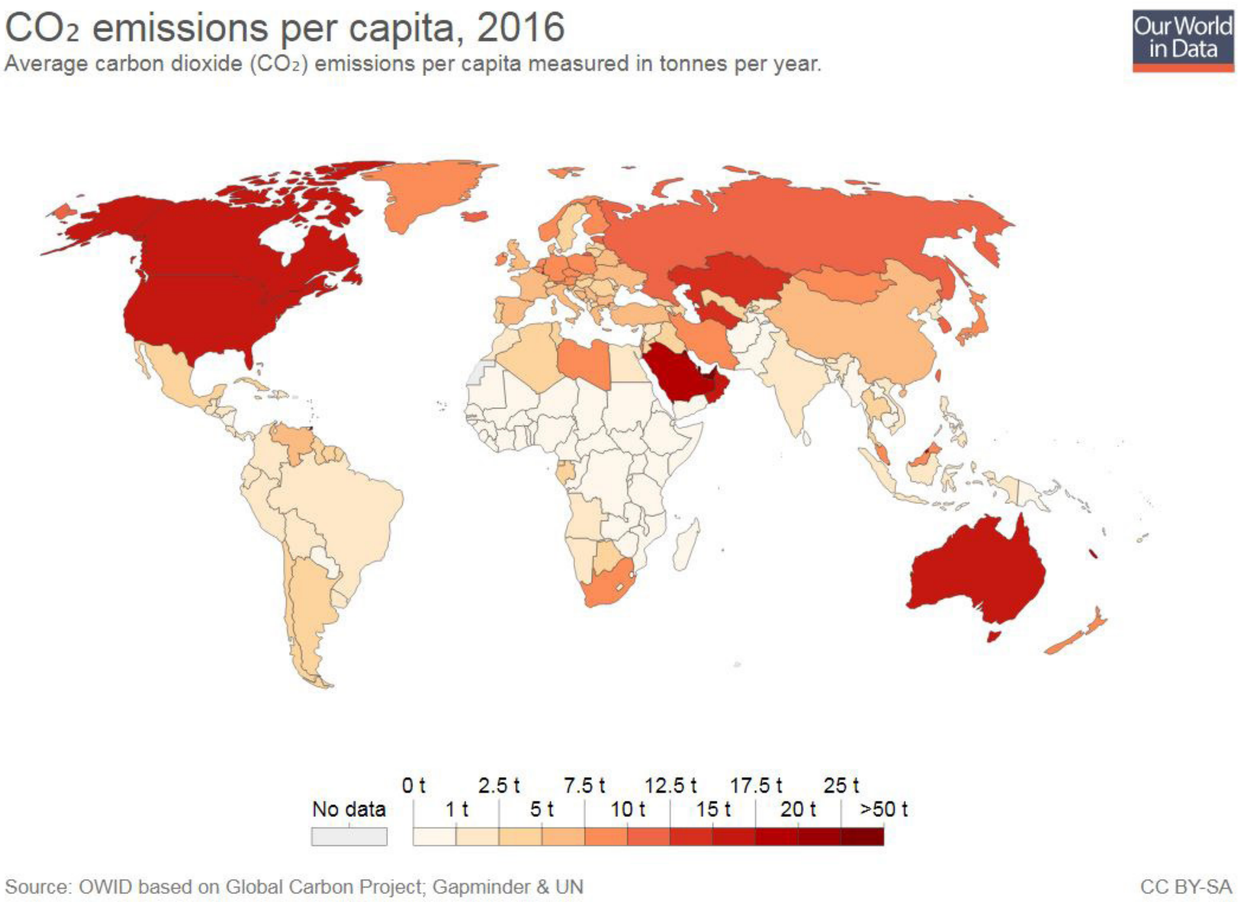


Figure 1. Source: (Ritchie and Roser, 2017)

year were awarded for their work on modelling the interactions between climate change and the economy, and growth and innovation (Harford, 2018). The first, William Nordhaus, previously explored the monetary and environmental cost of lighting since the usage of Neolithic lamps in 38000-9000BC (Nordhaus, 1996). By the end of the 20th century, a day's worth of work had gone from producing 10 minutes of light to 10 years. The environmental cost has also fallen drastically, and both these factors are used to illus¬trate the potential for innovation to dig us out of any hole. The second, Paul Romer, emphasises there is a chance, without any government intervention, people will innovate themselves to prevent climate change through developments in areas such as batteries and solar panels. However, this is only a small chance and to make it a certainty, it will require some government intervention, even just in the form of a carbon tax.

To continue the work in these fields, governments must encourage students to enter science and engi¬neering fields, and corporations must then follow this up with continued private investment. It is not suffi¬cient to rely solely on government investment as this can often fluctuate with the current governing party and their ideals or campaign promises. Innovation in the private sector has the potential to make a signifi¬cant difference and it has already been proven that the financial sector is willing to support new ideas.

Perhaps so far it has been shown that governments are entirely at fault and any progress so far has been all due to the efforts of people in different fields, but that would be a gross misunderstanding. Statistics such as 99% of purchases being thrown away after 6 months, or that there are 2.12 billion tonnes of annual global

> *"Governments must encourage students to enter science and engineering fields, and cor-porations must then follow this up with con-tinued private investment."*

waste, illustrate the fact that right now the average person either does not care or does not know how to reduce their footprint (The World Counts, 2018).

However, some blame must rest with the industries producing either low durability goods – requiring constant replacement – or goods smothered in cheap plastic. The motivation for both is profit and the EU recently proposed a single-use plastic ban to combat the problem. The proposal involves educating con¬sumers and providing incentives for producers to use sustainable materials, with carbon emissions expected to be reduced by 3.4 million tonnes. Slightly harsh¬er actions include plastic producers to be charged for water disposal (BBC, 2018). Fundamentally, the intentions are good but with the proposal largely com¬prised of minor incentives, it is unlikely corporations will make a genuine effort unless the education aspect causes consumers to actively seek out producers with greener intentions.

A study was also conducted in 2015 at the University of Gothenburg, Sweden, discussing how best to get people involved with tackling climate change; this is especially important as environmental issues are so closely tied to political beliefs (Jex, 2015). The under¬lying theory is based around co-benefits: connecting existing, relevant issues with environmental ones. For example, the building of new renewable infrastructure being linked to boosting employment in a region. The study suggests changing political rhetoric away from a negative, accusatory attitude to one focussed on mu¬tual gain could encourage the general population to act, especially if used on a smaller, community-based scale.

Ultimately, the task of reducing carbon emissions has

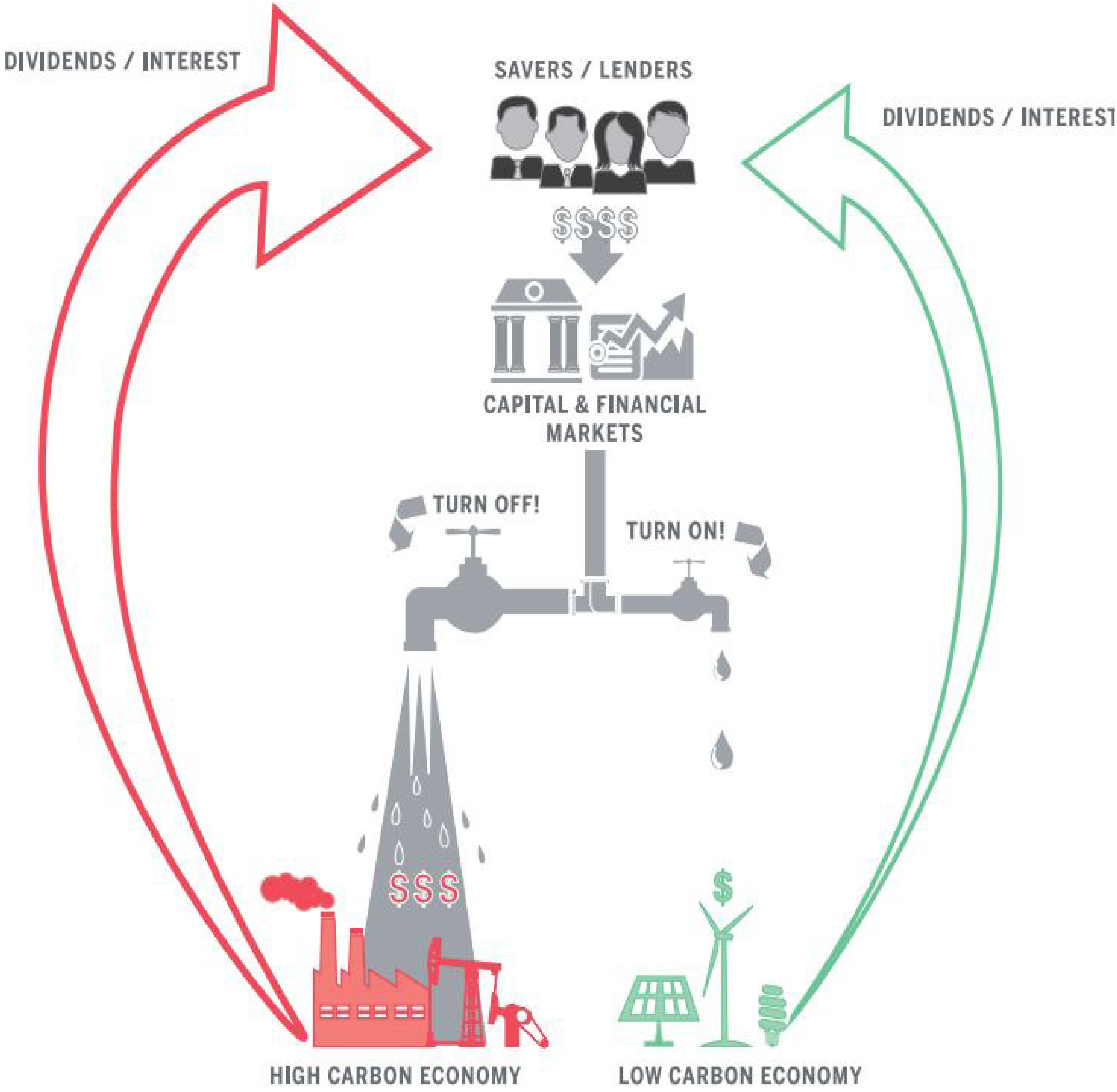


Figure 2. Diagram illustrating how the finance sector can influence a shift to a low carbon economy. Source: (UNEP, 2018)

been left to the general populace and particularly those in investment and research. The finance sector has made significant strides in funding green and sus¬tainable projects but still has plenty to do. Its impor¬tance cannot be undervalued. Research continues in fields such as carbon capture and improving efficiency of existing manufacturing processes, as well as clean fossil fuels. For these projects to be implemented on a large scale, they require vast investment and com¬mitment from multiple sources. Strides are also being made to get people involved and accountable, either in the form of education or a change of emphasis in political rhetoric through co-benefits.

Let's Change the Conversation

Joana Barragan. Imperial College London
joana.barragan-cirne18@imperial.ac.uk

Time is against us. The Intergovernmental Panel for Climate Change, the world's authority for climate change assessment and impacts, reported at the beginning of October 2018 that, at current greenhouse gas emission rates:
"temperatures are expected to rise 1.5 degrees Celsius above pre-industrial levels by 2030 [1]."
To this, environmentalist activists say "we have 10 years to save the world" [2]. This puts us in a predicament regarding the irreversible damage threshold at 2 degrees Celsius, which, it is predicted, we will reach by 2035 [3].
I don't know about you, but hearing this leaves me somewhat discomforted about the world that I will be forced to live in, and that future generations will have to endure.
Look at it this way: The Earth has existed for 4,540,000,000 years and, according to the Middle Palaeolithic fossil record, humans have been around for 200,000 years [4]. We have been around for barely a gnat's eyeblink in the grand scheme of things – barely 0.004% of the age of the Earth.
And whilst we have always interacted with our planet to a greater or lesser extent, it wasn't until the Industrial Revolution [5] (starting in 1750) that the greater damage was unleashed (Figure 1).
Let's rewind to 1750. In only 0.13% timespan of modern human presence (or in 0.000006% of the Earth's existence) we have managed to increase emissions from 9.4 million tonnes of CO_2 from pre-industrial levels [7] to 36.2 billion tonnes of CO_2 as well as to threaten the planet's biodiversity, our own lifestyle, health and safety, and that of our future cohorts.
However, on a more positive note, we have also been able to spot this incongruity - things are starting to change. Claire Perry, UK Minister of Energy and Climate Growth, suggests a three-rule check for new energy innovations known as the 'Three Cs':
- **Cost of energy**
- **Carbon**
- **Creativity and competitive advantage**

We are currently seeing these changes in action.

Instability of energy prices

Energy prices carry an everlasting burden of instability for different reasons, mainly politically-motivated:
Politicians are now embracing policies towards sustainability that lead to the closure of coal plants and a reduced dependency on cheap coal.
Wholesale market gas prices have soared globally because of an increased demand for gas to step away from coal.
Renewable energy incentives have been decreasing in some countries such as in the UK, as it is believed that their energy prices have reached a stage where they are able to go on without any incentivised support.
There might be questions with regards to the cost of sustainable technologies but, as Martin Pibworth (Managing Director at SSE) pointed out at the Energy Live Expo in October 2018, people are starting to value the power of long-term worth over the short-term cost.

Coal vs. renewable energy technology

Low-carbon initiatives are instigating renewable energy development which, in turn, is driving down technology costs. The current UK plan is to phase out coal by 2025 [8]. Heads up —the UK has been able to go for 3 days without coal generation for the first time [9]!
This societal change will force big companies such as EDF and SSE to close coal power stations.
To this, Richard Hughes, Sales & Marketing Director

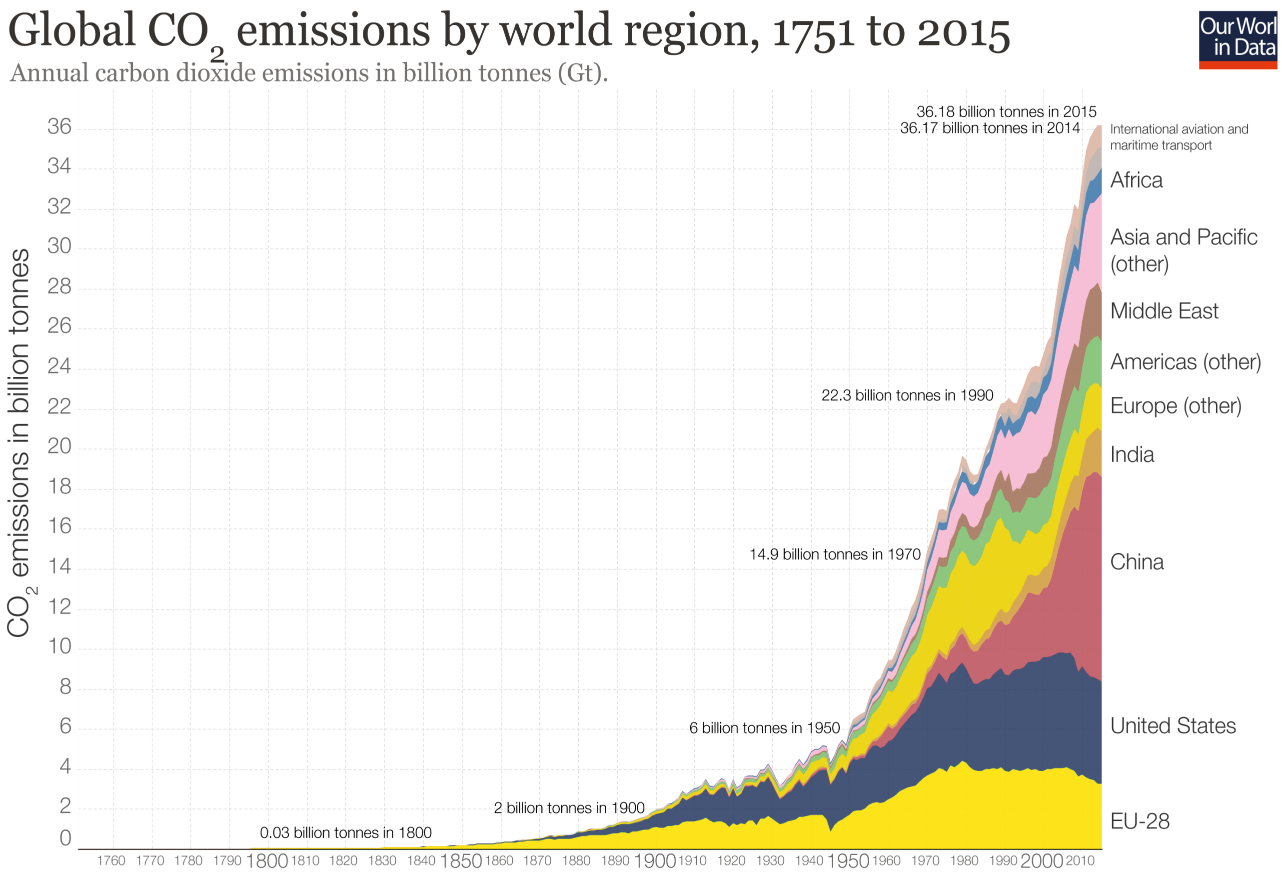


Figure 1. Global CO2 emissions by world regions, 1751 to 2015 [5]

at EDF Energy, attributed at the Energy Live Expo, an opportunity to adapt and innovate knowing that "technology is the fuel that drives the change".

We are seeing an upsurge in solar photovoltaic panels installed on roofs that are used to provide energy to homes or to make profit by selling to the grid; in big offshore wind farms that harness high winds in the North Sea; in the development of electrification and hydrogen for efficient heating; in the use of lithium-ion batteries in electric and hybrid cars that are able to accelerate to 100 km/h in less than 2 seconds [10]. We are seeing the introduction of the world's first production model of a hydrogen fuel cell vehicle – a Hyundai vehicle with a range of 594 km [11]. We are even seeing the interconnection of smart meters that communicate with your house's fridge and lighting... the list goes on and on.

These developments epitomize the shift in people's minds. People are becoming more and more aware, taking ownership over their consumption patterns and embracing a more active role. This change in focus and perception is well-accompanied by efficiency improvement at a consumer level, achieved through smart devices that optimize our consumption according to our real needs. Effectively, we are becoming smarter users.

The combination of technology, consciousness and efficiency enkindle the beauty of a perfectly-integrated energy network based on renewable generation and smart, mindful consumption.

Interconnectedness, transparency and power to energy "prosumers"

For the past few years, the energy paradigm has been based on centralization. The governmental agency sets the prices, the energy supplier provides the electricity, and the consumer has no say in the matter.

This is now changing. The shift is tending towards the participation of different entities in generation, distribution and operation, and where energy

> *"In only 0.13% time-span of modern human presence (or in 0.000006% of the Earth's existence) we have managed to increase emissions from 9.4 million tonnes of CO_2 from pre-industrial levels to 36.2 billion tonnes of CO_2."*

consumers become proactive players in the system. In fact, they are no longer referred to as "consumers". Given that they are able to generate to their own energy, they are now becoming producers and consumers, ergo the concept of "prosumers" arises.

This structural change is pushing for digitalization. This is where smart meters and smart grids come into play. Energy data helps us, the daily consumers, to understand how we are using our energy and where it comes from.

By setting this foundation, we can explore a radically more exciting facet of data in order to build, layer by layer, a smart flexible mesh wherein we can collaborate between one another in a decentralized manner, with energy coming from multiple sources. This is called the smart grid.

In case the previous trends did not subside your unease, I'll try to shed some light onto a more optimistic outlook for the future. Humanity has its way to develop solutions to the most challenging problems distinctive to each generation. Look back to the discovery of fire to light the dark, to warm up and to cook; the invention of the wheel for transport and human mobility; the development of microwaves from WWII radar technology; the inception of the internet and the growth of the mobile phone for global communications, thus bringing the antipodes of the world together...

In the 21st century, we have developed powerful tools that can propel us towards a smart and efficient future and which have the potential to transcend our capabilities whilst solving our current climate peril. Several technologies are coming to facilitate the trend towards decentralization and interconnectedness:

- **Sensors & Smart Grids**. Sensors and smart meters capture data and contextualize a physical entity in a virtual place, creating something referred to as the digital twin.

- **Machine Learning and Artificial Intelligence.** Contextualization of assets is done by combining all the data in one place, analysing, recognizing energy usage patterns, identifying trends of energy waste, and even performing predictive analysis for the winter demand, in order to optimise systems.

- Blockchain. These is a latent technology that aims to completely decentralise the network and consents users trade energy to one another directly, without the need of a middleman. This allows systems to automate transactions between one another. With this technology, we will soon see machine-to-machine interactions such as fridge-to-meter, car-to-charging point, battery-to-lights, etc.

We are now at a time where we must make critical decisions for the future of our planet and future gen¬erations, and everyone will play their part. Regulation and policy makers, for instance, are already working hand-in-hand with technological developers to evaluate impact and set the path for a brighter and cleaner future together.

But, most importantly, I suggest we change the conversation from catastrophic, irreversible, and foretold disaster to a more optimistic discourse such as innovation, collaboration, and creativity. We have to "innovate in all sort of ways: technology, financing. [...] The next generation requires another step up in innovation; and that is the healthy thing about change, technology and competition. It forces you to be the best and invent the next." [12].

Guest Articles

04

SES 2019 - Interview with the Co Chairs

The Student Energy Summit 2019 (SES 2019) is the leading Energy Summit dedicated to undergrad and postgrad students eager to produce and consume energy more sustainably. From the 17th to the 20th of July 2019, 650+ delegates will meet in London to discuss the future of energy, along with 50+ leaders from industry, academia and policy.

We interviewed our two co-Chairs Geraldine and Jochen on a sunny yet cold fall morning, asking them a broad set of questions, from what drove them to SES 2019 in the first place, to the impact they sought with younger generations. Here is the interview:

Tell us who you are and what you do

Geraldine: I am a third year PhD student at Imperial College, working on international climate change policy. I studied sustainable development in France and Germany before coming to London.

Jochen: I am also a PhD student at Imperial College, researching how to operate the power system when we have a significant share of renewable energy. Before joining Imperial, I studied engineering in Aachen, Germany. Now I am here in London, enjoying the city, researching, playing football and of course, SES 2019.

How long have you guys been interested in Energy, and sustainability around energy?

G: I think climate change is one of the biggest challenges of our time, and obviously the energy system plays a central part in that - around 60% of global emissions come from the energy sector. At the same time, energy obviously fuels everything that we do, so you can't talk about the energy transition without having to consider how it affects the most vulnerable people, or a country's security, to name just two examples.

I therefore think it's both an important and fascinating topic, and I'm really excited to have joined the SES 2019 to share this passion with other students and get a great momentum going at Imperial College.

J: I became interested in Energy pretty early in school and soon saw myself attending an engineering course at RWTH Aachen (Germany). I discovered early on in my studies that above interest, I felt the necessity and responsibility to help to implement more sustainable Energy... and that's why I'm here.

Let's talk about climate change: where are we headed and what are your hopes?

J: My hope is that, with SES 2019, young students from every corner of the world will be eager to challenge the status quo we see with energy supply. My hope is that these students will go back to their respective sectors of activity – whether it is engineering, geography, economy, finance… - and become the next generation of energy leaders.

G: I couldn't agree more. So much is happening right now: we know that climate change is happening, we're seeing it everywhere, and probably even quicker than what we were expecting. This is fostering strong innovation, not only technical innovation, like what we are seeing with the cost of renewables but also of institutions on how we organise ourselves to produce and share energy. I'm hopeful that we can tackle the challenges ahead of us.

Switching to SES 2019, since you mentioned it – walk us through an average day at SES 2019: what do you do, what are the activities involved, struggles and funny parts?

G: (laugh) well you need to know that the SES 2019 committee is really international . Because the Summit will take place at Imperial College London, 15 students are based here in London, but we've also got members in Northern England, Ireland, France and Canada. Obviously, this means a lot of Skyping, talking to each other on the phone, chatting on Slack and always always wrestling with the Internet connection.

J: A typical working day with SES 2019 would be... I wake up in the morning and the first thing that I do is checking my SES emails, then there are a few new problems to be tackled together within the team. This makes it interesting and fun. Other than that, we have

For more information about the Student Energy Summit 2019, please visit www.studentenergysummit2019.com. Registrations open in January 2019.

a weekly meeting with the Vice Chairs and Directors to catch up with everyone: it's on Wednesday night at 6.00 pm. It's fun!

So how has the SES 2019 experience been so far; would you recommend it?

J: I've learned so much already. Managing such an incredible team allowed me to develop new skills. It also gave me confidence to undertake larger projects. Well, we're just halfway, looking forward to the second half of the journey!

G: and it's not only about us, but really seeing everybody in the committee developing and growing in their respective teams: we've got sponsorship people, programme people, events and marketing people, and they're all growing so much and gaining confidence at what they do. I'm really happy with what the team has achieved so far and it's quite a unique experience in one's student life to get to run an event of this scale.

What would motivate a speaker to come to SES 2019?

J: I think the real strength of SES 2019 is that it will enable speakers to educate our delegates, as well as interact and reflect with delegates. We are planning to have panels, workshops, contests, and innovation jams that will spark the discussion between experts and students eager to learn more. Our vision is for SES 2019 to be a reflective, creative environment where everyone benefits.

As for delegates, what words of wisdom do you have for them to come?

G: We are working hard to make SES 2019 really exciting for delegates. As Jochen said, we will have panels and workshops with high-level speakers like the Executive Director of the International Energy Agency. Delegates will get to be part of meaningful conversations on the hottest energy industry and policy topics. . And it's not just all work: we are organising some incredible parties every night: we've got a Gala Dinner and a Final Night Party organised in the iconic Natural History Museum where delegates will be able to network and show off their dancing skills.

One final Question: what is our biggest hope for SES 2019?

J: my biggest hope is really that you, as a delegate, will end the 3-day Summit by feeling empowered and confident to go back home and tackle real energy challenges: it can be any kind of challenge, whether big or small, that you are passionate about and that you believe is important to solve.

G: I completely agree with you. It's all about understanding challenges and coming together to tackle them. My hope is that delegates get to meet each other, understand their similarities and differences, and work together to find innovative solutions to transform the current energy landscape. We are looking forward to seeing you in London!

The importance of policy coherence to ensure a just transition for fossil fuel workers and communities

Dr Maria Carvalho

Abstract

The objective of this paper is to show how a lack of policy coherence between climate policies and policies supporting high carbon industries – particularly for fossil fuel extraction – delays action in addressing potential transition risks to associated workers and communities dependent on these industries. However, the risk of policy incoherence can be avoided if the development of climate policies can assess if governments determine if such climate transition risk does exist; and if it does, develop policies and processes that ensure fossil fuel workers and communities are part of the low-carbon transition, rather than be left behind from a shift away from fossil fuel consumption.

1. Introduction

Historically, the focus of transitions for climate policy was on the resulting changes in the economy, and particularly, the composition of the energy sector. Global consensus of the need to undertake climate action has increased, culminating with the international climate agreement in Paris in 2015. Simultaneously, there has been a greater focus on the social implications of a transition away from fossil fuels that will allow governments to meet the targets set out in the Paris Agreement.

Specifically, labour organisations and governments are considering the potential negative impacts of more stringent climate policies on workers and communities that are dependent on high carbon industries, such as fossil fuel extraction (Gambhir et al. 2018). Indeed, the pre-amble of the Paris Agreement, "[takes] into account the imperatives of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities" (United Nations Framework Convention on Climate Change [UNFCCC] 2015).

The inclusion of this text in the Paris Agreement was due to the efforts of several international labour organisations, such as the International Trade Union Congress (ITUC) and the International Labour Organisation (ILO). The latter developed and adopted the Guidelines for a just transition towards environmentally sustainable economies and societies for all (ILO 2015)as part of their governing body, a few months before the negotiations for the Paris Agreement. Therefore while these labour organisations recognise that a transition away from high carbon industries is an evitable and necessary part of the low-carbon transition – particularly with reduction in fossil fuel extraction – they also advocate for greater transition plans be developed concurrently for labour and communities.

Indeed, it is unlikely that countries with workers and communities that are employed in high carbon industries will be able to implement ambitious climate policies without

explicit policies addressing the implications to these stakeholders. The most recent case is Spain, where the Minister of Ecological Transition negotiated a 250 million euro fund to help coal mining workers and regions that would be unemployed by the shut-down of 6 private coal mines by the end of 2018. These transition policies for workers are set concurrently to a draft climate bill that includes fully decarbonising the electricity system of Spain by 2050, and reduce its greenhouse gas emissions by 90 percent on 1990 levels. Other examples include the Task Force on Just Transition for Canadian Coal Power Workers and Communities in Canada to support the policy to shut down coal power generation by 2030; Germany's Commission on Growth, Structural Change and Employment (also known as Coal Exit Commission) to support Germany's Climate Action Plan 2050; and Scotland's Just Transition Commission, who has a policy to phase out sale of new petrol and diesel cars by 2032, and will be voting on a bill to increase

Scotland's emission reduction targets, including setting a climate neutral target.

2. Policy coherence between sectoral policy, and domestic and international climate policy

The past 10 years have, arguably, seen a strengthening of international and domestic policies to address climate change while simultaneously growing the economy. The Paris Agreement on climate change commits 197 signatory parties (including the European Union as one) to a collective long-term goal of "[h] olding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change" (UNFCCC 2015). The Agreement explicitly recognises that greenhouse gas emissions would have to peak as soon as possible (with 2020 being the latest year for peaking), and become net zero by the second half of the 21st century.

Therefore, the targets set out in the Paris Agreement indicate that global demand for all fossil fuels would need to decrease (International Energy Agency [IEA] 2017; International Panel on Climate Change [IPCC] 2018). McGlade and Ekins (2015) even estimates that in order to meet the targets set out in the Paris Agreement, it would require over 80% of current coal reserves to remain unused, along with a third of oil reserves, and half of natural gas reserves.

While most governments do not have climate targets now that are consistent with the 1.5 °C or 2 °C targets, governments have committed to increasing their emission reduction efforts over time. In fact, the international climate negotiations for 2018 will focus on the preparation of countries to update the targets and policies (referred to as Nationally Determined Contributions) they will submit in 2020, as part of the Paris Agreement.

If governments continue to increase ambition of climate policy by having more stringent greenhouse gas reduction targets, then they would simultaneously also need to ensure policy coherence with domestic policies supporting high carbon industries. 'Policy coherence' is defined by Curran et al. (2018), citing Meuleman (2018), as "the need for a logical consistency across all dimensions of policy development and implementation".

The test of policy coherence would be if the associated greenhouse gas emissions from the production or consumption of high carbon commodities would not lead to a breach of the emission reductions required to meet the domestic climate targets. If there was a breach of emissions limits, governments would need to reconsider either its support to that sector, or its willingness to take on more stringent climate targets, in order to be coherent.

However governments cannot just consider policy coherence between the sector policy and climate policy at the domestic level, but also with international climate policies. Consideration of international climate policies would need to occur in two ways. First, governments would have to consider the climate policies set in foreign economies, particularly foreign economies that it expects to export high carbon commodities to. Second, governments would have to consider whether its climate and sector policies are aligned with international climate targets, as set out in the Paris Agreement. While domestic governments could limit the climate ambition of domestic policies to not undermine the economic viability of high carbon industries – and hence, technically ensure policy coherence between domestic climate and sector policies for high carbon industries – it cannot stop other countries from taking more stringent climate policies to be in-line with the Paris targets.

3. A lack of policy coherence increases the transition risk to investors and firms

A lack of policy coherence between climate and sector policies also increases the risk of an unprepared transition for key stakeholders. Specifically, governments may be unaware that there is a lack of policy coherence between its sector policy and domestic/international climate targets. Therefore governments will continue to develop support policies for both.

However the increasing stringency of domestic and international climate policies could translate into a reduced demand for high carbon commodities. The economic risk of this reduced demand for high carbon commodities is referred to as 'climate transition risk'. Transition risks is one component of a broader concept of climate risk (Taskforce on Climate-related Financial Disclosures [TCFD] 2017). Climate risk also includes physical risks of assets that are exposed to climate shocks; or litigation risk, where companies/governments

are sued for their liability on climate damages inflicted on others due its own activities.

There have been greater calls for transparency for stakeholders such as investors and firms to disclose such climate risks, as part of the Taskforce of Climate-related Financial Disclosure (TCFD), an initiative led by the Governor of the Bank of England, Mark Carney. The TCFD itself is part of a broader initiative of the Financial Stability Board, whose objective is to identify and manage risks that could undermine the financial systems, so as to avoid underappreciated risks that led to the 2008 financial crisis.

The TCFD was developed to ascertain how climate risk can undermine the financial system. Therefore, the TCFD asks investors and firms to assess how exposed their portfolios and business operations are to the scenario of meeting the Paris targets of 1.5 °C or 2 °C target, regardless of whether governments currently have policies in place to meet these targets. In assessing these climate transition risks, it calls on investors and carbon-intensive firms to manage such climate risks to avoid financial losses caused by a lack of economic competitiveness in a global economy that is compliant to Paris targets.

Therefore, a lack of policy coherency sends confusing signals to investors and firms, and indeed, can undermine the credibility of government's climate policies. Averchenkova & Bassi (2016) define credibility as the trust governments will be able to implement and execute policies to achieve its own targets. Therefore the confusing signals caused by a lack of policy coherence between domestic sector policies, with domestic and international climate targets, undermines the confidence that governments will truly implement stringent policies to address climate change. As such, it can delay action from investors and firms to manage climate risks, if they do not believe these targets will be credibly achieved.

4. A lack of policy coherence increases the transition risk to workers and communities

However there is no call to governments to undertake a similar climate transition risk exercise. Governments can undertake such transition risk assessment analysis in order to identify those stakeholders who would bear a greater proportion of the climate costs. These stakeholders include poor households, and fossil fuel/ high carbon workers. Geographically, it includes a necessity of transition risks to communities and regions that have a high concentration of poor households, and/or workers that would become unemployed if action was taken to meet the Paris targets. It also includes regions whose economy is heavily dependent on high carbon industries that are exposed to climate transition risk.

Governments can also incorporate transition risk to their fiscal budgets. This can include: (1) expected tax revenues from the profits of fossil fuel extraction or high carbon companies under Paris targets; and (2) potential tax payments to companies and workers suffering from sudden losses due to a structural shift away from high carbon commodities due to reduced demand from climate policy. Governments would also need to think about welfare payments to workers and regions that face such sudden deprivation, which can persist generations after the initial shutdown. Beatty & Fothergill (2017) estimate that the UK Treasury paid about £20 billion (as a sum of various benefits, and foregone tax revenues from lower wage jobs) in the 2015/2016 fiscal year, to regions that faced deindustrialization and closure of coal mines 20 years ago. The OECD (2017) report recognises that climate policy needs to be flanked with policies for labour and regions, addressed at multiple levels of government in order to avoid the unintended consequence of climate policy: that is, the sudden welfare loss of workers and communities with the shift away from fossil fuels. Therefore climate policies need to also be coherent with social and regional policy by setting transition plans for workers and regions well in advance of the climate target years.

Climate policy can thus learn to avoid the consequences of other types of policy induced changes that had similar social implications, such as the liberalisation of economies that led to the sudden de-industrialisation of regions and lay-offs of workers; or the removal of coal mining subsidies in the UK, which led to the closure of the mines (Caldecott et al. 2015). By identifying those workers and regions that are most vulnerable from a transition away from fossil fuels resources and high carbon commodities, climate policy can address a key social distributional consequence of climate policy.

In order to ensure these social consequences of climate policy are addressed, there needs to be greater policy coherence between policymakers who develop climate policy, with policymakers that address labour and regions. In the case of labour, there can be both short and long-term policies to address potential unemployment of workers in these declining industries by: (1) providing retirement packages for those willing to take early retirement; (2) re-skilling and educational programs for younger workers; and (3) mechanisms to help labour move to regions where the jobs exist (in case it is not in the same region).

Regional policy will also need to be considered. It should be noted that having policies to ameliorate sudden unemployment of fossil fuel labour is not equivalent to avoiding deprivation of the region. First, the shutdown of high carbon industries can have broader economic implications within the region, in terms of local supply chains and services that support those facilities. Regional deprivation can be particularly acute if a significant proportion of economic activities and employment are dependent on the operation of these high carbon industries. Relatedly, the fiscal budget of the region can also be heavily dependant on the corporate and labour taxes coming from high carbon industries. The sudden shut down of these facilities not only reduces income for the fiscal budget from foregone revenues, but it can also require the regional government to increase its welfare payments to the unemployed.

Another underappreciated aspect of the sudden shutdown of facilities is broader implications to the regional labour market. Beatty (2016) demonstrates how the labour markets of UK coal mining regions were distorted with the influx of coal mining workers in the regional markets, resulting in an increased number of labour competing for the same number of jobs in other sectors. This led to a 'crowding out' effect of coal mining workers taking the jobs that younger labour, and even women, would have taken. This crowding out effect has led to long-term unemployment and regional deprivation (Fothergill 2017).

Therefore regional policies focus on enabling the resilience of a region through: (1) economic diversification opportunities, including policies to make these industries globally competitive; (2) preparing local labour for these industries through establishing universities and research institutes; and (3) transport infrastructure to connect to other regional economic hubs to benefit from economic spill overs.

5. The need to develop a just and inclusive low-carbon transition

This paper has so far argued that a lack of policy coherence between sector support policies, and domestic and international climate policy, can increase the transition risk to workers and communities involved in high carbon industries. The lack of policy coherence stems from government not ascertaining whether the sector policies supporting high carbon industries could lead to a breach of its own climate targets, or international climate targets.

By not determining such policy coherence, governments can also fail to put in transition plans for vulnerable workers and communities' that face an accelerated transition from a high carbon to low-carbon economy. While governments could choose to reduce their own climate ambition in order to protect domestic workers and communities, it would be difficult for them to prevent other governments from implementing more stringent climate policies (particularly in export economies). Therefore, it is essential for governments to determine its economy's exposure to climate transition risks, including to workers and communities dependent on high carbon industries. In doing so, it can ensure a just and inclusive transition for these workers and communities by addressing the social implications of domestic and international climate policy.

05

What's to come?

Meet like-minded people who speak energy. There are so many events happening around London which you can take advantage of. Remember to book the tickets online so you aren't disappointed.

10 DEC 2018

Practical Implementation of Sustainable Smart Cities

Institution of Mechanical Engineers

Free to all

The lecture will focus on the practical implementation and the lifetime functioning of smart city projects, taking into account local cultural, political and structural factors as well as the engineering challenges. There have been cases in which much of the vision has become washed away as implementation has become a reality and this talk with present a robust demonstration of what is truly workable.

https://events.imeche.org/ViewEvent?e=6769

25 JAN 2019

Making a material difference to green energy – batteries included

Royal Institution

Free to members, £15 - concessions

The supply of clean sustainable energy is one of the greatest challenges of our time. Better batteries for electric cars and solar power for homes require advances in new materials and underpinning science. Using 3D glasses, Saiful Islam will show how atomic-scale modelling and structural chemistry are helping us explore new energy materials for a low carbon future.

https://www.eventbrite.co.uk/e/making-a-material-difference-to-green-energy-batteries-included-discourse-tickets-51545097775?aff=ebdssbdestsearch

23 JAN 2019

Practical Implementation of Sustainable Smart Cities

UCL Faculty of Laws

Free for students and academics

The purpose of the event is threefold. First, to examine the design and implementation of the price cap. Second, to reflect on the interaction of the price cap, essentially a consumer protection measure with the ongoing process of consumer empowerment. Can price caps be reconciled both conceptually and practically with the process of competition and consumer empowerment? Finally, to explore the legal implications of the price cap, with a focus on appeals against the price cap.

https://www.eventbrite.co.uk/e/the-energy-price-cap-towards-a-fairer-market-for-the-uk-consumers-tickets-52478370218?aff=ebdssbdestsearch

25 JAN 2019

Blue Energy for the Future – tidal streams, lagoons and barrages

25th January 2019, IET London

Free to all

The UK has the second highest tides in the world with the potential to provide the UK with substantial renewable energy. The lecture will describe the various ways of harnessing it, the various schemes proposed, their impact and comparison of cost.

http://www.theiet.org/events/local/257942.cfm?nxtId=256921

Energy Efficiency Conference

Energy Institute

£95 - student

For the sixth consecutive year, our renowned Energy Efficiency Conference brings together key representatives including energy managers, psychologists, large end users, designers, consultants and academics to discuss the latest issues surrounding energy efficiency

https://www.energyinst.org/whats-on/search/events-and-training?meta_eventId=61903C

27 MAR 2019

25 APR 2019

IoT Tech Expo, Cyber Security & Cloud Expo and AI & Big Data Expo

Royal Institution

Free entry

All three expos are co-located with the events expected to bring together thousands of industry leaders for two days of world-class content from the leading brands embracing and developing cutting-edge technologies.

https://www.eventbrite.co.uk/e/iot-tech-expo-global-2019-tickets-47953440030?aff=ebdssbdestsearch

06 FEB 2019

Power from Poo

The Adelaide, Teddington

Free to all

This talk includes a review of the sewage business, covering:

- How did sewage treatment develop?
- How do we treat sewage today?
- What energy value does sewage have?
- Where we operate
- How much power we generate
- Future developments

http://www.theiet.org/events/local/257597.cfm?nxtId=256403

Not able to make it? Explore from the energy space from your own home.

r/energy

Reddit users deliver a mishmash of anything and everything energy-related.
https://www.reddit.com/r/energy/

Veolia Energy Recovery Facilities

Veolia released some videos inside their energy recovery facilities, such as Battlefield in Shropshire. Think 'How it's Made', but for energy
https://www.youtube.com/watch?v=6gzm9XbN3nU

Chatham House

Chatham House is an independent, London-based policy/international affairs institute with a focus on sustainability – environmental, economic and social. They are a hub in London for reports and key events. They even have their own podcast – not strictly energy-related, but interesting in their own right.
https://www.chathamhouse.org/multimedia/podcasts-audio

FT Energy Transition Guide

Part 5 out of 6 dropped on December 3rd, and it covers the politics of global energy use. You don't want to miss it.
https://www.ft.com/reports/energy-transition-guide

energy
journal

https://energyjournalonline.wordpress.com

https://www.facebook.com/EnergyJournal

@JournalEnergy

Energy Journal

https://www.linkedin.com/company/energy-journal

ICL energysociety@imperial.ac.uk

LSE lsesuenergysociety@gmail.com

UCL https://www.facebook.com/groupsuclupogs

ATKINS
Member of the SNC-Lavalin Group

bp

NAVIGANT

Statoil

Energy Aspects

OIL&GAS UK