Tripling the global nuclear fleet will require massive capacity building

In our last post we looked at the pledge signed by more than 20 countries at COP28 in Dubai to triple the amount of nuclear globally by 2050. This month we consider the pledge made by more than 120 companies in the nuclear industry to meet this challenge and support a tripling of nuclear power by 2050. This is all part of the Net Zero Nuclear initiative started by the WNA (World Nuclear Association) and ENEC (Emirates Nuclear Energy Company) calling for unprecedented collaboration between government and industry leaders to at least triple global nuclear capacity to achieve carbon neutrality by 2050.

Some of the companies that have signed the industry pledge
Source: WNA photo COP28 December 2023

Tripling the global nuclear capacity is no small feat. Today there are 437 reactors in operation with a combined capacity of about 400 GW. Tripling means adding another 800 GW by 2050. In a combination of large nuclear and new Small Modular Reactors (SMRs), this would mean anywhere from 800 to 2500 or so new units being built around the world. Currently, there are 61 units representing about 68 GW under construction, only 7.6% of the way there. And two thirds of these units under construction are in or exported by China and Russia. In other words, the western nuclear industry has a long way to go to do their part in achieving this lofty goal. The question is then, how can we get there from here and why is this pledge so important?

Some say it is a pipe dream. We say the first step in solving any problem is to clearly define it. In this case, to express an ambition – and that was clearly set out at COP28. Understanding the need, the question then becomes how the industry can scale to meet this demand? This requires a rapid increase in development of both the global supply chain and the human talent needed to deploy at this scale.

This is huge change for the industry. It is (except for China, Russia and possibly Korea) used to being in a global market with few new projects and too many suppliers. On top of that there have been many false starts on a renewal (or renaissance) in the past that did not work out. So, the industry has been reluctant to make the necessary investments to support the capacity building needed.

The first step is to firm up this new demand. This must be driven by government. And it has begun. Already since COP, France has announced its plans to build 14 new EPR2 units by 2050 and the UK has issued its nuclear plan on how it will meet its target of 24 GW by 2050. The UK document is clear in that capacity building and human workforce development is a critical part of this plan. Here in Canada work is underway to look at how to scale to meet 2050 growth projections as well. The US has a lot of work to do to determine how to deliver its ambition of 200 GW of new nuclear by 2050. And yes, where will the resources then come from for projects in Poland, Czechia, Estonia, Slovenia, Bulgaria, Saudi Arabia, South East Asian countries and the many possible nuclear newcomers in the global south?

The nature of global competition will also change. There will be enough work to support multiple vendors, both for traditional large nuclear and SMRs. To be successful, there must be a focus by each vendor on delivering fleets of their designs to be as efficient as possible. This can then support development of global supply chains with sufficient capacity and the human talent needed for delivery.   The potential volume of work will encourage productivity improvements resulting in more on time and on budget delivery at lower total cost.

To meet the goals of net zero by 2050 and global energy security, the effort to build industry capacity is required now. All countries interested in new nuclear need to work on developing the people they will need to succeed. The ambition is clear – now is the time to act.

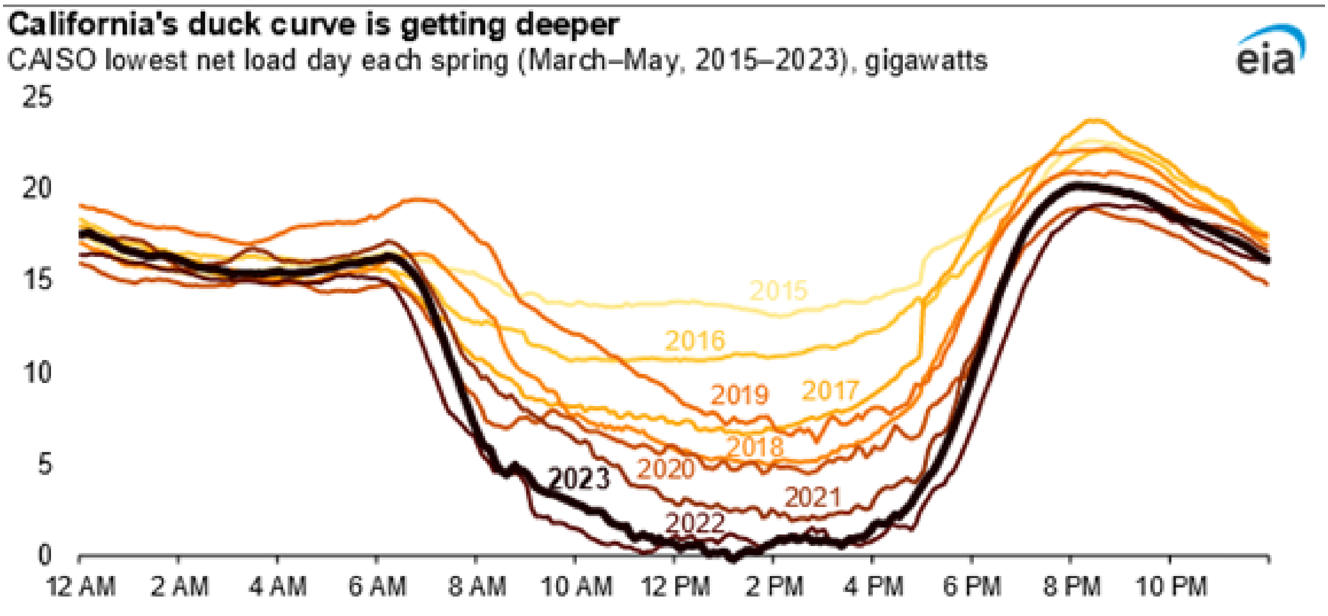
The California Duck Curve gets deeper – the challenges of high levels of intermittent variable renewable energy

A recent article caught our eye – "*Stanford study warns against overnight charging of electric cars at home*" in California. This study noted that most electric vehicle (EV) owners tend to charge their vehicles at home during the evening or overnight (which should come as no surprise to anyone), leading to significant costs for the electricity grid as California relies more and more on solar energy. It projects the rapid growth of EVs and their reliance on nighttime charging could lead to a 25% increase in peak electricity demand within a little over a decade. This study's solution, get people to shift towards daytime charging at public charging stations or workplaces. It goes on to explain that "*if more people charged their vehicles during the day at work or public charging stations, it could reduce greenhouse gas emissions (*presumably by avoiding gas usage at night*) and avoid the added costs of generating and storing electricity*".

Source: istockphoto.com

This is the beginning of an awareness of what happens when you rely too much on intermittent variable renewables for your electricity needs. It forces you to use the electricity when the sun shines (in this case) or the wind blows, which is not necessarily when you actually need it.

California has had this issue for years. Due to a rapidly increasing amount of solar electricity, the net load on the system (total load less renewables) reduces rapidly in the morning when the sun comes up and solar power comes online, then increases again as the sun goes down and solar drops off. This has come to be known as the “Duck Curve”, as the shape of the curve looks like a duck! What we see below is that the depth of the curve has continued to get deeper over the last eight years as California adds more and more solar power.



Source: https://cleantechnica.com/2023/07/07/california-duck-curve-getting-deeper-with-solar-growth/

Don’t get us wrong, we like solar especially in sunny locations like California. Generally, solar plants produce about 15 to 20% of the time depending on location (based on the level of sunshine). Well, in very sunny California, the average capacity factor for solar is just over 28%. Excellent for this type of generation. This clearly has an important role to play in the generation mix.

But we also see that too much of a good thing can create new challenges. The cost to the system of being able to accommodate this rapid change in load when the sun comes up and again when it goes down is large. Storage and other dispatchable sources of electricity (likely gas) are required to meet the needs the 70% of the time the sun is not shining. The duck curve also reduces the amount of time dispatchable conventional power plants operate, reducing their revenues, making them less economic to operate in the California market. If these plants are then retired without replacement, it becomes even harder to meet the needs of the system.

The other issue is grid stress. Grid operators need to drastically ramp up non solar generation as the sun sets, a very difficult thing to do. In the past, when we considered how big of a single generating plant a system could accommodate, we often used a simple rule of thumb that no unit should be larger than 10% of the entire system. Larger than that, the ability of the system to manage a unit outage would be compromised putting system reliability at risk. That is what solar has become in California. While you may think that there are many solar units in place, due to their intermittency, they operate on the system as one extremely large plant. They all come on at the same time when the sun comes up and they all go off at the same time when the sun goes down. What is the system to do?

We had a wonderful vacation in southern California this past July. Spent some time in Palm Springs where the temperatures were on the order of 45 to 47 degrees Celsius (~115 degrees Fahrenheit). I can assure you that we needed air conditioning as much at night as during the day.

Now imagine what would happen without having the back up needed. Storage is part of the solution but requires a huge overbuild of daytime capacity to both meet the day's energy needs while also filling storage for other times. And mostly current storage technology is good for hours, not days or weeks creating issues for when the weather is simply not cooperating (two weeks of continuous rain for example) or to meet seasonal load changes. The result is a growing consensus that firm dispatchable capacity also needs to be an essential part of any clean energy solution.

The Diablo Canyon nuclear plant in California produces energy about 90% of the time, in other words each MW of capacity of California nuclear produces more than 3 times the amount of energy in a year than the equivalent capacity of solar. That is what builds a resilient system.

I don't have an electric vehicle yet, but when I do, I will definitely feel better knowing I can leave home in the morning with a full charge.

In 2022 the world acknowledged that net zero needs nuclear – in 2023 it will realize it needs a whole lot of it

Early last month, Vogtle Unit 3, the first new nuclear plant to be built in the United States in decades, went critical, meaning it started to nuclear fission and move down the path to producing its first electricity and becoming operational. This was great news as the project has had a troubled history of delays and cost overruns. Once fully operational the Vogtle site will have four operating units and be the largest nuclear operating site in America.

But this was not the most important nuclear news coming out of the US this past month. On March 21 the US Department of Energy released its "*Pathways to Commercial Liftoff*", a set of reports to strengthen engagement between the public and private sectors to accelerate the commercialization and deployment of key clean energy technologies. This included a report on “*Pathways to Commercial Liftoff: Advanced Nuclear*” in which the DOE estimated a need for an additional 200 GW of advanced nuclear by 2050 on the path to net zero. This is a huge change from the past (equivalent to tripling the current fleet) when most felt that nuclear would struggle to play an important role in the country’s future.

Source: istockphoto.com

And the US is not the only country to set huge nuclear ambitions. In December of 2022 in Canada, the Ontario Independent Electricity Operator issued a report, ”Pathways to Decarbonization”, in which it suggested Ontario may need another 18 GW of new nuclear to complement its current 14 GW fleet.

In the UK, the government has set a target of 24 GW of nuclear by 2050 delivering about 25% of UK demand. In France, work is underway to deliver 6 new EPR units followed by another 8 by 2050 for a total of about 22 GW of new nuclear.

Meanwhile South Korea, after suffering an administration that wanted to phase out nuclear energy, is planning to expand its nuclear fleet in its *10th Basic Plan for Electricity Supply and Demand (2022 – 2036).* The plan includes 6 new 1.4 GW units coming into service and nuclear reaching 34.6% of electricity generation by 2036 as coal use declines. And even in Japan, 12 years after the accident at Fukushima caused by the Great Tohoku earthquake and tsunami, has adopted a plan to extend the lifespan of nuclear reactors, replace the old and even build new ones as part of its commitment to fighting climate change.

This commitment to large new nuclear fleets is not only by countries that have nuclear power, but even those just planning their first plants. For example, Poland, Europe's largest coal burning country, is planning at least 9 GW of new large nuclear plus a range of small nuclear power plants by 2040.

Why is this important? In the last year more and more governments have accepted that nuclear power must be part of any climate plan that achieves net zero targets by 2050. Nuclear was accepted (albeit marginally) in the European taxonomy as a low carbon technology, the UK is defining nuclear as green, and many other governments have noted there is no path to net zero without nuclear.

And then there is the war in Ukraine increasing concerns about energy security to a level not seen in many years. This is hastening the movement away from fossil dependence which further supports the energy security strengths of nuclear power.

So, if 2022 was the year that governments around the world finally embraced nuclear power as a necessary part of the path to net zero, 2023 will be the year they start to accept this means building a whole lot of it, expanding the global nuclear fleet at a pace and scale not seen before. What does this mean for the global nuclear industry as it readies itself for this massive increase in demand? This is a topic for another day.

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.

Advocating for nuclear power – the time is right

We live in strange times. Globally, populism is growing in response to a deep-seated anger with so-called liberal elites. Experts are no longer respected over louder voices that support peoples' strongly held views. There are no facts, only beliefs.

While most of the world continues to support the Paris agreement on climate, there is a reluctance by some to include nuclear power in the tool-kit to help meet this global challenge. There is wide spread belief that Germany is going down the right path as it eliminates nuclear from its mix and drastically increases its use of renewables. The only problem is that fossil fuel use is also increasing and emissions are not going down. This has not stopped other countries like France, which has one of the lowest emissions in Europe due to their nuclear fleet, setting out a policy to reduce reliance on nuclear. And now Korea seems to be going down the same path even though it would probably be hard to find another country that has benefited more through successfully implementing its nuclear program.

Does this mean that nuclear power is getting ready to move over and cede the future of energy supply to a fully renewable world? Not even close. With 58 units under construction there are now more new nuclear units coming into service each year than in the last 20 years. The UAE is nearing completion of its first units, a four-unit station as it becomes the newest entry into the nuclear club.

On the other hand, in the USA units are struggling to stay in service in de-regulated states and one of two new build projects has been stopped in the face of Westinghouse bankruptcy.

In the midst of all of this apparent chaos, there is a bright light. People are standing up saying – don’t close my nuclear plants. People are recognizing that removing large low carbon emitting stations from the energy mix is no way to improve the climate. And most of all these people are ready and willing to fight. In the more than 35 years we have been in the nuclear industry I don’t remember a time when there were strong vocal pro-nuclear NGOs. Yes, that’s right – there are those who are not directly in the nuclear industry who have taken up the fight for nuclear. Not because they have any great passion for the technology, but because (as we discussed in May), they see nuclear plants as the ultimate solution to important issues. They want to save the environment. They want plentiful economic energy and they know that nuclear is an important part of the solution.

More vocal pro-nuclear NGOs today than we have had in 35 years

These organizations include a growing list of environmentalists such as Environmental Progress, Energy for Humanity, Bright New World and Mothers for Nuclear – to name a few (this list is not meant to be exhaustive so if your organization is advocating for nuclear power, please comment with your name and a link). What they have in common is an understanding that nuclear power is not the evil that some think it is and that in fact it can help to make the world a better place. And of more importance they are willing to advocate for it.

The way I look at it, there are two types of advocacy. First there is the broader objective of securing public support; and then there is the more targeted advocacy that fights in the trenches to get political support for specific projects and actions. It is this second approach that I want to focus on here. These pro-nuclear groups consist of many who have spent their lives advocating for what they believe in; and therefore, bring a knowledge of how to influence decision makers and raise the profile of their cause. I have talked before about Meredith Angwin's wonderful book on how to be a nuclear advocate. It's a "how to" on getting out there and taking action. Or take the case of the nuclear bus – old fashion grass roots activism.

As was once explained to me, it is always easier to be against something than to be a supporter. It is anger about things that people believe is wrong in the world that ignites passion and brings them to the streets; supporters often stay at home and discuss these projects with their friends over a glass of wine. That is in part why there is so much passion about stopping the closure of existing nuclear plants. It is easier to be against closing them with the impacts to emissions and our communities than to argue in support of building something new. This is the beginning.

Because after all, it is a numbers game. 200 anti-project protesters can get a lot of press even though there may be 2000 who support the project but who stayed home. It's about getting people out – politicians want to do the will of the people and they need to see this will. Supporting continued operations of a plant or even a new build is much easier if the preponderance of the people speaking at public hearings are in favour of the project.

The word we use today is "social license". But what does this really mean? If it means securing significant local support for something then it is a laudable goal. However, most anti-nuclear (or anti-anything) groups take it to the extreme and mean that they have to agree with proceeding; which is something they will never do. As stated so eloquently by Rex Murphy in his piece on the efforts of the new NDP government desire to develop oil in Alberta – "*Notley [the Premier] missed the central point of social licence: its preconditions can never be met, and are not meant to be. It is an* *obstructionist tactic, designed to forestall and delay*."

So why are countries ignoring the potential benefits of nuclear power as they strive to feed their energy hungry citizens with low carbon economic energy? There are many reasons as we and others have discussed before. We certainly believe that the overriding issue is fear. But we can also see that when people become supporters based on nuclear power being a solution to issues of importance to them, they do their homework and are able to resolve their fear. So we need to ask ourselves are people really that afraid, or is this also a remnant of the past where environmentally conscious groups were synonymous with being anti-nuclear? Are we seeing the last vestiges of a generation that fears nuclear power at all costs? Do we now have the opportunity to start to change the minds of a new generation that is willing to stand up and advocate for nuclear power? It may well be.

One thing is for sure, we all need to get out there and advocate for what we believe in. The time for talk is over – it is time to act. We need to organize and be sure to be out there every opportunity we can to support the decisions that we believe are necessary to achieve our goals.

So,

- if you believe that climate change is a threat and that fossil fuel use is the main culprit; or
- if you believe that access to economic reliable energy is essential for progress and is critical to lift people out of poverty; or
- if you believe that high quality jobs and technological innovation is good for our communities and our economies; or
- if you want a future for your children and grandchildren with abundant plentiful reliable economic and low carbon energy to support them as they create their own future;

Then the answer is clear – and that answer is nuclear power.

This is a call to action. We all need to work together to advocate for what we know is right. We have been involved in this industry for close to 40 years and still are passionate supporters – because we truly believe we can leave the world a better place than when we started.

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.

Dreaming of a future with abundant clean reliable

energy – then dream about nuclear

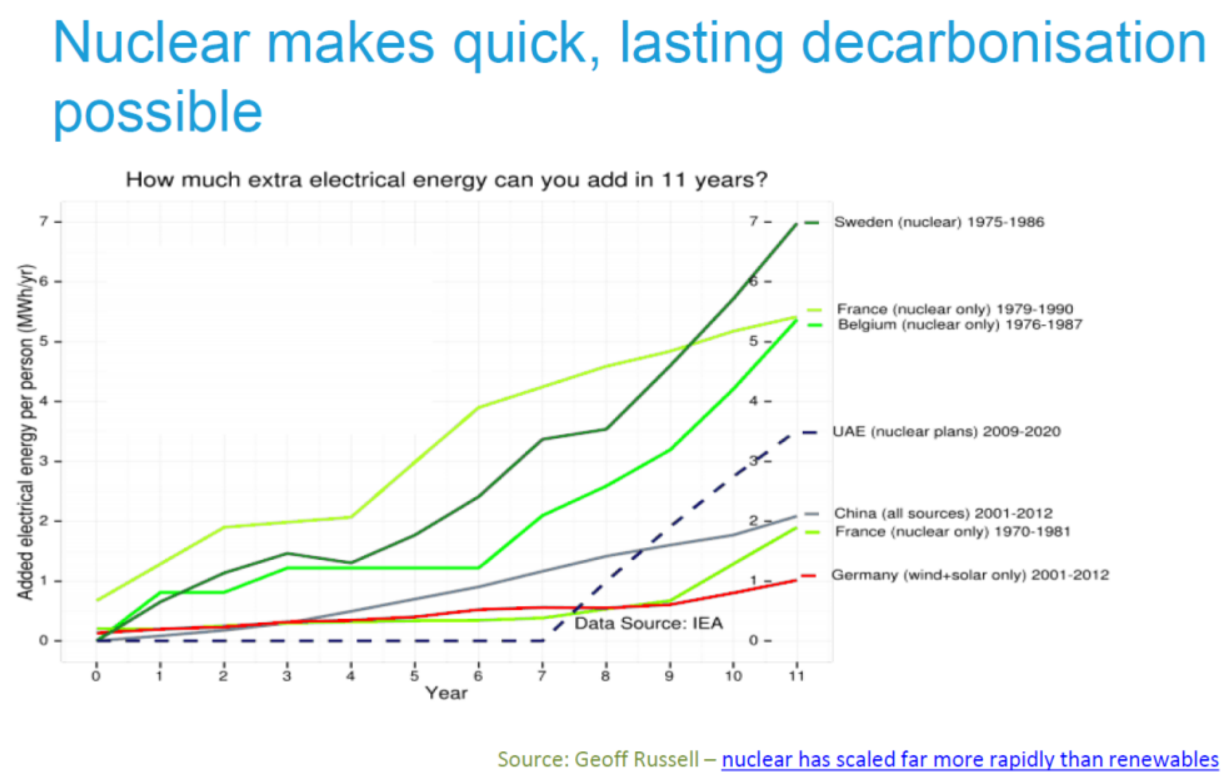
When we look to the future, people the world over are hopeful for an era of abundant reliable electricity supplying all of our energy needs; all at a reasonable cost and with little to no impact to the environment. Unfortunately, in many western countries the politics of electricity planning has become largely a case of exploring the depths of our imagination with no real path to achieving this essential goal.

As stated by Malcolm Grimston at the World Nuclear Association (WNA) Annual Symposium last month in his brilliant talk "***Sclerosis at the heart of energy policy***" (in advance of a book he has coming out), we have become so accustomed to reliable and cost effective electricity supply that we can no longer ever consider a scenario where this can be at risk. He noted we even use the less than frightening phrase "keeping the lights on" when talking about reliability which greatly understates the importance of reliable electricity supply to our modern society. (As he said, he turns out his lights every night without concern – certainly a large scale disruption to our energy supplies would be much worse than having the lights go off.)

Given we can't imagine electricity reliability to be at risk; and given we have relatively slow growth in most western advanced economies there is a major reluctance to take decisions to protect and invest in our infrastructure for the future even while we want to work towards decarbonizing the system. Yes electricity demand growth is modest, but our lives depend more on reliable electricity supplies than ever before. Without electricity society quickly becomes paralyzed with no ability to communicate, travel, maintain our food supply, sanitation, deliver health care and so on…in fact it is very difficult for us in all of our modern comfort to imagine how severe the consequences would be. Therefore in our great complacency we continue to do nothing because we all expect that the next great technological breakthrough is just around the corner. All we need to do is wait and advanced renewables will be available so we can have clean limitless energy forever. And so goes the narrative.

Ben Heard in his excellent WNA presentation “***World without Nuclear***” quotes Naomi Klein as she spoke to the media against the nuclear option in South Australia – “*What’s exciting about this renewables revolution spreading around the world, is that it shows us that we can power our economies without the enormous risk that we have come to accept*”. She said the latest research showed renewables could power 100 per cent of the world’s economies. “*We can do it without those huge risks and costs associated with nuclear so why wouldn’t we*?” she said.

But of course if it sounds too good to be true, it probably is. Ben’s presentation goes on to review 20 studies that suggest that a world powered by 100% renewables can be a reality. However, in his review he rates most of these studies as poor. Overall he concludes that there is actually scant evidence for 100 % renewable feasibility while the literature affirms large dispatchable, i.e. guaranteed 24/7 supply is indispensable. His final conclusion is that global decarbonization requires a much faster-growing nuclear sector.



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But how can we have more nuclear when it has this perception of huge risks? We have written extensively on the issues associated with the perception of nuclear as a dangerous technology when in reality it has the best safety record of all technologies out there so we won't talk about that again now. In his presentation Malcolm Grimston places much of the responsibility for this public perception squarely on the nuclear industry noting that the industry "*spends half of its time implying that it is the new priesthood, with superhuman powers to guarantee safety; and the other half of its time behaving as if radiation is much much more dangerous than it actually is*." While it is hard to know what comes first, the fear or the industry reaction to it, we certainly agree that Malcolm makes a good point.

Then there are those that say nuclear power is way too expensive to be part of our future electricity system even though there is no doubt that wind and solar power are clearly the more expensive options. The most recent edition of

“Project Costs of Electricity”; an important report that is now in its 8th edition from the IEA and NEA looking at the costs of various forms of electricity generation has just been published. (This report is a must for anyone seriously looking at trends and costs of electricity generation around the globe.) While the report acknowledges the huge gains made by renewables in reducing their costs, it also demonstrates that nuclear power is one of the lowest cost options available depending upon the scenario. Of more importance, the report notes that the belief that nuclear costs continue to rise is false stating that, in general, baseload technologies are not increasing in costs and specifically “t*his is particularly notable in the case of nuclear technologies, which have costs that are roughly on a par with those reported in the prior study, thus undermining the growing narrative that nuclear costs continue to increase globally*”.

We will have more to say about this report in upcoming posts. But for now, let’s all do more than dream about a future of abundant, reliable, clean and yes, economic electricity; let’s make this dream a reality by making sure that the electricity system of the future includes highly reliable 24/7 nuclear power.

Reliability means being connected – we need a strong integrated electricity system

with nuclear generation as its workhorse

It was with great fanfare that Tesla launched its home battery recently. Headlines like "*Tesla launches Powerwall home battery with aim to revolutionize energy consumption*" were the norm as the public read about this revolutionary jump forward in energy storage. A recent article on where famed author Margaret Atwood is investing says it all …. "*if [Tesla CEO] Elon Musk was putting his Powerwall on the market, I would certainly buy a piece of that. My feeling is that, once that becomes affordable, everyone is going to do that. I think that's definitely the wave of the future*."

After all, this is the dream isn't it? We can all generate our own electricity with clean energy efficient solar panels and store enough on our home batteries to keep us going when the sun goes down. What can be better for our common future?

Well, in fact, just about everything.

It must be my age and my years in the energy industry that remind me of what are the real essential attributes of electricity supply. **Reliability and Economics**. Yes, that's right. For anyone who works in a modern electricity utility, that is what they focus on; delivering cost effective reliable electricity to users. And in today's energy intensive world where we need electricity for every aspect of our hyper active and energy intensive lives, this is even more critical. We have all experienced temporary blackouts and know well the negative impact it has. The problem then with renewable energy generated at home is that, at least for now, it is neither reliable nor economic. Since the announcement from Tesla there have been a number of articles that explain this in detail, but of course supporters will just say that in time all problems will be solved. And frankly they may be right.

" Will I be able to have a night light if we switch to *solar power* ?

So let’s step back and ask ourselves a more important question – are we trying to solve the right problem? Most people have no idea what it takes to generate and deliver the electricity (the so-called “grid”) we take for granted in the modern world. In fact, many just think electricity is something that comes out of the wall outlet. What we all want is that when we turn on the switch, or plug in our phones, it just works. We are not in any way prepared for a world in which we say – oh, it’s cloudy so we better not charge our iPhone today! I love the recent TV ads where BMW is explaining how they build their new I3 electric car in wind powered factories. Yet, do any of us really think that on days when it is not windy, these factories sit idle? No, of course not.

In most advanced economies around the globe we have achieved a high level of reliability in electricity supply. In fact this is one of the measures that makes an economy ‘advanced’. **The problem is that much of our electricity is generated with fossil fuels; primarily coal.** (Coal continues to be the largest source of Germany’s electricity where BMW has its factories, at nearly 50% of total supply). And along with this comes both pollution and a high level of carbon emissions. Therefore, the only way to address these environmental issues is to reduce the use of fossil fuels, not to eliminate an integrated grid.

Just like being connected to the internet improves our lives, so does being connected to a reliable electricity grid. Do we really want to live a life where if it is cloudy for a few days and our batteries run dry we do without? Of course not. Just imagine how much excess battery capacity we would each need to avoid this possibility. Even Elon Musk notes that his battery is currently for emergency backup – not for daily use – and yes it would be great to have some amount of reasonably economic backup for when we experience an outage. But as is starting to be seen in California where there are numerous discussions of the "duck curve", people want it all – they want to generate their own electricity when they can believing this is the best approach, but they also want the system to be there just in case they need it; and at a moment's notice. The result – higher costs all around. The less the grid system is used, the more it costs to keep the infrastructure in place to make up the shortfall when needed.

The answer is simple, let's take what works and make it even better. That is a large interconnected grid that includes large scale reliable economic generation based on nuclear power, and hydro where available, supplemented by wind and solar depending upon the local availability of these resources. To be reliable and cost effective, a system needs generation that can run all the time, not just when the wind is blowing or the sun is shining. As storage technology improves, it can then contribute to both help manage the intermittency of renewable generation as well as flattening the demand curve to enable an even larger share of nuclear generation.

Remember, our economy, and in fact our very way of life, is completely dependent upon the availability of reliable, clean and economic electricity. So while we may dream of not needing the grid as we each generate our own electricity, what we really need is a strong well interconnected grid made up of reliable economic nuclear power as its work horse, with wind, solar and other forms of generation contributing when they can; all coupled with new forms of large scale storage to both even out demand and supply. Now this is more likely to be the system of the future.

The challenge of financing nuclear plants – financing energy requires huge investment

Quite often we hear about the problem of attracting financing to support new build nuclear projects. In fact financing will be a topic of major interest at a number of upcoming nuclear conferences. While it is easy to agree that financing nuclear projects is a big challenge, in my view difficulty securing financing is not the issue – rather it is a symptom of a number of other very important issues that are the root cause. Necessary conditions to secure financing for any project is first and foremost, an economically viable project. Next comes the project structure – or to state it more simply – ensuring the risks are managed in a way that can satisfy investors that they will receive an adequate return for their investment. These concepts will be discussed further in a future post.

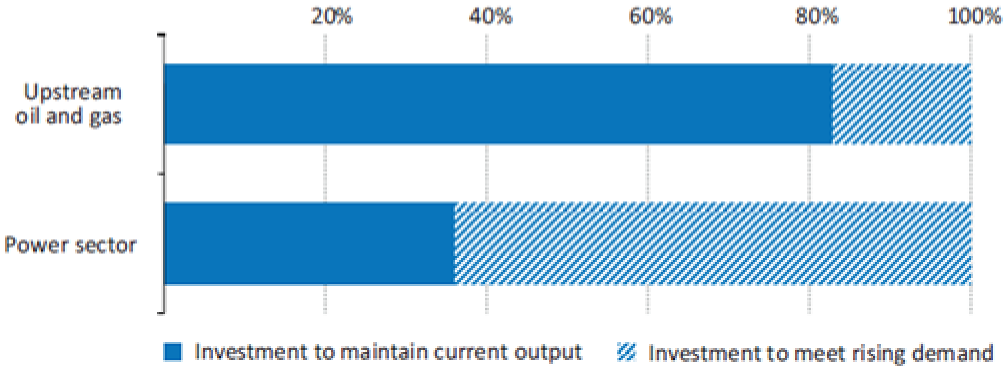
For today, I will look at the $40 trillion energy industry and consider nuclear's share of the overall expenditure needed for energy over the next 20 years. I would like to put some context on the issues related to financing nuclear plants by looking at a recent IEA report called the "World Energy Investment Outlook" or WEIO. I found this report of interest because it provides useful data on global funding required to support energy. Or as stated in the Forward to the report "…. *data on today's investment flows have not been readily available and projections and costs for tomorrow's investment needs are often absent from the debate about the future of the energy sector*."

We often talk about the large size of nuclear projects and how they require huge amounts of funds. Nuclear projects are very capital intensive and have relatively long project schedules; both important issues when trying to secure financing. When we talk about large, a good first step is to try and understand how much funding is required for nuclear projects relative to the rest of the energy industry. And for this we turn to the WEIO.

With annual spending in 2013 of $1.6 trillion rising to about $2.0 trillion by 2035, meeting global demand for energy requires an enormous amount of money. This excludes another $500 billion or so per year to be spent on energy efficiency to try and moderate this growing demand.

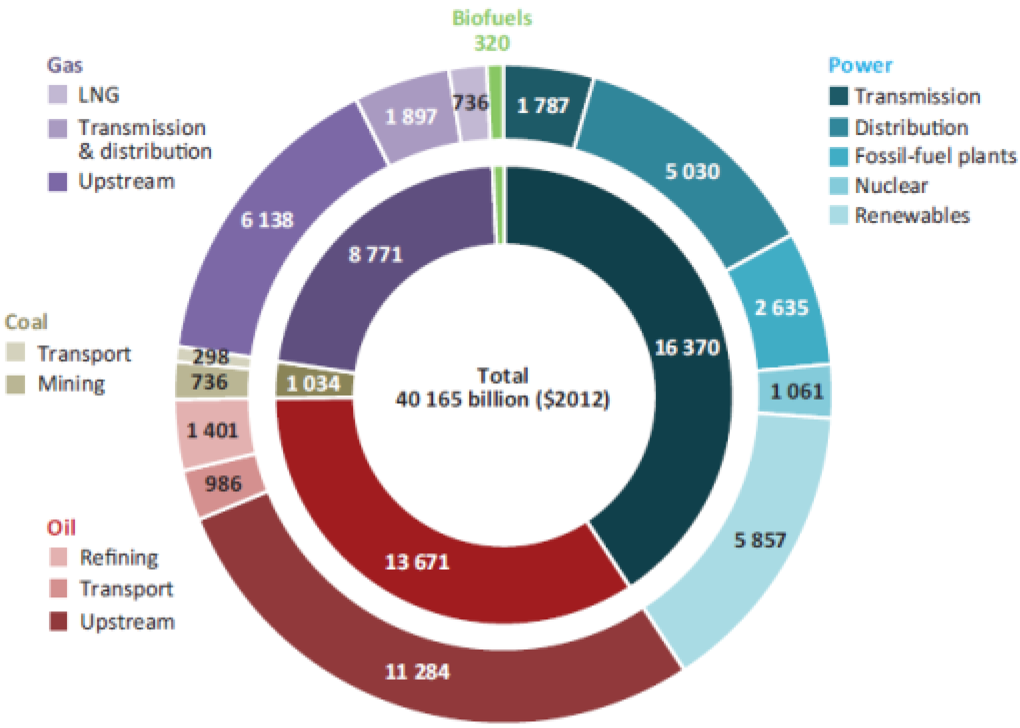
Of even more interest, the report specifies that less than half of the $40 trillion dollars required to meet energy demand between today and 2035 goes to meet demand growth; the larger share is required to offset declining production from existing oil and gas fields and to replace power plants and other assets that reach the end of their productive life.

Figure 1.5 ▷ Share of investment required to keep global output at current levels versus total investment required in the New Policies Scenario, 2014-2035

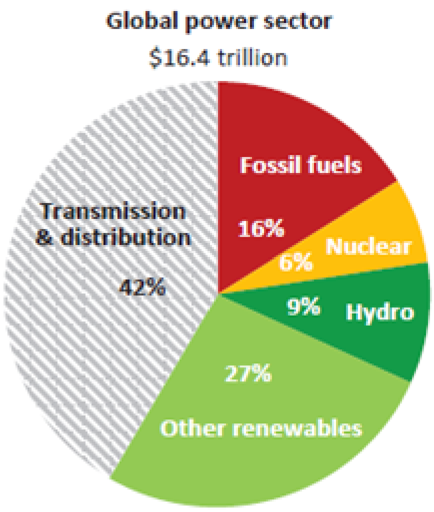


A staggering statistic – more than $20 trillion is required over the next 20 years just to stand still. And of course, most of this investment is in fossil fuels that continue to emit carbon as the world tries to find a way to turn the corner and find alternatives.

Figure 1.3 ▷ Cumulative global energy supply investment by type in the New Policies Scenario, 2014-2035



If we drill down and focus on the electricity sector, we can see that of the above $40 trillion about $16.4 trillion is investment in the electricity sector. The largest component of this investment (about 40%) is in transmission and distribution. In the developed world this essential infrastructure is ageing and requires significant investment to meet growing needs. In the developing world, there is a huge need to build up the infrastructure for a population hungry to enjoy the benefits of using electricity.



Looking further we can see two important facts. First, nuclear power only needs about 6% of the funds for the electricity sector; this is assuming the very modest growth for nuclear in the WEO New Policy Scenario. The other is that renewables are demanding a very large share of the available funds as more and more markets turn to these forms of energy to meet their growing energy needs while trying to curb carbon emissions.

What can we learn from this high level look at the funding requirements for the energy industry? On the one hand, nuclear projects require only a very small portion of the total funds being invested today and for the next 20 years in energy. The main uses of funds are to replace existing depleted fossil fuel reserves – usually at a cost higher than the resources they replace; to invest in critical T&D infrastructure, in part due to the need to expand transmission to be able to accommodate renewable energy generation; and the investment in renewable energy generation itself, virtually all of this last investment subsidized by governments to encourage growth.

On the one hand, there is tremendous competition for funds in the energy industry meaning nuclear projects need to be an attractive financial proposition to get its share of these funds. And on the other hand, much of the competing technologies are being supported by governments with subsidies based on policy decisions.

So what is it that makes nuclear plants so difficult to finance? As I said at the start of this post, there are a number of issues that need to be discussed. These include project economics, energy market structures, poor project construction performance in a number of markets; and of course, public perception that skews the risk profile of nuclear projects in a way not seen in other industries. But a discussion of these factors will have to wait until another time…….

Note: all figures above are from the IEA World Energy Investment Outlook.

As a solution for climate change – nuclear power is falling behind

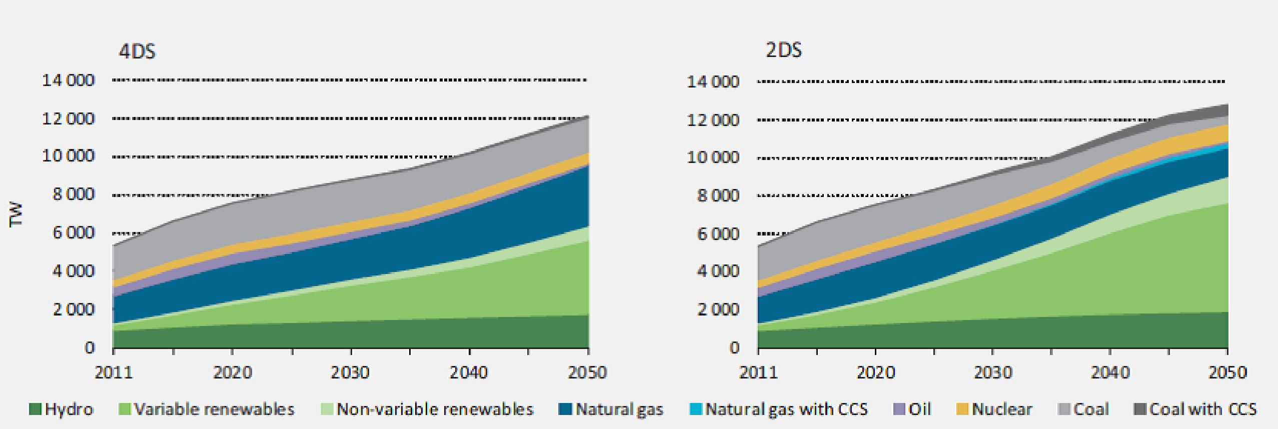
Recently, the 2014 edition of the International Energy Agency's (IEA) Energy Technology Perspectives (ETP) was issued. The ETP is issued on a two year cycle; the current edition takes the World Energy Outlook 2013 forecasts and looks to the longer term out to 2050. With climate change now becoming even more pressing I thought it would be interesting to see the progress over the last two years (I wrote about the 2012 edition back in June of that year). According to the report, as an important contributor to meeting climate requirements going forward, nuclear power is falling behind.

On the positive side, the IEA sees the opportunity by which "*policy and technology together become driving forces – rather than reactionary tools – in transforming the energy sector over the next 40 years.*" The report looks to balance energy security, costs and energy-related environmental impacts. But in the end it concludes that "*Radical action is needed to actively transform energy supply and end use*. "

Why is radical action required? Of all the technologies required to meet the 2D target (this scenario sets a target of only 2 degrees C change as compared to 6 degrees in the status quo scenario), the IEA suggests that only renewables are on track while pretty much every other clean technology is not moving fast enough. Two important technologies not meeting targets are Carbon Capture and Storage (CCS) and Nuclear Power. To no one's surprise, CCS has yet to be proven and become a viable commercial option to de-carbonize fossil fuel emissions. As for nuclear power; after the Fukushima accident, growth has been slower than previously predicted and is expected to be 5 to 25% below the level required by the 2D scenario in 2025.

This leaves much of the burden on renewables to meet the need for lower carbon emissions. Surprisingly, in the hi-renewables scenario, solar becomes the dominant source of electricity reaching 40% penetration by 2050. Realistic or pipe dream? I don't know. One thing is certain, (see chart below), with almost half of future electricity generation coming from variable renewables, compared to almost nothing today, the IEA is demonstrating the need for a huge technology transformation in how the world generates electricity.

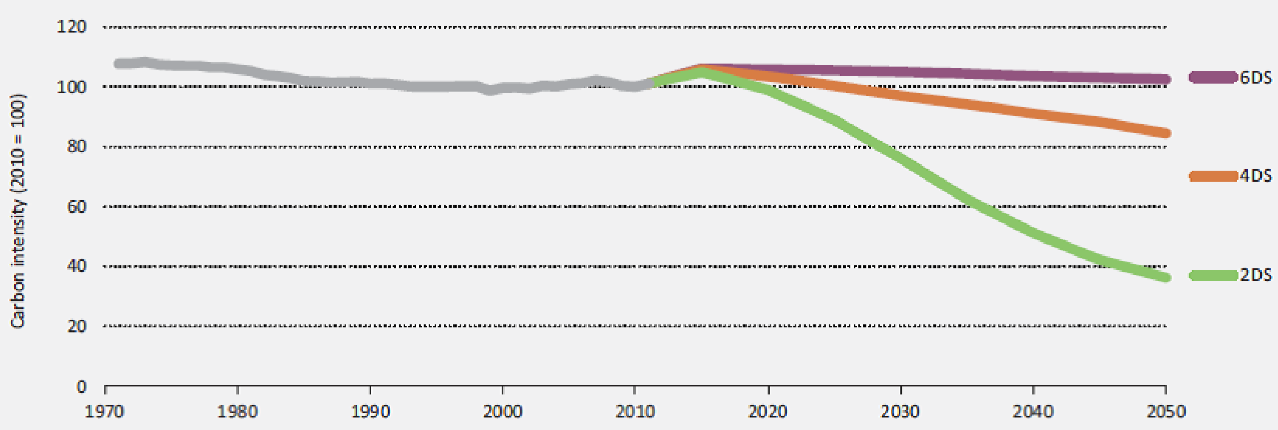
Figure 3.4 Global electricity generation capacity by technology



Note: TW = terawatts.

The following chart is the most telling of all. Over the past 40 years carbon intensity (the amount of carbon emitted per unit of energy supplied) has barely budged. Almost no change at all. Yet now we require the carbon intensity to be cut in half in the next 35 years (meaning less than half as much carbon produced per unit of energy supplied). This requires a complete change in how energy is delivered.

Figure 1.1 The Energy Sector Carbon Intensity Index (ESCII)



Notes: the ESCII illustrates the aggregate impact of technology shifts on carbon emissions in the energy sector. It measures how many tonnes of CO_2 are emitted for each unit of energy supplied. Under the ESCII, 100 represents CO_2 intensity in 2010, providing a base to measure progress. Unless otherwise indicated, all tables and figures in this chapter derive from International Energy Agency (IEA) data and analysis.

Key point *The carbon intensity of the global energy supply improved only slightly over the last 40 years, but with growing energy demand, annual emissions have increased by more than 17 gigatonnes (Gt) of CO_2 per year.*

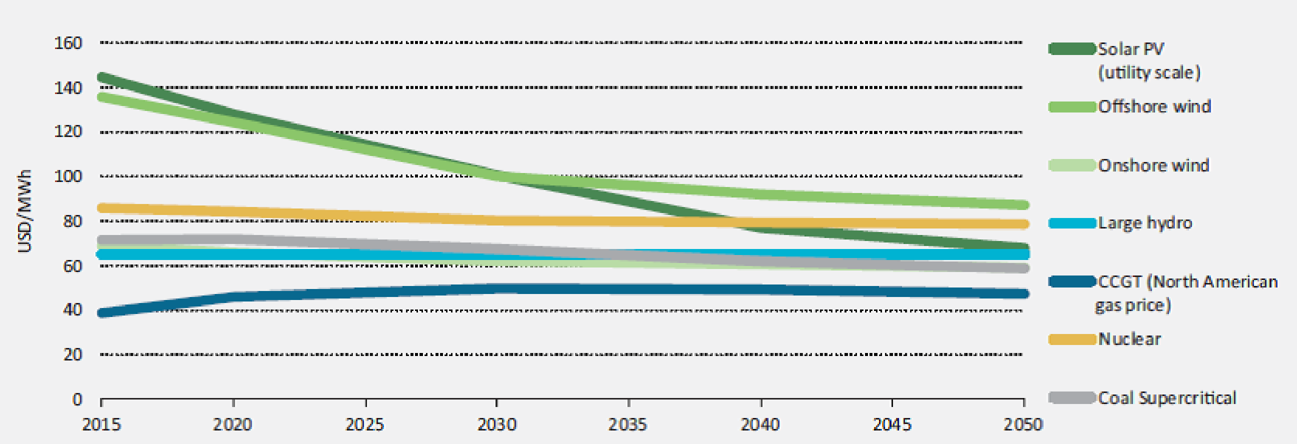
The reason is simple. Fossil fuels still represent 80% of global electricity generation and most of the energy used for transport. To disrupt the curve requires going off fossil fuels to cleaner alternatives. To achieve the 2D scenario, electrification is paramount given the option of generating electricity with clean alternatives. Fossil fuel use must then be cut in half to about 40% of electricity generation and much of the remainder makes use of CCS to reduce its carbon footprint. The report notes that gas must only be a bridging technology to support renewables in the short to medium term as gas still represents a major carbon source. So what's left? Solar and wind to replace fossil fuels and CCS to make them cleaner.

Of course nuclear power is an obvious candidate to make a larger contribution. It is a mature technology and already is an important source of low carbon energy. Given its energy intensity it is certainly feasible to implement more nuclear power on a very large scale. And even with recent set-backs, there are now clear signs of renewal as the industry puts the Fukushima accident behind it.

For example, China continues to expand nuclear power at an ever increasing pace. Japan has reconfirmed its commitment to nuclear although restarts are slower than anticipated and the ultimate level of nuclear in post-Fukushima Japan remains unknown. Russia is increasing its commitment to nuclear and, of most interest, is becoming a major exporter offering innovative risk and financing structures that have not been seen in the market to date. Other markets are also starting to move; the latest being Hungary which has just approved a new plant for the PAKS site. However some other important nuclear markets are having challenges. Korea has cut back its long term plans and France is looking to limit the contribution of nuclear power in the future.

While nuclear power has challenges with public acceptance, this report notes the commercial issues – economics and implementation risk. As can be seen in the following chart, the IEA estimates nuclear to be the most expensive option after off-shore wind. I have not had time to delve into the details and review the numbers. However, taking this at face value, we know that some projects in the west are not doing as well as they should be. On the other hand, standardized series-build in countries like China and Russia are demonstrating a strong path to lower project costs and risks.

Figure 8.1 *ETP's LCOE excluding a carbon price*



Notes: unless otherwise noted, material in all figures and graphs in this chapter derive from IEA data and analysis. PV = photovoltaic. CCGT = combined-cycle gas turbine. MWh = megawatt hour. Figures and data that appear in this report can be downloaded from www.iea.org/etp2014.

Key point *Based on LCOE, low-carbon technologies remain more expensive than generation from fossil fuels over the transition period to the 2DS.*

There is no hi-nuclear scenario in this edition of the report. That is quite unfortunate as a strong renewed commitment to nuclear power is a very good way to help move this plan to achieve a 2D future become a reality. By stating that nuclear power is not meeting expectations, the report lays out a clear challenge. Now it's time to show the nuclear industry is up to it. If we really want to bend the carbon intensity curve, then more than ever, the world needs more nuclear power as an important part of a low carbon future.