6/5/09 PRESENTATION: TOSHIBA/ WESTINGHOUSE 4S REACTOR

AS-2009-000036 Rev.1
PSN-2009-0563

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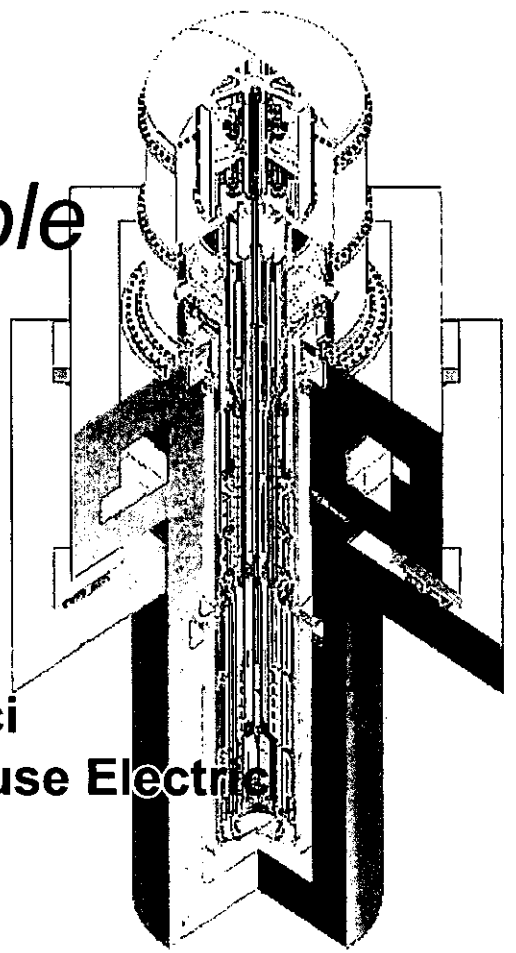
4S Reactor
Super-Safe, Small and Simple



June 2009

Kazuo Arie
Toshiba Corporation

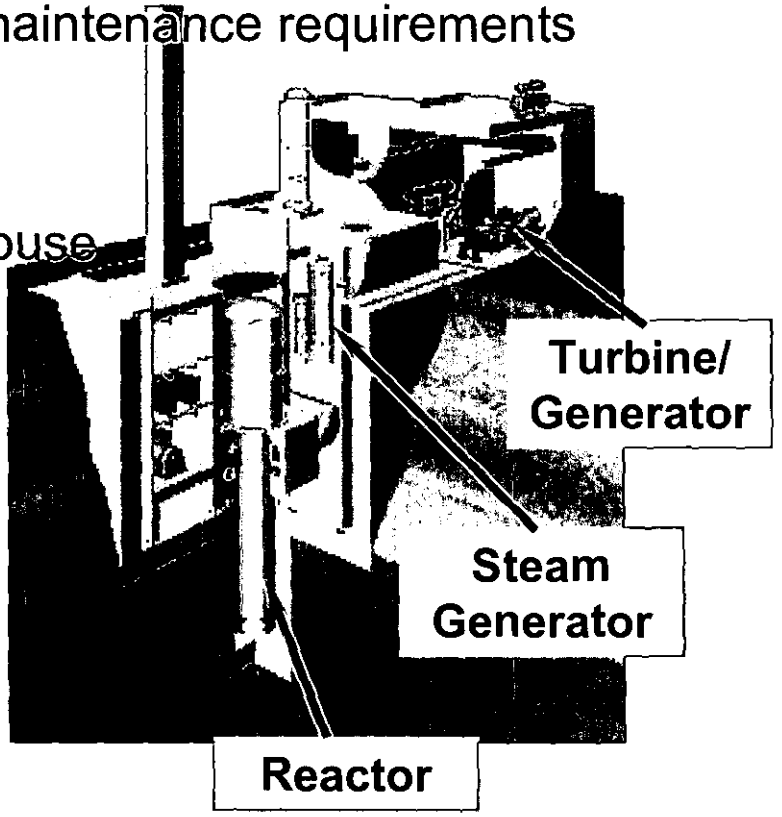
Tony Grenci
Westinghouse Electric Company

4S Presentation

- Introduction – Marvin Yoder
- 4S Overview – Kazuo Arie, Toshiba
- 4S Design - Tony Grenci, Westinghouse
- Licensing Status – Tony Grenci, Westinghouse
- Questions

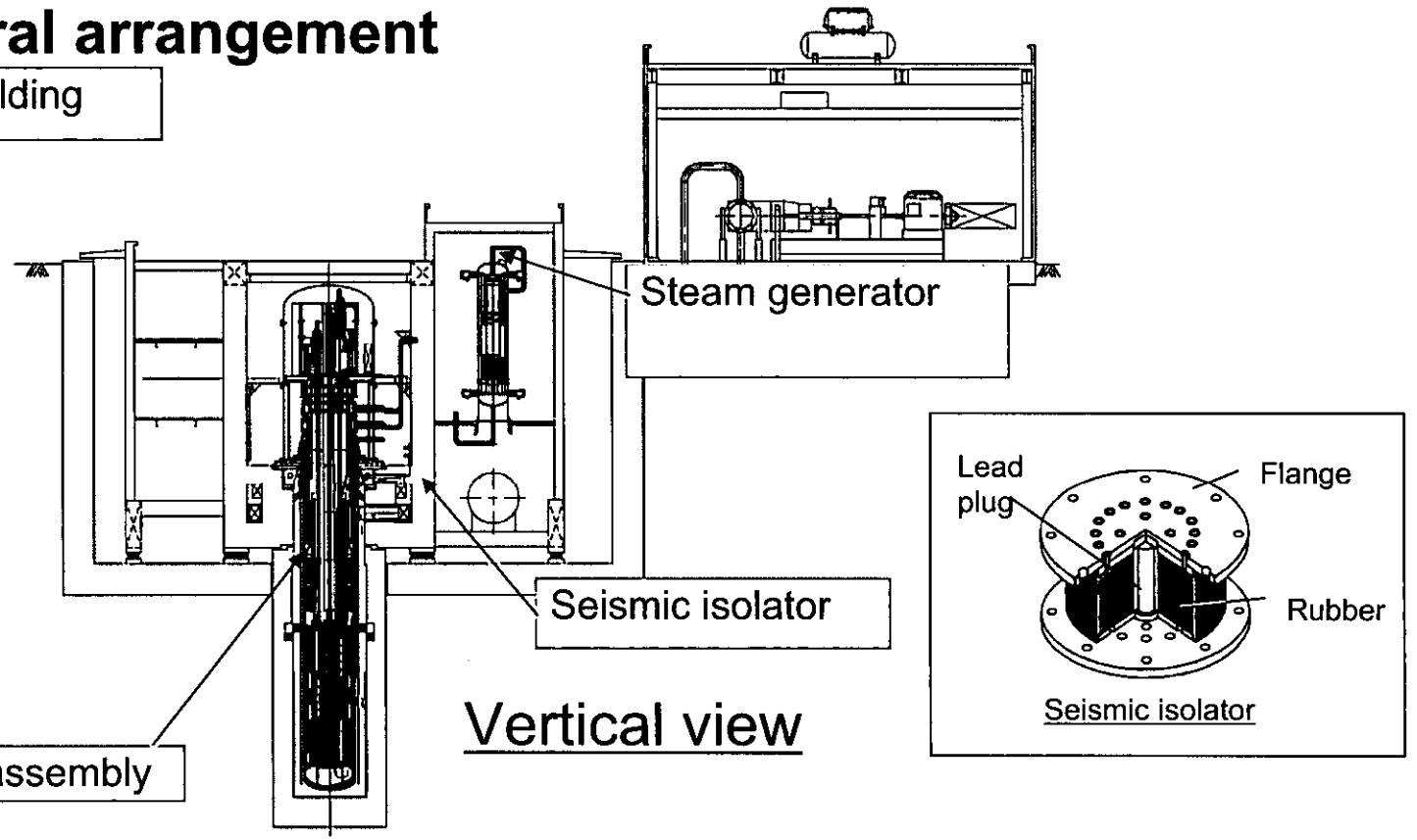
Overview

- **Goals**
  - Provide safe, clean, reliable, grid-appropriate power
  - Minimize security and proliferation risks
  - Minimize infrastructure, operation & maintenance requirements
- **Sodium cooled fast reactor**
  - Co-developer: CRIEPI
  - Developing Partners: ANL, Westinghouse
- **30 MWt (10MWe)**
  - (Initial Configuration)
- **Main features**
  - Passive safety
  - No onsite refueling for 30 years
  - Low maintenance requirements
  - High inherent security



Plant Description

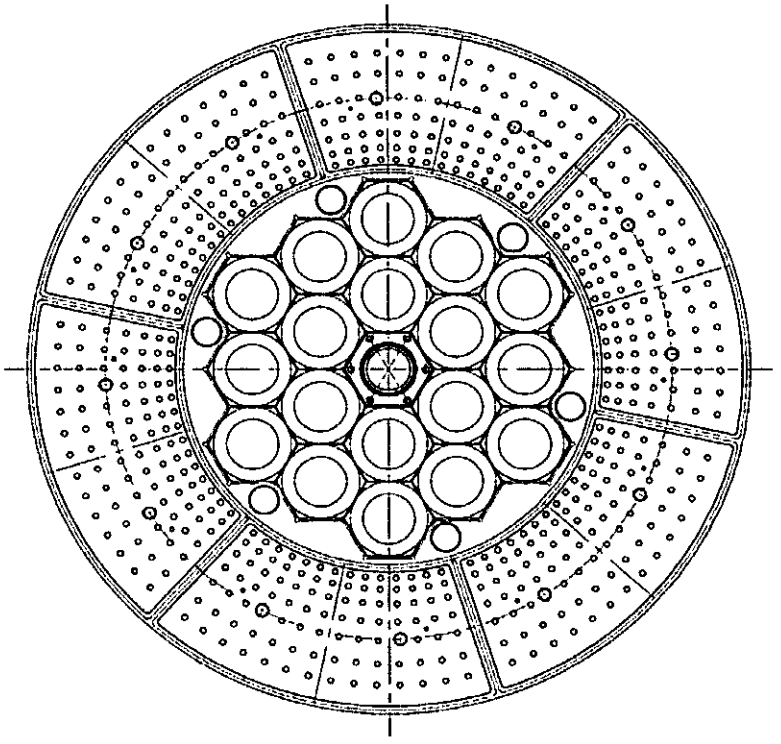
▫ General arrangement



– Seismic isolation is provided for the reactor building.
– Reactor building is below grade.

4S Advantages - Economy

- Diesel fuel prices are high and unpredictable.
- Long refueling interval (10-30 years) front-loads the fuel costs.



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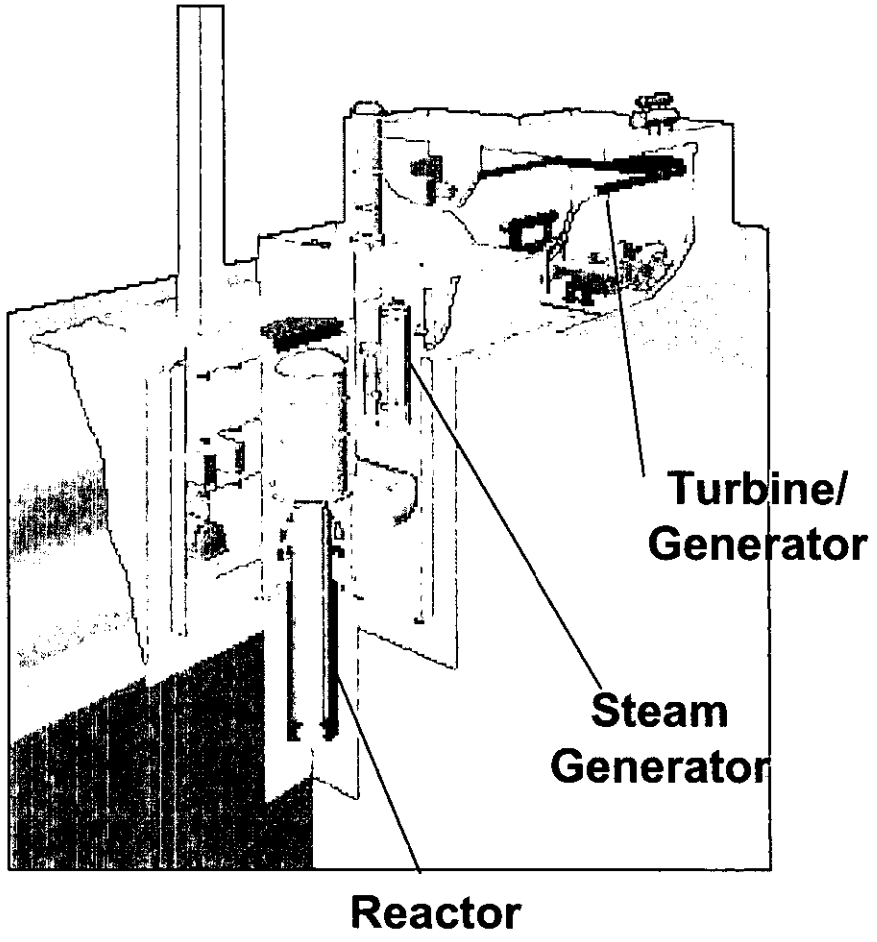
4S Advantages - Operations

- Small operations and security force
  - Simplified operations, load changes accomplished using turbine bypass
  - Automatic burnup compensation
  - Passive safety systems
  - Small plant footprint

4S Advantages- High Inherent Security

- Below-grade siting to protect from missile or airplane impact.
- No onsite fuel storage (10 MWe).
- Sealed Reactor Vessel.
- Heavy Lifting and Fuel Handling Equipment removed from site.
- Fuel enrichment below proliferation grade.



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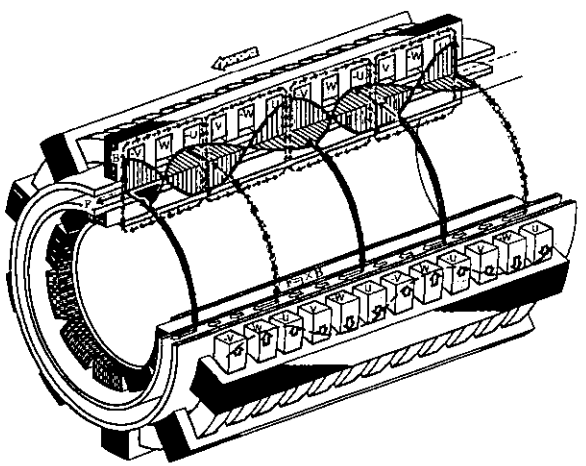
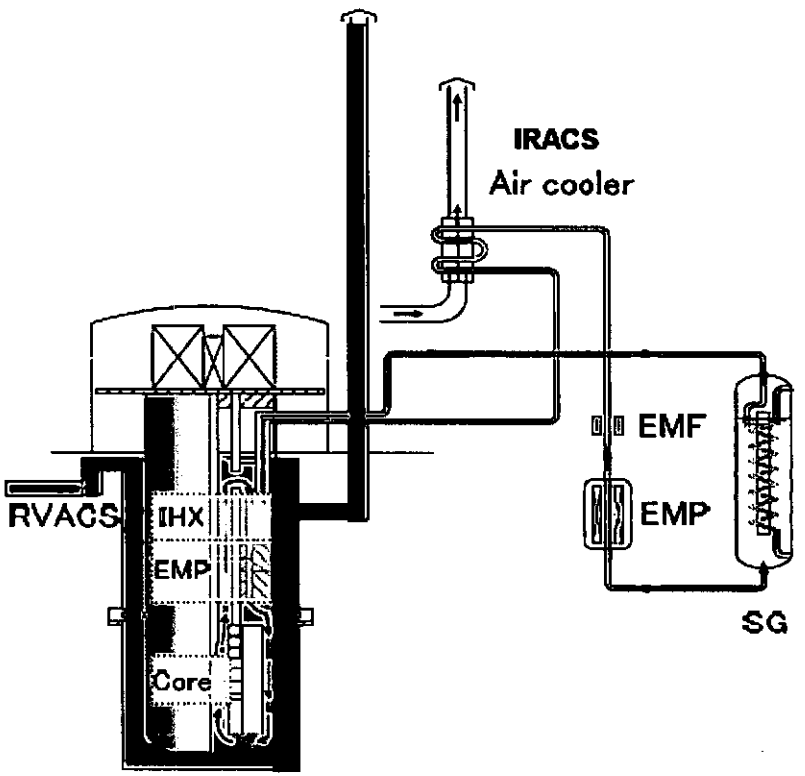
4S Advantages - Maintenance

- Passive systems
- Materials compatibility
- Minimal moving parts
  - EM Pumps

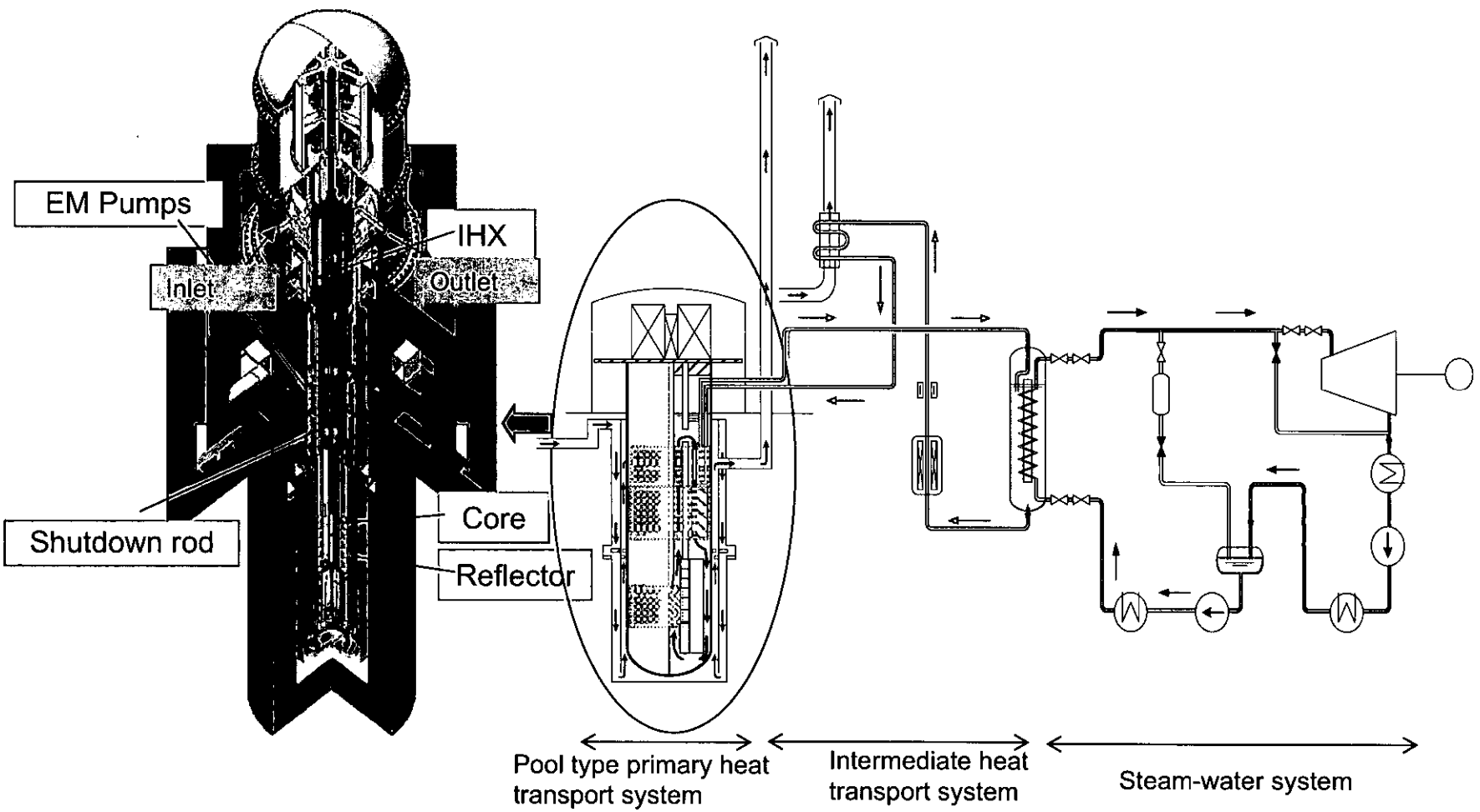




4S Versions

- Two versions being designed simultaneously.
  - 10 MWe version
  - 50 MWe Version
- Rx Vessel, Rx Building identical for both versions.

4S System Configuration



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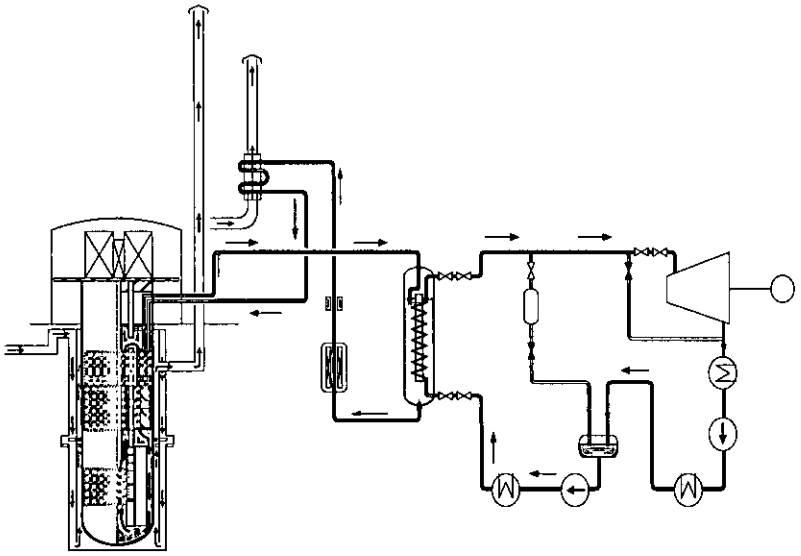
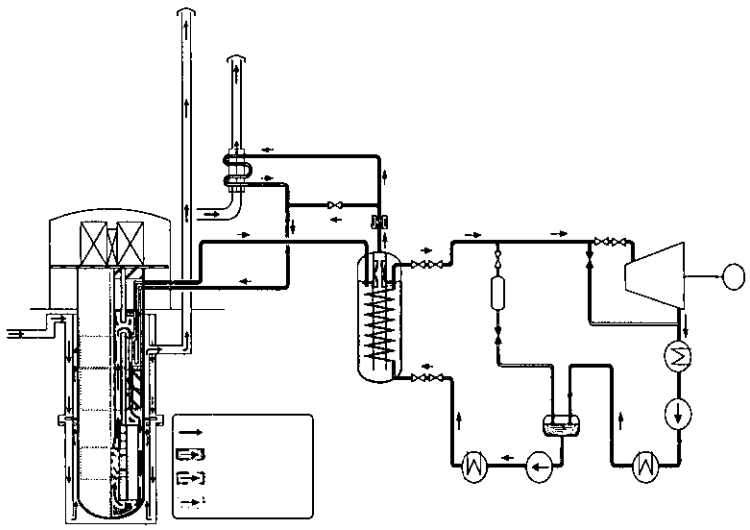
4S Versions

- Steam Generator, IHX, Air Cooler sizing
- IRACS operation



10MWe



50MWe

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Plant Design Parameters

Reactor Core

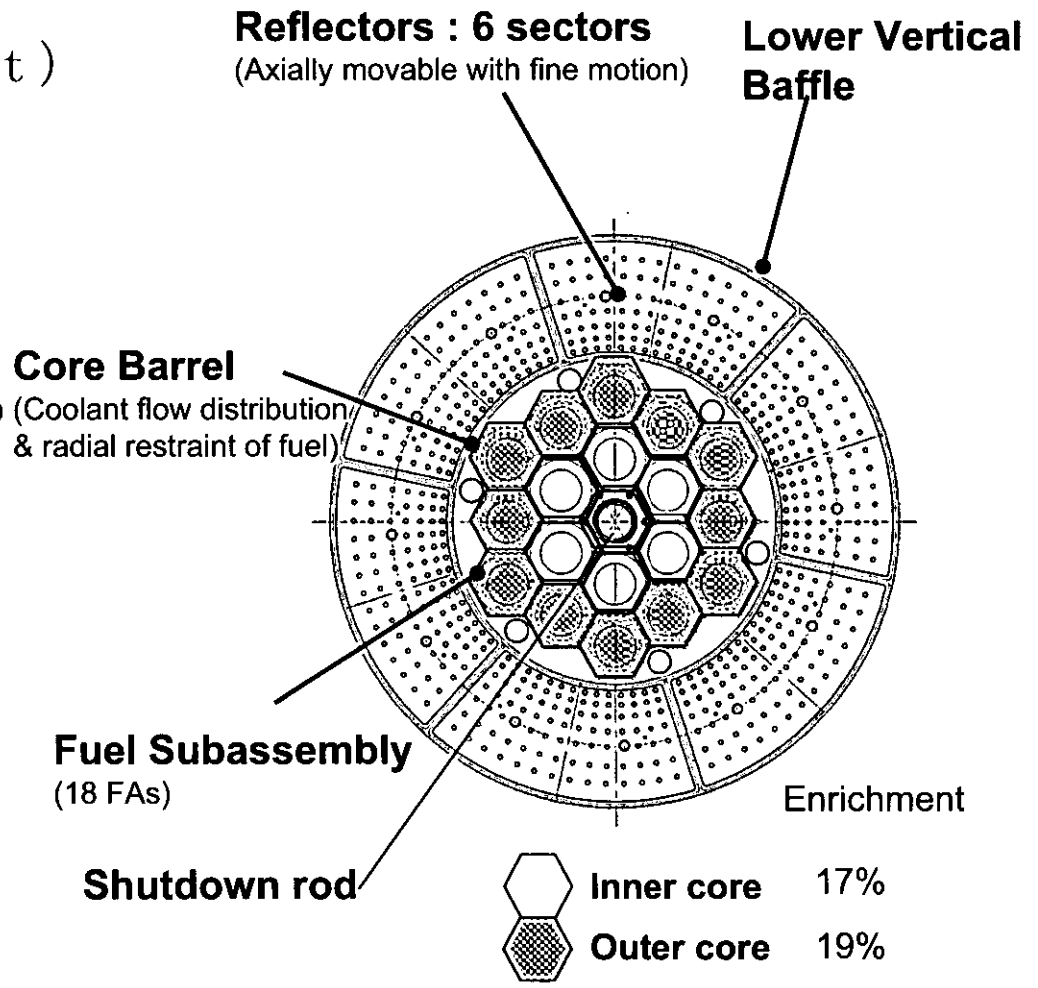
Core Height	2.50 m	**(8.2 ft)**
Equivalent Core Diameter	0.95 m	**(3.1 ft)**
Fuel / Clad Material	U-10%Zr / HT-9 steel	
235U Enrichment (inner / outer)	**17 / 19 %**	
Average Burn-up	34,000 MWd/t	

Reactor Vessel

Design Pressure	0.3 MPa	**(44 psi)**
Design Temperature	550 deg.C	(1022 deg.F)
Inner Diameter / Thickness	3.5 m / 25 mm	(12 ft / 1.0 inch)
Total Height	24 m	(79 ft)
Material	Type 304 stainless steel	

Core Design

- Core
  - Core height 2.5m (8.2 f t)
  - Equivalent core diameter 0.95m (3.1ft)
  - Fuel subassembly number 18
  - Enrichment (Inner/outer) 17/19%
- Reflector control
  - Movable annular reflector
  - Material: Mod9Cr1Mo
  - Size Thickness 38cm (1.2ft)
  - Height 2.7m (8.8ft)

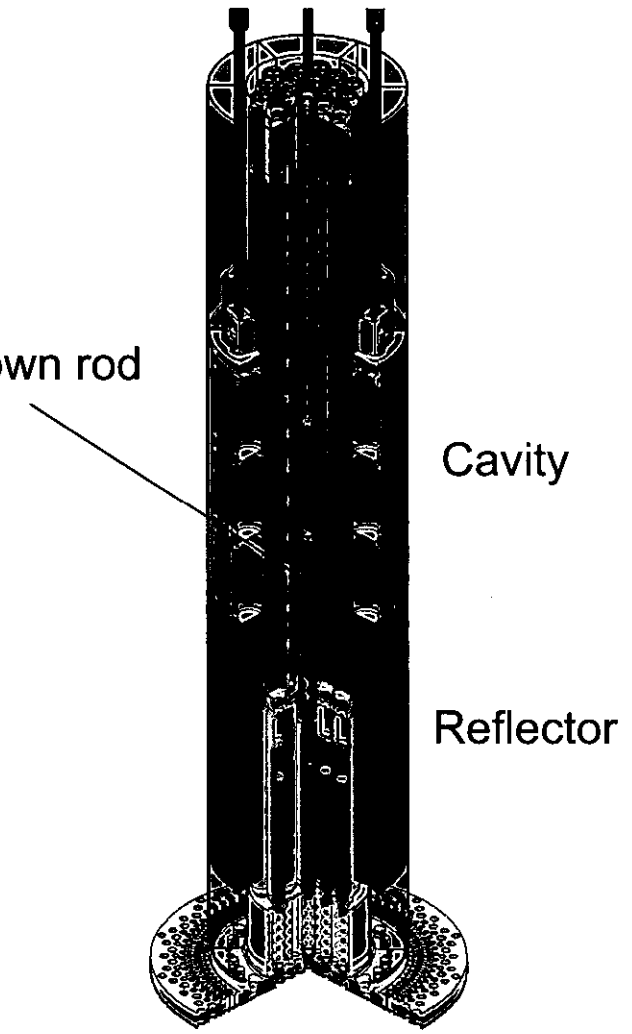


Reactivity Control System

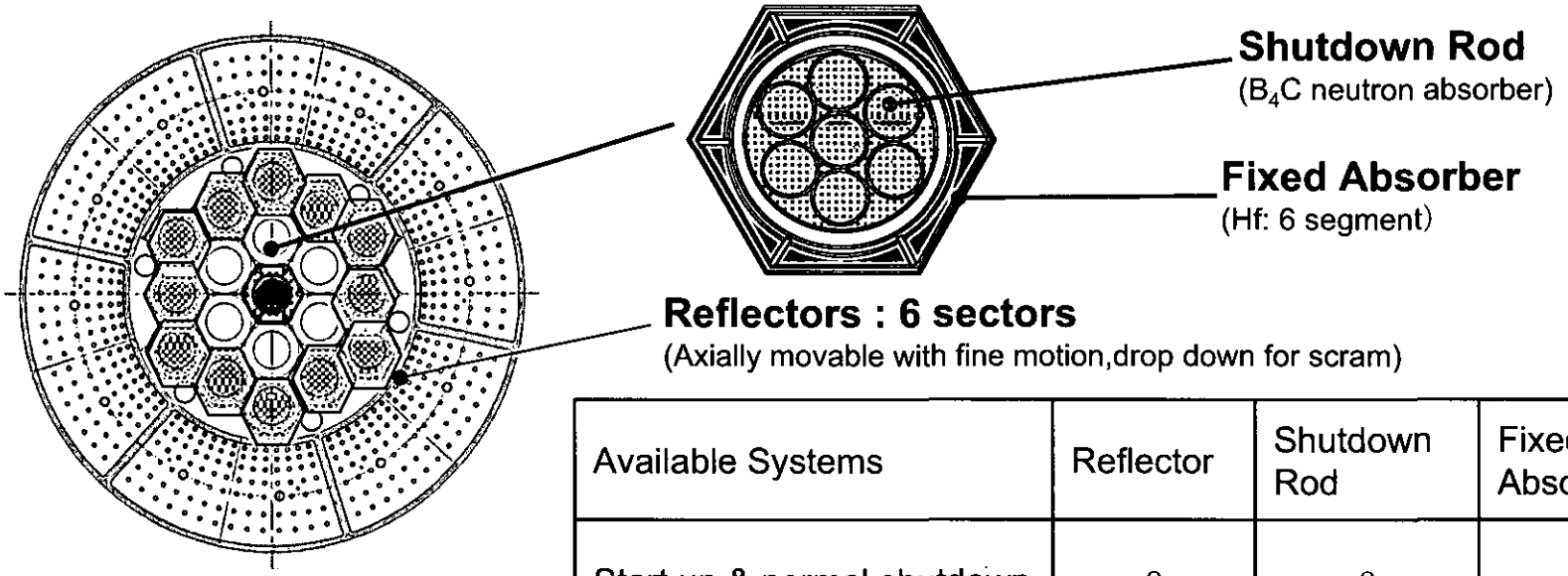
■Reflector	
Number	6
Reflector stroke	2.7m (8.8ft)
Scram	gravity

■Shutdown rod	
Number	1
Rod stroke	2.5m (8.2ft)
Absorber material	B4C
Scram	gravity Insertion

■Fixed absorber	
Number	6
Absorber stroke	2.7m (8.8ft)
Absorber material	Hf



Reactivity Control



Available Systems	Reflector	Shutdown Rod	Fixed Absorber
Start up & normal shutdown	0	0	-
Burn-up compensation	0	–	0
Scram	Δ*	Δ	-

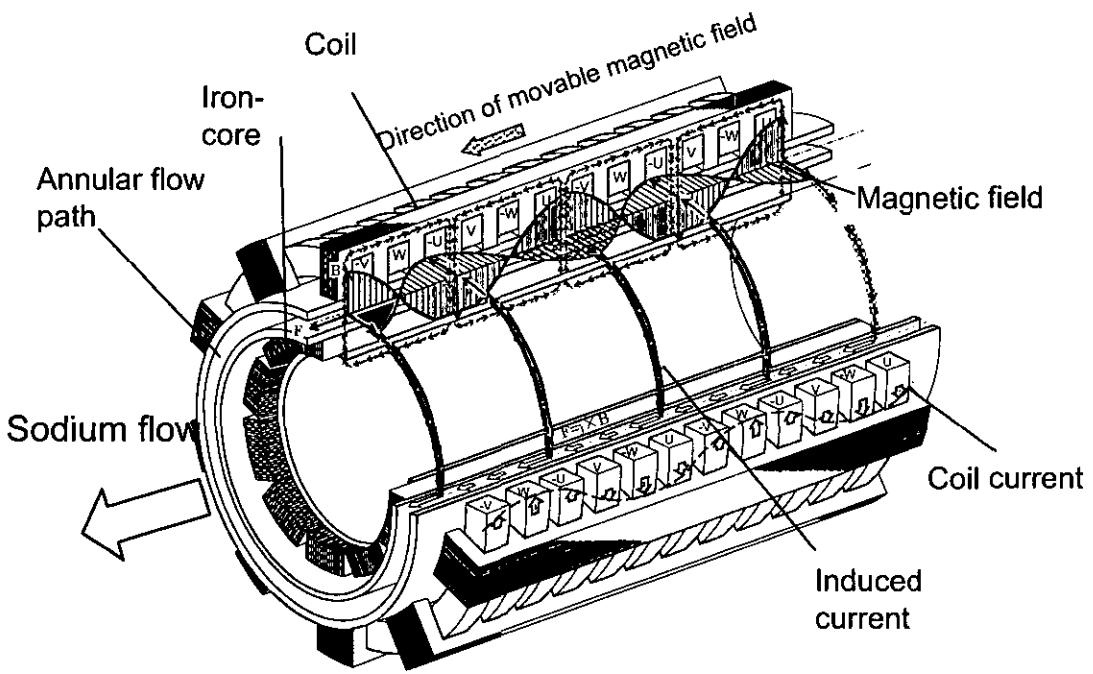
O – Needed

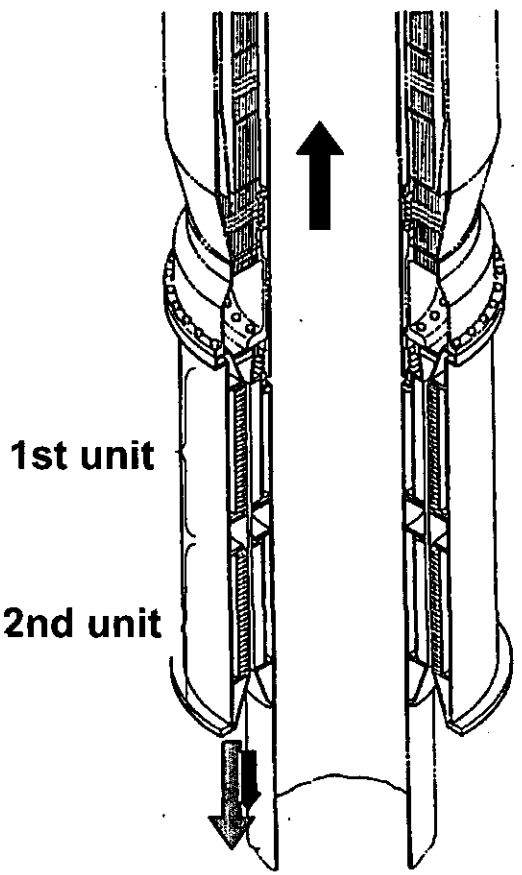
Δ – Redundant and diverse

* - Provides one reflector stuck margin

Primary EM pumps

- **Two pumps in series**
- **No moving parts**

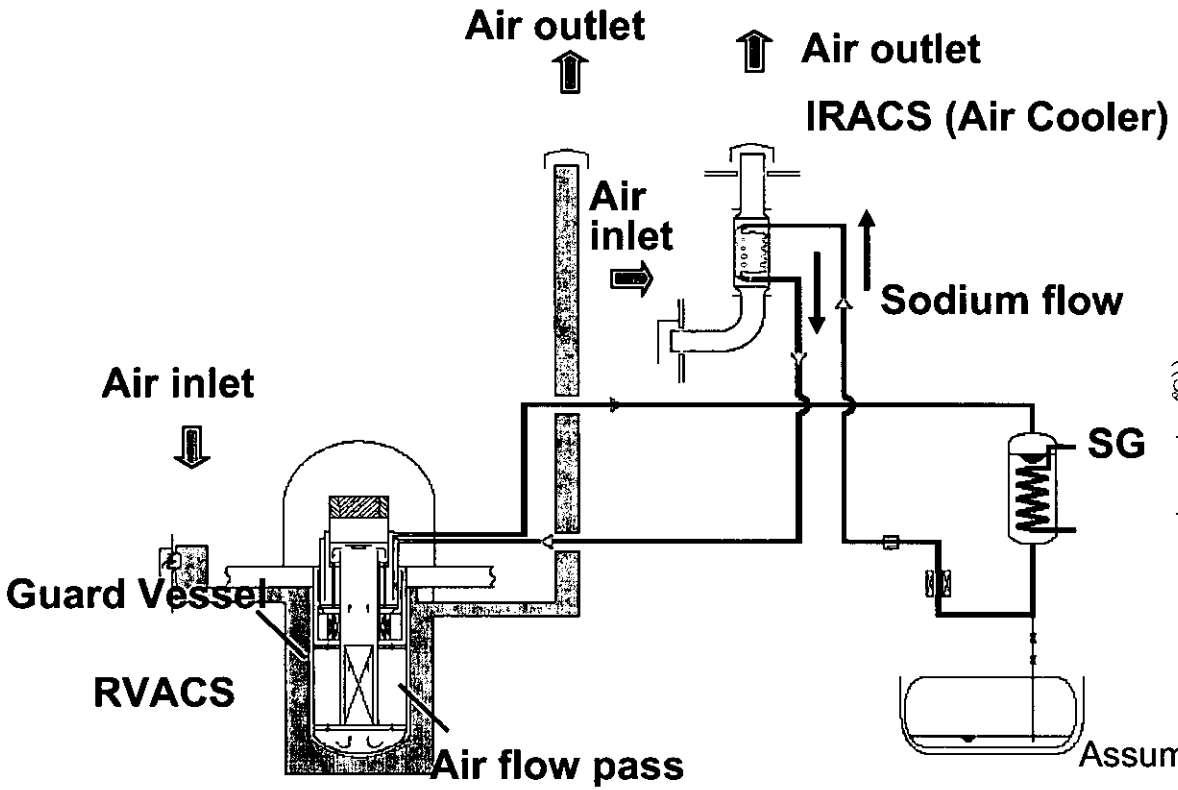


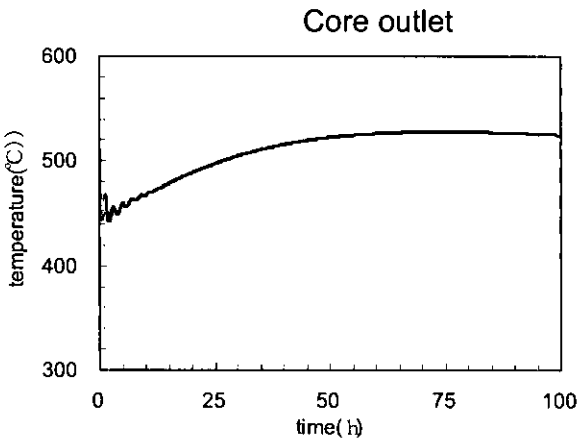


EM pumps in series

Passive Decay Heat Removal

- **Heat removal by natural circulation & natural air draft**
  - Redundant and diverse residual heat removal
  - RVACS: Natural air draft outside the guard vessel
    - Sufficient cooling capacity by only RVACS
  - IRACS: Natural circulation of sodium and air draft of air cooler





Loss of offsite power
Assumption : Heat removal by only RVACS

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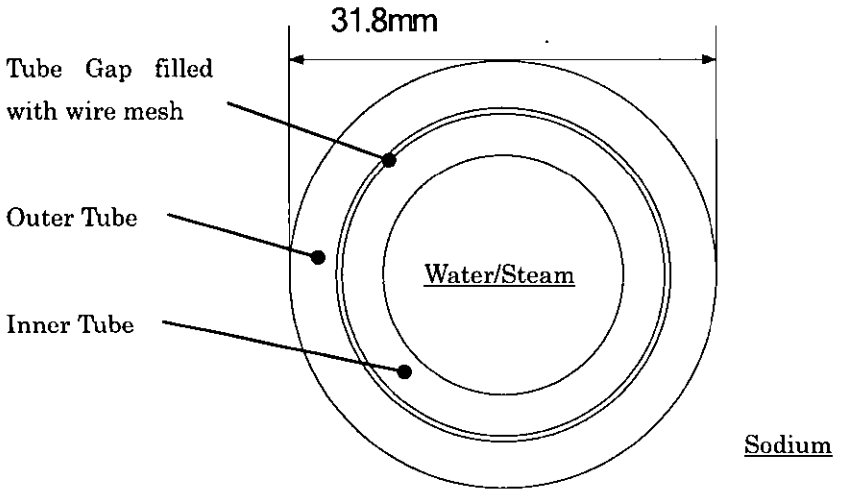
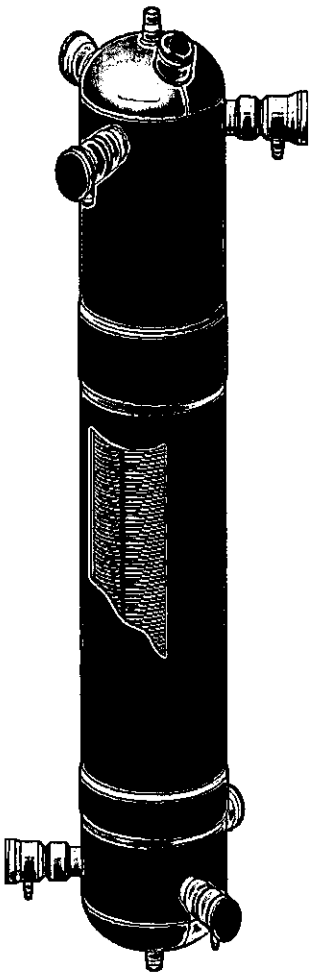
Steam Generator

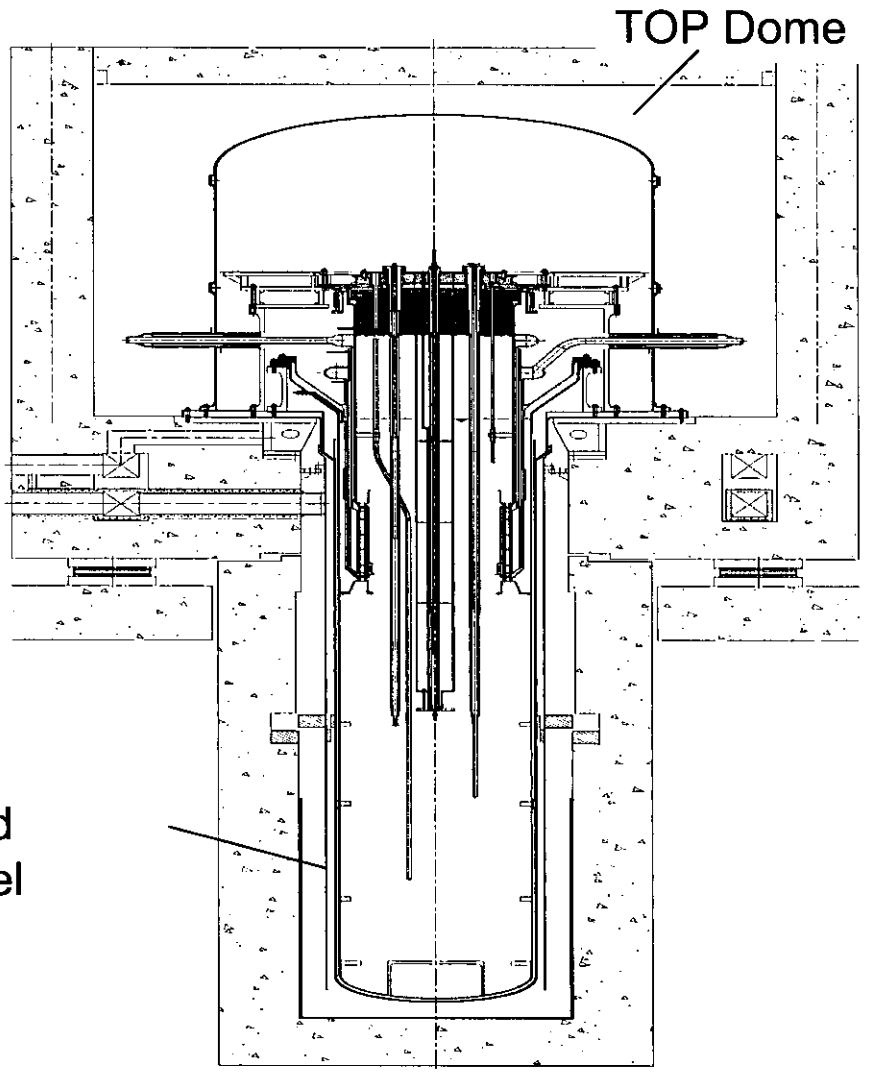
- **Double wall tube steam generator**
  - Minimizes potential for sodium-water reaction





Containment

- **Guard vessel**
  - **Material:** **2 1/4Cr-1Mo**
  - **Diameter:** **3.65m**
- **Top dome**
  - **Material:** **2 1/4Cr-1Mo**
  - **Diameter:** **8m**
- **Passive heat removal system**



Safety Features of 4S

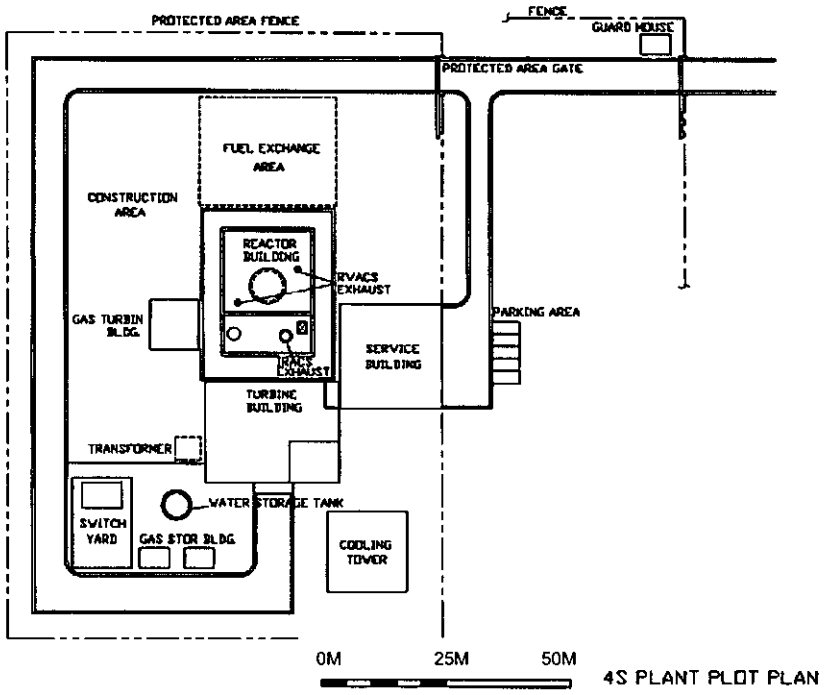
- **Source term reduction**
  - Low power results in low fission product inventory
  - Sodium affinity for fission products minimizes release
  - No significant release to containment due to absence of energetic and pressurization events
- **Radioactive release reduction**
  - Sealed reactor vessel and containment
  - Minimize penetrations and isolation valves
  - Threat to containment integrity is minimal due to absence of damaging phenomena (direct containment heating, steam explosion, hydrogen burning or detonation, missiles)

Safety Analysis Results

- **Large margin to acceptance criteria for site suitability and emergency planning**

Distance (m)	50
EAB (rem)	0.004
LPZ (rem)	0.2
Acceptance dose criteria (rem)	25

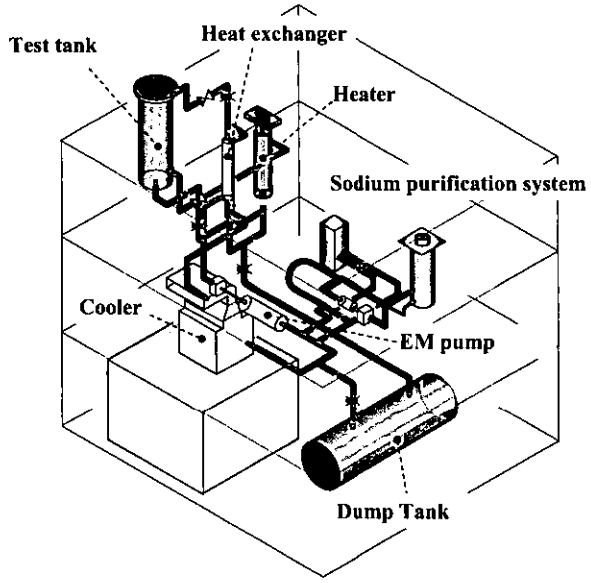
TEDE: Total equivalent dose
EAB: Exclusion area boundary
LPZ: Low population zone



Test Facility for Further Tests

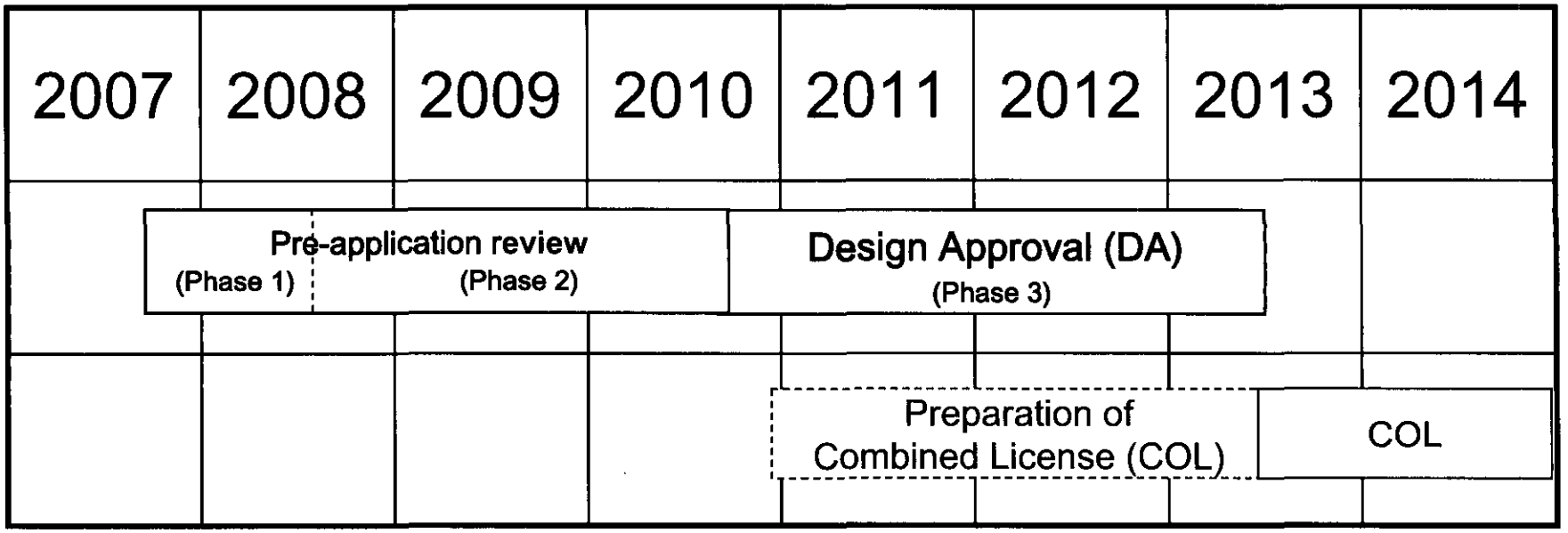
▫ TOSHIBA Sodium Component Test Facility

- Facility completed December 2008.
- Functional testing begun January 2009.
- Planned tests
  - Demonstration of large-scale EM pump.
  - Verification of leak detection system for a steam generator outer tube failure.



Current Licensing Schedule

- **Submit Design Approval application on October, 2010**
  - **Phase 1:** Complete a series of meetings with NRC to identify issues to be addressed before Design Approval application
  - **Phase 2:** Submit technical reports and obtain NRC feedback to address the issues identified in Phase 1
  - **Phase 3:** Submit Design Approval application and obtain SER



The licensing activity is been conducted in cooperation with CRIEPI, ANL and WEC.

Conclusions

- **4S is a mature technology that is ready for regulatory review and commercialization.**
  - Preliminary systems design complete and detailed design in progress
  - Significant body of test data to support key components
  - Proven and tested fuel experience to support the 30-year core lifetime
- **4S U.S. licensing process has begun.**
  - Pre-application review meetings & technical reports
  - Target for FDA - 2013

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Region	City of	Population[iii]	(MWe) Net Capacity[iv]	Type[v]
Aleutians	Unalaska	4,388	29.5	IC
Bering St	Unalakleet	741	4.1	IC
Bristol Bay	Diilingham	2,373	17.5	IC
	Naknek		20.1	IC
Interior	Tok		11.6	IC
Kodiak	Kodiak	6,138	41.6	IC, 91.9 HY
Kuskokwim	Bethel	5,899	41.2	IC
M Yukon	Galena	763	9.4	IC
NW Arctic	Kotzebue	3,076	20.9	IC
S Central	Copper Valley		16.6	IC, 50.8HY, 22.5GT
	Cordova	2,372	20.8	IC, 2.9 HY
Southeast	Yakutat	691		IC
Seward P	Nome	3,448	27.8	IC

CHUGACH

RESOLUTION

RESOLUTION IN SUPPORT OF ALTERNATIVE ENERGY IN ALASKA

WHEREAS, Chugach Electric is currently 90% dependent on natural gas for its existing electric generation and produces just 10% of its energy with hydroelectric power;

WHEREAS, Chugach Electric has a goal to reduce its dependence on fossil fuels and transition to 90% dependence on renewable sources in the future; and therefore we adopt the 90/10 to 10/90 concept as a long-term goal.

WHEREAS, Chugach recognizes that our intermediate goals may best be meet with alternative energy sources and as such, these potential sources must be considered to help diversify our energy resources and limit price volatility for any one energy commodity.

WHEREAS, Chugach Electric strongly supports the current review and analysis of a Susitna hydroelectric generation project,

WHERAS, Chugach Electric supports continued development of additional reserves and gas storage in Cook Inlet, and the study of a natural gas bullet line from the Alaska North Slope to assure availability of natural gas for local needs;

WHEREAS, the Alaska Energy Authority (AEA) is currently undertaking a 50-year Integrated Resource Plan (IRP) and Chugach encourages AEA to analyze all alternative energy generation technologies on a level playing field of consideration to include economic, environmental, political and longevity criteria, so that we and/or the State of Alaska may construct a portfolio of alternative electric generation capabilities to meet the needs of all electric consumers in Alaska;

WHEREAS, alternative energy generation technologies include but are not limited to the following: hydroelectric, coal to liquids, coal gasification, gas to liquids, nuclear, geothermal, biomass, conservation and efficiency measures, incineration of municipal waste, tidal, wind, or solar;

WHEREAS, there are provisions in existing state law currently that limit the ability of the State of Alaska, any electric utility, any set of electric utilities, or any private entity from consideration and development of some forms of alternative energy, for example current prohibitions against nuclear energy;

NOW, THEREFORE BE IT RESOLVED that Chugach Electric Association, Inc. adopts a 90/10 to 10/90 strategy to transition away from fossil fuels to renewable energy sources and supports the evaluation by AEA of all possible potential alternative electric generation technologies to reduce our current dependence on natural gas;

CHUGACH

BE IT FURTHER RESOLVED that The Chugach Board of Directors support the immediate repeal of relevant portions of Alaska Statutes that currently prohibit development or funding of any alternative energy solution in the State of Alaska.

CERTIFICATION

I, Alex Gimarc, do hereby certify that I am the Secretary of Chugach Electric Association, Inc., an electric non-profit cooperative membership corporation organized and existing under the laws of the State of Alaska: that the foregoing is a complete and correct copy of a resolution adopted at a meeting of the Board of Directors of this corporation, duly and properly called and held on the 20th day of November, 2008; that a quorum was present at the meeting; that the resolution is set forth in the minutes of the meeting and has not been rescinded or modified.

IN WITNESS WHEREOF, I have hereunto subscribed my name and affixed the seal of this corporation the 20th day of November, 2008.

_____

Secretary