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OVERVIEW OF GALENA'S PROPOSED APPROACH TO LICENSING A 4S NUCLEAR REACTOR BASED POWER GENERATION FACILITY

Prepared by the City of Galena, Alaska

OVERVIEW OF GALENA'S PROPOSED APPROACH TO LICENSING A 4S REACTOR-BASED POWER GENERATION FACILITY

I. EXECUTIVE SUMMARY

In order to open lines of communication with various stakeholders and the U.S. Nuclear Regulatory Commission (NRC), the City of Galena, Alaska, has commissioned a set of white papers that discuss important aspects of the deployment of a Toshiba "Super Safe Small and Simple" (4S) nuclear reactor-based Power generation Facility (4S-NPF) in the city. This paper provides an overview of the site characteristics, describes the proposed power generation facility and the unique design features of the 4S reactor that bear upon the certification of its design by the NRC, and outlines the licensing steps that Galena and Toshiba must successfully accomplish in order for the NRC to issue a license to construct and operate a 4S reactor-based power generation facility in Galena.

The City of Galena has no connection to an outside power grid, and must meet current electrical demand with industrial diesel generators. Although there are several advantages to diesel generator deployment, primarily stemming from the fact that it is an established technology, there are also several environmental, logistical, and cost drawbacks to operating large diesel fuel generators in remote locations such as Galena.

To help address Galena's future power concerns, the city cooperated in a 2004 study sponsored by the U.S. Department of Energy. That study concluded that based upon the available information, a 4S NPF is the best long term economic and environmental choice for meeting Galena's power supply issues. Subsequently, the Galena City Council passed a resolution calling for the evaluation and eventual deployment of a 4S NPF in the community.

II. BACKGROUND

A. THE CITY OF GALENA

The City of Galena, Alaska (Galena) is located in west-central Alaska, along the banks of the Yukon River. Galena has no roads linking it to the rest of the state. A former United States Air Force base is located 1.5 miles west of the city, and is now operated as a public airport. The airport, known as the Edward J. Pitka Sr. (PAGA) Airport, is state owned and operated, with a subsidy from the United States Air force to keep the pavement serviceable should the need arise. The main runway of the airport (runway 7-25) is 7,254 feet long, and is capable of handling heavy transport type air traffic. The airport is the primary access point into and out of the Galena area, and operates year-round. The Yukon River serves as the major heavy transportation resource during the unfrozen summer months. Galena has a population of approximately 700 persons, and serves as an educational and cultural center for the region. There are many public use and commercial buildings in the area of the airport and the city itself including schools, workshops, and municipal buildings. Homes are predominately located around the "New Town" area, 1.5 miles east of the airport.

B. THE GALENA POWER SUPPLY

Galena has no connection to an outside power grid. The city currently depends on diesel generators for its electric power supply. Galena experiences long, severe winters (winter low temperatures may reach –50°C (-60°F) or below and temperatures below -40°C (-40°F) are common). The lack of low cost year-round heavy transport into Galena requires the city to maintain large diesel fuel tanks in order to meet energy demand. The escalating price of fuel and the associated costs of fuel transportation, storage, and financing make the cost of electricity prohibitively high to Galena residents. These economic issues, coupled with environmental pollution concerns, make it prudent for Galena to explore alternative ways to meet its energy needs.[1]

C. THE GALENA 4S PROJECT

In August 2003, Galena received presentations from Toshiba Corporation (Toshiba) on a "Super-Safe, Small and Simple" (4S) reactor-based electrical facility. The 4S reactor was developed jointly by Toshiba and the Central Research Institute of Electric Power Industry (CRIEPI) of Japan.[2] Following those presentations, the U.S. Department of Energy (DOE) sponsored a study on ways to meet Galena's power requirements.[3] The study included analyses of the thermal and electric load profiles for Galena, technologies available to meet those loads (the technologies evaluated in detail were enhanced diesel power, coal, and a 4S reactor-based facility, which were determined to be the only viable alternatives), the environmental and regulatory issues associated with each of these technologies, and the overall economics of each energy option. The DOE study concluded that the 4S reactor-based power facility is the best economic and environmental choice for Galena.

On December 14, 2004, the Galena City Council passed a resolution calling for the deployment of a 4S reactor-based power generation facility in the community. The resolution stated, among other things, that: "It is in the public interest to pursue the siting of a Toshiba 4S nuclear battery in Galena." The council further directed the City Manager to "establish a process and timeline leading to evaluations, industrial partners, and financial and contractual arrangements necessary to bring the economic and environmental benefits of the 4S to Galena."

Since the passing of the resolution, Galena has been investigating the regulatory and economic feasibility of locating a 4S reactor-based power generation facility in Galena. In parallel, Toshiba has been developing a preliminary design document (PSID) to submit to the U.S. Nuclear Regulatory Commission (NRC) for its review.[4]

In order to move the siting evaluation process forward and open lines of communication with various stakeholders and the NRC, Galena has commissioned a set of white papers that discuss

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1 Adams Atomic Engines, Inc., Atomic Insights, "Nuclear Power for Galena, Alaska" (March 2005), available online at http://www.atomicinsights.com/AI_03-20-05print.html.

2 See, e.g., http://www.uaf.edu/aetdl/Presentations.htm.

3 Robert E. Chaney et al., "Galena Electric Power- A Situational Analysis" (DE- AM26-99FT40575) (December 2004). Science Applications International Corporation (SAIC) coordinated the study, in which the University of Alaska and Idaho National Engineering and Environmental Laboratory participated.

4 "Galena Project Officials Gear Up for Pre-Application Activities," Inside NRC, February 6, 2006.

important aspects of the small nuclear power facility project including a General Overview, Nuclear Liability, Emergency Planning, Physical Security, Decommissioning, Containment, and Seismic Isolation. This paper is part of the white paper series.

D. FEATURES OF THE 4S REACTOR

The 4S design introduces a small liquid metal nuclear reactor to the commercial power industry in the United States. Liquid metal reactors (LMRs) have been operated successfully worldwide and have been used in the United States at test facilities, with over 300 reactor years of operational experience. The small, advanced design of the 4S has several important operational and safety advantages, particularly for remote location deployment, when compared to the large light-water commercial nuclear power plants currently operating in the United States. The peak thermal output of the reactor is approximately 30MW thermal (MWt), which is a small fraction of the standard commercial reactor thermal output of around 3,000 MWt. Important features of the design of the 4S include:

- Modular construction, which will reduce costs and construction time
- Nuclear systems that are embedded below grade, resulting in safety and security benefits
- Liquid sodium coolant, which does not react with core internals or piping
- Sodium coolant that is not highly pressurized, which minimizes stresses on the plant systems
- Passive safety systems that do not depend on emergency power to function
- Negative reactivity temperature coefficients, including coolant void reactivity, that cause the reaction rate in the core to slow down as temperature rises
- Air-cooled reactor vessel, steam generator and condenser, so that no coolant water and associated intake structures are required
- 30-year core life, which avoids the need to refuel, eliminates fuel storage, and minimizes fuel handling concerns
- Capability of load following without mechanical operation of reactor control system
- Ease of decommissioning by containment of all radioactive materials within the reactor module throughout the life of the plant.

These unique features are among those that provide the 4S reactor system with significant benefits in operational capability, physical security, and protection of public safety. Many of the systems that increase cost, raise safety concerns, and pose potential security hazards at current plants (such as use of numerous mechanical pumps and valves, the need for a spent fuel pool, and the reliance upon high and low pressure water injection systems) have been eliminated in the design of the 4S. While the 4S reactor system does raise some new issues, such as the need to deal with highly reactive liquid sodium and potential accident scenarios involving sodium-water interaction, these issues have been addressed in the 4S system design and in past LMR facilities. On balance, the licensing of a 4S reactor should be a relatively straight-forward process, provided that good communications are maintained between all parties involved and there is a timely flow of complete and accurate technical information.

E. WHITE PAPER OBJECTIVES

The "white papers" in this series are part of an effort underwritten by the State of Alaska to provide "expert legal and technical analysis for [a] proposed mini-nuclear plant" at Galena. The objectives of the papers are threefold: (1) to discuss some of the more important issues that will need to be addressed by the NRC in its consideration of applications for an early site permit (ESP) and a combined construction/operating license (COL) for a 4S reactor–based power generation facility located in Galena; (2) to identify approaches for handling issues to ensure that the overall cost of operating a 4S reactor-based power generation facility in Galena is competitive with alternative electric power generation methods; and (3) to increase the awareness of government officials and the general public regarding the process for obtaining authorization from the NRC to construct and operate a 4S reactor based power facility in Galena.

Ultimately, Galena must determine if proceeding with the licensing and construction of a 4S reactor is economically justified. These papers are intended to assist the City in making that determination.

III. RELEVANT LAW

The following NRC regulations are applicable to many of the topics addressed in this paper, as they form the framework for nuclear power reactor licensing:

- 10 C.F.R. § 50
- 10 C.F.R. § 50.33
- 10 C.F.R. § 50.33(k)
- 10 C.F.R. § 50.34
- 10 C.F.R. § 50.34(b)
- 10 C.F.R. § 50.54(m)(2)
- 10 C.F.R. § 50.75
- 10 C.F.R. § 50.75(c)(1) and (2)
- 10 C.F.R. § 52
- 10 C.F.R. § 52.79
- 10 C.F.R. § 73

IV. ANALYSIS

A. THE GALENA SITE

1. THE SITE AND ITS VICINITY

Galena is a community located on the north shore of the Yukon River in central Alaska. The closest communities to Galena (within 100 air miles or less) are Koyukuk (pop. 100) approximately 30 miles to the west, Nulato (pop. 330), approximately 40 miles to the west, Kaltag (pop. 230), approximately 60 miles to the west, Ruby (pop. 190) approximately 50 miles to the east, and Huslia (pop. 300), approximately 70 miles to the northeast. The nearest major population center is Fairbanks (pop. 30,500), 270 miles to the east.[5]

2. SOCIOECONOMICS

Census data for the town are available for the year 2000. Galena has not undergone a dramatic change in population or employment since then, so these data are presumed to still be reasonably accurate. Year 2000 census data[6] estimates the population of Galena at 675. The ethnicity of the town is mainly American Indian at 67.4%, followed by White Non-Hispanic at 29.6%. The median household income (year 2000) was $61,125, with the median house value being $75,600. According to local sources, the city government employs 38 people full time. A major source of employment in the town is listed as educational[7], with both instruction and other (related support) activities employing approximately 200 people full time.

The people of Galena are by nature and necessity hearty and industrious. The city is interested in developing a sustainable economic model, which will allow the population to continue their existing culture while improving their quality of life. The lack of low cost sustained power is viewed as a primary obstacle in developing stable businesses and retaining young people in the area. Excess available power beyond current consumption, which the 4S reactor-based power facility could easily provide, would have many positive uses in the region. Affordable and readily available power would allow commercial development where it previously could not succeed. Some envisioned energy uses include the increased use of electric heating, agricultural development via greenhouses, transmission of power to nearby communities if economically feasible, and assisting with the environmental remediation of fuel and contaminant spills at the former Air Force Base.

3. ECOLOGY

The land surrounding Galena is a kaleidoscope of the boreal wildlife and habitats of Alaska's Interior. The low-lying wetlands are an abundant breeding ground for several types of waterfowl, and form the base for an ecologically diverse ecosystem. The Middle Yukon branch of the

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5 U.S. Census Bureau, 2000 Census data, available online at http://www.census.gov/popest/cities/tables/SUB-EST2004-04-02.csv.

6 http://www.city-data.com/city/Galena-Alaska.html

7 http://www.city-data.com/city/Galena-Alaska.html

Koyukuk –Nowitna Wildlife Refuge is headquartered in Galena. Over 6 million acres of boreal forest, wetlands, and uplands are included within this protected region.[8]

The eventual location of the 4S reactor-based power production facility will need to be chosen with ecological factors in mind. Specifically, optimum site selection and good construction practices will have to be followed to preserve the existing natural habitat to the maximum extent possible. There are extensive wetlands in the area, and efforts will have to be made to minimize the impact of construction and operation activities on these wetlands.

4. METEOROLOGY

Meteorological data have been recorded at the PAGA airport for several decades, officially starting in 1949 at the then operating Air Force Base. These data have been collected at the traditional 10 Meter level. There have been some breaks and inconsistencies in the gathered data, mostly due to changes in status of the Air Force Base and the transfer of aviation (and weather monitoring duties). Historical weather data from 1949 through 1999 and later are available online through the Western Regional Climate Center station, located at the airport.[9] There are several other sources / repositories of meteorological data available for Galena and the surrounding region including the University of Alaska – Fairbanks (UAF). Additional data as required by the NRC for licensing purposes will be provided by a suitable meteorological monitoring system. Existing meteorological data are expected to be used as support data to the NRC required plume modeling information.

As the table and figures below show, Galena temperatures are generally between a mean of 61^{o}F the summer, to a mean of –9^{o}F during the winter. Record temperatures have varied between 92^{o}F and –70^{o}F.

	Avg. High	Avg. Low	Mean	Avg. Precip	Record High	Record Low
Jan	-1°F	-16°F	-9°F	0.70 in	43°F (1974)	-70°F (1989)
Feb	5°F	-13°F	-4°F	0.55 in	41°F (1982)	-57°F (1968)
Mar	17°F	-5°F	6°F	0.49 in	50°F (1954)	-54°F (1971)
Apr	34°F	14°F	24°F	0.52 in	64°F (1953)	-35°F (1964)
May	54°F	36°F	45°F	0.57 in	82°F (1974)	-2°F (1992)
Jun	66°F	49°F	58°F	1.44 in	92°F (1969)	33°F (1968)
Jul	69°F	52°F	61°F	1.72 in	89°F (1977)	28°F (1971)
Aug	63°F	48°F	55°F	2.39 in	87°F (1968)	28°F (1969)
Sep	51°F	37°F	44°F	1.76 in	75°F (1957)	2°F (1992)
Oct	29°F	17°F	23°F	1.04 in	56°F (1969)	-29°F (1975)
Nov	10°F	-3°F	3°F	0.91 in	45°F (1979)	-52°F (1990)
Dec	2°F	-13°F	-6°F	0.94 in	44°F (1973)	-62°F (1961)

Table 1 – Galena Temperature Data Per Month

[8] http://www.alaskanha.org/koyukuk-nowitna-wildlife-refuge.htm

[9] http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?akgale

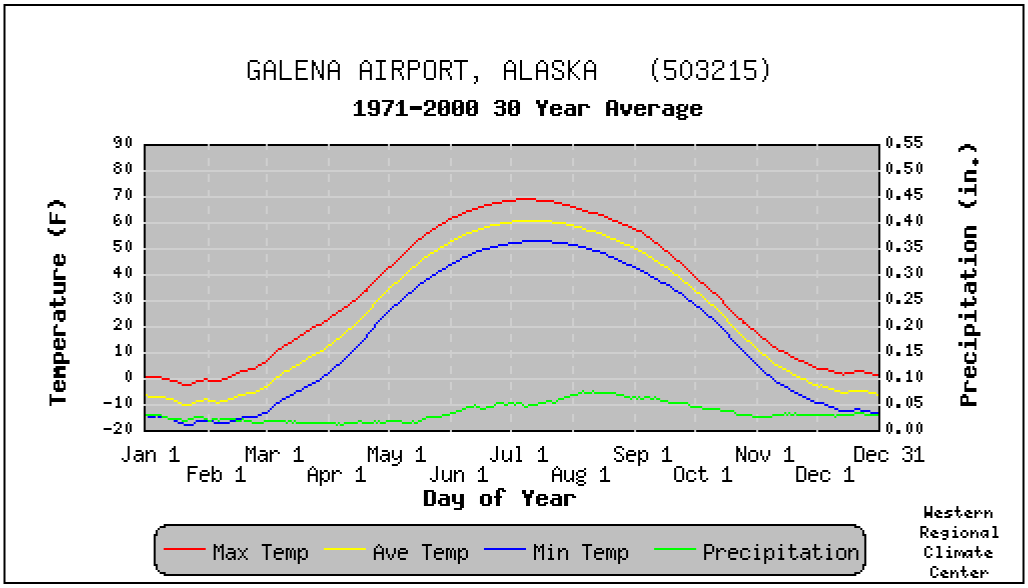

Figure 1 – Thirty Year Average Monthly Temperatures Recorded at PAGA Airport

- Max. Temp. is the average of all daily maximum temperatures recorded for the day of the year between the years 1971 and 2000.
- Ave. Temp. is the average of all daily average temperatures recorded for the day of the year between the years 1971 and 2000.
- Min. Temp. is the average of all daily minimum temperatures recorded for the day of the year between the years 1971 and 2000.
- Precipitation is the average of all daily total precipitation recorded for the day of the year between the years 1971 and 2000.

Precipitation in the region is generally light, and reaches its high point in August as rain. The average precipitation for August is 2.5 inches. January generally has the lowest precipitation amount, at less than .75 inches. Monthly averages are shown below:[10]

[10] http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?akgale

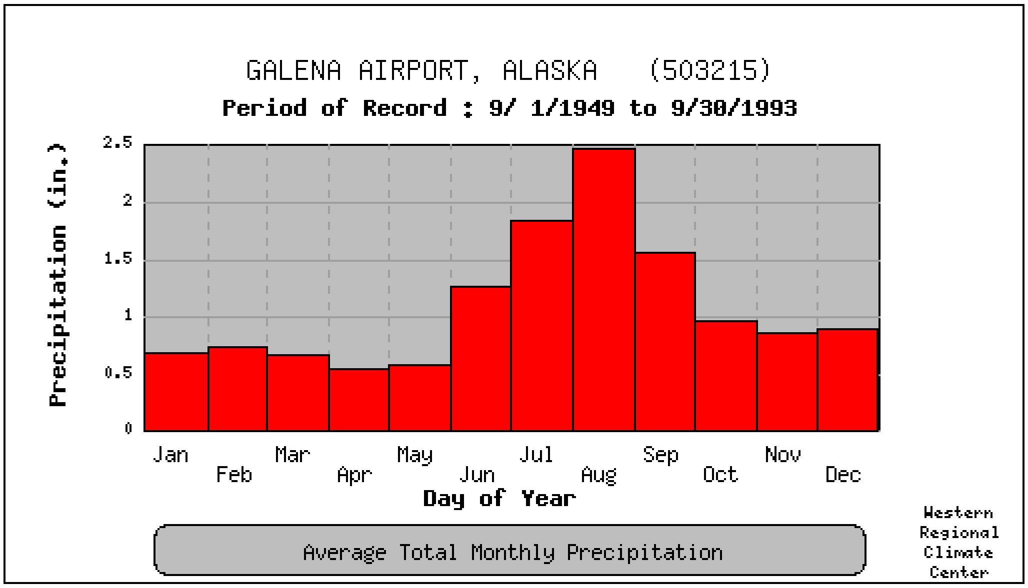

Figure 2 – Average Monthly Precipitation Recorded at PAGA Airport

Snowfall is included in the precipitation values, as water, and accumulates at a moderate rate due to the cold temperatures in Galena during the winter. Snowfall accumulation during the winter averages around 22 inches, with extremes reaching approximately 42 inches in depth.[11]

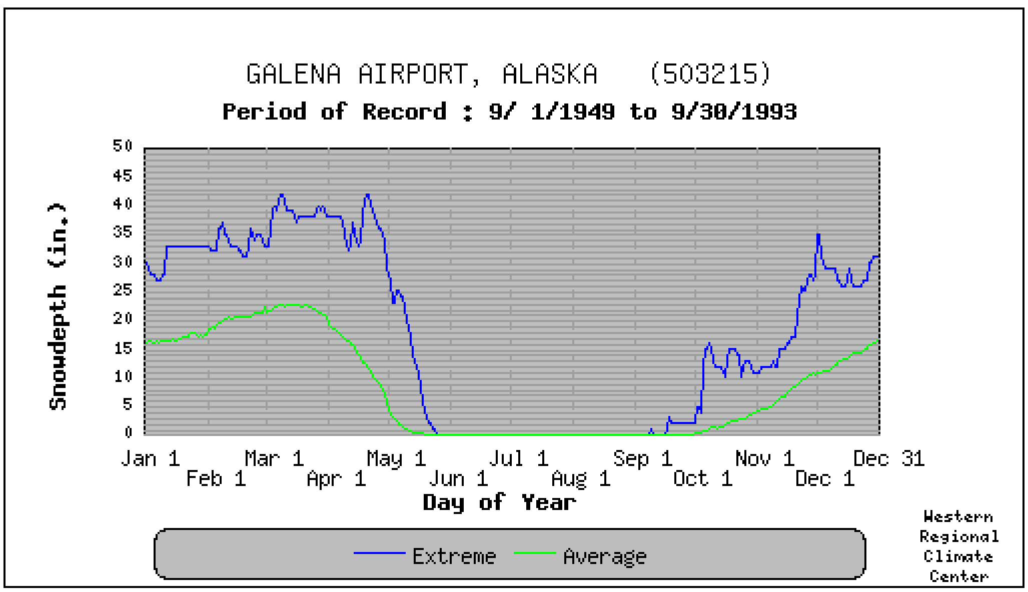

Figure 3 – Extreme and Average Monthly Snow Depth Recorded at PAGA Airport

- Extreme is the greatest daily snow depth recorded for the day of the year.
- Average is the average of all daily snow depth recorded for the day of the year.

[11] http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?akgale

Wind speed data has been collected at the airport. One such data set[12] from (taken between 1996 and 2002) has been reformatted into the following table. As seen in the table, average wind speeds are relatively low. This region is classified as a Class 1 wind power region.

Month	Average Wind Speed	Direction
Jan	4.7	N
Feb	4.5	E
Mar	5	N
Apr	6.5	N
May	6.2	N
Jun	4.9	WSW
Jul	5.5	SW
Aug	6.4	SW
Sep	5.4	E
Oct	5	N
Nov	4.2	E
Dec	3.5	E

Table 2 – Average Galena Wind Speed Data Per Month

5. GEOLOGY

The geologic characteristics of Galena are consistent with those of the west central Yukon valley. The regional subsurface is composed of moderate depths of surficial alluvial deposits over sedimentary bedrock. Surficial characteristics are consistent with those of interior Alaskan river valleys, with the surficial stratigraphy being primarily composed of sand and gravel deposits with lenses of clays or silts interspaced at varying intervals.

The region exhibits a flat stratigraphy, with depth to bedrock estimated at approximately 500 to 700 feet below ground surface (bgs) via a seismic reflection/refraction investigation conducted in the area.[13] These seismic reflection/refraction investigations represent the current best information available for the underlying geology near the city. Further site characterization activities will address these uncertainties with specific geologic/seismic borings to accurately determine depth to bedrock, quality of soils/deposits, and bedrock composition.

Intermittent permafrost is present in the area, and generally extends to a depth of 100 feet in the forested and shaded areas. Galena is located in a region of non-uniform permafrost depths and locations, and small changes in surface covering, such as tree cover, can significantly affect permafrost depth. Permafrost at the airport and other uncovered areas is generally non-existent due to summer warming. Permafrost is not present under the Yukon River, as the warmth of the

[12] http://www.wrcc.dri.edu/CLIMATEDATA.html

[13] USGS Open File Report 02-450: "Reconnaissance Shallow Seismic Investigation of Depth-to-Bedrock and Possible Methane-bearing Coalbeds, Galena, Alaska." W.J. Stephenson, R.A. Williams, J.K. Odum, C.E. Barker, D. M. Worley, A.C. Clark, and J.G. Clough.

river and the flow of ground water through unconsolidated alluvial deposits do not allow the subsurface to freeze. Permafrost may however be present in certain areas adjacent to the river.

6. HYDROLOGY

The hydrologic characteristics of Galena are intrinsically linked with the geology of the region. The major influences on hydrologic conditions are the nearby Yukon River, the surficial alluvial deposits (approximately 550 feet deep), and the intermittent permafrost (on average 100 feet deep). Near the river and by the airport there is little or no permafrost, and ground water travels freely in the subsurface. Ground water levels near the river vary with the height of surface water of the river. Normal ground water levels at the airport are in the 8 to 10 feet bgs range.[14] During flood periods the river may be elevated above ground level; however, the highest recorded ground water level at the airport was approximately 2 to 4 feet bgs. High river levels are diverted around the airport and important areas by a system of levees. To simplify hydrological analyses, the permafrost that is located under much of the city (away from the river) can be considered solid impenetrable bedrock. The rest of the hydrologic layer is made up of unconsolidated sand and gravel deposits with lenses of silt and clay, and is essentially a homogeneous unconfined aquifer.

Extensive groundwater monitoring has been conducted at the airport in relation to groundwater cleanup efforts. Various Air Force operations, most notably leaks at the fuel tank farms and discharges of chlorinated solvents, have contributed significantly to ground water pollution present in sub-surface areas near the airport. Cleanup efforts are currently under way, though progress has been slow due to limited funding, the extent of the contamination, and the harsh weather conditions.[15]

Much of the hydrologic information that has been gathered via monitoring and cleanup activities can be utilized for a more detailed hydrologic classification of the area, if the rights to such data can be secured. Additional classifications will have to be performed in areas outside of the airport boundary, with the location of those possible regions being dependant on the precise location of the 4S reactor based power facility.

The only deep drill hole information currently available exists from a water well that was drilled by the City of Galena in 1998. That drilling penetrated at least 360 feet of soft, water-saturated, fluvial and swamp-derived sediments, without hitting the underlying cretaceous bedrock layer.

7. SEISMOLOGY

Alaska is located in a seismically active region of the globe, with the most active area being along the Aleutian Megathrust. The Aleutian Megathrust is located immediately south of the Aleutian Islands and extends east to Canada, past Anchorage, and then south down the coast. Galena is located approximately 330 statute miles northwest of Anchorage, and around 700 miles north-northeast of the Aleutian Megathrust.

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[14] http://www.globalsecurity.org/military/facility/galena.htm

[15] http://www.dec.state.ak.us/spar/csp/sites/galena.htm

The fault nearest to Galena is the Kaltag Fault, which extends east from the west coast of Alaska and ends about half way between Galena and Fairbanks. Other faults are the Kobuk Fault (200 miles North), the Tintina Fault (500 miles east), the Kigluajk-Bendeleben Faults (300 miles east-northeast), and the Denali Fault, approximately 400 miles south of the city. Maps of recorded earthquake locations are available through the U.S. Geological Survey (USGS),[16] as is extensive detailed seismic data from UAF. Though having recorded prior seismic activity, Galena has not experienced levels of seismic activity of the intensity encountered in the Anchorage area.

Direct shock damage is usually the major item of concern when performing engineering analyses of seismic events. It is prudent, however, to give attention to other seismic related events, which may also cause site damage. The Galena site is well protected from indirect seismic events, as its location along the wide but relatively shallow and flat Yukon River valley provides protection against seismic-related flooding, mudslides, and tsunamis.

As shown in the USGS graphic represented below, Galena is located in the in the 65 degree latitude / 204 degree longitude region (the light green shaded area in the northeast quadrant of Figure 4), which lies in the 8%g peak ground acceleration ring.[17] This means that there is a 10% probability that, over a period of 50 years, there will be a peak lateral ground acceleration of 8% of the force of gravity (i.e., a 10% chance that, over 50 years, there will be peak lateral ground acceleration of 0.785 meters/second^2.)

In the event of major seismic activity, natural alluvial deposits not in the permafrost zones are expected to behave in a fluidized manner, while permafrost effected surficial layers are expected to remain relatively solid and behave more like bedrock. It should be noted that the PAGA airport is located by the Yukon River in a non-permafrost area, and has not sustained major building damage or land subsidence from seismic activity since its construction.

[16] http://www.aeic.alaska.edu/html_docs/images/earthquakes_in_alaska.jpg

[17] http://earthquake.usgs.gov/research/hazmaps/products_data/Alaska/aks/pga1050n.gif

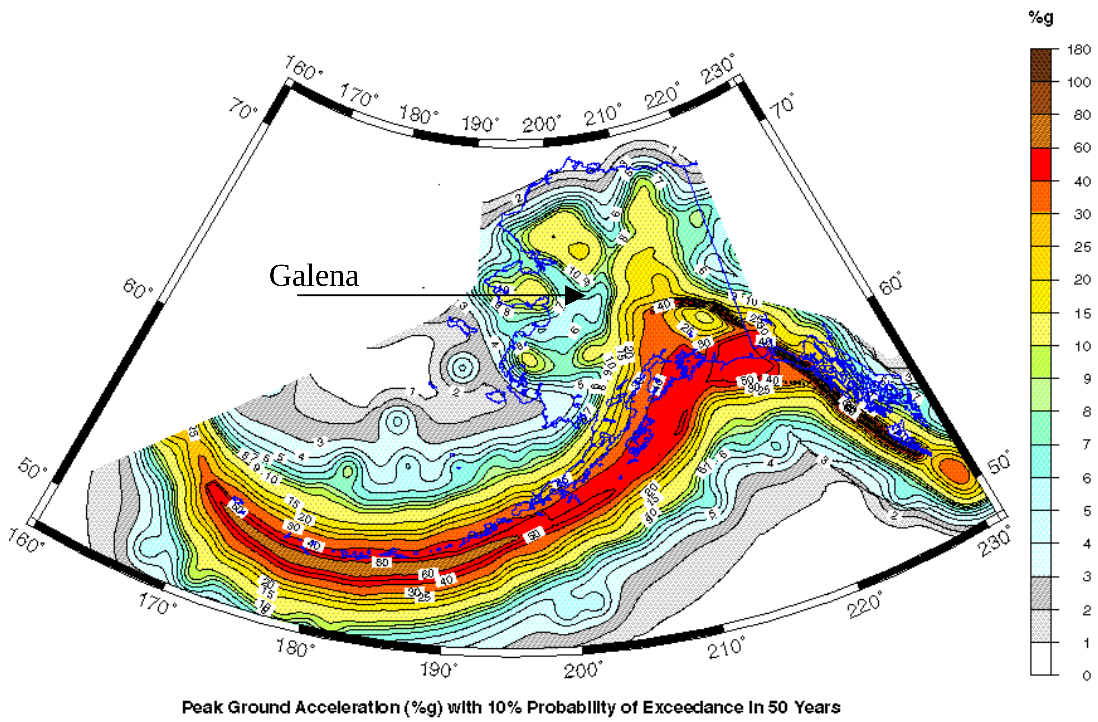

Figure 4 –Peak Ground Acceleration with 10% Probability of Exceedence in 50 Years for Region Surrounding Galena

B. DESCRIPTION OF THE PROPOSED FACILITY

1. GENERAL DESCRIPTION

The 4S is a small liquid sodium-cooled reactor. In combination with power generation equipment, it is designed for use as a power source in remote locations, and is intended to operate for decades without refueling. These features have led to the reactor being compared with a nuclear "battery". The use of liquid-sodium as a coolant is not new, having been used in many previous designs.[18]

The 4S reactor being considered for the Galena facility is a pool type fast neutron reactor that, when coupled to power generation equipment, has an electrical output of 10MWe (30MWt). The primary heat transport system (PHTS) consists of the containment guard vessel, reactor vessel, intermediate heat exchanger (IHX), electromagnetic (EM) pumps, internal structures, core and shielding, all of which are located below grade. Heat from the intermediate heat transport system is exchanged in a steam generator (also located below grade) to produce steam, which drives conventional steam turbine generator equipment. In the standard plant the ultimate heat

[18] U.S. Department of Energy, Energy Information Administration, "New Reactor Designs," available online at http://www.eia.doe.gov/cneaf/nuclear/page/analysis/nucenviss2.html.

sink designed to be air cooled heat exchangers, although district heating may be possible as a plant modification.

Figure 5 is a schematic rendition of the overall 4S-based power generation facility depicting its major components. To put the size of this facility in perspective, the overall area covered by the below and above grade structures of the plant is approximately 190 feet long by 90 feet wide (less than ½ acre of land).

The Nuclear Island is below grade (this includes the steam generators as well as the reactor vessel and all vital equipment). The balance of plant includes facilities located within the security barrier (turbine building, diesel generator, switchgear, control center, and the security facilities) and facilities located outside the security barrier but within the owner controlled area (administration facility, offices, etc.). The non-nuclear safety related facilities within the Protected Area security barrier will be designed to conventional industrial construction requirements. The BOP facilities located outside the security fence are conventional construction as well.

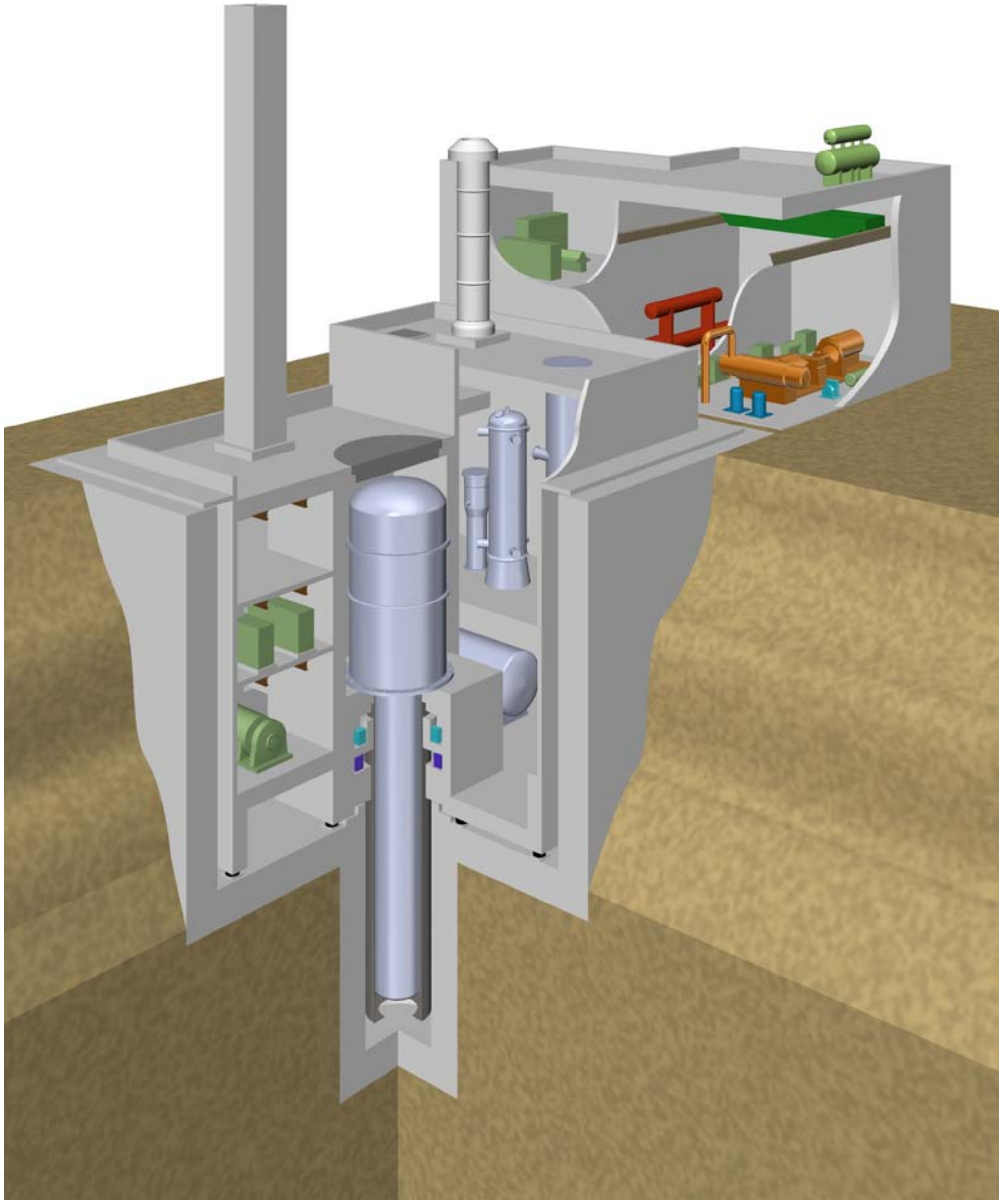

Figure 5: Representation of 4S Power Generation Facility

Figure 6 is a schematic cross-section view of the 4S power generation facility, showing its main features. As seen in the figure, the 4S reactor assembly is housed in a reactor building that includes the reactor vessel, the containment guard vessel, the base mat, the steam generator (SG), and equipment cells. The SG is separated from the reactor vessel and connected by a below grade pipeway. The reactor module is located in its own below grade silo-like guard vessel. The reactor support system provides horizontal seismic isolation for the reactor vessel, the containment guard vessel, and the steam generator. Composite rubber/ steel/lead core isolation pads are used to limit horizontal seismic input to the reactor assembly, guard vessel and reactor vessel auxiliary cooling system (RVACS) and SG.

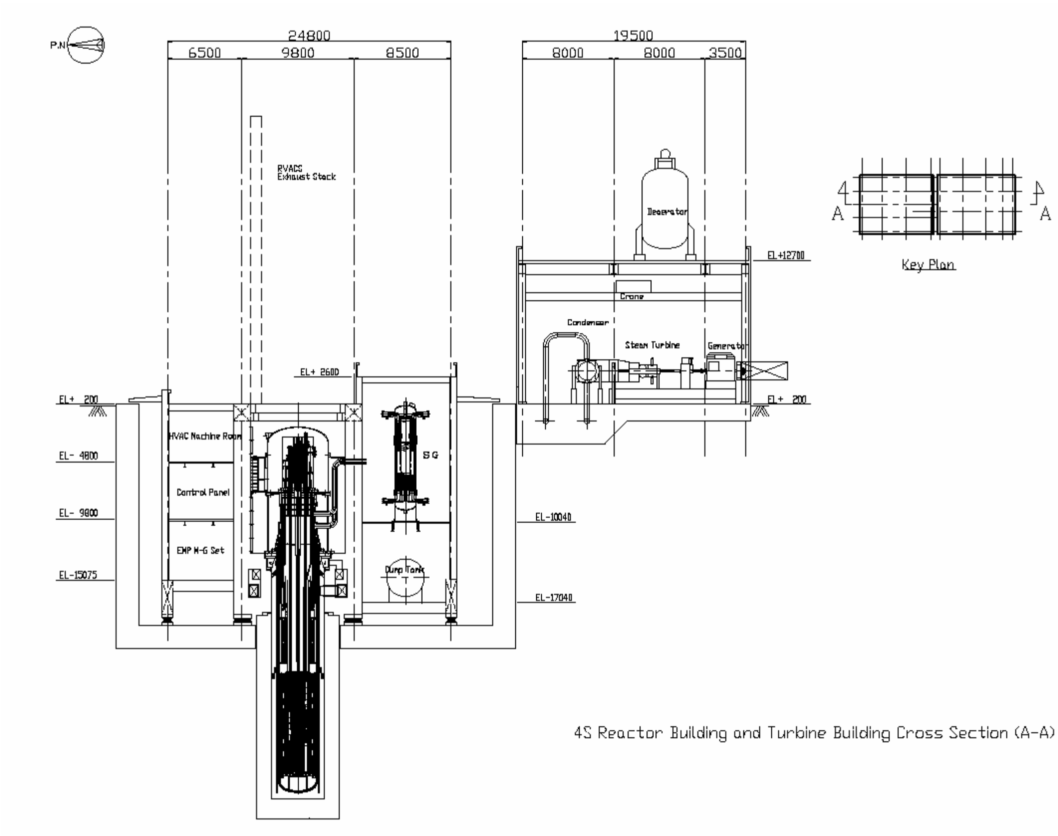

Figure 6 – Schematic Cross Section 10 MWe 4S Power Generation Facility

2. DESIGN DETAILS

a. Reactor assembly and support structures

The reactor assembly and support structures consist of the reactor vessel, the guard vessel, RVACS ducts and structures, and seismic isolation supports. The reactor module assembly enclosed by the guard vessel is seismically isolated from the fixed structures so as to limit the horizontal and vertical seismic input to the reactor assembly. The seismic isolation feature of the design is depicted schematically in Figure 7.

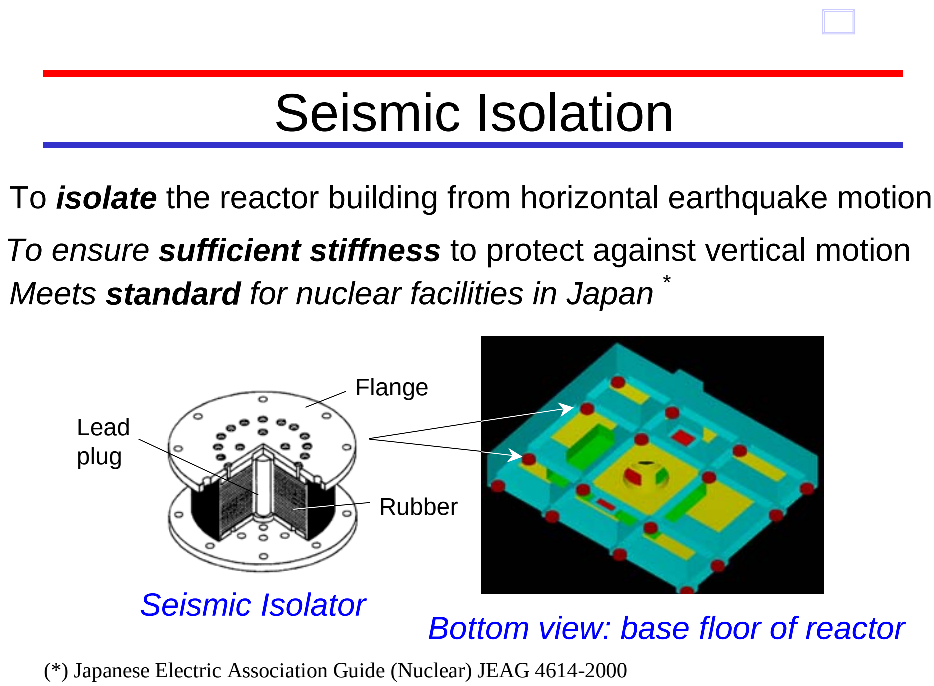

Figure 7 – Schematic Representation of 4S Seismic Isolators

The major components enclosing the reactor assembly are the reactor vessel, the containment guard vessel, and the guard vessel closure head. The containment guard vessel ensures that the core will not be uncovered and that core cooling can be accomplished even if the reactor vessel leaks. The reactor vessel is a closed container and is the support for the reactor core and the primary sodium intermediate heat exchanger structures.

The containment guard vessel and guard vessel closure head, RVACS plenum, ducting, and shield walls are supported on seismic isolators, which are anchored to reinforced concrete structures. In addition to being located where the normal radiation dose is low, the seismic isolators are protected by a shield wall and a labyrinth type RVACS flow path. Space is provided between the isolator and the shield plate to accommodate in-service inspection and isolator maintenance.

b. Reactor Internals

Structures internal to the reactor vessel include the core support structures, electromagnetic pump supports, and intermediate heat exchangers. Primary sodium is directed to the electromagnetic pumps through an internal plenum and then downward through the annulus to the lower head region, where it is forced up through the core.

The 4S reactor core has a heterogeneous configuration with an active core height of 2.5 meters. The metal core's high thermal conductivity allows it to operate at relatively low temperatures. Inherent core reactivity feedback causes reactivity shutdown for postulated beyond design basis events such as loss of flow without scram[19] and loss of normal heat sink without scram. The core reactivity also limits core power to a safe level for a postulated transient overpower caused by reflector withdrawal without scram.

A single control rod has absolute control on the nuclear reaction, but is fully withdrawn during steady state operation. During standard operating conditions reactor core power is controlled by movable reflectors and coolant flow through core circulation pumps. The core can be maintained in the cold shutdown condition with the control rod inserted. The control rod drive consists of a combination of fine and fast adjustment mechanisms. To scram the reactor the brake of the fast adjustment mechanism releases and the control rod moves via gravity into the core causing reactor shutdown. Burn up reactivity compensation and margins for uncertainties in temperature effect, criticality, fissile enrichment, and fuel loading, are included in the reflector and fixed neutron absorber design. The radial reflectors are movable, and creep upward slowly during the service life of the core via the fine adjustment mechanism to maintain neutron flux and power levels. In case of electrical power loss or failure of the reflector drive, the assembly is designed to fall to the bottom of the core. Reflector bottoming will reduce reactivity and thus slow or stop the nuclear reaction, depending on the operational age of the core. The impact on hindering the nuclear reaction increases as the core ages (to a point), providing another level of operational safety.

c. Power Conversion Facility

The power generation facility for the reference design is comprised of the reactor, the steam generator and one turbine generator. Two EM pumps of 50% capacity each combine to circulate primary sodium within the reactor vessel. A single IHX transfers reactor thermal energy in a single intermediate heat transport (IHTS) loop. Heat is transferred from the IHTS via the SG to a single steam turbine generator. The PHTS is contained within the reactor vessel. It is composed of the hot pool, the shell side of the IHX, the pumps and the pump plenum. As shown in Figure 8, sodium from the reactor enters and flows through the IHX where it is cooled as it heats the intermediate sodium. The primary sodium exits the IHX and is drawn into the pump plenum. The primary EM pumps discharge the sodium downward into the bottom of the reactor. The sodium is then heated as it flows upward through the core and back through the IHX.

The IHX consists of upper and lower tube sheets separated by straight tubes. The cold leg intermediate sodium flows downward through the IHX tubes and, as it is being heated, flows upward to leave the IHX through the intermediate outlet nozzle for use in the intermediate heat transfer loop (IHTS).

[19] Per the NRC Glossary (http://www.nrc.gov/reading-rm/basic-ref/glossary/scram.html): Scram is an Acronym for Safety Control Rod Axe Man, a reference to the first reactor (the Chicago Pile). It refers to the sudden shut down of a nuclear reactor

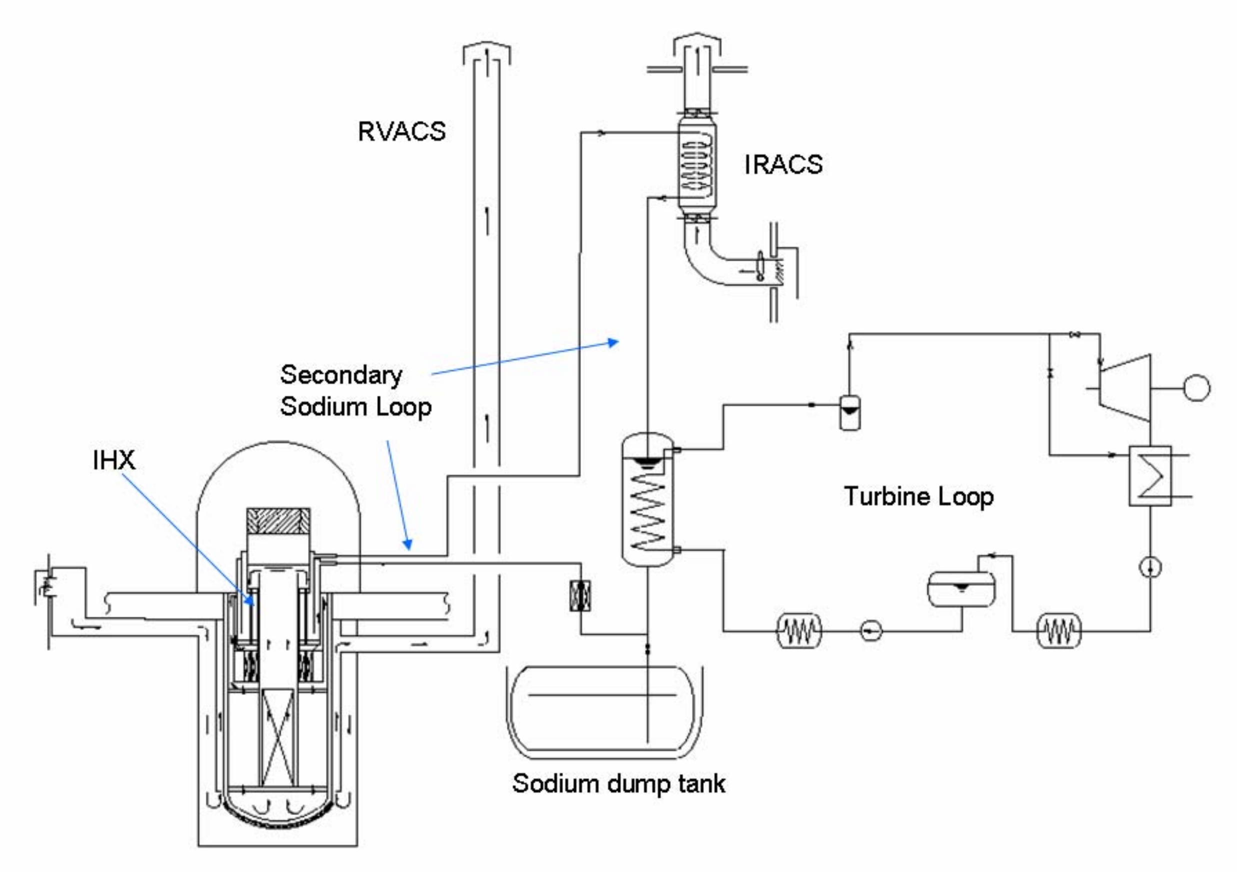

Figure 8– Schematic Representation of 4S Secondary Sodium Loop

The IHTS transports heat from the primary system to the SG system. The IHTS is comprised of a piped loop thermally coupled to the primary system by the IHX located in the reactor vessel and to the SG system located in the SG compartment. The IHTS is a closed loop system with an expansion tank and argon cover gas to accommodate thermally induced system wide volume changes.

Intermediate sodium is circulated by an EM pump, located separately from the SG, through the the shell side of the IHX and SG. The IHTS piping connecting the IHX with the steam generator and pump are located in the IHTS pipeway running from the head access area to the steam generator compartment. A sodium dump tank is provided to drain sodium from the IHTS in the event of a pressure increase from a water sodium interaction. All materials for the IHTS piping and components are designed to minimize corrosion and erosion, and to ensure compatibility with the operating environment.

The SG is a shell and tube heat exchanger with water / steam on the tube side and sodium on the shell side. The tubes are of double wall construction with the concentric tubes pre-stressed during fabrication to ensure tube wall contact. The tube sheets are fixed, and a shell expansion joint provides for differential thermal expansion between the shell and tube bundle. The double wall tube provides high reliability and significantly reduces the probability of a tube leak.

Double fillet welds are used to join the tubes to a single wall tubesheet (using front and back face fillet welds).

Sodium entering the shell side of the steam generator at the inlet nozzle is uniformly distributed around the tube bundle by a cylindrical shroud. Sodium is then uniformly distributed to the tube bundle in the upper support plate. Crossflow baffles maintain sodium velocities to provide acceptable flow distribution and heat transfer.

The generator is powered via a steam turbine that operates at 3600 rpm at rated steam conditions, and exhausts to a single condenser. A feed water pump system is provided for the water /steam loop to circulate water from the condenser back to the SG.

d. Shutdown Cooling

The 4S reactor shutdown heat removal systems consist of main condenser cooling, an intermediate reactor cooling auxiliary system (IRACS) located on the pipe between the IHX and the SG, and the safety related reactor vessel auxiliary cooling system (RVACS), which removes heat directly from the reactor.

When the reactor is brought from full power down to hot standby shutdown under normal operation, cooling is provided by having steam from the steam generator bypass directly to the condenser. In the condenser the steam changes state to water and, using the feedwater pumps, is fed back to the steam generator. Feedwater flow to the steam generator is maintained by the local control system. Sodium flow within the PHTS and IHTS is maintained by the EMP of the secondary cooling system, with power supplied by an auxiliary generator.

In the event normal condenser cooling is not available, decay heat can be removed by the RVACS system alone. IRACS can remove additional heat from the core via an air cooler which is set on the pipe between the IHX and SG. IRACS is a backup for normal condenser cooling, and its use allows faster removal of core heat than by using the RVACS system alone.

The RVACS is a passive safety related system. The system transports heat to the atmosphere by natural circulation of air. It functions continuously with its heat transport rate governed by the reactor vessel temperature. During an event involving the loss of ability to remove heat via the steam generator/IHTS (such as sodium drain or loss), the resultant higher primary sodium temperatures will raise the reactor vessel temperature and cause the RVACS to respond automatically with a corresponding increase in heat removal rate. The system is self-regulating in that the higher the reactor vessel temperature the higher the RVACS heat removal rate. The RVACS operates continuously at all operating conditions, including normal power operations. The Flow of sodium within the reactor is aided by natural convection caused by heating in the core and cooling along the reactor vessel wall. Airflow in the RVACS is maintained by natural draft in the main RVACS riser.

e. Auxiliary Systems

Sodium receiving and transfer subsystems consist of equipment and piping to melt the contents of sodium drums and transfer the molten sodium to the respective heat transfer systems. The primary sodium process subsystem provides purification of sodium contained in the reactor vessel. It also provides the capability to transfer and purify fresh sodium prior to plant start up.

3. SALIENT FEATURES OF THE 4S DESIGN AND OPERATION

a. Overview

The 4S design concept emphasizes inherent safety characteristics and modularity. The reactor modules are of a standard design that would be built in a factory and shipped by barge or air. The reactor module and a minimum of auxiliary equipment comprise the safety related portion of the plant, together with fueling equipment. The remainder of the plant is non-safety related, although designed and manufactured to high quality industrial grade standards.

The small size of the reactor facilitates the use of passive, inherently safe shutdown and shutdown heat removal features that permit simplification and reduction of the safety-related systems in the plant. Factory fabrication of the reactor modules, combined with construction practices that also emphasize factory fabrication of the system modules (where appropriate) in the remainder of the plant, is expected to contribute significantly to cost reduction and shortening of construction schedules.

Operator requirements for a 4S reactor are kept to a minimum by the small size of the reactor, the use of passive safety systems, the incorporation of advanced Instrument and Control (I&C) systems, and overlapping automated safety features. Due the passive safety features and advanced design, no operator control is required to assure safe operation of the plant, even under abnormal events. The function of plant operators is to monitor plant operations, report abnormalities, and ensure expected plant performance during normal and emergency conditions. The small size and simplified systems of the 4S also reduce the manpower requirement for maintenance personnel, and the 30-year fuel cycle eliminates the need for re-fueling personnel. The on-site manpower requirement for physical security personnel for a 4S facility is also expected to be small compared to those for conventional reactors because of the small reactor size, the completely capped and underground reactor building, the overlapping safety features, and the general difficulty of extracting nuclear material from the sealed core.

b. Principal Design Criteria

The goal of the 4S design is to provide an advanced concept electrical power generation facility utilizing an inherently safe, reliable, and economical liquid metal reactor plant. This design is intended to be competitive with electric power generation alternatives available to remote communities, mines, and other applications calling for grid-independent sources of power. The principal design criteria for the 4S are presented below, in terms of power generation design criteria and safety design criteria.

i. Power Generation Design Criteria

- The overall plant equivalent availability factor shall equal or exceed 90 % for the standard design and is targeted at > 95% for the Galena facility.
- The nuclear steam supply system (NSSS) shall be designed to operate for 30 years. Any NSSS component not capable of meeting the 30-year design life will be designed to be replaceable.
- The reactor module shall be designed to be replaceable in order to provide the capability of extending the plant life beyond 30 years.
- The reactor module shall be capable of being installed and ready for sodium fill within 6 months after site delivery.
- The standard plant shall be capable of being in operation from 2 to 4 years from the start of site work, with the duration of the construction period depending on of site-specific weather conditions.
- The capital and operating costs shall be competitive with projected busbar costs for other power sources to the remote customers.

ii. Safety Design Criteria

The plant's safety design criteria will include criteria covering, but not limited to:

- Protection against natural phenomena
- Protection against sodium reactions
- Control of radioactive release to the environment
- Reactor systems design
- Fuel handling design
- Containment design
- Electric power systems design
- Reactor protection systems design
- Control systems design
- Reactor coolant pressure boundary design
- Shutdown heat removal design.

The safety design criteria will be implemented through the detailed design of the plant's safety systems, structures and components. The safety design criteria and their implementation will be described in detail in the 4S Design Certification application to be filed by Toshiba with the NRC in accordance with the requirements of 10 C.F.R. Part 52.

C. REGULATORY FRAMEWORK FOR THE LICENSING OF A 4S REACTOR-BASED POWER GENERATION FACILITY AT GALENA

1. NRC'S APPROACH TO THE LICENSING OF NEW REACTORS

In 1989 the NRC issued regulations (Part 52 to Title 10 of the Code of Federal Regulations) (10 C.F.R.) that allow parties seeking to license new reactors to apply for a combined construction/operating license (COL) instead of the two-stage licensing that had been utilized up to that time. As envisioned by the NRC, the COL licensing process is primarily based on pre-approval of a facility's site and/or its design, plus the definition of the final inspection and acceptance criteria for the plant's systems, structures and components, all before the start of construction.

Under the NRC's approach, the COL application (a required step in the process) can be submitted all at once or in phases. One optional phase that can be pursued in advance of the filing of the COL application is obtaining an "early site permit" (ESP) for the intended location of the facility. Another optional phase that can be accomplished in advance of filing the COL application is obtaining the NRC's certification of the reactor design. These phases can be pursued consecutively or overlap fully or in part. Therefore, a number of permutations are possible, allowing the plant owner flexibility in choosing a licensing strategy that is optimal for its particular circumstances.

The licensing outlook of a proposed plant can become more predictable at the outset if the site has been approved and/or the reactor design has been certified for use by the NRC by the start of the COL process. This predictability results in lower risk to the plant owner. Also, due to inefficiencies encountered during the concurrent review of submitted information, the NRC has expressed concerns over applicants filing complete COL applications without previously obtaining either an ESP or DC, or both. These inefficiencies should not affect the ability to license a power facility, but may have an impact on the time and cost of reviewing the COL application. Additionally, because ESP and DC applications have their own review and public comment time period, after which most information can not be further challenged, obtaining a ESP and DC prior to COL application will limit the items that are reviewable before the final COL is granted.

2. EARLY SITE PERMIT

The NRC can issue an ESP approving a site for one or more nuclear power facilities independently of the filing of a COL application. Granting an ESP is subject to all the applicable standards in the NRC regulations regarding construction of nuclear facilities, particularly those in 10 C.F.R. Parts 50 and 100. ESPs, once issued, are valid for up to 20 years and can be renewed for up to 20 additional years. The NRC's review of ESP applications addresses site safety issues, environmental issues, and emergency response plans.

ESP applications are submitted and reviewed in accordance with the provisions in Subpart A of 10 C.F.R. Part 52. An ESP application consists of three parts: a site safety analysis, an environmental report, and emergency planning information. If the applicant is undecided as to what reactor design will be used for the facility, it can utilize a bounding "plant parameter envelope" (PPE) approach in which the application assumes the most extreme characteristics of each design under consideration – e.g., the tallest building from which radioactive effluents may be released. ESP applications must evaluate the major structures, systems and components from the standpoint of radiological consequences of potential accidents.

With respect to emergency planning, the regulations do not require an ESP applicant to submit a complete set of emergency plans. It is sufficient if the major features of the plans are described in enough detail to allow the NRC to make a finding that there are no significant obstacles to the development of satisfactory emergency plans.

The NRC Staff will review the ESP application for compliance with regulatory requirements and will issue a safety evaluation report (SER) that reaches conclusions as to whether there is reasonable assurance that the site can host a nuclear power plant with characteristics bound by the PPE. The NRC Staff will also prepare an environmental impact statement (EIS) in accordance with the National Environmental Policy Act (NEPA) and 10 C.F.R. Part 51. The EIS must address the benefits and impacts of issuing an ESP. The impacts to be addressed include those resulting from construction and operation of the facility. In addition, the SER will contain a determination regarding emergency planning based on the information provided by the applicant. If the information submitted is relatively limited, the Staff's evaluation will only determine whether there are significant obstacles to the development of satisfactory emergency plans.

The public has the opportunity to participate at the various stages during the NRC review of the ESP application, and in particular can request an evidentiary hearing on the application, subject to the requirements for participating in such hearings established in 10 C.F.R. Part 2.

3. REACTOR DESIGN CERTIFICATION

The reactor design certification process, established by the NRC in Subpart B of 10 C.F.R. 52, seeks to facilitate the development of new reactors by resolving design issues prior to construction. Design certification is an optional but highly beneficial process that ideally should be completed (or at least significantly advanced) prior to the submittal of an application for a construction operating license. Reactor design certification is the responsibility of the reactor vendor.

The design certification process involves three sets of activities: (1) Pre-application review of a proposed new design; (2) Pre-approval of the design approach, known as a "design approval;" and (3) Pre-approval of most or all of the reactor's standard design, known as "final design certification." Whatever portion of the design has undergone final design certification is not subject to examination in the COL application review process.

Although the regulations do not require it, it is the uniform practice in the nuclear industry to have pre-application design reviews and the NRC encourages them because they serve to clarify matters in advance of submittal of the application. Toshiba is in the process of requesting a pre-application review of its 4S design before filing a design certification application.

The pre-application review starts with the submittal by the applicant of the Preliminary Safety Information Document (PSID), an extensive document that presents the generic design whose certification is sought. The length of the NRC review of the PSID depends on: the complexity of the design and the issues it raises; the novelty of the design concepts; how diligent the applicant is in addressing NRC concerns; how well equipped the NRC is to handle the review; and what priority is given to the review of this design as opposed to others also being reviewed by the agency.

At the end of its review the NRC will issue a "Pre-Application Safety Evaluation Report" (PSER) describing the proposed design, the issues it raises, and the questions the applicant must address in its formal application. The agency may also issue a "licensability letter" stating (without making any commitments) that the proposed design appears to be licensable.

The NRC Staff has expressed interest in the 4S and has manifested its willingness to give due attention to its review. A meeting was held to update the Staff on the Galena initiative in February 2005, and senior NRC Staff members who attended the meeting exhibited a cooperative attitude. Because in-depth NRC interaction and scheduling feedback can not begin until the DC application process is initiated, the priority that the 4S design will receive will not be known until the PSID is filed and preliminary technical exchanges between Toshiba and the NRC Staff get underway.

Certification of a reactor design is a two-part process: design approval and final design certification. Design approval, which is conducted pursuant to Appendix O to 10 C.F.R. Part 52, is the first stage of design certification. A design may receive approval without proceeding to obtaining final design certification.

At the design approval stage, the NRC examines the fundamental elements of the design as described in the Safety Analysis Report (including its interfaces with the balance of the plant) and the generic testing program that would have to be carried out to validate the design. The review takes place largely without public participation, and involves only the applicant, the NRC Staff and the Advisory Committee on Reactor Safeguards (ACRS), although review meetings are typically open to the public unless the information being discussed is proprietary in nature or involves nuclear safeguards. Reviews by the NRC Staff are iterative with questions or comments by the Staff being provided at various points as the technical reviews advance.

Upon completion of its review, the NRC Staff will publish in the *Federal Register* a determination as to whether the design is acceptable, subject to such conditions as may be appropriate, and an analysis of the design in the form of a report. An approved design shall be utilized by and relied upon by the NRC Staff and the ACRS in their review of any individual facility license application that incorporates that design. While a design that has been approved will be utilized by the NRC Staff as the basis for reviewing a license application, design approval does not assure ultimate certification of design.

At the final design certification stage the NRC examines the compliance of the design with various U.S. regulatory requirements. At that stage, the reviews focus largely on the establishment of acceptance criteria that will ensure that the constructed plant implements the design and meets regulatory requirements.

The final design certification stage includes, in addition to internal reviews by the NRC Staff and the ACRS, a formal rulemaking proceeding open to public participation. When the review is sufficiently advanced, the NRC will issue a notice of proposed rulemaking providing for an opportunity for submittal of written comments and an opportunity for some form of public hearing if one is requested.

When the full record for the rulemaking has been assembled, the Commission will make a determination whether to grant the certification, and what conditions, if any, to impose. The certification is valid for fifteen years, renewable for no less than 10 or more than 15 years upon application and review by the Commission. Certification is final unless changes are needed to protect public health and safety.

The entire design certification process (design approval plus final design certification) will take several years. Actual duration would generally depend, among other things, on whether there is public opposition expressed via intervention in the design certification rulemaking proceeding.

4. CONSTRUCTION/OPERATING LICENSE

Filing a COL application is a prerequisite to being authorized to construct and operate a new reactor. As noted above, a COL application may reference an ESP and/or a design certification, but can be a stand-alone filing. Issues resolved in an ESP or design certification proceeding are deemed resolved and are not subject to NRC Staff review or litigation at the COL stage. If the COL application does not reference an ESP or a certified design, it must contain the same level of information that would have been provided in the ESP and design certification proceedings.

The COL application must include essentially the same information about the applicant, the design of the proposed reactor, and the intended plant operations as is required of an application for an operating license under 10 C.F.R. Part 50. One requirement that has been added in the new Part 52 procedures is the provision (if not included in a referenced design certification) of a detailed set of inspections, tests, analyses and acceptance criteria (ITAAC) needed to verify that the facility, as constructed, meets the design requirements and is in conformance with the COL once it is granted.

By the time the COL application is filed, the plans for the construction and operation of the facility must be finalized. Those plans must include:

- *The identity and financial qualifications of the owner of the facility*. The current practice in the nuclear industry is to establish a limited liability company (LLC) to hold the title to a new plant. If the LLC vehicle is used, the applicant must demonstrate the financial capability of the LLC to meet the costs of operating the facility and maintaining it in a safe condition in the event of a plant shutdown, all in a manner that satisfies the requirements in 10 C.F.R. § 50.33. The information on the financial qualifications of the plant owner needs to include: (a) the costs of building the facility and providing fuel for it, and the source of funds to cover these costs; (b) the costs of operating the facility for the first five years of operation, and the source of funds to cover those costs; (c) the costs of maintaining the plant in a safe condition during a postulated six month outage, and the information on funds available to pay fixed operating costs during such an outage; and (d) the legal and financial relationships the company has or proposes to have with its stockholders or owners.

- Galena's current plan is to establish a special purpose LLC to hold title to the Galena facility. Using some combination of equity and debt the LLC will raise the funds to construct the facility, procure the fuel, and provide operating reserves and decommissioning funding. The LLC will have a Power Purchase Agreement (PPA) with Galena and the LLC's operational costs and postulated 6 month outage costs would be covered by the PPA revenue and the reserve fund. The identity of the shareholders that will have ownership interests in the LLC has not yet been established; they could include Galena, the State of Alaska or an agency or instrumentality thereof, private investors, and/or the plant operator. The legal and financial relationship of the LLC with its shareholders will need to be defined by the time the COL application is filed.

- *The identity and technical qualifications of the operator of the facility.* The operator of the Galena reactor must demonstrate, in accordance with 10 C.F.R. § 50.34, that it possesses the technical qualifications to operate the facility safely. The operator must also provide its staffing and other plans for operating the plant, present the technical specifications governing plant operations, describe the quality assurance and testing programs, and develop jointly with Toshiba the ITAAC that will be used to determine conformance of the constructed plant with the design.

- The size of the operating staff will be a key issue to discuss with the NRC, since the characteristics of the 4S make it possible to conduct operations with only a small number of personnel. While the required size of a plant's operating staff is set by regulation (10 C.F.R. § 50.54(m)(2)), there is precedent for adjusting operator staffing in accordance with the plant design, provided the applicant can justify a smaller crew size by submitting function and task analyses for normal operation and accident management.[20]

- A U.S. company that operates nuclear power plants in the United States with staff, policies and procedures already approved by the NRC will be contracted by the LLC to apply for an operating license from the NRC and operate the facility. In the COL process, the operator will provide its staffing and other plans for operating the plant, present the technical specifications governing plant operations, describe the quality assurance and testing programs, and develop (jointly with Toshiba) the inspections, tests, analyses and acceptance criteria (ITAAC) that will be used to determine conformance of the constructed plant with the design.

- *The detailed design of the plant.* The regulations in 10 C.F.R. §§ 52.79 and 50.34(b) require that a COL application include a Final Safety Analysis Report (FSAR), a multi-

[20] In its pre-application review of the Power Reactor Innovative Small Module (PRISM) Liquid Metal Reactor – a facility analogous in a number of respects to the 4S -- the NRC Staff accepted in principle decreased operator staffing from that specified in 10 C.F.R. § 50.54(m)(2) if the applicant could demonstrate, among other things, that smaller operating crews could respond effectively to a worst case array of power maneuvers, refueling and maintenance activities, and accident conditions. NUREG-1368, Preapplication Safety Evaluation Report for the Power Reactor Innovative Small Module (PRISM) Liquid Metal Reactor (Feb. 1994), Section 13.2.4.

volume document that provides a description of the facility, presents the design basis and the limits on its operation, and contains a safety analysis of the structures, systems, and components of the facility as a whole. If, as it is anticipated, Galena will use a 4S design that has been certified by the NRC, the sections of the FSAR that deal with elements of the design that are covered by the certification need only reference the certification documents. However, site-specific portions of the design must be described in the FSAR and their interface with the certified portions of the design must be described.

- *The plan for decommissioning the facility.*[21] In accordance with 10 C.F.R. § 50.33(k), a COL applicant is required to submit information in the form of a report indicating how reasonable assurance of decommissioning will be provided. The report should be based on applicable formulas contained in 10 C.F.R. §§ 50.75(c)(1) and (2), or upon a site-specific estimate. In addition to estimating the costs of decommissioning the facility based on the decommissioning method selected, the applicant must demonstrate that funds will be available for the decommissioning the reactor. Methods found acceptable by the NRC, as enumerated in 10 C.F.R. § 50.75, include (a) prepayment, (b) external sinking fund,[22] (c) guarantees such as surety bonds, letters of credit, insurance policies, or parental guarantees; (d) contractual obligations, and (e) other mechanisms providing suitable assurance of fund availability.

- *The emergency plans for addressing radiological emergencies at the facility.*[23] If the ESP application does not include a full complement of emergency plans, the applicant must provide those with the COL application, and emergency planning issues will be subject to review by the Staff and potential examination at the COL hearing.

- *The physical security plans.*[24] Physical protection (also called physical security) consists of a variety of measures for the protection of nuclear facilities against sabotage, theft, and diversion. The extent of physical protection required is based on the significance of the facilities being protected. NRC establishes the requirements and assesses compliance with the requirements, and the licensees are responsible for providing the protection. The regulations (10 C.F.R. Part 73) require that the COL application for a new reactor contain, as a separate document, a physical security plan that describes the physically secure areas of the facility and the barriers and controls provided to limit access; the intrusion detection devices; and the provisions for responding to intrusions, including the defined threat and the respondent force available at the site to defeat the postulated threat. Most information regarding physical security is classified as "safeguards information" and not available to the public.

- The *ITAAC* needed to verify that the facility, as constructed, meets the design requirements and is in conformance with the COL once it is granted.

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[21] Decommissioning is addressed in a separate paper in this series.

[22] Plants that are not directly regulated by an external agency or whose decommissioning funds are not provided through a mechanism approved by the NRC may not use an external sinking fund exclusively to provide financial assurance of the ability to decommission the plant.

[23] Emergency planning issues are addressed in a separate paper in this series.

[24] Physical security is addressed in a separate paper in this series.

After issuing a combined license, the NRC will authorize operation of the facility only after verifying that the licensee completed the required ITAAC and that the acceptance criteria were met. At periodic intervals during construction, the NRC publishes notices of these completions in the *Federal Register*. Then, not less than 180 days before the date scheduled for initial loading of fuel, the NRC will publish a notice of intended operation of the facility in the *Federal Register*. There is an opportunity for a hearing at this time, but the NRC will consider petitions for a hearing only if the petitioner demonstrates that the licensee has not met or will not meet the acceptance criteria.

D. GALENA'S LICENSING STRATEGY

1. ANALYSIS OF AVAILABLE OPTIONS

There are three main options (plus several possible partial combinations) for Galena to proceed to license a 4S reactor while Toshiba seeks to obtain a certification of the 4S design:

- Option 1: Pursue an ESP in parallel with the design certification effort undertaken by Toshiba and only file the COL application when both the ESP and the Design Certification (or at least the Design Approval) have been granted

- Option 2: Pursue an ESP immediately and file a COL application when the ESP is granted, regardless of the status of the design certification process.

- Option 3: File a COL application without pursuing an ESP and without waiting for the Design Certification to be completed.

Under Option 1 the COL application is only filed once the ESP has been obtained and the design certification process is accomplished. This course of action makes the COL proceeding simpler but potentially delays it because two potentially complex proceedings (ESP and design certification) need to be completed before the COL application is filed. This option is viable without undue COL delays if the design certification can be completed expeditiously.

Under Option 2 little or no credit is taken in the COL licensing process for the ongoing review of the generic 4S design. This may add complexity to obtaining the COL because the entire design is subject to review by the Staff and open to challenge in the licensing hearing.

Use of Option 3 could shorten the overall process towards obtaining a COL if the review of the COL application is not delayed and if the licensing hearings are not contested or otherwise become complicated. On the other hand, there would not be a prior opportunity for the NRC Staff to examine site suitability issues nor examine the proposed design in detail. Therefore, the licensing risk involved in this option is the highest, and the potential time and cost savings of having a single proceeding may not materialize.

After consideration, Galena has chosen to implement Option 1, at least through preparation and substantial NRC Staff review of the ESP application. Pursuit of an ESP application will allow Galena to identify, through its contacts with the NRC Staff during the review process, if there are any issues that would seriously impede proceeding with the project. Receipt of an ESP would provide a series of benefits to Galena that would tend to bolster the viability of the 4S project, including: (1) the potential for securing additional sources of financial support; (2) incentives to Toshiba to complete the certification of the 4S reactor in the United States; and (3) increased credibility with, and attention by, the NRC Staff in the later stages of licensing.

Depending on the status of the application for certification of the 4S design when the ESP is granted, Galena will then decide whether to continue under Options 1 or 2, or take other appropriate actions. This approach appears to minimize the licensing risk and defer the full commitment of resources to the project until the site has been approved and there is a better understanding of the outlook on 4S design certification.

A variation of Option 1 could be to file the COL application while the ESP application is still under review. This approach would make sense if, for example, the design certification had progressed sufficiently to allow a COL application referencing the 4S design to be submitted and docketed (i.e., accepted for review) by the NRC Staff. Under those circumstances, it would be necessary to ensure that the already completed ESP reviews by the Staff were fully credited in the COL review process.

2. MAIN REQUIREMENTS FOR FAVORABLE ACTION ON ESP APPLICATION

In order to file a successful ESP application, Galena will need to retain consultants to perform a series of site investigations, accident dose assessments and environmental reviews.[25] In addition, the emergency planning provisions at the plant, in the surrounding areas, and at the state level will need to be addressed, though not necessarily finalized.

At present, no condition has been identified that would be a major obstacle to the granting of the ESP or the ultimate licensing of a 4S reactor-based power facility in Galena. However, it will be necessary to conduct detailed investigations before the suitability of Galena as the site for a 4S reactor-based power facility is demonstrated.

As part of the requirements for the granting of an ESP, Galena will need to have enough information available about the 4S design to allow the performance of the accident dose assessment that must be submitted with the ESP application. In addition, in order to support a COL for the Galena site, Toshiba must obtain a generic design certification (or at least a design approval) for the 4S reactor technology. While it is incumbent on Toshiba as the vendor of the reactor to accomplish the design certification, Galena and Toshiba will need to provide any elements of the design into the COL that are not encompassed by the certification.

The unique characteristics of the Galena site and the 4S reactor-based power facility suggest that a number of the existing regulatory requirements that apply to other facilities may warrant modification or relaxation for Galena, consistent with NRC policy. Acceptance of such modifications by the NRC may be critical to whether the deployment of a 4S reactor-based power facility at Galena is economically viable.

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[25] Some of these topics, for example seismic issues, will be addressed in separate papers in this series.

For example, as is covered in greater detail in the Emergency Planning white paper, the emergency planning regulations specify a ten mile radius plume exposure pathway emergency planning zone (EPZ), centered at a nuclear reactor, within which responsive actions must be taken in the event of a radiological emergency at the reactor. However, the regulations indicate that "the size of the EPZs also may be determined on a case-by-case basis for gas-cooled nuclear reactors and for reactors with an authorized power level less than 250 MW thermal." 10 C.F.R. § 50.47(c)(2). The small power output (30MWt) and underground placement of the 4S reactor, and the low population density of the Galena community, make it ideal for a drastically reduced EPZ and to provide the responsive actions within the smaller EPZ.

In cases where there may not be specific regulatory authority for giving different regulatory treatment to a 4S reactor at Galena – in such areas as physical security, operating staff requirements, and decommissioning funding – it may be necessary for Galena to apply for an exemption from the NRC regulations, as permitted by 10 C.F.R. § 50.12. Among other things, that regulation authorizes the Commission to grant an exemption from the requirements of a regulation where it is shown that "[a]pplication of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve [its] underlying purpose." 10 C.F.R. § 50.12(b)(2)(ii).[26] In demonstrating that various NRC regulations need not to be applied to a 4S reactor located at Galena, Galena will be able to rely upon risk informed principles to which the Commission is committed to adopting in its regulatory programs and seek to show that relaxing otherwise applicable requirements would pose little or no risk to public health and safety. It is anticipated that Galena will initiate discussions with the NRC Staff at the earliest possible time to determine whether it would be feasible to obtain such exemptions.

V. CONCLUSIONS

Barring unexpected developments during the NRC review of the 4S design, the technical and legal research conducted for the completion of this white paper supports the conclusion that a 4S NPF can be safely and economically operated in Galena. As discussed in the accompanying white papers, the NRC should review certain issues related to the 4S (such as physical security, emergency planning, containment, seismic isolation and decommissioning) in a different manner than the one it has used licensing power reactors in the past.

VI. RECOMMENDATIONS

With the appropriate risk informed justification, Galena should ask the NRC to impose lesser requirements in some areas than those applied to conventional reactors, such as the required number of plant operating personnel. An alternative approach to certain 4S licensing issues is warranted and is consistent with protecting public health and safety. Use of such an alternative approach will allow the overall cost of operating a 4S reactor in Galena to compete very favorably, as concluded by the DOE study, competitive with those of alternative electric power generation methods with no sacrifice in safety.

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[26] The requirements for the granting exemptions from the NRC regulatory requirements are discussed in more detail in other papers in this series.

Representatives of Galena and its outside support team should engage in constructive discussions with the NRC Staff in the near future, based in part on the information provided in these white papers. Such discussions will pave the way for the submittal and approval of an ESP application and the eventual granting of a COL by the NRC so that a 4S reactor-based power facility may begin operation in Galena within the next decade.