Keeping the lights on is of critical importance for a prosperous future

We previously talked about energy security and the impact on global energy markets resulting from the crisis in Ukraine. In that post we discussed energy security from the traditional perspective of risk of disruption in global energy flows as a result of geopolitical issues. Today we will expand upon the concept of energy security to go beyond the political and address the technical issues that impact our ability to deliver energy reliably to consumers. For society to truly prosper, we need strong **reliable** and **resilient** energy systems.

Source: pexels.com

System reliability – means a system (or grid) where electricity flows can be counted on to be available when required – i.e., customers need confidence that when they flip the switch, the lights come on, and stay on. Given that electricity supply and demand must be always in balance, our very reliable electricity grids are nothing short of an engineering marvel. Expert planners design systems where supply adjusts to changes in demand as needed, and that can tolerate most supply disruptions (outages – both planned and unplanned) without impacting customers. Some simple rules of thumb (actual system design is quite complex) suggest no single generating station should be larger than 10% of the capacity of the total system and grids should have 15% or more excess capacity to accommodate outages.

Somehow, over the past years, attention to this very important objective seems to have been diluted as the focus shifted to emissions reduction and market deregulation. Therefore, in some jurisdictions, system reliability has suffered due to a too rapid increase in intermittent variable renewable generation that needs dispatchable back up, and poorly designed electricity markets that focus on cost above all else with real time energy markets.

Renewables present two major challenges to system planners. First, their intermittency and reliance on weather complicate system design to ensure there is sufficient back up supply for when the sun doesn't shine, and the wind doesn't blow. We have seen, as stated in an article by Robert Bryce, where an excessive focus on renewables just doesn't make sense. For example, in hot climates like Texas, the times when you need the most energy are also going to be the times when you have the least wind. That's just how the weather works.

And the other, less talked about issue is that even though there may be large numbers of solar panels or wind turbines in operation within a given jurisdiction, they actually behave on the system as one very large super plant. Hence the famous "duck curve" in California where all solar panels come on at once when the sun rises in the morning and then all go off when the sun sets. This causes additional stresses for reliability planning as the system tries to respond to these large sudden changes in supply.

We talked about the issues with deregulated market pricing in a previous post noting that least cost does not necessarily mean most reliable. And now as we did then, we will recommend reading Meredith Angwin's book, "*Shorting the Grid*."

System resilience – which is related to how well the system can withstand external events that may cause it to go down such as extreme weather or other man made events. This concept took hold post 9/11 when the concern was how to harden power plants against potential terrorism. More recently the issue has been extreme weather such as hurricanes, tornadoes and wildfires that have forced systems down and damaged them to the point of disaster. The unfortunate thing is that the same jurisdictions we listed above, Texas and California are also suffering from these kinds of extreme weather events, that are challenging the ability of their systems to operate reliably.

This is where nuclear power can play an important role. Nuclear power's high energy density, low carbon emissions, highly reliable operations and built-in resilience can provide the stable energy source we need. It is one of the reasons law makers in California have provided overwhelming support for a bill to keep the Diablo Canyon nuclear plant operating at least another five years, once thought impossible.

Having reliable affordable access to abundant energy is one of the tenets of a prosperous society. Our lives are much better for it. A public threatened with losing this reliable access will not respond well. We have become so used to having a reliable grid that we now take it for granted. However, assuming it will always be, misunderstands how complex an electricity grid actually is. It's time to go back to basics and ensure that system reliability and resilience are the cornerstones of our energy systems. Given the need for a stable baseload 24/7 supply, nuclear power has an important role to play.

The World Nuclear University Summer Institute is back – and I am just so happy

I recently returned from making my modest contribution to the World Nuclear University (WNU) Summer Institute (SI) in Spain. I was so excited to be able to attend in person!! I wrote about this great program after the last summer institute in Romania back in 2019. At that time who knew we were about to enter a global pandemic that would make in person events impossible for the next two years?

It has been a dark time for us all. Crisis after crisis – pandemic, war, inflation and economic uncertainty, political upheaval. It has been easy to have a negative outlook. No sooner does it appear that one major world event is finally in the rear-view mirror than the next one takes hold.

WNU SI 2022

A reminder of what the WNU SI is as stated on its website. "*Built on a foundation of instruction from the world's leading nuclear experts, World Nuclear University's annual immersive,* *five-week leadership development programme brings together nuclear professionals from around the world to share knowledge and broaden horizons. Through a mix of taught lectures, mentored group work, industry-focused projects, and technical site visits, Summer Institute Fellows will improve their leadership capabilities and team effectiveness.*"

This year the SI included 70 fellows from 30 countries. These are young bright people who are not only expert in their own areas of the nuclear industry, but who are kind, hard working and most of all, respectful of each other. I saw people from different backgrounds and cultures helping each other learn as they make friends for a lifetime. Asking deep penetrating questions to the experts providing the lectures and working together with their mentors in groups to discuss interesting issues that make this industry what it is. The most important part of the WNU SI is community building – a strong global community of nuclear advocates who want to collaborate to build a better future for us all.

This is not the first time in the last year we see the future of this industry. We reported following the COP26 meetings in Glasgow last year how the young generation truly made a difference. Now we can see this generation working together to continue to hone their skills as they prepare themselves to be the industry's future leaders.

I want to thank all the fellows who welcomed me to this year's SI and took the time to listen, ask questions and generally build a long-lasting relationship. I am so proud to have been a small part of the WNU for the last 15 years and hope to continue well into the future. Most of all I am happy to know this industry attracts the world's best and brightest, those needed to make sure our shared future is a world with a sustainable environment and abundant clean economic and reliable energy. As this year's program comes to a close, we can be confident that the future is in very capable hands.

(Note: The “I” in this post is Milt Caplan.)

A war raises fears about nuclear plant safety

As the 11th anniversary of the Fukushima accident passed in March, there were none of the regular articles that we see in the press every year to remind us how scary that event was. Often these articles have focused more on the nuclear accident and barely mentioned the catastrophic impact to Japan of the Great Tohoku earthquake, the cause of both the nuclear accident and more than 20,000 deaths.

This year the news was all about the shocking events in Ukraine, where it was reported that Russia occupied and attacked two nuclear sites; the Chernobyl site, home to the worst civil nuclear accident in history (1986), and the Zaporizhzhya plant – which is Europe’s largest operating nuclear power station. This created a new level of fear for what may happen in the event these plants are damaged due to a planned attack.

Source: Pexels.com

The war in Ukraine is causing untold horror and suffering to its people. However, excessive worry about an event at a nuclear plant greatly increasing the devastation is misplaced. There could be military reasons to occupy a power plant such as the desire to control critical infrastructure. There is also the view that setting up a base at a nuclear plant would deter defensive attacks to avoid damaging the plant. Whatever the reason, the likelihood of actually trying to damage the plant and release large amounts of radiation to the environment is small. There have been many articles on why these nuclear plants are safe. Here is one to provide some context.

First of all, nuclear plants are extremely hardened against attack. The fire power needed to do damage that would result in large releases is substantial. It would be far easier to damage the switch-yard or transmission lines to stop energy from flowing. And when it comes to dramatic consequences, there are many easier industrial targets that would inflict more damage.

As of the most recent report from the IAEA on April 28, "*Regarding the country's 15 operational reactors at four nuclear power plants, Ukraine said seven are currently connected to the grid, including two at the Russian-controlled Zaporizhzhya NPP, two at the Rivne NPP, two at the South Ukraine NPP, and one at the Khmelnytskyy NPP. The eight other reactors are shut down for regular maintenance or held in reserve. Safety systems remain operational at the four NPPs, and they also continue to have off-site power available, Ukraine said*."

There is also little to gain and much to lose from damaging a nuclear plant. Russia is on the border with Ukraine and would be at risk of radiation affecting its own territory. Prior to the war, Russia was the most prolific exporter of nuclear plants around the world with a reported project backlog in excess of $100 Billion. This export market will certainly be impacted by this war. Russia would not want to demonstrate their plants are not safe and that they are readily subject to catastrophe.

This is not the first time fear of what may happen at a nuclear plant has exceeded the fear of the initiating event. In each case, the nuclear industry responded by making improvements at nuclear plants to reduce the risk. Following 9/11 in 2001, fear of a terrorist attack on nuclear plants resulted in much hardening of plants to withstand such an attack. Following Fukushima, all the plants in the world made changes to better withstand the impact of natural disasters such as earthquakes and tsunamis. And now, the fear of what may happen at a nuclear plant seems to be even greater than other consequences of war.

This all comes down to the narrative that nuclear plants are just a whole different level of risk compared to the many other things that can cause serious consequences. Nothing can be further from the truth. In reality, people don't die from nuclear plant accidents. They do die from plane crashes, bombings, exploding gas from leaks and natural disasters. To date, many thousands have perished during this terrible war. Yet fear is greatest when thinking about what may happen should a nuclear plant have an accident. That being said, of course there can be consequences from attacking a nuclear plant and it is important that the plants in Ukraine are maintained and operated safely. But one thing is for sure, we need not be afraid of nuclear plants. We do need to be concerned about terrorism, natural disasters and of course, the horrific consequences of war.

The nuclear industry approach to managing waste is a model for all

This month, as we continue our short series on energy economics, our focus is the nuclear industry's commitment to safely managing its wastes. More specifically how this commitment ensures the cost of managing waste is included in nuclear power economics and how funds are set aside to pay for it.

As we have noted before, almost every article on nuclear energy, including the supportive ones will comment on the *enduring problem of nuclear waste.* This waste "problem" is often presented as insurmountable. Yet, the world is full of toxic wastes from human activities. Everything from mining to chemical processes to simple garbage thrown out from everyday household products are cause for concern.

Caption: If all your energy was produced from nuclear power for your entire life, the resulting waste would fit into a pop can Source: iStockPhoto.com

Every form of electricity generation creates waste products. Even renewable sources of electricity like solar and wind contain toxic substances in their panels and turbines and result in a need to manage their waste. The International Renewable Energy Agency (IRENA)'s official projections assert that "*large amounts of annual waste are anticipated by the early 2030s*" and could total 78 million tonnes by the year 2050.

You would be led to believe that nuclear waste is the worst of the worst (In this case waste is referring the used fuel coming out of the reactor). But is it? The reality is nuclear waste is in a solid form, the volumes are relatively small, are easily contained and well managed. There has never been a fatality due to the storage of nuclear waste.

From an economic perspective, it has long been required by regulation to accommodate the cost of managing waste and the cost of decommissioning the nuclear plant at its end of life into the cost of electricity production. In other words, every operating plant is required to charge a fee for every MWh produced to create a fund to pay for waste management. In most jurisdictions this fund is required to be segregated and funded (rather than just an item on the owner's balance sheet) so that in case the owner is no longer solvent when the plant reaches end of life, the fund will be there to pay for waste management and decommissioning.

In the International Energy Agency's (IEA) Projected Cost of Electricity report, the assumed cost of managing used fuel waste is $2.33 / MWh. The fee for decommissioning is even smaller in the $0.1 / MWh range. This compares to about $7.00 / MWh as the fuel cost and a total Levelized Cost of Electricity (LCOE) of about $70 / MWh (or 7 cents/kWh). Therefore, accounting for the cost of managing waste and decommissioning requires adding about 3% to the cost of electricity throughout the unit's operating life. One reason this is relatively small is once again due to the high energy density of nuclear fuel. Or in other words, a very small amount of fuel produces a very large amount of energy. Each jurisdiction has its own method for calculating the amount of money to put aside. Here in Canada, the cost to manage waste is updated every five years and then the amount collected in the cost of electricity is adjusted to ensure the fund remains adequate to pay for final disposal.

If only other forms of energy managed their wastes so responsibly. We have issues in western Canada with oil rigs abandoned with no one to clean them up. Coal burning pollutes with much of its waste being airborne particulates that cause significant harm to our health. And as solar panels and wind turbines reach their end of lives there is going to be a large volume of waste that will need to be safely managed.

The nuclear industry has always focused its efforts on ensuring it provides reliable economic electricity while minimizing any impact to the environment. This approach has the industry taking full responsibility to manage its waste. Rather than being concerned about nuclear waste, this model of ensuring that fully funded plans are in place to safely manage waste should be a standard applied to all forms of energy production. This is the path to a sustainable future.

The war in Ukraine has raised concerns about global energy security as well as the safety of nuclear reactors under siege. On the one hand, the safety concerns have stoked fear; and on the other, energy security issues support discussions of increasing the use of nuclear power as an option to reduce dependence upon imported fossil fuels. We will comment on these issues in future posts.

Energy economics – why system costs matter

In our last post, we quoted from recent reports that clearly lay out the environmental benefits of nuclear power. This month we want to start off the year by launching a short series addressing some of the issues that impact energy economics. Today we will talk about the importance of **system costs** in understanding the relative costs of different generation technologies.

Last year at this time we wrote about the IEA/NEA report, Projected Cost of Electricity 2020, that shows nuclear is competitive with alternatives in most jurisdictions using the traditional Levelized Cost of Electricity (LCOE) approach. LCOE is a great way to compare costs of electricity as it is generated from two or more different options to be implemented at a single spot on the grid with similar system characteristics. With intermittent variable renewables on the system, LCOE alone no longer provides a sufficient basis for direct comparison. By their very nature, deploying these renewables add costs to the system to be able to deliver reliable electricity in the same way as more traditional dispatchable resources like nuclear, hydro and fossil generation.

Source: pexels.com

What are system costs? In a report issued by the OECD Nuclear Energy Agency (NEA), system costs (see the report for a full definition) are basically the additional costs to maintain a reliable system as a result of intermittent variable renewables only producing electricity for a limited number of hours when the resource is available (e.g. daytime for solar), their uncertainty due to the potential for days with little resource (e.g. rainy or cloudy days), and the costs to the grid to be able to access them given their more distributed nature (e.g. good source of wind but far from demand).

A 2018 study undertaken by MIT "The Future of Nuclear Energy in a Carbon Constrained World" considers the impact of nuclear power on the cost of electricity systems when deep decarbonization is desired. It looks at various jurisdictions around the world and the conclusion is always the same; the cost of electricity is lower with a larger nuclear share than trying to decarbonize with intermittent variable renewables (and storage) alone.

The reason for this impact is fundamentally due to the relatively little time these resources produce electricity. Solar and wind only generate when the sun shines and the wind blows, meaning they produce only some of the time and not always when needed. The average capacity factors of these technologies vary by location with world average capacity factor of just below 20% for solar and about 30 – 35% for wind (capacity factor is the amount of time a resource produces compared to if it would produce 100% of the time). Contrast this with the 24/7 availability of nuclear power, which can operate at capacity factors of more than 90%.

The impact on electricity systems is clear. Given the limited duration of operation of intermittent variable renewables, there is a need to dramatically overbuild to capture all the electricity needed when the resource is available to cover periods when the sun is not shining, and the wind is not blowing (all assuming there is reasonable efficient storage available which is not yet the case). The result is a system with much larger capacity than a system that includes nuclear (or any other dispatchable resource). In the MIT study for example, the system in Texas would be 148 GW including nuclear but would require 556 GW of capacity with renewables alone.

In New England a system with nuclear would have a capacity of 47 GW but would require a capacity of 286 GW with renewables alone. In the UK this would mean 77 GW with nuclear compared to 478 without. And so on. The costs of adjusting the system to accommodate these much larger capacities is significant.

Since that time study after study finds the same result. This includes a study in Sweden in which 20 different scenarios for full decarbonization always come out the same; in every scenario the most cost-effective system has continued long-term operation of existing nuclear. And more recently a study in France has shown that decarbonizing without nuclear means a system more than twice as large as one with nuclear and the more nuclear in the system, the lower the overall average cost of production.

So, what does this mean for planning? The approach to implementing a reliable economic low carbon electricity grid must start with looking at the entire system. A study should assess the total costs of deploying the system under a range of scenarios using different shares of available resources. Different forms of generation have different capabilities and these need to be modelled. Once an efficient mix is determined, a plan should be put in place to implement it (i.e., X% nuclear, Y% solar, Z% wind, A% storage, etc.). When looking to deploy each technology, LCOE can be used to compare various options. For example, when comparing one solar project to another or one nuclear project to another. And of course, should the costs of any given technology vary too significantly from the assumptions in the system study that determined the efficient mix, then the system study should be updated.

Today's energy markets are most often based on the assumption that all electricity generated is the same (to be discussed in a future post). This is true at the moment of generation when yes, an electron is an electron. Unfortunately, the ability of any given technology to actually be there to produce at the moment it is needed varies substantially. Therefore, a direct comparison of the LCOE of one option vs another is only part of the story.

To fully understand the costs of electricity generated, the costs of integrating any given technology into a reliable system must also be considered. After all, what really matters is how much we pay as customers for our electricity and the studies are clear, nuclear as part of a fully decarbonized system is always lower cost than a system based on renewables alone.

2021 – The year the nuclear energy narrative started to change

This past year, as COP26 came and went, and the climate discussion turned from emission reductions to net zero targets; more and more governments have come to accept that nuclear power should, and in fact must, play an important role in meeting their aggressive climate goals.

China is leading the way with plans to build 150 new units over the next 15 years. Other countries with plans for new nuclear include Poland, Czech Republic, Hungary, Finland, Slovenia, Romania, the UK and the Netherlands, just to name a few. In France, President Macron has stated "*We are going, for the first time in decades, to relaunch the construction of nuclear reactors in our country and continue to develop renewable energies.*" The US, the UK and Canada are leading the way in the development and deployment of Small Modular Reactors (SMRs). And Belarus and the UAE started up their first nuclear plants this year becoming the newest members of the nuclear family.

Source: pexels.com

We have reliable assessments this year that make the environmental benefits of nuclear power unambiguously clear from a range of multilateral global organizations.

- In March 2021 the European Joint Research Centre (JRC) issued its report on whether nuclear meets the EU Taxonomy requirements and stated – *"there is no science-based evidence that nuclear energy does more harm to human health or to the environment than other electricity production technologies already included in the EU Taxonomy as activities supporting climate change mitigation "*.
- An October 2021 study (**Life Cycle Assessment of Electricity Generation Options)** from the United Nations Economic Commission for Europe (UNECE) looking at a broad range of energy technologies concluded that

> nuclear technology has the lowest lifecycle carbon intensity of any electricity source, ranging from 5.1-6.4g CO_2 per kWh. It also found nuclear has the lowest lifecycle land use, as well as the lowest lifecycle mineral and metal requirements of all the clean technologies.

Given the evidence supporting nuclear as an environmental champion, why is it such a struggle for people to think about nuclear power in a positive way? I was listening to one of the great podcasts from Dr. Chris Kiefer (Decouple podcast), (who also went above and beyond in his efforts at COP26) where he spoke to Angelique Oung earlier this year, an energy reporter and supporter of nuclear energy from Taiwan. She said it best when she said, "*Before I started reporting on this issue, it (being against nuclear) is just the default position in our society. I never thought that much about it, it was just nuclear is scary, nuclear bad, nuclear old fashion, nuclear is expensive – never had reason to challenge those beliefs.*"

And there is the challenge. We have discussed this before. There is a narrative of fear that goes along with nuclear energy that is part of our collective psyche. Almost every article on nuclear energy, including the supportive ones include something like "*The spectre of Chernobyl and Fukushima, along with the enduring problem of nuclear waste, kept energy generated by splitting atoms on the sidelines, even if that energy was virtually carbon free.*"; or "*Nuclear power can go horribly wrong and is notorious for cost overruns, but it is gaining high-profile champions*."

Nothing demonstrates this point more than when the Director General of the IAEA, Rafael Grossi, was being interviewed at COP26 and was explaining the benefits of nuclear energy. He mentioned that nobody died from radiation at the Fukushima accident in Japan – and some in the audience responded with laughter. Grossi replied "*I don't know why you're laughing,* *it's a fact. Thousands of people died because of the tsunami but there were no deaths attributable to exposure to radiation. People died also because of the evacuation, it was very traumatic*," he continued. "*We're taking this very seriously. This is not a laughable matter*."

And then something unexpected happened. Following the interview, journalist Gillian Tett decided to do her homework and learn more. As she stated, "*For me, the incident acted as a (somewhat uncomfortable) reminder of the need for all of us, journalists most certainly included, to periodically question our own assumptions.*" What she was found was published in an article in the Financial Times "**What I got wrong about nuclear power – A debate with the head of the International Atomic Energy Agency challenged my preconceptions**." This reassessment led her to conclude "*With my preconceptions about the radiation impact in Fukushima shifting, I am now doubly convinced it is time to have a wider debate about nuclear power.*"

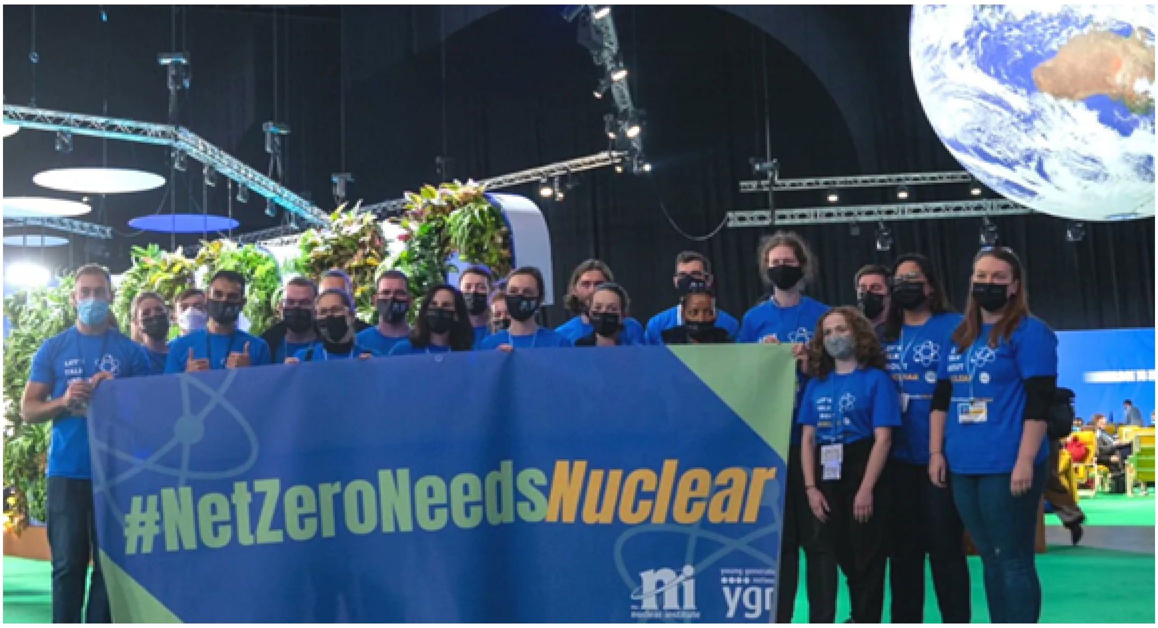
Going back to the critical comment made by Angelique, she "*never had reason to challenge those beliefs*." Until now. The challenge of achieving net zero carbon emissions is massive and requires new thinking. Young people are more focused on climate issues than any generation before them. They are ready to question the entrenched beliefs of others and make up their own minds about how to solve this climate crisis. For many, being willing to take a fresh look at the nuclear option was the first step on the journey to changing their minds about this technology. As this support continues to grow, governments are becoming more willing to include nuclear in their climate plans than ever before. Who knows? 2022 may well be the year that realistic comprehensive climate plans including all low carbon technologies start to show a truly viable path to a decarbonized world.

Thank you for reading our blog. Wishing you all a very happy holidays and looking forward to more discussion in 2022.

At COP26 – the nuclear young generation showed the world the future of nuclear

The role of nuclear power in supporting global decarbonization was discussed more at this COP than at any previous one. We have seen articles with headlines like "**Nuclear Was the Quiet Hero of COP26**" talking about the gains made in getting people to listen to the arguments in support of nuclear power. World Nuclear Association Director General Sama Bilbao y León was in attendance and noted, "*There has been a change in how nuclear is perceived at this COP*."

While there were many hard-working people who deserve thanks for their efforts in advancing the discussion on the merits of nuclear power, it is the energy and commitment of the nuclear young generation that really stood out.



NIYGN at COP26

The Nuclear Young Generation consists of groups of young people in 50+ country/continental chapters around the world that come together as the International Youth Nuclear Congress. For COP26 they were organized by the Nuclear Institute Young Generation Network (NI YGN). Their small team was supported by about 80 volunteers from countries around the world.

Their efforts to advocate for nuclear power and influence world leaders and policy makers were well received. Their message was heard in numerous talks and panel sessions right across the conference.

What was amazing is the way in which these young people engaged. There were no old men in white lab coats giving monotonous lectures on the how nuclear power works. Rather there were symbols like Melty the polar bear and Bella the 3 metres tall inflatable gummy bear who represents the amount of uranium that could power all of Glasgow's electricity for 16 months.

Their voices were heard. And they made a difference. They even organized a flash mob to get attention to their slogan for the event – Net Zero needs nuclear. Antinuclear activists and aligned politicians have called this video cringe worthy. Yet in their criticism they also widely shared the video giving it even more attention.

As stated in one of the articles coming out of COP26, "*Nuclear is losing its stigma, in other words, it's been invited to the cool kids' table.*" And these cool kids are smart passionate young people who are well on their way to being the future leaders of a strong global industry that is playing a major role in solving climate change. From those of us that are not as young as we once were, but remain passionate about nuclear power, and are still young at heart – thank you. The future is in good hands.

Preparing for COP26 – a little less conversation – a little more action

In advance of COP26, the next important global meeting to discuss climate change, the International Energy Agency (IEA) released it World Energy Outlook 2021 (and for the first time is offering it for free). And while it notes “*a new energy economy is emerging*”, it is telling us what we all know – “that *this clean energy progress is still far too slow to put global emissions into sustained decline towards net zero, highlighting the need for an unmistakeable signal of ambition and action from government leaders at COP26.*”

Source: Unsplash.com

If you are anything like us, as this pandemic has continued, your normal day is probably something like this – check email, join a Zoom, WebEx or Teams meeting – then the next one after that and so on – and sprinkle in a good number of fascinating webinars through the week to keep you glued to your seat.

After a year and a half of this routine, one thing has become clear. We talk a lot. Really a lot. We all have great ideas on how to do better, how to improve the climate, and in our case, how and why nuclear power should play a bigger role. Or as so eloquently put by Greta Thunberg – "*Build back better. Blah, blah, blah. Green economy. Blah blah blah. Net zero by 2050. Blah, blah, blah*".

Yes, we have learned some things from all this talk; that reaching our global climate goals by 2050 is extremely difficult. Even with massive growth in renewables and extraordinary efforts in improving efficiencies, the goal is eluding us. We know nuclear, one of the only scalable baseload low carbon options, must be part of the solution.

Yet we are still fighting to get nuclear accepted within the EU taxonomy (the decision to include nuclear was just delayed once again). We are still fighting the early shutdown of perfectly good operating plants even though they are most often replaced by increasing use of fossil fuel. In many markets we have projects ready to go but securing government approvals seems to be a never-ending task.

Every year we talk without action is one less year we have to reach our goals by 2050. Thinking we can do everything we need at the last minute is a plan to fail. Tackling climate change is hard. And making hard decisions is not easy for governments. We have seen in the last year governments around the world delay hard decisions needed to defeat the covid pandemic. Or try to choose balance and compromise. In all of these cases, the result was more suffering and death than we would have had if decisions were taken more quickly.

Independent of politics, climate change is about science. And math. Between now and 2050 carbon emissions will either rise or fall. And if we all are convinced the right thing to do is to make them fall, and fall dramatically, then we need to take the hard decisions required to make this a reality.

Nuclear power can play a critical role in helping us all achieve our climate goals. The WEO 2021 and many other forecasts suggest that the amount of nuclear will double between now and 2050. But we can do more. The global nuclear industry has set a target of reaching 25% of global electricity generation by 2050 (WNA Harmony goal). This would require increasing the amount of nuclear by a factor of 5. The time has come to make things happen. Solar and wind are growling rapidly. Nuclear needs to do the same and this requires commitment.

We need governments to declare that nuclear is a clean low carbon energy source that must contribute to achieving global climate goals and then step up and make strong commitments to making this happen. There have been many recent announcements demonstrating that progress is being made. But more is needed. Governments need to:

- Stop the early phaseout of safely operating plants and provide the necessary supports to keep them operating
- Accept nuclear into the EU taxonomy
- Approve new projects that are ready to go – Sizewell C in the UK, the 6 new EPRs in France, new build in India etc. Only China is consistently approving new build at a rate of many units per year.
- Advance the development of new projects in the planning phase such as in Ukraine, Poland and Romania with a focus on getting these projects built sooner rather than later; and
- Approve first of a kind SMR projects to launch these programs in the US, Canada and elsewhere and quickly move on to deploying a global fleet.

And of course, it is not all about government. Goals can only be reached if the industry performs. The industry has done a superb job of keeping the existing fleet operating safely, economically and at high capacity factors, even as they age.

However, the experience on new build has been mixed. Countries with vibrant programs like Russia, China and Korea have built new plants quickly and efficiently. Other projects, especially those with first of a kind designs and in markets where there have not been new builds for a long time have struggled. The industry must work together to learn the lessons required and deliver a large new global nuclear fleet on time and on budget. This is possible but not guaranteed. What will make it happen is orders and lots of them. This will drive efficiencies and create even more innovation just at it has done for renewables.

The most likely outcome of COP26 will be meetings and new targets and pledges. We will all then go back to our daily routines of talking and meeting. But if we truly want to reach the stated climate goals, the time for talk is over – it is now the time to do, and do more than we ever have before. As Elvis Presley sang so many years ago – A little less conversation, a little more action.

For a little Elvis press play!

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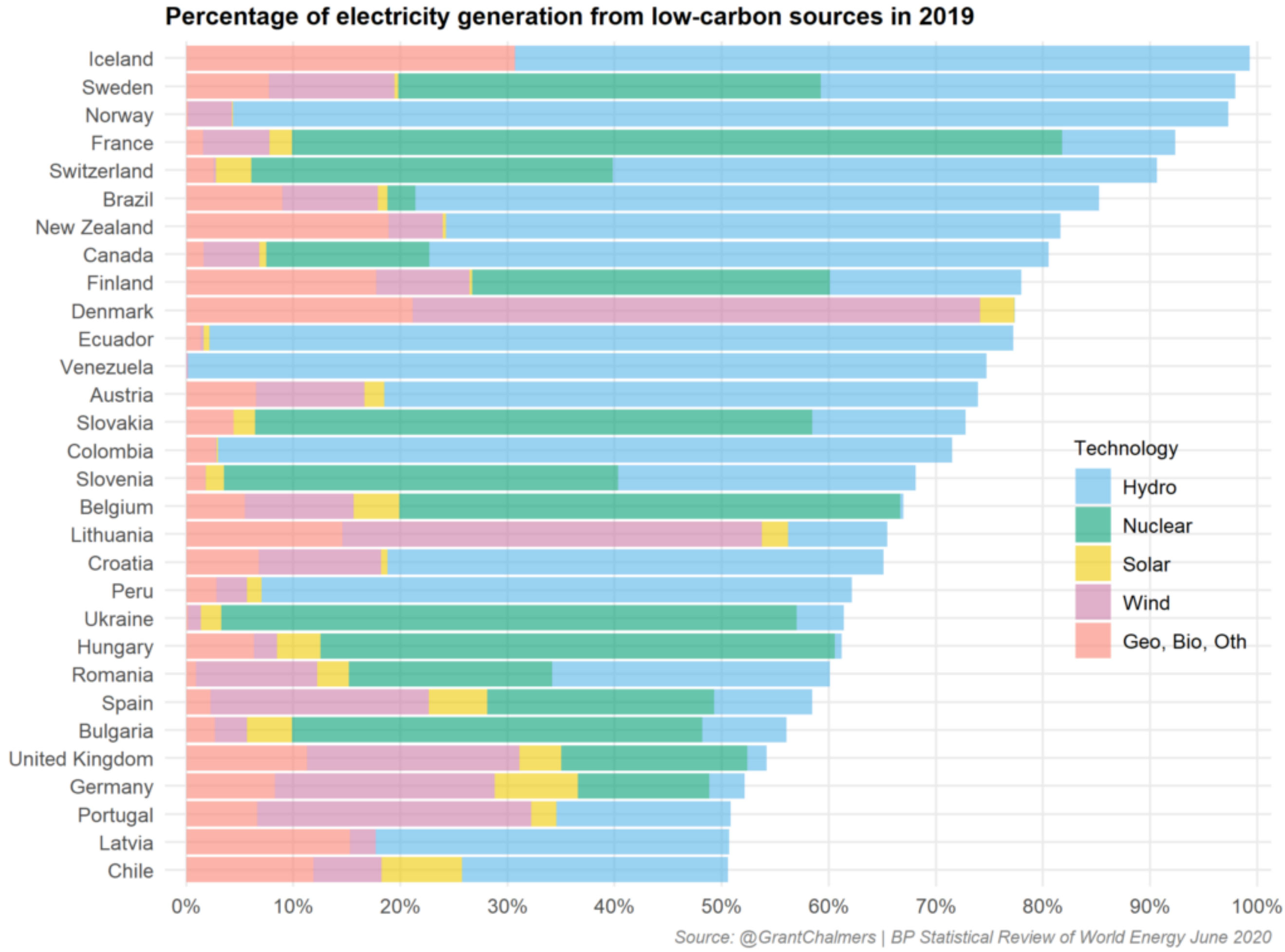
Welcome nuclear newcomer countries to the nuclear family

So far in 2021 two new countries have started producing nuclear energy for the first time. The UAE has put the first unit of its 4-unit Barakah plant into service with the second one following close behind. In Belarus, it is the same story, as the first unit of the Ostrovets station entered service and the second is going through its start up.

We know that the countries that have the lowest carbon emissions rely on either hydro or nuclear power (or both) as the backbone of their electricity systems. And these countries have achieved this low carbon footprint in reasonable time frames. So, a country like the UAE who has almost 100% fossil fuelled electricity will quickly decarbonize as the four-unit Barakah plant comes into service at which time nuclear will be 25% of their mix. Their further investments in renewables will help them meet their carbon targets.



Often when considering the future of nuclear power, the case of Germany comes up. Here we have a high-tech industrialized country who has decided to not only meet its climate goals without nuclear power but has put phasing it out as a higher priority than reducing emissions. This is often given as the example to demonstrate that nuclear has no future in a clean energy world.

Nothing could be more wrong. These decisions tend to be purely for ideological reasons. Germany who has invested heavily in renewables while at the same time phasing out nuclear power has struggled to meet its carbon objectives. Belgium announced it would build new gas plants to replace its nuclear fleet given its commitment to a nuclear phase out. Frankly, these countries have every right to meet their carbon targets as they see fit. But if they are so certain that renewables can do it alone, then they should just do it and remove nuclear when it is no longer needed. But this is not the case. Each of these countries has had to rely more on fossil fuel when nuclear is removed from their systems even as they invest heavily in new renewables.

Given the urgency of decarbonizing the world, the solution is clear. Countries that rely on fossil fuel for their energy should pursue both hydro and nuclear for their baseload needs and supplement with renewables to fully decarbonize their systems. Unfortunately, hydro is limited by geography but nuclear can be implemented almost anywhere. This means nuclear is an important option and countries planning to decarbonize are taking note.

According to the IAEA there are up to 30 countries looking into nuclear power for the first time.

The World Nuclear Association (WNA) has just this month updated it biannual Nuclear Fuel Report. In this report the industry surveys companies around the globe to develop its scenarios. This year's update sees an expansion of the market with new countries embarking down the path of deploying nuclear power. In the reference scenario there are 9 new countries including Bangladesh, Egypt, Ghana, Indonesia, Kenya, Poland, Saudi Arabia, Turkey and Uzbekistan. Of these countries, Bangladesh, Egypt and Turkey have their first plants under construction. The Upper Scenario adds an additional 7 countries: Chile, Jordan, Kazakhstan, Nigeria, Philippines, Thailand and Vietnam. And there are others who are starting to consider nuclear for their future.

All of these projections do not take into consideration the increased demand on energy systems as the goal becomes net zero carbon emissions. Once those pledged to meet net zero by 2050 start to develop their plans, and with the new nuclear options such as SMRs entering the market, we expect to see many more countries taking a hard look at implementing nuclear as part of their future energy systems.

So, for those countries that are truly committed to decarbonizing their energy systems and want to deploy nuclear as part of their solution – welcome to the nuclear family – you are on the path to abundant, reliable, and economic low carbon energy.

The Energy transition requires a huge increase in mining of critical minerals

When considering the sustainability of future low carbon energy sources, the focus tends to be on where the energy comes from. Renewable energy is seen as environmentally sustainable in that it is both low carbon and the resource unlimited; energy from the sun, wind and water will never run out. But, as with everything in life, nothing is perfect. All these energy sources require a variety of critical minerals for their manufacture. This means mining – a lot of mining. The issue is so important to the energy transition, the International Energy Agency (IEA) recently (May 2021) released a World Energy Outlook Special Report, "*The Role of Critical Minerals in Clean Energy Transitions.*"

Source: istockphoto.com

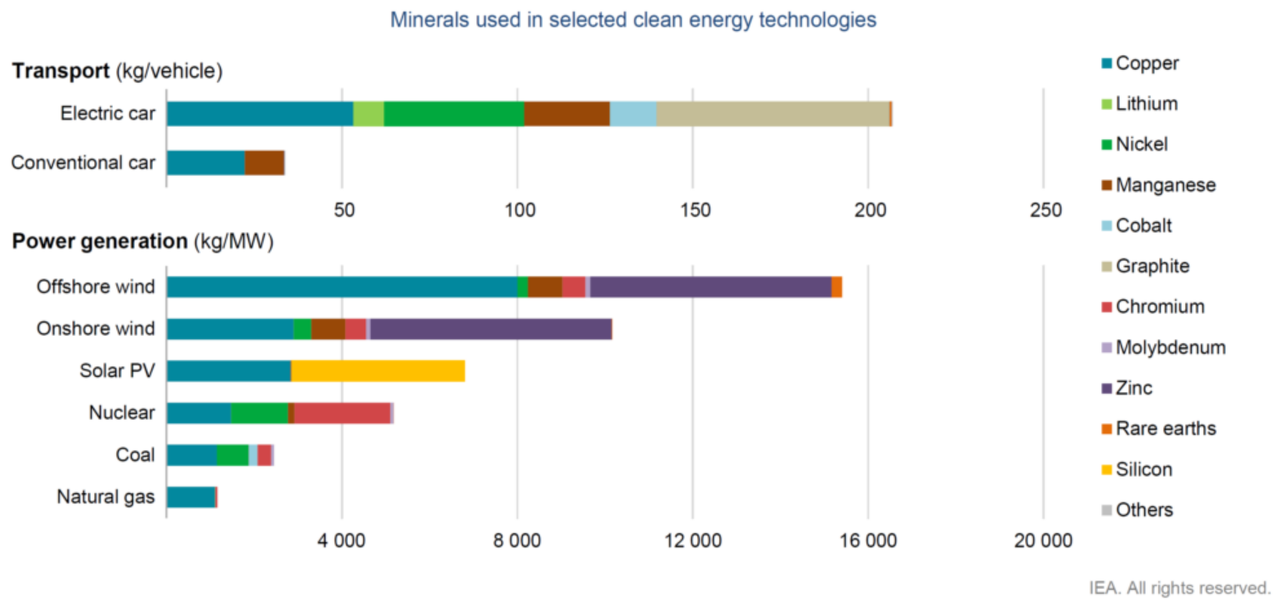
As stated by IEA Executive Director Fatih Birol, *"Today, the data shows a looming mismatch between the world's strengthened climate ambitions and the availability of critical minerals that are essential to realising those ambitions."*

Reading this report, one thing is for certain – **demand for minerals goes up, way up.** [all numbers in the next paragraphs come directly from the IEA report.]

An energy system powered by solar, wind and electric vehicles (EVs) requires more critical minerals than today's fossil fuel-based generation and transport. An electric car requires six times the critical mineral inputs of a gas fuelled car, and an onshore wind plant requires nine times more mineral resources than a gas-fired power plant. Since 2010, the average amount of critical minerals needed for a new unit of power generation capacity has increased by 50% as the share of renewables has risen.

And this is going to increase even faster going forward. To hit net-zero *globally* by 2050, would require six times more critical minerals in 2040 than today. Examples of the magnitude of this growth would see critical mineral demand for use in EVs and battery storage grow at least **thirty times** to 2040.

This represents dramatic change. Prior to the mid-2010s, the energy sector represented only a small part of total demand for most minerals. Now, clean energy technologies are becoming the fastest-growing segment of demand. In order to meet the Paris Agreement goals, clean energy technologies' share of total demand rises significantly by 2040 to over 40% for copper and rare earth elements, 60- 70% for nickel and cobalt, and almost 90% for lithium. EVs and battery storage have already displaced consumer electronics to become the largest consumer of lithium and are set to take over from stainless steel as the largest end user of nickel by 2040.



This rapid increase in demand and the world's hunger for these critical minerals will also change the geopolitical landscape. In the past, much of the world was concerned about security of supply of fossil fuels, primarily oil. Policy makers will now have to consider the challenges with security of supply and prices from a different set of resources which are mostly concentrated in a small number of countries.

And of course, with expanded supply, comes the issues of expanding waste volumes as these new sources of energy reach their end of life. In 2016, IRENA (International Renewable

Energy Association) estimated there would be up to 78 million tons of used solar infrastructure to look after by 2050. However, this assumed solar panels would all stay in service to end of life. But newer better solar panels have people replacing their panels early so that this number can increase by 2.5 times if the current trend continues. To date there is no clear path as to who will pay for this disposal and/or recycling.

With massive projected growth in renewables as they become the main source of energy replacing fossil fuel in the IEA scenarios, we can see the impact of their low energy density and relatively low resource availability. In other words, while these technologies produce very low carbon renewable energy, they do not use minerals very efficiently.

This is where nuclear power shines. It is extremely energy dense and operates at very high-capacity factors. The IEA report notes that nuclear has comparatively low mineral requirements. But the figure above is deceptive. Comparing on a MW capacity basis does not reflect the true nature of the mineral use as 1 MW of solar does not produce the same amount of energy as 1 MW of wind which does not generate the same amount of energy as 1 MW of nuclear. So, while it may look like solar uses 40% more and wind double the materials used in nuclear from the figure, this is not the whole story. Solar generates energy less than 20% of the time (when the sun shines) and wind about 35% of the time (when the wind blows), much less than nuclear that operates more than 90% of the time. And the average life of a solar or wind farm is 30 years or less while a nuclear plant lasts 60 years or more. In other words, a nuclear plant will produce between 10 and 15 times more energy per kg of critical materials used over its life than a solar panel or a windmill making nuclear plants much more mineral efficient. And, given the long life of a nuclear plant, this also greatly reduces the future mineral waste burden.

We often write about nuclear being a low carbon, reliable and economic source of electricity. Now we can add another important environmental attribute, it uses much less critical minerals than renewables per unit of energy produced. Therefore, increasing the share of nuclear power in the future energy mix will greatly reduce the burden on the mining industry (and the planet) as it tries to keep up with a rapidly growing critical mineral demand.