Canada’s nuclear industry continues to shine

On December 15, 2022, the Ontario Independent Electricity System Operator (IESO) issued ”Pathways *to Decarbonization – A report to the Minister of Energy to evaluate a moratorium on new natural gas generation in Ontario and to develop a pathway to zero emissions in the electricity sector*”. This report considers a decarbonized supply mix in the Canadian province of Ontario by 2050 with contributions from new nuclear, conservation, demand response, renewables and storage. This includes **18,000 MW** of new nuclear.

So ended a year of major steps forward for the nuclear industry in Canada.

Source: pexels.com

Nuclear power produces about 15% of the Canada’s electricity with operating plants in two provinces, Ontario, and New Brunswick. In both provinces nuclear power is essential to their electricity generation with Ontario getting about 60% of its electricity from nuclear while New Brunswick uses it for about a third.

This year the federal government made its view of nuclear clear when the Canadian Minister of Natural Resources stated unequivocally there is no path to net zero without nuclear power and included funding to support this statement in its 2022 budget.

Here are some of the major achievements for nuclear in Canada in 2022.

- Both Ontario Power Generation (OPG) and Bruce Power (BP) are continuing with their combined $26 Billion dollar refurbishment (life extension) programs for their Darlington and Bruce plants respectively. These programs are going extremely well, both on time and on budget. OPG has completed it first unit and is in the final stages of reassembly of its second while BP is in the final assembly phase of its first. These projects are being executed brilliantly to the point where OPG has recently been awarded second place for the Project Management Institute's global PMO (Project Management Organization) of the year award.
- OPG announced it is assessing the feasibility of refurbishing the Pickering nuclear station, currently scheduled to shut down in 2026.
- Bruce Power, already the largest nuclear operating site in the world, is working to increase the output of its site by 700 MW by 2030 through unit uprating
- OPG is moving forward with its first grid scale SMR project, a BWRX-300, at its Darlington site and has started site activities this year as well as submitting an application to the regulator for a licence to construct. This unit is expected to produce first power around the end of 2028. The Canada Infrastructure Bank has announced an investment of up to $970 Million for

the early works of this project.

- OPG is also a partner in Global First Power, who are in the process of establishing the first micro reactor, a USNC MMR, at the Chalk River site. Licensing activities are underway.
- New Brunswick has announced it is working with two SMR vendors (Moltex and ARC) to establish SMRs in the province. The Belledune Port Authority (BPA) says an ARC-100 providing energy for hydrogen production and other industries could be in operation by 2030-2035.
- SaskPower has selected the BWRX-300 for its first nuclear plants in the province to be in operation in the mid 2030s.
- Alberta is contemplating nuclear using its ability to generate heat to help it decarbonize its oil extraction.

And there is more. But you get the point. Nuclear Power is alive and well in Canada. But why is this important? Because when it comes to nuclear as a solution for climate change, in Canada, we are walking the walk. We have a vibrant industry currently demonstrating that complex large scale nuclear projects can be completed on time and on budget. Based on this success, we have the confidence to take on First of a Kind (FOAK) risk by building the first of more than one SMR design setting the stage for global fleet deployment. This is only the beginning. With demand for clean energy increasing, we can expect to continue with life extensions (refurbishment), new SMRs and yes, even new large nuclear.

And most of all, if a jurisdiction like Ontario, Canada with an already heavily decarbonized electricity system producing well under 100 kg/kWh of carbon is saying it needs to more than double the nuclear fleet to fully decarbonize; just imagine what other jurisdictions still heavily dependent on fossil fuels need to do. The world needs nuclear power and lots of it.

Canada’s success is based on many factors, but transparency is key. Constant listening and learning assure the program continues to improve. To that end, we are ready and willing to share what has been learned to help others succeed just as we are. There is little doubt that collaboration is essential if the global industry is to meet its full potential – and we in Canada are ready to play our part.

As another year comes to an end, we want to thank you all for reading our blog and wish you a very happy and healthy 2023!

The Energy Trilemma – important lessons from recent events

With COP27 in Egypt coming to a close, there is broader acceptance of the role for nuclear power in solving the climate crisis, as it is one of the few electricity generation options that positively impacts all three dimensions of the energy trilemma. What is the **energy trilemma**? It is the three often conflicting challenges requiring consideration when setting energy policy: *energy security, energy equity (accessibility and affordability), and environmental sustainability*.

Source: istockphoto.com

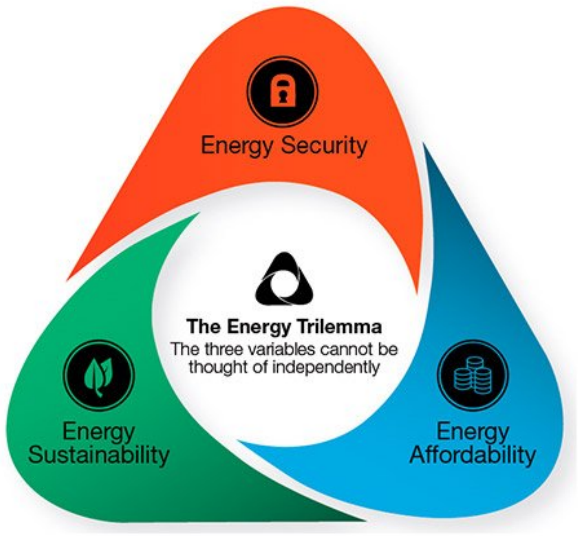
Addressing the trilemma is about creating a balance. How do we ensure there is enough energy (security), at an affordable price (accessibility) while minimizing the impact to the environment (sustainability)?

At COP, as would be expected, the focus is on the environment. We have often discussed the path to net zero emissions and the pathways to achieve this important goal. But over the past few years, a pandemic, together with a war that exasperated an already developing energy crisis in Europe has shown that when it comes to considering the 3 dimensions of the trilemma, security and affordability will always come before the environment. In other words, we are happy to have meetings and discuss how to save the planet, but when the price of energy rises or energy security is put at risk, we treat it as urgent and act.

As the energy crisis plays out in Europe, the first and biggest issue is will there be enough energy to meet the needs of the population. Will they be able to heat their homes in the winter, get to work and feed their families? Of course, energy being available is not helpful if you can’t afford to pay for it. We have seen huge increases in price in electricity markets as well as at the gas pumps. And people are angry about it. Inflation (driven mostly by energy and food prices) are the most talked about issues today in many parts of the world.

And that leaves the environment. It is easy to say we want to protect the environment. But until we see it as urgent (which is easier with more traditional pollutants that we can see and smell), the idea of doing things to make the environment better in the future as carbon emissions rise is a tougher sell. We all want to do it, but only so long as it doesn’t mean we lose ready access to energy (security) and we don’t have to pay more (affordability).

We have seen how people behave from the recent pandemic experience. The desire to do what may be necessary, from the extreme (lock downs) to the more benign (use of masks or staying at home when sick) is limited. Even with a daily death count, people have been left exhausted and their willingness to take even the most basic precautions has mostly disappeared. So, if we struggle to make an effort when we see the impact of a disease on our society every day, what are we going to be willing to do to protect the environment 20 years or more down the road?



More traditional environmentalists see a path that must include doing without. Suffering is part of the penance we need to pay for destroying the environment. Turn down the thermostat in the winter (or up in summer), don't use our cars as much, change our eating behaviour, are all ways to use less energy and show that we are willing to sacrifice for a better world. We are not saying we shouldn't do these things. They all help but they will never be enough to reach our climate goals. People are not motivated by sacrifice. They are driven to try and make their lives better and energy is key when it comes to improving quality of life.

Hence the role of nuclear power. It can provide energy security due to its very high fuel energy density and its reliability, operating 24/7 at capacity factors of 90% or more. It is economic and helps keep electricity rates low. And most of all, it has the lowest carbon footprint of any low carbon technology.

Given the choice of higher price energy, not enough energy, or cheaper abundant dirty energy, we will pick dirty energy every time. If we really want to solve the energy trilemma, we need solutions that provide abundant, reliable economic, clean energy. We need nuclear power.

Achieving net zero requires building all low carbon technologies including lots of nuclear

In its 2022 report on the role of nuclear power in fighting climate change, "*Nuclear Power and Secure Energy Transitions*", the International Energy Agency (IEA) says "***Nuclear energy can help make the energy sector's journey away from unabated fossil fuels faster and more secure***."

It goes on to clearly lay out why nuclear power is so important to a clean energy future noting that achieving net zero globally will be **harder** and **more expensive** with less nuclear.

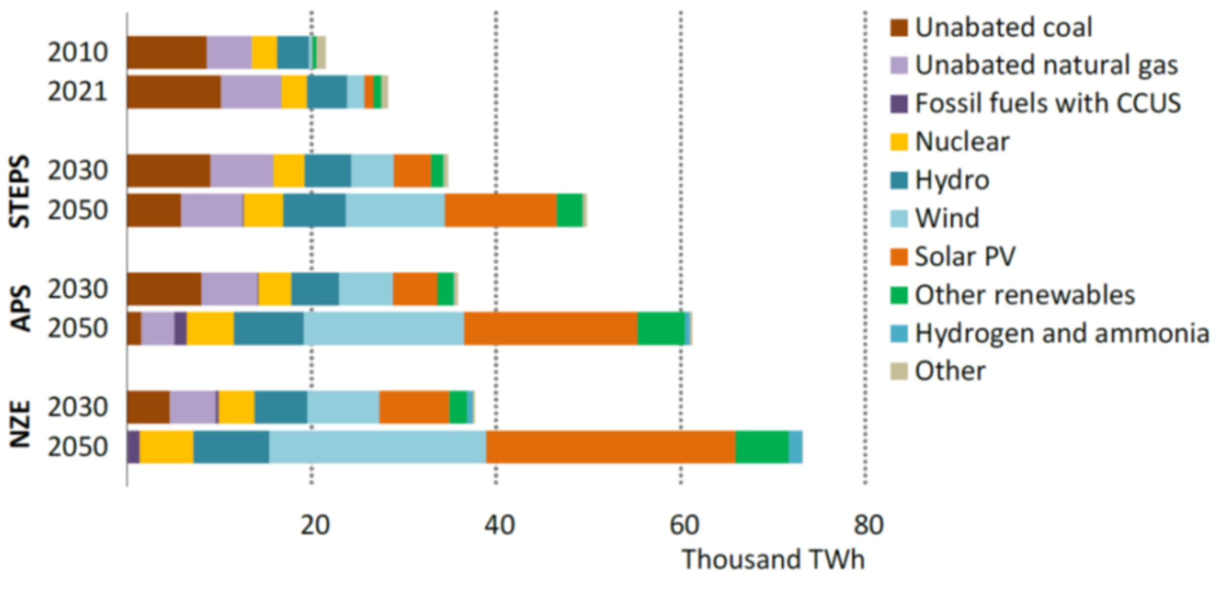
Source: Pexels.com

The report also notes there are challenges to further nuclear deployment emphasizing the importance of continuing to reduce costs and ensure projects are built to cost and schedule. These are indeed justifiable issues and there is no doubt the industry must perform for long term success.

While the IEA may say nuclear is important for net zero, this has not resulted in projections for a large new nuclear program. Rather, as is shown in the 2022 World Energy Outlook (WEO 2022) just released from the IEA, the role for nuclear remains modest. Yes, there is a doubling of nuclear capacity to 2050, but because of continued electricity demand growth the nuclear share falls from 10% of global electricity supply to only 8% in its Net Zero Scenario.

On the other hand, renewables are projected to account for the majority of capacity additions over the outlook period (to 2050). In the base STEPS scenario, wind and solar PV together set new deployment records every year to 2030 and then continue with increased annual growth through to 2050. For the IEA Net Zero scenario, wind grows by a factor of 12 and solar even faster with 27 times more solar in 2050 than in 2021. The assumption when it comes to renewables growth is that there are no limits. No concern about land use, or volume of critical materials required, or how storage technology will develop to support increasing the share of renewables from its current 28% of electricity supply to 88% of a larger global electricity system. Yet we know from experience in Germany, California and others where variable renewables have successfully achieved a relatively high share of electricity supply, that system reliability suffers, often requiring fossil fuel back up to support their intermittency.

Figure 6.7 ▷ Global electricity generation by source and scenario, 2010-2050



Electricity generation from unabated fossil fuels peak by 2030, as low-emissions sources ramp up and renewables dominate electricity supply in all scenarios by 2050

Note: Other renewables include bioenergy and renewable waste, geothermal, concentrating solar power and marine power.

Notes: STEPS (Stated Policy Scenario), APS (Announced Policy Scenario), NZE (Net Zero Scenario)
Source: IEA World Energy Outlook 2022

To be fair, we don't blame the IEA for their views. Based on recent experience in western countries with little ongoing nuclear new build and projects that have gone over budget and schedule, it may be difficult to see a path for more rapid nuclear growth. But that certainly doesn't mean there shouldn't be a challenging goal. Just look at China that has built over 50 GW of nuclear capacity in the last 20 years and has approved 10 new large reactors this year alone. In the west we have examples as the US built about 100 units and France built a fleet of 59 units in less than 30 years. Twenty years ago, there was little confidence in the ability of renewables to scale and here we are today, now assuming almost unlimited growth given their success. Just as with renewables, increasing the scale and pace of nuclear new build as we have achieved in the past is also possible given the political will.

There is an international study that considers a more balanced growth for all the clean technologies. UNECE (United Nation Economic Commission for Europe) has recently released its report "*Carbon Neutrality in the UNECE Region Technology Interplay under the Carbon Neutrality Concept*" which takes a fresh look at how to use a broad range of technology, both existing and new to meet its net zero challenge.

This report finds "*there are achievable pathways for governments to design and implement a carbon-neutral energy system through technology interplay.*" In its carbon neutrality innovation scenario, UNECE considers the potential of three innovative low- and zero-carbon technologies: a new generation of nuclear power, CCUS, and hydrogen – to deliver on carbon neutrality. In this scenario nuclear grows to 3.4 times its current base in the region by 2050 (as opposed to 2x by IEA*) and reaches 27% of energy supply (compared to 8% by IEA*). It also notes challenges with all technologies. For example, it predicts 4,430 TWh of solar power in the region by 2050 (compared to the 27,000 TWh globally in the IEA net zero scenario) and notes this requires 7 million utility scale panels covering an area equal to 2.8 million football pitches equal to the entire surface area of Belgium.

There is little doubt the challenge of achieving net zero emissions in our energy systems by 2050 is enormous. Given the view to electrify everything, electricity use will at least double. To meet this growth, it has been generally accepted that nuclear power has a critical role to play, but the size of that role remains in question. Concerns about the industry's ability to deliver has limited its potential in many studies such as the IEA WEO 2022. However, UNECE has taken a different approach and explored a more rapid expansion of all low carbon technologies, rather than assuming wind and solar can do all the heavy lifting. This seems a more viable model. Get all technologies growing as fast as possible to ensure the primary goal of carbon neutrality is achieved. We only have one world, and we need to build all low carbon technologies as quickly as we can if we really want to reach our climate goals.

** It should be noted the UNECE projects are limited to the UNECE region and the IEA projections are global.*

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.)

Deregulated electricity markets don’t support a viable energy transition

In the early 1990s, deregulating electricity generation seemed like a good idea. Led by the UK, many markets rushed to dismantle their vertically integrated electric utilities with the goal of creating competition to benefit their customers, the electricity using public. The view was that utilities had become fat and lazy and since they were mostly able to pass on their costs through a regulated pricing system, they didn’t do their best to keep prices low. Competition would remove the fat.

Fast forward 30 years or so and much of the world has followed this path. There is a large relatively integrated European electricity market, the UK continues to operate its market and there are multiple states in the United States that operate this way. But is it working – and of more importance – is this the right path to support the transition to a low carbon energy system?

Source: iStockPhoto.com

To fully answer this question is a subject that requires a much longer discussion than is possible in a blog post. We will address some of the issues and explain why we believe large scale market redesign is required. For another excellent perspective we strongly recommend the book “*Shorting the Grid*” by Meredith Angwin that clearly explains how the current US deregulated model is failing the customer while reducing the reliability of the electric grid. Read it – please.

The original concept was sensible. Create competition in the electricity market to force electricity generation companies to become more efficient (In most cases transmission and distribution were not deregulated). It seemed to work in telecom. Why wouldn’t it work in electricity generation? And at the beginning it did work. Government owned electricity companies were sold off and broken up. New generating companies competed with existing companies and yes, the result was improved operations of the existing generation fleet.

The markets were mostly created as **energy** markets, where generators competed on marginal cost of production (variable operating and fuel costs) in basically real time markets to sell electricity. All that mattered was the price of electricity at any given moment. This was happening at about the same time as gas was ascending to be a major player in electricity generation both in the US and in the UK. Each generator would bid into the market at its marginal cost. The market would accept bids at the lowest cost available and continue to accept higher prices until the demand was met. The market price was the energy cost of the last generator who bid, and all participants received this price (the clearing price). When demand was high, the last bid accepted was usually gas generation which has the highest marginal cost of production and this price seemed to be enough to keep the other players with lower marginal costs but higher fixed costs content.

Then three things happened that started to change the equation.

First, at least in North America, the price of gas fell dramatically so that the only technology actually making money were gas generators. Their marginal cost had become very low given the low cost of gas and other forms of generation could no longer survive at that price. Hence the current situation where nuclear plants are closing before their end of life as they struggle to compete at very low gas prices. The US government has just launched a $6 Billion program to help save these plants. Market supporters may say – who cares? The market is the market. If gas plants are the lowest cost, then just run gas plants. And yes, that is certainly an option if a single source electricity system based on 100% gas is deemed acceptable. But if the objectives of the system are broadened to include diversity of generation for security purposes or to mitigate the risk of volatile fuel prices (yes, gas prices can and do go up), or to lower carbon emissions, then change is required.

Second, having an **energy** market only made it impossible to build new **capacity**. Since everyone was operating on marginal cost, there was no possibility to recover full costs – which is needed to support new plant investment. The solution was to create **capacity** markets. Payments would be made for capacity based on a bidding process so that low-cost capacity would be added to the system. Once again, in most jurisdictions, gas came to the rescue. The cost structure of a gas plant is just right for this type of market. The capital to build a plant is relatively low. Once the capacity is paid for, you only operate the plant when the energy is needed, at an energy cost that covers the marginal costs (which is primarily based on the cost of fuel).

The issue with this market structure is that gas generators were always price makers, and all other technologies were price takers. In other words, the business of electricity generation for all other technologies became a competition with gas. While these technologies made or lost money based on this competition, gas generators were always whole, no matter the price of gas. In effect, gas generation is pretty much a risk-free business in this market structure. Consumers are happy as long as gas prices are low – but will be very unhappy when prices rise.

Next, countries committed to decarbonization goals and started to support adding low carbon electricity, primarily intermittent variable solar and wind power on the system. To get these to work, subsidy was required both for price and to ensure the market takes the output of these resources when they produce, when the sun is shining and the wind blows.

To keep this story short, this structure made it near impossible for any other technology than gas or subsidized renewables to be built. Other projects were just too risky, especially those technologies like nuclear power where the bulk of the cost of energy is based on their capital investment. Even though a nuclear project is projected to be economic, once built, the price of the alternatives may change in the future so that the plant becomes unprofitable. Or in other words, no matter how successful and low cost the project, the risk of having to compete with daily changes in gas prices would be unmanageable. The solution was once again to contract outside of the market. Power purchase agreements, contracts for difference (Hinkley Point C) and other approaches were developed to support these types of projects. The result, more complexity, and complexity tends to increase costs. That is why we see the Sizewell C project in the UK moving to a Regulated Asset Base (RAB) model, to simplify the project structure and keep costs lower. (We will talk about this model in a future post.)

The reality is that data from the US DOE Energy Information Administration (EIA) show that customers do not benefit from these market structures. 2020 data shows that customers in deregulated states pay on average about 23% more for electricity than those in regulated ones. And while most states remain regulated (about 32 to 19), when you consider the actual amount of generation under both regimes, it is much closer to half of US generation is deregulated and half regulated.

Back to the point of this post. If you want to ensure grid stability, the markets need to change. If you want to encourage diversity of generation, the markets need to change. But most of all, a completely new structure has to be developed because the low carbon options (wind, solar, nuclear, hydro) have relatively high fixed costs and near zero marginal costs making an energy cost based market unworkable. For these forms of generation, a market structure based on recovering fixed costs is required.

If we really want to work towards net zero carbon emissions, now is the time to re-imagine how we are going to generate electricity and pay for it. One thing is certain. The existing deregulated model in place in many jurisdictions will not take us where we need to go and the longer we take to accept that, the longer it will be to reach our carbon goals.

A secure supply of energy is critical to our way of life

Energy is life. We depend upon it to get from place to place, warm (or cool) our homes, cook our food and communicate with one another. Everything we need to live our lives comes from a supply chain that uses energy to mine raw materials, manufacture products and ship them to our door. For most of us, we depend upon other countries as our source of energy. When the security of that supply is put at risk, we know our lives are about to get a whole lot harder.

What do we mean by “energy security”? The traditional definition is secure access to fuel whether coal, oil, gas or uranium. Unfortunately, fuels are located in some parts of the world and not others. Energy rich countries gain political power due to the importance of their energy exports in meeting global demand. When markets lose access to these exports it is often a result of geopolitical issues whereby energy trade has been weaponized.

The war in Ukraine is the most recent conflict that has disrupted global energy flows. Russia is a major supplier of both oil and natural gas. Realigning global energy markets to reduce or eliminate this source of supply causes great challenges. Whether by design as the first oil embargo by the OPEC nations in the early 1970s, or later conflicts in the middle east, ensuring energy security has always been an essential element of countries’ energy policies. Normally, global market demand and supply of energy products tend to be relatively in balance. The market can tolerate small changes but any significant sudden reduction in supply impacts everyone.   The economic laws of supply and demand work as markets losing their supply look for alternatives. The result is that prices go up everywhere. This can be seen today as consumers in North America, far away from the Ukrainian conflict, are experiencing huge increases in the cost of gas to fuel their vehicles.

It is easy to say the answer is for nations to strive for energy self sufficiency. Of course, this is a great idea but unfortunately you can’t change your geography. If you live in one of the countries blessed with energy (like we do in Canada), that’s great. But for the others, what can be done? The objective of many nations when considering energy security is to mitigate their risk by reducing the amount of energy that must be imported to the extent practicable and then ensuring the remainder is imported from friendly trading partners. Diversity is also helpful, both in terms of sources of supply and types of energy used.

One way to define the short-term risk is to consider how much energy is stored locally should supply be disrupted providing time to correct the imbalance. The global flow of energy is complex and vast. Energy on hand in any given market depends upon the type of fuel, but in most cases, storage capacity is limited. Gas is generally transported by pipeline with little storage at the point of use so that supply issues are felt immediately. Coal is transported by rail or ship and storage may account for a few weeks supply. Oil is transported by pipeline where feasible and by tanker (ship, rail and truck) where pipelines don’t exist and stored in tanks.

One way to improve security is to reduce demand for imported energy by increasing use of renewables like wind and solar power (in addition to their environmental benefits). This can be helpful and should be pursued but is not sufficient to ensure a reliable supply of needed energy on its own. As with all types of energy, renewable resources are also geography dependent. Some countries are rich in wind and solar resources and some less so. Also, these intermittent variable renewables raise other issues as the sun doesn’t always shine nor the wind always blow, so they need to be supplemented by a reliable backup source of energy.

When it comes to storing energy locally, energy density matters. Nuclear power’s extremely high energy density, low carbon emissions and highly reliable operations make it an important source of a secure energy supply. While uranium mining is limited to some parts of the world as is the supply of other sources of energy, the relatively small volumes needed to generate vast amounts of energy provide the ability to store large amounts of energy on site. There is normally one to two years fuel in an operating reactor that can be supplemented by storing another one or more reloads on site which guarantees it is not subject to short term disruption. Nuclear's ability to operate at capacity factors of 90% or more means it is always on to meet the needs of energy hungry consumers.

Building a secure energy system takes planning and most of all, time. There are no quick fixes. However, since most of the global energy trade is based on fossil fuels, the solution to a secure energy system is consistent with the transition to a low carbon energy system. Weaning our economies off fossil fuels will lessen dependence on others. A high level of electrification supplied by renewables and nuclear energy will result in a secure and low carbon energy future.

Today's issue is how to reduce the need for energy supply from Russia, especially in Europe. Nuclear power can contribute by replacing fossil fuels as a source of abundant, affordable and reliable electricity. In the short term, keeping currently operating nuclear plants open is a simple solution. Countries like Germany and Belgium who are closing nuclear plants before their end of life and replacing them with gas are reducing their energy security. As a result, Belgium has decided to extend the lives of some nuclear plants. Germany has not. For the longer term, many countries in Europe are returning to nuclear for its security as well as its environmental benefits – new nuclear fleets in France and the UK – new plants in Czech Republic and Finland – possible new plants in Estonia, Slovenia and Romania, just to name a few of the countries looking to a nuclear future. And of course, there is Ukraine, already one of the largest users of nuclear energy in Europe who is committed to new nuclear as soon as this war comes to an end.

That being said, there will always be an element of global trade to support our energy needs. All generating options require technology and raw materials. Improvements in operations come from collaborating, not isolating. It is nice to think we can put up walls and each of us support our own needs. But there is no doubt we are all better off in a peaceful world with global markets that work. Unfortunately, this cannot always be the case and given the importance of energy to our everyday lives, building secure energy systems to mitigate the risk of energy disruptions is critical.

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.