Implementation Of Arizona's Nuclear Future - 153192.doc10

Senator Al Melvin, John Van De Beuken
Arizona Energy Education Fund

ABSTRACT

The Arizona Energy Education Fund (AEEF), now a 501(c) (3) non-profit entity, is an assembly of stakeholders from the private sector, government, education and energy industries dedicated to supporting K-12 (kindergarten through 12th grade), community colleges and universities through an enhanced program of smart nuclear generator expansion, isotope production, testing of breeder reactor power plants, recycling spent nuclear fuel in power generation facilities, and nuclear fuel cycle support.

AEEF priorities are to collaborate with stakeholders in Arizona to develop safe plans that will make Arizona the most nuclear friendly state benefiting all stakeholders. Long-term plans include promoting:

- education of K-12 students as well as the general Arizona population so that they fully understand the benefits and safe use of nuclear power;
- reliable supply of medical and industrial radioisotopes;
- Arizona as host of new reactor concepts which are being developed and demonstrated;
- development of nuclear engineering programs in Arizona universities to drive the development of the next generation of nuclear power plants; and
- supply of nuclear-generated electricity to California and Sonora, Mexico to power desalinization plants in exchange for Colorado River water currently allocated to California and Sonora.
  The development described will generate significant long-term employment for Arizona while delivering a critical service to the nation.

Arizona's location advantages include the lack of significant seismic activity, hurricanes, tsunamis, floods or frigid weather. Interstate highways and railroads are well developed and provide good, all-weather access to many potential development sites.

INTRODUCTION

During the WM2014 conference, AEEF recognized the Blue Ribbon Commission (BRC) Report [1] was undertaken and completed as a result of the 2010 decision to reject Yucca Mountain for long-term nuclear storage. As of 16 May, 2014 the Department of Energy has officially stopped collecting the fuel storage fee mandated by the Nuclear Waste Act of 1982. This is in response to a November 2013 US Court of Appeals ruling. Nuclear power generators no longer have to pay the fee to the federal government for storage since spent fuel rods must be stored by the generators on their sites. The federal government is not supporting the recycling of spent fuel rods even though about 95% of the original fuel energy value remains in the fuel rod, unused and available for recycling.

Arizona's population could double by 2060. A similar, though slightly lower, rate of growth is projected as an average for states bordering Arizona including New Mexico, Utah, Nevada, California, and Sonora, Mexico. Significant power and water infrastructure must begin in the near term to supply population increases.

The states around Arizona are not planning to increase power capacity sufficiently to provide electricity and water for the increasing population. Because of the development of nuclear plants that will use almost all of the fuel value in fuel rods, combined with lower capital cost through smaller modular components manufactured in plants and trucked or railed to the generator site, nuclear generated power will become more competitive with natural gas fired plants. Nuclear fuel is more abundant than natural gas and greenhouse gasses are not generated by nuclear power.

DISCUSSION

Arizona Border State Population Increase

Arizona currently has a population of 6.6 million and by 2060 it will grow by an additional 6.4 to 8.8 million for a total of 13 to 15.4 million people. In forty-five years Arizona will need to increase power and water supply to accommodate its 98% to 132% growth in population [2].

There are 55.5 million people in Arizona and the surrounding states including New Mexico, Utah, Nevada, California and Sonora, Mexico. This population will grow by an additional 30 to 40 million people by 2060 [2, 3, 4, 5, 6, 7, and 8].

The southwestern U.S. and Sonora, Mexico use more water from their aquifers each year than rainwater replaces. Electrical service matches current population. Short range plans call for more natural gas power stations and renewables to supply additional electricity.

The Southwest is subject to severe droughts.

Desalinization & Electricity For 30 to 40 Million New Residents

Increases in water must be met through water conservation and desalinization plants. Perhaps water conservation efforts, including recycling and price increases, can cut current and future water consumption by 25% [8, 9, and 10]. A 25% water conservation estimate was selected based on similar variation of per-capita consumption rates observed between individual states as well as an effort to conservatively estimate water requirements. The cost of providing the water will increase and will likely be passed on to the consumer who will reduce consumption. Presently, this Southwestern area consumes 7.2 billion gallons per day. To supply the population increase we will need between 3 and 4 billion more gallons per day by 2060 even with a 25% usage reduction per capita [9].

The biggest desalination plant in the U.S. is being built in Carlsbad, California to supply 50 million gallons per day or 7% of the domestic need of the 3 million people in San Diego County [10]. This is about 210,000 people. With conservation supplying 25% of total needs for 30 to 40 million new people; the Southwest will need 58 to 82 new desalinization plants the size of the Carlsbad plant. This water requirement is 3 billion to 4 billion gallons of water per day. This does not include any agricultural or industrial water consumption increase for the additional 30 to 40 million people.

The states bordering Arizona are also planning on new natural gas fired power plants to supply an increase in short term electricity demand. Wind and solar are also in the mix but they are not available 24 hours per day and at any given time the base load must be satisfied by sources other than those intermittent renewables.

An additional 30 to 40 million people will require an additional 42 GWe to 56 GWe of electrical generating capacity as a flat base load [11]. This would be roughly the size of 13 to 17 Palo Verde nuclear generating facilities of 3.3 GWe each running at a constant load with no transmission losses. This understates capacity demand because it has no allowance for power plant availability, diurnal or seasonal variation or type of generation such as solar or wind vs. natural gas or hydro. This understatement of required capacity could be offset by technology breakthroughs or slower optimization over the next 45 years.

Arizona is part of the Western Electricity Coordination Council (WECC) including British Columbia and Alberta, Canada as well as 11 western states of the USA. No nuclear power facilities are being considered in WECC planning.

Nuclear vs. Wind and Solar

Wind and solar cannot compete with nuclear power grids. Grids must be prepared to supply the base load 24 hours per day and seven days per week. Residential and industrial electricity users do not want to have electricity rationed. Wind and solar are not dependable and there is no economically available technology that can store energy from wind turbine farms or major solar facilities. The base load power plants must be capable of supporting the entire electrical load on those days that the wind does not blow or nights when the sun does not shine. Battery backups are used on some homes with solar panels but batteries are not yet practical for large wind farms or major solar generating plants. There is a $50 million test in progress where a 32 megawatt-hours battery system was installed in California's Tehachapi Wind Resource Area [12]. Other tests include pumped hydro and compressed air storage.

Recycling

In line with the BRC Report recommendations, Texas and New Mexico are working with the Department of Energy (DOE) to site some Spent Nuclear Fuel (SNF) storage. The opportunity to host recycling would be greater if the SNF storage is located next to the recycling site as well as in a competent underground salt deposit. These exist in Arizona and a proposal to the DOE during 2015 would be timely.

In 2012 electricity generation in the USA was 4300 TWh of which nuclear was 800 TWh. The energy capacity of the spent fuel rods, used to produce the 800 TWh nuclear component is approximately 16,000 TWh or nearly 4 times all of the electricity generated in 2012 [13].

Fast Neutron Reactors (FNR)

As mentioned above there is a need to significantly increase nuclear power plants in Arizona. This will also provide siting for fast neutron reactors that are much more efficient than the light water reactors currently used in the U.S. Light water reactors use less than 4% of the fuel potential in new fuel rods.

The objective of FNR reactors is to use 100% of the fuel potential in a new fuel rod.

There are three American/international companies (GE-Hitachi-PRISM, TerraPower and General Atomic-EM2) that have competing FNR designs to utilize most of the fuel value in their nuclear fuel rods. FNR power generators will have the reactors manufactured in a central location to be small and modular. Fabricated components will be trucked or railed to the site which will significantly reduce construction manpower, construction time and capital cost. FNR generators should become more competitive with natural gas fired generators because of this construction as well as operations cost breakthroughs when 60 to 70 percent of the fuel value is useable instead of 4%.

Since FNR power generators use closer to 60 to 70 percent of the fuel value compared to 4 percent in light water reactors, the spent fuel would have closer to 30 percent of the fuel value of light water spent fuel. The half-lives of the radioactive residue from FNR generators would be far shorter than that of light water reactors. Tailored waste forms would only have to remain intact for 500 years, not the 10,000 years required for Yucca Mountain [14].

The development of nuclear reactors in the USA has been significantly retarded through concern about proliferation of plutonium which is required for nuclear explosives. FNR reactors consume the plutonium as it is created from uranium. FNR reactors eliminate the opportunity to collect plutonium and concentrate it, which should diminish fear of proliferation.

Isotopes

Mo-99 is normally produced in a test reactor with a half-life of 2.74 days. It decays to Technetium-99 which is used in approximately 80% of all procedures involving medical isotopes. Chalk River supplies about half of the Mo-99 used in the U.S. for medical imaging. It will be decommissioned in 2016. In 2017 Phoenix Nuclear Labs of Madison, Wisconsin will commission an electrostatic accelerator which will replace the Chalk River capacity to produce Mo-99 [15]. A second accelerator could be built in Arizona to supply the other half. The isotope market is complex so a lot of marketing would be involved. Until now research reactors were required to produce Mo-99. Since the development of the Phoenix Nuclear Labs accelerator, Mo-99 can be produced with a much lower cost facility with almost no associated nuclear waste and with a lower operating cost. Airlines provide timely international shipment of Mo-99 from international research reactors but many of those reactors are due for major overhauls which provides significant leverage for Phoenix Nuclear Labs whether they locate a new accelerator in Arizona or in another country.

Arizona Energy Education Fund

AEEF's role is education to help the residents of Arizona understand the benefits of nuclear power and to help resolve misunderstandings regarding nuclear power. The Blue Ribbon Commission (BRC) recommended improved communication and support from communities which might host spent nuclear fuel (SNF) storage. We agree that this approach has great merit and we will extend the consensus building to siting more nuclear power generators.

AEEF is working with schools and science fairs and the public to improve the understanding of our nuclear future. This will include teacher and student participation in the Waste Management Symposium. Beyond supporting STEM (Science, Technology, Engineering and Math), AEEF is challenging students

to select and pursue nuclear-related science fair projects.

AEEF is active in Southern Arizona Research, Science and Engineering Foundation (SARSEF) which has been the largest and most active outreach to teachers and students of southern Arizona since 1955. "Each year, more than 75,000 students throughout Southern Arizona create research projects at their own schools, with the goal of winning a spot at SARSEF. About 1,800 projects, representing more than 4,000 students, are chosen to compete at the Tucson Convention Center and from there, we select the "best of the best" to honor. Over 400 judges and volunteers come down to help us choose the winning projects" [16]. SARSEF is working with interested parties in other areas of the state to spread the success. AEEF supports this effort.

AEEF supports Arizona Public Service which has provided a visitors center near Palo Verde, the largest nuclear power station in the United States located 45 miles west of downtown Phoenix, Arizona. AEEF is focused on school tours of the visitor center to provide a clear understanding of the safety and value of nuclear power plants and the key role they will have in our future. The Science Center, next to the Phoenix Convention Center, is also interested in more nuclear exhibits.

AEEF is creating a one stop website, http://arizonanuclearsolutions.org/. Our objective is to link all useful nuclear-related websites to Arizona Nuclear Solutions and organize to provide self-directed educational opportunity.

AEEF Short and Long Term Education and Planning Outline

Short Term

- Education – Develop a series of short PowerPoint presentations aimed at the elementary, middle school and high-school levels and the general public and suitable for our website too.
- Awareness – Develop an AEEF newsletter targeted at middle school, junior high, high school and general public to increase awareness.
- Marketing – Involve AEEF in SARSEF activities, especially judging.
- WMS March 2015.

Long Term

- Link nuclear and desalination.
- Medicine
  - Medical therapy – isotopes
  - Medical profession
    - ✓ Nuclear cardiologists
    - ✓ Radiologists
    - ✓ Oncologists
    - ✓ Nuclear pharmacists
    - ✓ Nuclear pharmacy technicians
    - ✓ PET Cyclotron workers
- Nuclear powered energy grid.
- Benefits of nuclear - research in nuclear physics, chemistry, medicine and engineering has a powerful and beneficial effect on the economy, technology, and security of our society.
  - Diagnosing physical ailments without need of exploratory surgery

  - Alerting families to the threat of fire
  - Guarding against biological agents carried through the mail
  - Providing for our national security
- Develop and maintain an effective pro-nuclear education website directed to K-12 and general public.

CONCLUSIONS

All 6 of the issues below provide great opportunities for Arizona to become the most nuclear friendly state in the USA. They also provide the opportunity to create an abundance of high paying, technical permanent jobs in Arizona. The role of AEEF is support of education to realize the safety of nuclear power in Arizona and to encourage the social support required to realize the opportunity.

1. There is no urgency regarding the location of a replacement for the geologic repository at Yucca Mountain for spent nuclear fuel rods. The program used by producers to cool spent fuel rods and eventually place spent fuel in concrete casks at the producers' reactor site is sufficient in light of recycling to fuel FNR power generators as well as light water reactors.
2. Spent nuclear fuel, from light water reactors, retains about 95% of the fuel energy value because light water reactors were not designed to extract the entire potential. Spent nuclear fuel rods are not waste but a tremendous energy resource. If spent fuel rods contain 5% of the original fuel value instead of 95%, nuclear waste will have 90% less nuclear fuel value and a similarly shortened half-life. Tailored waste forms would only have to remain intact for 500 years not the 10,000 years required for Yucca Mountain. [14]
3. Fast neutron reactors are being designed and tested to use much more of the remaining fuel value in spent fuel rods and possibly close to 60 to 70 percent. China has a 65-megawatt, sodium cooled, fast neutron prototype power plant running at full capacity as of December 2014 [17]. The United States does not have a fast neutron power plant or prototype in operation.
4. Arizona and the states bordering Arizona will grow faster than any other part of the USA during the next 45 years from 55.5 million people now to 85.5 million or at the upper edge of the window to 95.5 million people by 2060. Only one nuclear plant is in line to submit an environmental study permit sometime in the near future. It would be located in Green River, Utah with a name plate capacity of 2.4 GWe. The region needs 42 GWe to 56 GWe of new capacity by 2060. The potential Green River site is not included in the WECC planning.
5. To support 30 million additional people will require 3 billion gallons of desalinated water per day and 40 million will require 4 billion gallons per day. This does not include any additional water for agriculture but it does include a 25% reduction from current usage rates through conservation.
6. The most important medical isotope is Mo-99 which can now be produced with an electrostatic accelerator. An accelerator is far cheaper to build and operate than the research reactors that currently accomplish the production of Mo-99. Building an accelerator in Arizona, an area of rapid population growth, to produce roughly half the Mo-99 needed in the USA makes a great deal of sense.

REFERENCES

1. LEE H. HAMILTON and BRENT SCOWCROFT, Blue Ribbon Commission on America's Nuclear Future, Lee Hamilton & Brent Scowcroft, January 2012
2. TOM R. REX, New Population Projections for the United States, Arizona and Arizona Counties, ASU, W. P. Carey School of Business: January 2013

3. Population Projections-AZStats.gov, Arizona Department of Administration, Office of Employment and Population Statistics, 12/07/2012
4. University of New Mexico Geospatial and Population Study Group (GPS)-Population Projections for New Mexico and Counties, Bureau of Business and Economic Research, UNM, Last Revised: 12/4/12
5. California Department of Finance Demographic Research Unit, Report P-1 (County) State and County Population Projections July, 2010-2060 (5 year increments), January 31, 2013
6. JEFF HARDCASTLE, Nevada County Population Projections 2014 to 2033, The Nevada State Demographer's Office, October 1, 2014
7. H. D. PALMER and BILL SCHOOLING, New Population Projections: California to Surpass 50 Million in 2049, Department of Finance, State of California, January 31, 2013
8. Estimación de Población Total 2014 por Jurisdicción Sanitaria, Coordinación Médica Local y Municipio, http://www.conapo.gob.mx/en/CONAPO/Proyecciones http://www.conapo.gob.mx/es/CONAPO/Consultas_Interactivas COESPO (consejo estatal de la población)
9. J.F. KENNY, N. L. BARBER, S.S. HUTSONK, S, LINSEY, J.K. LOVELACE AND M.A. MAUPIN, USGS (United States Geological Survey) 2005 per capita water consumption by state, http://water.usgs.gov/edu/wateruse/pdf/wudomestic-2005.pdf
10. http://carlsbaddesal.com/desalination-plant
11. Assessment of the 2012 Integrated Resource Plans of the Arizona Electric Utilities, December 11, 2012, see page 45 showing a Western Electricity Coordinating Council (WECC) graph showing total energy consumption in the WECC area is 1,200KW per capita.
12. DAVID SONG, Edison International, SCE Unveils Largest Battery Energy Storage Project in North America, September 24, 2014, http://newsroom.edison.com/releases/sce-unveils-largest-battery-energy-storage-project-in-north-america
13. World Nuclear Association "Nuclear Power in the USA" updated 23 October 2014.
14. WILLIAM H. HANNUM, GERALD E. MARSH AND GEORGE S. STANFORD, Scientific American, "Smart uses of Nuclear Waste", December 2005
15. Phoenix Nuclear Labs, Madison Wisconsin, http://phoenixnuclearlabs.com/
16. SARSEF, Southern Arizona Research, Science and Engineering Foundation https://sarsef.org/
17. Nuclear Street News Team, Dec 22, 2014, China's Prototype Fast Reactor Is Running At Full Capacity