Building nuclear on time and on budget – yes, it is possible…and essential

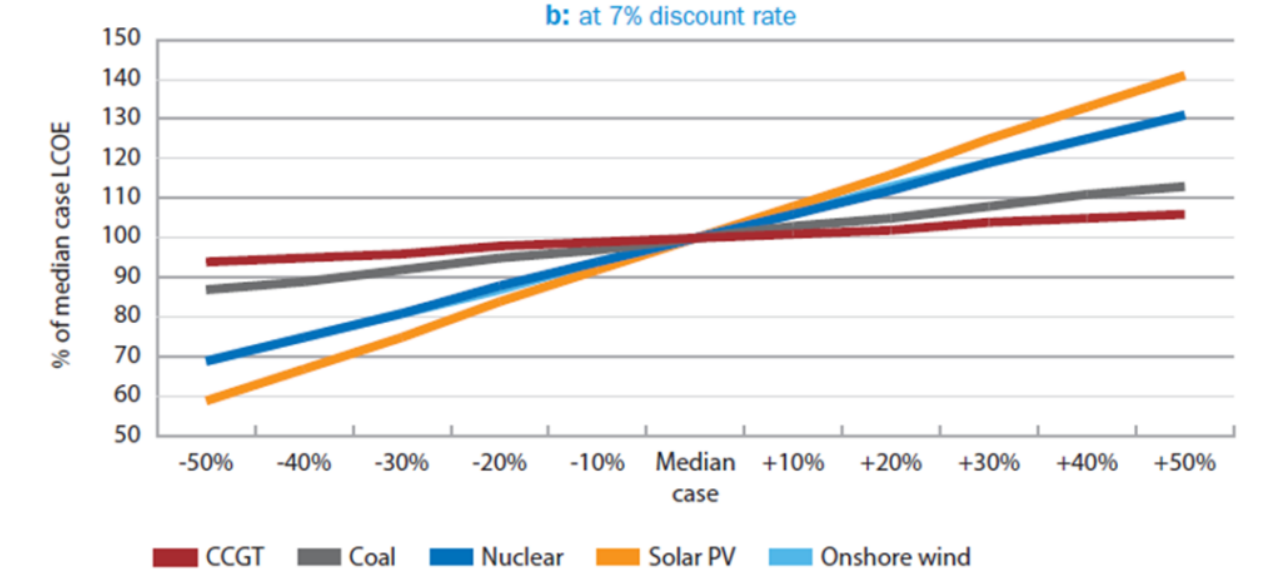
Large capital projects are hard. They require a huge amount of planning, the logistics are often staggering and depend upon many contractors and suppliers, all who must perform completely in step for everything to come together as planned. The project manager is like the conductor of a large orchestra and as good as all the musicians may be – it only takes one misstep to ruin a beautiful piece of music. Strong leadership and good people are the key.

Nuclear projects are often criticized for being delivered well over cost and schedule. Examples abound. Currently we have the Olkiluoto plant in Finland, the Vogtle plant in Georgia and the Flamanville plant in France all running late and over budget while Watts Bar 2, the first unit to enter service in the USA in 20 years was also recently completed well over its original budget. On the other hand, many plants being built in China and Korea are on time and on budget and even the first new plant in a new nuclear country in a long time, Barakah in the UAE, was built on time and on budget, although there are now some delays in the first unit entering into operations. Of course, nuclear projects are not the only large projects to suffer from overruns. A 2017 report on North American projects by EY Canada has determined that "*Canadian infrastructure megaprojects run 39% (US$2.2b) over budget and behind schedule by 12 months on average. However, Canadian megaprojects perform better than those in the US, where the average project delay is a little more than three years*."

Now, we have talked in the past about the economics of nuclear plants and one thing is clear, the largest component of the

cost of energy from a nuclear plant is the capital cost representing about two thirds of the total cost of energy. Therefore, building to budgeted cost and schedule is essential to maintain the estimated economic competitiveness of the plant that was the basis for securing project approval. And because the capital cost is such a large component of the cost of nuclear (and solar) energy, the cost of energy is very sensitive to cost overruns. This can be seen in the chart below from the IEA/NEA report "Projected Costs of Generating Electricity – 2015 edition".

Figure 7.8: LCOE as a function of overnight cost



There are many reasons why large projects go over budget and are late. What is in vogue these days is to put the blame primarily on the fact that these poorly performing projects are First of a Kind (FOAK) projects, meaning they are building a new design for the first time. Other factors include the significant regulatory burden placed on the nuclear industry and the challenges being experienced by a supply chain that has not delivered to a nuclear project in these jurisdictions in a long time and needs to re-establish its capability.

Clearly the strength in the Chinese and Korean programs are from both standardization and the relatively large number of

units being built, which provides for more certainty and a well-developed supply chain. And while it is true that doing things for the first time makes a project more difficult, the fact that a project is FOAK may be an explanation but is not a good excuse for the magnitude of overruns we are seeing. If we want to be credible, we must deliver on our commitments. After all, these are large multi-billion dollar projects. While there are many excellent reasons to support nuclear power, who will approve future projects if the outcome is not predictable?

We recently wrote about using fixed price contracts to mitigate some of these risks and why this has resulted in a false sense of security. Today, lets look at some of the things we can do to assess and mitigate the risk of overruns on nuclear projects, primarily those with larger FOAK elements.

Why do we say FOAK elements? Those that know us well, know our complete preoccupation with standardization as a means to controlling project risk. But as much as we would like to say that after the first project the next units will be standard, it is always a matter of degree. For example, the highest level of standardization is when there are multiple units being built at the same site. This allows for everything learned on the first unit to be immediately implemented on the subsequent units by the very same people that have just completed the previous project. Then there is the case where the same design is being implemented on a different site in the same jurisdiction so that most (but not all) of the supply chain and management can also be the same. But for other projects, we know that even when repeating a design, there are many things that can be new or different. Often there are different suppliers and contractors as projects are built in different jurisdictions; and there can also be changes in the financial and contractual structure of the project, that can impact project implementation. And of course, there are

always design changes as designs are updated to meet new codes, address site specific issues and meet local regulatory requirements.

As we stated above, large nuclear projects are hard. But hard does not mean impossible. Hard takes the right approach to deliver success. So, what are we to do to deliver projects to time and budget?

We need to all learn from each other. We do not implement enough projects in most jurisdictions to benefit from the series effect on our own. Here are some of the lessons learned gathered from those that have succeeded:

- Plan, plan and plan some more. Nothing is more important than understanding what has to be done before you do it. Large overruns and delays usually come from surprises, i.e. issues that come up that nobody thought about and now take time to resolve when the project clock is ticking.
- Ensure adequate design completion before construction. Understanding scope can only be done when the plant is designed. This is where FOAK plants need a larger investment before the first shovel hits the ground. You cannot plan your project if it is not designed.
- Ready your supply chain. If there are many new suppliers in the mix, or a number have not supplied in a long time, invest in their development and allow time in the program for them to come up to speed.
- Develop and implement a robust risk management program. Identifying and understanding the project risks, and then developing risk mitigation plans are essential to being ready for whatever comes up during project execution. This risk plan should be the basis for project contingencies for both cost and schedule. And even if the risk that comes up was not in the original risk register, having a robust process will ensure that action can be taken quickly and effectively to mitigate

and keep the project on track.

- Develop a project financial structure that enables the investment necessary to prepare for the project so that the project plan, estimate and risk program are at a level that can support project success when the project cost and schedule are committed; and finally,
- Get the best possible people you can. We think of large projects as a combination of technology and commodities. But in reality, it is people who build projects and strong leadership is the special sauce that leads to project success.

As we have said many times before, nuclear plants are extremely reliable, efficient, low carbon and cost-effective producers of electricity. As they are capital intensive, their economics depend upon successful project implementation. Project delays and overruns have large impacts on the project economics and negatively impact the credibility of the industry. After all, just like a great symphony, there is something beautiful when a large complex project comes together as planned – and there is nothing more important for the long-term health of the nuclear industry than building projects to cost and schedule.

It's not about being "advanced", it is ongoing innovation that will keep nuclear strong

This month in the United States, the Nuclear Energy Innovation

Capabilities Act was passed to support federal research and development and stimulate private investment in advanced nuclear reactor technologies. All this good news about investment in the future made me think about how we use the words **advanced** and **innovation** in the nuclear industry. We first wrote about innovation in the nuclear sector two years ago. And what we said then still applies, in fact even more so, today.

When thinking about innovation in the nuclear industry, the discussion often centres around future reactor designs. However, this far too narrow focus tends to an argument that a so called **advanced** design is what is required to save the industry and implies that today's designs are just not good enough. When we have a technology that produces abundant economic and reliable electricity with very low carbon, all while being one of the safest on earth; what we have today is something worth celebrating. Yet it is not unusual for some supporters of nuclear power to use the idea that new advanced designs are the magic sauce that will make nuclear great again.

Futuristic Thorium Plant from the Norwegian series "Occupied"

I was recently at a meeting where it was noted by someone who had recently visited Havana Cuba, that without access to newer technology, cars in Cuba are stuck in the past. The Cubans have found ways to keep these old cars running well past their original lives as they had no access to anything newer. And while we may find these relics fun to look at, we certainly don't expect to be driving cars of this vintage. In fact, we know that while the cars of today basically look the same and operate in a similar manner to those of the 1950s, there is likely not one part that is the same as was made 50 years ago. Today's car is made up of different materials, is computer controlled, is way more efficient and much much safer. This is all due to years and years of innovation. The same applies to nuclear plants. What would have happened if back in 1955 or so people only talked about and invested in what would replace cars for individual transport (i.e. "**advanced**" cars meaning electric vehicles or even flying cars) instead of how to make them better? The thought of it is just ridiculous. Yet that seems to be a common view of nuclear – that all we are doing is keeping old outdated plants (like 1950's cars) operating until we get these shiny new plants of the future ready for deployment. Nothing can be further from the truth.

While yes, it is important to research and develop new concepts based on specific needs, for example closing the fuel cycle or using new types of fuel such as thorium; it is not the case that this is what is required to continue to evolve safety, reliability and economics. For that we must continue to focus our efforts on improving what we have – innovating, taking the reactor designs available today – and making them better. Just like cars, there is abundant technology in any given nuclear plant that extends far beyond what kind of fuel we choose to burn. Implementing changes means using a large spectrum of new technologies that are being constantly developed as is necessary in every industry that wants to keep moving forward.

A great current example is the commitment in the US through the "*Delivering the Nuclear Promise: Advancing Safety, Reliability and Economic Performance*" initiative as the way forward to address falling prices of alternative generation options. As stated, this "*three-year program will identify efficiency measures and adopt best practices and technology solutions to improve operations, reduce generation cost and prevent premature reactor closure*." Now this is what drives innovation.

Extending the lives of current reactors through better understanding of how materials age, first to 60 years and next possibly to 80 years, use of remote tooling to reduce dose and shorten outages, use of new technology in controls to improve reliability; all of these things require innovation.

When it comes to new build, there is innovation in methods to reduce construction time and improve quality such as computer engineering tools, modularization and even simple things such as moving platforms to replace scaffolding and on and on and on. This is innovation. And let's not forget about commercial innovation. Innovative business models such as those used in Canada for refurbishment and in the UK for new build are critical to future industry success. This even includes models from places like Russia where they are working with foreign customers in ways thought not possible in the past. Will this all work? Some things will and some things wont, but this is innovation. It is messy, it takes time – and it continues to move the industry forward. And most of this innovation will apply to all reactor types, todays and those of the future.

I support the development of future designs– just not at the expense of making the public think our current designs have hit their 'best before date'. I am concerned that the industry is risking too much on the importance of government money for advanced designs– i.e. here is a few hundred million dollars to study designs for the 2030s so shut up and focus on

the future – then come back in 20 years or so when you have the next great thing. We cannot afford a mindset that says nuclear must stop until then as the world continues to build more and more gas plants and renewables. Every year these alternatives, wind and solar get better – and we need to do the same (and frankly we are).

The world needs abundant low carbon, economic and reliable electricity now if we are to replace coal and meet the needs of an energy hungry world. To meet the WNA target of 1,000 GW – 1000 new, 1000 MW nuclear plants by 2050 means we need to be building lots of new plants TODAY – not waiting until the next big thing comes around in a decade or two.

So, today's nuclear technology must continue to move forward and demonstrate it is a technology of the future and that improvements are continuing to come that make every project better than the last. We need to better celebrate our achievements and we need to continue to invest in further innovation because there is no choice but to continue to get better.

Our strength is through our performance. And our performance continues to get better through innovation, each and every day.

Today's hottest business model – FREE – Review of the book by Chris Anderson

Just finished reading "Free – The future of a radical price" by Chris Anderson. It was interesting reading and builds on

many of the themes from Jeff Jarvis' book "What would Google do?" that inspired me to start this blog earlier this year.

This book is well written and makes a strong case for free as a business model. The argument is that the web provides an easy low cost way to distribute information at a near zero marginal cost. Therefore it is much easier to make information available rather than try and protect it. Of course many will argue against this principle; noting that people's time cost money and nobody (with some exceptions) works for free. However, reading between the lines I do believe that Chris Anderson recognizes that for FREE to work, money must be made somewhere. At a more strategic level, I think the main point of the book is that dramatic changes are happening in business models and to succeed – innovation in the way money is made is now a requirement.

Three FREE models are discussed.

1. Direct Cross Subsidies – where products or services are effectively bundled with some provided for free and the others for a fee. In this model, usually you need the paid for product or service to get value from the free one. e. g. Cell phone is free, cost is to use it.
2. Three party or "two sided" markets – a traditional model in which one class of participant subsidizes the other. This is standard way of receiving a good at the cost to advertisers. e.g. any advertising supported delivery of content such as TV or ad supported web sites.
3. Freemium model – in which a basic service is free but there is a fee for a more sophisticated version. This is has evolved into a model where the base free service is good and quite usable for a large quantity of users and that a smaller set of users are willing to pay for a premium service. e.g. Skype where there is free computer to computer talk but it costs to call a phone.

This book provides a good history of using free to entice

customers to move up the value chain. What is different in today's world is that we now have services where a majority of the users will only use the free service and are subsidized by either a small group of specialty users or by advertising.

While this may be the case – is this model really sustainable?

Chris Anderson suggests that this is something that you can't fight. Trying to fight against free will ensure failure as a competitor will likely embrace it. This is where the discussion gets interesting. The challenge is to find new business models where something is free and new different ways of payment are discovered. The example is for consultants (since I am one – this is relevant) who provide free general information that results in paid individual consulting or speaking opportunities. Now of course, there may be a level of naiveté in this thinking. As consultants, one thing we always know is that any manhour not paid for is gone forever!! But what I do know is that things are constantly changing. As soon as you assume something new will work, it too is replaced by new thinking. Innovation is the new constant! What we have in this era of almost unlimited free information is a huge global exchange of ideas. And this has extreme value – the question then becomes how to find that value. Malcolm Gladwell has another interesting view in his review of this book. This shows the level of debate which I think will continue for some time. However while the debate is raging, more and more still seems to be available for free.

As an energy economist, I find the economic model fascinating. What is being said here is that in the area fed by the internet, there is abundance. And as we know, abundance means a low price as economics clearly points out that we value what is scarce. But as is also pointed out in the book, every time we create abundance we end up with scarcity somewhere else. So in this case, the abundance of information means that our time to absorb, understand and use

this information is becoming scarce. Or as the example goes – some people have more time than money and others have more money than time. For the latter group, payment to save them time is valuable indeed!

The other issue is that sometimes abundance isn’t abundance. Externalities must be considered or we end up in the situation that we now find ourselves, warming the earth with green house gases because the true cost of the impact to society is not included. Abundance leads to waste and sometimes waste leads to societal damage elsewhere down the line.

But what is clear is that we have now moved to a state where certain things that we valued in the past; we are no longer prepared to pay for. Does this mean the end of these things? In fact no, they are shared freely because they are abundant. What it does mean is that we all need to think up new business models that make sense in the world of FREE.