

PIPELINE

ISSUE 03
MAY 2021

THE CHEMENG SOC ULTIMATE NEWSLETTER



THE ENERGY TRANSITION



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HI READER,

THE PAST YEAR HAS BEEN AN IMMENSE CHALLENGE. AS THE COVID-19 PANDEMIC RAGED ACROSS THE WORLD AND NEW VARIANTS EMERGED, WE'VE HAD TO ACCEPT THAT FOR BETTER OR FOR WORSE, THIS YEAR WOULD BE A REMOTE YEAR. NO IN-PERSON ACTIVITIES MEANS WE'VE HAD TO SETTLE FOR ZOOM CALLS AND TEAMS CHAT, BUT I HOPE YOU'VE MANAGED TO STAY CONNECTED WITH YOUR FAMILY AND FRIENDS.

IN THIS TRYING TIMES, I ALSO HOPE THAT PIPELINE HAS BEEN A TRUSTY SOURCE OF INFORMATION AND A WELCOME RESPITE FROM COURSEWORK. WE'VE TRIED TO SPICE THINGS UP A BIT THIS YEAR, REDUCING THE NUMBER OF ISSUES TO FOCUS MORE ON THE QUALITY OF EDITORIALS WE PRODUCE. THE WORLD CAN SEEM A BIT MAD SOMETIMES, AND WE'VE TRIED DISTILLING COMPLEX TERMINOLOGY INTO SIMPLER ARTICLES, SO YOU HOPEFULLY HAVE A BETTER UNDERSTANDING OF THE KEY CHALLENGES WE FACE AS CHEMICAL ENGINEERS.

ON HAPPIER NOTES, THE END OF TERM IS FAST APPROACHING. FOR THE FOURTH YEARS, WE'RE ALMOST DONE WITH IMPERIAL. IT'S BEEN A ROLLER-COASTER RIDE WITH HIGHS AND LOWS (AND PROBABLY MORE LATE-NIGHT STUDY SESSIONS THAN I'D LIKE TO ADMIT), BUT IT'S BEEN FUN. TO THE REST, ENJOY IMPERIAL WHILE YOU CAN. I WAS TOLD AS A FIRST YEAR THAT I'D GRADUATE QUICKER THAN I IMAGINED AND LOOKING BACK, BETWEEN THE CRAZINESS OF COURSEWORKS AND THE GENERAL IMPERIAL STRESS, I THINK THE ADVICE HAS MERIT. SO, ENJOY IT WHILE YOU CAN.

ON THAT NOTE, I'LL LIKE TO WISH YOU ALL THE BEST OF LUCK AND A HAPPY SUMMER. (WITH THE VACCINATION PROGRAM KICKING IN, IT LOOKS LIKE IT'LL BE A GOOD ONE.)

CHEERS,

KARYSHMA

FOREWORDS

DEAR ALL,

WELCOME BACK TO ALL!

I REALISE THAT I AM WELCOMING MANY OF YOU BACK TO YOUR OWN HOMES, AND THAT IT IS PERHAPS UNLIKELY THAT THERE WILL BE MUCH FACE-TO-FACE TEACHING BEFORE THE END OF THE ACADEMIC YEAR, BUT LOOK ON THE BRIGHT SIDE - LECTURES CAN NOW BE ATTENDED WITHOUT WORRYING HOW SCRUFFY YOU LOOK, AND WHETHER YOU ARE WEARING MATCHING SOCKS (AND NOT JUST IF YOU ARE THE PROFESSOR GIVING THE LECTURE). SIGH. WELL, LOOK ON THE BRIGHT SIDE - SOME COUNTRIES HAVE FINALLY GOT AROUND TO RECOGNISING THAT, POSSIBLY, LETTING THE VIRUS RUN WILD ISN'T A BRILLIANT IDEA.

I AM VERY PLEASED TO BE WELCOMING A NEW SET OF LOVELY COMMITTEE MEMBERS TO THE TEAM (AND SHALL BE BRAVE AS THE CURRENT COMMITTEE DISAPPEARS OFF INTO THE SUNSET). THANK YOU TO EVERYONE WHO STOOD, AND REMEMBER THAT THERE ARE STILL A NUMBER OF POSTS THAT ARE NOT CURRENTLY FILLED - THE SOC IS VERY LUCKY TO HAVE SUCH COMMITTED VOLUNTEERS.

I HAVE BEEN PARTICULARLY ENJOYING THE SOC'S YOGA PRACTICES, AND RECOMMEND YOU ALL COME ALONG WHEN THEY ARE NEXT ORGANISED. DON'T MIND THE FAT PUFFER AT THE BACK, WHO IS GENERALLY WONDERING HOW HE *EVER* MANAGED TO DO THESE POSITIONS.

IT LOOKS LIKE IT'S GOING TO BE VIRTUAL INSANITY FOR THE NEXT FEW WEEKS, SO ANYONE WHO HAS A GOOD IDEA OF A VIRTUAL EVENT PLEASE LET US KNOW, QUIZZES SEEM TO BE A *LITTLE* WORN OUT, THOUGH MASTERY TASK WAS CERTAINLY FUN FOR AT LEAST ONE OF THE PARTICIPANTS.

KEEP GOING, THERE'S LIGHT AT THE END OF THE TUNNEL WITH COVID.

CHEERS,

PAUL

TRANSPORTING AUSTRALIA TO 2050: LONG DISTANCE TRAVEL

BY: DOUGLAS LAU

Sydney – Melbourne. 877 km. 40 minutes.

James hurried up the steps to the Hyperloop platforms, briefcase in hand, and checked his watch.

Nice, I'll make my 7:30 pod.

As if his mind was read, the PA crackled, “the pod to Melbourne Southern Cross will leave in 1 minute.”

James could not be late. As CEO of GreenHydrogen, he had been invited to a prestigious energy and infrastructure conference in Melbourne which started at 8:30. All major industry players were invited, and more importantly, big investors would be present.

The pod hovered next to the platform, its sleek white exterior contrasting with Central station's old colonial architecture. At the far end of the platform was the airlock.

James stepped into the pod and quickly found his assigned seat. There were 26 seats arranged in pairs on either side of a central aisle. The cabin had long sweeping curves and was softly illuminated by a central light strip running along the off-white ceiling. Soon after he sat down the doors slammed shut, locking with a click and pneumatic hiss. The pod gently glided into the airlock and came to a stop. After a short wait, it entered the vacuum tubes and began a smooth acceleration. Displays in the walls slowly came to life with a virtual feed of the outside world. James watched the speed display rapidly climb to 1,200 km/h as the pod hurtled past suburbs and streaked into the countryside.

As James settled into the journey, he reached into his briefcase and pulled out reports his senior engineer and intern had prepared. He glanced over the company's historical hydrogen production, making a note to highlight their ten-fold increase in capacity. He also made a note to emphasize the importance of domestic fuel production – it was critical for Australia's security to isolate transportation networks from global market shocks. James was hoping to attract more investment.

James put away the reports and closed his eyes. His thoughts briefly drifted to his intern and the future of GreenHydrogen. It pleased him to know there were young minds with the skill and drive to keep propelling the company forwards.

He took a deep breath.

Maybe there's time for a short nap.





SYDNEY – GOLD COAST. 845 KM. 9 HOURS.

The light flashed green. Jeremy stomped on the accelerator and felt the instant torque of the Tesla shove him into the bucket seat. The Harbour Bridge quickly receded from view. He heard giggling from the back.

“Do it again papa!”

Jeremy grinned and stomped on the accelerator again. His wife rolled her eyes.

“What? I earned my fun,” he quipped.

Jeremy’s request for a month-long vacation had been granted by James and he was determined to enjoy every second of it. He had spent the past two years as senior engineer completing GreenHydrogen’s conversion to tidal power and he needed a break. Jeremy had promised his daughters a trip to the Gold Coast but had been forced to postpone multiple times.

Well, we’re going now!

He was going to buy air tickets but the wife had wanted to take the car to visit some lesser known tourist spots on the way. So naturally, they took the car. His thoughts turned to vehicle technology and he marvelled at the progress. He remembered a time when the majority of cars were petrol-powered and incredibly noisy. Since the government banned sales of ICE vehicles and legalised autonomous driving in 2030, uptake of electric and hydrogen-powered vehicles skyrocketed.

The air certainly is fresher and the commute less stressful these days.

Jeremy thought back to his career. He felt lucky to join GreenHydrogen just before the ban. The company saw incredible success, riding the wave of investments in clean fuels, and his career was rapidly propelled forward.

Jeremy slowed down as they came upon a highway onramp and engaged autopilot, releasing the controls. The Tesla gently accelerated and seamlessly merged into traffic. Jeremy tapped the central touchscreen, switching from “Fun Mode” to “Charge Mode”. After a short pause, the Tesla automatically merged to the left-most lane and connected to the induction chargers buried beneath the asphalt. Jeremy glanced at the dash. The charging symbol flashed orange.

Nice.

He swivelled his seat to face his daughters.

“So, game of Scrabble?”

The cool glass pressed against her temple as she stared at the clouds below. The muffled roar of the hydrogen-turbine engines filled her head, lulling her into a meditative trance. Michelle was flying back home after a long internship at GreenHydrogen. She hadn't seen her parents in a year and was looking forward to her mother's kangaroo pie.

Michelle glanced at the engines. They looked and sounded like old technology, but she knew they were not producing any emissions. An intense feeling of pride bubbled up from within as she realised the reach of her work at GreenHydrogen.

GreenHydrogen brought hydrogen power to Australia!

It felt good to work at the company that dragged Australia into the 21st century. Without GreenHydrogen and companies like it, Australia would not have reached its 2050 emissions targets. Michelle's thoughts turned to the CEO and senior engineer. She loved working with James and Jeremy and had learned so much about the business and the wider industry.

Hopefully I made a good impression... I'd like to work there again.

Her thoughts drifted to home. Michelle was the first in her family to attend university and she felt the pressure on her shoulders.

She was one of many from Alice Springs who could now afford tuition due to the tourist boom and investments pouring into rural Australia. With significant reductions in air fares from the switch to domestically-produced hydrogen fuel and advancements in autonomous vehicle and electric highway technologies, it was cheap and easy to go anywhere. Just last year, a brand-new high street had popped up near her house. It was constantly packed with tourists frequenting cafes and trinket shops.

Michelle groaned at the thought.

She grudgingly knew she should appreciate the tourists. After all, employment was up and money was pouring in. Drugs and crime in Alice Springs had plummeted too. Michelle remembered the stories her mother told of life back then – of how they could not walk around at night and how they lost countless friends to opioid overdoses.

She sighed.

Well, I'm glad those days are over. Maybe I can bring more money into the community when I start working too.

The plane banked left and start to dip. Michelle glanced at the interactive display.

30 minutes remaining.



NARRATIVE PERSPECTIVES

This collection of interlinked narratives is set in Australia in the year 2050. It takes the form of a vision – a best case scenario of the future which society can strive to achieve. In this future, strong social and political support has led to massive investments in transportation infrastructure and technology. With this, there has been rapid progress over the past three decades. As a result, long-distance transportation has become more environmentally friendly, widely-available, and less strenuous on the individual.

This piece is in the form of three mini-narratives linked by a common thread. Each narrative is told from the point of view of protagonists with unique backgrounds who have interacted with each other in some way in the recent past. The protagonists are in different stages of their lives, each travelling on unique modes of transportation for differing reasons. This way, the diversity of options and benefits of each future transportation mode are explored.

The narratives are written in such a way that all events occur concurrently. They capture a snapshot in time, exploring the surrounding environment of each protagonist and diving into their thoughts. As the reader follows the narrative, it is hoped that a vivid picture of the future is painted in their mind. It is hoped that the reader walks away with a yearning for this vision and helps promote change such that society can attain this future. The narratives are also written such that the reader can easily relate to the protagonists. Daily life situations are explored, and the technologies introduced are within the realms of possibility. This is done to avoid a disconnect between the reader and the narrative which would diminish the effect of the vision.

This piece actively avoids being a radical hyper-futuristic vision – such a piece would prove too jarring – but rather acts as a gentle subconscious nudge in the right direction.



RENEWABLE ENERGY: DOWNSIDES OF AN IMPERFECT SOLUTION

BY: NATHAN FORNSHAW

In a world where 89% of annual CO₂ emissions stem from the burning of fossil fuels (Olivier & Peters, 2020), renewable energy sources (RES) are seen as a necessary alternative if we are to avert a climate catastrophe. The two most common alternative sources of power are wind and solar, both of which have a negligible carbon footprint compared to conventional energy sources (Evans, Strezov, & Evans, 2009). However, it is important that we avoid blind faith in these technologies and consider their downsides, so that we can solve the issues associated with them in advance rather than retroactively.

There have always been objections to wind and solar development, whether from people who lived local to installations, people worried about the environmental impact, or from people who stood to lose out financially. These objections are not without credit; wind turbines do stand out against the countryside and are prone to killing animals such as birds and bats, albeit a very small number (Saidur, Rahim, Islam, & Solangi, 2011). There is also some evidence to suggest that the noise of wind turbines can affect people's sleep patterns and potentially pose other health risks (Leung & Yang, 2012). However, these problems are easily solved with proper planning and by building installations away from populated areas. Another common issue pointed out by those in the energy industry is the inconsistency of wind and solar power, which results in a mismatch between supply and demand (Denholm & Hand, 2011). This necessitates either keeping conventional energy (i.e. fossil fuels) around to compensate, or in the case of a 100% RES scenario, developing energy storage technologies in the form of batteries, pumped hydroelectric storage, or combined heat and power plants (Weitemeyer, Kleinhans, Vogt, & Agert, 2015) (D.Connolly, H.Lund, B.V.Mathiesen, E.Picana, & M.Leahya, 2012) (Mathiesen & Lund, 2009). Otherwise, rebuilding the grid into one much more flexible than the existing one, for example via micro grids (Lund & Munster, 2003) (Majzoobi & Khodaei, 2017) provides another option. The common thread between all of these problems is that they primarily affect us, and do not pose so much of a threat to the environment as an inconvenience.

What then are the environmental impacts of wind and solar energy, since no power source sufficiently large enough to meet our needs would be without its toll on the Earth? Some of the largest impacts would come from mining the materials needed to construct enough solar and wind generation. At present, 82% of mining activity produces resources critical for RES, and around 8% of the global area affected by mining coincides with protected biodiverse areas, a number set to increase in the future (Sonter, Dade, Watson, & Valenta, 2020). A growth in the demand for materials will also diminish natural reserves, in some instances existing reserves may not be sufficient to meet demand for materials such as cobalt and lithium (Manberger & Stenqvist, 2018). Copper is another already somewhat scarce material that is critical for RES, and a 2050 100% RES scenario would see a 2-7 times increase in the energy cost of copper extraction (Harmsen, Roes, & Patel, 2013). In order to cope with demand without damaging the environment more than necessary, more efficient methods of mining will need to be developed.

Recycling may also play a small role in supplying these materials and will be crucial in the case of solar panels to prevent discarded panels from polluting the environment with toxic components including cadmium (Brouwer, Gupta, Honda, & Zargarian, 2011), as well as recovering rare elements such as indium, gallium, and germanium (Xu, Li, Tan, Peters, & Yang, 2018). Solar panel recycling still needs development in both technology and policy, and this must be done within the panels' 25-year lifespan to avoid a scenario similar to the current e-waste problem (Brouwer, Gupta, Honda, & Zargarian, 2011). Nonetheless, as more Renewable energy sources built, more materials will become locked up in the active turbines and panels meaning recycling will only have a limited contribution to supply chains. How do we solve - or at least minimise - these problems? One of the best ways would be to diversify the technology used in RES, to avoid high demand for a few materials, and to aim to centre technologies around materials that are more abundant and avoid those that aren't (Manberger & Stenqvist, 2018). This, in conjunction with improved mining and recycling technologies, and finding a way to minimise global energy, will maximise the benefit of transitioning to RES.

Wind and solar power is a better alternative in nearly every way to conventional energy sources, especially with respect to the environment. Even so, this 'energy transition' is about more than changing what spins our turbines and heats our water, it's about moving to a model of humanity that can function in harmony with nature as much as possible. We need to be mindful of the problems we're going to face as a result of their use ahead of time if humanity is to last, foresight that we lacked over previous centuries to disastrous effect.

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A CASE STUDY FROM FOSSIL FUELS TO RENEWABLES: SCOTLAND

BY: JAMES WHITE



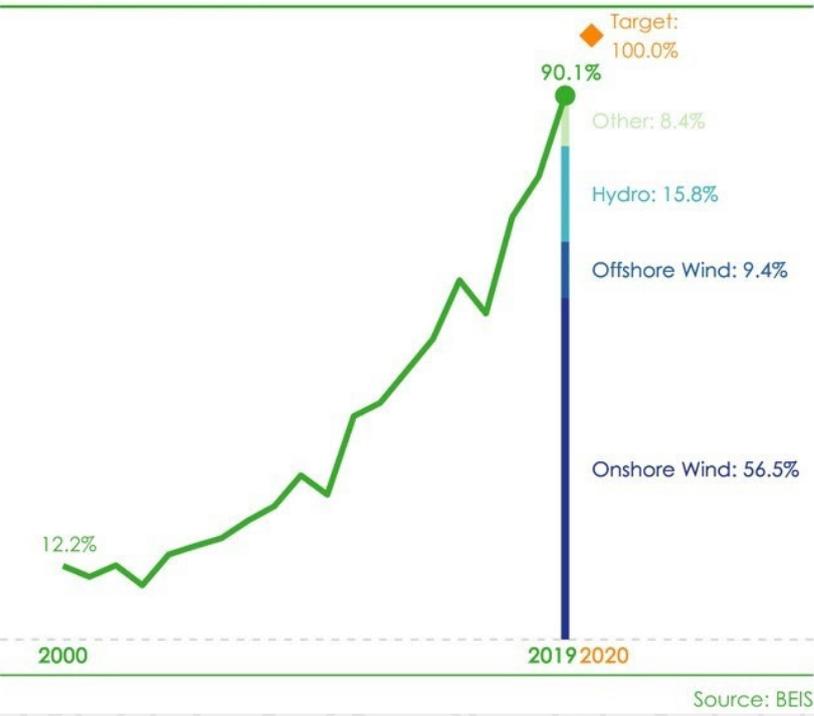
The climate change emergency is critical. It is inevitable that the fossil fuel energy sources such as oil and gas will be consigned to the history books. Despite signing the Kyoto Protocol in 1997 (effective 2005 with 84 signatories) and more recently the Paris Agreement in 2016 (with 195 signatories), different countries have taken multiple approaches to the issue. However, there is one country's approach which is too often overlooked: Scotland.

The first thing that comes to mind when thinking about the Scottish economy is the North Sea oil and gas fields. This ignores the huge renewable energy potential of Scotland and the role of the chemical engineer. In this article, the devolved Scottish Government reports will be used to highlight this.

Industry

The Scottish industrial sector's contribution to greenhouse gas emissions have been reduced by 46% from 1990 to 2017 with targets to both further reduce these levels and improve industrial and commercial energy production by 30% between 2015 and 2032. To achieve this goal technologies such as carbon capture and storage (e.g. our Pilot Plant) plus hydrogen production and injection into the grid need to be demonstrated by 2030 as well as finding suitable renewable heat sources to replace traditional blast furnaces. ([Scottish Government's Climate Change Plan Monitoring Report for December 2019](#))

Share of renewable electricity in gross electricity consumption
Scotland, 2000 - 2019



ELECTRICITY GENERATION

In 2019, 30,528 Gigawatt hours (GWh) electricity was generated from renewable sources in Scotland which accounts for 90.1% of gross electricity consumption and is up from 74.6% in 2018. In addition, 71.8% of Scotland’s renewable electricity came from wind. The overall target is for 100% of electricity consumption from renewable electricity sources by 2020. This is possible because Scotland is a sparsely populated country. If this milestone is reached then Scotland would be the fifth country on the planet to achieve it after Albania, the Congo, Iceland and Paraguay. (Scottish Government Annual Energy Statement 2019)

SOURCE: SCOTTISH ENERGY STATISTICS HUB

(UK ENERGY STATISTICS, 2019 AND Q4 2019).

	Scotland	Rest of UK
Renewable Electricity % of consumption (2019)	90.1%	36.9%

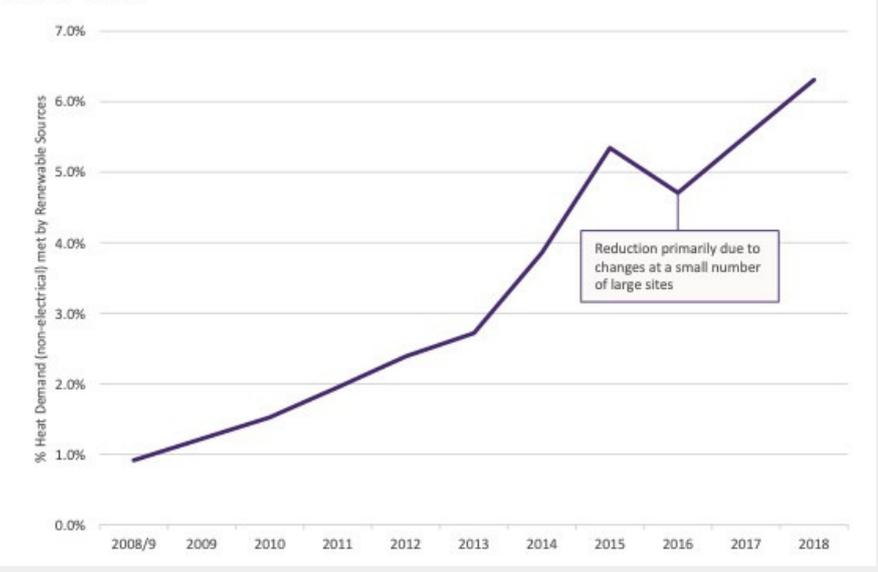
At present, Scotland has two active Nuclear power stations: Hunterston B which is scheduled to close in 2021 and Torness B in 2030. Therefore, with the electricity from both of these stations and the renewable electricity it can be argued that Scotland is currently already a low carbon economy to some extent. (EDF Energy and BBC News)

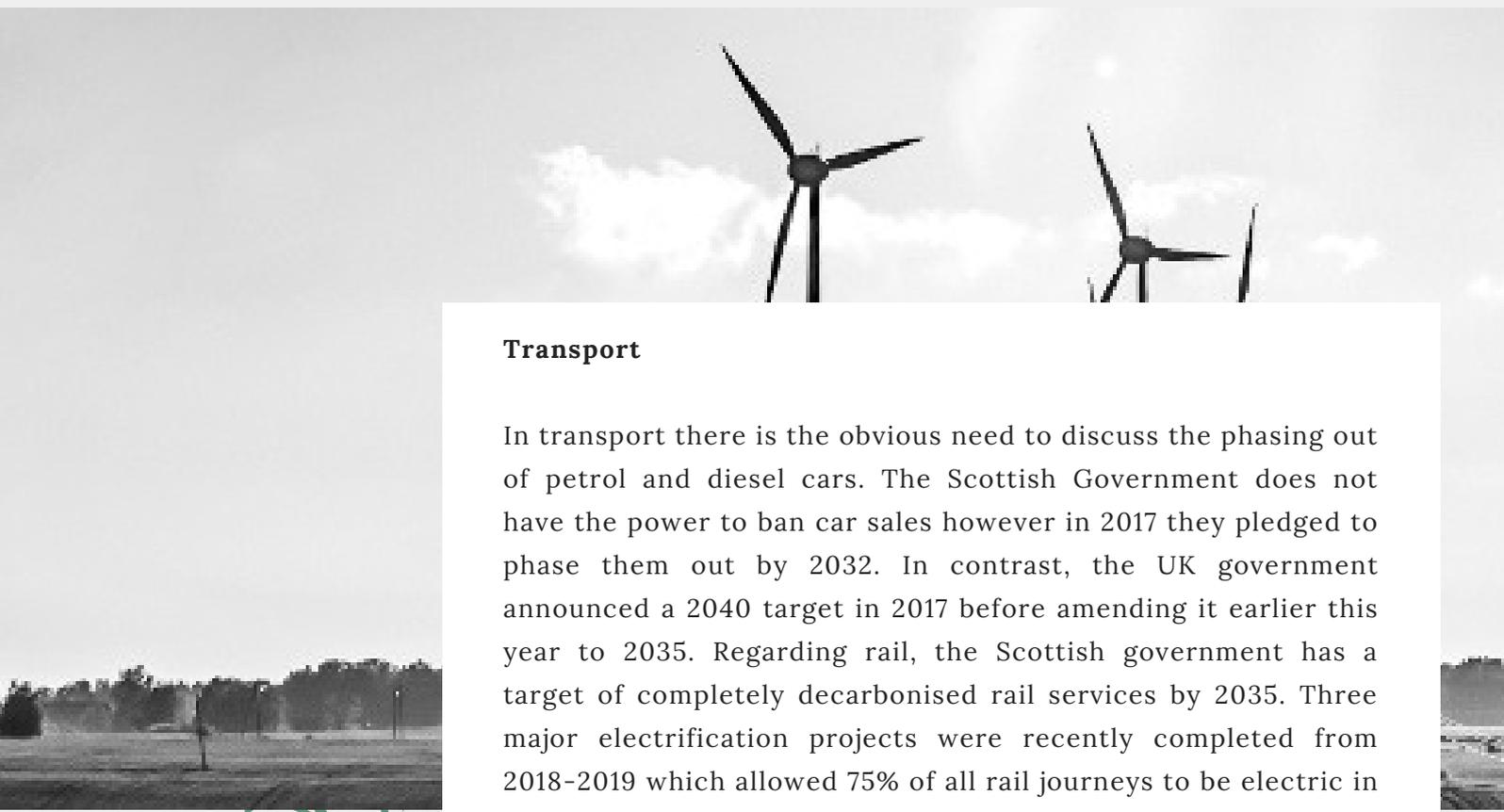
There is also a political element. Support for Scottish Independence is increasing with the governing Scottish National Party (SNP) polling consistently above 50%. The SNP will be keen to use this renewable electricity generation as a bargaining chip and leverage in the event of a second independence referendum.

HEAT

With non-electrical heat generation, the figures sound less optimistic. In 2018, renewable heat accounted for 6.3% of total heat generation which is up from 5.5% in 2017 with a target of 11% by 2020. The majority of this heat production comes from biomass primary combustion and biomass combined heat and power (CHP) which together account for 83% of Scotland’s renewable heat capacity. However, demand is not consistent and has varied for example between 2008 and 2015 heat demand fell predominantly due to increased efficiency but has increased since 2015.

Figure 2. Percentage of non-electrical heat demand met by renewables in Scotland, 2008/9 – 2018





Transport

In transport there is the obvious need to discuss the phasing out of petrol and diesel cars. The Scottish Government does not have the power to ban car sales however in 2017 they pledged to phase them out by 2032. In contrast, the UK government announced a 2040 target in 2017 before amending it earlier this year to 2035. Regarding rail, the Scottish government has a target of completely decarbonised rail services by 2035. Three major electrification projects were recently completed from 2018-2019 which allowed 75% of all rail journeys to be electric in 2019. (Scottish Government's Climate Change Plan Monitoring Report for December 2019)

Conclusion

The question is where does chemical engineering come into this?

Chemical engineers may not be required for production of wind turbines however they are required for solar panel production. The Scottish government may dislike nuclear power however Hunterston B and Torness B will still require extensive decommissioning (good news for the chemical and nuclear engineers). It is still necessary for chemical engineers to be involved with the manufacture and processing of biofuels and biomass. Finally, not every rail route can be electrified especially in remote areas and so research into hydrogen fuel cell and battery powered trains has taken place involving chemical engineers.

To conclude there are many opportunities for the chemical engineer to get involved with the renewable sector in developed economies such as Scotland and it is an essential asset for breaking the myth that "chem eng is only for the oil and gas industry".

(There is further information available from the Scottish Government's website showing the full extent of the Scottish economy's fossil fuel to renewable transition).



WELLBEING TIPS

BY: FAITH MARSH



Exams are ongoing and this means that for some of you that your wellbeing might be impacted. Most people do experience some level of stress when it comes to sitting exams which makes sense, however sometimes this level of stress becomes more difficult to manage.

If the level of stress that you have means you are finding it difficult to focus or manage please do get in touch for support. This article covers the most important things to keep in mind to have good wellbeing during exams, which will help you to achieve your goals. Most of them are simple to keep in mind, however can be a challenge when we are feeling stressed so it is good to keep them in mind!

Firstly, try to stick to your usual routine as much as possible.

Sleep

I know that I have written before about the importance of sleep, it is easy to think that getting a bit less sleep to spend more time revising will be useful. However more often than not this can mean that you may feel tired or less able to concentrate. Sleep is really important to consolidate learning and also to help with memory recall. It is best if you can try and stick to a good sleep routine throughout exams so 7-9 hours each night.

Staying Active

Exercise will help to relieve some stress & anxiety and also gives break from revision and focus on work. If you

really want to, you can listen to some recording notes while doing this! Check out some technology to make your study more efficient here

Food/Nutrition

Try to make sure you are sticking to usual meal times and perhaps introduce healthy snacks if you are really focusing for longer periods of time. This will give your brain the energy it needs to keep focused.

I will also be running some group sessions on Teams on exam wellbeing in April/May so keep an eye out on your emails for the links to these.

Please also feel free to get in touch for one to one support on Teams or via email at f.marsh@imperial.ac.uk