UK commits to nuclear new build – a critical decision for the future of nuclear

More than a decade since then Prime Minister Tony Blair launched a review into UK energy policy, a positive decision has been taken to approve the construction of the first new nuclear station in the UK in a generation, Hinkley Point C.

Finally, after more twists and turns than a good British mystery novel, including: EDF's purchase of British Energy, the nuclear accident at Fukushima in Japan, agreement to an innovative Contract for Difference (CFD) type of contract to support the project, the introduction of a significant role for the Chinese, and most recently the Brexit vote; the UK decision shows that Europe remains a nuclear continent.

The project is not without its opponents; some of whom are supportive of nuclear new build in the UK, but do not support

this particular project. Concerns range from the cost of energy to the inclusion of the Chinese. But following extensive review and assessment, the decision has been taken, and its importance goes well beyond just approving a single new nuclear project in Britain.

Following the Fukushima accident in Japan, a number of European countries reconsidered their commitment to nuclear power, the most significant being Germany, who immediately shut down a number of their nuclear units and made a clear plan to retire the remainder. Many said nuclear in Europe, where there are the most nuclear units in the world, is a technology of the past. Renewables are the future. Even the French government, with the world's largest nuclear fleet in terms of share of electricity generated, said it would cut back on its use.

Through it all, the UK maintained its strong commitment to new nuclear. Its existing fleet is aging and with domestic gas waning and energy imports on the rise, it recognized that new nuclear is the best, and likely only way, to both achieve energy security and meet its carbon reduction goals.

While all the talk has been about delays in securing approvals for its new nuclear ambitions, EDF Energy, the operator of the current UK fleet, has been quietly going about its business and making game-changing improvements in its operations. On September 16, Heysham II was taken off line after 940 days of continuous operations, a new world record beating the record held by Pickering Unit 7 in Canada (894 days) for more than 20 years. **[***As we all think about light water reactors (PWRs and BWRs) as the global standard, we often forget that these other reactor types, AGR in the case of Heysham and CANDU in the case of Pickering, have their own specific advantages.***]** In addition, EDF has been able to extend the lives of the AGR fleet by an average of 8 years. This shows the strong capability of EDF Energy as an operating entity and bodes well for the next step; new build.

So why is the approval of Hinkley Point C so important to the nuclear industry? First of all, it is the first new build nuclear project in the UK since Sizewell B came into service in 1995 and, even more importantly, is expected to be the start of a major ongoing new nuclear program. It is the base to rebuild the UK nuclear supply chain, once a world leader, and support the broader European nuclear supply chain. It is the first new unit to be built supported by a CFD type agreement and as stated by Duncan Hawthorne, CEO of Horizon Nuclear, likely the next to build in the UK, it "blazes the trail" for those that follow. The UK is taking an interesting approach to new nuclear going forward as there are multiple companies who are planning to build a multitude of designs (EDF Energy with the EPR, Horizon with the ABWR, NuGen with the AP1000 and CGN with its HPR1000). And finally, after years of cooperation in China, it entrenches EDFs global partnership with CGN and establishes China as a reputable exporter of nuclear power.

But most of all, it is further evidence that Europe remains a nuclear continent. While most articles on nuclear tend to say nuclear is languishing everywhere except for its saving grace – China – Europe is moving forward. Sweden is taking real steps to keep its fleet operating, France and Finland have new build underway albeit while experiencing First of a Kind (FOAK) issues, Finland now has a second new unit going ahead, Hungary is waiting for an imminent decision from Europe on state aid and is ready to start its a new station at Paks, with other countries continuing to plan for new nuclear plants. And now the UK starts a new program – one that will ultimately include a number of vendors and countries.

Of course the real challenge is just beginning – that is for EDF Energy to demonstrate that it can build Hinkley Point C on time and on budget – and as the 5th and 6th EPR units to be built, there is certainly a very good chance that they will.

Nuclear, a technology of the past in Europe – I don’t think so – in Europe nuclear power is a technology of the future.

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.

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.

If we are serious about carbon free electricity – there must be more nuclear power

Last month, we wrote about the ongoing push by the United Nations to combat climate change and its underwhelming support for nuclear power as an important part of the solution. To no one's surprise, the final volume of the current IPCC report on climate change issued November 1 is no different. Yet this report is very clear in its conclusion that limiting the impact of climate change may require reducing greenhouse gases emissions to zero this century. So while the world is focused on developing a range of new technologies to meet this challenge, fossil fuel use continues to grow. In reality, the answer is right in front of our eyes. What the world needs is a massive increase in nuclear power.

While many will write about this most recent IPCC report, we want to bring some new perspective and once again discuss the role of nuclear power as an essential tool to reduce carbon emissions. There are a few new studies and announcements this past month that show the paradox of current policies.

First there was a study released in Nature that suggests that even though natural gas emits about half the carbon of coal, abundant natural gas alone will do little to slow climate

change. The study's lead author Haewon McJeon, an economist at the US Department of Energy's Pacific Northwest National Laboratory said, "*Global deployment of advanced natural gas production technology could double or triple the global natural gas production by 2050, but greenhouse gas emissions will continue to grow in the absence of climate policies that promote lower carbon energy sources*." This is in contrast to many who believe that gas is an important part of the solution. We have no issue with gas and believe it can be an important part of a diversified electricity system; but according to this study, it is not a great tool in the fight against climate change.

Of even more relevance to the discussion, a recent report issued by Hatch Ltd. in Canada,"*Lifecycle Assessment Literature Review of Nuclear, Wind and Natural Gas Power Generation*", demonstrates the challenges of relying too much on wind to drive down emissions. This report notes that wind as an intermittent resource is usually backed up by gas. So if wind generally operates about 20% of the time, the gas backup would be operating the other 80% continuing to emit carbon. Therefore nuclear emits some 20 times less carbon than a wind/gas combination (see figure below). Most of us in the energy industry know this is why gas producers are often strong supporters of wind and solar. While the public believe wind is good for the environment; it's even better for the gas industry.

Even the wind industry acknowledges these results. They note this is only one scenario and that there are more plausible scenarios where wind would be supported by demand side management, storage and other means of clean generation. This is indeed a laudable goal for the future, but the reality remains, today most renewables are backed up by gas.

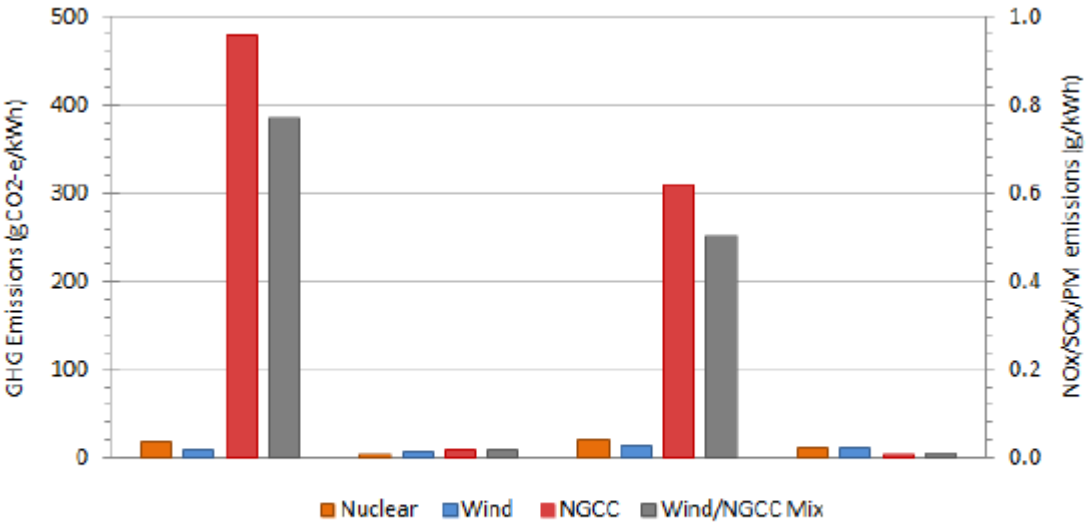


Figure 18. Summary of Total Lifecycle Emissions

All of the above would suggest that there should be more support for nuclear as a very important element for a solution to climate change. It is effective and available today and most of all can provide large amounts of clean reliable electricity.

In fact, the public is quite aware of this. A just released study in the USA is showing eighty-two percent of those surveyed agree with the statement, “We should take advantage of all low-carbon energy sources, including nuclear, hydro and renewable energy, to produce the electricity we need while limiting greenhouse gas emissions.” Further 75 percent of those polled said nuclear energy will be “very important” or “somewhat important” in meeting America’s future electricity needs. Seventy-three percent of those surveyed associate nuclear energy with clean air. Clearly a very important step in securing the support required to increase the use of nuclear energy.

On the other hand, we have also seen more negative political views. In Sweden, after reconfirming the need for more nuclear power in 2009; the outcome of the most recent election had the new government stepping back in order to gain support from the Greens. Social Democrat leader Stefan Lofven said “*Sweden*

has very good potential to expand renewable energy through our good access to water, wind and forests. In time, Sweden will have an energy system with 100% renewable energy." Reality clearly has no place in politics.

And of even more concern is the recent vote by the French parliament to reduce the use of nuclear energy from 75% to no more than 50% by 2025. They must remove a plant from service when Flamanville comes into service in the next year or so as the amount of nuclear power cannot increase. And it looks like the French president himself will take the decision on which plant to shut down. Taking safe clean reliable power out of service prior to its end of life purely as policy seems foolish at best. The Hatch study shows this strategy will most likely lead to increased use of fossil fuels and thus higher carbon emissions at least in the short to medium term. This is exactly what we have seen in Germany. Taking a large amount of nuclear out of service is requiring the construction of new coal generation even though Germany is expanding renewable generation at a very high rate.

So what does this all mean? As we have said many times before, removing and / or reducing nuclear strictly for policy reasons, especially in the case of successfully operating units means only one thing – that there remains an overriding societal belief that nuclear is not safe – and therefore less is always better than more. While some environmentalists now realize this is not the case; this truth has not yet caught up with the public at large and hence is not always supported by their politicians.

The IPCC report is clear that the world must take action to combat climate change. Nuclear power is the only large scale source of clean abundant reliable electricity generation available and that should make it an essential part of the solution. Trying to generate all electricity with zero carbon emissions without making extensive use of nuclear power is simply making what is already very difficult, pretty much

impossible.

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.

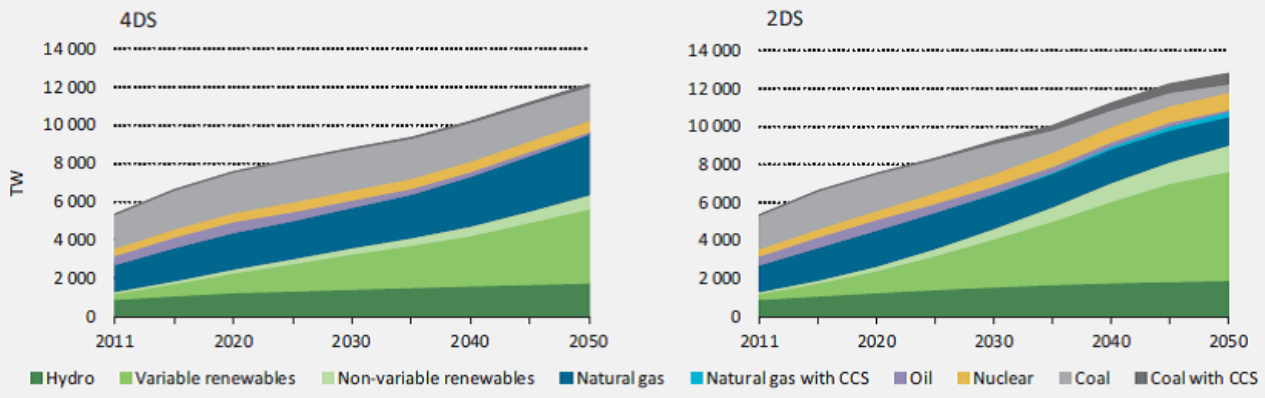
On the positive side, the IEA sees the opportunity by which "*policy and technology together become driving forces – rather than reactionary tools – in transforming the energy sector over the next 40 years.*" The report looks to balance energy security, costs and energy-related environmental impacts. 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.

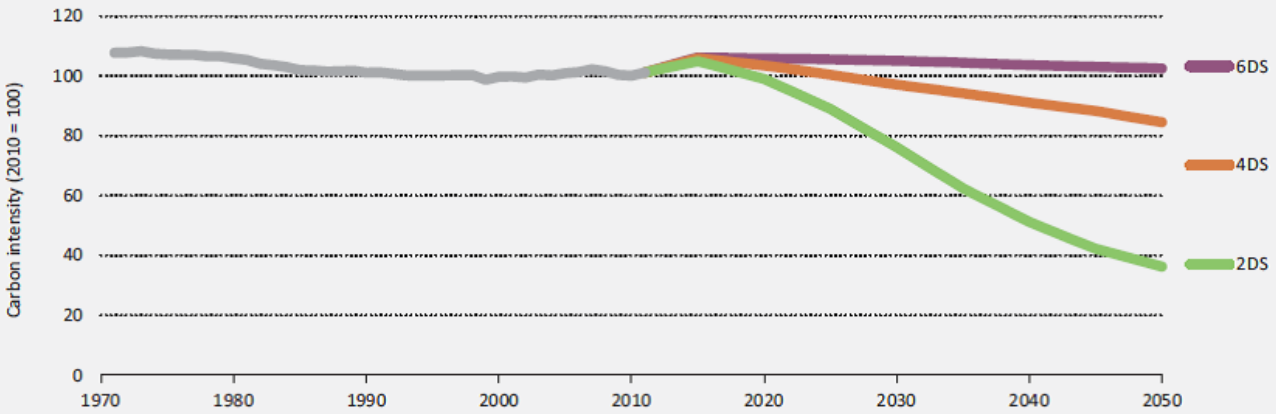
Figure 3.4 Global electricity generation capacity by technology



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.*

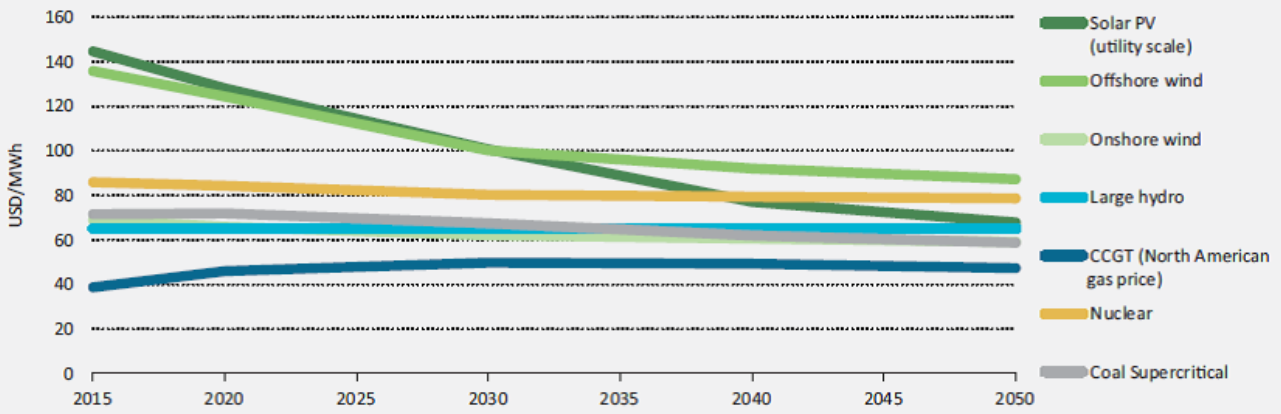
The reason is simple. Fossil fuels still represent 80% of global electricity generation and most of the energy used for transport. To disrupt the curve requires going off fossil fuels to cleaner alternatives. To achieve the 2D scenario, electrification is paramount given the option of generating electricity 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.

It's passion that will lead to brighter nuclear future

Last month I talked about innovation in the nuclear industry focusing on the perception that nuclear is not innovative. Since then I attended the Canadian Nuclear Association annual conference. Its theme this year was "Developing the next

generation” which in this case focused on developing the workforce of the future.

While the discussion at the event was about Canada, the theme can be applied to many countries. Essentially, it was noted that the industry has numerous opportunities that offer well paid interesting work for the long term. And, of more importance it was made clear that the industry is only as good as its people; hence the need to attract the best and brightest.

With all the good discussion, what caught my interest was the guest breakfast speaker, Taylor Wilson, known has the boy who played with fusion. At 19 years old, he gave a great talk (already having given two TED talks) about his passion for all things nuclear. I am not going to discuss Taylor’s achievements or strong technical skills, both of which are certainly impressive; and he is also extremely articulate proving that scientists can indeed communicate well. But what really got me excited was his passion for nuclear science. This passion ignited the audience by reminding us all of our own passion for the industry.

I remember being a young student studying nuclear engineering at RPI in Troy New York during the 1970s. What drove me to go into nuclear was the mystery and excitement of this still relatively young industry. I wasn’t looking for a job; I was looking for a future. The oil shocks had happened and it was clear that the world needed alternate energy. Being able to provide almost limitless energy to power the world, nuclear power seemed to be the solution and I wanted to be part of it.

I was not unique. Many of my colleagues; many of whom (older than me) were the pioneers of nuclear energy, were inspirational in their dedication and passion for nuclear power. I am not talking about the early great scientists who harnessed the atom, but rather the next wave of people, both technical and political who drove the industry forward

securing commitments to, and then building the 400 plus Generation II reactors in service today. This past December was the sixtieth anniversary of President Eisenhower's Atoms for Peace speech to the United Nations. This speech launched a new industry around the world. I would name some of those who contributed but they are too many and I don't want to leave anyone out. Rather, I invite you in your comments to note who inspired you either to enter the industry or along your career to keep on moving forward. (Some of the pioneers of the Canadian industry are listed here.)

And they succeeded. They developed one of the most important energy technologies known to man. In less than fifty years, an idea was turned into a commercially viable energy technology meeting about 12% of global electricity. And that number, of course, is deceptive since about half of the countries that rely on nuclear energy use it for 20% or more of their electricity supply.

Of course there have also been numerous challenges along the way that saw the industry slowdown in the latter part of the twentieth century. Recent developments as the world looks for solutions to climate change has re-ignited interest in nuclear power as a part of the solution. This is also in the context of the 2011 accident in Japan which once again raised fears of the industry and its potential negative impacts.

For most of us who have spent our careers in the nuclear industry, we remain just as passionate today as we were when we were young and our belief in the benefits that nuclear energy bring to society continues to be strong. There are others who have been worn down by the relentless effort required to sell these benefits and the years of attacks against the industry. The result is a defensiveness along with a weariness that has reduced efforts to move forward as many in the industry focus on survival. It is now time for a new generation of passionate young people like Taylor Wilson to take this industry into the future. I know they exist.

There is the nuclear Young Generation Network (YGN) with chapters around the world. For those of you YGN members who read this, please give your views.

It is not just about opportunities for employment, but rather about opportunity to make a difference. The question becomes, not how do we find the nuclear workers of the future – but how do we inspire the passion in a nuclear future that we all had (and continue to have) when we started our careers to attract the best and brightest to our industry going forward? I would guess that if you went to any university graduating class and asked for the 10 most innovative and exciting industries of the future, we would likely not make the list.

I talk about communications in this blog quite often. But most of the time I talk about how we can promote the industry and reduce the fear of radiation in the public. But we must also consider how to communicate to a new generation of potential nuclear industry professionals the excitement, innovation and societal imperative so that they can develop their own passion.

I love working in this industry and I wouldn't change my experiences for anything. Now it's time to help build the industry of the future – and that means inspiring young people to take a leap of faith and jump on board.

When it comes to our need for electricity, reliability is

essential.

As we come to the end of another year, it is not a nuclear issue that I want to discuss but rather the broader issue of our need for reliable electricity. Last month I started with a quote from the IEA's World Energy Outlook 2013 highlighting how important energy has become to our society – affecting the economics of nations and our environment as well as our daily way of life.

Over this holiday season in North America the importance of electricity to our very survival has become more evident. On the Friday before Christmas the northeast United States and Canada were hit with a massive ice storm. Hundreds of thousands of people lost power. The cause was primarily due to power lines being affected both directly by intense icing as well as by debris from trees and other items that fell onto the lines as they became heavy with ice causing the lines to fall.

And here we are days after Christmas and while most households have had their power restored (many after more than 5 days without), thousands continue to wait. This is different from other extreme weather events such as hurricanes that have been responsible for mass destruction of homes and infrastructure. This ice storm, while also an extreme weather event, has only caused power loss as its lasting effect. The result is we are able to specifically see the importance of electricity to our modern societies.

So what is the impact of a prolonged loss of electricity? Frankly it is very difficult for those without – especially for those most vulnerable – the elderly, the sick and those without friends or family nearby to take them in.

Living a large city in a cold climate, just imagine your home without heat in subfreezing weather, no power for the refrigerator or freezer (although outdoors can work), no water to flush the toilet or bathe or even more importantly drink; and you have the makings of a catastrophe – people freezing and hungry without the basics required for survival. And to make matters worse it is over the holiday season when most had plans to be with family. In some cases large family holiday meals were no longer possible as the emphasis was on finding ways to stay warm. The added downside of the season is that on Christmas almost everything is closed, no supermarkets, very few restaurants; no services of any type.

On the positive side, the number of people without power is now in the minority so there are many options for them to seek help and get warm. But others continue to struggle. The news has recently reported on police and fire departments having to visit large apartment buildings and take elderly sick residents down numerous flights of stairs to safety. These people have been stuck in their cold apartments for days without food or water. With no one to check on them, their lives were at risk.

As stated earlier, the cause of this mayhem is related to the transmission and distribution system failing in the weather, not generation. But the point to be made is that without electricity in our cities; it would only take days until the population would need to find ways to feed and warm themselves on mass.

So it is pretty obvious that we need to have reliable electricity supply to keep society working. And reliable supply means robust generation and distribution. Our aging infrastructure can no longer be left to decay further so that with every extreme weather event, we take days or weeks to recover. After the major blackout in the North American northeast a decade ago, the focus was on ensuring system reliability. The rules changed and all North American utilities now adhere to these rules, making our system better. But here we are a decade later and the issue has changed. It is no longer about reliability in general, but the ability to withstand extreme weather events. And most of all our ability to recover when the system is damaged during such events.

And of course we have the issues associated with individuals that oppose what is necessary to keep our system running. For example, power lines have fallen when tree branches have damaged them. While simple measures like pruning may be the cost-effective way to protect power lines, it can carry a public-relations price. As stated by the CEO of Toronto Hydro "You can imagine … our arborists show up on the curb and knock on the door and say 'We're here to cut your branches down.' They're not necessarily a welcome news," he said. "So it's really finding that right balance." This shows that no matter what the issue, there are always those opposed (as with those opposed to nuclear power); but these are also usually the first to complain when they lose power and need their lines restored.

So while this is not directly about generation or nuclear

power, it is important to remind ourselves of the importance of reliable supply as we continue the debate on how we want to generate our electricity going forward. Robust, reliable baseload electricity is important. And this is where nuclear power plays a very important role. We also talk about economics and environment. Both essential – so how can we meet the challenge of having reliable, economic and environmentally benign electricity?

As we prepare to enter a new year, let's remember that fossil fuels like coal and gas are reliable, can be economic, but impact our environment. Renewable sources like wind and solar are good for the environment but can be costly and unreliable. Nuclear Power is an important source of electricity that can provide large amounts of clean, reliable and economic electricity to keep our society moving.

I hope that all power is restored to those without as soon as possible so they can enjoy what is left of the holiday season.

Wishing you all a very happy and healthy 2014

Meeting the energy needs of the 21st century – is it time for a real nuclear renaissance?

As I started to read this year's World Energy Outlook (WEO 2013) from the International Energy Agency (IEA), it was the very first line in the executive summary that caught my interest. The report starts out with "**Many of the long-held**

tenets of the energy sector are being rewritten."

It then goes on to explain: "*Major importers are becoming exporters, while countries long-defined as major energy exporters are also becoming leading centres of global demand growth. The right combination of policies and technologies is proving that the links between economic growth, energy demand and energy-related CO2 emissions can be weakened. The rise of unconventional oil and gas and of renewables is transforming our understanding of the distribution of the world's energy resources. Awareness of the dynamics underpinning energy markets is essential for decision makers attempting to reconcile economic, energy and environmental objectives. Those that anticipate global energy developments successfully can derive an advantage, while those that fail to do so risk making poor policy and investment decisions.*"

What is clear is that energy is important! Most of all there is change in the air – ignore it at your peril. And with change comes opportunity. This is where I want to focus my discussion this month. But before I go on, I think it is useful to summarize the key points from the report to further clarify the paragraph above. The WEO 2013 is concluding the following:

- The centre of gravity of energy demand is switching decisively to the emerging economies, particularly China, India and the Middle East, which drive global energy use one-third higher.
- As the source of two-thirds of global greenhouse-gas emissions, the energy sector will be pivotal in determining whether or not climate change goals are achieved.
- Large differences in regional energy prices have started a debate about the role of energy in unleashing or frustrating economic growth.
- Energy price variations are set to affect industrial competitiveness, influencing investment decisions and

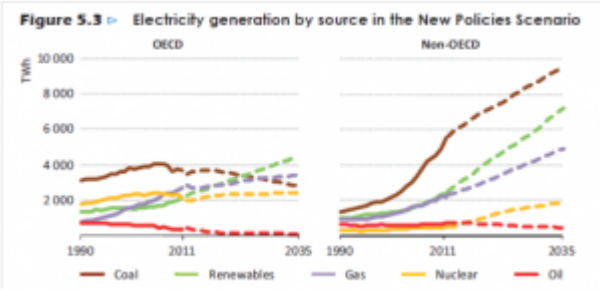
company strategies.

- Countries can reduce the impact of high prices by promoting more efficient, competitive and interconnected energy markets.
- A renewed focus on energy efficiency is taking hold and is set to deliver benefits that extend well beyond improvements in competitiveness.
- Enhancing energy competitiveness does not mean diminishing efforts to tackle climate change. Renewables account for nearly half of the increase in global power generation to 2035, with variable sources – wind and solar photovoltaics – making up 45% of the expansion in renewables.
- Coal remains a cheaper option than gas for generating electricity in many regions, but policy interventions to improve efficiency, curtail local air pollution and mitigate climate change will be critical in determining its longer-term prospects.
- Market conditions vary strikingly in different regions of the world, but the flexibility and environmental benefits of natural gas compared with other fossil fuels put it in a position to prosper over the longer term.

So there you have it. The fastest growing economies have the fastest growing demand, high energy prices are slowing growth in some markets and giving an economic advantage to others with lower prices; and climate change is having an impact on energy decisions.

The above makes it sound as if the path to a low carbon future is built on more renewables and gas. But is it really? Looking at the following chart we can see that in the OECD countries where demand growth is modest and electricity supply is already robust, gas is the go-to fuel both due to cost and as a cleaner alternative to coal; and renewables are the supposed clean generation of the future. Not surprisingly in the non-OECD countries where demand is growing much more

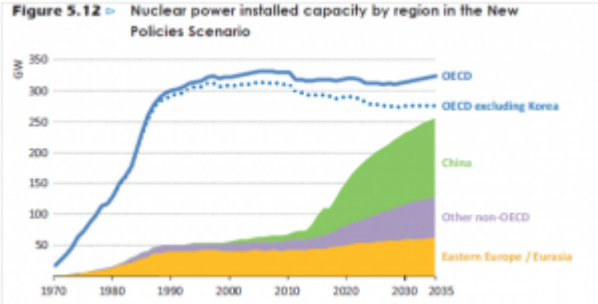
quickly (read mostly China!), they are doing everything they can to develop all kinds of supply – including more coal, more gas, more renewables and yes, more nuclear.



So what does this mean for nuclear power? According to the IEA, "*Nuclear power generation increases by two-thirds in the New Policies Scenario, reaching 4,300 terawatt-hours (TWh) in 2035. Demand is driven heavily by expansion in just a few countries: China accounts for around half of the global increase; Korea experiences the next largest increase over the projection period (the only OECD country to see appreciable growth), followed by India and Russia. Overall, non-OECD economies see their share of global demand for nuclear power jump from less than 20% to nearly 45% in 2035. While prospects for nuclear power at the global level are now less uncertain than they were two years ago, there are still key issues that remain unclear. These include the possibility of further changes in government policy, implications of the ongoing safety upgrades for plant economics and public confidence, and the impact of increased competition from shale gas*."

It should not be a surprise that those countries with the largest demand growth see a large benefit from increasing the use of nuclear power. They need clean reliable baseload and nuclear meets this need. In the more advanced OECD countries, many of these already have significant nuclear fleets (80% of current nuclear capacity is in OECD countries), have lower baseload growth and can (or at least they think they can) look at other alternatives. Gas is replacing coal as a cleaner fossil option so long as it remains competitive and the

challenges of new nuclear coupled with low demand growth put it more on the back burner.



But is this the right path? As I said last year when I reported on the WEO 2012, it is important to remember the WEO is not a forecast per se; rather it is a projection of how existing and potential government policies would look once implemented. And what we still see one year later is a world investing heavily in fossil fuels to protect the status quo while also investing in renewables as a token path to the future. Of more importance, the WEO shows a path to meet climate change goals that is based on efficiency to lower demand, movement from coal to gas and CCS technology to clean up some of the coal and then more renewables.

What goes unsaid is how this is fantasy. Not that the world will continue down the path of burning fossil fuels for our electricity, but rather that we can do so and meet climate goals. The 2013 WEO New Policy scenario "*leaves the world on a trajectory consistent with a long term average temperature increase of 3.6C, far above the internationally agreed 2C target*". In their 450 scenario where the target is 2 degrees, there is more renewables, more conservation, more technology to clean fossil fuels and yes, a little more nuclear.

Given the need to decarbonize the electricity sector and the limits to using wind and solar (about half the renewable additions), it should be obvious that nuclear be a stronger option. Yes, currently in North America low gas prices are challenging its competitiveness while in Europe, green

ideology has a larger impact. There is a onetime carbon improvement as coal is replaced by gas; but then gas becomes the largest carbon producer on the system – so where do we go from there? And renewables will remain intermittent and likely costly for some time to come. Nuclear power is clean, reliable and in most cases, economic; but of most importance – abundant. Yes, in a resource constrained world, the amount of electricity we can potentially generate with nuclear power is almost limitless. So why don't we see more of it in the developed world?

The answer is that we still don't have the political will. And that comes from lack of public support. Just this week the World Bank reiterated its policy that they don't support nuclear power – even though they support all other forms of electricity generation. Continued negative press about the status of Fukushima keep the public on edge. For example this past month TEPCO started to remove the used fuel from the Unit 4 spent fuel bay. This should have been a good news story yet most stories made it seem like a horrifically dangerous undertaking (and of course it is not).

The WEO makes the case that government support is what drives nuclear. "*The rate of expansion of nuclear power continues to be mainly policy driven. It expands in markets where there is a supportive policy framework, which in some cases actively targets a larger role for nuclear in the mix in order to achieve energy security aims. But policy frameworks can also hinder or eliminate nuclear power, often as a result of public opposition: even where there is no explicit ban, long permitting processes, such as in the United States, can significantly hinder development by increasing uncertainty about project completion and increasing costs*."

I was listening to a radio interview this past week with climate change scientist Richard Peltier. [Interview starts at about 31:40 in the link]. He makes a strong case for getting the message out about scientific consensus. While he

notes that between 95 and 98% of scientists agree on the science of climate change, the press reports make it seem there is much more disagreement than there really is with the result that the public is confused. The answer is to get out and speak at the grass roots level. Governments will not strongly support policies that battle climate change until the public believes it is necessary. The same is true for nuclear power. Governments will not strongly support increasing its use until the public are in agreement that it is safe and necessary.

We are seeing some progress. In Pandora's Promise, five environmentalists are now convinced of the advantages of nuclear power and they are actively advocating its use. This past month four other environmentalists have released an open letter calling on world leaders to support development of safer nuclear power systems. In their letter they state, "*As climate and energy scientists concerned with global climate change, we are writing to urge you to advocate the development and deployment of safer nuclear energy systems. We appreciate your organization's concern about global warming, and your advocacy of renewable energy. But continued opposition to nuclear power threatens humanity's ability to avoid dangerous climate change*."

Some governments are also taking on the challenge. In the UK there is pretty much political unanimity that new nuclear is required to meet their climate goals. The result is strong political support for nuclear new build. A recent quote by Hergen Haye, Head of New Nuclear & Strategy, Department of Energy and Climate Change (DECC), UK government *"To replace Hinkley alone, we have to build 6000 wind turbines. Nuclear will help us to cut costs and to face the other environmental challenges. We cannot do without nuclear because renewables will not do things alone without making electricity bills rise." (*21 November 2013 in Brussels).

In France, after pandering to the greens and committing to

close Fessenheim, the French government is finally saying that there will not be more closures. We see strong political support where nuclear is needed most in China, Russia and India although Korea is wrestling with their future plan due to recent scandals.

I come back to the first line of the WEO 2013, "**Many of the long–held tenets of the energy sector are being rewritten.**" This is a time of great opportunity. So let's make sure nuclear power is playing its increasingly important role by providing clean reliable generation to support economic growth and a brighter more secure future for us all.

The only thing more powerful than the truth is fear

As I was thinking about what to write this month, I was invited by my dry cleaner to attend a protest in a nearby park against genetically modified food. This somewhat infuriated me as I know without doubt that GMO has helped millions around the world and had never killed anyone (although denial of these foods has), yet, as with nuclear power, opposition remains strong, especially in Europe.

My dry cleaner argued trying to tell me that 500,000 were killed in India due to GMO and, as you can imagine, there was no winning the argument. Mark Lynas, who I have quoted in previous posts has recently taken a hard stand against those who oppose GMO. Mark makes his position clear in his talk at Cornell University this past April where he opens with the following: *"I think the controversy over GMOs represents one of the greatest science communications failures of the past*

half-century. Millions, possibly billions, of people have come to believe what is essentially a conspiracy theory, generating fear and misunderstanding about a whole class of technologies on an unprecedentedly global scale."

It is no mistake that environmentalists like Mark have also changed their views on nuclear power and are now vigorously supporting it. The simple reason is that Mark and others like Stewart Brand and George Monbiot, are taking positions that are founded in science rather than a set of beliefs that may feel right, but cannot be supported by scientific evidence.

Most of the opposition to nuclear power is founded in fear – primarily the fear of radiation. However, scientific evidence continues to grow demonstrating the benefits of nuclear power while disproving widely held beliefs of many who oppose it.

For example, this past week (on May 23), a new study was reported on by the Canadian regulator (CNSC) looking at cancer rates near Canadian nuclear plants. Not surprisingly, once again the results were clear. No indication of any increases in cancer near nuclear stations relative to the rest of the province. "*The most important finding of this study is no evidence of childhood leukemia clusters in the communities within 25 km of the Pickering, Darlington and Bruce NPPs*."

Next I return to the study I wrote about last month published in the Journal of Environmental Science and Technology by Pushker A. Kharecha and James E. Hansen of the NASA Goddard Institute for Space Studies and Columbia University Earth Institute. They found that nuclear power has saved an estimated 80,000 lives annually – 1.84 million in all – since widely introduced in the 1970s and could save another 5 million if construction continues at a decent pace due to a reduction in air pollution. Nuclear power has also reduced carbon emissions by 64 Gt over the same period.

And finally UNSCEAR has now released the results of its latest

study on the Fukushima accident. It clearly concluded "*Radiation exposure following the nuclear accident at Fukushima-Daiichi did not cause any immediate health effects. It is unlikely to be able to attribute any health effects in the future among the general public and the vast majority of workers*". But of even more importance this study also concluded that there are health effects from the Fukushima accident stemming from the stresses of evacuation and unwarranted fear of radiation.

So what does all this tell us? Looking at these three studies we can confirm that

i) operating nuclear power plants do not cause cancer to the residents of nearby communities from normal operations;

ii) over the past 40 years nuclear power has in fact saved almost 2 million lives through a real reduction in pollution by not burning fossil fuels and its resultant health impacts; and finally

iii) that after the biggest nuclear accident in the last 25 years, radiation has not harmed any of the people of Japan and is unlikely to do so in the future.

Considering these kinds of results, why aren't we seeing this reported in the main stream media? With this kind of story there should be universal praise of nuclear power and strong support for its expansion. Frankly, if it were any technology other than nuclear that was reported to have saved millions of lives we likely would have seen it in the headlines at CNN, BBC and other mainstream media. So why are we primarily seeing these nuclear studies reported in trade magazines and blogs? Why is the world not blown away by this fantastic evidence of the benefits to our lives of nuclear power? As I was pondering these developments I came upon a chapter title in the book I am currently reading by Ben Goldacre called "Bad Science" (Good book by the way). The

chapter title is "**Why Clever People Believe Stupid Things**". The chapter then goes on to discuss many of the things we have discussed in this blog before such as confirmation bias, seeing patterns where there are none and a host of other standard reasons why people tend stick to their beliefs in light of strong evidence that they should consider alternatives.

The reality is that some people will never change their view of nuclear power and will oppose it no matter what evidence is brought before them. But for those of us who are frustrated, there is hope. We are starting to see positive change. We have well known environmentalists seeing the benefits of nuclear power. This is now captured in the new documentary "Pandora's Promise" coming in June. Film maker Robert Stone is quoted as saying "*It's no easy thing for me to have come to the conclusion that the rapid deployment of nuclear power is now the greatest hope we have for saving us from an environmental catastrophe,*" Entertainment Weekly says "*the film is built around looking at an issue not with orthodoxy, but with open eyes*". (I know some of you have already seen it. I haven't seen it yet but I am looking forward to it).

Our story is strong. The message is positive and one of hope for the future. But overcoming fear is no easy task. Fear is a powerful emotion. It will take hard work, commitment – and most of all – time. But if we all persevere, the future is bright. The time has come to get the message out and show how much nuclear power contributes to society, and how necessary it is in a high energy and resource intensive world.

Pricing carbon in North America

It was with great interest that most of us listened to President Obama put climate change back on the US agenda in his state of the union address this month.

"*After years of talking about it, we are finally poised to control our own energy future. We produce more oil at home than we have in 15 years. We have doubled the distance our cars will go on a gallon of gas, and the amount of renewable energy we generate from sources like wind and solar – with tens of thousands of good, American jobs to show for it. We produce more natural gas than ever before – and nearly everyone's energy bill is lower because of it. And over the last four years, our emissions of the dangerous carbon pollution that threatens our planet have actually fallen.*

But for the sake of our children and our future, we must do more to combat climate change. Yes, it's true that no single event makes a trend. But the fact is, the 12 hottest years on record have all come in the last 15. Heat waves, droughts, wildfires, and floods – all are now more frequent and intense. We can choose to believe that Superstorm Sandy, and the most severe drought in decades, and the worst wildfires some states have ever seen were all just a freak coincidence. Or we can choose to believe in the overwhelming judgment of science – and act before it's too late."

The real question is will there be policy to support acting before it's too late?

I think most would agree that any strategy that would change behaviour requires an economic impact – because we all respond to prices. This means we need a price on carbon; either a carbon tax or a cap and trade program. In the past most

jurisdictions in North America have favoured consideration of the cap and trade approach as new taxes (to nobody's surprise) are very difficult to implement. In North America (in contrast to Europe) we generally believe we have a right to low cost energy and there is genuine concern that higher energy prices further weaken the economy and negatively impact jobs. And with jobs being a huge priority, many have said that there will not be any price on carbon in the foreseeable future.

But for all of those who have said there will never be a price on carbon in America, I am sorry to say – YOU ARE WRONG. Today there is a price on carbon – the only problem is that it is negative. That's right – its negative. In other words, we have significant subsidies on oil and gas that encourage more production and consumption; whereas pricing carbon positively would encourage reduced oil demand and use of lower carbon alternatives.

The 2012 World Energy Outlook (WEO) shows ever-growing subsidies to fossil fuels. It only considers consumer and consumption subsidies, commonly applied in the developing world and in oil producing countries. In 2011, this subsidy amounted to almost $300 billion, far greater than any other form of energy.

In North America we do not provide consumer subsidies for oil but rather producer subsidies in the form of tax relief through various exemptions and special provisions in the tax code. Most talks by President Obama have quoted the cost of these subsidies at about $4 billion per annum federally (some estimates show that state subsidies are many times greater than the federal subsidy). In Canada, subsidies to the oil industry are estimated at about $2.8 billion per annum (both federally and provincially).

The argument in support of these subsidies is that they are generally intended to encourage drilling, agreeably a very

risky endeavour. The arguments against fall into two categories: first there are many subsidies that have outlived their usefulness but somehow are never removed from the books; and second, that at a price of over $100/bbl, oil companies are making record profits (the three largest oil companies made profits of $80 billion or $200 Million/day in 2011) so they shouldn't need subsidies to encourage them to find more oil, i.e. the current price of oil is incentive enough.

Examining the subsidies a bit further, we can calculate the cost (if you see any errors in my calculations, please let me know). Using production data from the WEO 2012, we can take $4 billion and divide it by 8.1 mb/d in the US and take $2.8 billion and divide by 3.5 mb/d in Canada. The result is about $1.35/b in the US and $2.20/b in Canada. Assuming a carbon content of about .43 t/bbl would result in a subsidy cost per tonne of carbon of just over $3 in the US and about $5 in Canada. The US number is smaller because it is limited to federal subsidies while the Canadian number is for both federal and provincial subsidies. What this shows is that carbon indeed has a price and it is negative, i.e. it incents more fossil, rather than less or alternatives.

So let's take this one step further. Again going back to the WEO, they assume a carbon price reaching $45/t in the New Policies Scenario (base case – continue down the current path) rising to $120/t in the low carbon 450 ppm scenario. Or to put it more simply, a large positive price on carbon (equivalent to $20-50/b) rather than the current subsidy (i.e. negative price) is required to move the world to a low carbon scenario that will actually have an impact on climate change.

In summary, if a price on carbon is a key tool to help reduce fossil fuel use and combat climate change, then we are clearly going in the wrong direction. Because yes, today we do have a price on carbon in Canada and the United States – and it is negative.

Note to readers – I did not comment on the benefits of nuclear in this blog as I was focused on making a point about the impact of subsidizing oil and gas prices. There have been a number of other blogs that have done a good job on this point. See Steve Alpin's blog showing how Ontario in Canada has drastically reduced its carbon emissions through increasing production from its nuclear fleet while reducing coal use. There is also the point to be made about how large a subsidy is required to implement renewables even with large carbon prices. And there is the pressure that most are expecting to come to Canada from the US in exchange for approval of the Keystone pipeline. But we will leave that for another day……