# Nuclear project structures – it’s about managing risk

In our recent post on nuclear project financing, we noted the importance of reducing risk to investors to ensure projects can raise sufficient competitively priced capital needed to build them.  Today we will discuss project structures.  What are they and why are they important?

The project structure is how the project is organized contractually to build the plant and then sell the electricity to the market.  Good structures help the project to succeed while poor ones end up with lawyers arguing where to lay blame rather than people delivering on their commitments.

Source: pexels.com

There are four major categories of participants in a large energy project.

- The customer – who needs the energy and pays for it to be reliably delivered to their home or business;
- The owner/operator (yes these can be separated, but we will keep them together for simplicity), who is responsible for building and operating a generating station to provide the energy to the customer;
- The contractor(s), who have technology, design, and construction capabilities to build the plant; and
- The investors, who provide the funding to support this construction and who will be repaid during plant operations when there are revenues from selling electricity.

When talking about contractual structures, the primary relationships are between the owner/operator and the customer (market structure); and between the owner/operator and the contractor (project structure).

There are a whole range of contractual structures for both relationships. Some are simple and some are complex. None are perfect. Historically, electric utilities tended to be vertically integrated monopolistic companies, often owned by governments, who were charged with delivering electricity to customers at low cost. Utilities carried most project risks and passed them on to the customers. A government regulator was charged with setting rates for customers (while looking out for their best interests) based on the utility costs and performance.

Poor project performance and a belief that competition would incent better results led to a shift to deregulated markets in many jurisdictions in the early 1990s whereby the utilities would be broken up and generators would have to compete to sell their electricity to the market. (We wrote a previous post on why these deregulated markets do not work well for building new low carbon generation.)

Being forced to take on more risk by their customers, owners wanted more certainty of outcomes and believed contractors, as the experts in performing the work, were in the best position to take on these risks.  Wanting this work, contractors agreed to take on more project risk, for a price.  This provided a sense of security to the owners that their risk was limited, and that they could rest easy, knowing it would be up to others to ensure successful project delivery.

Unfortunately, this has been proven to be nothing more than an illusion.  In reality, the contractor's ability to take on additional risk is limited and when project costs increase, they will generally make a claim for a change in scope requiring additional funds.  This often results in contractual disputes that slow down project progress and negatively impact company relationships.  In the end, there is no escaping the project risks for the owner, as it is their project and their money.  After all, there is no scenario where the contractor fails, and the project succeeds.

The lesson is that when developing project structures, the objective is to manage risk while incentivising the behaviours from the project stakeholders necessary for project success; not to decide who suffers the most in the case of failure.  Because for **long term commercial success**, there is one truth.  All costs must be borne by the customer.  There is no one else (unless government provides a subsidy in which case taxpayers are involved which is a different discussion – we will talk about the potential role of government in mitigating risk in a future post).  When the investors state that they do not want to be exposed to excessive risk, what they mean is that they want a credit worthy borrower who can reliably replay loans and deliver a return on equity.  And while ensuring they are contractually protected from risk is important, the best way forward is to confidently deliver projects to cost and schedule.

This is changing the way that projects are structured to more

collaborative models whereby all parties' objectives are aligned, and everyone sinks or swims together. Good project contracting is important in defining the project, but on its own is insufficient to ensure good project outcomes. Successful project delivery results from good project planning, doing enough work upfront to set a realistic cost and schedule; and excellent project management, supported by a high level of transparency together with a strong set of project metrics to enable informed rapid decision making to keep the cost and schedule under control. Continuously improving the ability to deliver successful projects to cost and schedule will ensure that nuclear power can meet its full potential on the road to a Net Zero future.

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

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


Source: pexels.com

**System reliability** – means a system (or grid) where electricity flows can be counted on to be available when required – i.e., customers need confidence that when they flip the switch, the lights come on, and stay on. Given that electricity supply and demand must be always in balance, our very reliable electricity grids are nothing short of an engineering marvel. Expert planners design systems where supply adjusts to changes in demand as needed, and that can

tolerate most supply disruptions (outages – both planned and unplanned) without impacting customers. Some simple rules of thumb (actual system design is quite complex) suggest no single generating station should be larger than 10% of the capacity of the total system and grids should have 15% or more excess capacity to accommodate outages.

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

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

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

We talked about the issues with deregulated market pricing in a previous post noting that least cost does not necessarily

mean most reliable.  And now as we did then, we will recommend reading Meredith Angwin's book, "*Shorting the Grid*."

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

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

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

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

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

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


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

It is easy to say the answer is for nations to strive for energy self sufficiency. Of course, this is a great idea but

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

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

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

When it comes to storing energy locally, energy density matters. Nuclear power's extremely high energy density, low carbon emissions and highly reliable operations make it an important source of a secure energy supply. While uranium

mining is limited to some parts of the world as is the supply of other sources of energy, the relatively small volumes needed to generate vast amounts of energy provide the ability to store large amounts of energy on site. There is normally one to two years fuel in an operating reactor that can be supplemented by storing another one or more reloads on site which guarantees it is not subject to short term disruption. Nuclear's ability to operate at capacity factors of 90% or more means it is always on to meet the needs of energy hungry consumers.

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

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

an end.

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

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

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

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

When it comes to the actual impact of the accident on human health, the science is absolutely clear. No one died from radiation from this event (the Japanese have associated one death of a nuclear worker with radiation, but the science does not support it). A recently (2020 edition) updated United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) report on the levels and effects of radiation exposure due to the accident said that future health effects, e.g. cancer directly related to atomic (nuclear plant) radiation exposure are unlikely to be discernible. But that doesn't mean there was not a large impact on people and Japanese society as a whole. People are suffering consequences related to the fear of radiation and its potential impact to them and their families, rather than from the radiation itself. As stated in the earlier 2013 UNSCEAR report, "*The most important health effect is on mental and social well-being, related to the enormous impact of the earthquake, tsunami and nuclear accident, and the fear and stigma related to the perceived risk of exposure to ionizing radiation.*" Addressing this impact is essential for both the Japanese people that continue to suffer and to minimize these kinds of impacts in the future.

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

In 2018 and 2019 two Boeing 737 MAX aircraft crashed (in Indonesia and in Ethiopia) killing 300 people. After the second accident the world reacted (two accidents so close together for a new design has never been seen in the history of modern aviation), and these planes were grounded for over two years as serious safety culture issues were identified at Boeing. Changes have been implemented to correct the deficiencies with the planes now declared safe and returned to

service.  Why did it take so long for the industry to react and why did the public not become more concerned about flying?  Flying is important to the world as we all want to travel.  We accept flying as safe and are willing to overlook an accident as a rare event even though the consequences are tragic.  (Since the pandemic we miss travelling more than ever.)  Reporting was more related to how the issue can be resolved to get the planes flying again than in creating fear of flying.

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

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

Looking at these examples, we see that:

- It takes two crashes to convince authorities to look for

problems with a new aircraft design. The public, although concerned, does not become afraid to fly as long as it is on a different aircraft model (easily compartmentalizing the risk to a specific model) and most are likely to feel comfortable flying on the 737 MAX now that it has been approved to fly again;

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

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

contextualized, and science better explained to ensure the best possible response when tragic events occur.

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

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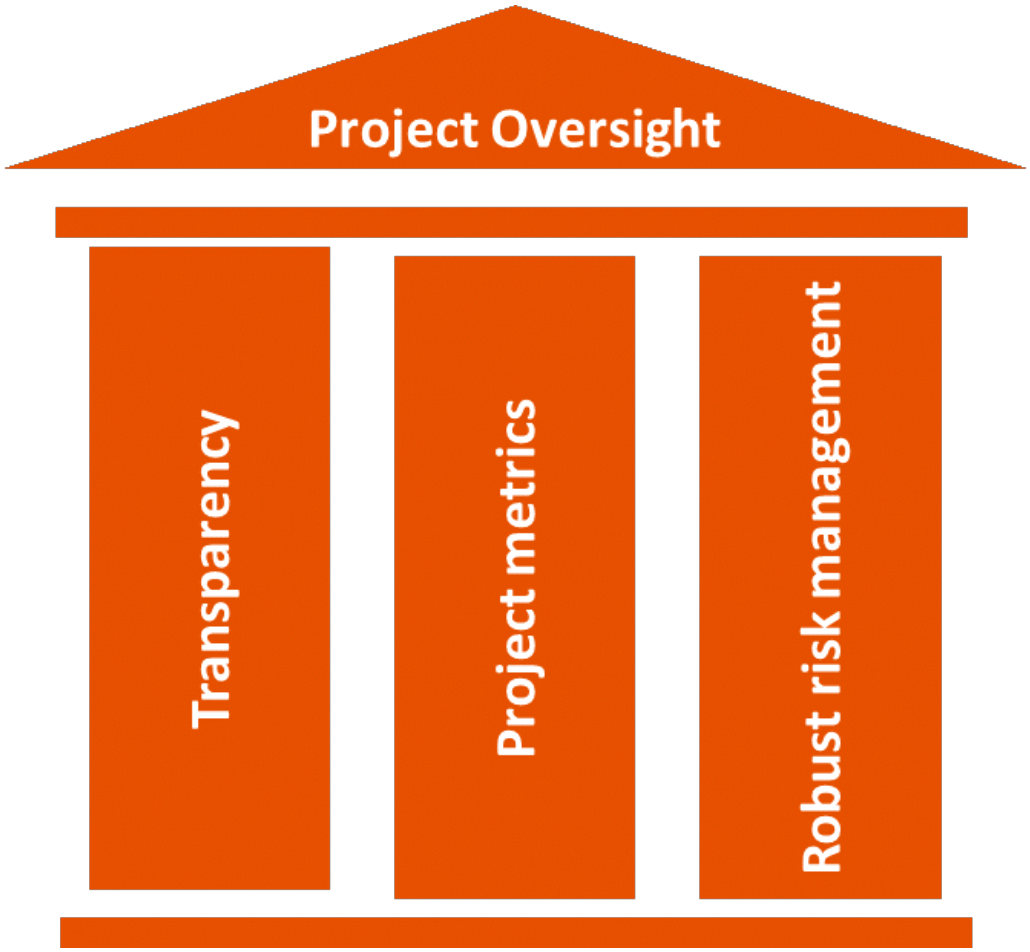
# The importance of strong and effective project oversight to project success

Nuclear projects are large and large projects are hard.  They are hard to organize, and they are hard to execute.  We have seen what happens when we try and convince people they are easy – or that we can make them easy by shifting the risk onto the vendor/contractor – and then expect everything to turn out all right.  The outcome is either a project that is cancelled before it starts, or that runs over budget and over schedule.

Last year we did a three-part series on how to manage nuclear costs.  We focused the discussion on how to build to cost and schedule, how to control the cost of capital and finally, how to control the capital cost.  Today we are going to focus on

an essential element of managing large projects to cost and schedule – project oversight. Project oversight can mean both the direct project management of a project, as well as the indirect and independent oversight that may be put in place by project investors or customers. In all cases, the need is the same. We must make sure projects are well managed and proper oversight plays an essential role in meeting this objective.

The purpose of project oversight is to ensure the project is proceeding on time and on budget – and of more importance, that problems are identified early so that corrective action may be taken while the cost to correct the issues are manageable. In our work on various nuclear projects we have identified a set of three pillars for successful project oversight:




**Transparency** – Transparency incentivizes good behaviour. The owner and other stakeholders must all have complete transparency through

to every project detail. Once there is project transparency, it becomes clear that all project participants must line up with the same objective, completing the project successfully. Don't listen to contractors that say they are taking a firm price so you can't see the project details – no matter what the contractual model, there can be no secrets when it comes to project progress. This is the only way to see issues early and then take decisive action to resolve them quickly and efficiently. Otherwise, there will be delays as the contractor will only approach the owner for assistance after all other efforts have failed, greatly increasing the cost of correcting the issue and adding time that cannot be recovered.

**A strong set of project metrics** – numbers don't lie, people do. The next step adding to transparency is to base project reporting on a clear unambiguous set of project metrics. These metrics must be kept current and be used to assess real project progress. If there has been poor progress in the past period, the metrics will show it, but more importantly, force a realistic recovery plan. We have all seen reports that say things were slow last week but will be made up next week – but the numbers show that this is not possible without adding resources i.e. to make up time, you need enough people to do the planned work for the next period AND the additional work that is behind. Metrics keep the project on track and demonstrate where there are issues that need

attention, and then whether
the attention is having the desired impact.

**A robust risk**
**management plan** – we don't create confidence by being told not to worry and
that everything is under control; rather we want to know the risks are well
understood and that a mitigation plan is in place should they be realized. Large projects will have things go
wrong. It is inevitable. It is what we do about it and how well
prepared we are that will make the difference on the project outcome.

All big projects are hard; nuclear projects are not unique. Clear precise reporting is an important
element to understand project status and take action for project improvement. We have all been on projects that have "what
I did on my summer vacation" type reporting telling us what has been achieved
in the last period without providing context.
This will not get the job done.
However, if a project has adequate oversight based on these three pillars,
it has the tools in place necessary for project success. Remember, success means finding ways to manage
and mitigate risk, not pretending it doesn't exist because it has been passed
on to specific project participant making it their problem. As we have said many times, there are no
scenarios where your contractor fails, and you succeed.

Nuclear plants have an important role to play in our current and future energy mix. To properly play
its part requires projects to be economic with predictable outcomes. If we do our part to demonstrate we can

deliver on our commitments, we can then work to secure more support from our stakeholders,
and of most importance, the public.

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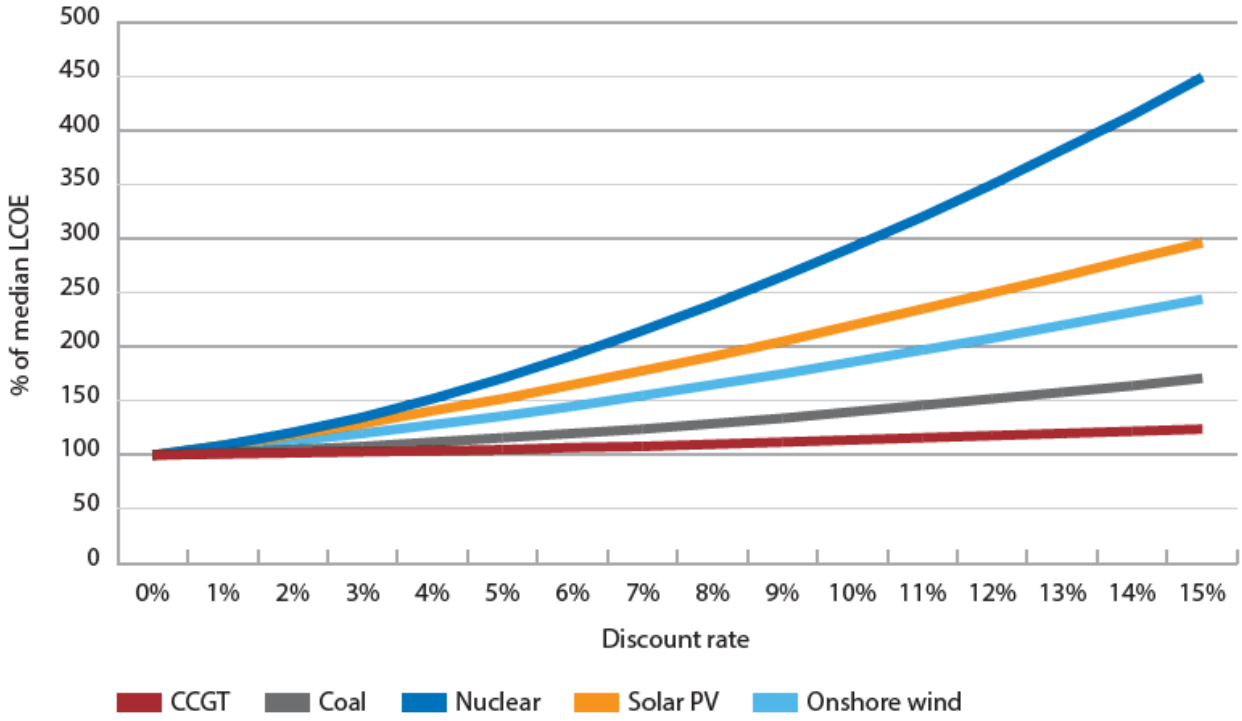
# Nuclear economics – reducing costs by managing the cost of capital

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

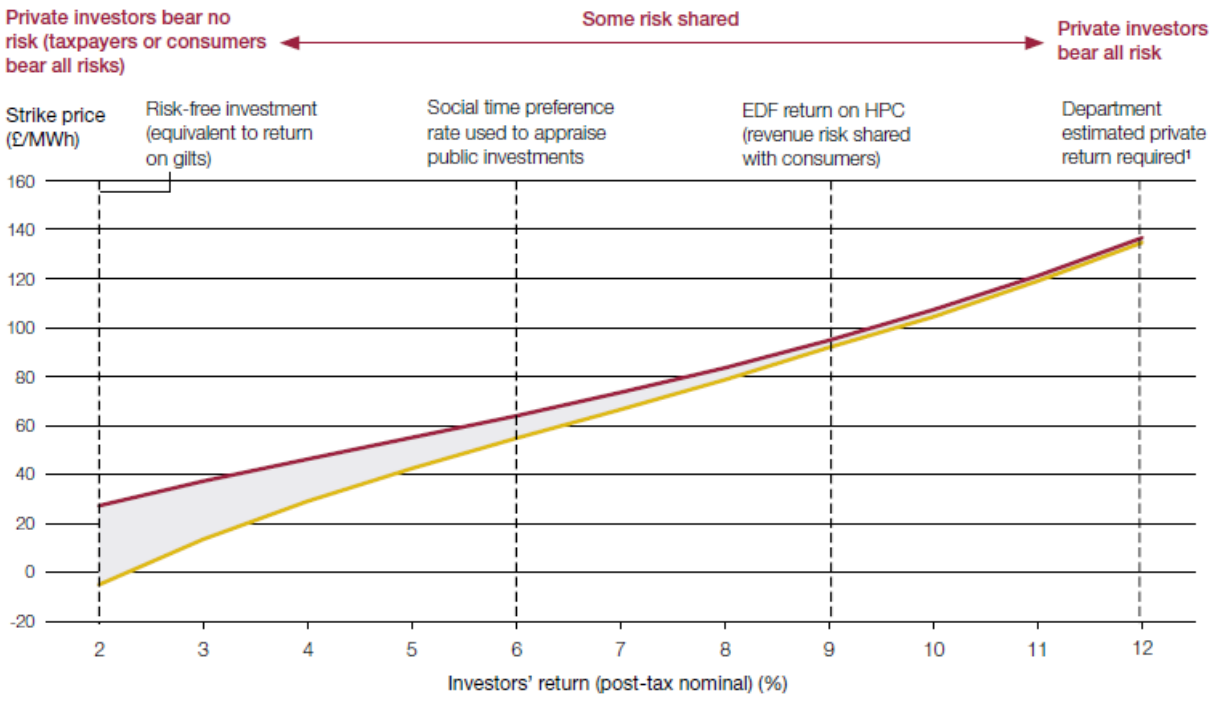
Edition. As can be seen by the dark blue line, small changes in discount rate have relatively large impacts on the cost of energy.

**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.

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

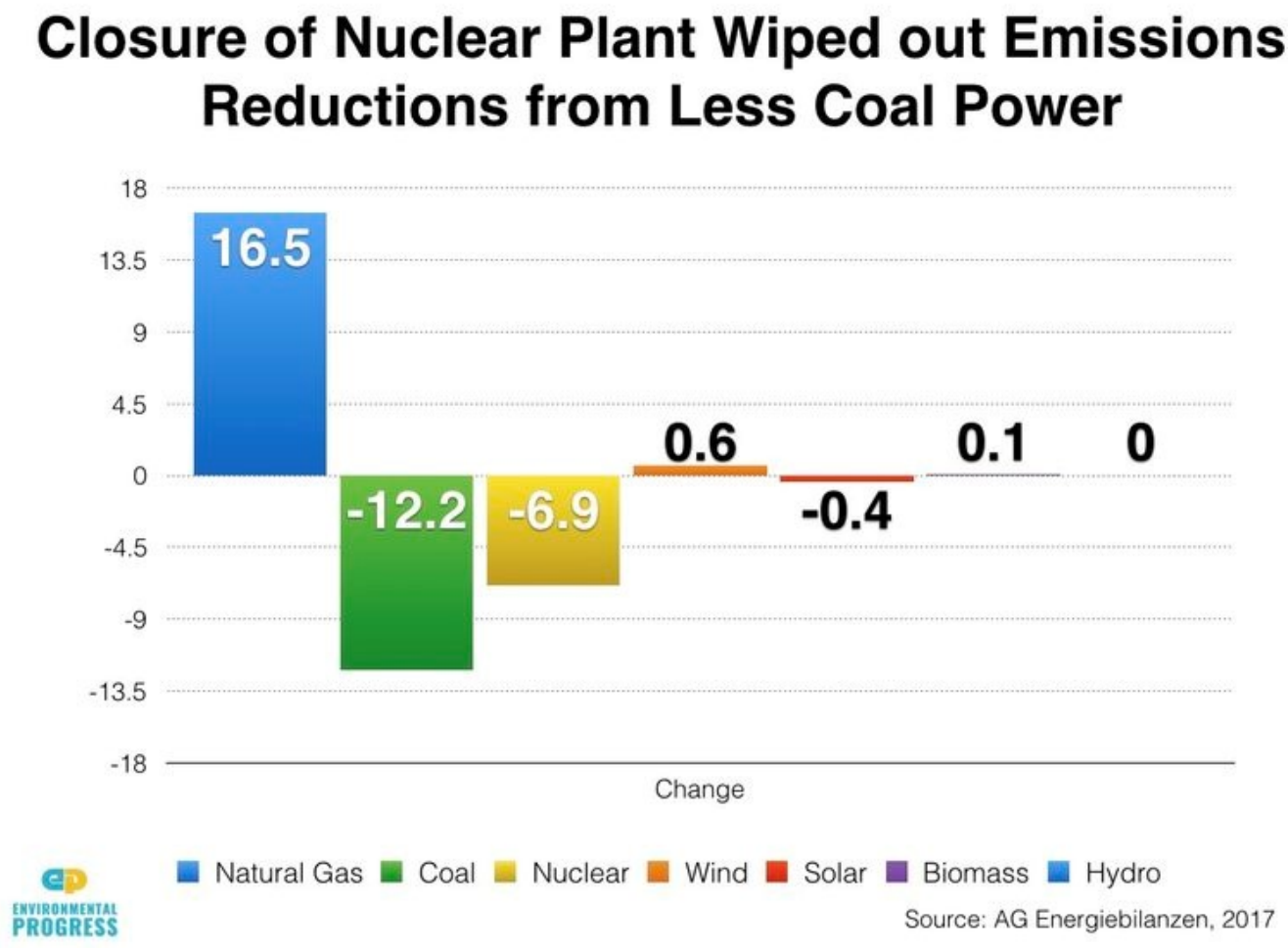
Over the last few years, we have written extensively about the strength of peoples' beliefs and how difficult it is to change them.  In spite of this, I thought we were making progress with a push to more evidence-based decision making.  For something as polarizing as nuclear power, facts-based decision 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.

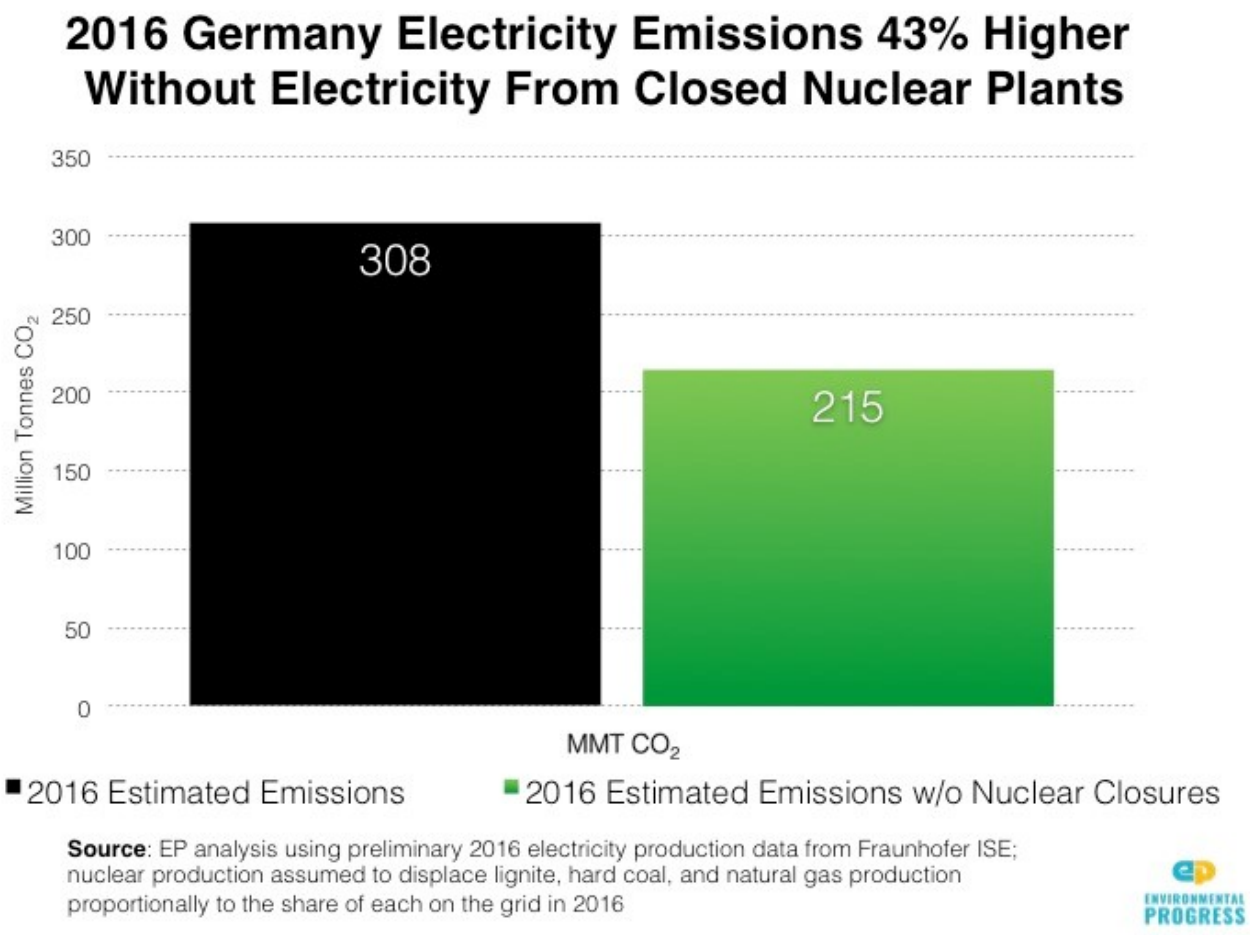
And after adding 10 percent more wind turbine capacity and 2.5 percent more solar panel capacity between 2015 and 2016, less than one percent more electricity from wind and one percent less electricity from solar was generated in 2016. So, not only did new solar and wind not make up for the lost nuclear, 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?"?

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# Want to minimize radiation from power generation – build more nuclear

Yes, you read that right. For years, there have been efforts to demonstrate that people who live near nuclear plants or work at nuclear plants are getting sick from all that darn radiation they are receiving. Over the years these stories have been debunked as study after study has shown that there is no impact from radiation from living near or working at a nuclear plant.

But now a study has been done that shows that of most of the options to generate electricity, nuclear actually releases the least amount of radiation. This is documented in UNSCEAR's, the United Nations Scientific Committee on the Effects of Atomic Radiation, most recent report to the United Nations General Assembly, on its study to consider the amount of radiation released from the life cycle of different types of electricity generation.

The Committee conducted the comparative study by investigating sources of exposure related to radiation discharges from electricity-generating technologies based on nuclear power;

the combustion of coal, natural gas, oil and biofuels; and geothermal, wind and solar power. The results may surprise some, especially those that strongly believe that nuclear pollutes the earth with radiation, coal with a range of air pollutants and carbon, and that solar and wind are environmentally wonderful.

Coal generation resulted in the highest collective doses to the public, both in total and per unit energy. Coal radiation emissions result from coal mining, combustion of coal at power plants and coal ash deposits. The study also considered occupational doses to workers. Here is the biggest surprise. As stated "*With regard to the construction phase of the electricity-generating technologies, by far the largest collective dose to workers per unit of electricity generated was found in the solar power cycle, followed by the wind power cycle. The reason for this is that these technologies require large amounts of rare earth metals, and the mining of low-grade ore exposes workers to natural radionuclides during mining*." It is important to note that in all cases these levels of exposure are relatively low and have little impact to public health.

This study only addresses normal discharges during the lifecycle of the station. Possible larger releases as a result of nuclear accidents are not considered and we recognize that many will argue it is accidents and their consequences that create the largest fear of nuclear power.

So why talk about this?  The reality is that this information is not likely to change even one single mind on whether someone supports nuclear power or fears it.  We live in a world where facts no longer matter – the only truth is the one that any one person believes.  Well, we believe that scientific study remains the best way forward to establish truth and that studies such as these are part of the path forward.  No one electricity generation technology is perfect.  Coal is cost effective and technically strong, but is also a strong emitter of a range of pollutants (including radiation); renewables such as solar and wind are clean but their resource is intermittent and they have issues with both their front end (mining of rare earths) and disposal at the end of their life cycle.

Nuclear power continues to have a good story to tell, with respect to its economics, reliability, environmental attributes and the many good jobs it creates for local economies.  Concerns about nuclear relate mostly to one major issue – fear of radiation.  And fear is a strong emotion that is not easily changed.  But at least what we have here is another study to show that radiation emissions from normal operations of the nuclear fuel cycle is not something to fear – and in fact if you really want to minimize the collective dose to the public, nuclear power remains the option of choice.

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# It is broken markets, not uneconomic plants that are

# putting nuclear plants at risk

A huge milestone has been achieved in the United States as Watts Bar Unit 2 produced its first electricity; becoming the first new nuclear plant in the US to start up in 20 years since Watts Bar Unit 1 came into service in 1996. Unfortunately, this good news was overshadowed by the announcement by Exelon that its Quad Cities and Clinton power stations in Illinois would close. This decision was the most recent but not the first, with headlines such as “Nuclear plants need boost to stay open, industry warns” or” Nuclear power plants warn of closure crisis” pointing to more nuclear plants that are at risk of premature closure because they are no longer economic in the competitive markets in which they operate.

**Watts Bar – America’s newest nuclear plant**

There are many explanations as to the cause of this “crisis”. Gas prices are currently very low, renewables are subsidized and the costs of some of the smaller oldest single unit nuclear plants in the country have been rising as they age. While all of these points are true, they are not in and of themselves, the direct cause of the problem. They are symptoms of deep structural issues in those parts of the country where electricity is bought and sold in so called open or deregulated markets.(Note: Watts Bar, owned by the Tennessee Valley Authority, is in a regulated market.)

This was the topic of a recent DOE summit on how to “save” the nuclear fleet (“*Summit on Improving the Economics of America’s Nuclear Power Plants*”) to address the crisis and take steps to avoid the unnecessary closing of a significant number of plants. So here we are and once again, we fall into the trap of incorrectly defining the problem as costly inefficient nuclear plants. After all the US summit is on how to **improve the economics of nuclear plants**, not how to fix poorly structured markets – the real problem. (Note: In Europe there are similar issues driven by a high level of subsidized renewables rather than low gas prices. But the need to find a solution is the same. A European Commission official assured delegates at a recent nuclear financing conference held in Paris that the design of European wholesale electricity markets and the emissions trading system (EU ETS) will be improved to help – and no longer hinder – nuclear energy as a low-carbon source of electricity.)

In the guise of providing the lowest cost to ratepayers, most markets are completely focused on the short term. There is little consideration of risk built into the pricing mechanisms, only what is the lowest cost to generate electricity right now. This means that there is no value attributed to any of the other important operating attributes required for a reliable and secure electricity supply system such as fuel availability, maneuverability, flexibility and

price volatility. On top of this, things like government environmental policies and subsidies further distort the markets to ensure that mandated renewables have a role in the system. (Of course nuclear has not benefited from such support even though it is a low carbon option.)

This may have all worked fine 25 years ago when markets were opened with the objective of creating efficiencies in the existing operating fleet –a time when many jurisdictions were in oversupply. But when it comes to adding capacity or making other substantive changes to the system, electricity markets are not nimble. While there may be a desire to respond to price signals in the short term, building new plant takes time. And one thing is for sure, no one will build new plant of any kind without some confidence that they will generate sufficient revenue to operate for their projected lives and earn a return on their investment. Or as stated in the OECD report Project Costs of Electricity, "*The structure of the electricity generation mix, as well as the electricity demand pattern, is quite inelastic in the short term: existing power plants have long lifetimes and building new capacity and transmission infrastructure may require a considerable lead time as well as significant upfront investments. In other terms, electricity systems are locked in with their existing generation mix and infrastructure, and cannot quickly adapt them to changing market conditions*."

It is also important to understand that not all market participants are equal. In most markets gas is the price maker, not a price taker. So when gas prices are high, everybody else in the market makes money and when gas prices are low, everybody struggles. And yes, today gas prices are very very low. Yet gas operators are relatively indifferent as they are the risk free players in the market. Even in this enviable position, gas generators did not have sufficient incentive to build new plant, so many markets have responded with the development of capacity markets. These capacity

payments then compensate gas plants for sitting idle – effectively removing the risk to gas generators of building new plants.

So you may ask, what's the problem with that as long as we have low energy prices?

If open markets are so efficient then we should expect that prices in these areas should be lower than in areas where regulated markets have remained. Not so, says an April 2015 study by the American Public Power Association. In fact, in 2014 prices in de-regulated markets were as much as 35% more than those in regulated states. (Note: this study has been done by an organization with an interest in the result and as such may contain bias.)

So let's go back to electricity system structuring. When it comes to managing risk, we know risk is generally reduced through a diverse portfolio of alternatives. The more diverse, the more risk can be reduced. The current path will result in systems that are not diverse, but rather all gas, currently the most economic alternative. If markets do not adapt to better accommodate risk management into their pricing strategies, we face a future of volatile energy prices, possible energy shortages as new plant construction lags market needs and increases rather than decreases in carbon emissions; all in the guise of more efficient markets. Back to the decision in Illinois. As stated in the referenced article, not only are these two plants Exelon's best performers, they "*support approximately 4,200 direct and indirect jobs and produce more than $1.2 billion in economic activity annually. A state report found that closing the plants would increase wholesale energy costs for the region by $439 million to $645 million annually. The report also found that keeping the plants open would avoid $10 billion in economic damages associated with higher carbon emissions over 10 years*."

We only need one major market disruption to remind us all of the importance of truly reliable baseload power at a stable and economic price and how that protects us from the risk of higher prices and lower security of supply.  And today, there is only one low carbon highly reliable baseload option, nuclear power.

So while a short term fix to keep operating nuclear plants open is required and more urgent than ever, let’s stop talking about how plants are uneconomic and work to properly improve market structures to build and maintain the strong, reliable, economic and low carbon systems needed to power our modern economies.

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# Let’s create awareness for all the benefits that nuclear technology brings to mankind

When a report on the benefits of nuclear technology starts with “*The public are often unaware of the extent to which aspects of their everyday life involve products and processes originated from the application of nuclear technology via the nuclear industry*”, it tells me that the time has come to tell this story and increase public awareness.


I had the opportunity to attend the Nuclear Industry Summit in Washington last month and was privileged to participate in Working Group 3 which had the mandate to summarize the role of the nuclear industry globally. The NIS was a very successful event. It was a companion event to the Nuclear Security Summit held by President Obama and provided an opportunity for the nuclear industry to interact and present its views to global leaders on the key issues of nuclear security and how the industry addresses it.

With the 5th anniversary of Fukushima having just passed last month and the 30th anniversary of Chernobyl this month, we have a steady reminder of the issues that never seem to go away for the nuclear industry. It is our nature. In his very enjoyable talk to the Canadian Nuclear Industry Conference in February, Malcolm Grimston asks the key question of why is it that the safest source of large scale electricity generation we have ever come up with is considered so dangerous by enough people that in a number of countries there is an effort to

stop using nuclear energy? I have commented on Malcolm's presentations before and I really enjoy his perspective. We in the industry tend towards the problem being an irrational public – Malcolm insists the public are quite rational and that it is actually the industry that is providing much of the information that frames public views. An example is the constant talk by the industry about safety and how safety is the most important issue. While intended to provide comfort, it can achieve quite the opposite effect. If safety is even more important than generating electricity reliably and efficiently the answer is quite simple – shut down the plants and safety is assured. I won't go into more detail but I do recommend you watch Malcom's presentation when you have 25 minutes to spare.

Or as was so eloquently put by the CEO of Ontario Power Generation at the CNA conference when talking about the nuclear industry, "*we make sure to find the black cloud around every silver lining left to our own devices*." Yes, we in the industry often succumb to the narrative and as Malcom suggests, probably even feed the beast. (Aside: I also urge you to watch Jeff Lyash's presentation when you have 20 minutes to spare. It is an excellent view of the industry going forward.)

So rather than talk about safety and nuclear waste as we tend to do over and over again; in this post I want to help increase awareness of the many benefits that nuclear technology brings to us all across a range of industries. The paper submitted by Working Group 3 led by Dr. John Barrett, President of the CNA is a must read. It is one of those papers that once read makes you wonder; why hasn't this paper been written this way before? So please read the paper – it is about 20 pages and well worth it.

But for those who may not get there quickly enough here is a summary of the benefits that nuclear technology brings to society each and every day. As stated in the paper, "*Nuclear*

*technology is vital for more than just providing reliable, low-carbon energy. It also has life-saving medical application; improves manufacturing, mining, transport and agriculture; and help us discover more about the planet we live on and how we can sustainably live with it.*"

So for example, did you know that

- nuclear technology saves lives through use of radioisotopes for screening, diagnosis and therapy of various medical conditions? According to the WNA, over 10,000 hospitals worldwide use radioisotopes. Radioisotopes are used in therapy to control and damage cancerous growths. Iodine-131 is used to treat thyroid cancer; Phosophorus-32 to treat leukemia. Nuclear techniques are used for neonatal screening for sickle cell disease, hypothyroidism and cystic fibrosis, as well as childhood cancers.
- radiation is used to preserve seeds and food products and breed disease-resistant plants. In plant breeding, some 1800 new crop varieties have been developed through mutation induced by ionising radiation.
- irradiation technology is increasingly being used to preserve food – spices, grains, fruit, vegetables and meat. It avoids the use of potentially harmful chemical fumigants and insecticides
- use of the IAEA's Sterile Insect Technique irradiates the eggs of these insects to sterilise them before hatching. The IAEA estimates that, by suppressing insect pest populations with SIT, pesticide use worldwide has been reduced by 600,000 litres annually.
- in industrial radiography, nuclear substances are used for the non-destructive examination and testing of new materials. Radiation from the substances passes through the material and allows defects in welds or constituency to be recorded on film or a digital imager.

This list does not do justice to the report itself which I

strongly suggest you read.  It’s time to stop being on the defensive and make sure that we no longer have to write reports that start with “*The public are often unaware of the extent to which aspects of their everyday life involve products and processes originated from the application of nuclear technology via the nuclear industry.*”  It is time to celebrate our successes and not just talk about where we need to improve.  We are proud to be part of the nuclear industry and we are confident that we are making a difference that helps to make the world a better place.