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.

Energy is life – and nuclear power can provide the reliable clean energy essential to our future

It has been about two months that most of us have been staying home to help flatten the curve of the COVID 19 pandemic. While it may seem difficult, we keep telling our kids how lucky we are to have incomes as we work from home to limit our health risk. There are many who are struggling to meet their

expenses having lost their jobs and are extremely stressed about what their future may hold. We also have to appreciate those who continue to go to their workplace, to help us stay fed and have what we need to survive, often for very little pay while they are at increased risk of becoming sick. And most of all, we need to acknowledge the challenges faced by our health care workers who are working so hard to try and help those who are suffering most from this illness.

Just try to imagine what would it be like to be at home if we couldn’t count on the very basics such as staying warm or keeping our food fresh and having the means to cook it. What would we do without the internet and our mobile phones that keep us connected to the outside world and enable us to do our work? These things we need to maintain our health, be fed, work at home and stay safe, all depend upon access to reliable cost-effective energy.

Yes, some will point out the oil market has crashed, and energy demand has dropped the largest amount since the second world war. But what we need to understand is that while

demand is down as our economies have ground to a halt, our **reliance** on energy has never been greater. Without access to reliable economic energy, suffering would increase. Energy not only allows us to live, it enables us to thrive.

Many of you will have watched Michael Moore's latest film "Planet of the Humans". We will not review it here as there are numerous articles and videos out there to explain why it is both right and completely wrong in its assessment of the environmental movement. And while some may find it fun to watch progressives take on their own set of beliefs; what is really important is the recognition that intermittent renewables, wind and solar energy, cannot solve our climate crisis on their own. We talked about this last year when the International Energy Agency (IEA), issued it report "**Nuclear Power in a Clean Energy System**" that clearly stated "*despite the impressive growth of solar and wind power, the world's overall share of clean energy sources in total electricity supply in 2018, at 36%, was the same as it was 20 years earlier*" after spending billions of dollars to increase their use.

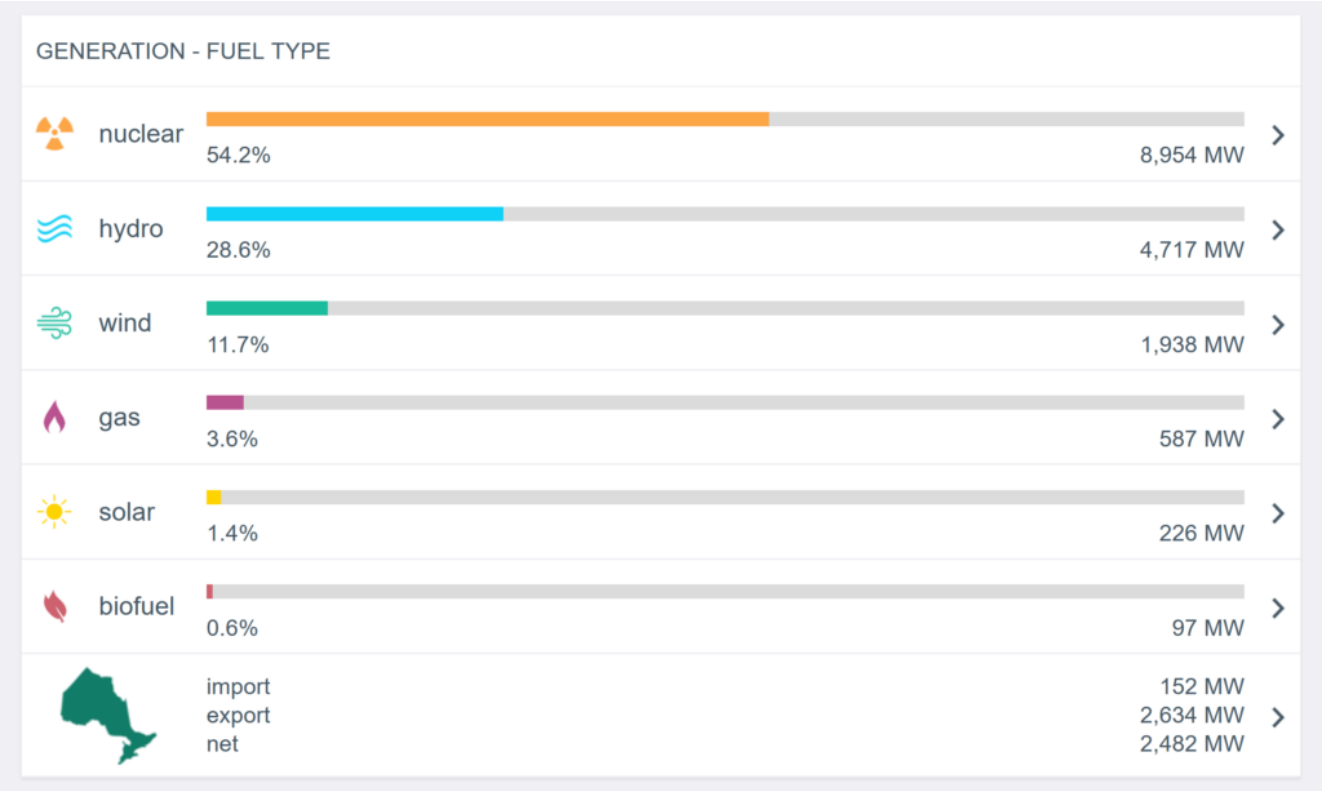
Unfortunately, the movie seems to say there is no solution. It takes the anti-capitalistic view that continued growth is simply unsustainable suggesting the only way to reduce the burden on the planet is to reduce both population and our consumeristic approach to life, so that we all must learn to live happily with less. These folks look to how much the environment has improved during this pandemic as we stay at home as an example of what is possible.

However, it should come as no surprise that if we sit home doing nothing, then the air will be cleaner, but at a what cost? While this may be able to be sustained for some time to help solve an urgent crisis if we all work together, it cannot be the way of the future as millions are out of work with no way to support their families' basic needs. And to suggest this is a viable path is an insult to the more than one

billion people on the planet that have no ready access to energy and who are suffering from the most difficult of human conditions, extreme poverty.

In fact, we know the best way to limit global population is to create wealth. World Bank data clearly shows that population growth is lowest in wealthier countries. The least developed countries have a growth rate of 2.4% (2018 data), while the richest are much lower with the US at 0.6%, the EU at 0.2%, and Japan not even replacing its population at -0.2% growth. The answer is not reducing our reliance on energy but rather ensuring that everyone has access to clean affordable energy.

We have this energy source available to us today, nuclear power. It was completely overlooked in Planet of the Humans (by design), yet it can provide the world with an almost unlimited amount of low carbon, economic and most of all, extremely reliable energy. The movie was right. Renewables cannot be counted on to solve this problem alone, but together with nuclear power, there is a future that meets all our needs. We see this in Ontario, Canada. Today is a typical work day during the pandemic and our electricity is being generated almost completely from nuclear and renewables (hydro, wind and solar), supplemented with a small amount of gas generation so that we are emitting an extremely low 16 g/kWh of carbon, essentially nothing.



Ontario Canada Electricity Generation May 12 (1-2 PM) – Gridwatch.ca

So, if the environmental movement can critically review its commitment to renewables and realize that maybe they can't do it all; then could they also be wrong about nuclear power? A critical look with an open mind may actually surprise them. Of course, for those that want to believe that going back to simpler times is the only path, having abundant clean energy is not desirable. But these are also the people who are sitting in their comfortable homes, with ample energy, so they can use the internet to do interviews, talk on the phone, and make movies.

[*This post is dedicated to my mother, Rennie Caplan, who passed away on April 25. This will be the first post in my 10 years of blogging she will not read. Although she had little interest in the subject matter, I was sure to hear after every post that she read it and thought it was wonderful. There can be no replacement for the absolute support received from a parent, even when we are well passed the age of needing it. Our family will never be the same without her. She will be missed, and we will always remember her for the wonderful*

mother and grandmother she was.] Milt

Is nuclear energy clean energy? Canada says yes!

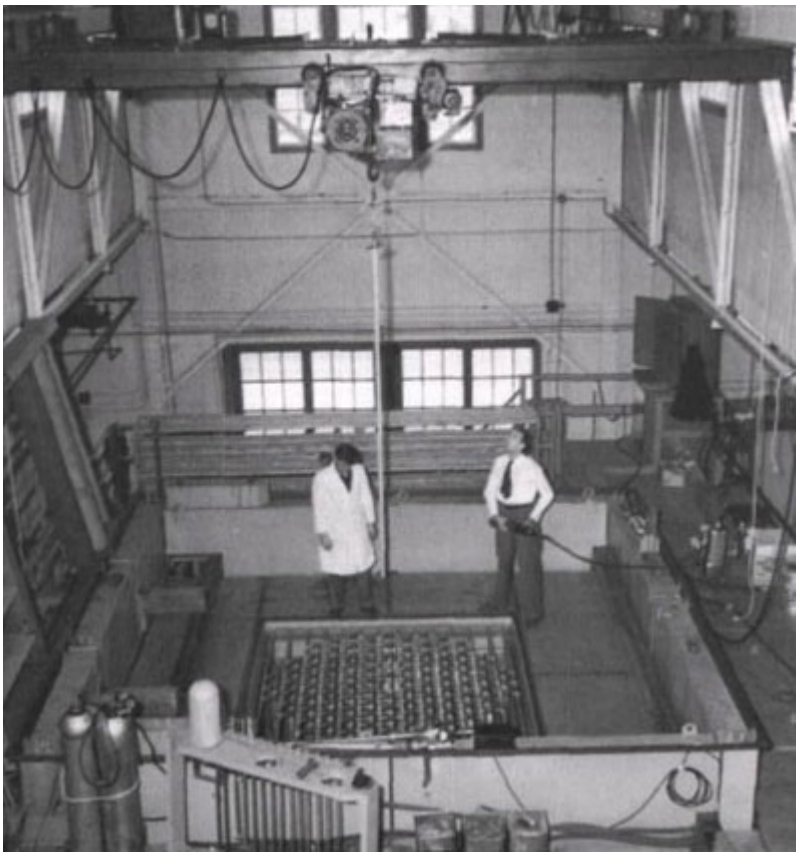
At the Canadian Nuclear Association conference on February 27, the Honourable Seamus O'Regan, Canada's Minister of Natural Resources, made the Canadian position on the role of nuclear power to combat climate change crystal clear. *"As the world tackles a changing climate, nuclear power is poised to provide the next wave of clean, affordable, safe and reliable power ……. Why? Because it can provide almost immeasurable amounts of energy with zero CO2 emissions. Zero."*

Absolute clarity when so many others continue to struggle. In January we wrote about the ongoing battle in Europe to recognize nuclear as a clean energy source, specifically as part of the EU taxonomy that would determine what technologies quality for clean energy and sustainable finance. France, Europe's largest user of nuclear power just closed the first unit at Fessenheim in February, with the second slated to close in June, even when they are still operable as part of a policy to reduce nuclear dependence. In the US, plants like Diablo Canyon in California and Indian Point in New York, are slated for early closure in the coming years, again for purely policy reasons. The result of these early closures is always the same, increased carbon emissions.

But here in Canada, where the most populous province, Ontario, generates over 60% of its electricity with nuclear, support is strong. Canada has many challenges in meeting its Paris climate targets, and this government has gone further,

suggesting it wishes to be carbon net-zero by 2050. It knows the only way to achieve this goal is to deploy all low carbon options available to it, and that includes nuclear power.

Of course, Canada is no stranger to nuclear power having played an important role in the global nuclear sector since its inception. The first sustained criticality in a nuclear reactor outside of the United States occurred at Chalk River in 1945 at the Zero Energy Experimental Reactor (ZEEP). Canada's Chalk River Laboratories has been at the forefront of nuclear research and development (R&D) and innovation ever since.



Canada's ZEEP – the first sustained nuclear reaction outside of the US

Canada was one of the few countries to develop its own nuclear technology, the CANDU reactor, the only non-light-water reactor to gain international recognition and be exported from its home country to a range of countries around the globe. Today there are 19 operating CANDU reactors at home (accounting for approximately 16% of the national electricity

mix, and more than 60% in the province of Ontario) and operating CANDU reactors in Argentina, Romania, India, Pakistan, Korea and China.

In addition to nuclear technology, Canada has been blessed with the world's richest uranium resource, in the Athabasca basin in Saskatchewan. Canada is the second largest producer of uranium in the world after Kazakhstan and is host to one of the world's leading uranium production companies, Cameco.

And Canada is not resting on its past glory. Today, the nuclear industry in Canada is vibrant and growing, primarily based on the decision in Ontario in 2015 to approve refurbishment (life extension) of the 4 nuclear units at Darlington and the remaining 6 units at Bruce (the first two units were already refurbished). This $26 Billion 15-year program is one of the largest clean energy projects in North America. The first unit at Darlington, Unit 2, started its refurbishment outage in October of 2016. The work on this unit is almost complete and the unit is expected to come back online in the coming months while remaining on budget. The first Bruce unit to undergo refurbishment is Unit 6, which just recently started its outage in January.

This refurbishment work is re-energizing the Canadian nuclear industry. With more than 90% of the work coming from Canadian companies, quality programs are being upgraded, new younger workers are being trained, project management skills are being enhanced, and new fabrication equipment is being purchased. This includes a commitment to increasing gender equality and being more inclusive of indigenous peoples.

But that's not all. In 2018, Canada issued its SMR Roadmap, a plan for the future looking to new Small Modular Reactors (SMRs) as the next phase in nuclear technological development. Work is ongoing with the 3 Premiers of the provinces of Ontario, Saskatchewan and New Brunswick signing a Memorandum of Understanding (MOU) December 1, 2019 agreeing to

work co-operatively to advance the development and deployment of SMRs with regards to addressing climate change, regional energy demand, economic development and research and innovation opportunities.

Government representatives from these 3 provinces (Honourable Greg Rickford, Ontario Minister of Energy, Northern Development and Mines, Honourable Dustin Duncan, Saskatchewan Minister of Environment, and Bill Breckenridge, Assistant Deputy Minister, Natural Resources and Energy Development, New Brunswick) sat on a panel at the CNA conference to discuss how they are going to collaborate to make this a reality. The provinces and the Canadian federal government do not always see eye to eye but on this issue, there is unanimity.

Or as stated by Minister O'Regan, "*This is nuclear's moment. This is your moment. To shape the next wave of nuclear technology. And move to the frontlines in the battle against climate change and the plan to get Canada to net zero by 2050*."

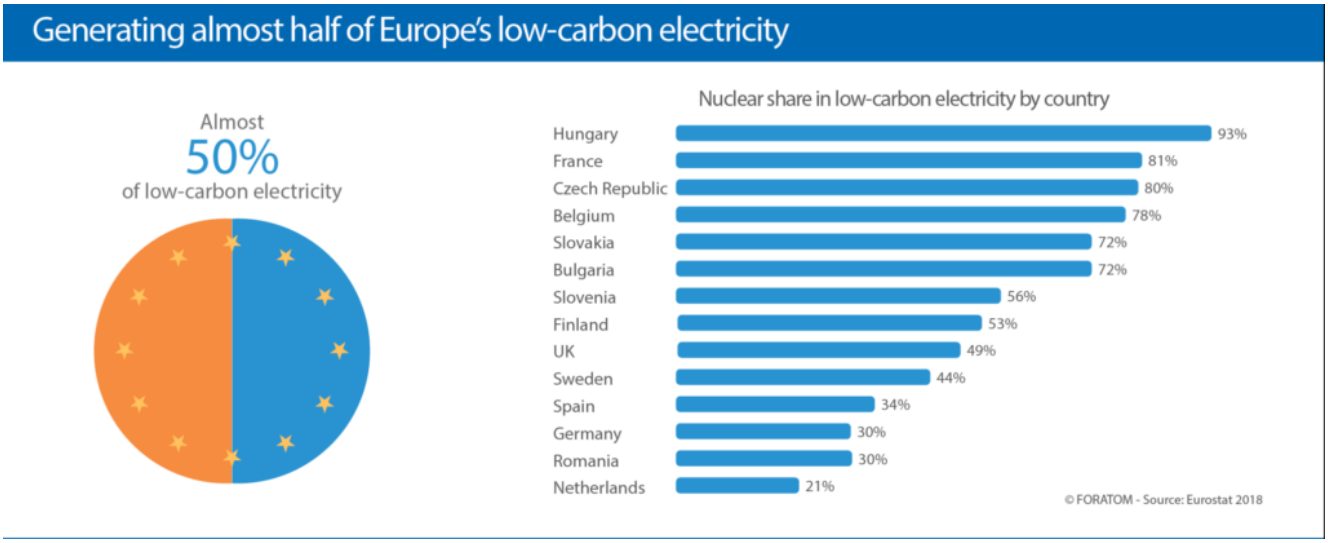
The debate is over. Now is the time to act. After all, saving the planet is hard work, but with nuclear power as part of the solution, we are definitely up to the task.

Europe says it wants to be carbon neutral by 2050 – nuclear must be part of the

plan

In December European leaders agreed to make the European Union carbon neutral by 2050. European Commission President Ursula von der Leyen described it as Europe's "*man on the moon*" moment. With this kind of strong statement of commitment, you would think that EU countries would use every option available to them to meet this goal.

But you would be wrong. There remains a vocal group within Europe trying to ensure this goal is met without the use of nuclear power. Today, with 126 nuclear units in operation, nuclear power accounts for almost half of the low carbon electricity in Europe. So how do you create a policy that excludes this critical source of low carbon electricity?



You do this with something called "taxonomy". What is taxonomy? Well, the dictionary defines it as "the science of classification; laws and principles covering the classifying of objects". In this case it is the development of an EU classification system – the so-called EU taxonomy – to determine whether an economic activity is environmentally sustainable. With the objective of reorienting capital flows towards sustainable investment, only those activities that are environmentally sustainable can have access to sustainable financing. Given that nuclear energy is capital intensive,

and that its cost of energy is sensitive to the cost of funds, not being classified as environmentally sustainable, would have a profoundly negative impact on the ability to finance new nuclear build going forward.

It should be simple to demonstrate the contribution that nuclear power makes to the environment. The arguments are clear. But the reality is that after prolonged negotiations, the two sides in the discussion are at a stalemate. The current status of the taxonomy is that nuclear is neither included nor excluded as a sustainable energy source at this time. A difficult conclusion given there are nuclear units currently under construction in Finland, France and Hungary with a number of others in the planning phase.

So, how does one qualify to be sustainable? **First**, to be classified as sustainable in the taxonomy a technology must substantially contribute to **at least one of** the following six environmental objectives: climate change mitigation, climate change adaptation, sustainable use and protection of water use and marine resources, circular economy and waste prevention and recycling, pollution prevention and control and, healthy ecosystems. And **second**, is to Do No Significant Harm (DNSH) to the **other remaining** objectives.

Who decides if a technology meets these criteria? A Technical Expert Group (TEG) made up of 35 members from civil society, academia, business and the finance sector, as well as additional members and observers from EU and international public bodies. They work in sub-groups to address the various issues in their remit.

On the first criteria, given the very strong case provided to the TEG, they concluded that nuclear does make a substantial contribution to the objectives stating, "*Evidence on the potential substantial contribution of nuclear energy to climate mitigation objectives was extensive and clear*."

But those opposed to nuclear found their issue when it came to do no significant harm. In the compromise draft of the TEG report, the sub group on DNSH concluded *"It was therefore infeasible for the TEG to undertake a robust DNSH assessment as no permanent, operational disposal site for HLW (High Level Waste) exists yet from which long-term empirical, in-situ data and evidence to inform such an evaluation for nuclear energy."*

The reality is this is a political issue, not a technical one. Some technologies are given far more scrutiny than others. For example, solar and wind are included in the sustainable classification without any technical assessment.

Yet, just this month Vestas, the world's largest maker of wind turbines announced it is working towards a strategy to be waste neutral by 2050. They claim to be the first among their competitors to announce a zero-waste ambition and aims to publish a plan within two years. This is good news but also shows that even solar and wind are not waste free. How can they set the gold standard for sustainability if there is no data presented to enable a comparison by those technologies that are deemed less sustainable?

Any comparison will show that nuclear power is an environmental champion. It is by far the most resource efficient low carbon technology, using less land, mining less materials and producing the smallest quantities of wastes. It is the only industry on earth that knows exactly where all its waste is from its commercial operations which it then stores safely and securely. Can any other industries say that?

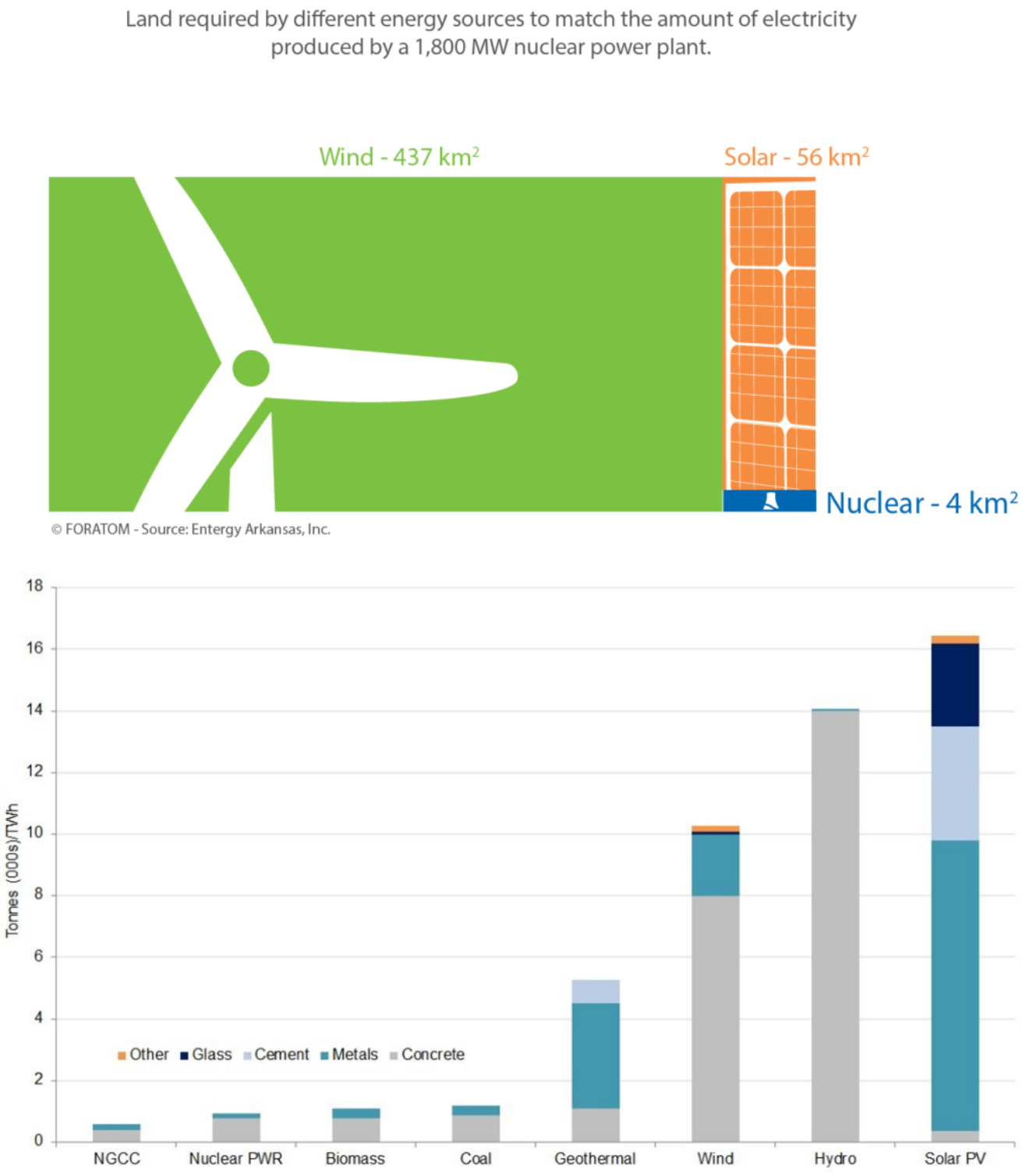


Figure: Extracted materials used for generating electricity

Unfortunately, facts don't matter. As this is a political problem, it requires a political solution. Never easy in this time of extreme partisanship where everyone already knows what the answers should be. What it shouldn't be is about choosing one solution over another; it should be about choosing them all.

And for those of us living outside of Europe, we cannot be complacent thinking this is just a European problem. Should this effort succeed it will have repercussions for financing nuclear projects the world over. And there is no doubt who the real loser would be – the environment.

Earlier this month activist Greta Thunberg took her argument to the world's elite at the Davos World Economic Forum. Her message was that those in power are doing nothing, noting that time is short and "*every fraction of a degree matters.*" Well, then every technology that can contribute to the goal must also matter. Without nuclear power, Europe's man on the moon moment will be nothing but a dream.

With a new decade upon us, clean energy is as simple as following the science

It's hard to believe, but a new decade is upon us. (We wrote the decade and nuclear power in our post earlier this year celebrating 10 years of blogging.) As the decade comes to a close, 2019 seems to be the year that climate change is finally being taken seriously, all led by a very unlikely champion. After all, who would have thought that a 16-year-old schoolgirl from Sweden would become not only a voice for a new generation, but a global leader in speaking truth to power on the importance of taking action to address climate change?

This is a young woman who has taken a stand. Starting her journey as a single protester sitting in front of the Swedish parliament less than two years ago, she has now met with world leaders and inspired the largest climate strike in history.

She acknowledges that as a 16-year-old girl, she does not have the answers, and as such, does not advocate for any one solution, nor claim to be smarter than anyone else. Her message is simple – this a climate crisis – and today's adults are not taking it seriously enough. Her recommendation to those older than her who do have the power, is to please do something and when choosing what to do, follow the science.

Time Person of the year

We have also been seeing one of the other less positive developments in the world over the last decade, trolling and personally attacking those we disagree with. In the case of

Greta Thunberg, the vitriol has been vicious and relentless. From world leaders such as Donald Trump who recently said she needed to work on her “anger management problem” to Brazilian president Jair Bolsonaro who called her a brat, to countless others whose attacks are so vicious that we wouldn’t repeat them. Her ability to respond with grace and humour when confronted with these attacks shows the strength of a new generation that cannot easily be bullied by those older than them.

When it comes to energy, criticism is nothing new for those of us in the nuclear industry. Recent polling has suggested that the younger generations are open to hearing more about nuclear power as it can be a part of the solution to the existential threat of their generation. But once again, there is conflict. On the one hand, there are those that believe nuclear is good. It is low carbon, nonpolluting, economic and provides an abundance of reliable energy to benefit all of us. Then there are those that believe that nuclear is dangerous. That it pollutes with dangerous waste products and is just the next accident away from destroying the world. These people believe that no benefits are worth taking such a risk. Our challenge in the new decade is to resolve this conflict with straight forward messaging. After all, the science is clear.

The reality is that nuclear power has been the largest contributor to carbon avoidance of any other technology in advanced countries and is a close second to hydro when considering the world as a whole. It has proven safe, having the best safety record of any form of energy generation. 2019 was the year this message started to resonate. From the important IEA report issued at the Clean Energy Ministerial meeting in Canada in June, to governments accepting nuclear as a clean energy source and undertaking the NICE (Nuclear Innovation: Clean Energy Future) initiative, to the recent MOU signed here in Canada between the Premiers of Saskatchewan,

Ontario and New Brunswick, to pursue and commercialize Small Modular Reactors (SMRs), the tide is turning.

It would be easy to leave this decade dismayed and worried about the future. It is a time when anything we disagree with is fake news and some say the very basic values of our liberal democracy are at risk. But we choose to enter the next decade full of hope. Yes, we have many challenges, one of them to protect the planet for future generations; while we want everyone—including the world's poorest—to have access to cheap, reliable energy. And yes, there are many who try to divide us; or we can listen to a new generation that are calling for us all to work together for the good of the planet with a compelling simple message – "follow the science".

Once again, thank you for reading our blog. Wishing you all a very happy, healthy and prosperous 2020!

Saving the planet step 2 – let's build as many Generation III nuclear plants as we can

It has been more than a decade since the nuclear industry focused
its attention on the next generation of nuclear plants, the Generation III
designs. Most of the world's current operating
fleet (440 nuclear reactors in 30 countries) are classified as Generation II
plants, the first generation of truly commercial nuclear

generating stations
(Generation I were the early demonstration units). The idea behind Generation III was to take
the lessons learned from the many years of operation of these plants and design
the next evolution of nuclear; new plants that would be more cost effective to
build, easier to operate and safer than their predecessors.

But these new designs did not progress as easily as their designers
envisaged. In many cases there were
delays in getting approvals, delays in construction and cost overruns. A decade passed and there were still no Gen
III plants in operation – until now. In
the past year or so, not only did one of these designs come into service, most
of them did.

Haiyang AP1000 nuclear plant China
Here is the list of newly operating Gen III nuclear plants:

- 4 AP1000 units operating at Haiyang and Sanmen China

- 2 VVER 1200 units operating in Russia
- 2 EPR units operating in China
- 2 APR1400 units operating in Korea
- 2 ACPR1000 unit operating in China

And there are many more on the way. EPRs in Finland and France. APR1400s in Korea and UAE, VVER 1200s in Russia, Turkey and Bangladesh, AP1000s in the United States, and the new Hualong One design in China which is nearing its first unit completion to name a few.

Why is this important?
We have often talked about building fleets of standardized nuclear plants to control both cost and risk and now these designs all have their First of a Kind (FOAK) challenges behind them.
This means the industry has never been in a better position to move forward with large standardized fleets to take advantage of all the lessons learned and the ready supply chains. And with a number of designs to choose from, there are options for everyone while maintaining a healthy competition amongst the vendors.

Governments are getting ready too. For example, recently the French government instructed EDF to prepare a plan for another 6 EPR units in France and India is preparing a site for 6 AP1000s.

And the need couldn't be greater, as the just released 2019 edition of the World Energy Outlook (WEO) shows how the world is struggling to find a way to meet carbon emission targets. There are no easy answers. It states, *"More than ever,*

energy decision makers need to take a hard, evidence-based look at where they stand and the implications of the choices they make." Even assuming a massive new build renewables program with solar growing its capacity by an order of magnitude, from about 500 GW today to almost 5,000 GW by 2040 the challenge is that "*the momentum behind clean energy technologies is not enough to offset the effects of an expanding global economy and growing population.*" So, as it did last year, in order to meet the emission targets in its sustainable development scenario, it assumes very aggressive energy efficiency to eliminate the projected 24% increase in energy demand growth to 2040 from its stated policy scenario. Now, does anyone really believe in 20 years time we will be using less energy than we do today? The conclusion is clear. Renewables cannot meet the challenge alone.

Our Generation III plants are here and ready to make their contribution to meeting the low carbon energy challenge. So, as we wrote before, if step 1 to saving the planet was to keep the current nuclear fleet operating as long as possible to avoid going backwards by having to replace one low carbon source with another, then step 2 becomes obvious – in addition to a rapid build of renewables, build as much more nuclear as we can. Keep in mind that the difference in efficiency means that every new GW of nuclear (typical size of Gen III reactor) is equivalent to about 5 GW of solar, not to mention the battery storage required to ensure the solar energy can be used when needed, not just when the sun shines.

Having been the largest source of low carbon electricity generation over the last 50 years in advanced economies, nuclear is already an indispensable part of the world's low carbon energy system. As an industry, it's time to show what we can really do to play an increasing role in meeting the challenges of the future. We are making progress. In 2018 10.4 GW of new nuclear were added to the global grid. Let's keep going and scale up our efforts to meet the industry

Harmony goal of nuclear providing 25% of the electricity supply by 2050. With a full suite of Generation III designs up and running and an industry ready to go, all that is left to do is build, build and build some more.

[Note: for those of you wondering how small modular reactors (SMRs) fit into this picture, you will have to wait until we discuss Step 3 to
saving the planet in a future post]

Environmental Symbols – demonizing pipelines won't solve climate change

Here in Canada, we recently held a bitterly fought federal election with the outcome being the existing government was returned to power
but reduced to a minority. One of the
big issues this election cycle was climate change. It was fascinating to watch as one side claimed
government was not doing enough on climate, while the other argued government
was unfairly targeting western Canada's lifeline, its oil sector. Interestingly,
both arguments had merit.

Now, we know better than to wade into political discussions and that is not the point of this post.
What we do want to discuss is how environmental activists may not always
pick the best symbols to create antagonists and support their arguments. In this case, we want to focus on the bitter

arguments over the future of pipelines.
The perception is that supporting the environment means opposing
pipelines. Nothing can be further from
the truth.

We
all accept that climate change is the existential issue of our time. We know that to address it we must reduce our
carbon emissions, and this means reduce our use of fossil fuels. And most of all, we know the time is short,
shorter than we thought.

Even
though fossil fuels are still our main source of energy, we are not going to
argue about how pipelines are the best and most efficient way to transport oil
and gas, as the alternative is by truck and rail. We all saw the disaster in Lac-Megantic,
Quebec in 2013 when a train filled with oil de-railed and

plowed into the town's downtown, blowing up and killing 47. Nor are we going to argue that reducing the amount of oil produced in Canada supports production from other countries with despotic regimes and significantly less environmental standards. Why? First of all, because the argument that we are the least worst option is a hard sell, but more important, because when it comes to carbon emissions, none of it actually matters.

What does matter is that without any doubt whatsoever, not proceeding with a given pipeline will not reduce the use of even one barrel of oil. That's right, not one person will drive their car less or trade in their SUV for a smaller more efficient vehicle. Not one person will cancel their travel for vacation by plane. And not one gas-fired power plant will reduce its output and produce less electricity.

The reason is simple. We cannot reduce fossil fuel use by trying to control supply. Someone recently provided an interesting analogy. For about 50 years in North America, the war on drugs has been focused on trying to disrupt supply. And now, most agree, this war has been a dismal failure. Why? Because when people want something badly, especially if they are addicted to it, they find a way to get it. And like drugs, our societies are addicted to fossil fuels.

Therefore,

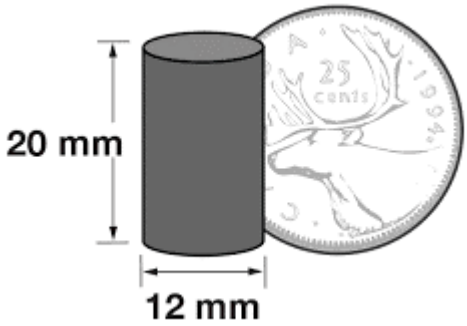
the only way to reduce fossil use, and carbon emissions, is to reduce demand. How do we reduce demand for fossil fuels? Again, some would have us believe the answer is personal sacrifice and hardship. Forego that holiday abroad with a staycation. Ditch the car and take transit or even better, ride a bike to work. Turn the thermostat in our homes down in the winter and up in the summer. Others would have us believe the answer is to price carbon, making its use more expensive, forcing us to economize and use less fossil fuels.

Once again, to some extent, both of these approaches can work. Is it reasonable to ask us to make better choices for the benefit of the planet? Sure. Many of us can make changes to our energy intensive lifestyles and may accept there is a cost to the emissions we make but the pain must be within reason. The problem is even with the best of intent, there are real limits to how much benefit these popular approaches can achieve by themselves.

Why? Because access to energy has made all our lives better. Therefore, the only real approach to reducing our dependence on fossil fuels is to find economic reliable alternatives to meet our energy needs. We cannot stop driving to work if we have no option to take public transit where we live. We will not stop visiting elderly relatives a flight's distance away if there is no other way to get there economically and efficiently. And we will not choose to live in a cold dark house. However,

we may well choose to drive an electric car and heat and cool our homes with electricity, so long as the electricity is produced from a low carbon source.

Many will have you believe the answer is to move to 100% renewable energy. We have discussed this in the past and, as with the symbol that pipelines are bad, the idea that the only solution is a renewable future, is just as flawed. While these forms of energy have made progress, they cannot meet global carbon targets on their own. We need all low carbon energy options to be pursued with vigour. Most of all, this includes a strong commitment to nuclear power as a base load, energy dense, economic and reliable option. As our newest young global environmental activist likes to say – follow the science. And the science is clear.



If we accept there is an urgent need to decarbonize our economies, then it is also time to give up the symbols that pipelines are evil and solar panels are all we need. Ideology will not get us to a carbon free future. Technology will. We need to embrace a new symbol for a better future, nuclear power. A single small fuel element provides as much energy as 1 ton of coal yet only emits about the same amount of carbon as a solar panel. **No other energy option can produce so much energy from so little.** So, let's not worry about pipelines;

rather, let’s focus our efforts on solutions that work – reducing demand for fossil fuels by producing the energy we need from all the low carbon sources we can.

Saving the planet step 1 – Keep the nuclear fleet operating as long as possible

On the cusp of the United Nations Climate Action Summit in New York where there was a collective outrage at the slow pace of decarbonization in the world, we lost another operating nuclear plant before its time as Three Mile Island Unit 1 closed after 45 years of operation. It made the news because of its more famous (or infamous) sister plant, TMI Unit 2 that had the USA’s worst nuclear accident 40 years ago. Of course, only the nuclear industry continues to talk about an accident that harmed no workers and had absolutely no impact on the public – other than fear. Certainly nothing to talk about after 40 years, and more so, should be a point of pride if this is the worst nuclear accident that ever happened in the US. But that discussion is for another day.

Today we want to focus on the importance of keeping the current nuclear fleet operating as long as possible. Once again, we go to the IEA report issued in May, “**Nuclear Power in a clean energy system**”. It notes the ”*failure to expand low-carbon electricity generation is the single most important reason the world is falling short on key sustainable energy goals, including international climate targets*.”

Probably
the most important point made in this IEA report is about the

absolute failure
of renewables to make a dent in carbon emissions on their own. As stated, *"Despite the impressive growth
of solar and wind power, the overall share of clean energy sources in total
electricity supply in 2018, at 36%, was the same as it was 20 years earlier
because of the decline in nuclear. Halting that slide will be vital to stepping
up the pace of the decarbonisation of electricity supply."*
That's right.
Spending vast sums of money on renewables and closing another major
source of low carbon electricity at the same time is a losing proposition. This is not progress, it is lunacy.

Earth's oceans and frozen spaces paying price for 'taking the heat of global warming
To
put this in perspective, TMI Unit 1 that was closed last week produced 819 MW
of electricity. For example, the Solar
Energy Generating Systems (SEGS) in California, which is rated

at 354 MW (or let's say half of the TMI unit for simplicity) is one of the world's largest solar thermal power plants with a total of 936,384 mirrors and covers more than 1,600 acres. Lined up, the parabolic mirrors would extend over 229 miles. With a solar capacity factor of about 20%, there would be a need for 10 of these gigantic solar farms to generate the same amount of electricity as the single TMI unit 1. And, as this electricity is not continuous, it requires gas to back it up when the sun is not shining. On the other hand, the TMI unit operated continuously for 709 days before its final shutdown on September 20. Now, no one is saying not to build solar farms, but having to build 10 massive ones to replace a single nuclear unit and not achieve a single ton of carbon reduction is an exercise in futility.

In the US, the challenge to keeping plants open is generally economic. Cheap gas in de-regulated markets is making it impossible to use any form of generation economically other than gas. On the other hand, gas is a significant carbon emitter and shutting down low carbon plants to burn more gas is not in line with environmental imperatives. So, what do governments do? They subsidize both solar and wind and balk at doing the same for nuclear. Back to TMI unit 1, its license was valid for another 15 years of operation and a subsidy of 1 cent a kWh would have kept it open, half of the subsidy provided to renewables. No one is suggesting that all plants should be kept open irrespective of its economics as there will always be cases that just don't make sense, but on average, keeping plants open is way better for both system costs and the environment.

In fact, Staffan Qvist (co-author of the excellent book "**A Bright Future**") presented a study at the WNA Annual Symposium in September for Sweden, which from a resource perspective is in a better position than most to achieve 100% renewables. Yet the results of his modelling about 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. (We will have more to say on this topic in a future post.)

In the US it's economics that are the driving force behind potential early closure. Much worse are the many other countries (with very successful nuclear programs) that want to close plants early simply on outdated antinuclear policies. From nuclear France closing Fessenheim when it is still operable for another decade to early closures in Belgium, Germany and host of other European countries; to South Korea's new found dislike of nuclear power, shutdowns in Japan and early closures in Taiwan, the world is doing itself no favours in meeting its carbon targets.

However, change is in the air. Many states in the US have implemented policies to keep plants open. Sweden, Switzerland and France have delayed plans to close some plants and others like Belgium may soon realize they have no other viable options to meet their electricity needs unless they move in the same direction. In Korea the public is much more supportive of keeping nuclear power than its government

and in Taiwan, a referendum that succeeded in demonstrating public support to keep nuclear is being ignored. And we all know that Germany is failing in its Energiewende as it delays coal closures to make up for shutting nuclear plants early. While it is acceptable to have a conversation about which technologies should be used in the future to best make progress on reducing carbon emissions, it is unfathomable to imagine why safe reliable low carbon plants would be closed before their time to make the already immense environmental challenge ahead even larger.

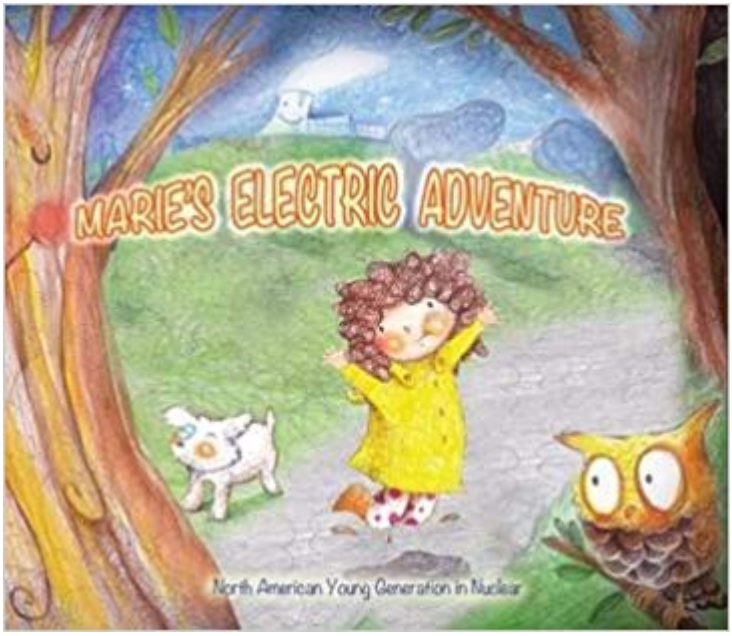
After all, the IEA report is clear. "*Lifetime extensions of nuclear power plants are crucial to getting the energy transition back on track*". It concludes with a Policy recommendation to governments, "authorise *lifetime extensions of existing nuclear plants for as long as safely possible*".

Or as stated by Greta Thunberg in her comments to world leaders, "*How dare you continue to look away and come here saying that you're doing enough when the politics and solutions needed are still nowhere in sight*". Well hopefully world leaders listen and stop making decisions that only put them further behind when it is so urgent to move ahead.

It’s time to take back the narrative and rewrite the nuclear story

The facts are clear. Nuclear power is a critical part of our global low carbon electricity generation system. It provides abundant, reliable and economic low carbon electricity needed to power our energy hungry economies. Yet, as stated in the recent IEA report, **Nuclear Power in a Clean Energy System**, even though the use of nuclear power has reduced carbon dioxide (CO2) emissions by over 60 gigatonnes over the past 50 years, (nearly two years’ worth of global energy-related emissions), nuclear power has begun to fade in advanced economies, with plants closing and little new investment made, just when the world requires more low-carbon electricity.

One issue that puzzles many in the nuclear industry is why we struggle to communicate our many merits to the public, unable to overcome the fear of nuclear that drives much of its opposition. The answer is simple. We talk in facts and figures, but people think in stories with emotion. As stated by Yuval Harari, in his newest book, **21 lessons for the 21st century** (make sure you also add his previous books, Sapiens, and Homo Deus to your to-read list), “*Humans think in stories rather than in facts, numbers or equations, and the simpler the story the better.*” It is therefore time to ask – what is the nuclear power story?



Marie's Electric Adventure: A Children's Book About Nuclear Energy, a book by NAYGN

For an example of a positive story, we only need look as far as the renewables industry, with their compelling story that the world can be powered by nature using energy from the sun and the wind. These energy sources are limitless (after all, we will never use up all the sun and the wind) and have no negative environmental impact because they come from nature. Obviously, we need to increase their use until they meet 100% of our energy needs.

This powerful story resonates with the public well beyond environmental groups to the point where many governments are fully supportive and are putting policies in place to realize this utopian dream. The fact that making this dream a reality is proving much more difficult than its supporters expected (as can clearly be seen in places like Germany and California), doesn't seem to phase any of the believers. They love their story and they know with absolute certainty that any technical impediments can be solved with time and effort and that wasting time on any other energy source is a foolish diversion from what is really important. This is in spite of the fact that you can't change the laws of physics or make the

sun shine or the wind blow more than they do. But the faithful know they are on the right path and will not be dissuaded from their goal.

Why does this work? As discussed by Harari, facts often get in the way of a good story. A story not anchored in facts requires faith, and faith is a very powerful motivator.

On the other hand, the nuclear story has been dominated by those that oppose the technology. The story, based on extreme fear of radiation, is the technology is so dangerous that when it goes wrong (not if, but when) it may actually destroy all of mankind. Even many who support nuclear power believe the industry is made up of smart capable people who are safely managing doomsday machines. The fact that nuclear is by far the safest form of energy generation gets lost in the story that while the probability is low, the consequences of a big accident are unimaginable. Yet the reality is we have had big accidents and while the impact has been significant, they have proven that people can indeed be protected from harm – the most recent big accident at the Fukushima plant in Japan has resulted in zero deaths from radiation, but nobody believes it – it is inconsistent with this nuclear story.

The companion to this story is that even without accidents we have to fear nuclear waste. It is told that it's so dangerous that we need to bury it deep underground and protect society from it for thousands of years, the time it takes to decay away. This is a good example of how stories are made. All other toxic waste streams remain toxic forever. Therefore, the fact that nuclear waste eventually decays away should be a positive, or alternatively just assume it is bad forever like every other waste stream. But somehow, the fact that nuclear waste takes a long time to decay has been woven into a story of absolute fear of what we will do to the environment somehow making many believe that this waste is much worse than all other forms of waste. (This does not consider the fact that this waste is in solid form and in very low quantities –

because who wants the facts anyway?)

After hearing these negative stories for so long, the industry is constantly on the defensive trying to fight the stories with factual arguments; in effect becoming part of the very stories we are trying to change. Well, the time has come to take back the narrative and re-write the nuclear story.

One position taken recently to try and shake things up is the story that wind and solar just aren't enough to meet all our energy needs reliably due to their low energy density and intermittency. We explain that storage at the levels required to make up the difference is very unlikely meaning that the 100% renewables goal only serves the fossil industry as gas and coal are needed to back up these unreliable energy sources. We then say that if we want to decarbonize and quickly, we need nuclear as it is the only large-scale low carbon dispatchable generating source. Or as said in this recent article, "*even if we don't love it, nuclear is the only carbon-free generating source that can provide backup power at the scale required*." The article then goes on to tackle all the anti-nuclear stories talking about safety and waste. The problem with this approach is that we are telling a story that is not a happy one – it is the story that while we may all agree we don't like nuclear; we need it. It is always hard to get people to stand behind things they don't like by telling them they are good for you. And in our experience, being the option of last resort (we wish we had other options, but we don't) is never a good strategy. Because as shown in Germany who had 30% of their generation from nuclear and is now phasing it out as they try and decarbonize at the same time; eventually fear becomes fact and as long as there seems to be an alternative, it will be taken (sometimes even when it is not working).

We need to keep the opening part of this story, i.e. that we

need to reduce carbon to address climate change, and that wind and solar are simply not up to the task – as this is the path to getting those concerned about climate and energy issues to consider other options. But once we get those opposed to nuclear to reconsider because they see the need, we must then tell them a positive story they can embrace, rather than ask them to reluctantly accept something they don't like. Some think that this is too late – that people can't change their thinking. But going back to Harari, he notes that individuals can "*knit revolutionary personal changes into a coherent and powerful life story: "I am that person who was once a socialist, but then became a capitalist; I was born in France, and now live in the United States; I was married, and then got divorced; I had cancer, and then got well again.""* So why not I was once against nuclear but now I support it?

Well then – what is our nuclear story? How about an optimistic story about an exciting prosperous future where we all benefit from abundant, reliable, economic energy; raising millions of people out of poverty, all while also protecting the environment? And the best part is that nuclear can actually deliver. Now that is a story I would want to tell my grandchildren. What do you think the nuclear story should be?

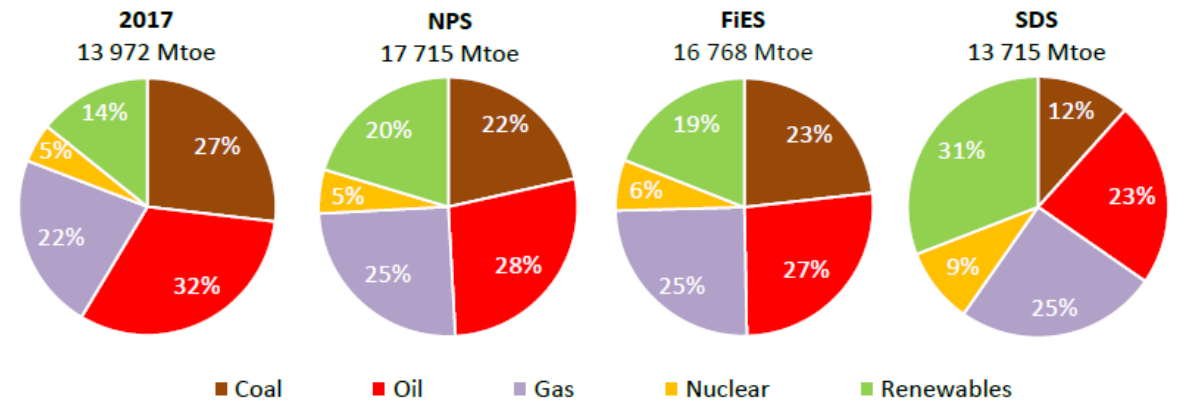
International Energy Agency (IEA) says we need nuclear

The International Energy Agency (IEA) plays an important role in looking at the global energy scene. Every year it publishes the World Energy Outlook (WEO) providing important information and analysis to countries to support their development of energy policy. Over the years, the focus of the WEO has been to consider alternative scenarios to business as usual to provide guidance on what is needed for the world to decarbonize. In various iterations of its report, it called this scenario the 2 Degree scenario, the 450 scenario (for 450 ppm) and now the Sustainable Development Scenario (SDS). Every year the IEA states the importance of decarbonizing our energy systems, and every year it laments how difficult this will be.

Yet, it rarely talks much about the role that nuclear power currently plays and must play in the future to achieve this decarbonization goal. Rather the analysis generally focuses its attention on massive increases in renewables which does reduce the fossil footprint but not nearly enough as fossil fuels remain more than half of global energy supply in 2040. The only path to meet its scenario emission targets then requires policies that reduce energy demand. Consider the following figure from the 2018 WEO that shows renewables doubling, coal being cut in half while gas retains its position as an important fuel in the SDS scenario – with the balance of the carbon reduction due to reduced demand in 2040 for this scenario

– 2% less than 2017 and much less than currently projected in the New Policy
Scenario (which projects a 26% increase to 17,715Mtoe). Do we really think that the world will use
less energy in 2040 than it does today?

Figure 10.15 ▷ Shares of fuels in world primary energy demand today and in 2040 by scenario



Promoting energy security is an important policy consideration; electrification, together with energy efficiency and other alternative fuels, can help achieve this goal

Note: NPS = New Policies Scenario; FiES = Future is Electric Scenario; SDS = Sustainable Development Scenario.

Source: World Energy Outlook 2018
But that was then, and this is now. At the Clean Energy Ministerial (CEM) meeting in Vancouver last month, the IEA issued a report "**Nuclear Power in a Clean Energy System**" and the message is unequivocal. The IEA is stating that to decarbonize our energy systems, WE NEED NUCLEAR!

The report notes that "*lifetime extensions of existing nuclear power plants are crucial to getting the energy transition back on track.*" And "*that without nuclear investment,*
achieving a sustainable energy system will be much harder."
In fact, "*a collapse in investment in*
existing and new nuclear plants in advanced economies would have implications
for emissions, costs and energy security."

Of more importance it says that "*achieving the clean energy*

transition with less nuclear power is possible but would require an extraordinary effort." And even though it talks about the economic challenges facing nuclear power, both existing and new, it also notes that "*offsetting less nuclear power with more renewables would cost more*" and that "*taking nuclear out of the equation results in higher electricity prices for consumers*."

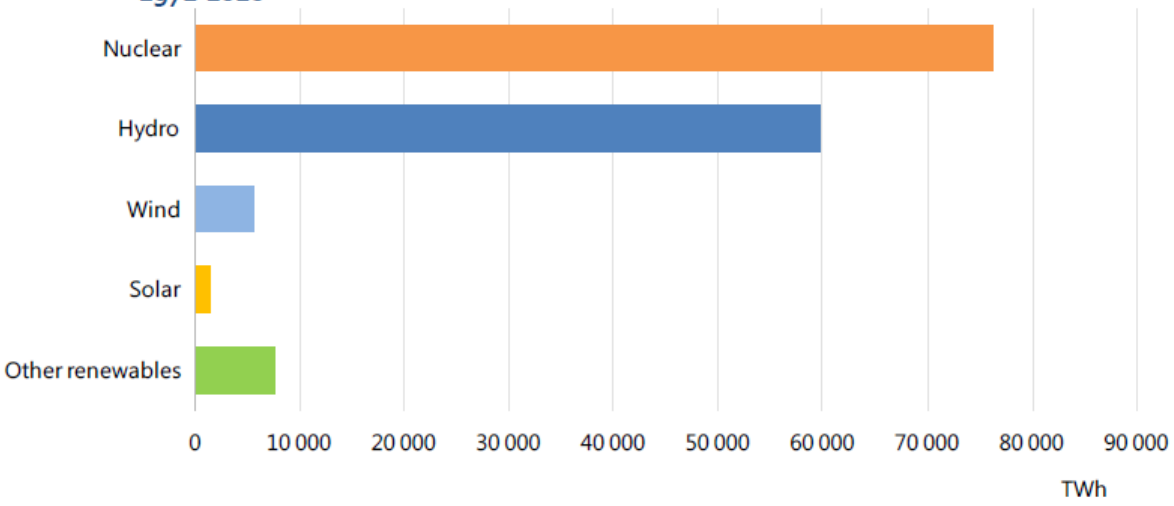
Finally, it concludes with a message to world governments, "*strong
policy support is needed to secure investment in existing and new nuclear plants*."

This is the strongest support given to nuclear power by the IEA in memory. Even back in 2014 when it had 3 chapters on nuclear in the WEO, it was a reluctant supporter. At that time it noted that "*Nuclear power is one of the few options available at scale to reduce carbon-dioxide emissions while providing or displacing other forms of baseload generation",* but also started its discussion with "*Provided waste disposal and safety issues can be satisfactorily addressed,"* while never discussing the challenges that other forms of energy face.

To their credit, in this new report, there is no discussion of these traditional nuclear bugaboos with the focus clearly on why nuclear is needed, why we are better off with nuclear in the system and then suggests policy options for government to make this happen going forward.

The report shows the role nuclear power plays in mitigating carbon emissions is nothing new as over the last 50 years it has displaced more carbon than any other electricity source. Yes, that's correct. No other electricity source has displaced as much carbon as nuclear. So, just imagine what can be achieved in the next 50 years.

Figure 3. Cumulative low-carbon electricity generation in advanced economies by source, 1971-2018



Nuclear power and hydropower account for 90% of low-carbon electricity since the 1970s.

Source: **N**uclear Power in a Clean Energy System . IEA 2019

This IEA report is a turning point in the global discussion. As one government official said, this is the kind of report that moves the world. I am not sure how far – but it is definitely a very important step in the right direction. Because one thing is now absolutely clear – if the world wants to decarbonize, the quickest and lowest cost option is to ensure an increasing role for nuclear energy.