Achieving Net Zero – A global problem requires global solutions

If you live in a relatively rich country (other than the United States), how often have you heard someone bemoaning government policies to cut carbon emissions say something like – "*since we only emit about 1% of global CO2, we could cut our emissions to zero, and it would make no difference. It is the large emitters like China and the United States who have to lead, not us.*"

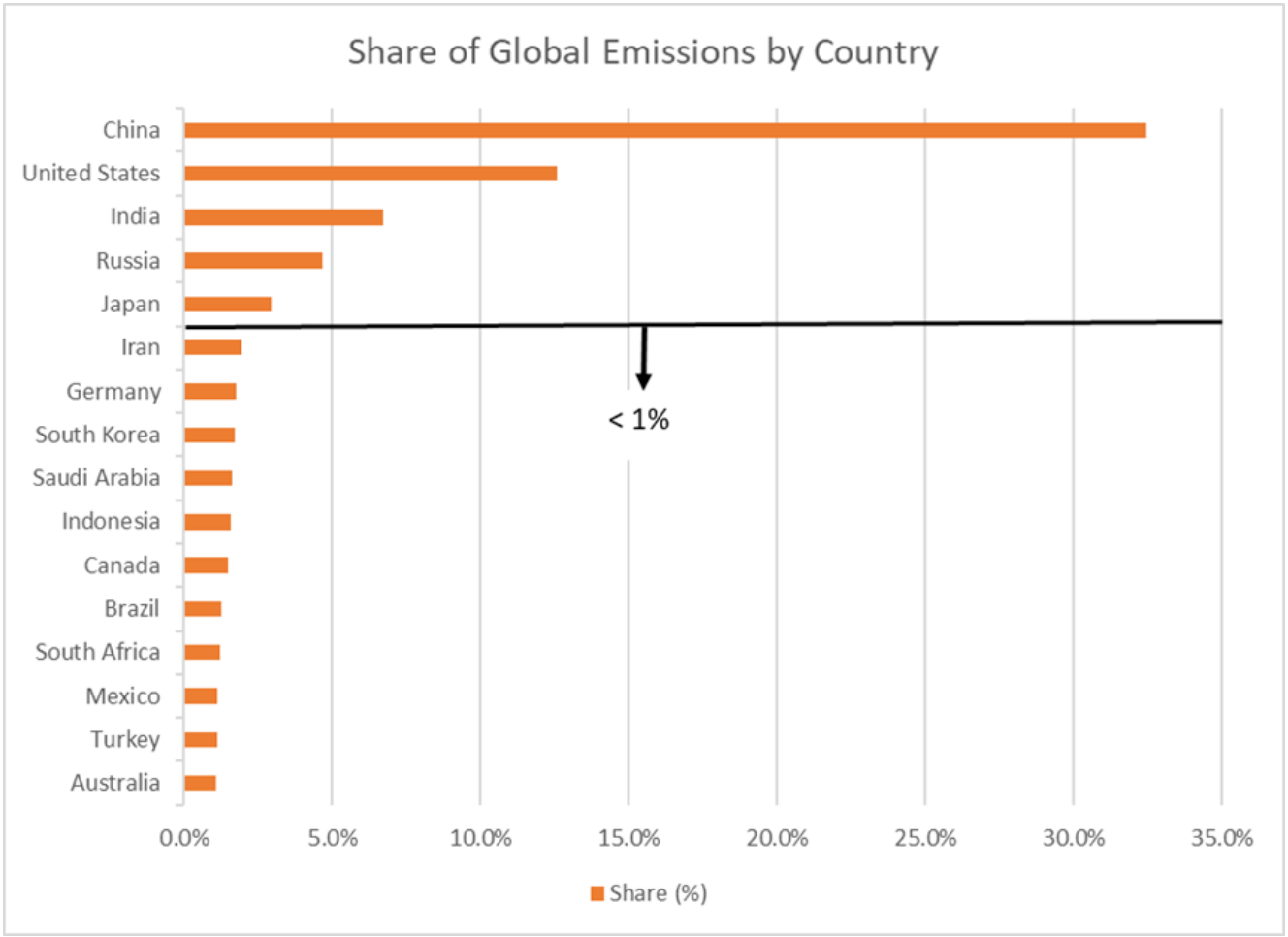
Well, it is true that the United States and China account for about 45% of global emissions. But does that really mean that what the rest of us do doesn't matter when it comes to combatting climate change?

Source: istockphoto.com

Global emissions are indeed concentrated in a very few countries. In fact, the top 5 emitters, China, United States, India, Russia, and Japan account for about 60% of global

emissions (2020 data). China is by far the leader at about 32%. Continuing down the list, there are only 16 countries that emit more than 1% of global emissions with the remaining 195 or so countries in the world each emitting less than 1% of global CO2.

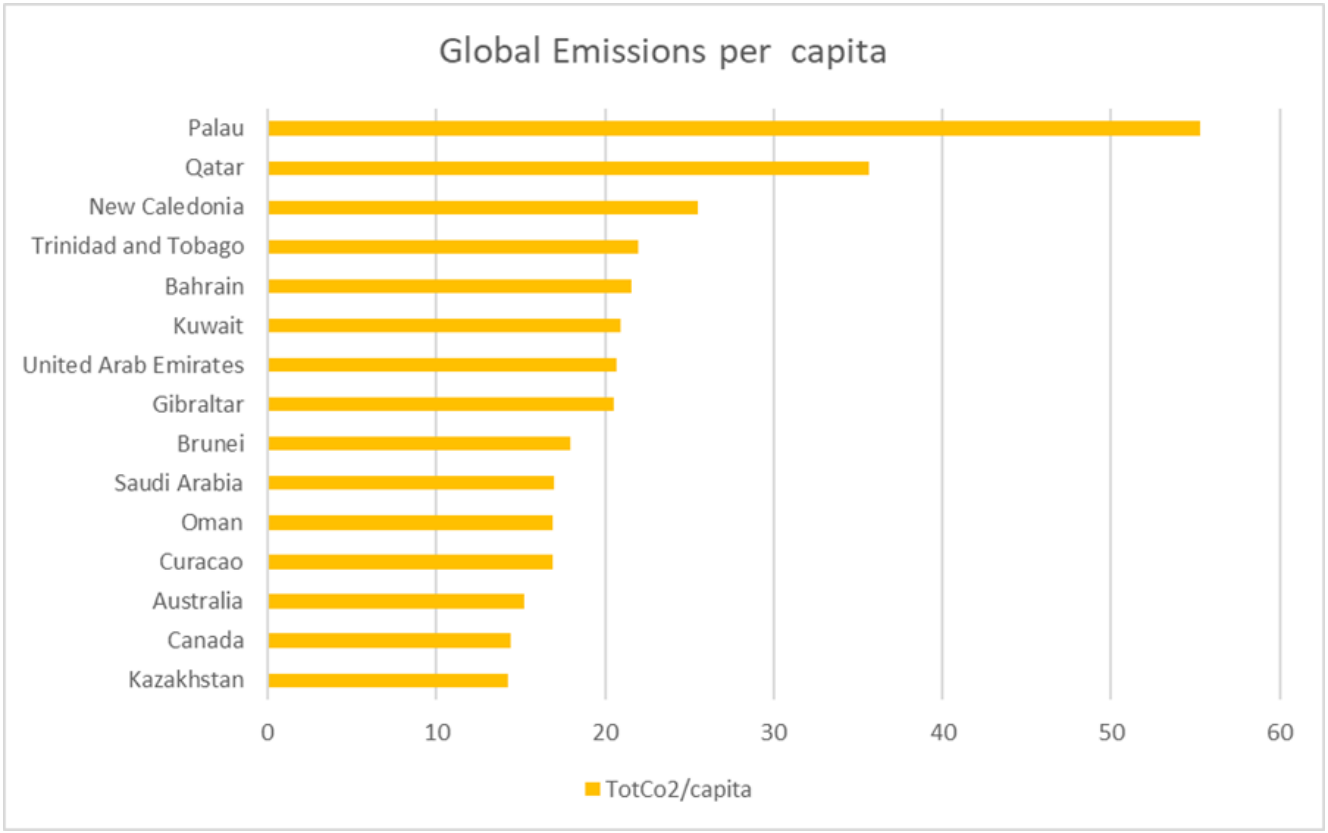
Does this then mean the rest of us need do nothing? Do we look to the top 5 emitting countries to do it all on the assumption that our efforts are just not worth the outcome? Of course not. At the simplest level, if we truly want to achieve net zero emissions, and assuming the biggest emitters do their part, then we can get 60% (assuming they go to zero) of the way there, but another 40% of emissions would remain. There would still be much more to do with each remaining country contributing a little bit. It is somewhat similar to replacing coal plants with gas fired plants. A big help, yes – they cut emissions in half, but then what?



Source:

https://worldpopulationreview.com/country-rankings/carbon-footprint-by-country (Year 2020)

In any case, are emissions by country even the best metric when considering global policies to reduce carbon? What about individual emissions? It should come as no surprise that India and China are in the top 5 since about a quarter of the world's population lives in these two countries alone. Yet if we look at where individuals use the most energy (and are responsible for the most individual emissions) it is in the smaller population richer countries. In this case the top 5 are: Palau, Qatar, New Caledonia, Trinidad and Tobago, and Bahrain. Of the big country emitters, the US is 16th on an individual level, Russia 23rd, Japan 29th, China 35th and India is way down the list at 133rd. This means that those countries that emit the most may use less energy per person than others but simply have very large populations. Can we expect India to do the heavy lifting to reduce emissions when every Indian used about 1/8 of the energy of the average American? Are small richer countries given a pass even though each resident emits a lot? Since access to affordable energy is directly related to quality of life, do poorer nations not have a right to a better life through using the same amount of energy of those in rich countries? (And of course, geography plays a part in energy use as does the current energy mix in each country, but this is beyond the scope of this discussion.)



Source: https://worldpopulationreview.com/country-rankings/carbon-footprint-by-country (Year 2020)

Of course. the largest emitters need to show leadership as they will have the largest impact. But we cannot expect them to reduce their emissions at a cost to their people's quality of life. And they cannot do it alone. Access to affordable low carbon energy including nuclear power is what is required for all the world's population to prosper. Climate change is a global problem that requires global solutions. And that means cooperation. So next time someone tells you that even if we in smaller emitting nations reduce our emissions to zero it will make no difference, disagree. We can choose to lead, collaborate, or in some cases, even follow, but we cannot do nothing.

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.

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

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

Source: pexels.com

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

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

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

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

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

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

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

economically devastating.

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

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

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

The world needs more nuclear – and it needs it now

The world is burning – or it's about to – so says the Intergovernmental Panel on Climate Change (IPCC) in its special report considering the benefit to the planet if we manage to keep the increase in temperature to 1.5 C rather than the target most often discussed of 2 C.

This report concludes, most often with high confidence, that the impact to the world will be considerably greater with only 0.5 degrees of difference in temperature.

It projects that by 2100:

- Global sea level rise would be 10cm lower with global warming of 1.5 C compared with 2 C.
- Extreme heatwaves will be experienced by 14% of the world's population at least once every five years at 1.5 C. But that figure rises to more than a third of the planet if temperatures rise 2 C
- Arctic sea ice would remain during most summers if warming is kept to 1.5 C. But at 2 C, ice free summers are 10 times more likely, leading to greater habitat losses for polar bears, whales, seals and sea birds.
- If warming is kept to 1.5 C, coral reefs will still decline by 70-90% but if temperatures rise to 2 C virtually all of the world's reefs would be lost.

Coal plant belching out pollution in Poland while climate is discussed at COP24

It also concludes that time is of the essence stating urgent and unprecedented changes are needed to reach the target, which it says is affordable and feasible. It notes that there must be dramatic change by 2030 (carbon reductions of 45% compared to 20% in the 2 C scenario) with carbon emissions eliminated completely by 2050.

Quite the message – and yet, the world has somehow become immune to this constant and ever-increasing threat. The sky is falling – yet many seem to not care.

There are those who choose to not believe it at all, and there are those who don't believe it is our fault. There are those that do believe it but also believe its consequences are too far in the future and the cost too high today politically to ask people to pay to resolve it. Well, if this report is correct, the future is now, and we must act. Yet at COP 24 in Poland this month, the best that could be achieved was to agree on the rules for measurement so that each country can report its Paris commitments in the same way.

One thing is for sure – the world needs energy, and lots of it. Yet getting the political support for meeting these needs while setting even more aggressive carbon targets seems impossible.

One of the reasons we don't see the progress we need is that the solutions are hard. The answer on the left is 100% renewables – which excludes a number of low carbon technologies; all while this option is being proven more and more to be an unfeasible solution. Looking at Germany we can see that huge investments in renewables have resulted in Germany still being the largest emitter in Europe as they remain a huge coal user. But the believers have no doubt that renewables are the solution and reject all other options.

The answer on the right is to downplay or in some cases ignore the problem and continue to push fossil fuels to maintain important jobs that are critical to local economies. They abhor the idea of carbon pricing seeing it as a job-killing government tax grab. Of more importance as we have seen in France with the massive yellow jacket protests, the answer cannot be to place the burden of paying for change at the feet of the most vulnerable in society who don't have ready options to use non-carbon solutions when the price goes up for their core energy needs.

The reality is that both sides make good points, and in both cases, there is some progress. Renewables are starting to contribute to lowering carbon. Replacing coal with lower emitting natural gas has had a big impact. The rising cost of energy due to increased renewables penetration and carbon pricing in some jurisdictions may also be impacting the outcome by reducing demand, but the stress of higher prices on those that live pay cheque to pay cheque cannot be ignored.

These are the low hanging fruits and it is clearly not enough. In 2017 emissions increased and will do so again in 2018. So, what are we to do?

The reality is we have a solution available today that can work for everyone – nuclear power – recognized as necessary in the IPCC report, but there is hesitancy across the political spectrum.

Nuclear power solves the main concern of the left – it is a very low carbon emitter – but long entrenched anti-nuclear sentiment of many environmental groups is hard to overcome. It solves the concerns of the right – providing large quantities of reliable energy while creating lots of high-quality jobs that boost local economies, but there are valid concerns about large project costs getting out of control negatively impacting its economics. And both sides remain concerned about the one overriding issue when it comes to nuclear generation – fear of radiation.

The real strength of nuclear power lies in its energy density. It can be built at very large scale. After all, currently it powers 11 % of the world with only 450 plants as opposed to literally thousands of what we otherwise use. For example, in the US, 98 nuclear plants generate about 20% of its electricity while about 3,000 coal and gas plants generate just over 60%. Or, in other words, it takes 30 times as many plants to generate only 3 times as much energy as the nuclear fleet.

Nuclear power can be the solution we are all looking for. It is reliable, economic, low carbon and creates many high-quality high paying jobs while contributing to the tax base of its host community. Its massive energy density provides a lot of energy from a small amount of fuel – and a new generation of smaller more versatile plants (SMRs) are being developed to expand the market potential and address new energy needs in addition to traditional on-grid electricity such as high-quality process steam.

We don’t see many governments championing nuclear as the solution. Korea and Germany, both with strong nuclear

programs, have seen their leadership move away from the technology. France, as the world's most prolific nuclear country seems to think reducing reliance on nuclear is the way to go. Yet there are bright spots. In Canada, a decision was taken to life extend Ontario's nuclear fleet at a cost of $25 billion for 10 nuclear units (producing more than 60% of Ontario's electricity), and this is now the largest clean energy project in North America.

Change is in the air. More and more environmental groups are realizing that their environmental goals cannot be met without nuclear and are opening their minds to this solution. On the other side, there is an acknowledgement that nuclear projects are good for communities, good for the environment and good for producing large amounts of reliable electricity. And even though much of the press has talked about nuclear plants closing in the US in 2018, it was a year of great progress globally. 15 GW of new nuclear were added to the global grid in 2018 and both the first EPR and AP1000 reactors have entered into service after substantial delays.

The public are moving forward as well. Sweden has stopped its nuclear phase out with support from its population. Switzerland voted to not accelerate the closure of its plants. In Korea, a citizen's jury, established by the current government to take a decision on whether or not to continue with two units under construction, strongly supported the project's continuation and polls show that in excess of 70% of the Korean public are supportive of continuing with its nuclear power program. To the government of Taiwan's surprise, a referendum on whether or not to continue with an early shutdown of its nuclear plants supported continued operation by a large margin.

And governments are starting to move in the right direction too. The NICE future (Nuclear Innovation: Clean Energy Future) which began as part of the Clean Energy Ministerial (CEM) recognizes that nuclear power has an important global

role to play in meeting international climate objectives. The three founding members of NICE are Canada, the United States and Japan. Other participating members include the UAE, UK and Russia. Three non CEM countries are also participating (Argentina, Poland and Romania).

But as we enter 2019, we in the industry have much work to do. The challenges are many, but they must be overcome.

The sky is falling, and the world is in crisis. However, the public recognize the increased magnitude and frequency of extreme weather events such as storms and flooding. What they don't know is what we know – that nuclear power is an excellent solution to many of the energy issues we face as a planet. We know that we can build and operate them successfully. We must all work together and engage with our communities to show people there is a viable solution out there that can be embraced by all.

Wishing you all a Happy Holiday Season and Healthy and Prosperous 2019. And thank you for reading our blog. We plan to keep on writing in 2019 and hope you keep on reading.

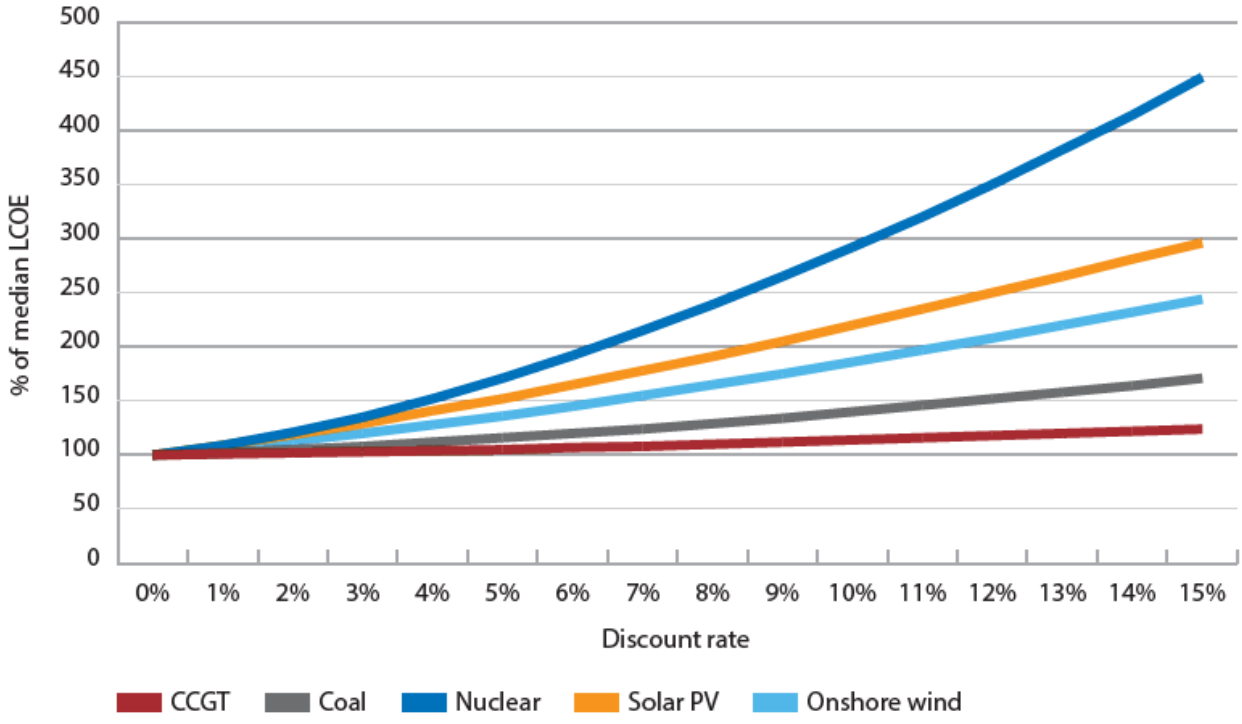
Nuclear economics – reducing costs by managing the cost of capital

Of the many challenges to expanding the use of nuclear power, economic competitiveness is essential for future success. Nuclear projects are large complex projects that have frequently experienced delays and overruns. Earlier this year, we wrote about the need to build nuclear plants on time

and on budget as the first step in making sure the economics of new build nuclear are robust. Improving the predictability of cost and schedule, i.e. making sure that when a project is approved, the costs and schedule are well understood and then they are reliably delivered, is a path to reducing the risk of these projects and securing public, government and investor confidence.

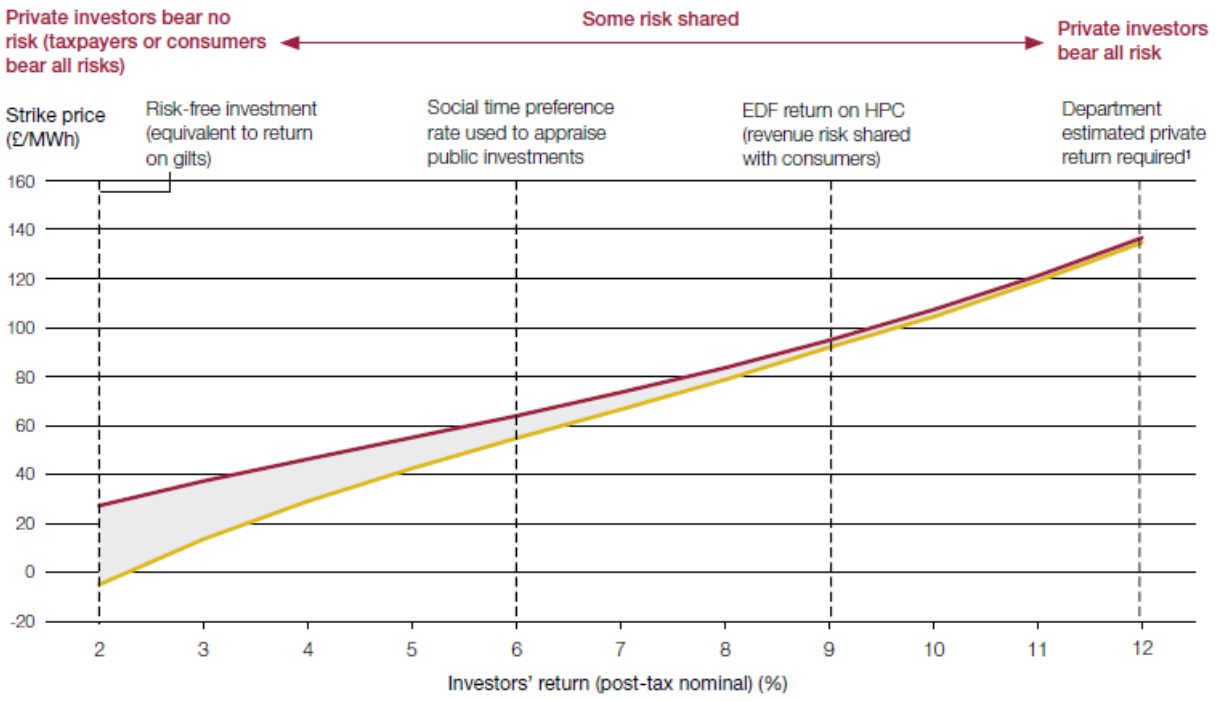
With project risk under control, the next step is to find ways to improve the overall economics of new nuclear plants. Studies have shown that the two largest drivers of the Levelized Cost of Electricity (LCOE) from a nuclear plant are the cost of capital and the capital cost. So today we will talk about lowering the cost of capital as a viable approach to improved economics and we will discuss ways to improve the capital cost in a future post. The diagram below shows the sensitivity of the cost of energy to the cost of capital from the OECD/NEA report Projected Costs of Electricity, 2015 Edition. As can be seen by the dark blue line, small changes in discount rate have relatively large impacts on the cost of energy.

Figure 7.6: LCOE as a function of the discount rate



For this discussion we go to the UK, where its own National Accountability Office (NAO) did a review of the contract for difference model agreed to for the Hinkley Point C project. While it concluded the HPC deal is competitive in price and comparable in IRR to the 40 other similar contracts with low carbon generators, it noted that the economics have deteriorated since 2013 when negotiations occurred as the costs of some alternatives have improved. A construction risk analysis presented in an appendix to this report considered alternative models in which the UK government and consumers might choose to provide more support to arrive at lower energy costs. Consistent with the graph above, the NAO came to the same conclusion; that if a model can be developed with a different risk profile that reduces the cost of capital, the customer can benefit greatly through reduced energy costs.

Sensitivity of strike price to investors' return



Strike price at BEIS electricity wholesale price projections (March 2016)

Strike price at HPC financial model electricity wholesale price projections

The chart presents the strike price necessary for investors to achieve different levels of return based on two sets of electricity wholesale price projections. The higher the level of risk private investors bear, the higher the strike price. In the summary table (Figure 19), we show three different scenarios:

- '100% private risk' assumes private investors carry all risks. The Department has estimated that the hurdle rate for nuclear projects is about 12% (post-tax nominal).[1] To achieve this return, the price they receive would need to be between £135 and £137 per MWh during the first 35 years of generation;
- 'HPC' scenario replicates the current deal. By removing the electricity price risk for 35 years as well as other risks, it reduces the investors' required return to 9% which results in a strike price between £91 and £95 depending on the forecasts for market prices after the CfD period; and
- '100% public risk' assumes all risks are transferred to the public sector and the taxpayer would have to pay the full project cost (£19 billion). In this case the strike price for 35 years would range from -£6 to £28 depending on the electricity price forecasts. The combination of low discount rate and high future electricity prices makes the present value of the cash flows post CfD so high that it compensates for the negative strike price during the CfD period to achieve an overall investor return of 2%. Such a strike price is a theoretical price based on a comparison with the 35-year CfD structure used in HPC.

This led to the UK government recently agreeing to a revised model for the upcoming Wylfa project to be implemented by Horizon Nuclear in Wales relative to that agreed for Hinkley C. By agreeing to some level of direct government investment, it reduced the cost of capital and is expecting the result to be a lower cost of energy. While Hinkley Point C has an agreed cost of £92.50 / MWh, it is anticipated that the Wylfa project may have a price in the range of £75 – 77 / MWh, a possible reduction of 15% or more in cost to the ratepayer. This is a game changer. By taking on a larger share of the risk, government can drive down energy costs. Of course, this also means that it must be comfortable that this risk can be

effectively managed. This is likely as the private players, in this case Horizon nuclear, are still heavily incentivised to perform. It would also be recommended that government install some form of oversight on the project to stay informed of progress and to ensure that there is transparent reporting of its risks. It should be noted that this negotiation is not complete, and the final outcome is still unknown.

In fact, there is now thought that government should consider a regulated asset base (RAB) model further reducing the cost of capital and hence the cost of energy. A paper by Dieter Helm suggests the cost of energy can be greatly reduced if this model were to be considered. It is in common use in other utilities in the UK such as water and rail where long term assets are the norm.

The outcome would be nuclear projects with significantly lower energy costs. With appropriate risk management, it can easily be shown that the magnitude of the potential savings in energy cost is well worth the increased risk sharing. In other words, the private sector is charging too steep a risk premium to take on risks that are too long term in nature and difficult to price effectively. A more balanced approach to risk sharing could bring benefits to all stakeholders. Not everyone agrees. Government advisors of the National Infrastructure Commission have recently suggested slowing down nuclear approvals since renewables costs are improving faster than was previously anticipated. Of course, if renewables can improve, so can nuclear and this is exactly what the UK government is trying to support. If the nuclear cost can indeed come down so dramatically, then there is no reason to slow down as all good options for future generation are improving with time and the result will be a robust set of diverse generating options going forward.

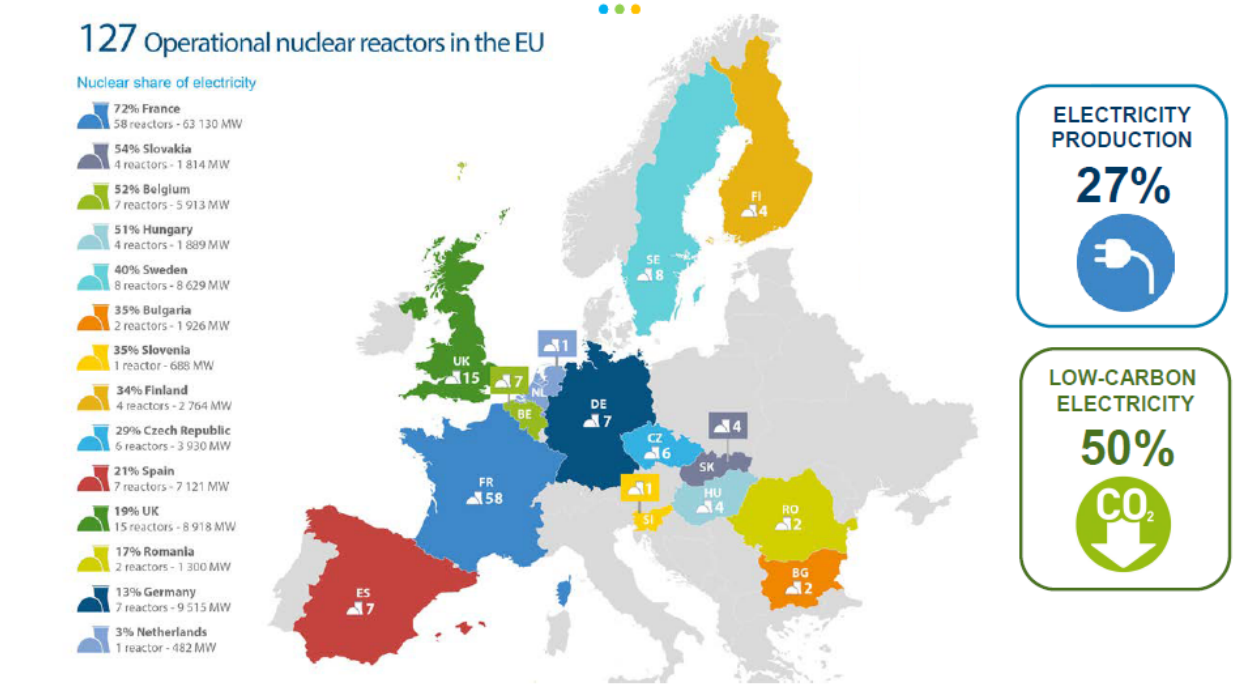
For many years Government has been making investments in renewables to support their development as viable options for future generation primarily through direct subsidy. Following

the commitment to Hinkley Point C, efforts are underway to develop policies that specifically target the unique challenges of nuclear power. These policies are creative ways to understand the investment and risk profile of nuclear and then address them in ways that are productive and continue to incentivize the private sector to perform.

Nuclear power is an essential tool in meeting the low carbon generation needs of the future. The UK government should be applauded for not only accepting this but now moving on to finding ways to improve this much needed option. The UK has got it right – focus on policies that reduce nuclear costs to customers and we all win.

The road to a low carbon Europe is nuclear power

There are more nuclear plants in the European (EU) than anywhere else. Yet a broad range of nuclear policies across the European nations is having a large impact on its future. Currently there are 127 nuclear plants in operation in the EU (plus another 5 in Switzerland). Of the 14 EU countries with nuclear power, a quarter generate more than 50% of their electricity with nuclear power and more than half generate more than 30%. In total, nuclear in the EU, generates 27% of its electricity and accounts for fully half of the EU's low-carbon electricity.



Source: Foratom presentation "Keeping Europe lights on – a role for nuclear", WNFC, Madrid April 2018

Nuclear power has provided decades of low carbon, reliable and very economic energy to the people of Europe playing an important role in fueling the European economy. It provides over 800,000 jobs at over 3,000 companies and provides security of supply needed by a region that mostly imports its fossil fuels (although some countries are coal rich). Most gas and oil come from Russia and Norway. It is not by accident that the lowest carbon emitters are the largest users of nuclear power.

You would think that there is nowhere on earth where nuclear has a brighter future. But you would be wrong. There has always been a strong anti-nuclear presence in Europe, more in some countries than others. Countries like Austria and Italy are anti-nuclear to their core, while other nuclear power houses such as Sweden, Belgium, Spain and of course, Germany, have continuously had to address strong anti-nuclear sentiment. These anti-nuclear forces are primarily based on ideology. They are the greens that have since the 1970s

simply believed that nuclear energy is dangerous and needs to be stopped. But there are also countries like the UK, Finland and Hungary that have relatively high support for nuclear and are either building new plants or are planning to.

Greens have been successful in convincing the public that if you support the environment, then you must be against nuclear power. This belief was re-enforced by the Chernobyl accident in the Ukraine 30 years ago, and then again following the Fukushima nuclear accident in Japan in 2011. Couple this with a strong belief that renewables, primarily in the form of solar and wind energy can simply replace nuclear, then the solution seems simple – who would say they don't like sun and wind?

Some European nuclear countries, where greens have had influence in government, have been fighting to sustain their programs for decades. Anti-nuclear supporters have succeeded in getting government to impose special taxes on nuclear to make it costlier while at the same time subsidizing renewables. Under pressure from the Greens, some governments have agreed to long term nuclear phase outs. These deals were made (Sweden, Germany, Belgium) at the time as a compromise to enable continued operations in the short term, with nuclear supporters maintaining hope that in the long term it would become obvious that the phase out would not be practical. Unfortunately, as the time for these phase outs is now approaching, the opposite rings true. These policies have been in place for a long time and the public have simply accepted that new renewable technology will be there to replace the aging nuclear fleet when its time comes.

With nuclear closures on the horizon, governments have had to take action with mixed results. Sweden has made progress to maintain their fleet having allowed plants to run longer and eliminating its nuclear tax, while Belgium has confirmed its phase out for 2025, and Spain is still working on its plan going forward.

Even France, Europe's largest nuclear country, has not been immune to anti-nuclear thinking. Its previous government mandated a maximum nuclear capacity to ensure the share of nuclear doe not increase and then a planned reduction of the nuclear share from about 75% down to 50% within 15 years. In the short term this means that for the soon to be completed new plant at Flamanville to come into service, an existing plant has to be shutdown; the country's oldest at Fessenheim. The new government has taken a more pragmatic stance and has deferred the target date while undertaking a review of its nuclear reduction plan. Let's face it, it is literally crazy to shut down an excellent operating asset at Fessenhiem for no reason other than it is politically mandated. The French regulator has said that these plants are safe to operate for another decade. This is an expensive political give –and needs to be seen for what it is, a plan by those opposed to nuclear to exert pressure to close plants, demonstrate there are viable alternatives, and over time push for a complete phase out.

Of course, the biggest change has been in Germany, Europe's technology powerhouse. After finally starting to reconsider the timing of its planned nuclear phase out, the Fukushima accident happened, and the Greens pushed for immediate closure, even sooner than was originally planned. And they succeeded. As part of its Energiewende, nuclear plants have started to close, and the share of nuclear energy has dropped significantly with a total shutdown only a few years away. In December of last year, one of Germany's top economists, Prof. Dr. Hans-Werner Sinn, made news when he published a paper stating it is unrealistic to believe that Germany can power itself with only wind and sun due to their immense supply volatility. He concludes that 30% renewable is a viable target although this can increase through cooperation with neighbouring countries.

To those of us outside of Germany, their strong commitment to

quickly removing nuclear from the mix is a complete mystery. Fear of nuclear in Germany has put the shutdown of nuclear ahead of reducing carbon emissions. No German has ever been hurt by a nuclear plant and German industry has benefited from abundant economic nuclear energy for a generation. With the highest energy carbon intensity in Europe, Germany recently accepted that it cannot meet its 2020 commitments as carbon emissions reductions have ground to a halt in the few years since nuclear started shutting down. Shutting coal plants instead of nuclear would have shown Germany as a carbon reduction leader, but for some reason they chose to continue to damage the environment by opening new coal mines and building new coal plants, as they prioritize nuclear shutdowns over carbon reductions. The German Energiewende is a good albeit expensive experiment, and the results to date should make others think twice about going down this path.

The fight for nuclear power in Europe has been long and hard. In some countries nuclear supporters have been worn down and sometimes wonder if they are fighting a losing battle. But they must always remember that European anti-nuclear sentiment is rooted in an ideology that is out of step with the current need to combat climate change. In reality, nuclear power has made Europe better in every way by delivering economic reliable electricity, while providing energy security of supply and preserving the environment by reducing the use of fossil fuels.

Even with the new build plans currently in place, Europe will need another 80 GW of nuclear by 2050 just to maintain the status quo. And that is not good enough. Rather than accept the political views of those that oppose; bold new plans should be made to increase the nuclear footprint in Europe including the very challenging task of changing views in anti-nuclear countries. If decarbonization is a goal, then there must be a realization that nuclear has been a great success in Europe and represents the best path forward to secure a low

carbon economic energy future for all Europeans. A strong Europe needs nuclear power.

Going for gold, nuclear plants contribute to a resilient electricity system

Over the years, when talking about the pros and cons of various generating assets, we have talked about economics, environment and reliability – but more recently a new word has entered the energy lexicon – **Resilience**. As defined by Oxford, "***resilience*** *is the capacity to recover quickly from difficulties; toughness, the ability of a substance or object to spring back into shape*"

Well, if you are anything like us, you have been glued to your TVs watching the winter Olympics in PyeongChang Korea over the last two weeks. Watching these athletes whose hard work knows no bounds do their best to represent their countries and try to secure a medal is truly inspirational and their **resilience** is what keeps them going above all odds. With close to 3,000 athletes competing and only 307 medals earned, most were disappointed in their quest for gold, yet they are all proud to have represented their countries and performed at their best. They never quit. They work for years to make it to a global competition where most do not win medals and then go back home, work even harder, and then hope to have the chance to do it all over again in another four years. I find that every time the Olympics are on, I feel inspired to work harder and do more to achieve my own goals.

The following Olympic ad by Toyota shows how shear

determination and hard work can overcome the one billion to one odds of winning Olympic gold. It still brings tears to my eyes every time I watch it.

https://www.youtube.com/watch?v=sefscV3GvWM

Now that we have all been inspired, what do we mean when we talk about **resilience** of generating assets like nuclear plants? We mean being able to continue to operate through difficult and extreme external events, usually weather related. We first took notice a few years ago in 2014 when North America experienced the polar vortex and it was clear that gas couldn't meet generating requirements in the extreme cold, but that America's nuclear plants continued to run and keep Americans' lights on.

Last year, the US Department of Energy completed a study that emphasized the importance of **resilience** to our energy infrastructure. The cover letter from the Secretary of Energy started *"A reliable and **resilient** electric grid is critical not only to our national and economic security, but also to the everyday lives of American families."* It also introduced the idea that **resilience** has value to energy customers stating, *"We also need to recognize the relationship between **resiliency** and the price of energy. Customers should know that a **resilient** electric grid does come with a price."* Ultimately the Energy Secretary recommended to FERC that they compensate nuclear and coal generators for their **resilience** based on fuel availability on site. Unfortunately, this approach failed but did start an important conversation.

This past fall during hurricane season, we used this word again when there were extreme storms in Houston, Florida and Puerto Rico. At the time it was noted that even though communities suffered greatly, the South Texas Project nuclear plant continued to run during the hurricane in Houston and that most nuclear plants were able to ride out the storm in Florida. On the other hand, even today, about 5 months after

hurricane Maria devastated Puerto Rico, approximately one third of the island's residents are still waiting for power to return. Much of the reason for lack of power is the collapse of the transmission and distribution system, but this clearly demonstrates the importance of the electricity system as critical infrastructure in being able to successfully recover from natural disasters.

Then as we entered the new year, it was once again extreme cold that impacted the supply of electricity in the North East. Wind and solar don't do well in these extreme conditions and gas is directed to homes first for home heating. The result – New England was saved by oil, yes it was oil that provided a third or more of New England's electricity needs. And even that was at risk if the cold spell would have lasted much longer as reserves started to dwindle. Yet there is still a discussion of closing nuclear plants that just keep on generating during these events. So let's remember what Secretary Perry said, "*Customers should know that a* ***resilient*** *electric grid does come with a price.*" What should really be said is that not having the **resilience** needed comes at a significant cost for us all should the electricity we need not be there when we need it.

So why talk about this now? We were thinking of writing about the importance of **resilience** to the electric grid for some time since the DOE study came out last year. We know that nothing continues to operate in extreme conditions better than our nuclear plants. But having been inspired by our Olympians, we realize it is not only the **resilience** of the nuclear plants we build that are so important to all our lives; rather, it is the **resilience** of those that work in the nuclear industry that will ensure our success. Just like those Olympic athletes, the people that work in the nuclear industry have unlimited passion for what they do – because they know they are working to make the world a better place, providing abundant economic, reliable, low carbon – and yes –

resilient – energy to power our dreams for a better future.

In 2017, the myth of powering the world with 100% renewables has started to crack

When thinking about 2017, it is easy to see the bankruptcy of Westinghouse and the subsequent cancellation of its Summer project in South Carolina as this year's big issue. But as the year has drawn to a close, the continuation of its AP1000 project at Plant Vogtle in Georgia has been approved by the regulator and there is every expectation that Westinghouse will emerge from bankruptcy in 2018.

So while important, to us there is a much more important defining issue for 2017. It is the very real start of a movement that recognizes that powering the world with 100% renewables is a myth – and that chasing a myth will not get us to our global goal of meeting the world's increasing energy needs while reducing carbon emissions and successfully combating climate change.

There were a number of defining moments in 2017 that highlight this change in attitude.

First there was the paper published in the Proceedings of the National Academy of Sciences, "Evaluation of a proposal for reliable low-cost grid power with 100% wind, water, and solar", by 21 prominent scientists taking issue with Mark Jacobson's earlier study claiming that 100% renewables is

feasible in the USA by 2050. In a nutshell, the paper found many poor assumptions in the Marc Jacobson paper and ultimately finds that its conclusion that 100% renewables in the United States by 2050 is false. And how does Marc Jacobson respond to this criticism? Does he review his work, make changes and then show that his conclusion remains valid? No, he does what some would do when their beliefs are under attack, he sues. This is one of the most shameful episodes of the year. A scientist suing when others disagree with him is just not the way things are done. Science is about skepticism and continuous questioning. A peer reviewed paper that is critical of another one is to be applauded and responded to, to continue the discussion. Suing those who disagree is simply not one of the options.

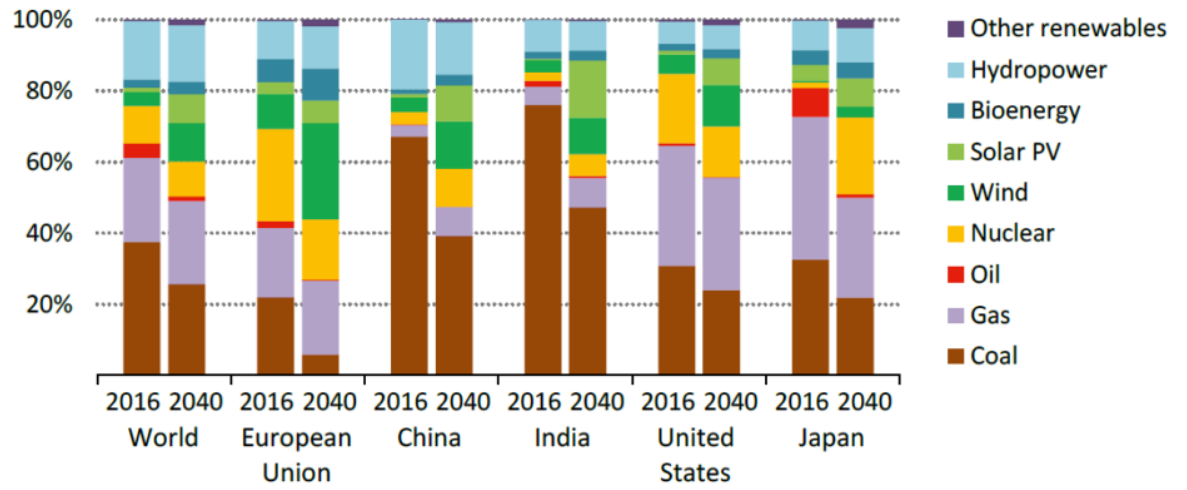
Second, we saw Germany called out for its lack of progress on decarbonization in recent years while holding COP23 in Bonn late this year. While massively investing in new renewables, these are unable to take the place of its closing nuclear plants, thereby making coal king in Europe's most polluting nation. This story shows how a 12-thousand-year-old forest that has been almost completely consumed by the country's ravenous addiction to coal power.

Other countries have seen the light as well. The UK is strongly committed to new build nuclear and Sweden and France have realized that removing nuclear from the mix will do nothing to achieve their climate goals. In Korea, the public decided to continue with a new build going against its new government's policy.

And finally, we saw something this past year, we have not seen before – the rise of the pro-nuclear environmental NGO – as those who care about the environment and climate change are starting to realize that renewables alone is a path to nowhere. This includes such organizations as Environmental Progress, Energy for Humanity and Mothers for Nuclear.

A look at the 2017 edition of the World Energy Outlook tells an interesting story.

Figure 6.14 ▷ Share of total generation by type worldwide and in selected regions in the New Policies Scenario



Current and proposed policies strongly reshape the power mix in the New Policies Scenario, nearly doubling the share of renewables and driving down coal's contribution

Source: World Energy Outlook 2017

Even with massive investment in renewable technology, fossil fuels remain king in electricity generation by 2040 still producing about half of all global electricity. Wind and solar increase to anywhere from 20% in the New Policy scenario to about a third of electricity generation in the Sustainable Development Scenario (the scenario that shows what can be done to meet Paris objectives). This is even though wind and solar make up about 45% of the total investment in new capacity and global subsidy for renewables grows from about $140 billion per year to $200 billion.

Looking deeper at the numbers, it can be seen that this investment results in a huge increase in wind and solar capacity of 5000 GW in the Sustainable Development Scenario. All other things being equal, this same amount of energy would only have required about 1500 GW of nuclear to be built since a nuclear plant produces about 3 times more energy than an

equivalent size of solar plant and more than 4.5 times as much energy as wind capacity. And this is before any consideration of the intermittency of wind and solar and the needed improvements to systems to accommodate that – and of course the predominantly fossil backup needed for when the wind doesn't blow, and the sun doesn't shine.

What this shows is that wind and solar are good ways to reduce fossil use, probably by about 30% or so. But they are not good ways to REPLACE fossil fuels in their entirety. This must be done by more robust alternatives such as hydro and nuclear. These are the only large-scale base load options that are both reliable and low carbon available today.

And what about storage? Often, we hear that once storage technology improves, this will be what is needed for renewables to break free of their intermittency. Of course, this sounds better than it actually is. In reality, storage would be ideal for base load plants like nuclear where it can help store energy generated during times of low demand reducing the need to build new peaking generating plant. On the other hand, storing enough energy from wind and solar would require massive overbuilding of capacity to collect extra energy during the 20% of the time the sun is shining and the 30%, the wind is blowing.

Changing beliefs is hard. We live in a time when all opinions are considered valid, whether from experts or lay people. And most of all, people are challenging expert views as never before. Yes, it is a romantic view of the future to believe that all of our energy will come from energy sources such as the wind and the sun. But beliefs don't change physics and if we really want to change the world, we need more nuclear power to replace a large portion of today's fossil generation. Only then will we be on our way to a truly low carbon economy. We are under no illusion that this change is coming quickly, but 2017 saw the start. There are now cracks in the 100% renewable myth. It will take hard work and

ongoing support from the new generation of pro-nuclear NGOs to keep broadening the crack in 2018 – and who knows? Maybe the tide will shift, and we will be on our way to a truly sustainable future.

Wishing you all a very happy and healthy new year!

If we want to breathe clean air – shutting nuclear plants early is insanity

People are dying – lots of people, each and every day. As stated in a study published by Lancet on October 19," Pollution *is the largest environmental cause of disease and premature death in the world today. Diseases caused by pollution were responsible for an estimated 9 million premature deaths in 2015–16% of all deaths worldwide–three times more deaths than from AIDS, tuberculosis, and malaria combined and 15 times more than from all wars and other forms of violence.*" And to make matters even worse, it continues, "*In the most severely affected countries, pollution-related disease is responsible for more than one death in four.*" (Note: James Conca wrote an excellent article following the release of the lancet paper).

Earlier this month authorities in New Delhi took a decision to spray water over the capital to fight toxic dust in the air. It's hard to imagine having to take such extreme action just so people can breathe.

And yet, we seem to want to make it worse, not better, by supporting the early shut down of safe, reliable, and of most

importance, CLEAN, nuclear power plants. Nothing can be more foolish than removing low carbon, non-polluting generating plants from the generation mix when the replacements are almost always dirtier fossil fueled generation. These nuclear plants still have years of useful life left and are operating safely as clearly evidenced by the regulators who are giving them licenses to operate in their respective countries.

This is sometimes based on local economics such as in the United States, where low cost gas is making nuclear uneconomic in some de-regulated states. But of more importance, it is more often a result of made-in-the-past anti-nuclear sentiment. In Germany, shutting nuclear early is accepted as more important than reducing carbon emissions even as new dirty lignite mines are opened to replace them. In Japan the slow return to service of nuclear plants following the 2011 accident at Fukushima is not only causing an increase in fossil usage but there are now plans to build more than 20 new coal plants. The previous French government decided to close its oldest two nuclear units early, even though they are licensed for another 10 years, and set a target to reduce the share of nuclear going forward when there is no clear option to replace them. In Korea, even though a large public review approved the completion of two partially built plants, the Korean government has cancelled further new build plans, and of more importance, is against extending the lives of existing operating units wanting to replace them with a combination of renewables and gas. They are also on the verge of closing Wolsong 1, their oldest operating plant even though its recent complete refurbishment has made it operable for another 30 years and frankly, makes its components the newest of the four operating CANDU type units on that site. In the United States, California has decided not to extend the life of Diablo Canyon, claiming it can replace these units with renewables and demand management. In Belgium, there are plans to retire their units without life extension, etc, etc, and the list goes on.

As for the argument on economics, let's remember that nuclear plants have very low operating costs due to the low cost of fuel. However, in some jurisdictions, mostly in the US, low gas prices and subsidized renewables make these plants less economic for now. Since in all cases, they would be replaced by fossil generation (with some renewable component), the replacements will increase both pollution and carbon emissions and if we include the cost to build new plants, then even with low fossil fuel prices, this new fossil generation will not be more economic than existing nuclear.

Many governments have started to see the reality of the situation. That is why the fight is on and in many countries efforts are underway to save these reliable non-emitting plants. In the US, a number of states including New York, Illinois and Connecticut are working to keep plants open and there is a federal initiative to support nuclear plants as a result of their "resilience" (a topic for another day). In Sweden there is support for extending the lives of existing units and recently the French government has decided to slow its plans to reduce its share of nuclear.

This is why I am proud to live in Canada where the commitment to our existing nuclear fleet is strong. The new 2017 Long Term Energy Plan in Ontario supports the decision made in 2015 to refurbish 10 more reactors and to maintain nuclear as the back bone of the system for the foreseeable future. A just released review by the Ontario Financial Accountability Office concluded "*Two of the primary benefits of nuclear generation are that it is both relatively low-cost and emits very low amounts of greenhouse gases. There are alternative generation portfolios which the Province could use to replace nuclear generation. However, currently none of the alternative generation portfolios could provide the same supply of low emissions baseload electricity generation at a comparable price to the Base Case Plan*".

So, it appears that we Canadians are indeed sensible people. We understand that our existing fleet of nuclear plants are reliable, low cost and low emitting. And it is this good sense that will keep our air clean. This needs to be an example to others so they can also see that removing existing well operating plants from service early to appease a big green lobby is a crazy risky proposition. After all, what can be more important than being able to breathe?

In an era where facts no longer matter, consequences still do

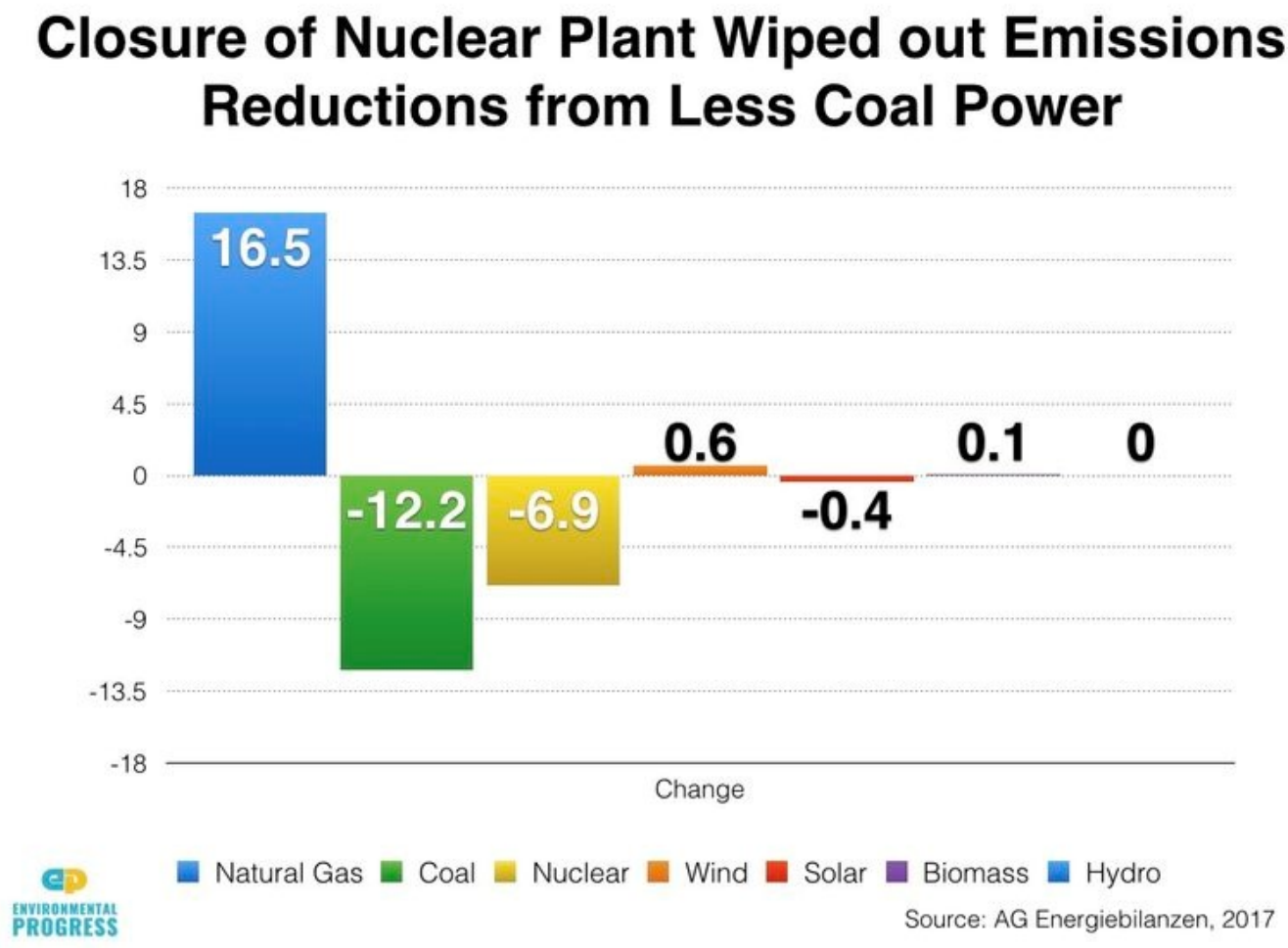
Over the last few years, we have written extensively about the strength of peoples' beliefs and how difficult it is to change them. In spite of this, I thought we were making progress with a push to more evidence-based decision making. For something as polarizing as nuclear power, facts-based decision making is critical to increasing support. (I understand the paradigm of fear of radiation is more emotional than fact based and I agree that we need to appeal to emotions to create the change we need – but let's leave that to a future discussion. In any case it certainly doesn't hurt to have the facts on your side.)

With the populist surge in 2016 we have seen an accompanying rise in complete disregard for facts; all the way to the propagation of absolute lies (or "alternative facts") to support peoples' beliefs. I don't want to get into a political discussion nor take sides on right versus left. What I do want to do in today's post is to discuss something

more fundamental – i.e. that although we are free to believe what we want – that beliefs have consequences – and that consequences matter.

So, let's look at what happens when countries believe they can eliminate nuclear power from the mix and replace it with more wind and solar power. Of course, I am talking about Germany. Reducing carbon emissions is a reasonable goal as evidence (alternative facts notwithstanding) shows that climate change is impacting our environment and has long-term implications for our entire society. On the other hand, removing a low-cost low-carbon source of energy like nuclear power because of safety concerns is based on a strong element of fear rather than evidence. In fact, Germany's nuclear plants are likely some of the safest in the world and there is no reason to suspect they will result in a catastrophic accident that means the end of Germany as we know it – yet that is what people fear.

So, what happens in a case like this? The results are in. Fossil fuel use is increasing in Germany, carbon emissions are going up and so is the cost of energy. The German people are paying more money for an outcome that does more damage to the environment and hence, their health. Frankly, it's a high price to pay for the piece of mind that comes from eliminating the perceived risk of nuclear. Or in other words, the extreme fear of nuclear is driving policy more than concern for either energy cost or the environment.



As shown above, closure of another nuclear plant in 2015 resulted in increased emissions in 2016 (the first full year it was out of service) even though there was a substantial substitution of gas to replace coal.

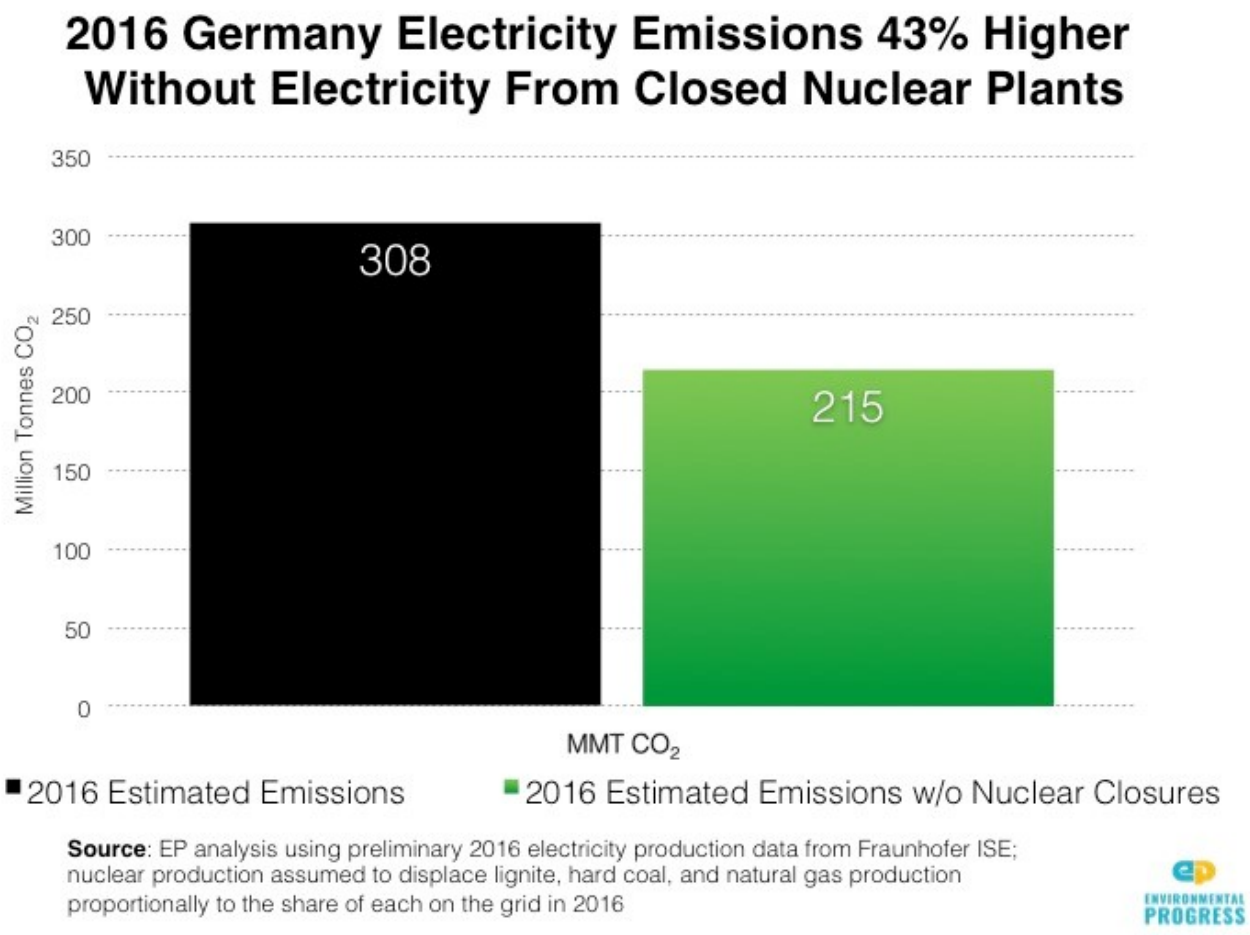
And after adding 10 percent more wind turbine capacity and 2.5 percent more solar panel capacity between 2015 and 2016, less than one percent more electricity from wind and one percent less electricity from solar was generated in 2016. So, not only did new solar and wind not make up for the lost nuclear, the percentage of time during 2016 that solar and wind produced electricity declined dramatically. And why was this the case? Very simply because Germany had significantly less sunshine and wind in 2016 than 2015.

This analysis was done by Environmental Progress and shows that the intermittency of these renewable sources of electricity both throughout the day and from year to year mean

that even huge increases in capacity of these forms of generation will continue to require fossil backup in the absence of nuclear power making 100% renewables an unachievable goal. Another study shows that to achieve a 100% renewable system in Germany would require a back-up system capable of providing power at a level of 89% of peak load to address the intermittency.

Comparing Germany to France, France has more than double the share of low carbon energy sources and Germany has more than twice the cost of energy as France.

So, trying to decarbonize by also removing nuclear from the mix at the same time is simply too high a mountain to climb. The following shows that German emissions were 43% higher in 2016 without the nuclear plants that have been already shut down. Keep in mind that they still do have operating nuclear and with more plants to shut down, the future trend is not likely to change.



It's not just about Germany. As Japan struggles to get its nuclear plants back on line after the 2011 Fukushima accident, its use of coal has skyrocketed. In 2015 its use of fossil fuels for electricity generation was 82% compared to 62% in 2010 when the nuclear plants were in operation. And now Japan plans to build 45 new coal plants (20 GW) over the next decade to meet its energy needs.

Finally, we can also look at South Australia, a nuclear free zone. Recent blackouts due in part to lower wind availability and the inability of thermal plants to make up the shortfall are also leading to questions on 'how much renewables is too much'.

So, we can all continue to hold our beliefs very dearly and only listen to those that support them, while vilifying those that do not. However, please keep in mind that in a world where the farcical becomes reality, results still matter. And

for now, the results are clear, taking nuclear power out of the mix in Germany is not achieving its political-planners' goals. Yet these results are also not likely to change any German minds when it comes to nuclear power. But hey, why worry about the outcome when you know you are right or as said by comedian Chico Marx in the famous Marx brothers movie Duck Soup "Who you gonna believe – me or your own eyes?"?