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General Comment

This submission has four parts: 1.) Macro view of the Environmental Issues of Nuclear Power, 2.) Some of my thoughts concerning comments made by others at the public hearing (afternoon session), 3.) The notes that I used for my comments at the public hearing. These notes are largely similar to my verbal comments but there are differences. And 4.) My submission to the California Energy Commission on their workshop/hearing on reducing greenhouse gases.

See attached file(s)

Attachments

BobGreenePhD.Docket ID NRC-2009-0552

SUNSI Review Complete
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Docket ID NRC-2009-0552
Diablo Canyon Power Plant License Renewal Environmental Scoping Meeting
August 5, 2015, Courtyard San Luis Obispo

Submitted by - Bob Greene Ph.D., Board Member of Thorium Energy Alliance of Silicon Valley

Lest there be any confusion, let me be clear that I am wholeheartedly in favor of NRC's extending the operating license for the Diablo Canyon Power Plant.

This submission has four parts: 1.) Macro view of the Environmental Issues of Nuclear Power, 2.) Some of my thoughts concerning comments made by others at the public hearing (afternoon session), 3.) The notes that I used for my comments at the public hearing. These notes are largely similar to my verbal comments but there are differences. And 4.) My submission to the California Energy Commission on their workshop/hearing on reducing greenhouse gases.

For the record, my Ph.D. is in Atmospheric Physics.

Part 1 – The environmental picture

Almost all who participated in the Environmental Scoping Meeting focused their microscopes on individual issues of interest to them. They hoped to sway the NRC in their investigation, one way or the other, with respect to the relicensing of the Diablo Canyon Power Plants. Naturally, this is a valid approach. Many came with the interest that somehow their individual objection or the sum of several objections might sway the NRC from relicensing. Some of their input was weak, misleading, irrelevant, or factually questionable. I have addressed a few of these comments in Part 2 (below). But mostly, I am relying on the NRC to distinguish between fact and emotion and to perform a scientifically based evaluation.

But to me there is an element missing in this approach, i.e., a broad holistic view of the issue. This is the area where my comments will focus. This approach should look at all the benefits, but I will not delve into the economic and social benefits

The Benefits of the Diablo Canyon Power Plant

Diablo Canyon provides inexpensive, dependable carbon-free base-load electricity to roughly 3 million Californians. This equates to a savings of 6 to 7 million tons per year of carbon dioxide emissions over fossil fuel sources. Not relicensing Diablo Canyon probably implies that California will increase its carbon footprint in a time when both

President Obama and Pope Francis have underscored the need to decrease it to tame climate change.

In addition, Diablo Canyon has entered into a five-year agreement to provide San Luis Obispo County with its excess fresh water from its desalination plant to help combat effects and challenges of California's long drought. This means about 825,000 gallons a day will be made available to the County. If climate change heralds a projected long drought, this capability may be vital to the well being of the County.

An impending disaster

A major issue is being systematically ignored. It is ocean acidification.

Since the beginning of the industrial age, we have been pumping massive amounts of carbon dioxide into the atmosphere, currently about 10 Gtonnes/yr. About one quarter of that is dissolved in the oceans in a given year. But this means of our total emissions of 1500 Gtonnes about two-third remains in the atmosphere (1000 Gtonnes). Approximately, 500 Gtonnes has been dissolved in the oceans. The natural sedimentation/sequestration process of the oceans is about 0.3 Gtonnes/yr but only if the pH>8. Relying only on this natural process it will take centuries to return the atmosphere and oceans to their pre-industrial state assuming that we cease all CO2 emissions.

The problem is that CO2 when combined with H2O produces carbonic acid. Before the industrial age ocean pH was about 8.2. Now it is about 8.1. We are making the oceans more acidic. And when the pH reaches 8.0 or less, the oceans will lose their abilities to provide any self-regulation.

What does this acid do? It removes available calcium from the water. This in turn impedes the growth of shells and skeletons in marine creatures. The oyster fishermen in the Pacific Northwest are already dealing with this issue. To make their beds less acidic they do the equivalent of adding 'Tums'. But as the problem grows, we will see smaller fish and decreases in yields. This problem reaches right down to phytoplankton, the lowest level of our food chain. We are placing at least 15% of the world's protein source in danger of extinction. This problem will also affect all marine mammals. And we are currently doing nothing about it.

There are things that can be done. But they all entail massive amounts of energy. Wind and solar energy are inappropriate since they are energy sparse and not carbon free (due to their backup gas-fired plants). We need zero-carbon power sources. We need as much nuclear as we can get, as fast as we can get it, especially Gen 4 Molten Salt Reactors that

can burn down existing radioactive 'waste' as fuel. We cannot wait. We need resources in place the moment we collectively wake up and decide to address the problem.

Climate change impact

Mankind has yet to wake up to the energy requirements to meet climate change challenges. I will only name a couple more without explanation: 1.) The need for desalination. I believe we will need to address it in a much broader way, especially as wild fires spread drought effects and 2.) The energy needed to address sea rise either through construction of seawalls or relocation of society to higher ground.

If one looks at all the global energy projections, one fact stands out. Despite large investments in solar and wind and conservation, the increase in energy demand will be met mostly by fossil fuel sources. In other words, instead of moving toward a zero-carbon dioxide world, we will be emitting more carbon dioxide at mid-century than we are today. The oceans cannot wait. If we do not take significant steps before 2030, we are in danger of permanently poisoning our oceans. Business as usual will not do the job.

Part 2 – Responses to comments made by other speakers at the public hearing

A. - Some of the speakers at the hearing were operating under a misconception about the incidents at Fukushima Daiichi. They stated their belief that the earthquake (9.0 magnitude) was the direct cause of the problems. They did not realize that the reactors shut down successfully after the earthquake.

The real issue was the tsunami that inundated power equipment for reactor cooling. The operating company (TEPCO) sited the reactors at only 4 m above sea level with a 6 m seawall. The inundation level was 14 m above sea level. TEPCO originally removed 25 m of earth vertically before laying the foundation. This was despite historic 'Sendai monuments' in the area, which essentially were inscribed with "Do not build below this point." A TEPCO sister plant a short distance down the coast did not receive substantial damage.

Meanwhile, there were no problems at Onagawa Nuclear Power Plant which was twice as close as the Fukushima Daiichi plant to the earthquake epicenter. Onagawa experienced a higher tsunami wave and an earthquake shock of greater magnitude, indeed the most severe earthquake experienced by any nuclear power plant. It also went on to provide shelter for 200-300 residents who were displaced from their homes. Onagawa holds the record for the fastest built nuclear power plant. But in fairness it must be pointed out that

Onagawa (commissioned 1984) was designed 10 to 15 years later than Fukushima Daiichi.

Diablo Canyon is sited on an 85-foot bluff. It was designed and constructed after the Onogawa plant. It has ample gravity-fed water storage above the site for a full cool down procedure regardless if power is active.

Considerations for the NRC – If Diablo Canyon was constructed to standards at least as good as Onogawa, then there is little reason to assume it would not withstand a 9.0 quake. But if there are additional concerns, then the NRC can ask to do what California has done for every other public structure in the state, i.e., an earthquake retrofit.

If the NRC deems that 85-ft above sea level is not high enough to protect against tsunami, then specify a height for a seawall to be added that also takes into account any envisioned sea level rise due to climate change over the length of the relicensing period and a follow-on period.

In other words, additional earthquake and tsunami safety is addressable, and does not seem to merit a refusal to extend Diablo Canyon's operation license.

B. – Some of the speakers express concerns about the physical security of Diablo Canyon. They fear terrorist attacks, drone attacks and attacks from the ocean. I cannot tell if their objective is to increase the number of drills to intercept these types of attacks or to shut Diablo Canyon down because it is indefensible.

Diablo Canyon is not the only nuclear power plant sited on the ocean. My recommendation to the NRC is that Diablo Canyon should be held to the same standards for physical safety as other US-based nuclear power plants. I am certain that the management of Diablo Canyon would be happy to comply.

C. – I may have missed it this time, but over time there has been criticism of Diablo's once-through cooling using ocean water (2.5 billion gallons per day). The criticisms seem to be two: 1.) That larvae of marine creatures are sucked into the system and that they are killed at alarming rates endangering marine life in the area. Even though I do not have the numbers in front of me. My recollection is that the kill rate is on the order of 1-2 larvae per gallon, a low amount for ocean water. And 2.) The water temperature in the outlet area is increased by 20-deg F at the outlet and this leads to poor commercial fishing in the area.

These concerns are of questionable value. There have been articles in the local newspaper quoting fisherman as stating the yields have been very good. But perhaps more importantly, one of the early speakers in the afternoon hearing session was a retired marine biologist (I did not catch his name.). He stated that in his position he helped accumulate data for over 40 years on this very issue. He stated that his finding was that Diablo Canyon had no appreciable impact on the marine populations in the area.

I urge the NRC to investigate this lead, and to do your own math.

Secondly, even if the worst-case scenario is true, it is a local effect. It has to be weighed against the broad set of economic and other benefits provided by Diablo Canyon. In that light, this issue would not justify denying Diablo Canyon relicensing. My secondary conclusion is that there appears to be no need to construct cooling towers. The once-through cooling has worked successfully for nearly 30 years.

D. – Critics have questioned the use of dry casks for high-level radioactive waste storage. This issue should be an easy one. Regardless of whether critics oppose this approach, the question is simply "Does Diablo Canyon Power Plant comply with existing NRC regulations with respect to handling and storage of high-level radioactive material in dry casks? If the answer is "No", they should be cited through the usual steps. If the answer is "Yes", then so point out and pat them on the back.

I suspect that the underlying issue here is that some folks don't like nuclear waste storage anywhere, including in their vicinity. But this decision is currently not Diablo Canyon's responsibility. They currently have no choice but to store the casks on site. They are not allowed to transport the casks anywhere. The prospect of arranging a long-term storage site has been made a political issue. It is fairly ironic since, there are a lot fewer of these casks than people imagine. If you started standing all the casks at US nuclear power plants up on the end line of a football field, would they even reach the 20-yard line at the other end of the field?

E. – I read a position paper from a anti-nuclear group in which they made what to me were some very odd claims. To me, their logic was very convoluted. After some thought, I think I now understand from where they are coming. I include comments here in case this logic showed up at the evening hearing session.

Their claims were several. A.) Nuclear power is outmoded. B.) That being base-power and not load-following is a disadvantage. C.) The existence of nuclear on the grid reduces the flexibility of the grid and impedes improvements to the grid.

I believe that their views are based on a vision of what our grid and power generation should look like, not what it currently is. In their view, power generation is more distributed and closer to points of usage. Then, the grid can be much more distributed as well, and therefore less susceptible to major disruptions either by man or nature. A key point in their view is that there is ample and efficient electrical storage available locally. I believe in their model all energy sources run at their current maximum efficiency, with any excess being dispatched to storage.

To me there are some major flaws in these arguments.

1.) This is unlike our existing electrical power infrastructure. I have never heard a good explanation as to how we would transition to this model. Any replacement strategy would entail massive costs.

2.) Nuclear power is outmoded? I find this to be fantasy. Nuclear power currently provides about 19% of US electricity. If it is outmoded, why are over 70 nuclear plants under construction around the world. Granted we have not yet moved to newer reactor designs, but this is understandable given that we suppressed nuclear power R&D for 5 decades.

3.) That being base-power and not load-following is a disadvantage? I think a couple of concepts are getting mixed up here. In their view, I think they believe that solar is load following because most of the energy is produced during the day coinciding with peak demand. That is not load following. If the demand goes up, solar power only increases if you add more sources, or if you decrease the excess amount you were curtailing. If it all of a sudden gets very cloudy, then the load must be followed by drawing on your storage and/or adding additional sources, which in today's world means gas-fired plants. The source never followed the load. There is a similar story with wind power, but it is double-bladed (excuse the pun). Wind is unreliable if there is either too little or too much wind.

   Today, PG&E uses the Helms Pumped Storage Plant. This is typically 'charged' at night with excess power from Diablo Canyon. It can be brought on line in 8 minutes. You could not reliably use this type of plant using solar and wind sources. Because of inefficiencies in pumping water uphill, the power is generated when demand is high and PG&E can charge its large customers a higher rate. Utilities are likely to use this logic in the future even if the storage is battery. They will not be doing it for any altruistic reason like general power availability, unless they are forced to.

This is an example where base-power shows a clear benefit.

4.) The existence of nuclear on the grid reduces the flexibility of the grid and impedes improvements to the grid? Again this envisions a different sort of grid. I am very skeptical that the government, utilities or society will embrace such a huge replacement cost.

Conclusion

In my opinion, none of the above concerns either singly or collectively justify refusing the relicensing of Diablo Canyon Power Plant(s).

Part 3 - My notes for my comments at the NRC public hearing

Diablo Canyon has an excellent, established 30-year safety record. This is real experience, not hypothetical scenarios. If you want a certainty, I guarantee you that if we do not get serious about greenhouse gas emissions the lives of our children and grandchildren will be significantly impacted.

Because of its effects on climate change, we need to cut CO2 generation as much as possible and as soon as possible. Renewable sources increase CO2 generation through their backup gas-fired plants.

The rest of the world recognizes the need for more nuclear. Approximately 70 new plants are under construction worldwide. In June, the China National Nuclear Power Corporation floated an IPO on the Shanghai Exchange hoping to raise US$2B. Instead they raised US$273B.

We need to diminish CO2 generation ASAP and combat the new challenges of climate change. Two examples

a.) Ocean acidification – If we do not take significant steps by 2030, we are in danger of poisoning our oceans permanently.

b.) Desalination – California might require broad desalination just for its cities, to say nothing if we also must desalinate for agriculture.

These two issues alone require immense amounts of energy.

We are kidding ourselves about climate change. It is happening faster and at a greater intensity. We need to react sooner. We are seriously underestimating the quantity of energy needed. Solar and wind cannot satisfy this need because they are intermittent and energy-density sparse.

We need as much nuclear and as fast as we can get it, especially Gen4 Molten Salt Reactors that are walk-away safe and can consume existing nuclear 'waste' as fuel.

If the NRC really wants to provide a public service, it will extend Diablo Canyon's operating limits to reflect efficiencies due to newer turbine technology. This could power an additional 70,000 homes, and reduce cooling and waste requirements.

Please renew the Diablo Canyon Power Plant operating license for the maximum extension.

Added note for this submission – The implication of China's large investment in nuclear development is that, unless the US becomes seriously active, the entire industry will be ceded to the Chinese. When we eventually wake up, as is inevitable, we will be buying all this sophisticated technology from them. But an additionally unpleasant implication is that we will not train and educate tomorrow's needed scientists, engineers and technicians. This seems a sure path to the US becoming a second rank intellectual and innovation power.

Part 4 - My submission to the California Energy Commission on their workshop/hearing on reducing greenhouse gases

Docket No. 15-IEPR-11
Workshop on the State of the Science on Scenarios to Deeply Reduce Greenhouse Gas Emissions from California's Energy System 7/24/15 and 7/27/15

Comments submitted by
Robert Greene, Ph.D.
Board Member, Thorium Energy of Silicon Valley

This submission is in addition to my verbal comments at the 7/24 workshop session. For the record, my Ph.D. is in Atmospheric Physics.

In my opinion there are some fundamental flaws in the belief that California can achieve a "real" 50% renewable portfolio. We can achieve one in "name" but the practical aspects are different, especially without significant storage options, which might be available only much later in the future.

Solar and wind are intermittent power sources. They produce an effective capacity of 20% to 40% of their nameplate capacity. And there are times when there is no sun and

no wind. To compensate for this issue, utilities build continuously-running, gas-fired power plants. Conceivably, these must provide up to 100% of the required power when alternative sources are not available. More practically, they probably have to plan on providing 2/3rds of that.

This means that your renewables portfolio is burning fossil fuels almost all the time and at some times it is close to being the only source of power. The renewable portfolio as currently defined contributes large amounts of CO2 to the atmosphere, which was opposite of its intent.

Additionally, with a gas infrastructure we are emitting large quantities of methane through leakage and incomplete combustion. Methane is a worse greenhouse gas than CO2 by a factor of about 20 on a per molecule basis. This means that we are still contributing heavily to global warming.

One simple workaround would be to add an excess of alternative energy nameplate capacity. But that would increase your energy costs by 2.5 to 5 times. Perhaps, this would make more sense if you have a real energy storage option. (Even though the new Tesla battery technology looks promising, the Commission should not kid itself that this is right around the corner as a viable utility-scale solution. Even when it is, the adoption and installation rates will be much longer than desired, as is typical for all new technology introductions.) It is simple to say that during peak times you can control the output of the alternative energy sources so as to not flood the grid. This is conceivable for wind. You can feather the blades. But you may have much greater maintenance costs if this is being done everyday. For solar, you can shut off the inverter at the solar plant. Then your panels, being non-reflective, become black body radiators, i.e. heaters. You would then be contributing to local warming directly.

This is just one set of issues as we address climate change. Here are others.

Scope – While the mission of the Commission is to find solutions for California's needs, we need to bear in mind that climate change is a global problem. Californians can also suffer from the CO2 problems in the rest of the country and the world. It is convenient to think that if we fix California, we are all set. We are not. So we should also be thinking in creating exportable technology to address climate change. Therefore, I believe there should be an economic development effort as part of your considerations, i.e., environmentally-sound export technology and products.

Time Frame and Intensity – Virtually all models have fallen short of reality in predicting the effects of climate change, such as polar cap and glacial melting. There is a

very understandable reason for this. Scientists are naturally conservative. They believe they do more harm by overestimating than by underestimating. But with climate change, I believe we will be better served by some overestimating. By underestimating, we take the risk of not taking the right steps while they can still be effective. In this game, if we are late, we are really screwed.

Suggested efforts talk about having things under control by 2050 or even 2100. According to Elizabeth Kolbert's *The Sixth Extinction*, the Great Barrier Reef is already 50% dead as well 80% of the coral in the Caribbean. A prime culprit is carbon dioxide. Ocean acidification is progressing much faster than anyone predicted. It impedes the ability of species at the base of the marine food chain to produce shells and skeletons. We are altering the chemistry of the oceans, the source of nearly 20% of the world's food supply and 50% of it oxygen. I believe all remediation dates must be moved in to at least 2030.

Quantity – Most efforts aim to replace combustion electrical energy production. Though desirable, it doesn't go far enough. We need to think in terms of massive amounts of additional energy to counter the effects of climate change. A few examples: a.) we must convert to an electric-vehicle world; b.) we need a broad program of desalination; c.) we need carbon-neutral industrial feedstocks, plus fuels for unique applications, such as aircraft, agriculture, mining, etc.; and d) we need clean power for massive materials-processing for ocean remediation to correct acidification.

Just taking desalination as an example, the Carlsbad Desalination plant will produce 50M gallons of fresh water a day, providing 7% of San Diego's need and using 40 MW. To service all the cities in California, you would need 140 such plants. That is approximately the power produced by three (3) Diablo Canyon Power Plants for this application alone. You can multiply this by much more, if we need to produce desalinated water for California's agriculture. These numbers pale in comparison to the energy needed to address ocean acidification.

Approach – Alternative energy sources cannot provide the quantities of energy required. See *A Cubic Mile of Oil* by SRI's Crane, Kinderman and Malhotra page 79 and chapter 9 for details. Most alternative energy sources are too expensive, demand too many resources and threaten too much of the environment, per kWHr actually delivered. I asked the author if this implied that we will have a primarily fossil fueled in 2050. He replied that it does.

Only nuclear has the energy density to address these needs. Nuclear also has a better safety record and lower environmental and health impact than alternative energy sources. Using Diablo Canyon as an example, it is also cheaper.

Recommendations

1.) Revise the goal of our environmental efforts to "Zero CO2 emissions".
2.) Revise California's Renewable Portfolio Standard to include nuclear power. This will make it much easier to meet aggressive CO2 emission goals. By using more nuclear, it will be much easier for utilities to flatten out the "Duck Curve"
3.) Actively support the relicensing of Diablo Canyon Power Station.
4.) Press for legislation changes to allow Diablo Canyon to install the latest turbine technology for its existing units, which will increase efficiency, decrease nuclear waste, decrease cooling requirements, and provide power for an additional 70,000 homes. (The issue here is that Diablo Canyon is restricted by state law from exceeding its current operating limit.)
5.) Recommend additional nuclear plants in the state and fix the San Onofre Power Plant (if it is not too late) just as Ohio did with its Davis-Besse Plant.
6.) Recommend the investigation of a Molten Salt Reactor industry in California. Molten Salt Reactors are walk-away safe and can burn down existing nuclear 'waste' as fuel. This is a tremendous opportunity for California. It is potentially an industry as large as the aircraft industry. It can provide exportable products and a large number of high-paying high-tech and manufacturing jobs. (These sorts of activities are already taking place in China. They have over a 1000 people working on a government supported project using technology developed at Oak Ridge National Laboratories. In June, the China National Nuclear Power Corporation sought US$2B in an IPO on the Shanghai exchange. They raised US$273B. If we do not enter this market, I guarantee we will be buying their products here, all built with Chinese technicians, not Californian.)

Below are the notes that I used to make my verbal statement at the 7/24 workshop hearing. My verbal comments differed based on input from the session.

Renewables **July 24, 2015**

a. Since renewable energy sources are dependent on climate and sunlight conditions, they produce variable amounts of energy below their maximum capacity ratings.

b. Since renewable energy sources produce variable power, they must be backed up by dedicated continuous-running gas-fired power plants to make up the difference.

c. Since the effective power capacity delivered by renewable sources runs from 20% to 40% of the maximum power capacity, to make up the difference you either have to have 2.5 to 5 times the number of power sources as the original or gas-fired power plants to handle the shortfall of 60% to 80%, and perhaps higher when the alternative source is not available

d. Because the power generated by renewables is variable, their backup gas-fired power plants usually run at less than peak efficiency, generating relatively greater amounts of CO2 than when running at peak efficiency.

e. Because renewable energy sources require backup gas-fired power plants that generate CO2, they cannot be considered truly carbon-free.

f. Because utility companies can be swamped by multiple renewable energy power generators during peak performance periods, they pay those power producers to provide less or zero power during those periods.

g. Because renewable energy sources are dependent on climate and sunlight conditions, they are relatively energy-sparse compared to nuclear or fossil fuels.

h. Because renewable energy sources are energy-sparse, they require much larger areas than nuclear or fossil fuel plants to generate the same amount of energy.

i. Because renewable energy sources require much larger collection areas, they require significant investment in transmission capabilities and roads.

j. Today, we do not have many and good mechanisms for storing excess electrical power that could be used on-demand during periods of low power production.

k. Because renewable power production is relatively energy-sparse and geographical broad, initial investment is comparatively high and requires taxpayer support.

l. Because renewable power production is energy-sparse it is relatively expensive to the consumer.

m. Because renewable power production is relatively energy-sparse and expensive, it cannot keep up with fossil fuel expansion to meet user demand.

n. Because renewable energy sources are relatively energy-sparse, geographically broad and expensive, they are difficult to ramp up fast enough to prevent degradation or collapse of climate factors upon which humans rely and enjoy.

o. Because renewable energy sources are relatively energy-sparse, geographically broad and expensive, they cannot be deployed fast enough to respond to abrupt natural and manmade disasters.

p. Renewables at present and projected development rates cannot meet the massive amounts of energy required to reverse ocean acidification and address other climate change induced issues.

q. Only nuclear overcomes all these difficulties.