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*

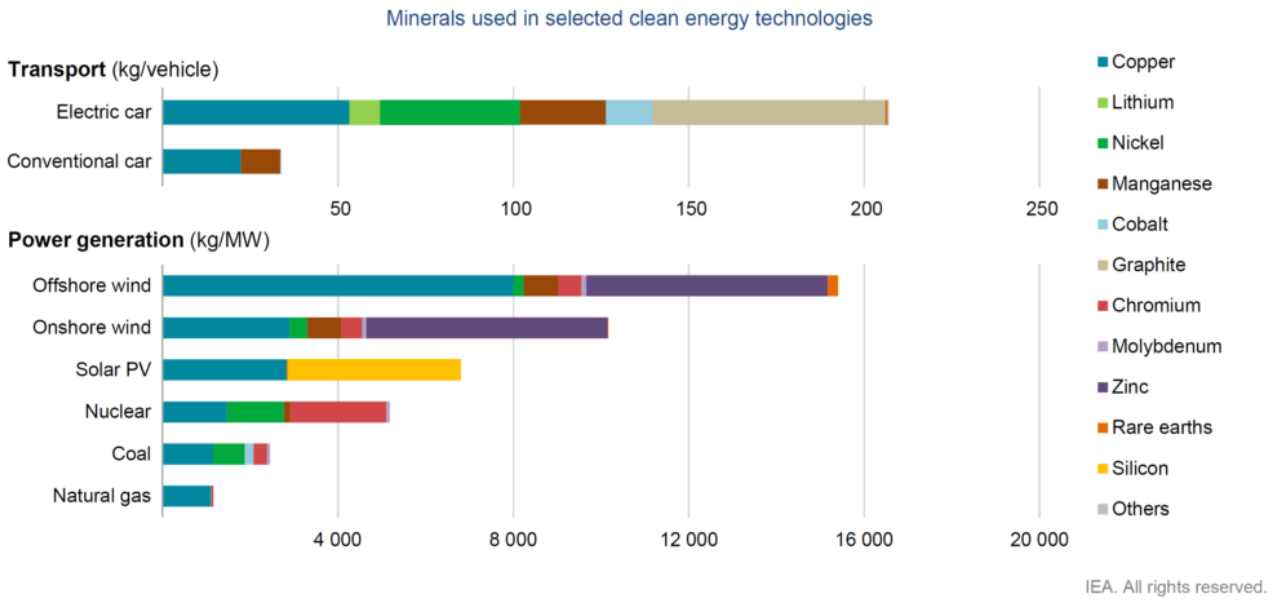
that are essential to realising those ambitions.“

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.

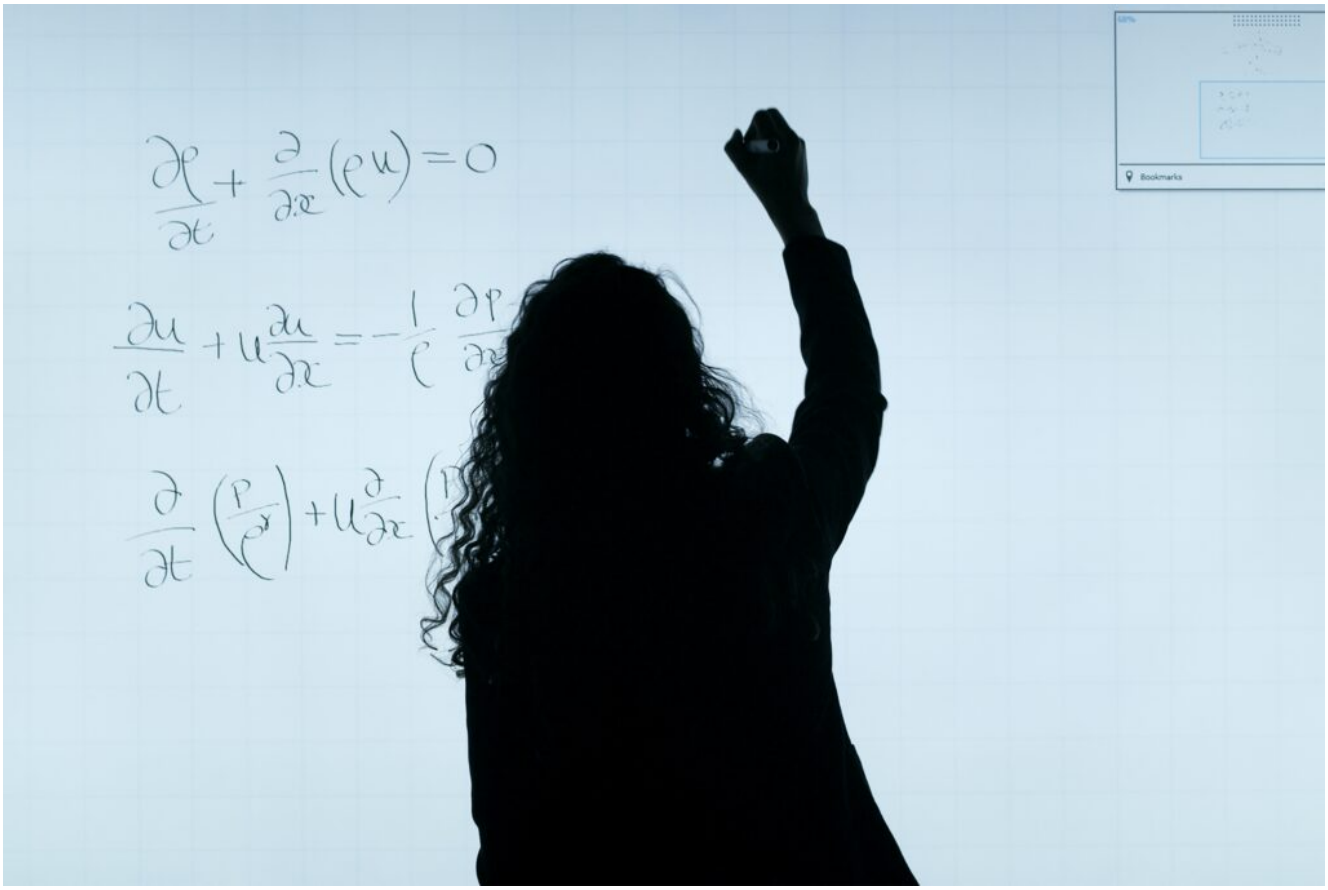
This is where nuclear power shines. It is extremely energy dense and operates at very high-capacity factors. The IEA report notes that nuclear has comparatively low mineral requirements. But the figure above is deceptive. Comparing on a MW capacity basis does not reflect the true nature of the mineral 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.

When ideology wins over science, we all lose

Europe is fully committed to addressing the climate crisis, targeting a 55% reduction in carbon emissions by 2030 (from 2020 levels) and then becoming the world's first carbon neutral continent by 2050. Today, almost half of its low carbon electricity comes from nuclear power as Europe has the world's largest operating nuclear fleet with more than 100 operating units in 13 countries.

Nuclear power brings many benefits to the people of Europe providing reliable clean economic electricity, while supporting about 1 million high-quality jobs. But Europe is also home to a vibrant anti-nuclear movement, that has varying levels of support in the governments of its many nations. This opposition tends to be strongly ideological in nature to the extent that for some, phasing out nuclear and its large role in providing clean electricity has become more important than their commitment to reduce carbon emissions.



Source: Pexels.com

The result is that some countries in Europe are implementing policies to phase out existing nuclear plants. France has shut down its two oldest units at Fessenheim (its regulator was clear they could safely operate for another decade). Sweden has shut down units when they could have operated longer even though they are committed to maintaining a nuclear fleet. Belgium has just recommitted to its nuclear phase out by 2025 and is replacing these nuclear units with gas generation, thus increasing their carbon emissions. Germany has shut down much of its fleet and is phasing out the rest even though it has been replacing much of this energy with coal generation. A recent report suggests that its objective to eventually phase out coal means it will end up with more gas.

This is hard to understand. Only those ideologically opposed to nuclear can find this approach of removing operating low carbon nuclear before its time and increasing carbon emissions with fossil fuels sensible. Clearly, they fear nuclear power

more than they fear climate change. When new gas and coal plants are built to replace retiring nuclear, fossil use is being institutionalized for decades. No new plant is built to operate for just a few short years. The International Energy Agency (IEA) in its most recent Projected Cost of Electricity report has added a new category of generation – life extended nuclear – and finds it to be the least cost of any new generation option. For governments that believe future energy needs can be met with renewables alone, it would make most sense to eliminate fossil fuel first to keep emissions coming down and then remove operating nuclear when a low carbon replacement is available. Rather than supporting a renewable future, supporting new fossil generation is tacit acceptance that renewables can't do it all.

Those who are against nuclear and don't accept its low carbon credentials, have worked hard to keep nuclear out of the European Taxonomy, the classification system of activities deemed beneficial to the climate to be eligible to attract various forms of green financing. As the taxonomy was being created, an assessment of nuclear by the technical expert group (TEG) (the group tasked with reviewing activities to determine their adherence to taxonomy principles) determined that nuclear power does produce very low carbon electricity. This was not sufficient to convince detractors of the merits of nuclear. For these groups the TEG raised questions about whether or not nuclear meets the other criteria for acceptance into the taxonomy, the Do No Significant Harm principle. This was based on the premise that nuclear waste may do significant harm to the environment. It was agreed that further study of this issue would be undertaken by an expert group (known as the JRC). In March 2021 the JRC issued its report and was unequivocal in its conclusion – "**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** ".

Many did not like this conclusion as no science-based argument can deter them from their righteous path. Countries like Germany have decided to phase out nuclear power and would like to see others do the same. The Energy minister of Luxembourg stated that the EU JRC nuclear report is biased, unscientific and complains over lack of transparency, calling the EU JRC a "pro-nuclear, industry organisation". Of course, why task an expert group with studying an issue if you are unwilling to accept its conclusions unless it confirms your current beliefs. Ultimately it is because when you are a believer, and something does not support your point of view, it must be wrong.

It is good to know that as of now, it looks like science is winning and the EU taxonomy will include nuclear, but in a separate delegated act to come out later this year. However, there will be many who fight to see this does not happen. If one argument fails, there will always be a new one to take its place. If science is demonstrating that nuclear power is indeed safe and that waste can be safely managed, the argument moves on to cost (no one is suggesting that a project proceed that does not meet economic criteria). And if that doesn't work, the current argument is that new nuclear just takes too long to make a difference and thus, deflects from the real solutions to climate change.

As stated by Bill Gates in his new book, nuclear power is "the only carbon-free energy source that can reliably deliver power day and night, through every season, almost anywhere on earth, that has been proven to work on a large scale". Accepting the science that nuclear power is a safe reliable low carbon option does not require any jurisdiction to build one if they don't want to or feel they have other better options. However, those that support it will be helping the environment. And for those that oppose, please don't shut down safely operating plants early and replace them with higher carbon options, especially new fossil plants. The

objective is to reduce carbon emissions, not increase them.

After all, you asked the scientific community to give its opinion on nuclear power and it has stated its result as clearly as it can – "**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** "

Fukushima 10 years later – its time to focus on the social science

Ten years have passed since Japan suffered the great Tohoku earthquake and tsunami that killed 20,000 people, caused US$300 billion of damage and initiated the accident at the Fukushima Daichi nuclear power plant.

Reviewing the media reporting last month, the nature of the stories has changed. There were of course many articles that continued to talk about the dangers of nuclear power but there were also numerous articles noting the real lesson to be learned from the accident is that nuclear power is safe. And when news outlets associated the deaths in Japan with the nuclear accident, complaints resulted in many of them accepting their articles were wrong and issuing corrections to state the deaths were all due to the earthquake and tsunami.

When it comes to the actual impact of the accident on human health, the science is absolutely clear. No one died from

radiation from this event (the Japanese have associated one death of a nuclear worker with radiation, but the science does not support it). A recently (2020 edition) updated United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) report on the levels and effects of radiation exposure due to the accident said that future health effects, e.g. cancer directly related to atomic (nuclear plant) radiation exposure are unlikely to be discernible. But that doesn't mean there was not a large impact on people and Japanese society as a whole. People are suffering consequences related to the fear of radiation and its potential impact to them and their families, rather than from the radiation itself. As stated in the earlier 2013 UNSCEAR report, "*The most important health effect is on mental and social well-being, related to the enormous impact of the earthquake, tsunami and nuclear accident, and the fear and stigma related to the perceived risk of exposure to ionizing radiation.*" Addressing this impact is essential for both the Japanese people that continue to suffer and to minimize these kinds of impacts in the future.

How society feels about different technologies and their dangers vary dramatically resulting in a broad range of public views when accidents happen. Let's look at some of the tragic events that have happened around the world in recent years and how society reacted.

In 2018 and 2019 two Boeing 737 MAX aircraft crashed (in Indonesia and in Ethiopia) killing 300 people. After the second accident the world reacted (two accidents so close together for a new design has never been seen in the history of modern aviation), and these planes were grounded for over two years as serious safety culture issues were identified at Boeing. Changes have been implemented to correct the deficiencies with the planes now declared safe and returned to service. Why did it take so long for the industry to react and why did the public not become more concerned about

flying? Flying is important to the world as we all want to travel. We accept flying as safe and are willing to overlook an accident as a rare event even though the consequences are tragic. (Since the pandemic we miss travelling more than ever.) Reporting was more related to how the issue can be resolved to get the planes flying again than in creating fear of flying.

Last summer, a large amount of ammonium nitrate stored at the port of the city of Beirut, the capital of Lebanon, exploded, causing at least 215 deaths, 7,500 injuries, and US$15 billion in property damage, and leaving an estimated 300,000 people homeless. This was a huge tragedy, with the blame focused on the corruption of the Lebanese government. There was no reporting talking about this dangerous substance and its risks. No one was asking how it should be safely stored and transported and whether there are shortcomings in the regulations on how to keep people safe. In fact, the industry that creates the chemical was nowhere to be seen in the discussion.

Finally, as we all continue to feel the impact of this global pandemic that to date has infected more than 145 million and killed more than 3 million, we still have many who are fighting against public health directives focused on keeping us safe and some who simply choose to not accept the danger posed by this disease. With the end of the pandemic now in sight because of the amazing success of vaccines developed in record time, the biggest risk remains vaccine hesitancy. Somehow there are many people who are more afraid of the vaccine than the disease.

Looking at these examples, we see that:

- It takes two crashes to convince authorities to look for problems with a new aircraft design. The public, although concerned, does not become afraid to fly as

long as it is on a different aircraft model (easily compartmentalizing the risk to a specific model) and most are likely to feel comfortable flying on the 737 MAX now that it has been approved to fly again;

- A devastating explosion of a dangerous chemical raises no questions at all about the chemical itself. The public are comfortable allocating the blame to government incompetence without any thought to whether or not others are unsafe who are using this substance;
- A global pandemic that to date has killed more than 3 million people and completely disrupted all of our lives for over a year is not enough for some to follow the science while erroneously worrying that the cure may be more dangerous than the disease risking a delay to the end of the pandemic; and
- An accident at a nuclear plant resulting from an extreme once in a hundred-year natural disaster disrupts the lives of many and kills no one. The conclusion for some is the technology is so dangerous that there are calls to completely shut down the industry, with some countries like Germany who have no plant models that are similar to Fukushima nor the conditions for a similar event deciding the risks are too great.

Our purpose here is not to go into detail but to contrast how we as a global population choose to see threats and risks and respond to them. Each one of these examples demonstrates a vastly different response as the public has varying degrees of concern when evaluating risk. Often many of us try and discuss why we think this is the case. However, truly understanding these differences in perception and reaction is a task for the social scientists. The issues are complex. Studies are needed to learn how to better address public concerns and develop strategies to ensure that risks are contextualized, and science better explained to ensure the best possible response when tragic events occur.

It is a good thing the nuclear industry learns lessons from its experience to make nuclear better, but we also seem to define ourselves by our accidents rather than by our successes. Perhaps its time for that to stop. It may have taken a decade, but the world is realizing the benefits of nuclear power far outweigh the risks (a phrase we hear every day about vaccines) and that climate change is the greater threat to humanity that needs to be addressed now, with nuclear power being an important part of the solution.

The energy transition must make society better and not leave people behind

In December we wrote about the world's drive to achieve net zero carbon emissions by 2050. A laudable goal, the World Energy Outlook (WEO) 2020 illustrates a possible path to getting there. This would be achieved through electrification (using clean electricity sources), efficiency gains and behaviour changes. The first two of these require technology solutions. The third, behavioural change, requires human commitment to change, often meaning a form of personal sacrifice. Turn down the thermostat in winter and up in summer, walk or bike instead of drive, eat less meat, and so on.

Source: pexels.com

In other words, stating a need for behavioural change is a way of saying that human beings are excessive users of the planet's limited resources which can only be overcome if we temper our desires. Unfortunately, telling people they have to endure some level of hardship may work for some in the environmental community who believe we need to pay for our environmental recklessness, but in real life, we are not going to achieve our goals by asking people to lower their standard of living.

The ongoing covid pandemic provides lessons to us all. It has highlighted current inequities in our societies in a way that we can no longer ignore. There are two economies, one for the well off, who can work from home and are saving money as they temporarily consume less. Then there are those who earn lower incomes who still must go out to work risking both their and their families' health. We even call them "essential workers" although we certainly don't treat them as such.

We are all living in a temporary state of emergency, where we are asked to change our behaviours to keep ourselves, our

families, and our communities safe. Even faced with daily numbers of sick and dead, many are not willing to maintain these behaviours as they are anathema to our normal lives. If we can't convince people to temporarily change their behaviour in a short-term crisis, how will we convince them to permanently change to benefit the longer term? Are we really going to make our lives less comfortable so that our grandchildren will inherent a better world?

The reality is no. We may give up plastic straws and put a solar panel on our roofs. There are no shortages of gestures we can do to tell the world we are trying and have good intention. But in reality, no one is willing to make their life more difficult because it is good for society. After all, access to economic abundant energy has made our lives better in every way. We will not move backwards.

One example is our use of cars. The WEO suggests this an area where behavioural change is required. Slower speeds and less automotive use (walk or bike for shorter trips) are needed. Unfortunately, if we look to North America as an example, the trend has not been positive. In recent years people have moved away from small cars in droves to larger SUVs, to the extent that some major auto manufacturers are removing many standard vehicles from their offerings. For example, Ford has said that in excess of 90% of its sales in North America are for trucks and SUVs, to the point where it has stopped production of all but two of its passenger cars.

And doing with less is only a possibility for those that have in the first place. For those less fortunate, they suffer from not having enough access to energy. And the access they have is not easily modified. We all understand that a price for carbon can be an effective way to incentivize change. However, it must be accompanied with reasonable alternatives to be effective. For those earning minimum wage who drive to work without access to any alternative means of transport, even a modest increase in their weekly fuel cost can be

economically devastating.

The answer is clear. Provide access to abundant economic reliable clean energy. And this is where nuclear power shines. With its high energy density, low carbon footprint and nearly endless supply of fuel, it is well positioned to power our society into the future. This will not require sacrifice and can bring energy to those who are currently under served.

Bill Gates has been out promoting his new book, "How to Avoid a Climate Disaster: The Solutions We Have and the Breakthroughs" noting we need to go from emitting fifty-one billion tons of greenhouse gases every year to zero. This requires we make big and hard changes. (Have not yet read the book and will comment more after I have.) He notes there is a "green premium", the increased cost of doing something in a low carbon way compared to the current higher carbon way. He suggests the priority should be to innovate to reduce these Green Premiums; not to make people suffer from these higher costs, nor to ask them to make do with less. His objective is to get these premiums "*so low that even developing countries with growing energy needs and relatively scant financial resources will adopt zero-carbon ways of doing everything from making steel and cement to generating electricity.*"

Fighting climate change needs to reduce inequities to succeed, not force those among us who are least advantaged to do the heavy lifting, nor expect that others will happily find a way to do with less. This means providing abundant, economic, reliable and clean energy to make a better future for us all – and nuclear power is the energy source that can help us get there.

Yes – Nuclear power is an economically competitive low carbon energy source

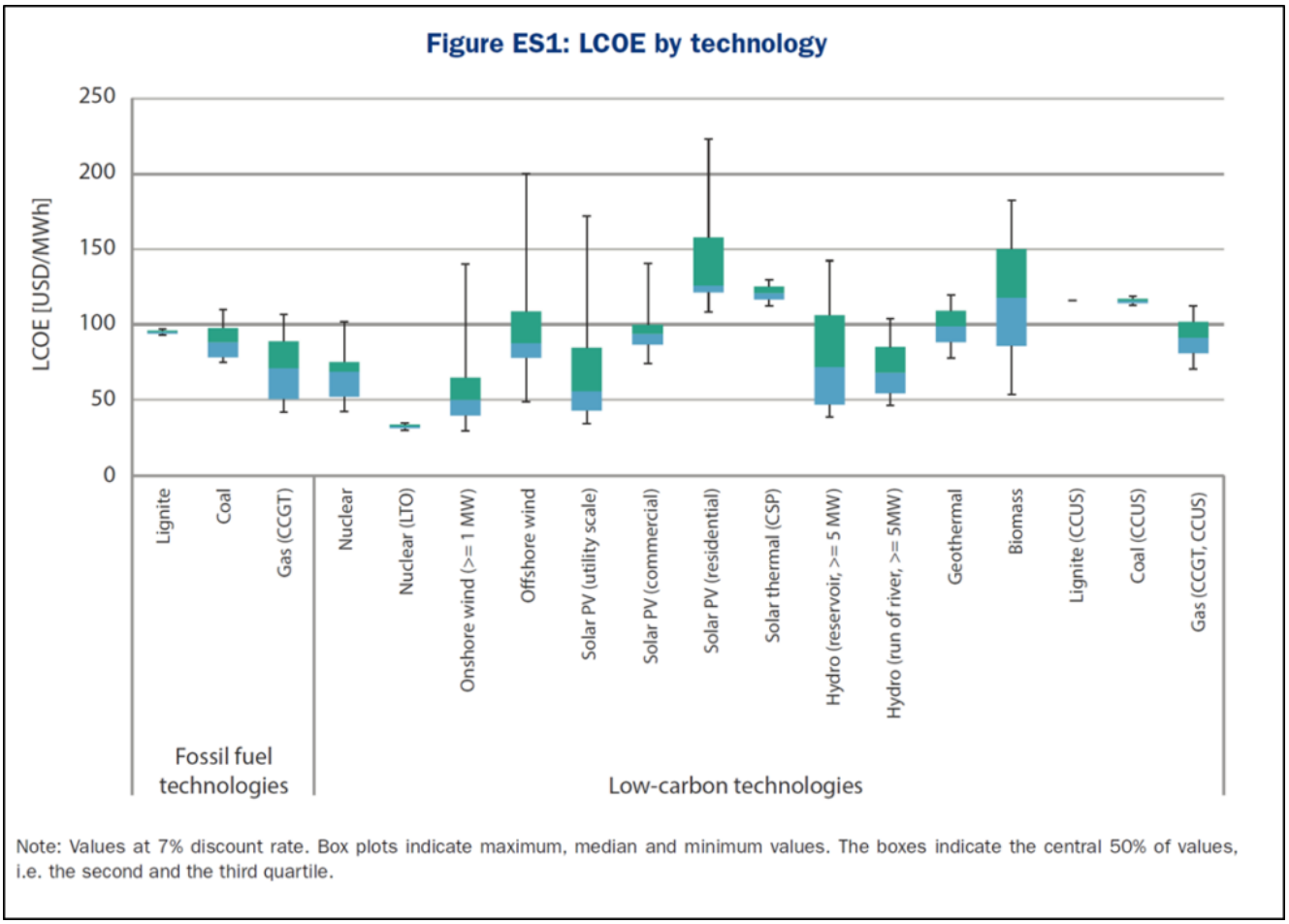
When it comes to the economics of electricity, there is no report more important than **Projected Cost of Electricity**, issued every 5 years by the International Energy Agency (IEA) and the OECD Nuclear Energy Agency (NEA). This report (now in its 9th edition) collects electricity costs of various technologies from a range of countries and reports on the competitiveness of each. The 2020 version of this report was issued in December and its conclusion is clear – nuclear power is the dispatchable (meaning always available) low-carbon technology with the lowest expected costs.

Source: pexels.com

This is in stark contrast to what we often hear – that even though nuclear power may well be a low carbon solution, its

costs are much too high to consider. Recent projects that have not gone well, primarily in the west due to a long absence from nuclear construction coupled with the challenges of building first of a kind (FOAK) designs are the evidence to support this argument. The successful economic deployment of nuclear in countries like China, Korea and Russia are ignored. We even have a good example that new countries can successfully build nuclear plants with the start up of the Barrakah nuclear power plant in the UAE.

This report sees through this bias. This is not a nuclear report. It is about electricity and its costs. The conclusions are based on the results of the analysis, not on any preconceived biases. It concludes that all low carbon options have improved their costs since the 2015 version.



Projected Cost of Electricity 2020 (IEA/NEA)

One change since the 2015 version of this report is the inclusion of nuclear life extension or Long-Term Operation (LTO) in addition to the traditional consideration of the

economics of nuclear new build. The results show that LTO provides the lowest cost electricity of all technologies considered. This makes for a very simple message – for the best low carbon, low-cost option – invest in keeping the current nuclear fleet operating.

Given the changing generating mix from traditional fossil fuelled plants to more and more variable renewables; there is an acknowledgement that to truly understand their economics the costs to the system of incorporating these variable resources must be considered. A model, called the Value Adjusted Levelized Cost of Electricity (VALCOE) has been developed but adds considerable complexity given, as would be expected, results are very sensitive to the actual system being analysed. This approach continues to be a work in progress. We should expect a more fulsome analysis in the next edition.

When it comes to nuclear, this report notes that countries willing to pursue the nuclear option have three main technology solutions to reduce cost at the system and plant level (interestingly consistent with our previous series on Saving the Planet):

1. LTO or investing to keep the current fleet operating into the future.
2. Building existing Generation III reactors. These designs have now passed their FOAK demonstrations and are ready to demonstrate improved economics going forward; and
3. New designs being developed such as Small Modular Reactors (SMRs). These designs are poised to extend the value proposition of nuclear power.

The IEA/NEA, in its updated Projected Cost of Electricity report, has assessed the costs of the many low carbon options to meet electricity needs going forward. Based on this analysis, nuclear power is well positioned to continue and expand its role in providing reliable, economic, low carbon

electricity to the world.

2020 was a year of global challenge – working together will make 2021 much better

What a year it has been! A year ago, we were all looking forward to the possibilities of a new decade. Today, as the year comes to a close, we are happy to see 2020 behind us.

We don’t usually write about events outside the energy industry. But this year is different. And most of you are probably feeling somewhat like we are – exhausted, frustrated and just plain sad. That being said; we must also acknowledge we are definitely the lucky ones. Most of us are able to work from home and maintain our incomes while generally being able to minimize our risk to the virus that is spreading pretty much everywhere.

Source: pexels.com

A global pandemic with catastrophic impact. Over 80 million cases of covid-19 and approaching 1.8 million deaths. In less than a year this virus has impacted almost every country on earth. It cares not **what nation you live in, what your politics are, the colour of your skin or your religion**. Unfortunately, it does highlight the inequities in our societies and our weaknesses. Who is not completely overwhelmed by the disproportionate share of fatalities in old age homes highlighting how little we spend on caring for our elders (yet somehow, we can effectively maintain a bubble to keep professional athletes safe)? While many of us work from home to keep the virus away, those that earn the least are now classified as "**essential workers**" making sure we all have food on the table at considerable risk to themselves and their families. Health care workers are exhausted as ignorant so-called freedom fighters argue the importance of having freedom to get a hair cut or cite the attack on our civil liberties when asked to maintain distance or wear a mask.

And nothing frustrates us more than the ongoing war against science. From bizarre conspiracy theories (Bill Gates is trying to insert chips to control us,) to many just believing

this virus is a hoax, **the move away from being interested in truth is alarming**. When asked to pull together for the war effort our parents and grandparents did what was necessary. And while some may have disagreed with government policies, there was no one who said our leaders were lying to us and the war was a hoax.

Thankfully, science knows no borders. The **absolutely miraculous rate at which vaccines have been developed** are testament to the hard work of scientists around the globe who worked together. The Chinese published the genome of the virus back in January for all to use. Vaccine trials took place in many countries to ensure the best possible data in the shortest time. Yet now we face the next threat to defeating this virus, **vaccine hesitancy**. Even prior to this pandemic the WHO defined vaccine hesitancy as a rising threat to global health.

2021 can be a year to look forward to. It will be difficult at the beginning, but it can also be the year the pandemic comes to an end. However, the speed at which we come out of this is not guaranteed. As with most things in life, **success is up to us**. For the best possible outcome, we need to focus on three things:

- **Acknowledging the science and taking the advice of professionals**, both to protect ourselves, our families and our friends and colleagues from infection; and to encourage all to take the vaccine when available to them;
- In spite of our increasing pandemic fatigue, be willing to continue to **sacrifice** for the common good. As a society we have become selfish and value our own wants before the needs of others. This is **a teachable moment for our children**. Learning the value of sacrifice to the benefit of others is a life lesson that will benefit them forever; and
- All work together to our common goal. **Leaving poor**

countries behind will not hasten the end of this pandemic. It took only months for the virus to reach every corner of the earth. To end, the efforts to eradicate it must have the same reach.

The nuclear industry has done well throughout these difficult times. This is because we have developed the systems necessary to keep our plants running and our workers safe. For that we should all be proud. **We are always prepared for a crisis and know exactly what to do when one is upon us**. We put the safety of our workers and the public above all else. And we collaborate to ensure the lessons learned from all the world's operating plants are known to each of us so we can keep improving.

For most of us, never have we had to face the fact that our normal daily activities can result in real, measurable, and immediate consequences. What each one of us does each day determines the path of this virus, with daily numbers of the sick and the dead, and the associated economic impact, showing us the outcome of our actions. The only viable answer is to work together to make good choices and exhibit the right behaviours to save lives, shorten the pandemic and ultimately eliminate the virus as a global threat.

Hopefully, we will then take the time to learn the important lessons from this experience and make the societal changes necessary to protect and improve the lives of those who are most vulnerable while being better prepared for the next challenges the world throws at us.

Once again thank you for reading our blog this year. Wishing your and your families a very happy and healthy 2021.

If you have an interest in seeing a topic covered in one of our upcoming blogs, please let us know. We welcome the opportunity to write about new topics of interest to you, our readers.

Net Zero needs more nuclear – it’s time to get on with it

Adopted in 2015, 196 countries signed the Paris Climate Agreement (to date 188 of them have ratified it) accepting global ambition to limit global warming to “well below” 2C and adding an aspirational goal of limiting warming to 1.5C. The Paris deal also commits signatories to balance greenhouse gas emissions and sinks in the second half of this century. This has become understood to mean “Net Zero” emissions.

By the end of August 2020, over 125 countries (including the European Union) had set or were actively considering long-term net-zero emissions targets by about 2050. As opposed to strategies to simply reduce emissions by 20 or 30%, a net zero target requires finding ways to totally eliminate fossil emissions and meet all of our energy needs with very low carbon options.

Source: istockphoto

The magnitude of the challenge is enormous, and more and more governments are realizing this means there is no single technology that can provide the complete solution. Rather, the time has come to stop thinking about competition between different energy sources and instead look at how they can best work together if there is to be a realistic chance of success.

In its current World Energy Outlook (WEO 2020), the International Energy Agency (IEA) recognized this push to net zero. In addition to its traditional Stated Policies Scenario (STEPS), based on today's policy settings and Sustainable Development Scenario (SDS) which examines what actions would be necessary to achieve 2030 climate goals; it created a new scenario, the Net Zero by 2050 (NZE2050) scenario to show a possible path for the world to reach net zero by 2050.

The NZE2050 scenario assumes large reductions in energy demand and massive increases in renewable generation, with a modest

increase in nuclear power, all to replace fossil fuels which show dramatic decline. This is a useful exercise. However, rather than provide a clear path to net zero, this scenario succeeds in demonstrating the sheer magnitude of the challenge ahead if we are to meet this ambitious goal.

For example, in this NZE2050 scenario primary energy demand falls by 17% between 2019 and 2030, to a level like 2006, even though the global economy is twice as large. This would be achieved through electrification, efficiency gains and behaviour changes. To put this in context, this same report estimates that energy demand will fall by about 5% in 2020 because of the global covid pandemic and the associated reduction in economic activity. It also points out there will be around 660 million people who will not have access to electricity and 2.4 billion who will not have access to clean cooking by 2030 globally if we stay on the stated policy scenario path. This makes it very hard to imagine achieving a demand reduction of 17% by 2030 with a fully recovered healthy global economy while trying to bring energy to those that are currently under served.

And yes, we certainly do agree that solar development has been nothing short of astounding and fully support continuing with this rapid growth. At the same time, it is hard to imagine the optimum solution to massive energy transformation requiring the large-scale replacement of much our energy infrastructure could be led by the electricity source (solar) that has the lowest energy density (requiring huge amounts of land) and that produces electricity only between about 13 and 23% of the time (when the sun shines). The WEO recognizes this large growth in variable renewables leads to issues related to system flexibility and creates further challenges requiring large investments in infrastructure including new sources of energy storage.

On the positive side, the IEA, as do many others, now clearly acknowledge that nuclear power is an important low carbon

source of energy and that it must play a role. In its analysis, nuclear and renewables grow while fossil use drops. The problem is that in this scenario, nuclear power only grows by about 36% to 2050. The result is the global share of nuclear hardly moves from today with renewables left to do the heavy lifting.

A larger nuclear share would provide energy security, reliability and be cost effective, mostly by reducing the large system (flexibility) costs required to implement such a large share of variable renewables all while reducing the pressure to reduce overall energy use. The IEA itself acknowledges that nuclear power plays a much larger role in many Intergovernmental Panel on Climate Change (IPCC) 1.5 °C scenarios, than in its NZE2050. (Half of IPCC 1.5 °C scenarios imply an increase in nuclear generation of 60% between 2019-30 compared with a 36% increase in the NZE2050).

The nuclear industry through the World Nuclear Association (WNA) has proposed its Harmony goal of 25% electricity generated from nuclear by 2050. This means about 1,000 GW (1000 large reactors) of new nuclear by then, which would be equivalent on an energy delivered basis to the growth assumed for solar adding a large amount of always on, 24/7 energy to the system. Achieving this goal requires strong commitments from governments and industry. This would complement the growth in renewables nicely and result in less pressure on demand reduction, less issues with flexibility requiring less infrastructure development and an overall lower cost energy system.

We are seeing exceptional innovation as vaccines for covid are being made available in time frames never before seen to address this pandemic. This shows what we can do as a society when we all work together to a common goal. As stated by Associate Deputy Minister of Natural Resources Canada Shawn Tupper in a web chat with OECD Nuclear Energy Agency Director-General William Magwood, “We’ve got to stop talking about

Utopia; we've got to stop just talking about what our targets are and actually articulate our plan starting tomorrow … what are the building blocks to getting there."

So, the time has come to talk less and do more to make sure nuclear can reach its full potential and set the world on a real path to net zero.

Delivering reliable electricity – nuclear plants just keep on running

On October 22, 2020 Darlington Unit 1 achieved a milestone never achieved before by a nuclear power plant running for 1,000 days continuously without an outage, either unplanned or planned[1]. And it is still running. This unit, operated by Ontario Power Generation (OPG) secured the world record for continuous operations last month, when it hit 963 days to take over from the Kaiga 2 unit in India, the previous record holder at 962 days achieved in 2018. Kaiga took the record from Heysham 2 in the UK which reached 940 days in 2016 breaking the record set by the Canadian Pickering Unit 7 reactor 22 years earlier[2].

Why does this matter?

Source: istockphoto.com

The world runs on energy. We need it to keep warm (or cool, depending upon the climate), cook our food, light our homes, communicate with one another and travel from place to place; and to enable pretty much everything that drives our economies. We need this energy to be affordable and most of all, we need it be reliable. For most people in the developed world, we fully expect that when we flip the switch, the lights will come on. Not sometimes, but each and every time. We also want this energy to not harm the environment (although unfortunately we will concede on the environment rather than do without).

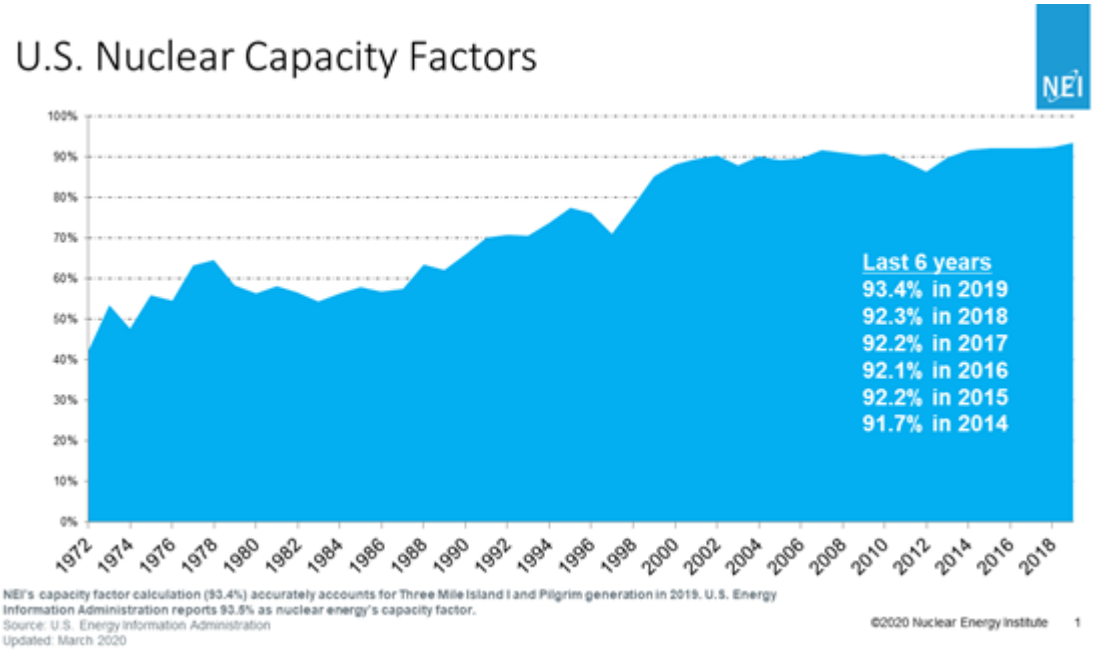
And there is no more reliable low carbon source of energy than from nuclear plants. Once in operation, they just run and run and run, like the energizer bunny. These plants run in bad weather and good, during the day and during the night, providing 24 / 7 electricity to their customers.

System reliability is not something we often think about until we experience an issue. It came as a shock to many this year

when California suffered ongoing blackouts and energy shortages. There are many contributing factors to poor reliability as electricity grids are complex systems that require a never-ending balance between supply and demand, meaning a need for reliable generation and a robust transmission and distribution system. In this case, the California Independent System Operator described the conditions that caused demand to exceed available supply: scorching temperatures and diminished output from renewable sources and fossil-fuelled power plants when electricity was needed most.

The president of the system operator blamed the California Public Utilities Commission for not ordering companies to make available sufficient supply. A critical issue is the changing mix of generation with solar growing quickly without sufficient back up when the sun goes down and the air conditioning load remains high. This demonstrates that solar power alone cannot meet the future energy needs of large energy intense systems like that of California, and that reliability must always be considered as we make structural changes to these systems.

On the other hand, the US nuclear fleet continues to hum along providing 20% of the country’s electricity supply.



Source: NEI.org

Once again in 2019, the US nuclear fleet operated at a very high capacity factor (the percentage of time the plant is producing compared to if it ran 100% of the time) achieving 93.4%. The US fleet continues this stellar performance, even as it is aging. For the past 20 years the fleet has produced in the range of 90% capacity factor or more, demonstrating how robust a technology nuclear power really is.

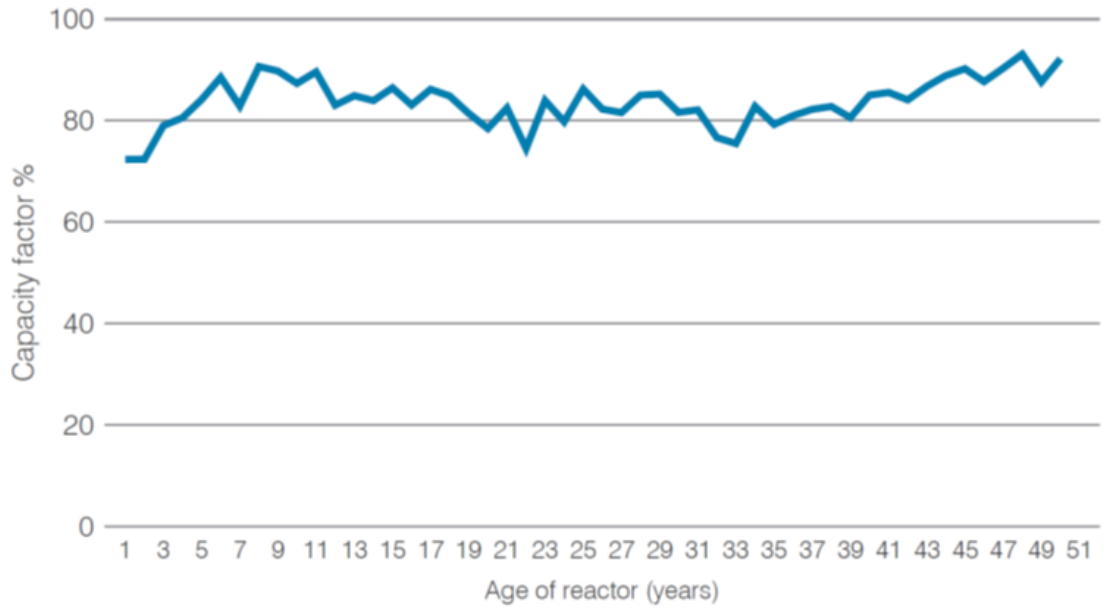
This is not just true of the US. It is true for the entire global nuclear fleet. As shown in the WNA Nuclear Performance report 2020, more than a third of the world's plants operate at 90% capacity factor or above and a full two thirds operate at capacity factors greater than 80%.

Nuclear technology is so robust that this excellent performance is not restricted to one specific type of plant. Light water reactors, gas cooled reactors, heavy water reactors – they all operate great. The distinguishing factor is more related to the expertise and excellence of the individual operator and to specific local market conditions, not to any specific technology. International cooperation through organizations like INPO (Institute of Nuclear Power Operators) and WANO (World Association of Nuclear Operators) ensure best practices are shared and that all have access to

the tools they need to achieve a high level of performance. This is an industry that collaborates to ensure continuous improvement across the global fleet.

What really demonstrates the strength of nuclear technology is the continued strong performance, even as the plants age. Heysham achieved it record run at 28 years of age and Darlington Unit 1 is 30 years old with only a year or so left before going down for refurbishment and a life extension outage. Many would expect that the life cycle of a nuclear plant would look like an inverted bathtub, with less than average performance when it is new as the kinks are worked out and then declining performance with age as it nears its end of life. But this is not the case. Nuclear plants run well when they are new, when they are middle aged and actually tend to run their very best as they get old.

Figure 7. Mean capacity factor 2015-2018 by age of reactor



Source: World Nuclear Association, IAEA PRIS

Need reliable electricity supply even when the sun is not shining, and the wind is not blowing? When it comes to reliable low carbon electricity, nuclear plants set the bar very high. They just run and run and run some more…….

[1] Every station in Canada had at least one unit set a station performance record this year.

[2] It should be noted that the AGR units in the UK and the PHWR units in Canada and India use on-power fuelling, so they are not limited by the need for refuelling outages.

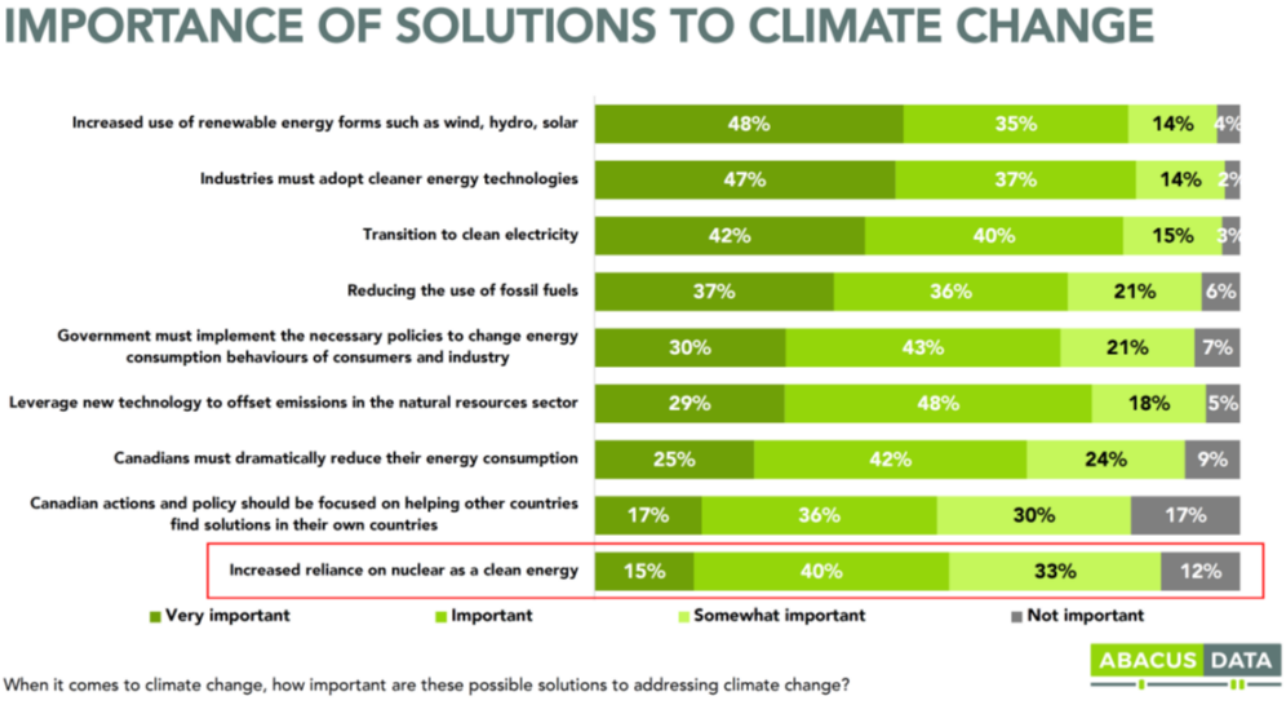
Forget about public acceptance for nuclear power – it's time for public enthusiasm!

Nuclear power can provide almost limitless economic, reliable, low carbon electricity to power the world, yet it continues to struggle to achieve the respect it so desperately seeks. For 40 years we have been hearing the same thing – that for nuclear power to achieve its potential we must work harder on securing public acceptance. This is seen as a one of the main impediments to future nuclear growth. As technocrats, we often think that if we can just educate the public on the technology, they will see the light and come to accept us. After years of effort and somewhat limited success, the time has come to refocus and set the bar even higher. Let's forget about trying to convince people to "accept" nuclear and strive to create true public enthusiasm for a technology that has the potential to solve the issues they care about most.

And we won’t get there until we focus on the right things. After all, why should anyone even think about nuclear power, never mind come to love it? It is definitely not by explaining all the reasons they shouldn’t worry about it; where it really starts is by having a clear understanding of the issues that are top of mind.

So, what are people concerned about?

A recent study from the Canadian Nuclear Association suggests that climate change continues to be a top of mind issue, with concerns not falling even though we are in the midst of a global pandemic. The large majority (82%) of Canadians are somewhat, very, or extremely concerned about climate change. Almost 8 in 10 (76%) feel that climate change or global warming are issues we currently face that are at least “serious” and a majority (57%) rate that the impact of climate change or global warming on themselves or their loved ones has been “Extremely/Very much”.



The challenge is that even with these concerns most people are completely unaware that nuclear power can be a solution. 68% of Canadians had no idea that nuclear power is the country's second largest source of low carbon electricity (15% of total generation) after hydro power. This is then re-enforced as nuclear is at the bottom of the list in solutions to solve climate change (although support remains strong). Keep in mind that Canada is a very nuclear-friendly nation with more than 60% of the electricity in the province of Ontario and more than 30% in New Brunswick coming from nuclear. So, it should be of no surprise this lack of awareness is not unique to Canada. A similar recent poll in the US showed that nuclear power is a very unpopular form of electricity generation, second only to coal. And even in the country with the most nuclear power in the world, France, most think nuclear contributes to, rather than is a solution to, climate change.

We first discussed how we need to take back the narrative from nuclear opponents in August of 2019. The industry has been complicit (although well intentioned) by endlessly trying to defend nuclear by explaining ad nauseum how safe it is and why people shouldn't be worried about nuclear waste. This

strategy has failed because the more time spent talking about why people shouldn't worry about these things, the more they understand there must be something to worry about. Rather, the priority should be on the important benefits nuclear brings – **reliable, economic, low carbon electricity in vast quantities to fuel an energy hungry world – and the many high-quality jobs and the positive economic impact to communities that support nuclear power plants.** This is what can get people excited, and only then, will they be willing to have a discussion on those aspects of the technology where they have concerns.

And yes, we are making progress. It is becoming clear that renewables alone cannot fuel a decarbonized world and that nuclear power is an important option to help meet the energy needs of the future. It has been recognized by global institutions like the International Energy Agency and most recently, Holland, with its single operating nuclear power plant, has joined the growing list of countries expressing interest in considering nuclear for the future.

Here in Canada, the Minister of Natural resources has been extremely clear – reaching net zero carbon emissions without nuclear is simply not feasible.

But this is not enough. People love the idea of renewables and strongly support them as THE solution to climate change (although they may feel somewhat different when a wind project is promoted in their backyard – but that is another story.) Many are eager to spend their hard-earned money to install solar panels on their roofs or buy electric vehicles even if they are expensive. This is because they know they are doing good in the battle for the planet and they accept and support that these technologies are the future.

While it is common to express concerns with nuclear power such as asking about nuclear waste for example, these questions are never considered when talking about renewables. Solar waste?

Low energy density land use? Variable generation dependent upon resource availability requiring not yet available storage solutions, mining of rare earths and other needed minerals? These are just silly questions that get in the way of environmental progress. Smart people will solve all. This is the strength of "knowing" that going down a given path is simply right. We don't want to hear about challenges for solutions we believe in, while we are happy to question those options we are suspicious of.

The world can only close its eyes to the truth for so long. As more people start to accept that renewables cannot be the sole solution, support for nuclear is rising as its potential as a low carbon option is being better understood. However, it is important that nuclear be considered because it is an excellent solution to climate change as well as providing reliable economic energy to society, not because the favoured options are falling short, forcing us consider this less desirable option of last resort. Accepting nuclear should never be like taking your bad tasting medicine. You accept it may be good for you, but you hold your nose while taking it and wish you didn't have to.

And positive change is in the air. We see many amazing groups, primarily a new generation of younger people who are making the positive case for nuclear power. There are pronuclear demonstrations, funny videos explaining nuclear on YouTube and even a pro nuclear rap song. If you are part of a group that is driving support for nuclear, please let us know in the comments below.

We live in a time where there are many that question technology with some causing more fear than others. We are in a horrific pandemic yet fear of vaccines is making many worried about taking one when available. There are even people who think 5G mobile technology is causing covid. Therefore, after decades of anti-nuclear activism, it should come as no surprise that many are concerned about nuclear

technology. And while more and more environmentalists are now seeing the opportunity to fight climate change that nuclear brings, many are still fundamentally opposed. Here in Canada, famed environmentalist David Suzuki said “I want to puke” in response to the Minister’s support for new nuclear.

We live in a time of both science skepticism and a lack of belief in facts. But we should not be daunted as both the facts and the science are clear. We have a great story to tell. Nuclear power is AWESOME and can help to save the world. So, let’s stop talking about public acceptance and all work together to generate a real sense of public enthusiasm to support this technology as a path to a better world where energy is economic, reliable, abundant and has little impact to the environment.

Saving the planet step 3 – Move forward with Small Modular Reactors (SMRs)

Last year we started a 3-part series on Saving the planet with nuclear power. First, we talked about keeping the existing nuclear fleet operating as long as possible (Saving the planet step 1). Then, in step 2, we talked about building a new global fleet of large Generation III nuclear plants. Today, we are concluding this series with a discussion on the role of Small Modular Reactors (SMRs).

SMRs represent the next generation of nuclear energy innovation. They are defined as nuclear plants that produce 300 MW of electricity (or combined heat and power) or less replacing the traditional economies of scale of large reactors

with economies of numbers. Their objective is to reduce the risks of delay and cost overruns associated with more traditional large nuclear units by deploying them more quickly and at lower cost.

Some of the many SMR designs available in the market

While the fundamental objective of SMRs is to enable the expansion of the nuclear market to include a broader customer base who can benefit from these lower cost solutions, SMRs actually represent two different sizes of reactors, each with its own well defined use case.

On-grid applications are an evolution of more traditional electricity generation and are rooted in the familiar. They will be connected to electricity grids as an alternative to fossil and other forms of generation. The owners/operators will likely be utilities who are in the business of generating electricity, both government owned and private corporations.

With their lower costs and shorter deployment schedules, they will appeal to a much larger market of new potential owners for whom large units are simply not an option to fit their systems or, who prefer to manage their risk by making their generation investments in smaller increments.

Off-grid applications are more revolutionary. Very small SMRs (vSMRs or micro SMRs – about an order of magnitude smaller than grid-scale SMRs) could meet the needs of remote communities or commercial enterprises that are not grid-connected including remote mining and other industrial applications demanding both heat and power. The customers are non-traditional users who are often in another business, such as mining, but who need low carbon economic energy as an input to their operations. While economies of scale do have an impact on costs at this very small size, these vSMRs often compete with diesel generation that can be very expensive, polluting, and in some remote applications, difficult to ensure fuel availability due to restricted transport options.

SMRs can be a game changer.

We know from previous studies (MIT and NEA) that renewables cannot decarbonize the world alone. In fact, these studies point to the same conclusion, that fully decarbonized systems are always lower cost with nuclear than without. A new recently released US study (Cost and Performance Requirements for Flexible Advanced Nuclear Plants in Future U.S. Power Markets – Report for the ARPA-E MEITNER Program, July 2020) considered the cost required for SMR market success. They found there will be large markets for advanced reactors that cost less than $3,000/kW which will also be attractive investments for owners; and that together, renewables plus advanced nuclear (with thermal energy storage) lower overall system costs, reduce emissions, and improve performance in future U.S. electricity grids.

And much progress is being made.

In the US, the DOE has an aggressive strategy through its ARDP (Advanced Reactor Development Program) now underway to demonstrate two advanced reactor designs within five to seven years, and is also planning two to five smaller awards to address technical risks in other advanced designs. In addition, the US Department of Defence is investigating very small, transportable micro SMRs to support tactical deployments.

Here in Canada, in addition to the Canadian SMR Roadmap setting out a plan, the provinces of Ontario, Saskatchewan and New Brunswick have signed an MOU (Memorandum of Understanding) to move forward with the development and deployment of SMRs across Canada. Work is underway to develop projects in all three provinces, both for on grid use and for remote locations. Just recently the province of Alberta announced it will soon join this MOU.

In the UK, in November 2019, the government confirmed that it is investing in the UK SMR consortium led by Rolls-Royce. Just recently, in June 2020, the consortium has submitted proposals to Ministers to accelerate the building of a new fleet of up to 16 SMRs in the North of England by 2050. Most recently, on July 10, The UK government awarded funds to three advanced reactor developers to kick start next-gen nuclear technology.

From the basic needs of ensuring we are warm and fed, to keeping us connected to our co-workers, friends, and family; having access to affordable energy is critical to our quality of life. To meet these needs while aggressively lowering carbon emissions requires investment in technologies to deliver a future where we no longer rely on fossil fuels. Most studies agree, a combination of nuclear power and renewables makes an excellent path forward while delivering the lowest cost energy solutions.

How do we ensure that nuclear power plays its role and meets

its potential? Three steps.

- Step 1 – Keep the existing nuclear fleet operating as long as possible – as a major source of existing low carbon electricity, losing these plants sends us backwards in meeting our goals
- Step 2 – Let’s build as many Generation III nuclear plants as we can – these large units all have completed and operating demonstration units with their standard designs ready to add large amounts of new low carbon electricity to our grids; and
- Step 3 – Move forward with Small Modular Reactors (SMRs) – to disrupt the electricity market and bring the potential of nuclear power to a whole new set of customers who would not have considered the nuclear option before.

Nuclear power currently provides the second largest amount of low carbon electricity in the world (slightly behind hydro) and stands ready to do so much more. While much work is already under way, there remains much more to be done. But one thing is certain, the world needs energy, and lots of it. With nuclear power making the contribution we know it can, our future is bright.