Vol. 43, No. 3 July 2014

PHYSICS & SOCIETY

A Publication of The Forum on Physics and Society • A Forum of The American Physical Society

Editor's Comments

The article in the April, 2014 issue by Mycle Schneider, *The Status of the Nuclear Industry in the World – Dawn or Dusk?*, concluded that "The global nuclear industry is well in the dusk with little prospect of seeing the dawn again." This view is not shared by all and we present two responses in this issue. First, Wallace Manheimer points out that renewable energy is not ready and, if we intend to reduce our fossil fuel consumption, nuclear energy is the only viable alternative. Then, Vojin Joksimovich reviews the global status of operating nuclear plants and planned construction and concludes that the Fukushima accident has created a temporary stagnation in nuclear energy, but an increase is inevitable.

Meanwhile, Mycle Schneider has a new article in this issue that looks at the current status of the Fukushima site and raises concerns over the challenges faced in the long-term stabilization of the area.

Stepping away from nuclear energy, we also have an article originally printed in APS' "Capitol Hill Quarterly" by US Representative Ted Yoho on the importance of federal investment in R&D. Congressman Yoho is a Republican and a member of the Tea Party Caucus.

Finally, we have two book reviews, one on "The Physics of War," and the other on the history of Israel's nuclear weapons program. In our April issue, we regretfully had identified the author of one of the reviews incorrectly and while we fixed that immediately in the online edition, we make the correction in the printed version now.

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IN THIS ISSUE

LETTERS

This letter concerns Mycle Schneider article in the April 2014 newsletter arguing that nuclear power is at dusk, not dawn. He presents many statistics, and makes what appears to be a convincing case. However I believe that he is not seeing the forest through the trees. He seems to think that renewables, that is solar, wind and biofuel will ultimately power the world. A Google search of worldwide sources of electricity shows that this is simply untrue. Google it and dozens of images will appear, all showing about the same thing. I have taken one from the Canadian Nuclear Association showing the breakdown of sources of electric power worldwide. It is shown below, along with the link to it. It shows that 98% of electric power is generated by fossil fuel (67%), nuclear (15%) and hydropower (16%) leaving all of 2% to all other renewables, after more than 20 years of heavily subsidized development. Can he seriously believe that renewables can power an energy hungry world any time soon?

He seems to assert that renewables are the fastest growing power source. Wrong again. It is coal. Google world coal usage and again, dozens of images will pop up, all about the same. Below is one from The Energy Collective and the link to it. It shows that coal use has risen by 60% in the past few years.

But if fossil fuels have to be reduced because of resource depletion, climate effects, or both, what else is there besides nuclear power? It simply has to be an important part of the mid century power mix. Paraphrasing Mark Twain, the death of nuclear power has been greatly exaggerated.

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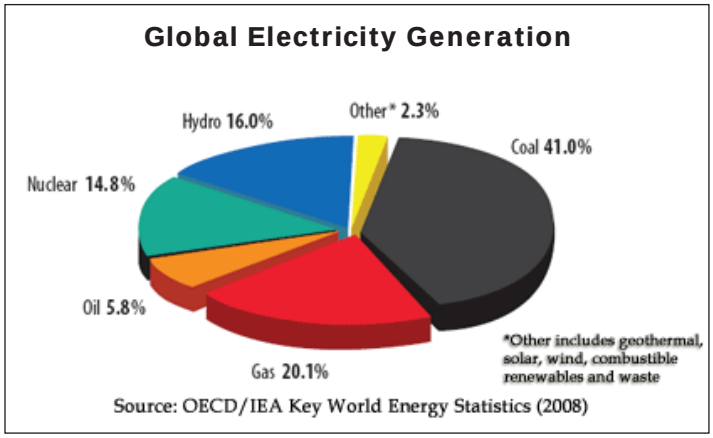

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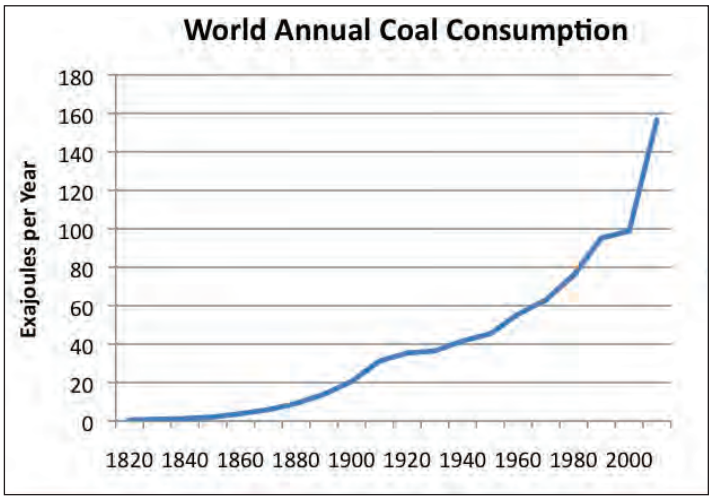

http://theenergycollective.com/gail-tverberg/107831/long-term-tie-between-energy-supply-population-and-economy

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Global Status of Commercial Nuclear Power

*Vojin Joksimovich, PhD**

OVERVIEW

It is highly questionable and misleading to characterize the global status of nuclear power as "Dawn or Dusk" as Mycle Schneider asserted in the April 2014 issue [1]. This author asserts that it is neither dawn nor dusk. It is a temporary stagnation with almost certain rapid rise in the longer term. Current nuclear electricity generation has been distorted by closure of eight German plants and 48 idled Japanese plants after the 2011 Fukushima Daiichi accident. In April 2014 the Japanese cabinet has given its approval to an energy policy, three years in the making, which recommends restart of idled plants.

Nuclear power plants were commercialized in the early 1960s. The construction (new builds) peaked in the late 1970s. The 1979 Three Mile Island accident in the US and the 1986 Chernobyl accident in Ukraine led to phase-outs, slowdowns and moratoriums in a number of countries, mostly OECD countries. The need for base-load power, excellent performance of operating plants, economics and carbon-free electricity led to a nuclear renaissance in the 2005-2006 timeframe. The Great recession of 2007-2008, ongoing conservation efforts and subsequently the 2011 Fukushima Daiichi accident in Japan have resulted in yet other slowdowns, moratoriums and phase-outs in some western countries. In the US cheap natural gas has been a key economic factor.

However, the current stagnation is temporary. Global electricity demand is expected to increase 50% by 2025. The International Energy Agency (IEA) has projected nuclear capacity to increase from the existing 371 GW to 578 GW [2].

According to the *Nuclear News*, as of 12/31/2013 there were 430 operating plants worldwide and 110 were forthcoming [3]. The International Atomic Energy Agency (IAEA) lists 68 units under construction. The World Nuclear Association (WNA) lists 160 units on order or planned. Planned units are those with approvals, funding or major commitments in place, mostly expected in operation within 8-10 years. Current planning doesn't reflect that many climate change experts predict that limiting global warming to less than 2°C cannot be achieved without nuclear power nor does it reflect some recent developments. In the US the Environmental Protection Agency (EPA) recently announced guidelines to cut power plant carbon emissions by 30% of the 2005 figures by 2030. Nuclear power's role in the future US energy mix will likely be the key to achieving this goal. The European Commission (EC) study concluded that nuclear power enhances energy security and should be expanded [4]. Recently G7 named nuclear power as an energy security asset[5}. The Czech government has expressed the common view of ten EU members (Bulgaria, France, Hungary, Lithuania, Poland, Romania, Slovakia, Slovenia, UK) in favor of nuclear power in a letter to the European Commission [6].

It must be recognized that momentum in future nuclear development has shifted to the developing world away from the OECD countries. According to the International Institute for Applied Systems Analysis (IIASA) among the plants under construction as of 6/26/2013 58.2% are being built in the Far East, 18.7% in Eastern Europe and only 5.2% in North America and 4.8% in Western Europe [7]. With regard to operating plants, the US and Western Europe contribute 30.7%

As an illustration, France has provided the world nuclear leadership for over two decades and continues to be a key player with 58 operating plants generating 75% of French electricity as well as nuclear exports to China, Finland, UK, India and elsewhere. France's Areva and EDF signed agreements to support Saudi Arabia's nuclear program. The French government recently announced a policy to cap nuclear energy at the current level of 63.2 GW and to be limited to 50% by 2025. The leadership has been passed on to China and Russia, India, South Korea, and nuclear novices such as UAE, Belarus, Turkey, Bangladesh, Vietnam and others. It is also important to understand the impact of the Fukushima accident.

FUKUSHIMA ACCIDENT

On March 11, 2011 the 9.0 Great Eastern Japan Earthquake produced a 13-15m tsunami which crashed over the seawalls and disabled the electrical equipment needed to run the plant cooling systems. The reactors overheated causing triple meltdowns and triple hydrogen explosions. This is the worst accident in the 55-year history of commercial nuclear power. Although about 16,000 died from the quake/tsunami, none of these were from radiation. This writer has delivered twelve Fukushima accident presentations and presented a paper at the 2012 ANS semi-annual conference [8].

The accident conclusively demonstrated the inaccuracies of long-standing overstatements of public risks from nuclear accidents. Testimony of Prof. Wade Allison, based on his landmark book *Radiation and Reason* [9], as well as reports by the World Health Organization (WHO), UN Scientific Committee on Effects of Atomic Radiation (UNSCEAR) and the Fukushima Medical University (2 million resident surveys) have all concluded that there are no observable health effects. The highest doses reported were 10-50mSv compared to the dose of 30-40mSv this writer has received in a hospital in one evening. Modern radiobiology provides scientific explanations.

The Fukushima accident, like the 1986 Chernobyl accident, has demonstrated that mandatory forced evacuations are counterproductive. The Japanese authorities have used the chronic dose of 20mSv/yr as the evacuation criterion, which is 10,000 times lower than the monthly dose of Japanese radiotherapy patients. In the Fukushima Prefecture, more than 1605 evacuees from their homes have died [10], none from radiation. Indoor sheltering, distribution of potassium iodide pills and a ban on contaminated milk are sufficient to protect the residents.

However, radiophobia (irrational fear of radiation) continues to dominate public perceptions. As a result, 48 Japanese plants have been idle (~30% nation's electricity) awaiting regulatory restart. The regulator, NRA, has introduced the most stringent nuclear safety regulations in the world. Thus far, 17 applications for restart have been filed with the NRA, Sendai units 1&2 have received the safety approval for the restart, and a number of restarts are expected later this year. Ongoing reliance on imported fossil fuels has had an impact on the greenhouse CO2 emissions as well as the trade deficit. Domestic uses of electricity have seen a 19.4% increase, while industrial users have seen a 28.4% increase.

In Germany, 17 nuclear plants generated ~25% of the nation's electricity. Eight of them were ordered to be shutdown 5 days after the Fukushima accident entirely for political reasons. Chancellor Merkel, claiming to be an electoral pragmatist, was concerned that the Green Party would benefit in upcoming state elections and would take the votes away from her Christian Democratic Party. The remaining plants are due to be phased out by 2022. The cost of energy transition, Energiwende, to 80% renewables by 2050, was estimated at 1 trillion euros [11].

No other nation has decided to phase out nuclear power. Italy has abandoned resumption of a nuclear program. Belgium and Switzerland have tentatively decided not to replace aging plants. In the US, France, China, Sweden, Finland and some other countries, the regulatory agencies have arrived at a package of safety enhancements reflecting lessons learned. In the opinion of this writer, the most significant were decisions to establish regional response centers ready to supply portable backup equipment (pumps, generators, hoses) to any of the country's nuclear plants facing an emergency situation. The first American response center is now in operation at Tolleson near Phoenix, Arizona. In France, the EDF has established four regional centers and a central response team to supplement 58 power plants. China has announced a 300-member strong response team to supplement regional response centers.

CHINA

China has approached nuclear power as it did high speed rail, i.e. take the best from around the world: French Pressurized Water Reactors (PWRs), American Westinghouse AP1000 PWRs, and Russian VVERs (Russian PWRs) technology followed by technology transfer agreements to develop domestic expertise and capabilities. The transfer of Westinghouse (W) AP1000 and French PWR technologies is illustrated.

In 2007, W and its partners the Shaw Group received authorization to build four AP1000 units in China: Sanmen 1&2 and Haigyang 1&2. The AP1000 design, Generation III+ advanced evolutionary and passive reactors, has been certified by the US Nuclear Regulatory Commission (NRC). W has licensed its AP1000 technology to the State Nuclear Power Technology Corporation (SNPTC), which has standardized the design, provided construction feedback and added some safety enhancements. AP1000 became CAP1000, C standing for Chinese. CNPTC became the reactor vendor for the Lufeng 1&2 CAP1000 plants, which are under construction with four other units to come. The CAP1000 design was then used as a basis for the conceptual design of a scaled up version of CAP1400 in 2010. In 2011, the basic design of CAP1400 was accomplished with consulting input from W. In April 2014, the first concrete was poured for the base mat at the Shidaowan 1 plant, the first of two demonstration CAP1400 units, scheduled to be connected to the grid in 2018. Conceptual design of yet another scaled up version of CAP1700 is now complete and CAP1400 is intended to be deployed in large numbers across the country. SNPTC has "independent intellectual rights" over the design paving the way for exports. The Shidaowan site is part of the Rongcheng Nuclear Power Industrial Park at which the prototype modular High Temperature Reactor (HTR) or HTR-PM is already under construction. Another 19 of the 210 MW units could follow. The French were initially contracted to build two reactors each at Daya Bay and Ling Ao. After the technology transfer the Chinese launched a program of 20 CPR1000s, which are now either operating or under construction.

China has accomplished unprecedented growth of their nuclear power from 15 units in operation generating 13.5 GW in 2012, or 1% of the nation's electricity, to 18 units in 2013 generating 19.6 GW, or 2% of total electricity generated. Further expected increase is to 58 GW operating in 2020 or 6% with 30 GW in construction, to 200 GW in 2030 or 16%, and to 400 GW in 2050. 28 plants are currently under construction.

Air quality has reached a crisis point with over a million dying each year prematurely as a result of coal burning. Ted Quinn, Past President of the American Nuclear Society stated: "The Real China Syndrome is Bad Air" [12]. Coal plants constitute 75% of generating capacity. The mortality rate from coal in China amounts to 280,000 deaths/trillion kWhr. China contributes to 28.5% of the global CO2 emissions compared to 15% in the US. China, which has built 350 coal plants in the last 7 years, is finally ramping coal down in favor of nuclear, gas and renewables. In December 2013, China's National Development and Reform Commission (NDNC) proposed to

speed up the development of hydro, nuclear, wind, solar and biomass energy. China intends to invest $4 trillion to double the generating capacity by 2030 to 1500 GW. It intends to reduce dependency on coal and hence is pursuing a strategy of building nuclear and renewables as fast as they can. There is no competition between nuclear and renewables.

The Chinese have introduced innovations in construction enabling them to build plants in 56-60 months after the first concrete poured [FCP] . Fuquing units 1&2 are running 3 months ahead of schedule. However, some delays have occurred in building the first-of-the-kind plants like Sanmen 1&2 and Taishan 1&2. For Sanmen 1 the FCP took place in April 2009, the control room was declared operational in April 2014 and the plant is expected to start up in October 2014, while Haiyang is slated for startup in December 2014. Four AP1000s are currently under construction in the US: Vogtle 3&4 in Georgia and Summer 2&3 in South Carolina. They are scheduled for operation in 2017-2019, Vogtle-3 will start commercial operation in the fourth quarter of 2017 with Vogtle-4 a year later.

Another objective of the Chinese program has been to provide a setup for exports. Thus far China has been successful exporting plants to Pakistan. Two CNP-300s are in operation, while two other units are under construction. In November 2013, a ground-breaking ceremony was held for the Karachi Coastal Nuclear Power Project for two 1100 MW ACP1000 plants to be built on turn-key basis by the China National Nuclear Corporation (CNNC). Recently the Chinese have purchased utility interests in the UK, including 30-40% ownership of the Hinkley Point C. EDF Energy is contracted to build two 1.6 GW French EPRs in China.

RUSSIA

Nuclear technology is a leading industry, the first nuclear electricity was generated at Obninsk in 1954. As of the end of 2013, 33 units generated 23.64 GW, 11 plants are being built, and the startup of 3 units are scheduled in 2014. VVERs constitute about 65% of the reactor mix. At Beloyarsk, two 1200 MW fast reactors are planned. Like in the US, life extensions and upgrades are under way. 51 GW is projected by 2020, with 40-50% electricity generation by 2050. In addition to Russia, VVERs are operating in Ukraine, China, India, Iran, Hungary, Czech Republic, Slovakia, Bulgaria, Armenia and Finland.

Rosatom, the state corporation consisting of 250 entities, runs the nuclear industry. It is the only complete fuel cycle company in the world. Rosatom's order book for the coming decade is approaching $100B. It includes the following exports of power plants: Bangladesh, Belarus, China, Finland, Hungary, India, Turkey, Kazakhstan, Vietnam and probably Iran and Jordan. The order book also includes a range of nuclear goods and services including uranium and low enriched uranium nuclear fuel for commercial plants worldwide. Rosatom is building a floating plant for 2016 operation, which will supply electricity to the city of Pevek (population 200,000) on the Chukotka Peninsula. Fast reactors feature in long-term plans to move to inherently safe plants with a closed fuel cycle and mixed oxide fuel (MOX). Russia is also developing the lead cooled BREST fast reactor and lead-bismuth cooled SVBR.

INDIA

Because India is outside the Nuclear Non-Proliferation Treaty (NPT) due to its weapons program it was largely excluded from international nuclear trade. This continued for 34 years until 2009 after an agreement was reached with the Nuclear Suppliers Group. As a result it relied mostly on domestic Pressurized Heavy Water Reactors (PHWRs).

Presently it needs an increase of 625% in electricity generation, to 5000 units per capita compared to the present 800, in order to maintain its economic growth. Nuclear and solar are the only two sources that can meet the requirement on a sustainable basis. In 2012, nuclear generated 30 TWh, while solar generated 1 TWh [13].

Twenty power reactors are in operation with a combined capacity of 4.38 GW, while 7 units are under construction adding 4.89 GW. Plans call for nuclear capacity to reach 20 GW in 2020 and 63 GW by 2032. Sites for up to 6 units/site have been approved for imports from France/Areva, Russia/Atomstroyexport, US/Japan: GE/Hitachi and W/Toshiba plus 6 domestic PHWRs.

SOUTH KOREA

South Korea imports some 97% of its energy resources at an annual cost of around $170B. It has a policy of reducing this dependency while establishing a reliable power system that reduces greenhouse gas emissions. Like Japan, nuclear power is viewed as domestic energy. The goal for nuclear plants in 2035 is to produce 29% capacity compared to 19% now.

Five APR-1400 plants are under construction and five more are planned. The recently approved Shin Kori units 5&6 are slated for operation in 2019-2021. A consortium of Korean companies (Doosan, KOPEC, Hyandai, Samsung) has been successful in landing a $20B contract to build and operate 4x1400 MW plants in the United Arab Emirate (UAE) at the Barakah site for operations in 2017-2020. Korean Hydro & Nuclear Power Company (KHNP), acting on behalf of the APR1400 consortium, plans to submit application to the NRC for the design certification.

NUCLEAR NOVICES

In addition to the UAE and its 4x1400 MW plants, 2 Russian 1200 MW AES-2006 VEERs are being built at Ostrovets in

Belarus for 2019-2021 operation, 4x1150 MW AES-2006 VVERs are being built at Akkuyu in Turkey for 2020-2023 operation, and two AES-92 VVERs are being built at Roopur in Bangladesh for 2020-2021 operation. Furthermore, announcements have been made by the following countries: Vietnam for 2x1200 AES-2006 VVERs, Jordan for 2x1000 MW AES-92 VVERs and Turkey for 4x1100 MW Japanese/French Atmea units. Countries planning or considering expansion of nuclear power are: UAE for 10 additional units, Vietnam for 12 additional units, Poland (2), Kenya (2), Kazakhstan (2), Malaysia (2), Morocco (2), Nigeria (TBD), Egypt (2-4), Saudi Arabia (16), Namibia (TBD), and Indonesia (TBD).

COUNTRIES WITH COMMERCIAL PLANTS CONSIDERING NEW BUILDS

Here is an incomplete list: UK (9) after 30-year pause, US (5+), Argentina (3), Hungary (2), Czech Republic (2), Brazil (1), Bulgaria (1).

CONCLUSION

Given the information summarized above leads to the assertion that it is neither dawn nor dusk for nuclear power. There is a temporary stagnation primarily due to delayed restart of 48 Japanese plants. The Japanese government supports restart of idled plants. However, the revamped Japanese NRA has been taking too much time reviewing the 17 restart applications submitted. The lessons learned from the Fukushima accident have been analyzed to death and timely implementation is apparent. No plants in the US or France have been idled.

Despite the fact that the future nuclear development has shifted to the developing world from the OECD countries, leadership from China and Russia plus entries of nuclear novices into the market guarantee a bright global nuclear future. Additionally, climate change concerns plus energy security considerations will likely lead to a revival of interest in the OECD countries.

*Vojin Joksimovich, retired nuclear safety consultant with over 40 years of experience in the nuclear industry in Yugoslavia, UK and the US.

[1] *Mycle Schneider,* The Status of the Nuclear Industry in the World-Dawn or Dusk?, *APS.org. April 2014*

[2] World Nuclear News, *January 17,2014.*

[3] Nuclear News, *March 2014.*

[4] *World Nuclear News, May 29, 2014.*

[5] World Nuclear News, *May 7,2014.*

[6] World Nuclear News, *July 4, 2014*

[7] Nuclear Plant Journal, *July-August 2013, Vol. 31, No.4*

[8] *Vojin Joksimovich,* Fukushima Insights: Public Risks from Nuclear Accidents Grossly Overstated, *2012 ANS Winter Meeting: Embedded Fukushima Topical.*

[9] *Wade Allison,* Radiation and Reason: The Impact of Science on a Culture of Fear, *Wade Allison Publishing, 2009.*

[10] *Torres, Evacuation-related deaths now more than quake/tsunami in Fukushima Prefecture,* Japan Daily Press, *Dec.18,2013.*

[11] *World Nuclear News, February 20,2013.*

[12] *Ted Quinn,* Growth of Nuclear Power in Mainland China, *The World Affairs Council of San Diego, March 6, 2014.*

[13] *Anil Kakodkar, Former chairman of the Atomic Energy Commission of India, WN*

The Status of Fukushima Three Years After

Mycle Schneider [1]

Three years after the Fukushima disaster was triggered, the situation at the site remains worrying. High levels of radiation lead to difficult working conditions and still render human access to the reactor buildings impossible. Huge, constantly increasing quantities of highly radioactive water and contaminated wastes need to be stored, treated and disposed of. However, their management still appears to be improvised, following short-term considerations without coherent long-term concepts. Radioactivity continues to be released into the environment, mainly into the groundwater and into the ocean. Over 150,000 people remain evacuated, many of them in provisional housing, most of them without any prospects to go back to their homes. Dose limits have been increased in order to suit the environmental conditions rather than being determined to protect peoples' health. And the dramatic further increase in radiation releases remains a credible scenario until the radioactive materials in reactor cores, spent fuel pools, water and waste have been stabilized and disposed of. This is expected to take decades.

Hans Blix, former Director General of the International Atomic Energy Agency, called the Fukushima catastrophe "a bump in the road" of nuclear development. The statement illustrates not only a remarkable level of arrogance and a rather exceptional cynicism towards the victims of the disaster that lost everything, but a startling loss of reality. The Fukushima events hit an industry that was already struggling to maintain the status quo prior to 2011 (see The Status of the Nuclear Industry in the World – Dawn or Dusk? in the April 2014 edition of this newsletter). While the Fukushima Prefectural Assembly passed a resolution in favor of a nuclear-free prefecture six months after the disaster started unfolding, it took the operator TEPCO until December 2013 to officially abandon Fukushima Daiichi (1) units five and six. The four Fukushima Daini (2) units, 15 kilometers from Daiichi and inside the evacuation zone, remain officially "in operation", although they have not generated power since March 2011 and will most likely never come back online. In fact, none of the Japanese reactors have generated power since September 2014, only two throughout the year 2013. The average outage time of the 48 reactors that are still accounted for by the International Atomic Energy Agency (IAEA) as "in operation" is over three years, as the *World Nuclear Industry Status Report 2014* [2] documents. The fate of the shut-down reactors is all but certain. As of 10 June 2014, eight nuclear power companies have applied to the Nuclear Regulation Authority (NRA) for safety assessments of 19 nuclear reactors. [3] While the Abe administration is committed to the earliest possible restart of as many reactors as possible, in early July 2014, it looks as if at best the two Sendai reactors in Kyushu could restart before the end of the year.

FADING MEMORY

Three years after the beginning of the Fukushima disaster, 77 percent of Fukushima residents in a survey by Japanese daily Asahi Shimbun, released on 4 March 2014, said they believe that "memories of the nuclear accident have been fading and Japanese citizens have grown less interested in the victims, compared with 19 percent who feel that concerns remain high in the rest of the nation." What would be the result of an international survey? The trust in the central government and operator TEPCO is eroding continuously. 74 percent of Fukushima residents are disappointed with the government's overall measures to deal with the accident and 83 percent are disenchanted with the handling of the contaminated water leaks.

In the meantime, former Prime Minister Junichiro Koizumi and a member of Prime Minister Abe's Liberal Democratic Party, declared on 7 July 2014: "The logic of those who have promoted nuclear power generation has completely failed" and announced: "I will lead a national campaign to reduce the number of reactors to zero." Combined with a large majority of the Japanese people and local authorities around nuclear sites opposing restarts, Koizumi will not make it any easier for the stranded program to get back up and running.

The triple disaster earthquake-tsunami-nuclear accident on 11 March 2011, frequently referred to as 3/11, triggered a chain of events of unprecedented proportions. Three reactors at the Fukushima Daiichi site 60 km from the city of Fukushima experienced core meltdowns. The reactor buildings of units one, three and four—the latter was not operating at the time of the earthquake—were also severely damaged by hydrogen explosions. If over 150,000 people were evacuated, an unknown number of people self-evacuated and 2,000 km^2 were turned into an exclusion zone. Recent announcements of the first lifting of evacuation orders for a few hundred people that could return to an area at the edge of the 20 km evacuation zone cannot cover up the fact that most of the evacuees will likely never be able to return home, if not under hazardous conditions. The lifting of evacuation orders comes at the same time as the announcement by TEPCO to end compensation for people who suffered loss of or reduced income. Obviously, both measures are aiming to limit soaring costs of the disaster. The most far reaching measure in this context is the post-3/11 decision to increase the admissible radiation dose from external sources—thus not including internal exposure through contaminated food and inhalation—by a factor of

20 from 1mSv to 20mSv per year. [4] This brings the dose limit for the public, including pregnant women [5] and small children, to the level of selected, trained nuclear workers.

Some aspects of the situation on-site are getting better, but many issues remain critical or are actually getting worse. The good news is that unloading of spent fuel from the pool of unit four has started in November 2013 and as of 23 April 2014 almost half of the spent fuel assemblies (726 of 1533) had been removed and transferred to the common spent fuel pool on site. The spent fuel pool of unit four was and remains of particular concern as it contained about as much fuel as the other three reactor pools together and less cooled fuel, as the entire core was in the pool during the 3/11 events while the reactor vessel was undergoing maintenance and inspection. A major leak of the pool or its collapse with a subsequent spent fuel fire was seen as the "worst case scenario" already two weeks after 3/11. The Japan Atomic Energy Commission then calculated that up to 10 million people potentially would have to be evacuated, including from an area around Tokyo, under such a scenario with unfavorable wind conditions. The fuel unloading from unit four is expected to continue for the entire 2014 year. The same work remains to be done on the other three units and is expected to take until 2023. Meanwhile, thousands of tons of debris and rubble have been removed from the reactors and their immediate environment. Covers have been installed on the units whose roofs were blown off by hydrogen explosions and provide some protection against severe weather impact.

On the other hand, many aspects are worsening. Likely amongst the biggest challenges is the task to maintain the integrity of the infrastructures, whether buildings and storage tanks or several kilometers of pipes and tubing, etc., which are permanently exposed to seawater atmosphere, typhoons and heavy rain. Surface vinyl tubes are exposed to frost in the winter and have experienced numerous leaks.

Significant amounts of water, about 350 m^3 per day, have still to be injected into the three reactor buildings in order to cool the molten cores. This water is contaminated by the damaged fuel and, since the containment buildings are fractured, leaks into the basements. Under the nuclear site runs an underground river that originally had been deviated from the building infrastructure. However, that engineered deviation was destroyed by the earthquake and since then an estimated 400 m^3 per day push into the basements and mix with the highly radioactive water from the core cooling. While some water is taken out of the basements, decontaminated to some extent and re-injected for cooling, in order to avoid massive, permanent overflow, an amount at least equivalent to the quantity of groundwater pushing in has to be taken out. In other words, an additional 400 m^3 have to be pumped out of the basements, decontaminated to some degree and stored every day, which means that one 1,000 m^3-tank is filled up every two and a half days. The water decontamination system has its own multiple problems ever since it was put into operation and is currently out of service. As a result, highly contaminated water is increasing steadily, to 440,000 m^3 by end of 2013, four times more than in September 2011, of which about 350,000 m^3 in over one thousand tanks and the rest in the basements of the reactor buildings. The amount of cesium-137 in the basements alone is estimated at about 1.5 times the quantity released into the environment at Chernobyl in 1986 or ten times more than released at Fukushima during the first weeks of the event in 2011. The water storage capacity is to be increased to a staggering 800,000 m^3 by the end of the year.

The storage tanks are sitting on poor, non-earthquake proofed concrete foundations that have already shown substantial cracks. More than 300 tanks, each of them containing about 1,000 m^3 of highly radioactive water, are bolted rather than welded together. In the fall of 2013, the Nuclear Regulation Authority (NRA) requested replacement of the bolted to welded tanks, but this will take a long time. Many of these tanks do not have volume gauges, so leaks are difficult or impossible to detect. Leaks are, however, frequent. In several occasions, TEPCO admitted that highly contaminated water has reached the ocean. In the future, it is planned to color the contaminated water as to simplify the visual identification of leaks and avoid confusion with rainwater puddles. Increased numbers of "patrol" staff should also allow for more rapid leak detection. The lack of well-designed, automated supervision comes at the price of increased radiation risks to workers.

Another complex area is the storage and disposal of the huge quantities of sludges and filters from decontamination activities as well as other solid contaminated wastes. The management, transport, storage and disposal of the high activity filters and sludges can be expected to be part of major future challenges.

All these activities require human intervention. Tens of thousands of workers have gone through the site. In an overview dated 30 August 2013, the Japanese Health Ministry indicated a total of almost 29,000 people that have been employed at the nuclear site. Less than 4,000 were TEPCO employees, while 25,000 were contractors and countless levels of sub-contractors. TEPCO has increasing difficulties finding new workers that can replace the ones that are leaving, either because they are demoralized or because they exceeded the official dose limit. The press agency Reuters has identified 733 companies performing work under environment ministry contracts and 56 subcontractors "listed on environment ministry contracts worth a total of $2.5 billion" in the most contaminated areas of the Fukushima exclusion zone. In a staggering investigation [6] Reuters illustrates how homeless people have become the target of headhunters for work in the contaminated areas. Many illnesses that might develop amongst Fukushima workers are unlikely to ever be reported.

EXCERPTS FROM UPCOMING WORLD NUCLEAR INDUSTRY STATUS REPORT 2014

Due to shortage of tanks and area to store the water, in early 2013, adjacent to the tanks TEPCO dug seven large (10,000-ton-class) sink ponds, which were easier to make and at lower cost. But a series of radioactive leakages was detected in March and April 2013. On 5 April 120 tons of radioactive water leaked from this reservoir. [8] This released the highest amount of radioactivity since December 2011 when the damaged reactors were declared to be in "cold shutdown".

In June 2013, it was revealed that the groundwater sampled from a monitoring well adjacent to the Unit-2 turbine building is contaminated with strontium and tritium, so the highly radioactive water that filled the unit basement had already made its way to the aquifer, hence it can easily flow into the sea. [9]

On 20 August 2013, TEPCO announced that about 300 tons of contaminated water leaked from a tank and that while a part of it was held back by a small dike around the tanks, the rest went underground and contaminated the soil. [10] The radiation level measured 50 cm above ground was roughly 100 mSv/h. [11] The contamination level was measured at 100,000 Bq/l of Cesium 137 and 80 million Bq/l of Beta emitting radionuclides. In this context the NRA decided to rate this event at level-3 of the International Nuclear Event Scale (INES) rating. [12]

On 20 February 2014, TEPCO announced that another significant leakage of contaminated water had occurred at one of the bolted tanks. Apparently, 102 tons containing 230 million Bq/l of Beta and 9,300 Bq/l of Cesium 137 were leaked. [13] It was the biggest reported leakage since August 2013, and TEPCO is investigating its cause. Some early findings indicate that a valve that was supposed to be closed was left open and the water in the tank overflowed. If this was the case, it would hint towards an operator error, and could be due to limited expertise of the staff.

The extraordinary complexity and the unprecedented scope of the challenges that the long-term stabilization of the Fukushima site represents have early on led to the proposal of the establishment of an *International Task Force Fukushima* [7]. This type of permanent group of top-level experts in the key fields at stake would elaborate strategic recommendations for short-, medium- and long-term measures. Conceived as a concerted international initiative, the group would have access to a large network of additional experts. Many people around the world support the basic idea but an institutional partner or initiator in Japan remains the essential missing piece. As they say: you can't push a rope.

ENDNOTES

[1] Mycle Schneider is an independent international energy and nuclear policy consultant, based in Paris. He is the convening lead author of the World Nuclear Industry Status Reports *and a member of the Princeton University based International Panel on Fissile Materials (IPFM).*

[2] Forthcoming, to be released on 29 July 2014.

[3] JAIF, "Nuclear Power Plants in Japan (In operation and under construction)", 10 June 2014, see http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS02_1402531967P.pdf, *accessed 11 June 2014; see also, Reuters, "Factbox-outlook for japan nuclear reactor re-starts", 2 April 2014, see* http://in.reuters.com/article/2014/04/01/japan-nuclear-restarts-idinl4n0mt0k020140401, *accessed 6 June 2014.*

[4] 1 millisievert

[5] A fetus is about two orders of magnitude more radiosensitive than an adult.

[6] Reuters, "Special Report: Japan's homeless recruited for murky Fukushima clean-up", 30 December 2013; See http://www.reuters.com/article/2013/12/30/us-fukushima-workers-idUSBRE9BT00520131230

[7] See Mycle Schneider, "Why Fukushima is worse than you think", *Special to CNN, 30 August 2013.*

[8] http://www.tepco.co.jp/nu/fukushima-np/handouts/2013/images/handouts_130406_05-j.pdf

[9] The contamination was confirmed in late May 2013, but it took TEPCO more than two weeks to publicly release the information, see TBS News, NHK News, Mainichi Shimbun, 19 June 2013. Also see http://enformable.com/2013/06/tepco-confirms-fukushima-daiichi-groundwater-contaminated-with-strontium-and-tritium/, *accessed 20 June 2013.*

[10] TEPCO, 20 August 2013, see http://www.tepco.co.jp/en/nu/fukushima-np/handouts/2013/images/handouts_130820_03-e.pdf

[11] http://www.tepco.co.jp/en/nu/fukushima-np/handouts/2013/images/handouts_130821_07-e.pdf, *accessed 2 May 2014.*

[12] NRA, Press Release, 28 August 2013, see http://www.nsr.go.jp/english/newsrelease/2013/0828.html, *accessed 7 June 2014.*

[13] NRA, News Release, 20 February 2014, see http://www.nsr.go.jp/english/newsrelease/data/20140220.pdf *accessed 7 June 2014 and TEPCO, Fukushima Daiichi NPS Prompt Report 2014, 20 February 2014, see* http://www.tepco.co.jp/en/press/corp-com/release/2014/1234394_5892.html, *accessed 7 June 2014.*

U.S. Needs Strong R&D Portfolio to Remain Globally Competitive

U.S. Rep. Ted Yoho

Six years ago, the worst economic crisis since the Great Depression consumed the United States. Since then, many American jobs have vanished and have yet to return. Due to the global nature of today's economy, the aftershocks of the Great Recession reverberated well beyond our own borders. This new, global economy is a highly technological one that rests upon scientific innovation through research and development. Therefore, in order for America to retain its dominant economic position in the world economy — and to pull itself out from this economic downturn — we must continue to support research for scientific innovation.

America's spirit, vision, and leadership has made this country an incubator of innovation. Our commitment to nurturing this spirit will continue to lead to economic growth and the next big scientific breakthrough. Imagine a cure for cancer or making hydrogen power available for everyone — advancements that will change the lives of all mankind. Promising research like this is happening in my district right now.

Since Florida's Third District is home to the University of Florida, I have a keen appreciation of the link between education, scientific innovation and economic prosperity. Over the past 20 years, we have seen amazing breakthroughs in research that have led to scientific innovation. The world is becoming more interconnected through high technology and will continue to do so.

Today, there is much talk about the "rise of the rest." Countries like Brazil, China and India, long considered impoverished nations in need of assistance, are now embracing all new forms of economic development that have transformed their countries into bastions of prosperity. In many cases, it has been their investment in scientific research and development that has granted them the prosperity they have long sought. Even fellow developed nations, like Canada and those that make up the European Union, have begun competing with the United States for dominance in the research and development field. All of these countries understand that the economy is permanently bound to greater and greater scientific advancement.

The one thing that is required to spur these advancements is a robust system of higher education. Unlike many of our competitors around the world, the United States has many of the world's leading research universities. These institutes are well-suited to spearhead the next phase of high-tech, economic development. Because of this, we have the opportunity to continue to ensure that the United States retains its place as the dominant economic power in the world.

Research programs such as the University of Florida's Institute of Food and Agricultural Sciences (IFAS), which is a federal-state-county partnership, has been instrumental in bringing $108.7 billion to the gross domestic product of the state economy. This, and similar programs, have not only expanded Florida's economy, but they have also helped pave the way for an expansion of high-tech jobs in our district and our state. These jobs are the key to America's future economic prosperity. Programs such as this also expand our research universities both in terms of size and personnel. The more we expand these institutions, the more people can be employed by the invaluable high-tech industry.

We have all experienced the negative impacts of the Great Recession. Given the globalized nature of our economy, there is no part of the world that has been left untouched by these tragic economic events. Since the world economy runs on high technology, the best chance for pulling ourselves out of this malaise is through sustained support for research and development.

One of the great developments of the past 20 years has been the creation of the Internet. This was the result of extensive research and development. Life-saving medicines, revolutionary communication technologies, and groundbreaking scientific methods that transform the way we live our lives have all stemmed from greater commitments to the research that leads to scientific innovation. As the century progresses, these innovations will only lead to a greater need for scientific advancement. The country that capitalizes on this need and becomes home to the knowledge required for expanding the high-tech economy will be an economic powerhouse. Furthermore, the cities and states that embrace these new developments will reap untold prosperity for a long time to come.

It is my wish that we continue to support research universities, as they will spearhead the next wave of scientific development that will enable our economy to flourish. The jobs created by these institutions — and the fields they contribute to — will be long-lasting and have immensely positive results for the communities that embrace and support these institutions. Such investments in our future will help save us from our present economic woes, while creating a more prosperous future.

Congressman Ted Yoho (R) represents North Central Florida's 3rd Congressional district. He was elected to the 113th Congress in November 2012. Prior to serving in Congress, he was a small business owner who operated several large animal veterinary practices.

CORRECTION: *There was an error in identifying the author of one of the book reviews in the April 2014 issue. The author of the review of "Arguments that Count" is not Frank Lock. It is Ronald I. Miller, DoD/DIA/Missile & Space Intelligence Center (Retired), rim@knology.net.*

The Physics of War: From Arrows to Atoms

by Barry Parker, Prometheus Books, Amherst, New York, 320 Pages, January 2014, Price $25.95, ISBN 978-1-61614-803-4 (Hard cover), ISBN 978-1-61614-804-1 (E Book)

This readable popularization examines the impact of scientific developments on conflict from prehistoric tribes to today's nation states. It focuses on physics with digressions into chemistry (poison gas, explosives). It presents historical and biographical accounts of scientific discoveries or applications, with numerous excellent illustrations. Tracing the evolution of weapons from the earliest wars to present thermonuclear ordnance, satellites, and drones is illuminating and thought provoking.

Parker examines the history of the Roman Empire which, despite its apparent military strength, was defeated by the superior cavalry skills of the barbarian Goths and Huns. He describes the encounters at the Battle of Hastings in England in 1066 between armies led by the English King Harold II and the French Norman Duke William II. William became King of England by using 8,000 crossbow archers within a total force of 20,000. The English Army, using the same number of men armed with axes or swords, couldn't withstand the archers.

The era of the Hundred Years War (1337-1453) saw great advances in the longbow and other weapons. These decided the Battle of Agincourt in France, immortalized later in Shakespeare's Henry the Fifth. Six thousand Englishmen defeated more than 25,000 Frenchmen. Many French soldiers wore armor that was vulnerable to longbow arrows. The French suffered 4,000-10,000 deaths while English deaths numbered a few hundred. Cannons first appeared during this era, although the Chinese, Arabs, and Mongols used earlier prototypes. Parker analyzes cannons, early muskets, rifles, pistols, and ammunition design.

Napoleon Bonaparte was educated in physics, mathematics, and astronomy, and understood the relevance of science to warfare. Nevertheless, he made important mistakes when presented with new ideas. Although hand-held rifles were known to be more accurate and longer-ranged than smoothbore muskets, Napoleon didn't like them. He was enthusiastic about the newly-manufactured cannons, and appreciated the bayonet's ability to terrorize enemy troops. A scientific advisor pointed out that gas-filled balloons could survey the landscape and even drop bombs, but Napoleon soon lost interest in this notion. Both sides used this concept in the American Civil War, particularly the North during the campaign against Richmond, the Confederate capital.

During the first bombing raids of World War I, the Germans used huge balloons (Zeppelins) each the length of three football fields, to terrorize the civilian population of England. "Quite quickly it became evident that they were easy targets" because they were filled with flammable hydrogen and could be shot down by ground fire or, later in the war, by fighter planes. But according to the PBS documentary "Zeppelin Terror Attacks" (15 January 2014), this may underestimate the technical difficulties in confronting balloons. There were twenty-three raids during 1915-1918. Peter Strasser, who first proposed the bombing effort, died while leading the final attack.

The author characterizes the Civil War as the first truly modern war, with a variety of advances including electric telegraph, electric generators, balloons, warships, submarines, and improved telescopes. Both sides expected the war to be short but it lasted four years and took 700,000 lives--more than the total American dead in all other wars from the revolution until today. Parker details machine-gun developments that produced huge casualties during World War I, "The Machine Gun War." That war also saw the first war planes, submarines, and poisonous chlorine and mustard gases. Poison gas was so horrific that despite large inventories and defense preparations in World War II, it was never used in Europe by combatants. Its use by Nazi Germany against innocent civilians is a different painful story.

World War II was by far the most destructive conflict with incomplete estimates of deaths ranging up to one hundred million. Parker studies the physics and history of radar, V-1 and V-2 rockets, jet aircraft, codes, proximity fuses, and sonar. Individual chapters discuss the atomic bomb, used by the U.S. against Hiroshima and Nagasaki, and thermonuclear weapons. Though nuclear weapons have not been used since 1945. they were considered by the Soviet Union and the U.S. during the Cold War.

Lasers, first postulated by Gould and Townes in the late 1950s, were achieved in 1960. Gordon Gould and this reviewer participated in a government research program on long distance laser ranging that also found unanticipated connections with medical applications.

There are a few editing problems. Leonardo DaVinci, finding difficulty in securing employment as an artist, left Florence for Milan and applied for work as a "military engineer" with

Duke Ludovico Sforza. On page 70, Sforza was unimpressed with DaVinci's "futuristic and fanciful" weapons drawings and rejected his application. Several pages later, "Leonardo proposed a design for an armored tank while he was working for Ludovico Sforza." We learn that in a letter to Sforza "he stated 'I also had types of mortars that are very convenient and easy to transport.... When a place cannot be reduced by the methods of bombards either because of its height or location, I have methods for destroying any fortress or stronghold, even if it be founded on rock'." The reader must conclude that Leonardo did in fact finally work as a military engineer for Sforza, who could have made use of his inventions, but how this came about after being turned down isn't clear.

A mathematical error occurs in Galileo's study of projectile trajectories (p. 82 ff). Galileo correctly deduced that a projectile would follow a parabolic curve but a diagram shows a cone obviously yielding an ellipse. Parker asks "What is a parabola? ...If you slice through it parallel to the base, you'll get a circle but if you slice it through an angle, you'll get a parabola (as long as you don't pass through the base)." This is incorrect. Hopefully, subsequent printings will correct this. Also, the elementary lever principle does not have to be described twice (pp. 41 and 72).

Despite these criticisms, this book has high merit and deserves a broad readership.

Parker's concluding paragraph states, "As physicists further expand our knowledge, it is almost certain that our weapons will continue to progress. The great hope for the twenty-first century and beyond is that rather than increasing the carnage of war, such progress will instead promote the development of precise nonlethal weapons that ultimately enable the resolution of conflict without the staggering human slaughter that became too common in the twentieth century."

Though sharing the author's hope, I cannot join Parker's limited optimism. Further extrapolation in weaponry, whether offensive or defensive, cannot overcome the large inventory of devastating nuclear weapons already in the world, with more nation states striving to secure them. Mankind's ultimate survival depends upon political will and diplomacy to eliminate these weapons and finally armed conflict itself. In a 1950 interview about nuclear weapons, Albert Einstein was asked "Is it an exaggeration to say that the fate of the world is hanging in the balance? " His reply: "No exaggeration. The fate of humanity is always in the balance but more truly now than at any known time."

The "Physics of War" makes it clear that the time by which we must attain balanced change for peace is shorter than ever.

Len Solon
Dr. Solon is a physicist whose work includes environmental radiation, radiological health and laser applications. He is a combat infantry veteran of World War II.

The Bomb in the Basement: How Israel Went Nuclear and What that Means for the World

By Michael Karpin (Simon and Schuster, New York, 2006).

In its listing of the world's nuclear powers, Wikipedia, uses four categories:

1) "NPT-designated nuclear weapon states" (those acknowledged to possess nuclear weapons when the Nuclear Nonproliferation Treaty was originally developed and signed): China, France, Russia (then the USSR), United Kingdom, and United States;

2) "Other nuclear weapons states": India, North Korea, Pakistan (none of which have signed the Nonproliferation Treaty);

3) "States formerly possessing nuclear weapons": Belarus, Kazakhstan, Ukraine, South Africa (the first three fell heir to former Soviet nuclear weapons when the USSR was dismantled; South Africa had constructed six "gun" devices with enriched uranium before it terminated its program in 1990 and signed the Nonproliferation Treaty in 1991);

4) "States believed to have nuclear weapons." Only one country falls under category 4: Israel. The story behind the belief that Israel has nuclear weapons is told by Israeli journalist Michael Karpin. He avoids betraying state secrets by basing his story on public sources of information, "foreign" assessments of Israeli capabilities, and information leaked by Israeli whistle blower, Mordechai Vanunu.

Karpin's book is in many ways a history of the early years of Israel, since he traces Israel's development of a nuclear weapon to the post-World War II belief of Israel's first prime minister, David Ben-Gurion, that two things were essential to saving the Jewish people from extermination: a homeland and a weapon of deterrence. The U.S. was unwilling to allow him to produce weapons fuel in the "Atoms for Peace" reactor it provided, but France was more willing to help, largely because Israel could provide intelligence about the actions of Egyptian President Nasser related to the rebellion the French were facing in Algeria. And by acting militarily to provide a pretext for France and Britain to retake the Suez Canal after Nasser had nationalized it, Israel received a larger reactor from France, erected at Dimona.

Since Israel had its own uranium resources in the Negev desert, it could use its Dimona reactor to produce as much plutonium as it needed to develop nuclear weapons. But it needed to do so discreetly. And when knowledge of the reactor's existence leaked out in 1960, Israel maintained that it was to be used only for peaceful purposes, an assertion that the Eisenhower administration accepted at face value. (At this point in his book, Karpin observes that the only area of the world for which spy satellite photos have not been published is Israel, and he speculates that this is to preclude evidence of U.S. awareness of the Dimona reactor.)

Continuing to the next presidential administration, Karpin writes that "[John F.] Kennedy's posture toward Israel was more positive than Eisenhower's had been" (p. 180), though Kennedy's determination to limit nuclear arms development and proliferation ran counter to Israel's interest. Karpin also notes that this warming between the U.S. and Israel also came at a time of cooling between Israel and France, as French disengagement from Algeria eliminated the need for Israeli intelligence. He wonders how this might have played out differently had Egypt's President Nasser not wandered into the Soviet sphere. And he notes that Kennedy's attitude toward Israel was balanced between considerations between the Jewish vote and nonproliferation. After a meeting with Ben-Gurion, Karpin quotes Kennedy as saying, "It is to our common interest that no country believes that Israel is contributing to the proliferation of atomic weapons." (p. 193)

Israel found an even more sympathetic ear from Lyndon Johnson, who was now dealing with a new Israeli prime minister, Levi Eshkol. While Ben-Gurion had no qualms about deceiving the U.S. about Dimona, Eshkol did. Eshkol was able to assure Johnson about Dimona without deceiving him by saying that Israel would not be the first nation to introduce nuclear weapons into the Middle East.

It was during Johnson's presidency that Israel amassed sufficient fissionable plutonium for a nuclear weapon, whose systems were tested by computer simulation in a "cold test." Karpin attributes this to assertions of "foreign experts," who based their conclusion from the following passage in the diary of Munya Mardor, the head of the Israeli Authority for Weapons Development, RAFAEL:

> On November 2, 1966, a test of special import was carried out. It represented the culmination of a period in the development of one of the principal weapons systems and the step which brought it to the final stages of its development and manufacture at RAFAEL. The success of the test was complete, for we achieved through it unambiguous experimental proof of the efficacy of the system . . . We had waited many years for this result. (p. 268)

But it was not until 1968 that, as a result of information from Edward Teller, the CIA assessed "for the first time that Israel had begun to produce nuclear weapons." (p. 287) Karpin also writes that Teller told fellow physicist (as well as Israeli statesman) Yuval Neeman that he was going to relate this information to the CIA in order to end the "cat and mouse game" (p. 292), a move subsequently supported by Eshkol, who would die in 1969.

Eshkol was succeeded by Golda Meir, and Johnson was succeeded by Richard Nixon, and Nixon and Meir got on even more famously than their predecessors – "after the Eisenhower administration's 1958 decision to relate to Israel as an asset, Kennedy's definition of relations with Israel as 'special,' and Johnson's silent consent to Israel's nuclear capability." (p. 319)

Karpin writes that Israel's nuclear capability has been able to co-exist peacefully in the Middle East because of the concept of nuclear ambiguity developed by Shalhevet Freier, "to achieve three goals: against the enemy, deterrence; to friendly nations, maintenance of a responsible image that makes normal relations possible; and for the Israeli people, a boost of self-confidence in the face of their security challenges." (p. 343) But he acknowledges that this equilibrium would be upset if another Middle East country gains nuclear capability, and the major candidate for this is Iran. He notes that eliminating the Iranian nuclear threat is not as easy as the 1981 Israeli bombing of Iraq's reactor, because Iran's facilities are very spread out, and U.S. technology would be needed to bomb Iran's facilities that are underground. He adds that Israel would support nuclear disarmament in the Middle East, but only through a process of building up trust in a lasting peace in a local framework, not in the larger context of a worldwide forum that is insensitive to Israel's interests or though signing the Nuclear Nonproliferation Treaty.

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Nuclear Weapon Issues in the 21st Century

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Edited by Pierce S. Corden, David Hafemeister and Peter Zimmerman

American Institute of Physics Conference Proceedings, Volume 1596 (2014)

At George Washington University, November 2-3, 2013