

# **CCST Report on Nuclear Power in California's 2050 Energy Mix**

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Dr. Long explained this morning the analysis that led to the inclusion of nuclear power as part of the California energy mix in 2050. I will briefly summarize the main conclusions of the nuclear energy report, and then go on to the two issues that are probably most in the minds of all of us; the impact of the Fukushima accident and what will be done about spent reactor fuel.

#### **Report Highlights**

The report assumes 67% of California's electricity will come from nuclear while the rest is renewables as called for in AB-32. This would require 44 Gigawatts of nuclear capacity or about 30 large reactors. While reactor technology is certain to evolve over the period of interest, we assumed that they will be similar to the new generation of large, advanced, light-water reactors (LWR), known as GEN III+ that are now under review by the U.S. Nuclear Regulatory Commission. This allows us to say something about costs since these are under construction in Asia and Europe, and a larger number of similar systems have been built in Asia recently. Our main conclusions on technical issues are as follows:

- While there are no technical barriers to large-scale deployment of nuclear power in California, there are legislative and public acceptance barriers that have to be overcome to deploy new nuclear reactors.
- The cost of electricity from new nuclear power plants is uncertain in the United States because no new ones have been built in decades. Our conclusion is that six to eight cents per KW-hr is the best estimate today.
- Loan guarantees for nuclear power will be required until the financial sector is convinced that the days of large delays and construction cost overruns are over. Continuation of the Price-Anderson act is assumed.
- Nuclear electricity costs will be much lower than solar for some time. There is insufficient information on wind costs yet to allow a comparison, particularly when costs to back up wind power are included.
- Cooling water availability in California is not a problem. Reactors can be cooled with reclaimed water or with forced air, though air cooling is less efficient and would increase nuclear electricity prices by 5% to 10%.
- There should be no problem with uranium availability for the foreseeable future and even large increases in uranium costs have only a small effect on nuclear power costs.

- While there are manufacturing bottlenecks now, these should disappear over the next 10 to 15 years if nuclear power facilities world-wide grow as expected.
- There are benefits to the localities where nuclear plants are sited. Property taxes would amount to \$50 million per year per gigawatt of electrical capacity (GWe) in addition to about 500 permanent jobs.

The full report discusses all these issues in more detail including weapons proliferation issues in a world with many more nuclear plants, spent fuel issues, and future options (including fusion).

## **Fukushima**

On March 11, 2011 a giant earthquake and tsunami struck Japan leaving 25,000 dead or missing and causing a huge amount of destruction. The complex of 6 nuclear power plants at Fukushima Dai-ichi was severely damaged with 3 of the 6 reactors suffering core meltdown and hydrogen explosions with a release of large amounts of radioactivity. The Fukushima accident is the first major reactor accident to be initiated by an extreme external event, rather than by some combination of equipment failures and human error. The investigation into exactly what happened is still going on, so we know only part of the story, but the events in Japan have triggered a review of nuclear reactor emergency response capabilities all over the world. Those reviews will or should look into organization issues as well as technical ones. In the US the regulators (the NRC) and the government promoters (the DOE) are independent, while in most of the world they are not. Japan has announced that it will make its regulators independent and India has already done so.

In the US our Nuclear Regulatory Commission is near the end of its 90-day study; the results will be out in a week or two. We have about 25 plants of the same design as the ones that were the problem in Japan; none in California. It is certain that there will be new requirements imposed on all.

Two potential problems are already clear. One is the possibility of multiple, simultaneous disasters. The catalogue that is considered in licensing includes earthquake, tsunami, fire, flood, hurricane, tornado, external power cutoff, etc. A design basis is set for each – how big an earthquake, how high a tsunami, how big a hurricane, etc., but consideration of multiple simultaneous disasters is not uniformly done.

The other issue is how long a plant has to be able to stand on its own. At Fukushima, it was 11 days before the external electrical grid was repaired enough to bring power to the reactor site. The required coping times in the U.S. are substantially shorter than this. Extending it will require more fuel to be stored at sites for emergency generators, more portable pumping and power generation equipment, more water, etc.

The reactor operators have begun planning for regional stores of emergency backup equipment.

Similar reviews are underway in most parts of the world. Personally, I think there will be a pause in the expansion of nuclear energy while the analysis continues and then it will begin again especially in Asia. Germany backed away from nuclear once before and then came back to it. Time will tell if they come back to it again. They will certainly import more nuclear generated electricity from France and from other countries where it will be generated from fossil fuels.

## **Spent Fuel Disposal**

The Obama administration has terminated work on the Yucca Mountain nuclear waste repository for political reasons. It is said that what goes around comes around and since it was politics that picked the site, it should be no surprise that politics unpicks it.

First, how we got where we are. An act of Congress set Yucca Mountain in Nevada as the nation's first repository for storage of intensely radioactive used nuclear fuel. In 1982 Congress directed the Department of Energy to come up with three prospective sites in the western US where this material could be kept isolated for hundreds of thousands of years; Congress would make the final selection. This is what I call a top down process; the locations would not have any choice in the matter. DOE did its job, picking in 1986 sites in the states of Nevada, Texas, and Washington.

Back then George H. W. Bush was Vice-President and Texans were big powers in Congress; Tom Foley of Washington was Majority Leader (later Speaker) of the House, and no one from Nevada was in any position of influence. It was not a surprise that Nevada won the prize, and it has fought the project ever since on environmental grounds, legal grounds, and through denial of all required permits until forced to issue them by the courts. The protest is nonpartisan: every Nevadan candidate for state-wide office from any party has sworn to do his or her best to kill it, and their efforts have now been crowned with success (unless the courts force the administration to bring it back to life). Personally, I think it would make a fine repository, but that is beside the point.

It may come as a surprise to learn that we do have a repository operating in the US called the Waste Isolation Pilot Project (WIPP) near Carlsbad, New Mexico. It takes very-long-lived defense nuclear waste that has to be isolated for hundreds of thousands of years. The material goes into a 2000-foot thick salt bed 2000 feet underground that has been there for more than one hundred million years. There was consultation with the neighbors before the final Environmental Impact Statement was issued in 1981. It took about 20 years to get it opened, but it is working now and the residents of the area are said to have expressed an interest in becoming a repository for nuclear reactor waste too. I would call this a bottom up system. Find a likely site or sites, work with the people affected, and come to an agreement on the location. This is what has been done in Sweden, Finland, and France.

When the Yucca Mt. license program was suspended, a Blue Ribbon Commission (BRC) was created to make recommendations on how to proceed. It has 15 members, is non-partisan, is co-chaired by Lee Hamilton and Brent Scowcroft, and has membership that includes techies, environmentalists, industry representatives, and academics. Draft subcommittee reports are available at [www.brc.gov](http://www.brc.gov) and a commission interim report will be issued July 29. They recommend, among many other things, that we change to a bottom-up approach and have the program run by a quasi-governmental corporation like TVA.

The BRC will almost certainly recommend the creation of regional storage sites in dry casks for some of our spent fuel until a repository is opened. Based on what we have learned in the last 20 years the easiest sites to develop are in granite (Sweden's choice), salt (WIPP), or alkaline clay (France's choice). It will take about 20 years to get a repository opened if we get at it now. Until then reactor operators will have to store their spent fuel as they do now unless regional storage sites are opened soon.

**In Summary:** There are no barriers to nuclear expansion in California except legislative and public acceptance ones. The lessons of Fukushima are still being learned and will result in some new regulations. The repository problem is entirely political rather than technical.