

**3/22/11
PRESENTATION:
POTENTIAL
THREAT TO
ALASKANS FROM
JAPAN'S
RADIATION**

<TARGET><BILL></BILL><SUBJECT>3-22-11 PRESENTATION
POTENTIAL THREAT TO ALASKANS FROM JAPAN'S
RADIATION</SUBJECT><COMM>HHSS27</COMM></TARGET>

Janet Ogan

From: Will Vandergriff
Sent: Friday, March 18, 2011 2:52 PM
Subject: AK State House Majority Caucus media advisory: H&SS Comm. Japan Radiation Hearing
Moved to Tuesday (3/22)
Attachments: 20110318_radiation_hearing_announcer.pdf

FOR IMMEDIATE RELEASE: Friday, March 18, 2011

JAPAN RADIATION HEARING MOVED TO TUESDAY
Committee pushes up from Thursday to accommodate experts

Juneau, Alaska – Health & Social Services Committee Chair Rep. Wes Keller, R-Wasilla, today announced that the committee’s planned hearing on the threat of radiation from Japan reaching Alaska has been moved to Tuesday of next week to accommodate testifiers. The hearing, entitled “Potential Threats to Alaska from Japan’s Radiation,” was originally noticed and scheduled for next Thursday, March 24, but due to the continued shifting situation in Japan, will now be held Tuesday, March 22 at 3:00 p.m.

Keller says he’s glad to move the meeting up, as it gives the public an earlier opportunity to hear from state experts and other professionals. “There are a lot of questions that still remain unanswered,” Keller said. “We are assured that the disaster at the Fukushima Daiichi complex will have little or no effect on Alaska, but the situation is constantly changing in Japan and could here as well. I hope the information we hear on Tuesday, now, will reassure Alaskans not to overreact.”

Officials from the Alaska Department of Health & Social Services, the AK Dept. of Environmental Conservation and the AK Dept. of Military & Veterans Affairs will testify at the event.

WHO: House Health & Social Services Committee
AK DH&SS officials
AK DEC officials
AK DMVA officials
WHAT: Potential Threats to Alaska from Japan’s Radiation hearing
WHEN: Tuesday, March 22 – 3:00 p.m.
WHERE: State Affairs Committee Room
Capitol Room 106

Teleconferencing is available through local LIOs.

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The Japanese Nuclear Crisis: What it Means for Alaska

Joe McLaughlin, MD, MPH
State Epidemiologist
Alaska Division of Public Health

Chris Laborde
Preparedness Program Manager
Alaska Division of Public Health



Implications for Alaska

- **There is no immediate or anticipated threat for harmful levels of radiation to reach Alaska**
- **Alaska's seafood is unlikely to be affected**
- **This is an important reminder that all Alaskans should assemble a home emergency kit and a family response plan**

Public Health Response to a Radiation Emergency

- Inform
- Protect the public from radiation exposure
 - Shelter-in-place and/or evacuation
 - Distribution of radiation medications (e.g., KI, DTPA, etc.)
 - Restrict consumption of contaminated food
- Decrease psychological effects of radiation exposure
- Long-term follow-up for exposed persons
 - Case identification and tracking (registry)
 - Access to care

DHSS Communication Response

- Responded to media requests
- Issued press releases and messages through social media (e.g., Facebook and Twitter)
- Issued an *Epidemiology Bulletin*
- Principal messages
 - No anticipated threat to the health of Alaskans
 - Alaskans should not be taking potassium iodide
 - Monitoring
 - Communicating with local, state, and federal partners
 - Important reminder that all Alaskans should be prepared

What can Alaskans do to be prepared for an emergency?

- Create a home emergency supply kit
 - Food with a long shelf life, water, change of clothes, plastic bags, bedding, radio, medicines, toiletries, flashlight, batteries, telephone, duct tape, heavy plastic, cash, important documents...
- Create a vehicle emergency supply kit
- Develop a family response plan
- Practice

Alaska Radiation Monitoring

- Alaska's monitoring stations continue to show normal background levels of radiation
- 5 EPA monitoring stations
 - Currently reporting: Anchorage, Fairbanks, and Juneau (γ)
 - Soon to be reporting: Dutch Harbor, Juneau (β), Nome
- If levels were to rise substantially, we would measure specific isotopes to determine if steps are needed to protect the public's health
- Data are available at the DHSS homepage:
www.hss.state.ak.us

Food Supply

- **FDA is closely monitoring**
 - Increased and targeted product sampling at the border
 - <4% of US imported foods come from Japan
- **Current models indicate that US fishing waters will remain safe**
 - “The great quantity of water in the Pacific Ocean rapidly and effectively dilutes radioactive material, so fish and seafood are likely to be unaffected” FDA

Exposure (rem)	Notes and Effects
0.00008	Amount of radiation reported in Tokyo on March 15
0.0016	Avg. amount of radiation absorbed per person per day
0.04	Chest x-ray
0.6	Avg. amount of radiation absorbed per person per year
1.4	Gastrointestinal series
40	Maximum radiation reported at the main gate of Fukushima Daiichi power plant (March 15)
5-50	Fetus/embryo: slightly increased risk of malformations, growth and IQ impacts, failure to implant Children/adults: changes in blood chemistry (e.g., WBC)
50-90	Nausea, fatigue, vomiting, hair loss, diarrhea

Availability of Radiation Medications

- Radiation medications are included in the Strategic National Stockpile
 - Potassium iodide, Prussian blue, DTPA
 - Antiemetics, Neupogen, antibiotics
- CDC will only deploy if there is a “credible threat”
- “No public health risks are expected in the United States” US DHHS

Summary

- There is no anticipated threat of harmful radiation exposure to Alaskans at this time
- Alaska's seafood is unlikely to be affected
- All Alaskans should be prepared for disasters
- More information is available at www.hss.state.ak.us

Briefing document on Fukushima Nuclear Plant Events, 3/18/11

Prepared by the Alaska Center for Energy and Power, University of Alaska Fairbanks

Chronology of events:

- Reactors scram (emergency shutdown) at time of earthquake
- Back-up diesel generators knocked off line by tsunami about 1 hour after quake (20 ft wave)
- Off-site power connections destroyed by tsunami
- Battery power used for emergency operation operate as intended, but only provide power for 8 hours
- All electrical power to site was cut, ie, “blackout”.
- A detailed timeline of events can be found on IEEE web site at <http://spectrum.ieee.org/tech-talk/energy/nuclear/timeline-the-japanese-nuclear-emergency>).

Design of “Boiling Water Reactors” and events at Fukushima:

- These reactors use water for multiple purposes—to move heat from reactor core, as a working fluid for turbine cycle, and as a “neutron moderator” for the chain reaction.
- Water does not come into direct contact with radioactive fuel — zircalloy cladding on fuel rods prevents contact. Uranium fuel surface temperatures are about 9000°F, zircalloy melts at about 5000°F so removing heat continually from the core is critical to safe.
- Temperature and pressure of the reactor is kept at about 550°F and 1100 PSI under normal operation.
- To maintain these temperatures and pressures, constant forced cooling of reactor core is required, provided through large recirculation pumps, in order to keep surface of the fuel rods below the melting temperature of the zircalloy cladding.
- Recirculation pumps are understood to be very critical and there are two pumps installed on each reactor (1 can sufficiently cool reactor). There are also multiple redundancies in power for electric pumps—from the turbine (under normal operation), from other reactors on-site, from offsite grid connected power, from on-site diesel generators, and from emergency battery bank (4 hours required in US, 8 hours in Japan).
- The Fukushima site lost all power for pumps in tsunami (turbine and on-site power lost at earthquake, diesel generator and offsite power lost in tsunami, and batteries died as expected after 8 hours).
- When a reactor scrams (experiences an emergency shutdown), the reactor still generates significant “decay heat” that must be removed from reactor core.
- If recirculation pumps are not operable, core temperatures quickly rise, causing commensurate pressure rise from steam.
- Pressure in system must be relieved, either by venting or by bursting pipes—controlled venting is preferred—but results in a drop in water level in reactor. Initial release of steam is not highly radioactive, as fuel rods are still intact at this time and the radioactive material is not in direct contact with the cooling water remaining in the core.
- As the water level drops, the zircalloy cladding on the fuel rods is eventually exposed to steam, which cannot conduct heat away from fuel rods adequately. Therefore, fuel surface temperatures rise above the melting temperature of zircalloy.



- Zircalloy also oxidizes when exposed to the steam, stripping oxygen from water molecules and generating free hydrogen (H₂), which presents an explosion hazard when vented.
- Damage to the zircalloy cladding also exposes uranium fuel to primary coolant, contaminating the steam with radioactive particles.
- Subsequent venting releases both hydrogen gas and radioactive particles.
- Water can be injected only if pressure is sufficiently relieved—the “bleed and feed” cycle that has been mentioned in reporting—which has been used to attempt to reduce reactor temperatures.
- Hydrogen explosions in units 1 and 3 destroyed much of the “secondary containment” system. This secondary containment is designed to blow away rather than cause damage to the primary containment system.
- However, most of the fuel is still contained inside the reactor and primary containment (only a small fraction of the radioactive material is released with the steam).
- Eventually, the pressure is lowered, the temperature is lowered, and the decay heat subsides naturally, and the reactor is “brought under control”—which seems to have occurred.

Spent Fuel Pool issue:

- “Spent fuel pools” are used to store “spent fuel” after it is removed from the reactor during normal operations. Spent fuel pools are covered with water, but are open to the atmosphere inside the secondary containment. They are located above the reactor level in the reactor design used at Fukushima—during refueling operations, the top is removed from the reactor and fuel is lifted from the core area to the spent fuel pool above.
- Spent fuel is cooled by water, but this water is also cooled by pumps and cooling systems during normal operations. Spent fuel is generally stored in this manner for years before the most dangerous radioactive elements decay to the point where the rods can be moved to a longer-term storage location (also usually still at the reactor site in the US and Japan).
- Fukushima reactor 4 was shut down for maintenance at time of earthquake, and fuel from the core that was not completely spent was being stored in the spent fuel pond (fuel is not critical unless arranged in tight configuration and can be stored safely under water in this pool so long as the fuel is spaced such as criticality cannot be achieved).
- If this spent fuel pond is cracked, it may be very difficult to cover fuel with water, which absorbs most of the energy from radioactive decay.
- Workers cannot safely approach spent fuel pool unless it is covered with water.
- If the fuel remains exposed, it could catch on fire, or melt into a mass that could become critical (start a nuclear chain reaction), although criticality is thought unlikely.
- If attempts are made to cover spent fuel with water, a steam explosion could occur.
- Either a fire or explosion would result in radioactive particles being released into the atmosphere, although probably not with the same force as the high pressure steam explosion at Chernobyl.

As of March 18, 2011:

- Measurable radiation has been released to atmosphere in multiple events from the Fukushima site, but releases beyond boundary of plant have been so far relatively modest (worse than TMI, but not nearly as bad as Chernobyl).



- The area around plant was ordered evacuated before most radioactive releases occurred, so public health is not in danger (yet).
- Workers may have been exposed to high levels of radioactive steam inside plants—reports of workers with radiation sickness is not encouraging—deaths among workers may occur (it usually takes 3-4 weeks for the danger of death from high exposure to pass).
- Spent fuel pond event is still developing—there is still significant danger of spreading of radioactive materials into surrounding area—although the likelihood of a vigorous explosion that would eject material high into the atmosphere where significant fallout would occur in Alaska or the US seems very low.

New reactor designs are intended to solve some of the issues:

- There has been a major efforts to create “passive” heat removal systems, so that a loss of electrical power does not result in fuel damage.
- Liquid metal reactors (Toshiba 4S, Hyperion) operate at atmospheric pressure, and are cooled by materials that will not vaporize.
- The use of natural convection (the natural buoyancy of hot fluids to rise) to move coolant past reactor core without pumps is another strategy, proposed by NuScale.
- Use of large “swimming pools” of water to surround much smaller reactor systems
- SMRs also have the advantage of using smaller reactor cores (45 MW for the NuScale system as compared to 1000 MW+ for current systems), which allows for easier heat management
- TRIGA research reactors are intrinsically safer—reaction limited by “Doppler effect” when fuel temperature rise.


What does this mean for Alaska?

It is too soon to tell what all the impacts will be from the events that have taken place in Japan over the past couple of weeks, and are still unfolding. Worker deaths or releases of large amounts of radioactive materials into surrounding area would be tragic at many levels, including the workers and their families, the community, the nation of Japan, and the world nuclear industry. If no deaths occur, and larger radiation releases can be avoided, the nuclear industry can claim that safety systems protected both workers and the public, even under the absolute worst of circumstances. However, this is far from a given at this time considering the possible high levels of exposure for some of the workers. At a minimum, this incident is likely to influence a new discussion about the design and safety of existing and proposed reactors. It is possible that one outcome would be to move the nuclear industry towards smaller, safer, and more modular reactor designs that would be less susceptible to a major failure such as precipitated by the sequence of events that took place in Japan.



Small Scale Modular Nuclear Power: *an option for Alaska*

DRAFT: Executive Summary



*Prepared by the University of Alaska, Alaska Center for
Energy and Power and the Institute of Social and Economic
Research with funding through the Alaska Energy Authority*

Small Scale Modular Nuclear Power: *an option for Alaska?*

EXECUTIVE SUMMARY: DRAFT March, 2011

Prepared for:

The Alaska Energy Authority
Project Manager Mike Harper, Deputy Director

Prepared by:

The University of Alaska Fairbanks, Alaska Center for Energy and Power in partnership with the University of Alaska Anchorage, Institute for Social and Economic Research

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This executive summary and report have been released in draft form to allow time for public input. We anticipate a final report will be published at the end of April, 2011. Please provide comments and feedback to:

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UNIVERSITY
of ALASKA
Many Traditions One Alaska

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It should be noted that the contents of this report represent the consensus of the authors, but do not necessarily reflect the views of those listed above.

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Photo Credits

Front Cover: Image of Denali, Jim Norman, ABS Alaskan; Image of TRIGA Research Reactor courtesy of General Atomics; Artist Rendition of Toshiba 4S Reactor courtesy of Toshiba and Marvin Yoder, MY:T Solutions.

Executive Summary

Alaska is home to some of the most abundant supplies of fossil fuels and renewable energy resources on the planet. While the Alaska treasury benefits financially from development of these resources for export, the supply of reliable, affordable energy to small and often isolated Alaska markets remains a challenge. These conditions result in energy prices for space heating and electricity that are volatile and expensive in many areas of the state. These high energy prices are a significant burden for Alaska residents and businesses and stifle economic development.

Ways to address high energy prices are being deliberated, including the possible construction of one of several proposed natural gas pipeline projects, funding of individual projects in rural communities with access to developable resources, and consideration of a large-scale hydroelectric project to serve the Railbelt. Another possible source of energy is nuclear power.

Why discuss the nuclear option? With Alaska's abundant energy resources, this form of energy might not seem needed. However, Alaska's resources are not equitably distributed geographically, with some areas located near energy sources (for example, the gas fields of Cook Inlet that supply energy for Anchorage), and many other areas less fortunate. In particular, communities in rural Alaska face very high energy prices due to reliance on imported diesel fuel, and many do not have access to developable local resources that can appreciably reduce this dependence. To a lesser degree, the Fairbanks area also lacks low-cost, locally abundant energy resources. It is possible that the new small-scale modular nuclear power plants could lower the cost of energy in some of these locations.

Alaska was not part of the first wave of nuclear power development in the U.S., as the nation's existing commercial nuclear industry is comprised of 1000 MW reactors that are too large for any Alaska applications. However, as part of a new generation of nuclear power plants worldwide, small modular reactors (SMRs) are being developed that range in size from 10 MWe to 300 MWe. These SMRs would be manufactured in factories, allowing standardized design and fabrication, high quality control, shorter power facility construction times, and reduced finance charges during construction. In larger markets in the Lower 48, multiple SMR modules could be combined to form a single gigawatt-scale power plant, which would have several advantages over a single large reactor, including reduced downtime for maintenance and improved safety. These SMRs would also be appropriately sized for use in Alaska, making nuclear energy a viable option to consider. In addition to providing energy (heat and power) for rural communities and/or the Railbelt, other potential applications include providing energy to military bases, remote mining operations, and other industrial users.

The Toshiba 4S nuclear power plant proposed for Galena in 2003 is familiar to many Alaskans. This project initiated a serious conversation about nuclear energy throughout the state when it was incorrectly reported that Toshiba was willing to "give" a 10 MWe prototype reactor to the community of Galena. Though this project did not advance past the early conceptual phase, it

influenced the national conversation about nuclear energy and brought the needs of small, remote communities to the attention of lawmakers and regulators in Washington, D.C. That conversation identified market opportunities for SMR technology, and highlighted regulatory barriers to such installations.

The purpose of this report is to explore the viability of SMR technology for meeting Alaska's current and future energy needs. We found that no small-scale nuclear reactor technology is currently approved or licensed for commercial use in the U.S. In fact, no SMR manufacturers have submitted a request for design review and certification to the Nuclear Regulatory Commission (NRC), a critical step toward development of a pilot project and a process that is expected to take several years to complete. Therefore, at least with regard to any SMR that could be installed in the U.S., this technology is still in a pre-commercial phase of development. Nonetheless, several manufacturers are actively advancing their designs, and the Department of Energy (DOE) is poised to invest \$500 million in SMR technology over the next few years. The question is not whether SMRs will become commercially available, but when. In the interim, a series of questions need to be answered, some at the national level and some in Alaska. These questions include, Does the technology exist to build these small reactors? Is the technology safe? How will the fuel cycle for SMRs be managed? Are suppliers willing to sell small-scale nuclear reactors in Alaska? Who would own a project? Would this technology be cost effective? What skills are needed if Alaskans choose to adopt SMR technology as part of their energy portfolio? Should Alaska be an early adopter of this technology?

This study, conducted at the request of the Alaska Legislature and managed through the Alaska Energy Authority (AEA), addresses these questions. The scope of this report includes identification and evaluation of all currently known existing or proposed small-scale nuclear power technologies worldwide. Information contained in this report was obtained through web-based and library research, interviews with technology experts worldwide, and attendance at conferences focused on SMR technology.

In addition, many of the policy options forwarded in this report are a direct product of discussions that took place during a SMR workshop held in Anchorage involving dozens of key stakeholders from around the state, as well as representatives from the DOE Nuclear Energy Agency, the Nuclear Regulatory Commission, and other industry specialists. This workshop specifically considered Alaska applications for SMR technology, including the special challenges associated with potential

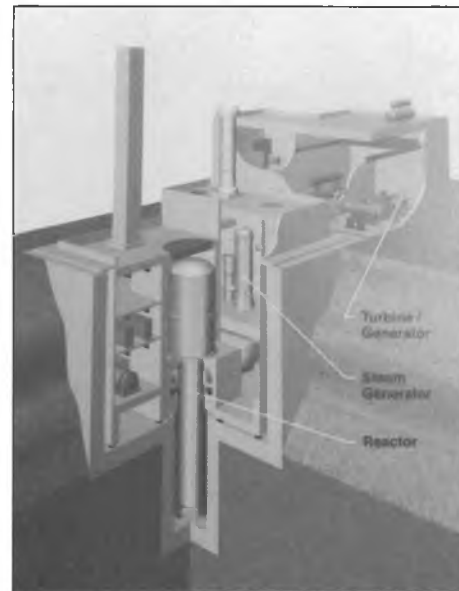


Figure 1. Artist rendition of the proposed Toshiba 4S 10 MW reactor proposed for Galena.

deployment in Alaska. We thank those who took the time to participate and contribute to that discussion. A full transcript is available.¹

The results of our study of current SMR technologies include the following observations:

- More than 50 nuclear reactor technologies have been proposed worldwide that are classified as small. These nuclear reactors vary in size from 1 MW_e to 300 MW_e. Many of the newer designs are “fast reactors” as opposed to currently used “light water reactor” technology. Fast reactors are designed to allow the use of spent fuel from light water reactors, but doing so requires the development and construction of expensive fuel reprocessing plants that do not yet exist.
- No SMR systems are expected to be in service before 2020. The first systems approved by the NRC will likely be smaller-scale versions of existing light water reactor technology, such as those proposed by NuScale and Babcock and Wilcox.
- All of the current SMR designs for which NRC approval will be sought are 10 MW_e or larger, a size too large for most rural communities. Radioisotope thermal generators (RTGs), used by NASA for long-term space missions or on Earth for powering critical remote communications sites, are unsuitable for village-scale power due to the high cost of radioisotope materials. Mini nuclear reactor systems that might be suitable for small communities have not been considered seriously because of the lack of an apparent U.S. market. Nuclear submarines and icebreakers use highly enriched (weapons grade) uranium that would pose safety and security issues if used for stationary power.
- Both state and federal laws require NRC approval for any project involving nuclear energy. The NRC has not reviewed any small reactor designs, although several companies have stated their intention to submit designs for review in the next year or two. The Galena Toshiba 4S project is not moving forward at this point, and no formal license application for this project has been submitted to the NRC for review. Some of the designs identified in this study are operating in other parts of the world - for example, a Russian design for a barge-mounted power plant - but cannot be permitted in the U.S. unless NRC approval is sought and given (the Russian developer, Rosenergoatom, is not considering applying for such approval).
- In addition to the reactor design review, the NRC requires a thorough review of any proposed site for a nuclear power plant. Such a review considers emergency planning, emergency zones surrounding the plant, and appropriate seismic design. Currently, there are no approved sites for commercial nuclear power plants in Alaska.
- The NRC evaluates the technical and financial capabilities of the plant owners, including the ability of the owners to finance construction of the plant; to attract, train, and retain a workforce with appropriate skills; and to construct and operate a plant that meets appropriate standards. For this reason, development of a nuclear power plant in Alaska may require partnership with a company from a location outside the state that has expertise in nuclear energy, especially when building and commissioning the first plant.

¹ <http://www.uaf.edu/acep/education-outreach/events/event-archive/nuclear-energy-explorator/>

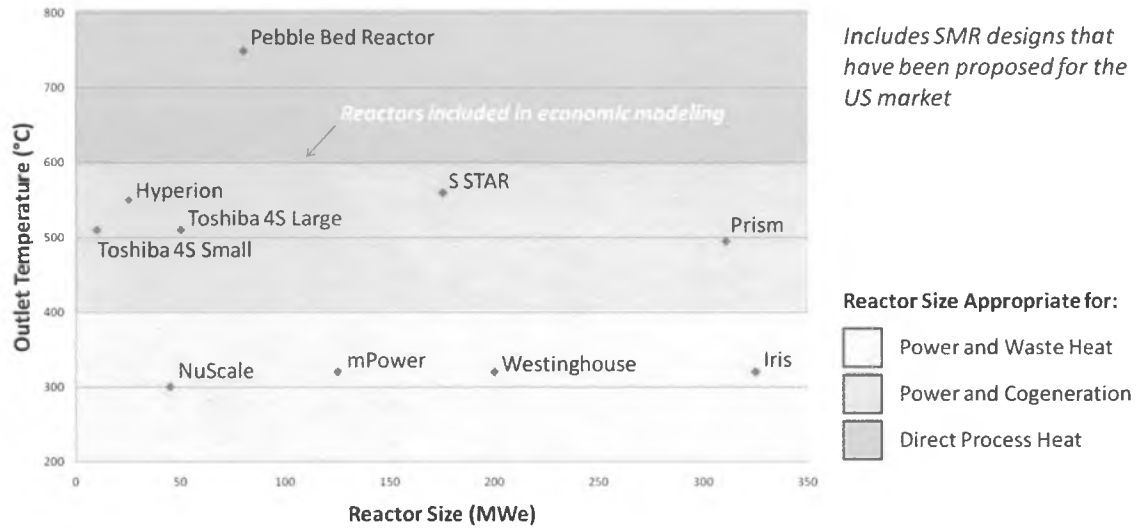


Figure 2. Representative small reactor designs and relative operating temperatures. Reactors with high and medium outlet temperatures are generally fast reactor technology, while designs based on more traditional light water reactor technology have lower outlet temperatures.

Economics of Small Modular Reactors in Alaska

As part of this project, we developed an economic model to serve as an initial screening tool to determine if and where SMR technologies could be economically deployed in Alaska, when the technology become available. Since SMR technology has not been commercialized anywhere in the U.S., our analysis is subject to significant cost uncertainties. Additional analyses can easily be conducted in the future as costs become more certain, because the screening model was designed to be readily adaptable as new information becomes available.

For our economic analysis, we identified technologies currently under development that potentially could be used in Alaska settings based on the capacity of the units and the anticipated date of availability. Thus, five manufacturer designs were selected for economic viability screening: mPower, NuScale, Hyperion, Toshiba 4S large (50 MWe), and Toshiba 4S small (10 MWe). Capital costs per installed kW are estimated to range from \$4,500 to \$8,000. The combined operating license (site and technology) is estimated to cost \$50 to 70 million, adding \$400 to \$7,000 per installed kW depending on the size of the unit. The combined operating license costs are expected to be relatively fixed so these costs would be spread across more installed kW for the larger units.

TECHNOLOGY	Installed Capacity (MW)	CAPITAL COST AND COMBINED OPERATING LICENSE (COL) COSTS					
		capital cost low [\$ millions]	COL \$/inst kW low	capital cost med [\$ millions]	COL \$/inst kW med	capital cost high [\$ millions]	COL \$/inst kW high [\$]
Hyperion	25	\$112.5	\$2,000	\$150.0	\$2,400	\$200.0	\$2,800
mPower	125	\$562.5	\$400	\$750.0	\$480	\$1,000.0	\$560
NuScale	45	\$202.5	\$1,110	\$270.0	\$1,330	\$360.0	\$1,560
Toshiba 4S large	50	\$225.0	\$1,000	\$300.0	\$1,200	\$400.0	\$1,400
Toshiba 4S small	10	\$45.0	\$5,000	\$60.0	\$6,000	\$80.0	\$7,000

Figure 3. Capital costs include all costs for the SMR project 'power island', which includes costs associated with buying, transporting, and installing the reactor, as well as power generation equipment, condensers, and construction of the reactor facility. It excludes costs of transmission, distribution, roads, and fuel. Combined operating license includes both NRC construction and operating license.

Communities that have at least an average annual power load close to, or larger than, 10 MW_e were considered in this analysis. Eliminated from consideration were communities that meet the majority of their electrical power requirements with installed hydroelectric capacity. In addition, our analysis was limited to assessing community-based applications rather than large industrial loads, although the model could be applied to other possible users. Based on matching community electric loads with SMR unit capacity, potential economic viability was analyzed for rural hubs, including Bethel (7 MW_e average annual load), Dillingham (3 MW_e), Galena (1 MW_e), Kotzebue (4 MW_e), Naknek (8 MW_e), Nome (9 MW_e), and Unalaska (7 MW_e). Galena was included in this group, despite its smaller electric load, for comparison with an analysis conducted in 2004. The other area with sufficient loads to justify considering SMRs is the Railbelt, including Anchorage (652 MW_e), Fairbanks (223 MW_e), and Tok (2 MW_e).



Figure 4. Communities analyzed for potential economic viability of SMR technology.

Economic scenarios involving assumptions of low to high price forecasts for crude oil, natural gas, and carbon, coupled with low to high costs for SMR power plant construction, fueling, and licensing, comprise 36 unique variations. We present the results of five scenarios that bracket economic viability of the alternatives based on the U.S. Energy Information Administration (EIA) crude oil and natural gas price forecasts, and the Massachusetts Institute of Technology (MIT) carbon price forecasts. In addition to EIA forecast-based scenarios, we conducted a Railbelt scenario using the natural gas price forecast of the Regional Integrated Resources Plan (RIRP).

Consistently, SMR technology is not feasible anywhere in Alaska under the current EIA low crude oil price forecast, even for the low-cost case of SMR construction and licensing. However, under the medium EIA crude oil price forecast of between \$80 and \$100 per barrel over the next 20 years, SMRs become a viable energy alternative for the Railbelt, regardless of the assumed SMR cost range used in this analysis. As would be expected, the same is true for the scenario that involves high crude oil prices projected at \$130 to \$200 per barrel over the next two decades.

In fact, four out of the five SMR power plants lower the currently projected cost of electrical power in Fairbanks as soon as or soon after the nuclear technologies are projected to become available (2020 or 2025). Most economically promising was a Fairbanks–Eielson Air Force Base scenario that

utilizes excess heat from the power plant for the existing Eielson district heating system, and delivered power to the Fairbanks market. It should be noted that our analysis was based on a comparison with current generation sources only, and did not take into consideration possible changes from this baseline that would occur if a large hydroelectric or gas pipeline project developed that could serve the Fairbanks market. The analysis also did not compare the relative costs of SMR technology against a natural gas pipeline or new hydroelectric project.

Using EIA natural gas price forecasts, SMR technology did not lower the cost of energy in the Railbelt south of the Alaska Range. However, under the RIRP natural gas price forecast, the larger light water reactor designs—NuScale and mPower—could potentially provide savings for Anchorage households shortly after the designs are expected to become commercially available (2020).

The rural communities considered as part of our economic model were at a disadvantage, because despite higher energy costs, most of the SMRs were oversized for the community load, even when heating was included in the analysis. For this reason, the only rural community where SMRs would potentially lower projected future energy costs is Bethel. For Bethel, the local diesel-fuel price threshold for SMR economic feasibility is \$7 per gallon (2010 dollars). More communities could benefit from nuclear energy if smaller reactors more appropriately sized for typical village-scale loads become available, but such reactors are not currently being considered in the U.S.

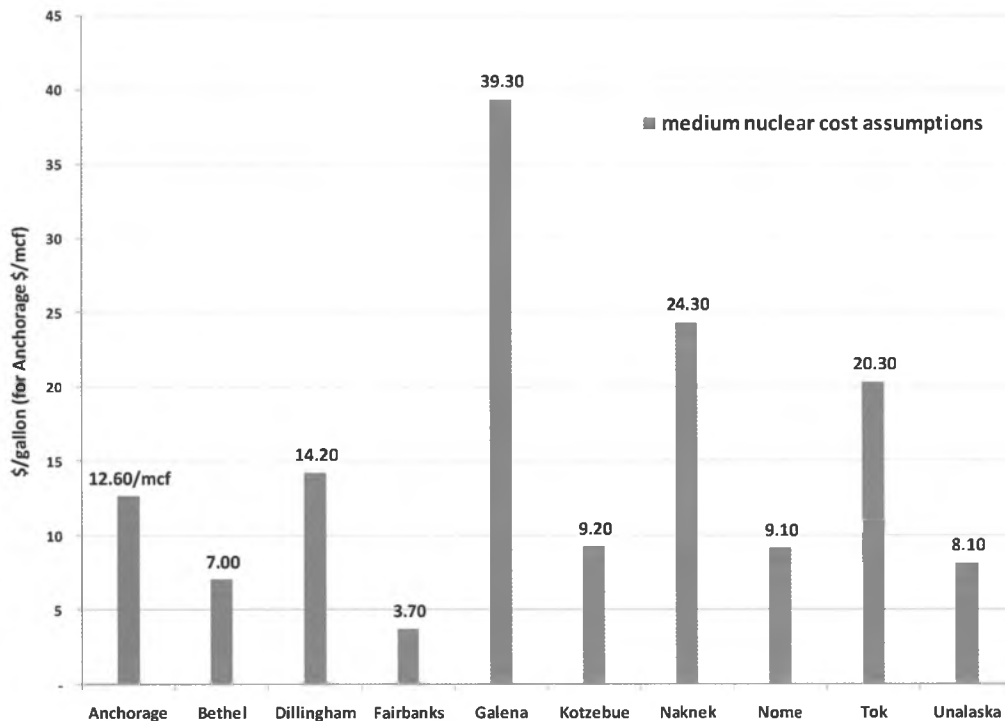


Figure 5. Approximate local fuel price thresholds for SMR economic feasibility (2010\$, per gallon or mcf)

Potential State Actions

While small modular nuclear reactors are not available for the Alaska market today, our findings do not preclude opportunities for SMRs to meet the energy needs of Alaska's communities and industries in the future. In fact, our economic screening analysis indicates that, were the technology available today, there would be sites in Alaska where development of a small nuclear reactor for heat and power would reduce energy costs. Furthermore, barring any unforeseen developments, we believe the chances are high that SMR technology will become commercially available sometime in the next two decades. Therefore, to explore this option further, the State of Alaska could take the following actions:

- 1) **Begin a site feasibility study for two locations in Alaska.** While much of the national focus is on technology design licensing, the site selection and permitting process will be as challenging and involves significant uncertainty. The state could fund preliminary site selection and permitting activities for two locations based on the outcome of the economic screening analysis. Leading contenders include Fairbanks and Bethel, but a final determination should be made with local community input. Moving forward to achieve a better understanding of the permitting process does not commit Alaska to installation of an SMR, or to becoming a first mover in this technology area. Instead, it provides flexibility and the ability to be an early adopter, while gaining a better understanding of the potential environmental issues associated with deployment in Alaska.
- 2) **Continue research into smaller scale (<10 MW_e) reactor technology.** There is virtually no market niche for mini nuclear power reactor technology in the U.S., and therefore little effort has been made to commercialize a product in this size range. However, research in this area has not been exhausted. There is no question that several small power reactors have been developed in the U.S. and other countries. For example, General Atomics has a standard design for a research reactor installed in dozens of locations around the country; it is a virtually fail-safe design with minimal NRC permitting and licensing requirements. This TRIGA reactor could be converted to a power reactor, something that was explored by the manufacturer twenty years ago but was discontinued due to a lack of apparent market potential. Alaska could seek a partnership with other groups interested in pursuing mini nuclear power, such as the Department of Defense. There is significant interest within the DoD related to nuclear energy. Applications would include providing primary power for domestic military bases to reduce vulnerability to commercial electric grid power outages, and for forward operating



Figure 6. Core of a TRIGA research reactor, designed and constructed by General Atomics.

bases abroad to reduce the need for the highly vulnerable fuel convoys used to supply those operations.

- 3) ***Continue studies of SMR economics and technology development.*** Collaboration with the U.S. Department of Energy in reviewing their forthcoming economic analysis of SMR technologies for power plant applications in the U.S. would provide Alaska with more data for the model developed as part of this study, as well as technology and permitting insights for the most advantageous applications for Alaska.
- 4) ***Ask Alaska's congressional delegation to strongly support the Department of Energy FY2012 budget request called the 'Light Water Reactor Small Modular Reactor Licensing Technical Support Program'.*** Through this budget request, totaling \$67 million for FY2012, DOE's Office of Nuclear Energy would establish a new program to support the design certification and licensing activities for SMRs through cost-shared arrangements with industry partners. This budget item tracks legislation (Nuclear Power 2021) introduced by Senators Bingaman and Murkowski in the 111th Congress, that would authorize DOE to assist in the design and certification of two SMRs by 2021, with the goal of using public/private partnerships to build one or more demonstration projects and move the technology closer to full commercialization.
- 5) ***Identify a state technology lead.*** The potential for this technology in the U.S. has been recognized nationally and in Alaska. Federal licensing and permitting processes are being developed to meet the growing interest in SMR technology as a way to meet energy demands of the future. To stay abreast of these developments, the State of Alaska could identify a lead entity to follow developments by industry and federal agencies that are relevant for Alaska. Specifically, the AEA could designate a Program Manager for Nuclear Energy, who could represent a portion of the duties of an existing staff member. The AEA could also contract with the University of Alaska to follow developments and report at regular intervals, but there should be a central point of contact for the State of Alaska, and AEA is the logical choice.
- 6) ***Consider SMR technology as one of several alternative scenarios to a large hydro project during the next phase of the Susitna FERC permitting process.*** While SMR technology is not available commercially today, it will likely become available in the future and as such would be worth comparing to other alternatives now and in the future as a replacement for aging generation on the Railbelt. The RIRP process did consider a single Hyperion SMR module in the first stage of its screening analysis, but did not consider an array of SMRs added in increments over time to meet expected load growths. A scenario where individual modules were added over time could have the benefit of more closely matching loads and distributing costs over a longer time horizon.

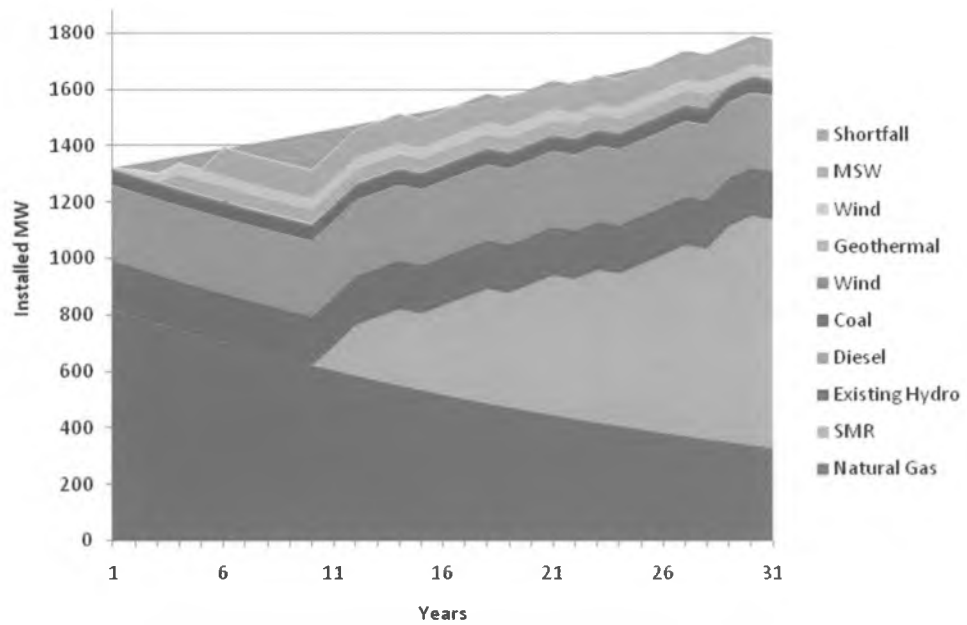


Figure 7. Conceptual cartoon based on RIRP model assuming 3% decline in natural gas supply per year, 1% growth in electrical demand year, and incremental additions of multiple 45 MW Nuscale SMRs beginning in 2020.

In conclusion, no immediate, large-scale actions need to be considered. Instead, the options as drawn from this study suggest smaller, prudent, measured actions that keep this technology option on the table and allow Alaska to provide some small influence over the development of SMR technology in this country.

Appendix A:

Small Modular Reactor Technology Screening Report

The following small modular nuclear reactor technologies were considered as part of this study.

Commercially available, NRC reactor design approved, could be deployed in US with NRC approval of site permit and operating license.

- No reactors identified in this category

NRC design review application submitted, design based on previously proven technology, approval expected within 3 years.

- No reactors identified in this category

NRC letter of intent submitted, design based on previously proven technology, approval expected within 6 years

- mPower 125 MW Reactor, USA, Babcock and Wilcox
- NuScale 45 MW Light Water Reactor, USA, NuScale Power company

NRC letter of intent submitted, design includes significant items not previously approved by NRC, approval time unknown

- Toshiba 4S Reactor, Japan, Toshiba
- Pebble Bed Reactor, South Africa, Pebble Bed Modular Reactor (Pty) Limited and Eskom
- Power Reactor Innovative Small Module (PRISM), USA, GE-Hitachi
- Hyperion Power Module, USA, Hyperion Power Generation Inc.

New design under consideration by large nuclear development group based on previous experimental reactor experience, but NRC approval process has not begun.

- International Reactor Innovative and Secure (IRIS), International, Westinghouse
- Secure Transportable Autonomous Reactor (STAR), USA, Argonne National Laboratory
- Small Sealed Transportable Autonomous Reactor (SSTAR), USA, Lawrence Livermore, Argonne and Los Alamos National Laboratories in collaboration with others.

Proposed design being researched by viable company with sufficient funding, but remains in modeling stage

- Medical Isotope Production System (MIPS), USA, Babcock and Wilcox
- Encapsulated Nuclear Heat-Source (ENHS), USA, University of California, Berkeley.
- LSPR--LBE-Cooled Long-Life Safe Simple Small Portable Proliferation-Resistant Reactor, Japan

- Liquid Fluoride Thorium Reactor (LFTR), USA, Oak Ridge
- Fuji Molten Salt Reactor (MSR), Japan, Fuji--Russian--USA
- Traveling Wave Reactor (TWR), USA, Terrapower (approaching Toshiba)
- Energy Multiplier Module (EM2), USA, General Atomics
- Advanced High Temperature Reactor (AHTR), USA, Oak Ridge National Laboratory
- Gas Turbine - Modular Helium Reactor (GT-MHR), USA--Russia--Japan, General Atomics in partnership with Russia's OKBM Afrikantov, supported by Fuji (Japan)
- Antares Reactor, International, Areva
- Advanced Reactor Concepts (ACR-100), USA, Advanced Reactor Concepts LLC (ARC)

International commercial design not seeking NRC approval for licensing in US

- NP-300, France, Technicatome (Areva TA)
- KLT-40 S Pressurized Water Reactor, Russia, OKBM
- Pressurized Heavy Water Reactors (PHWR-220) (PHWRs), India, Nuclear Fuels Complex, India

Proposed reactor design appears viable, but not supported by funded research

- Radix, USA, Radix Power and Energy Corporation
- TRIGA, USA, General Atomics
- Adams Engine, USA, Adams Atomic Engines

International research design not likely to result in application for NRC license

- ABV, Russia, OKBM Afrikantov
- Korean Fast Reactor Design (KFRD), South Korea, Korea Atomic Energy Research Institute
- BREST, Russia, RDIPE
- CAREM Pressurized Water Reactor, Argentina, CNEA & INVAP
- Pebble Bed Commercial Reactor HTR-PM, China, Institute of Nuclear & New Energy Technology (INET) at Tsinghua University north of Beijing
- Pebble Bed Demonstration HTR-10, China, Institute of Nuclear & New Energy Technology (INET) at Tsinghua University north of Beijing
- CNP-300 Pressurized Water Reactor, China,
- ELENA, Russia, Russian Research Centre "Kurchatov Institute" (RRC KI)
- High Temperature Test Reactor (HTTR), Japan, Japan Atomic Energy Research Institute (JAERI)
- System-integrated Modular Advanced Reactor (SMART), South Korea, KAERI
- VKT-12, Russia
- VKR-MT, Russia, Federal State Enterprises NIKIET and VNIIAM
- VK-300 Pressurized Water Reactor, Russia, Atomenergoproekt
- VBER-300, Russia, OKBM Afrikantov

- VBER-150, Russia, OKBM Afrikantov
- MRX, Japan, Japan Atomic Energy Research Institute (JAERI)
- SVBR-100, Russia, Rosatom/En+, Hidropress
- MARS, Russia, Russian Research Centre “Kurchatov Institute” (RRC KI)
- SAKHA-92, Russia, OKBM Afrikantov
- RITM-200, Russia, OKBM Afrikantov
- NHR-200, China, Tsingua University's Institute of Nuclear Energy Technology (now the Institute of Nuclear and New Energy Technology)
- Modular Transportable Small Power Nuclear Reactor (MTSPNR), Russia, N. A. Dollezhal
- Research and Development Institute of Power Engineering (NIKIET)
- UNITHERM, Russia, Federal State Enterprise NIKIET

Obsolete reactor design unsatisfactory for commercial use due to safety, non-proliferation, or other issues,

- SM-1A Fort Greely Reactor, USA, US Army
- EGP-6 Reactors, Russia,
- Big Rock Point, USA, Army
- PM-3A, USA, US Military
- MH-1A, USA, US Army

Small scale designs not suitable for utility power

- Radioisotope Thermoelectric Generator (RTG), USA, Teledyne Brown
- Rapid-L, Japan, Toshiba
- NASA Nuclear Sterling Engine for Lunar Base, USA, NASA