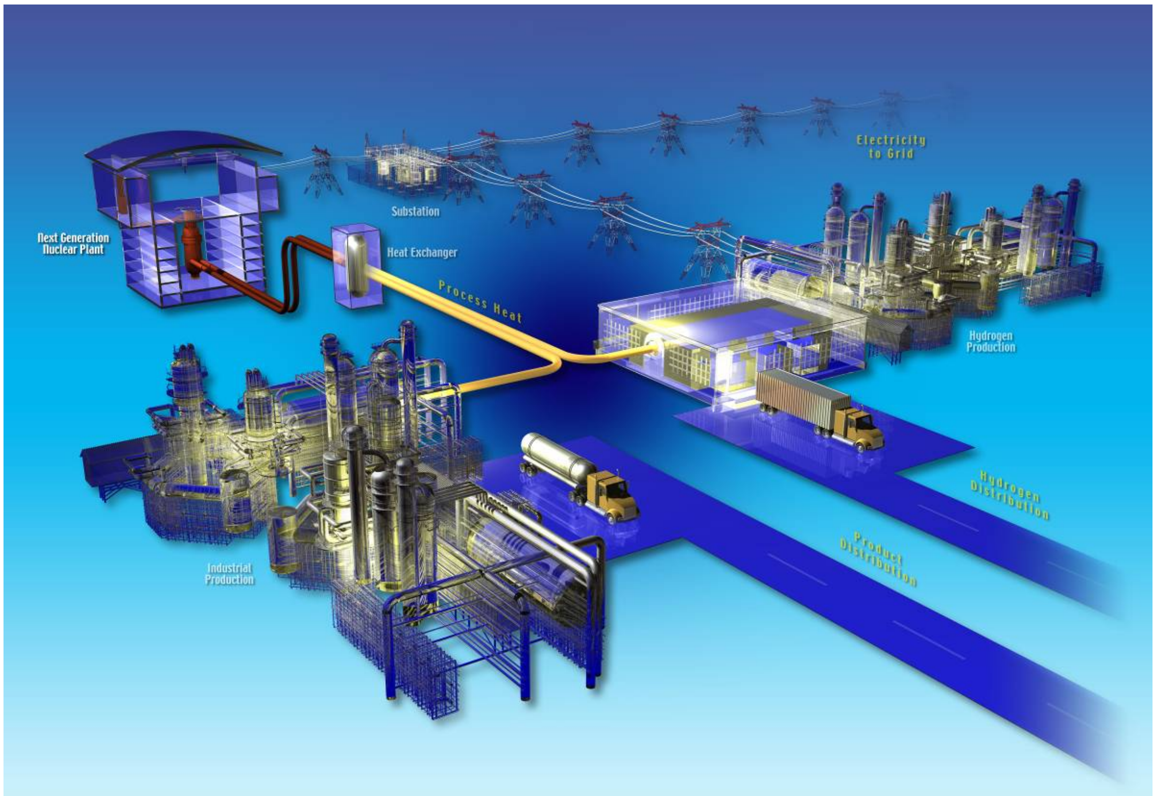
Next Generation Nuclear Plant Project

Senior Advisory Group Meeting
Reference Configuration

Crystal City, VA

October 28, 2008



Attendees

Senior Advisory Group
Steve Melancon (Entergy) – Meeting Chairman
Phil Hildebrandt (BEA)
Arkal Shenoy (General Atomics)
Finis Southworth (AREVA)
Ed Wallace (PBMR)

AREVA
Lew Lommers
Joe Stringer

Entergy
Curt Bregar

General Atomics
Mark Haynes

PBMR
Dan Mears

URS
Vytas Maciunas

INL
Larry Demick
Richard Garrett
Greg Gibbs
Jim Kinsey
Phil Mills
Keith Perry

DOE
Tom O'Connor

Meeting Objective

Reach agreement on the reference configurations that will be carried forward in the conceptual design work for NGNP.

Meeting Agreements

1. The NGNP Project will pursue two reference configurations for Conceptual Design as recommended by the HTGR Suppliers:

- PBMR will pursue an indirect[1] configuration using a pebble bed reactor design and a secondary gas loop to supply heat to the energy conversion processes, (e.g., steam turbine electricity generator, process steam demands). An Intermediate Heat Exchanger (IHX) provides the interface and heat transfer component between the primary and secondary gas loops. (see Figure 1, below)

- AREVA and General Atomics will pursue an indirect configuration using a prismatic block reactor design with a secondary loop using steam as the heat transport fluid. A steam generator transfers the heat from the primary loop in the form of steam that then supplies the energy conversion processes, (e.g., steam turbine electrical generator, process steam demands), see Figure 2, below.

- The NGNP Project Conceptual Design work will assume that the reference configurations will be used to supply process steam and electricity in a commercial co-generation application.

2. The group defined the following high level technical and functional requirements that impact HTGR configuration:

   - The Nuclear Heat Supply System (NHSS[2]) shall be design certified for a broad range of applications and sites.
   - The NHSS shall be licensed independent of the application. In this regard the licensing boundary and interface requirements shall be defined for the reference configurations, (e.g., transients, feed and gas return chemistry).
   - The NHSS designs shall be applicable, on economic, availability and reliability bases, to a broad range of co-generation applications supplying, singly or in combination, electricity, steam, and hot gas. A 95% availability is required.
   - The reactor gas outlet temperature shall be in the range of 750°C to 800°C
   - The plant shall be capable of completing design, licensing, construction, and startup testing for initial operation by 2021
   - The NHSS shall be capable of controlling the transport of radionuclides to the end products at levels below the concentration or exposure requirements for the product (e.g., tritium in steam, gas, hydrogen) [Initial acceptable tritium levels will be set at a fraction of the EPA limits for drinking water and air]

3. The Group identified the following developmental issues to be addressed early in Conceptual Design:

   - Define the required ranges of functional and performance requirements for target applications, (e.g., steam pressure, temperature and flow ranges, electricity supply, hot gas pressure, temperature and energy, hydrogen supply, availability)

[1] For the purposes of this discussion an indirect configuration is defined as one in which energy is transferred from the primary helium loop to one or more secondary loops that supply the energy conversion processes, (i.e., in the indirect configuration no energy conversion occurs in the primary loop.

[2] The Nuclear Heat Supply System includes the nuclear island (e.g., the reactor, primary coolant system and supporting systems) and the heat transfer/transport system.

- Continue development of the Project Systems Requirements Manual based on commercial end user functional and performance requirements
- Update the capital cost and schedule estimates for completing the design, licensing, construction and commissioning of the reference configurations for the target application
- Update the operating cost estimates for the reference configurations in the target application
- Identify operating conditions and transients of most concern, and the controls provided to maintain the operating conditions within acceptable bounds for the reference configurations in the target application
- Complete design and analysis for control of primary and secondary gas pressures for loss of heat sink transients in the secondary gas loop indirect configuration
- Complete design and analysis for control of temperature, pressure and material corrosion for the full range of potential steam generator tube leaks in the secondary steam loop indirect configuration
- Confirm the stability and control under normal and upset operating conditions for the reference configurations in the target application
- Define the boundaries for licensing each reference configuration; the objective is to license the NHSS within these boundaries independent of the energy conversion process. The uncertainties in this approach need to be clearly identified and addressed.
- The following generic safety issues need to be addressed in addition to the specific issues identified in the preceding:
    - General water and air ingress
    - Tritium management
    - Need for active safety systems
    - Loss of heat sink
- Determine if there are any significant differences in the following areas when comparing the reference configurations:
    - TDRM complexity and requirements
    - TRL of major components and systems
    - Reliability budgeting
    - Maintenance complexity, (e.g., IHX versus SG leakage, changeout)

4. The Senior Advisory Group (SAG) will be convened periodically.

Supplier and BEA Presentations made during the course of this meeting are attached.

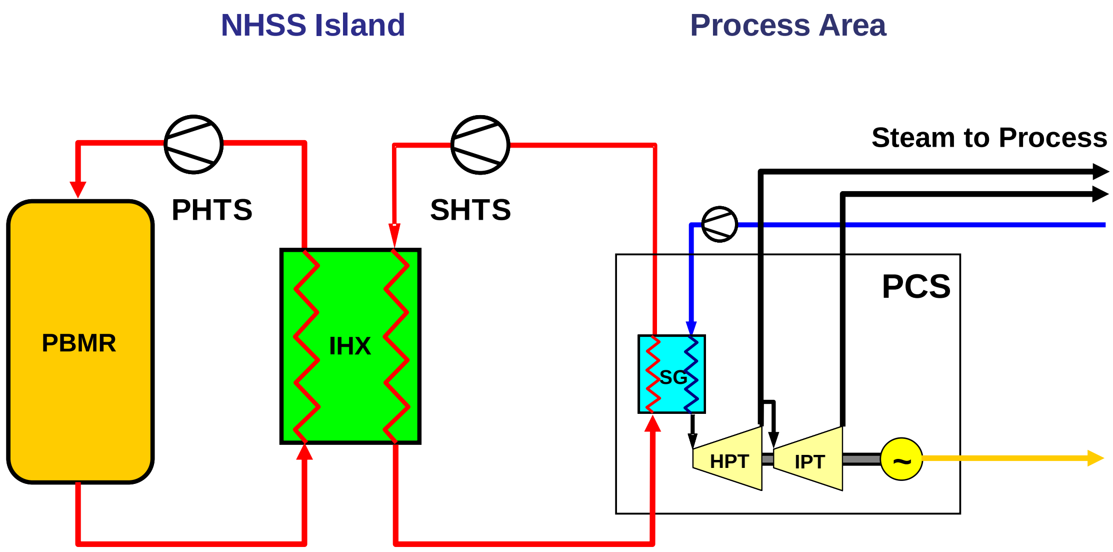


Figure 1 – Reference PBMR Design

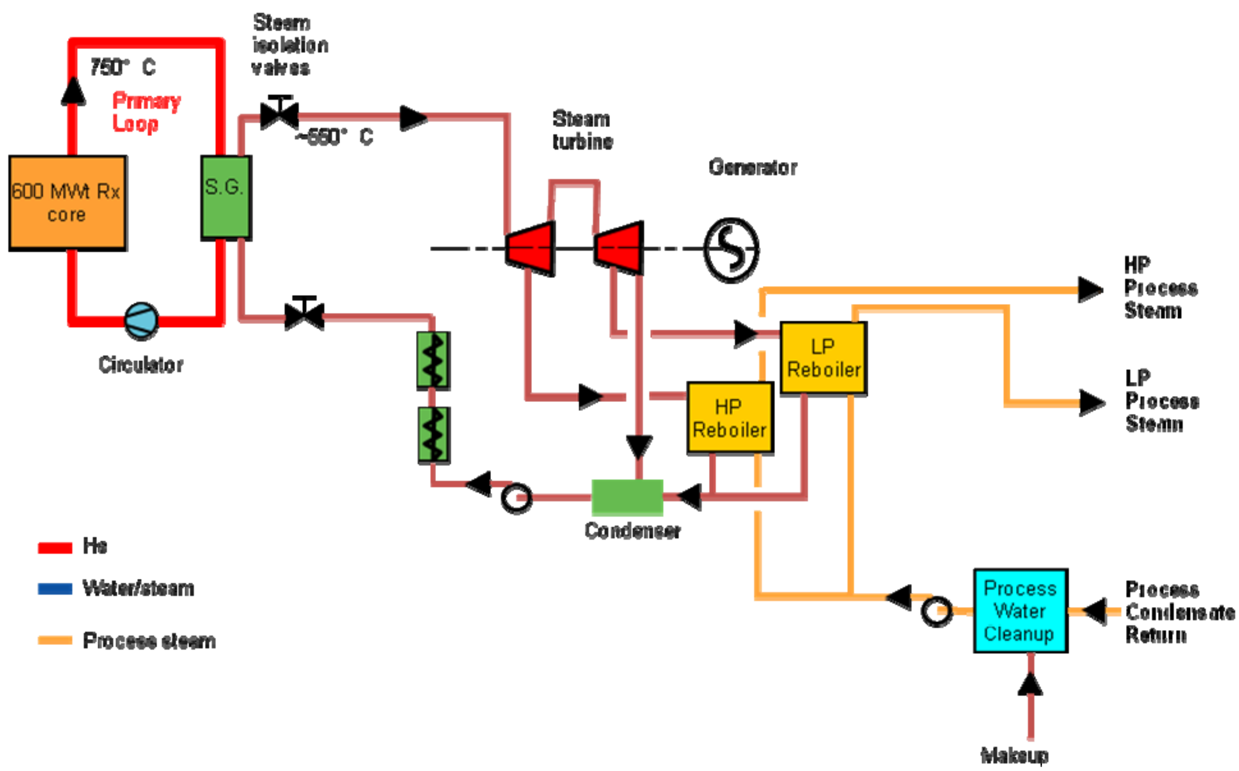


Figure 2 – Reference Prismatic Block Reactor Design

Additional Action Items

1. Determine what constitutes a production scale demonstration for fuel for NRC licensing purposes – INL (Petti)

2. Determine the strategy for certifying a design such that it can occur independent of a wide range of process applications for which a business case can be made. – INL (Kinsey)

3. Determine basis for radiological limits and controls, (e.g., for tritium). Consider domestic and international standards. – INL (GA)

4. Establish the design limit and basis for annual allowable worker exposure by unit and plant. (Contact NEI and INPO) – Entergy (Melancon)

5. Develop a basis document for defined functional and performance requirements. – INL (Garrett)

6. Evaluate TDRM impacts & TRL perturbations based on the two configurations and the performance and functional requirements chosen. – INL (Garrett)

7. Identify the breakdown between forced and planned outages that results in 95% availability – Entergy (Melancon)

8. Implement a process for posting all NGNP related reports on the NGNP Project web site. – INL (Perry)

Attachment 1 – PBMR/Westinghouse Presentation

PBMR - SG in SHTS R6.ppt

Attachment 2 – General Atomics Presentation

GA - NGNP Plant config.ppt

Attachment 3 – AREVA Presentation

AREVA NGNP Recommendation Oct

Attachment 4 – BEA Presentation

BEA - Reference Configuration Meeting

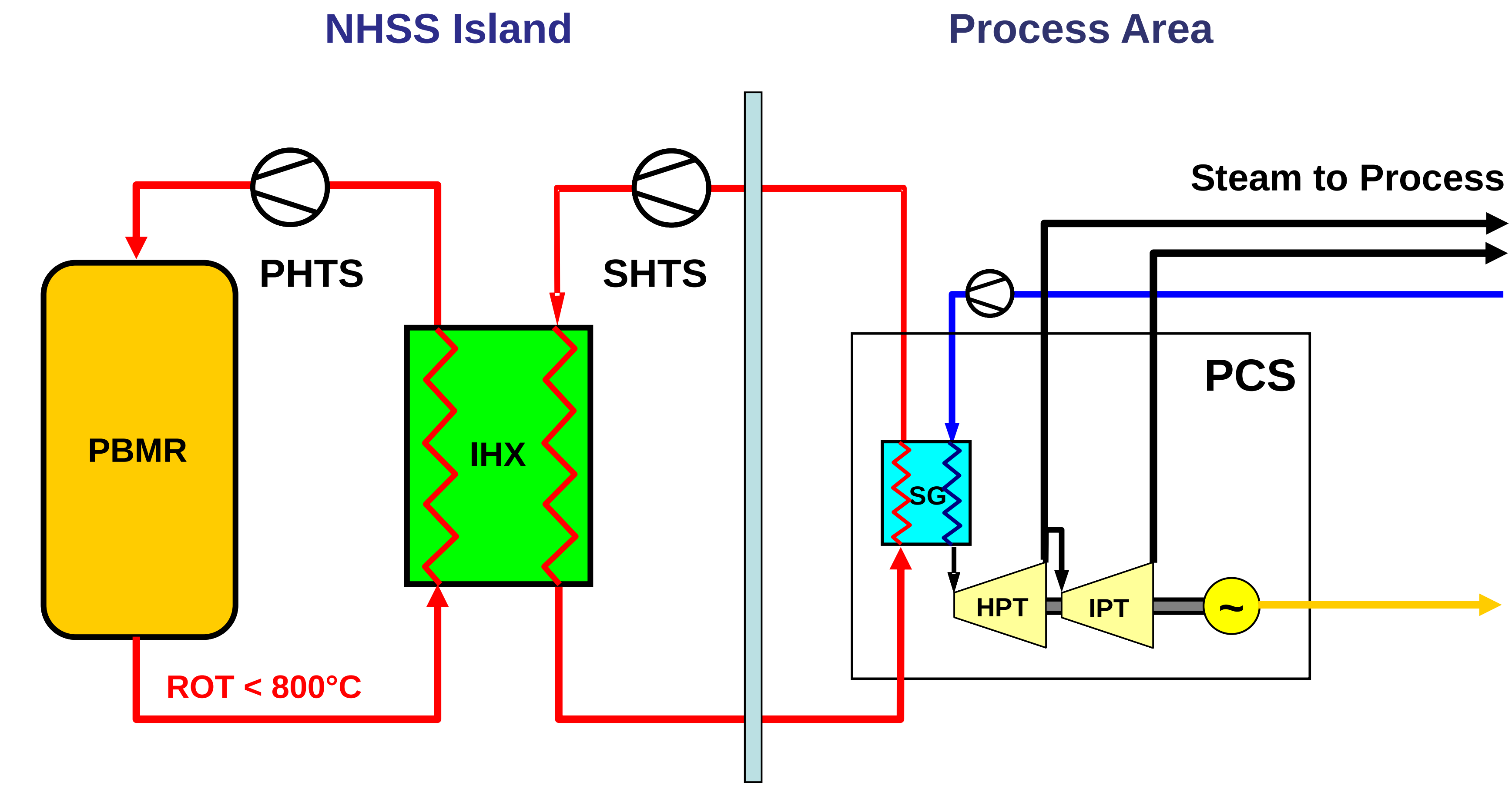
Market Considerations for NGNP Reference Configuration Selection

- Objective: selection of NHSS reference configuration for ROT $\leq$800C applications including steam/heat delivery, process steam injection and process heat delivery – all with potential for Rankine cycle cogeneration and/or waste heat applications, e.g. water desalination
- Steam/heat delivery
  - HTS is utilized in proximate SG for process steam heat input to user site for one or more closed loop processes, e.g. steam driven compressors
    - Condensate is returned to the NHSS for re-use with little or no quality degradation
- Process steam injection
  - HTS is utilized in proximate SG for process steam injection on the user site for one or more open loop processes, e.g., oil sands, coal gasification
    - Condensate is not returned to the NHSS or returned with poor quality
- Process heat delivery
  - HTS is utilized on proximate user site as thermal energy input to one or more processes in a closed loop, e.g. ethylene cracker

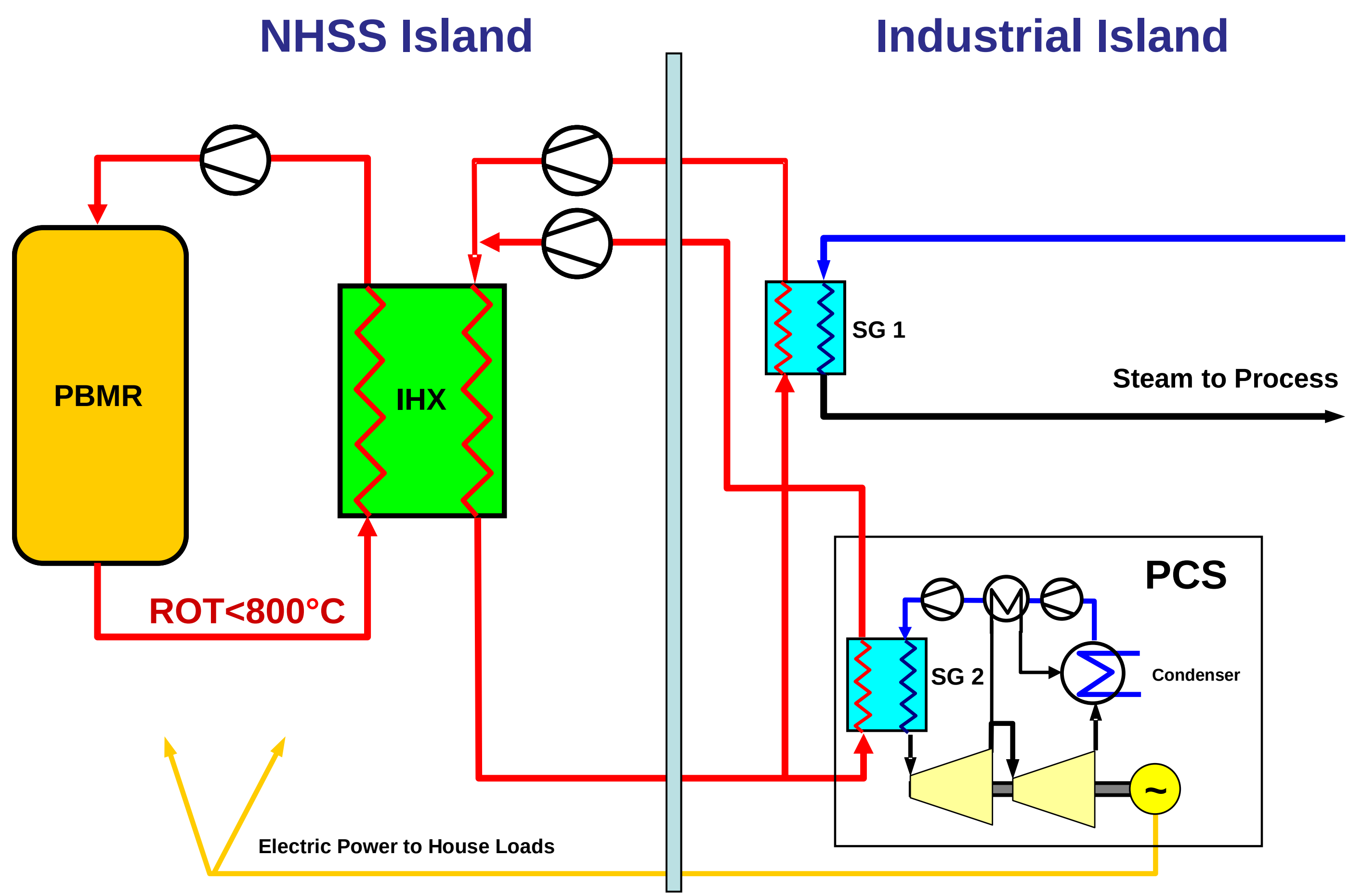
Key Considerations for NGNP Reference Configuration Selection – Placement of SG

- **For Rankine cycle electricity generation and/or steam/heat delivery applications, simplest and most economical configuration may be SG in PHTS, pending**
  - Water ingress, S/G integrity, related safety issues that must be addressed for licensing
- **For others, considerations favoring IHX in PHTS and SG in SHTS:**
  - More margin and greater certainty that tritium limits are met
  - Water quality concerns and related economics, especially for oil sands and coal gasification
  - Boiler/SG access, inspection and maintenance
  - Less onerous safety analyses, code V&V, and safety R&D without high pressure steam/water ingress with lower risk in today's licensing environment
  - Similar, standardized IHX configuration required for process heat delivery applications, e.g. NH_3, H_2 production
    - Path to such applications achievable w/o another nuclear demo plant
    - Avoids multiple design and licensing cycles for diverse configurations
    - Minimizes time and cost to market
- **Above must be weighed against:**
  - Capital and operating costs (power requirements, maintenance)
  - Reliability impact of IHX, secondary loop components

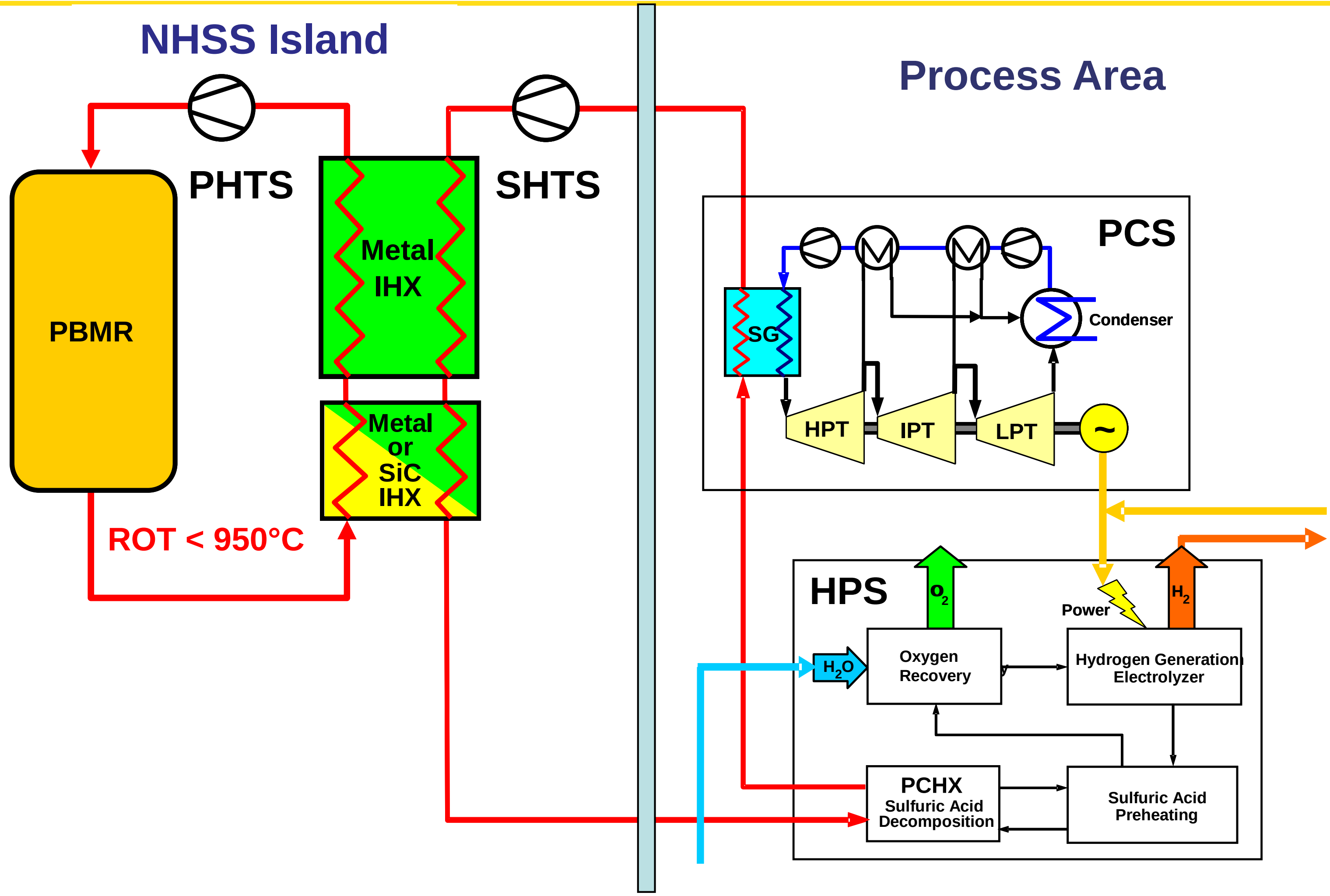
PBMR Reference
Process Steam / Cogeneration



High Pressure Process Steam / Cogeneration, e.g. Oil Sands

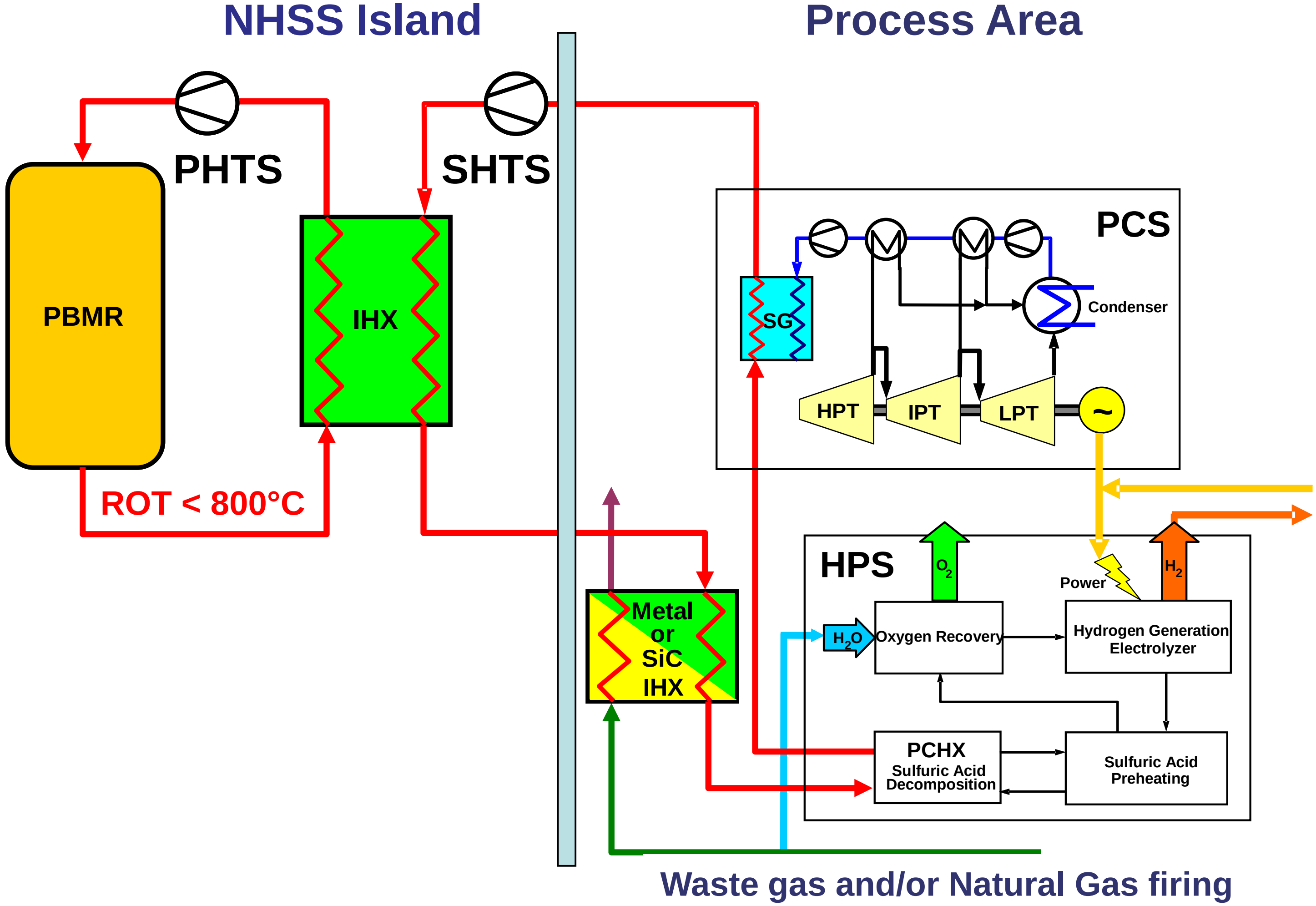


Illustrative Higher Temperature Application – Hybrid Sulfur H2 Production



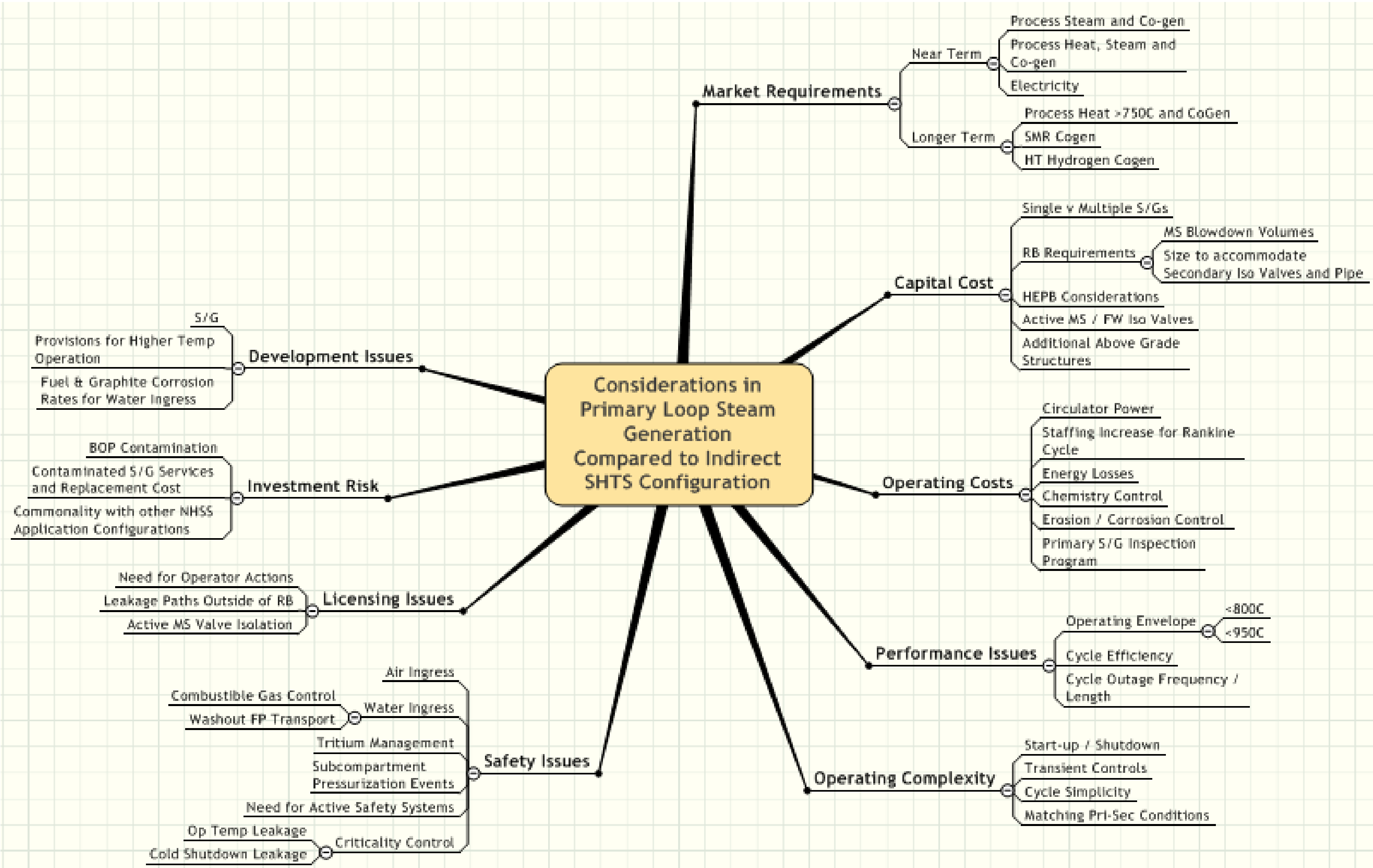
Westinghouse NGNP Team

Alternative Approach to Higher Temperature Application



Westinghouse NGNP Team

Reference Steam Generator Configuration Considerations



General Atomics' Recommendations On Plant Configurations

Presented to

NGNP Senior Advisory Group Meeting

Arkal Shenoy,
Director, Modular Helium Reactors

October 28, 2008

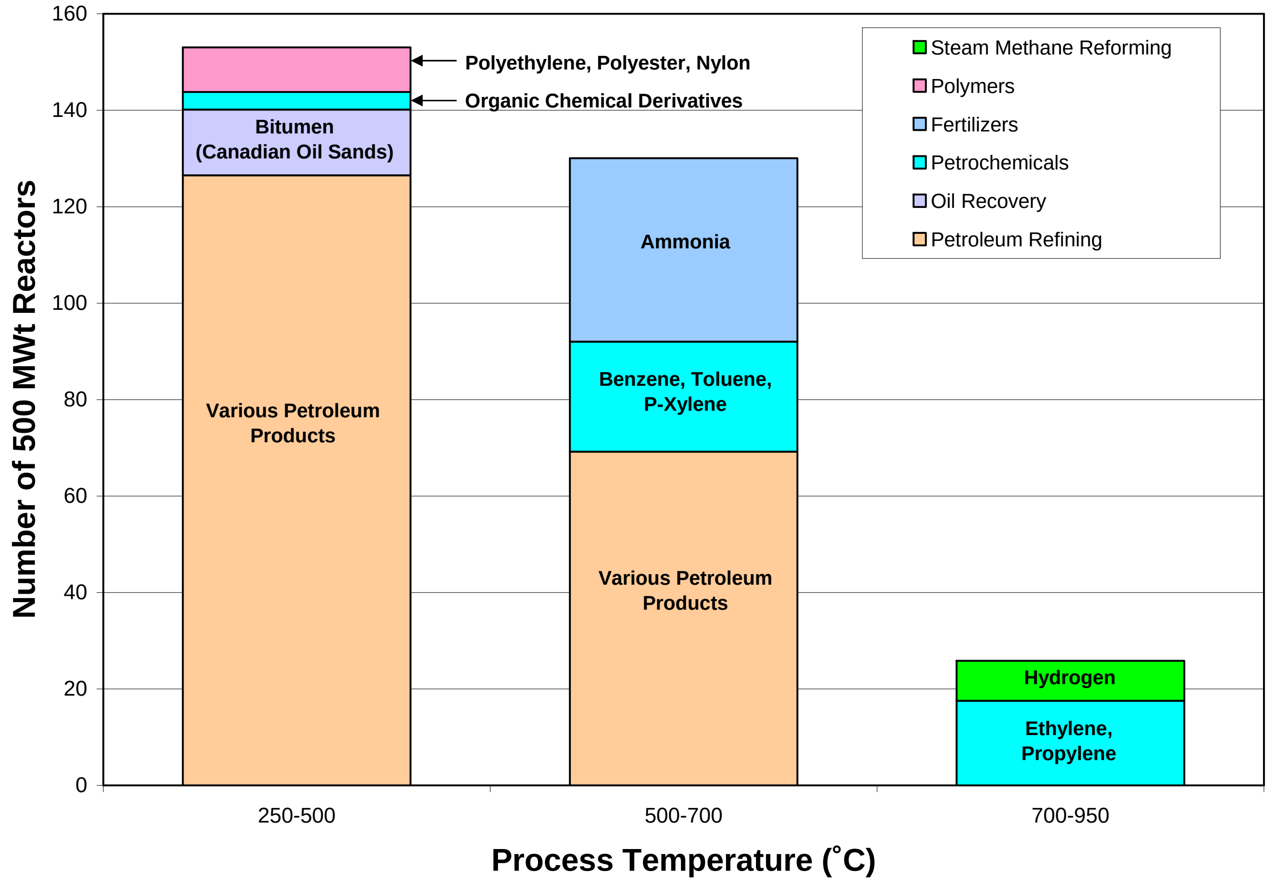
Rolls-Royce ОКБМ URS Washington Division TOSHIBA Leading Innovation Fe Korea Atomic Energy Research Institute

GENERAL ATOMICS

NGNP Fundamental Requirements:

- Applicable to a broad range of co-generation applications
- Reactor gas outlet temperature in the range of 750 °C to 800 °C.
- Capable of completing design, licensing, construction and startup testing for initial operation not later than 2021.
- Capable of controlling the transport of radionuclides to the end products at levels that meet or beat the concentration or exposure requirements for the product, (e.g., tritium in steam, gas, hydrogen).
- Can be collocated with the process; PAG limits met at site boundary of ~400 meters.
- Capable of following process load variations either through dispatch with the grid and/or reactor power load-following
- Costs for anticipated NOAK, based on design certification, construction and operation of FOAK design, supports viable economic business model; e.g., a target production price of $12/MMBtu, supplied energy equivalent.
- Normal maintenance exposure target limit of no more than 50 person-rem/year.
- Target availability factor of 90%
- Target design lifetime of 60 years

Number of 500 MWt HTGR Modules at 85% Capacity Required to Meet Demands (2000-2007)



GENERAL ATOMICS

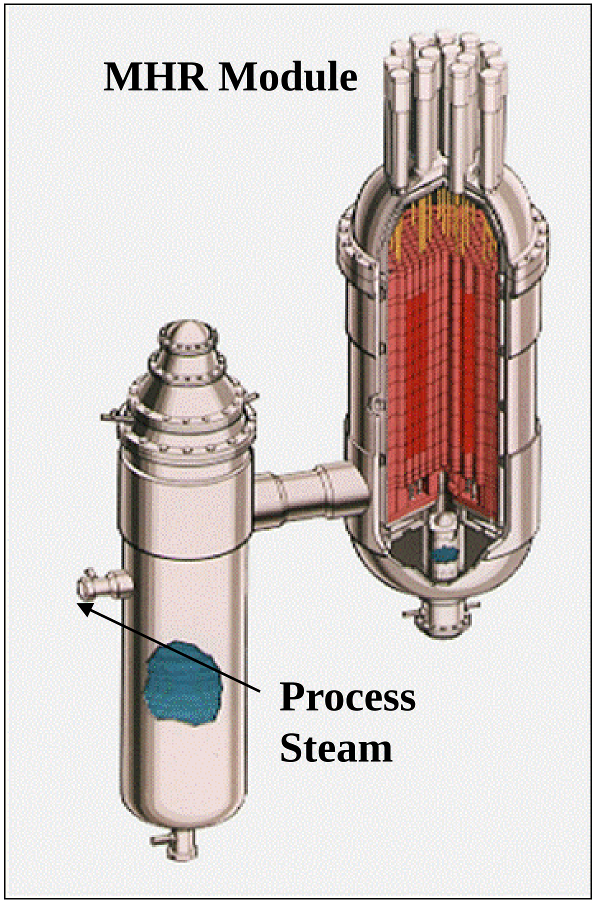
MHR Process Energy Applications

- PROCESS STEAM APPLICATIONS
  - Heavy Oil Recovery
  - Tar Sands Oil Recovery
  - Coal Liquefaction by SRC process
  - Coal Liquefaction by H-Coal process
  - Coal Gasification ECCG process
  - Process Steam for Steel Mill
  - Process Steam for Aluminum Refining
  - District heating for cold countries
  - Desalination for water starving countries
- PROCESS HEAT APPLICATIONS
  - Methanol Production by Hydro gasification
  - Hydrogen Production by steam reforming of Methane
  - Hydrogen Production by Thermo-chemical Water Splitting

Market size for process steam is much larger than process heat

PS/C plant configuration Developed

GENERATES STEAM AT 1000°F (540°C) AND 2500 PSI (17 Mpa)

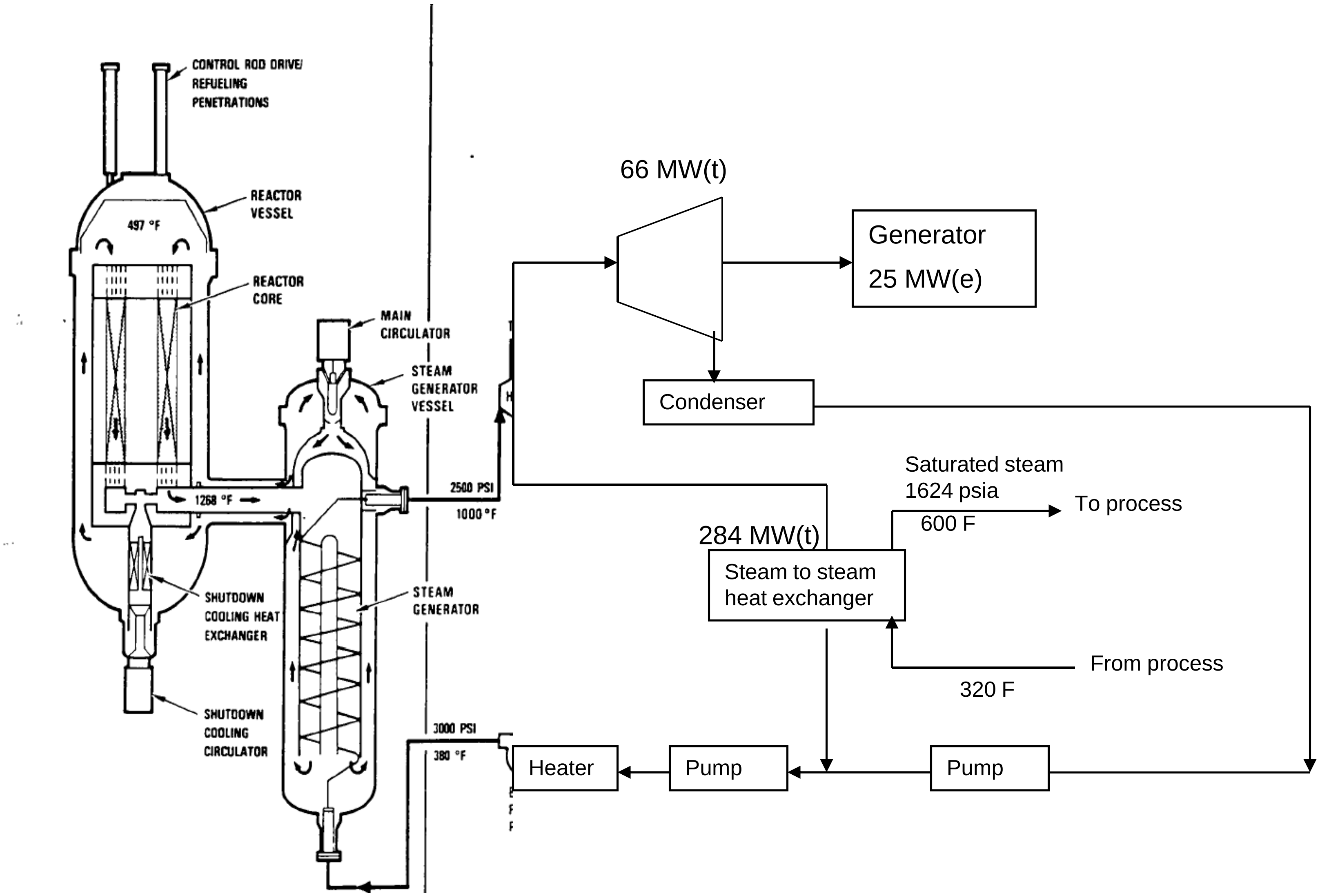


PS/C-MHR Typical Plant Parameters

Thermal Power, MW(t)	600
Fuel Columns	102
Fuel Cycle	LEU/Natural U
Average Power Density, W/cm^3	6.6
Primary Side Pressure, MPa (psia)	7.07 (1025)
Induced Helium Flowrate	281 kg/s
Core Inlet Temperature, ^{o}C (^{o}F)	288(550)
Core Outlet Temperature, ^{o}C (^{o}F)	704(1300)

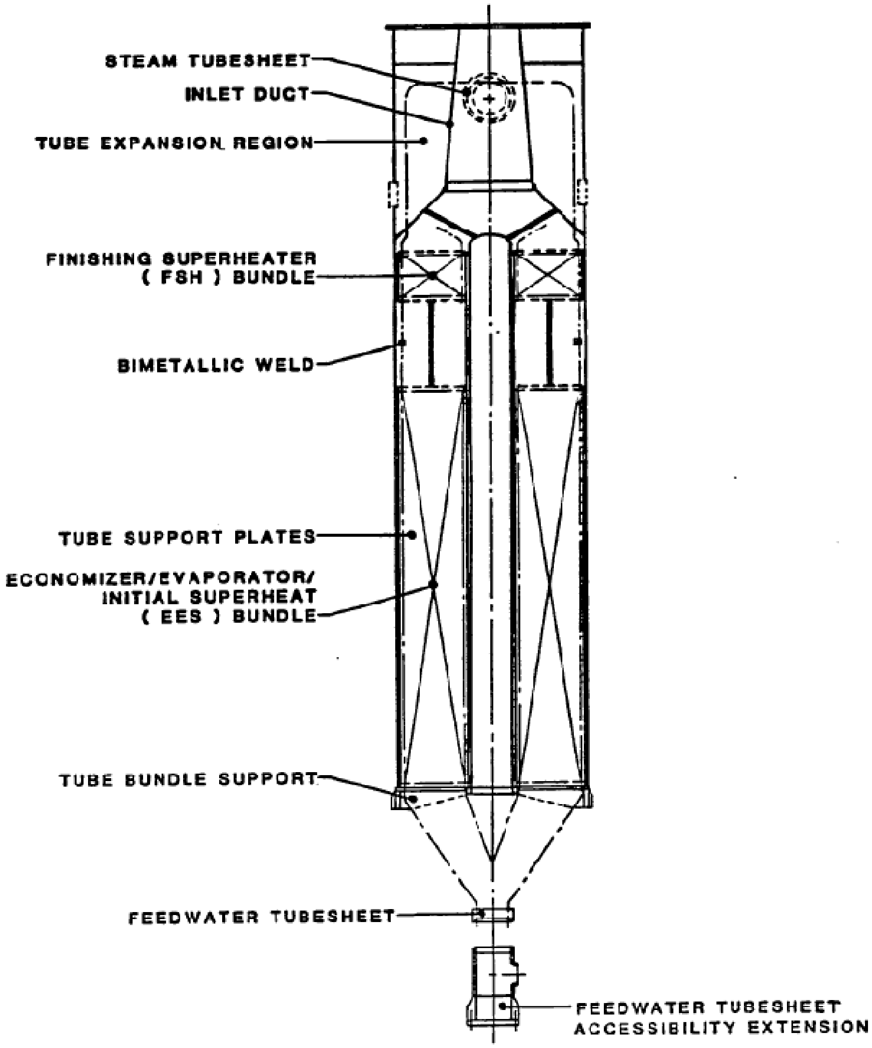
Applications

- Heavy Oil Recovery
- Oil from Tar Sands
- Coal liquefaction
- Coal Gasification
- Industrial process steam



CONTROL ROD DRIVE/ REFUELING PENETRATIONS
REACTOR VESSEL
497 °F
REACTOR CORE
MAIN CIRCULATOR
STEAM GENERATOR VESSEL
1268 °F
2500 PSI
1000 °F
SHUTDOWN COOLING HEAT EXCHANGER
STEAM GENERATOR
SHUTDOWN COOLING CIRCULATOR
3000 PSI
380 °F
66 MW(t)
Generator
25 MW(e)
Condenser
Saturated steam
1624 psia
To process
600 F
284 MW(t)
Steam to steam heat exchanger
From process
320 F
Heater
Pump
Pump

MHTGR-SC SG Design Configuration Assumed for Study of Alternative HTS Configurations



- **Key SG design characteristics:**
  - Vertical orientation
  - Up-flow boiling
  - Cross-counter flow,
  - Once-through tube–and-shell
  - Multiple tube, helically wound tube bundles
- **SG has two bundles:**
  - Lower economizer, evaporator and initial superheater bundle
  - Upper finishing superheater bundle

SG in Primary Circuit Previously Demonstrated in HTGR Plants

- **Peach Bottom I**
- **AVR**
- **Fort St. Vrain**
- **THTR**

Operating experience and technology from these plants used to develop primary loop SG designs for:

- **Large HTGR plants (circa 1972)**
- **MHTGR-SC (circa 1992)**
- **NP-MHTGR (circa 1992)**

Advantages of Steam Generator in Primary Loop

- **Demonstrated Technology**
- **Lower Capital Cost**
  - Reduced Equipment
  - Smaller plant footprint
- **Higher Efficiency**
  - Lower Circulator power
- **Higher Availability**
- **Lower O & M cost including ISI**
- **Lower Core outlet Temperature**

Risk evaluation factors

- Technical risk / technology development effort
- Manufacturability / constructability
- Transportability
- Flexibility in operation
- Insensitive to internal and external events

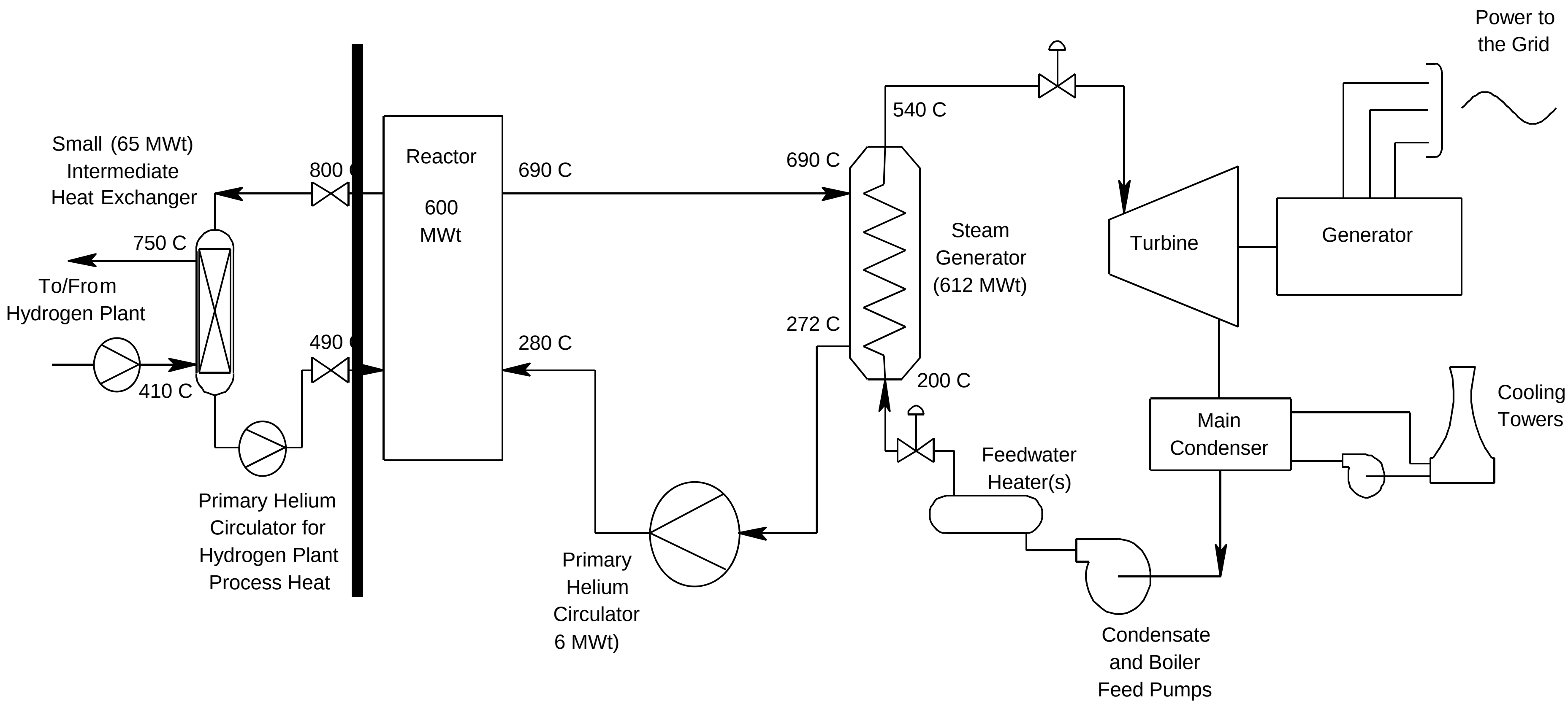
Economic evaluation factors (based on original "Goal Names")

- Performance (e.g., Heat Rate)
- Reliability, Availability, Maintainability
- In-Service Inspection
- Investment protection
- Modularity, (e.g., construction, maintenance

Plant Schematic for Electricity, Process Steam and Process He

Process Heat

Process Steam and Electricity



GENERAL ATOMICS

Overall Conclusion

- **Plant economics is an overriding consideration**
- **Best economics is provided by plant with simplest HTS configuration; SG in primary is simplest configuration**
- **HTS configuration with SG in primary is recommended for FOAK Module based on economic considerations:**
  - To meet requirement for NGNP to be prototypic of commercial co-generation plants
  - No significant control and protection issues identified
  - Moisture ingress safety concern not a discriminator
- **FOAK Module schedule could be shortened**
  - ~ 2 year if SG in primary selected, power reduced to 350 MWt, and reactor outlet temp reduced to ~700°C

AREVA

AREVA Recommendation NGNP Configuration

Lew Lommers

NGNP Reference Configuration Meeting
October 28, 2008
Washington, DC

> Configuration Considerations
> Proposed Configuration for INL Prototype
> Adapting to Commercial Markets
> Configuration for Commercial Application

AREVA Focus on Near-Term Commercial Deployment

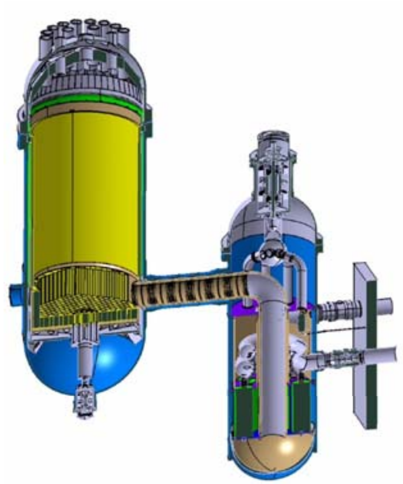
- Schedule
- Cost
  - Development and FOAK
  - NOAK
  - Performance
- Flexibility
  - Ability to serve multiple markets
- Safety and design margins
- Technical maturity
  - Required R&D
- Technical risk
  - Feasibility, uncertainty

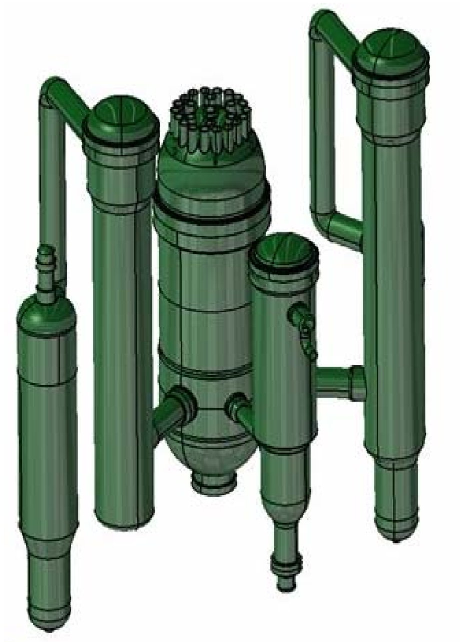
AREVA Evaluating Various HTR Concepts

> **AREVA internal program**
- **Indirect CCGT**
- **Conventional steam cycle**

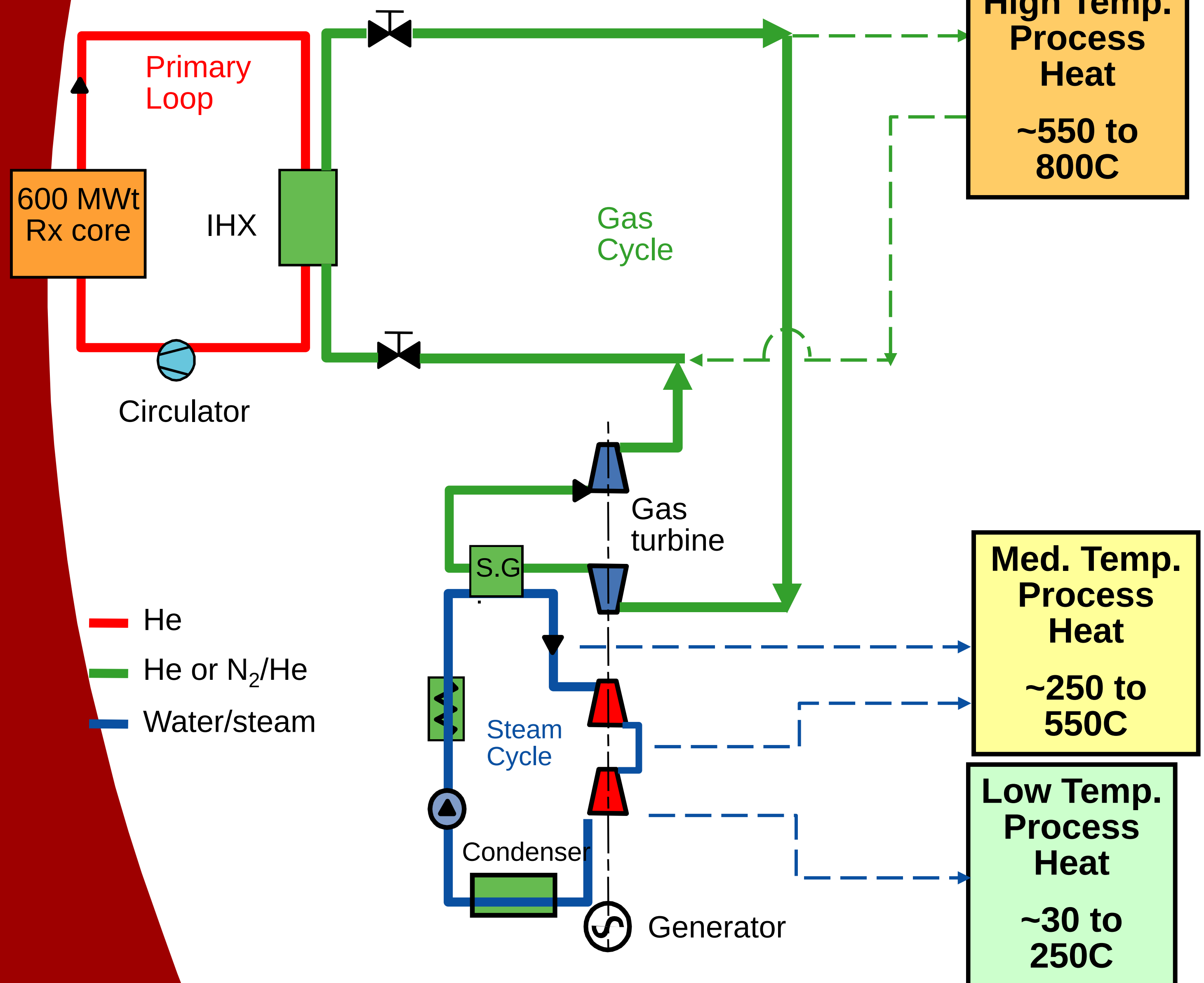
> **AREVA NGNP Scope**
- **Indirect CCGT**
- **Indirect steam cycle**
- **Conventional steam cycle**

> **AREVA recommendation**
- **Conventional steam cycle**





ANTARES Concept Provides Greatest Flexibility



Market Applications

- Hydrogen-SI
- Hydrogen-SMR

- Coal Liquefaction
- Coal Gasification
- Advanced Electrolytic Hydrogen
- Oil Shale
- Tar Sands
- Biomass

- District Heating
- Desalination

But CCGT Probably Not Best Solution for Near-Term Process Heat Applications

> **Most flexible concept**
  - **Very high temperature heat**
  - **Electricity**
  - **Steam (high and low temperature)**

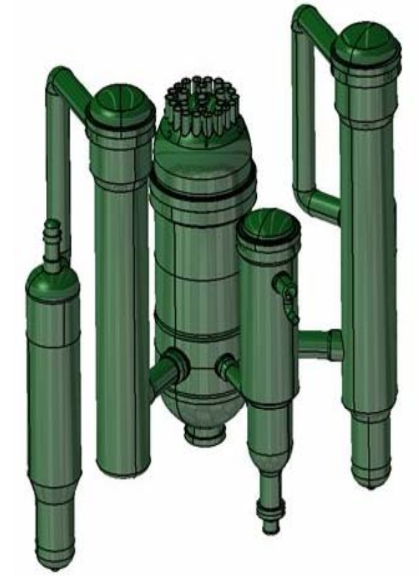
> **Very high efficiency**

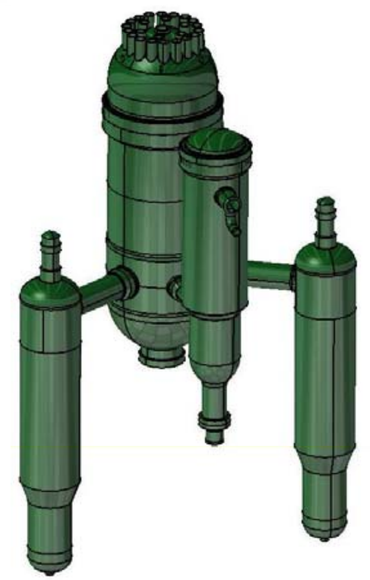
> **But not well suited for most near-term applications**
  - **Significant development challenges**
    - **IHX**
    - **Gas turbine**
    - **Secondary side**
  - **Long development schedule**
  - **High cost**

> **Conventional steam cycle can meet most markets sooner and at lower cost**

Both Indirect and Conventional "Direct" Steam Cycle Configurations Evaluated for NGNP

- > Indirect cycle separates PCS from primary
  - Allows development and retrofitting of PCS in non-contaminated environment
  - Rankine PCS does not require development
- > Both cycles have good flexibility
- > Both have acceptable safety impact
- > Indirect steam still requires substantial development for IHX
  - Lower temperature IHX may be less challenging
  - Lower temperature IHX does not support VHTR market
- > Conventional steam has lower cost
  - Indirect comparable to CCGT
  - Conventional steam 20% less per module



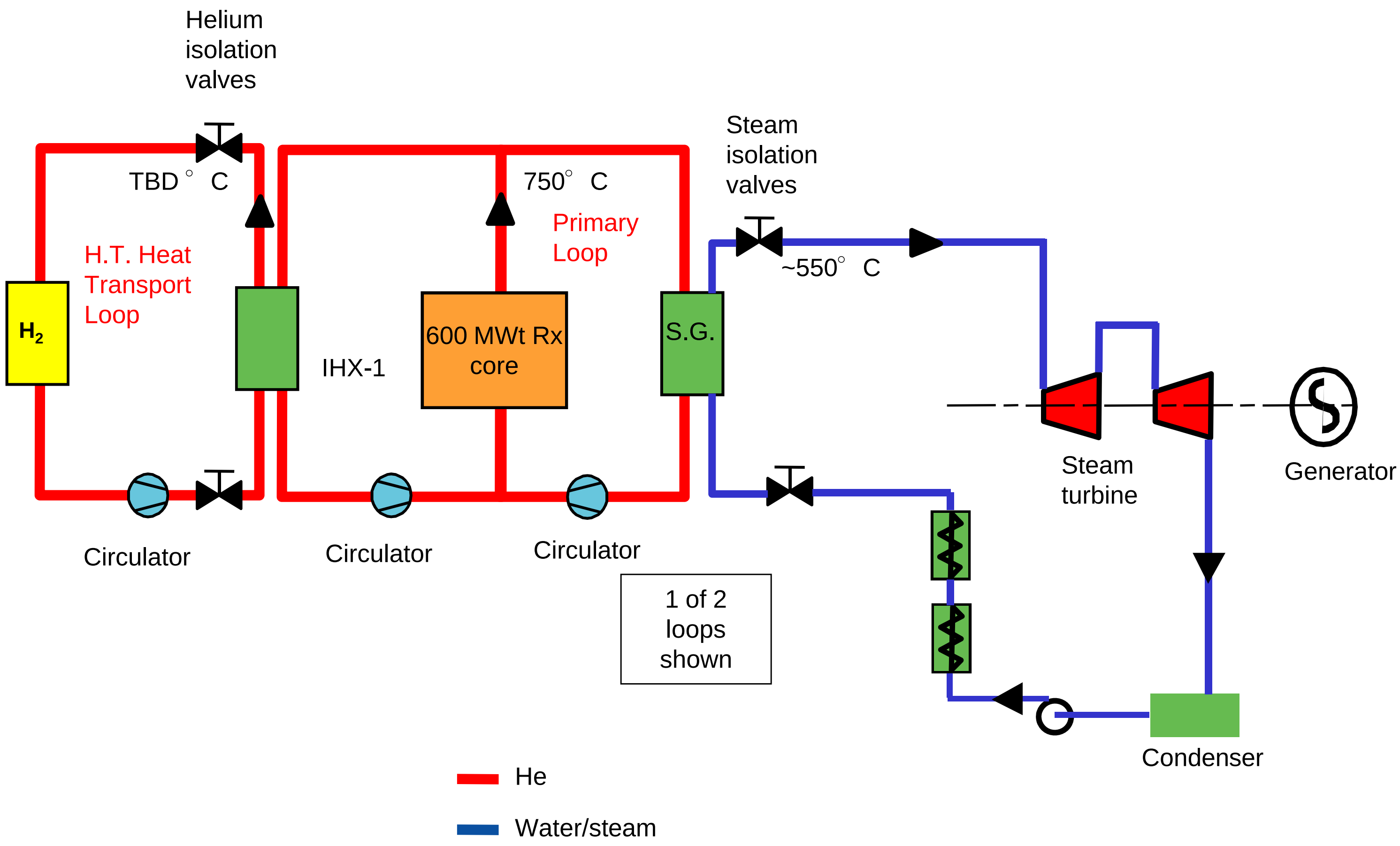


AREVA Recommends Conventional Steam Cycle for NGNP

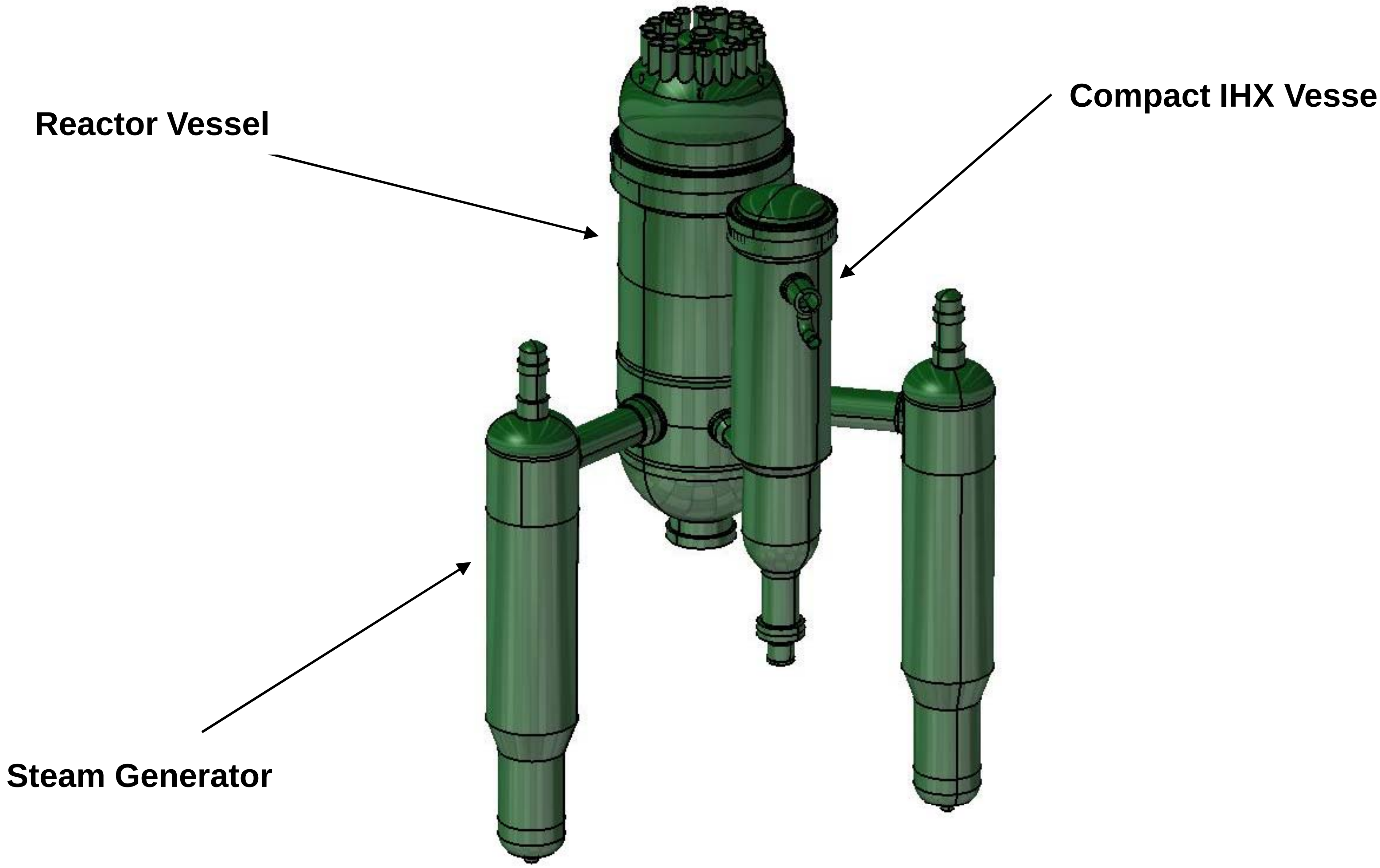
- Faster deployment – less development required
- Low technical risk
  - Builds directly on past HTR operating experience
  - Larger Nuclear Heat Source design margins
- Applicable to most near-term markets
- Equivalent performance at lower cost
- Logical first step toward future VHTR applications

	Direct Steam	Neutral	Indirect Steam
Technical Risk	++		
Safety		x	
Schedule	+		
Capital Cost	++		
Operating Cost	+		
Flexibility		x	
Contamination Control			+

Recommended NGNP Primary and Secondary Configuration



Conventional Steam Cycle NGNP Arrangement



Conventional Steam Cycle Is Logical First Step in Developing Full HTR Potential

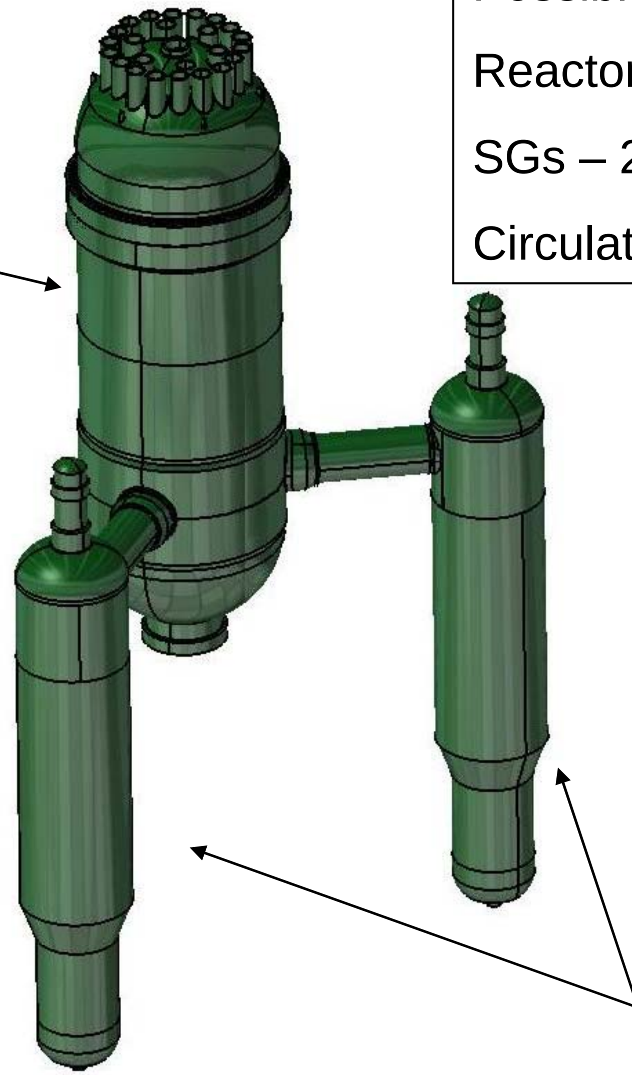
Required Development	Steam Cycle	Future VHTR
Fuel Qualification	X	
HTR Siting	X	
HTR Licensing	X	
Process Interface Issues	X	
Safety Case Validation	X	
Very High Temperature Materials (metals, ceramics)		X
High temperature fuel		X
IHX development		X
Very high temperature process interface		X

Adapting the Steam Cycle HTR to Commercial Process Heat and Cogeneration Applications

- **Use extraction and backpressure turbine(s) to optimize generation of electricity and steam**
  - **Current industrial practice**
  - **Analyzed for 2240 MWt SC/C HTGR project**
- **Reliability for steam supply**
  - **Standby gas-fired boilers**
  - **Extra HTR modules generating electricity (markets with very high electricity demand)**
- **Steam generator water quality requirements**
  - **No mixing of steam and process streams**
  - **Closed steam/condensate system**
- **Mixing of steam and process streams**
  - **Main steam may be used for processes without direct contact**
  - **Reboiler required for processes with direct contact**
- **Contamination control**
  - **Separation provided by process heat exchanger (or reboiler)**
  - **Detailed analysis required**

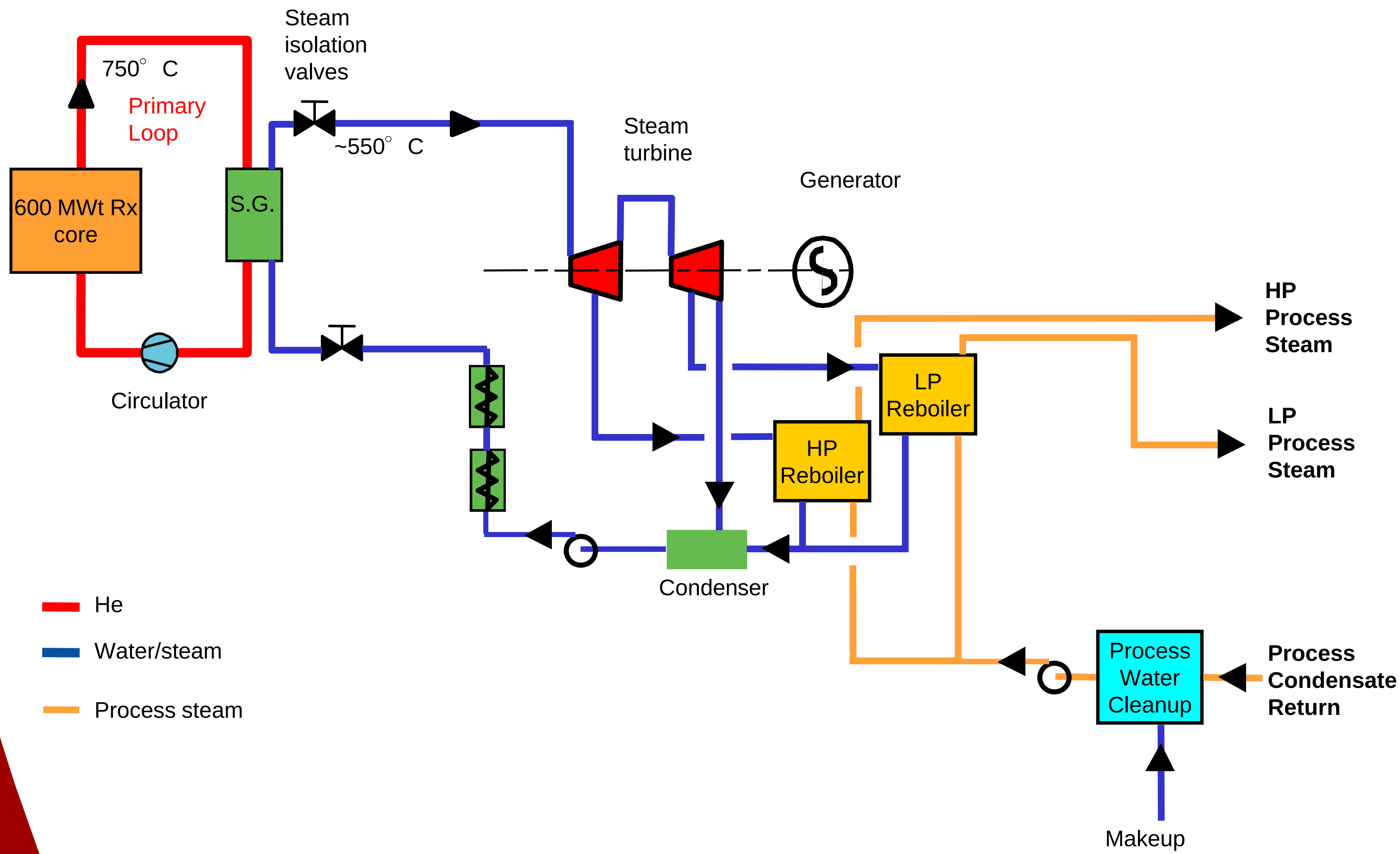
Commercial HTR Arrangement for Conventional Steam Nuclear Heat Source

Possible parameters:
Reactor 600+ MWt
SGs – 2 x 303 MWt
Circulators – 2 x 3.5 MWt



- **Simplest HTR heat source**
- **Delivers steam at 550°C for variety of applications**
  - **Electricity**
  - **Process heat**
  - **Cogeneration**

Commercial Process Heat Cogeneration Facility



Conclusions

- AREVA has evaluated several possible configurations
- Highest priority must be on near-term deployment to impact energy market as rapidly as possible
  - Low technical risk
  - Minimize required development
  - Flexibility for near-term applications
- Conventional ("direct") steam cycle best meets this objective
  - Serves a variety of markets
  - Most rapidly deployable
  - Most competitive economically
- Conventional steam cycle is low risk first step toward long-term VHTR deployment

Next Generation Nuclear Plant

Reference Configuration Meeting

Senior Advisory Group
Hyatt Regency Crystal City
October 28, 2008

Welcome / Introduction

- Welcome
- Introduction & Meeting Goal

Agenda

	Agenda Item	**Duration (mins)**	**Speaker**
	Welcome, Agree on Meeting Objectives	15	Steve M
	Discuss SAG Meeting, Address Comments	30	Steve M
	HTGR Fundamental Requirements, Discuss Handout	60	Richard G
	Break	15	
	Configuration Presentations by Suppliers in context of requirement / evaluation factor discussion		
	A	30	AREVA
	B	30	GA
	C	30	WEC
	Summarize Configurations, assure they meet fundamental rqmts	60	Richard G
Optional	Discuss evaluation factors (risk and economic)	60	Phil H, SAG
	Add, subtract, agree on potentially discriminating factors		
	Evaluate configurations	120	Phil H, SAG
	Differentiate using discriminating criteria		
	Summarize conclusions, decisions, actions	30	Richard G.
	Adjourn		

Overview of First Senior Advisory Group Meeting

- Summary of first SAG meeting

- Priorities
  - Design Objectives – Conceptual Design
  - Address High Project Risk items
  - Address Licensing needs/issues
  - R&D

- Commercialization Objectives
  - Single configuration applicable to broadest range of co-generation applications
  - Nuclear Heat Supply System that can be licensed independent of application
  - Application variables/combinations: 1) co-generation of electricity & steam, 2) production of hot gas, 3) hydrogen production, 4) generation of electricity, 5) open cycle heat generation, 6) de-salination
  - Address issues such as radiological isolation of heat source, quality of return feed, impacts on Safety Case, cost, RAMI

- Change in Reactor Outlet Temperature
  - 750°C - 800°C

Opening Comments

- Impact of setting a Reference Configuration on future work
- Goal of workable, vice perfect, solution
- Discussion of Meeting Objectives

Discussion of Evaluation Factors

- Evaluation factors include fundamental requirements (go/no go) and risk & economic discriminating factors
- HTGR fundamental requirements that impact configuration:
  - Nuclear Heat Supply System that can be design certified for a broad range of applications and sites
  - Applicable to broad range of co-generation applications supplying, singly or in combination, electricity, steam, and hot gas
  - Reactor gas outlet temperature in the range of 750°C to 800°C
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Discussion of Fundamental Requirements, cont.

- Can be collocated with the process; PAG limits at site boundary of ~ 400 meters
- Capable of following process load variations
- Costs for anticipated NOAK, based on design certification, construction, and operation of FOAK design, supports viable economic business model (competitive with natural gas price at $8/MMBtu)
- Normal maintenance exposure target limit of no more than 50 person-Rem/year per module in a refueling year
- Target availability factor >= 90%
- Target plant design lifetime of 60 years (calendar)

Reference Conceptual Design Configurations

- AREVA
- General Atomics
- Westinghouse
- Summary

Evaluation Discriminators - Risk

- Risk evaluation discriminators
  - Technical risk / technology development effort
  - Manufacturability / constructability
  - Transportability
  - Flexibility, operability, sensitivity to internal and external events

Evaluation Discriminators - Economic

- Economic evaluation discriminators
  - Performance (e.g., in the context of satisfying the business case requirement)
  - Reliability, Availability, Maintainability
  - In-Service Inspection
  - Investment protection
  - Modularity, (e.g., construction, maintenance)

Evaluation Configurations

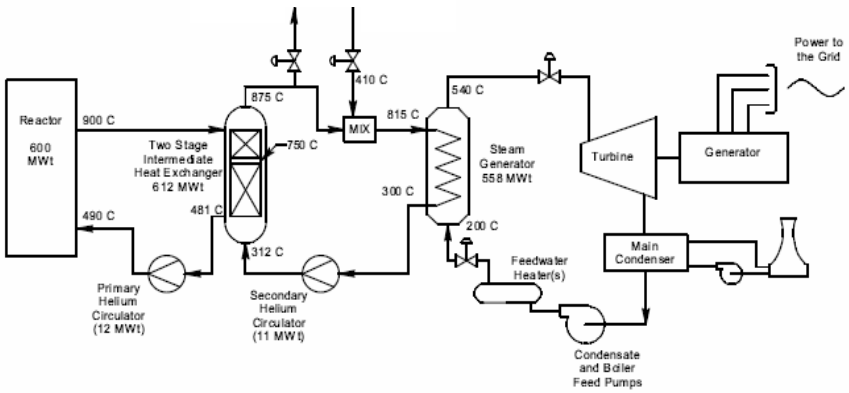
- Assure fundamental requirements are met
- Differentiate using discriminating criteria

Meeting Review /Adjournment

- Review of meeting
- Action Item Assignment / Review
- Meeting Minutes
- Adjourn

Back-up Slides

Possible Configurations for Supply of Steam, Electricity and High Temperature Process Heat

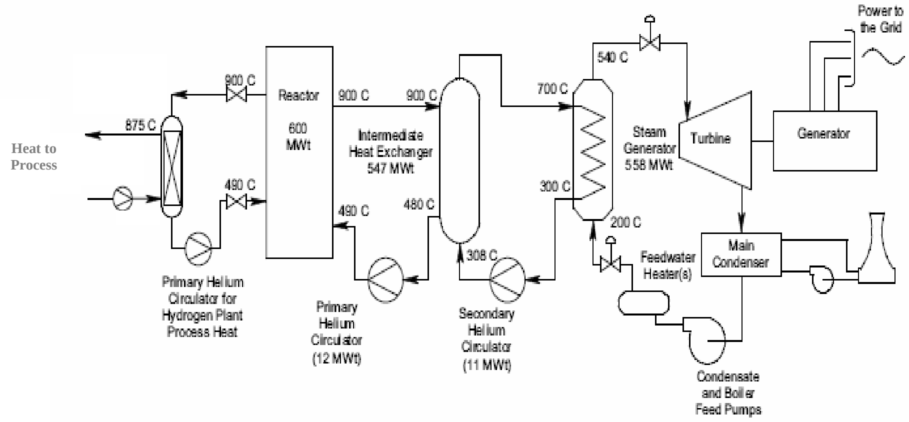


Serial HTS Configuration (Configuration I)

The high gas temperatures are not required for steam and electricity production

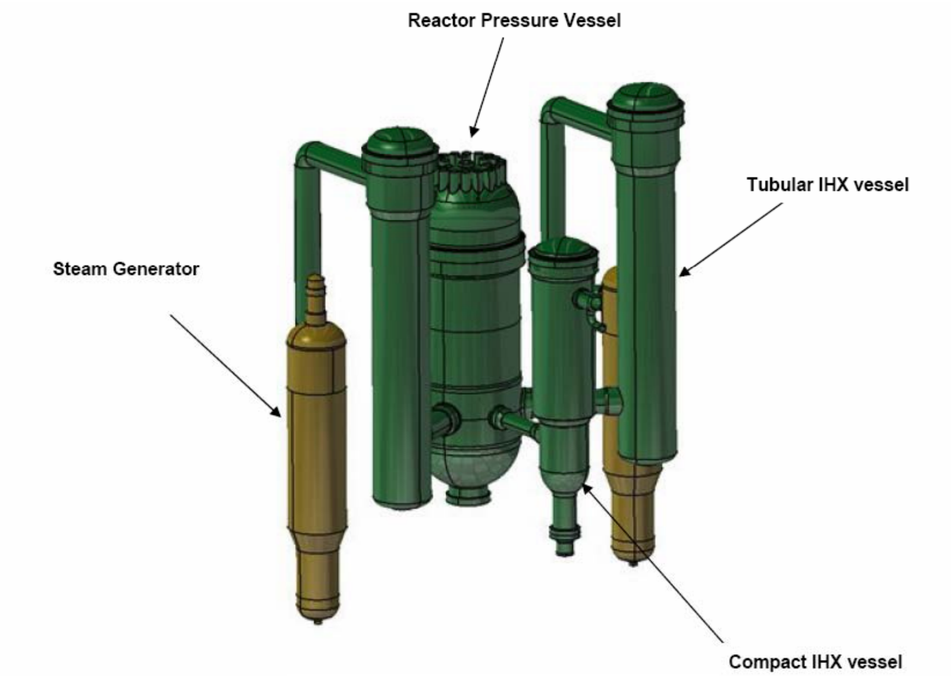
They may not be required for process applications

Lower gas temperatures reduce cost and schedule risk for implementation of project

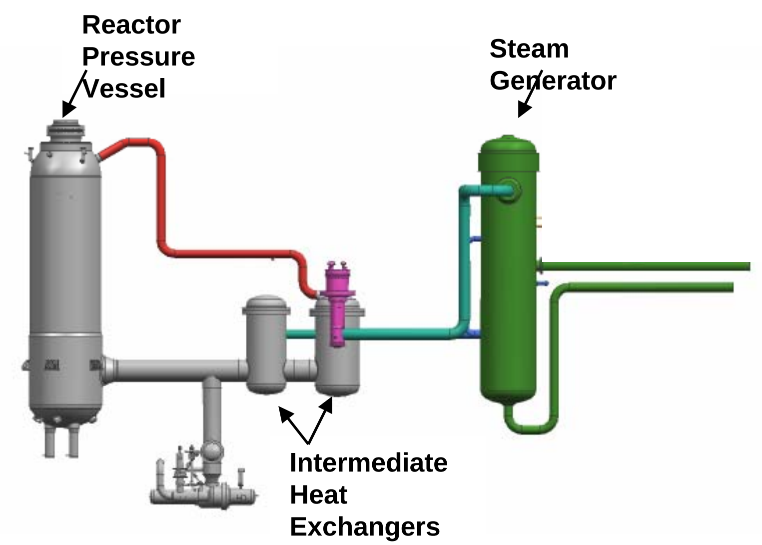


Parallel Primary Loop Configuration (Configuration II)

Possible Configurations for Supply of Steam, Electricity and High Temperature Process Heat



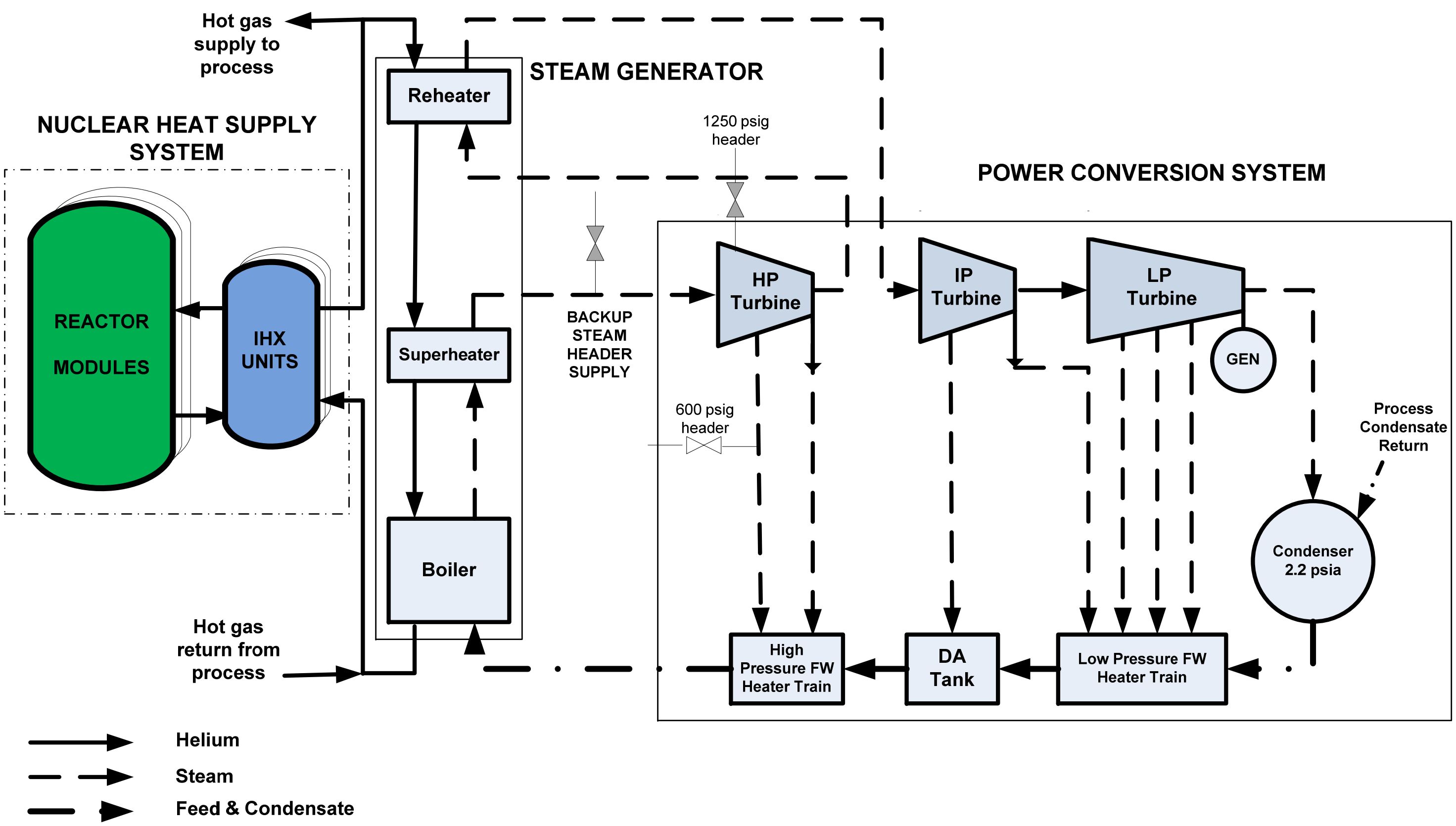
Parallel IHX Arrangement



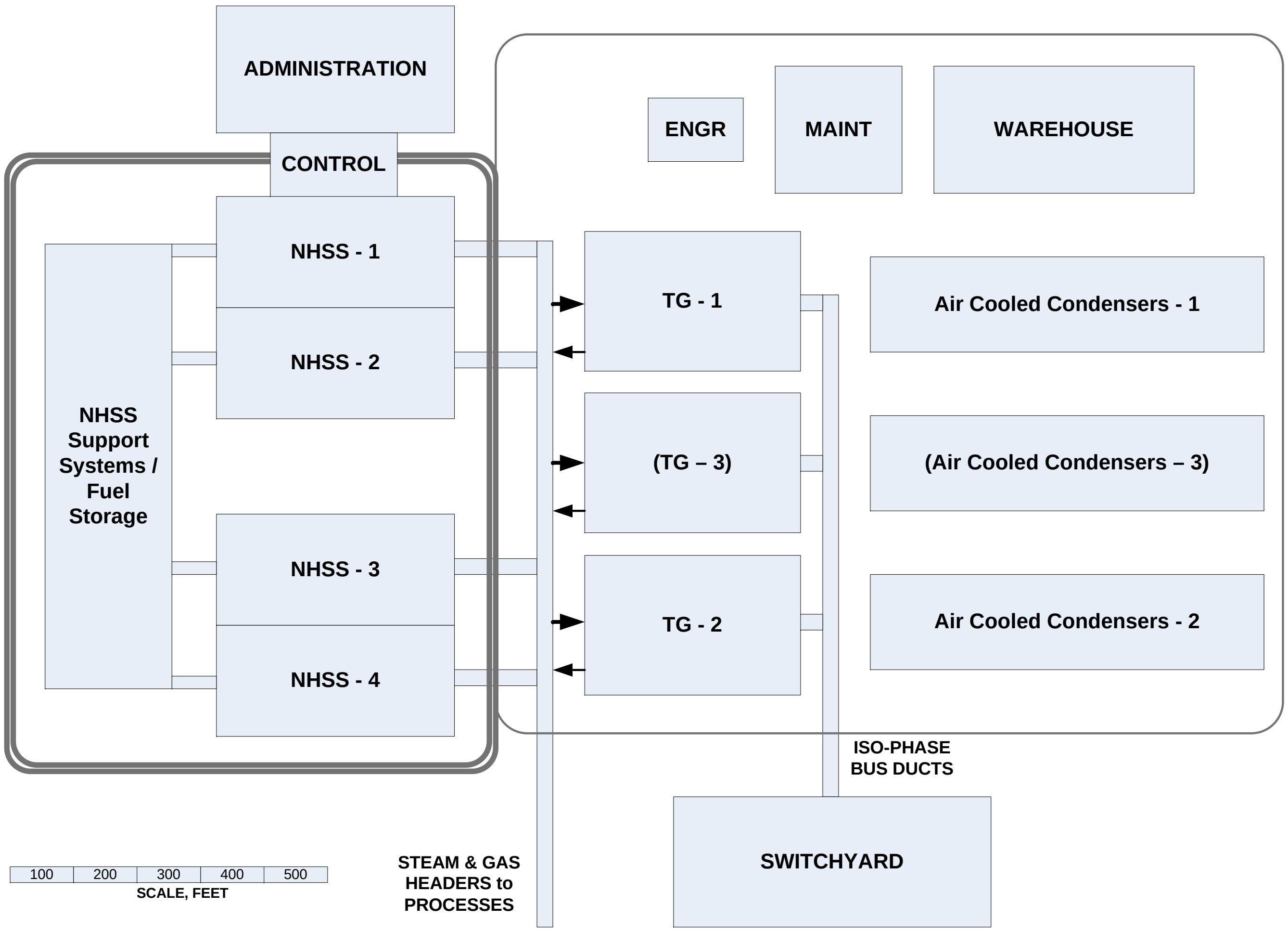
Series IHX Arrangement

Use of HTGR to Supply Steam, Electricity & Hot Gas

Potential Configuration



A Conceptual Plant Layout
4 NHSS / 3 STG



Pre-Conceptual Design Report Design Requirements

- Documented in INL/EXT-07-12967, Rev. 1, dated November, 2007
- NGNP Design Requirements:
  - Nuclear Island
    - Both pebble-bed and prismatic reactor designs should be considered
    - The nuclear island design should not preclude achieving a gas outlet temperature of 950°C
    - The NGNP nuclear island will not include a direct-cycle PCS

Pre-Conceptual Design Report Design Requirements, cont.

- Intermediate HTS
  - Heat transfer system should incorporate multiple primary and secondary heat transport loops
  - System should be configured to facilitate change out of heat exchange, circulating, and valve components
  - Secondary side of plant will supply heat to the power conversion and hydrogen production system and other applications as they are identified over the life of the plant

Pre-Conceptual Design Report Design Requirements, cont.

- Nuclear Heat Supply System (NHSS)
  - NHSS should be defined to include:
    - The nuclear island and all of its support, control, monitoring, maintenance, refueling, spent fuel storage, etc. SSCs
    - The Intermediate HTS(s) including, at the least, the IHXs, primary circulation systems, and the support, control, monitoring, maintenance, etc. SSCs. Depending on the design, it may also include the secondary circulation system up to and including isolation valves.

Pre-Conceptual Design Report Design Requirements, cont.

- Power Conversion System (PCS)
  - The PCS should incorporate steam generation
  - The configuration should not preclude use of Brayton-cycle gas turbine PCSs in a combined-cycle configuration
- Licensing and Permitting
- Design Features to Support Short-Term and Long-Term Operating Objectives
  - The NGNP should be designed to monitor key operating parameters in the NHSS, PCS, and hydrogen production plant required for proving the principles of the designs
  - The plant should also be designed to permit change out of principal components and to vary operating conditions to perform special testing to collect data/experience to support validation of design assumptions, extension of operating conditions (e.g., to higher gas temperatures), and upgrade of components (e.g., design, capacity, efficiency, maximum temperature and lifetime of the IHXs, and higher heat capacity heat transport fluids, such as liquid metals and molten salts) over the lifetime of the plant

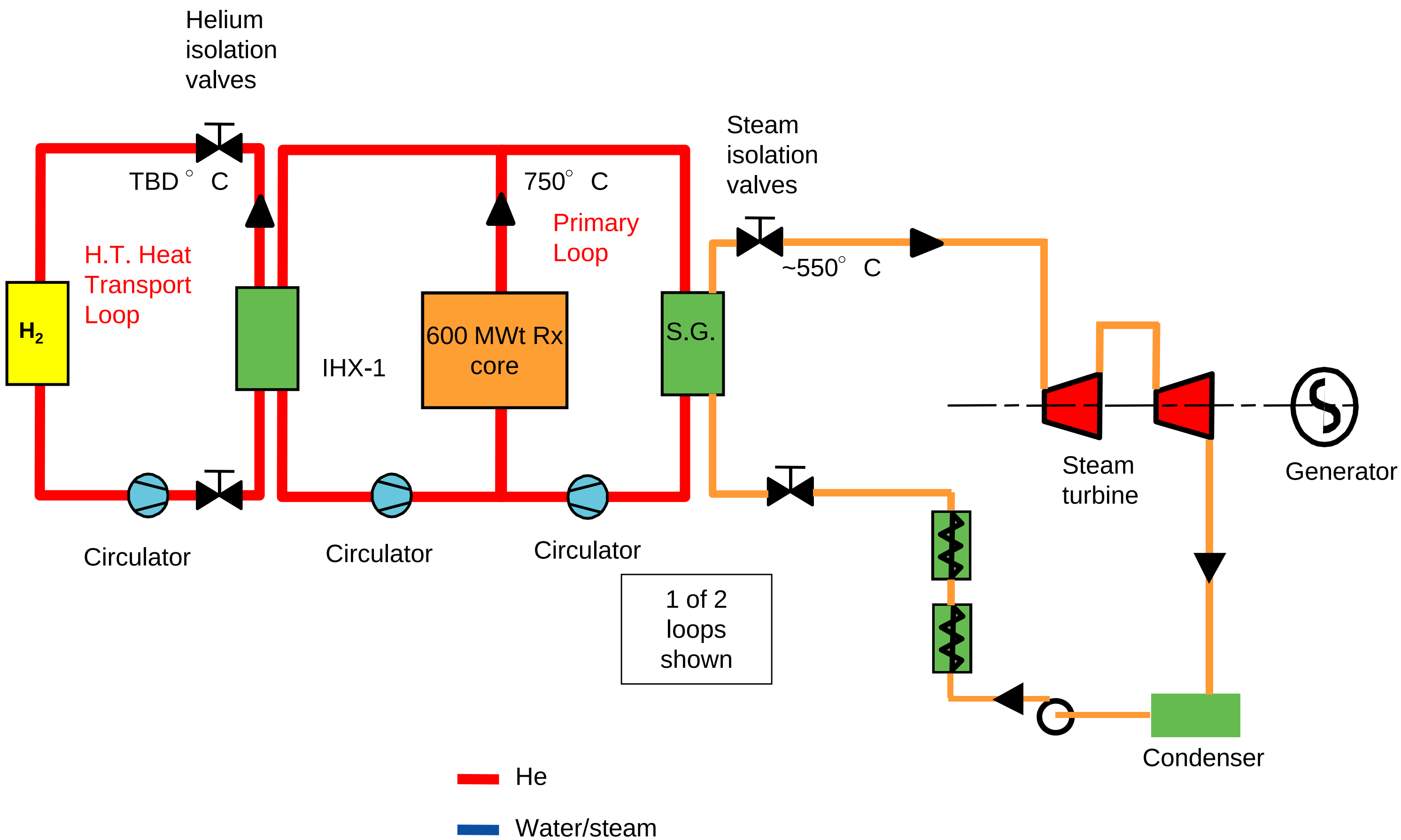
Pre-Conceptual Design Report Design Requirements, cont.

- Initial Operating Conditions
  - The initial operating conditions and configuration of the NGNP (i.e., at initial operation in 2018) will be based on these requirements and consideration of the impact of the technical development risks on the schedule for operation
  - The selection of initial operating conditions and the plant configuration for the NGNP must be balanced against the schedule and cost risks associated with design, licensing, R&D, and construction. This balance must also consider the impact of technology selections on the viability of translating the NGNP experience to the private sector.

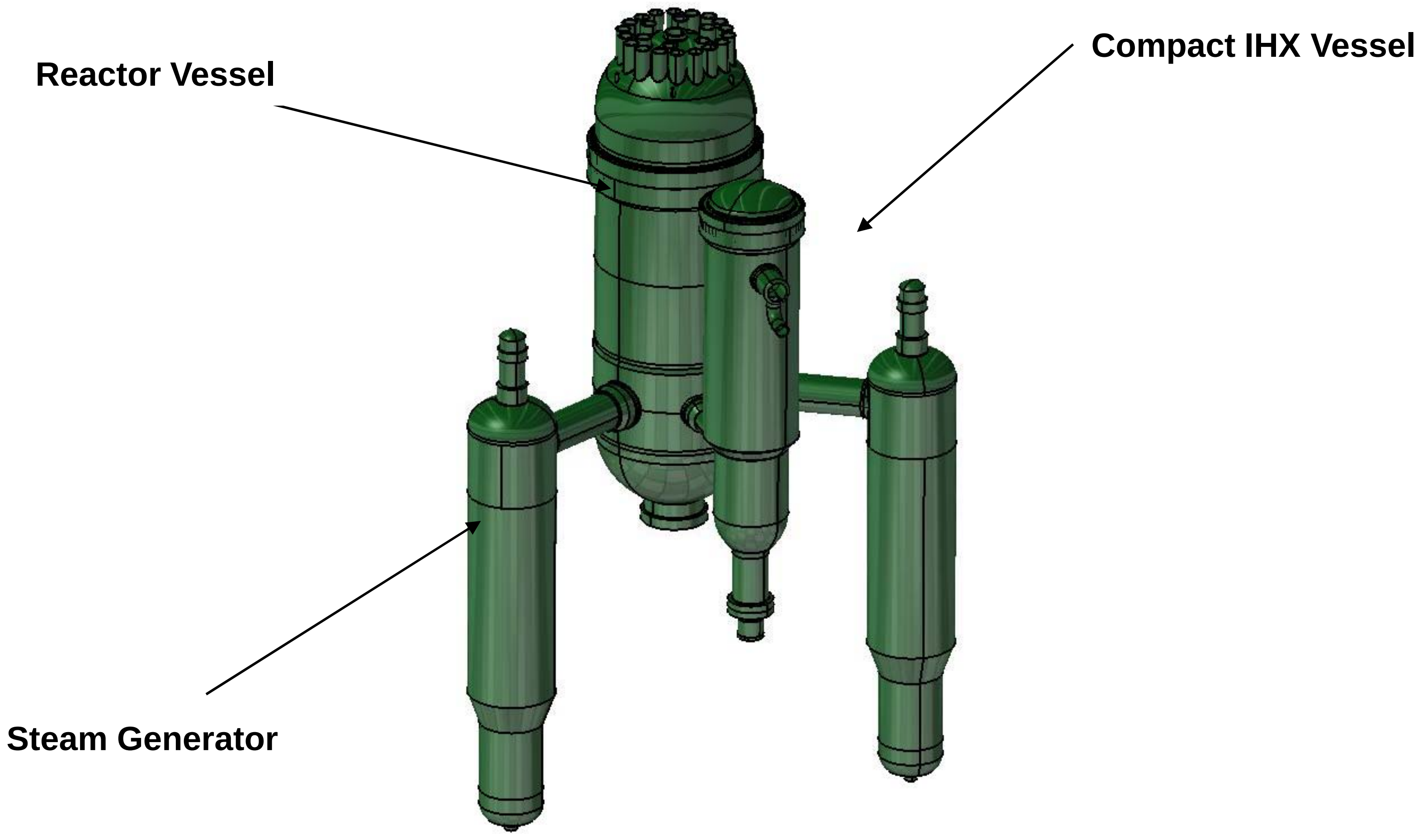
Identified NGNP Requirements Documents

- Energy Policy Act of 2005
- *Next Generation Nuclear Plant – High Level Functions and Requirements*, INEEL/EXT-03-01163, Idaho National Laboratory, September 2003
- Independent Technology Review Group, *Design Features and Technology Uncertainties for the Next Generation Nuclear Plant,* INEEL/EXT-04-01816, June 30, 2004
- *Next Generation Nuclear Plant Pre-Conceptual Design Report,* INL/EXT-07-12967, Rev. 1, November 2007
- *Next Generation Nuclear Plant System Requirements Manual,* INL/EXT-07-12999, Rev. 1, June 2008
- (*Summary of Bounding Conditions for Development of the NGNP Project,* INL/EXT-08-14370, June 2008)
- (*Summary of Bounding Requirements for the NGNP Demonstration Plant F&ORs,* INL/EXT-08-14395, June 2008 [contains INL/EXT-07-12999 as Appendix A])

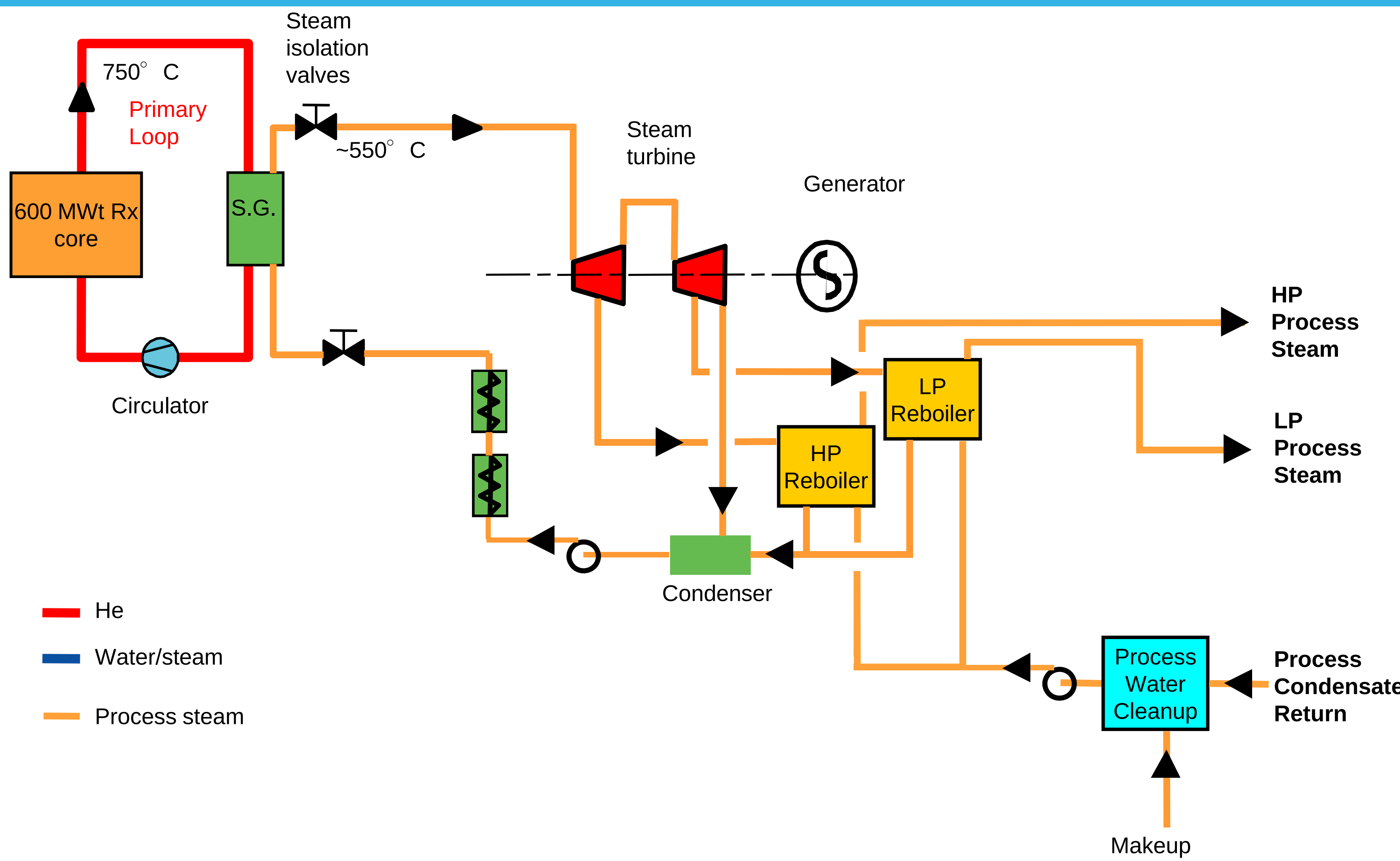
Recommended NGNP Primary and Secondary Configuration, AREVA



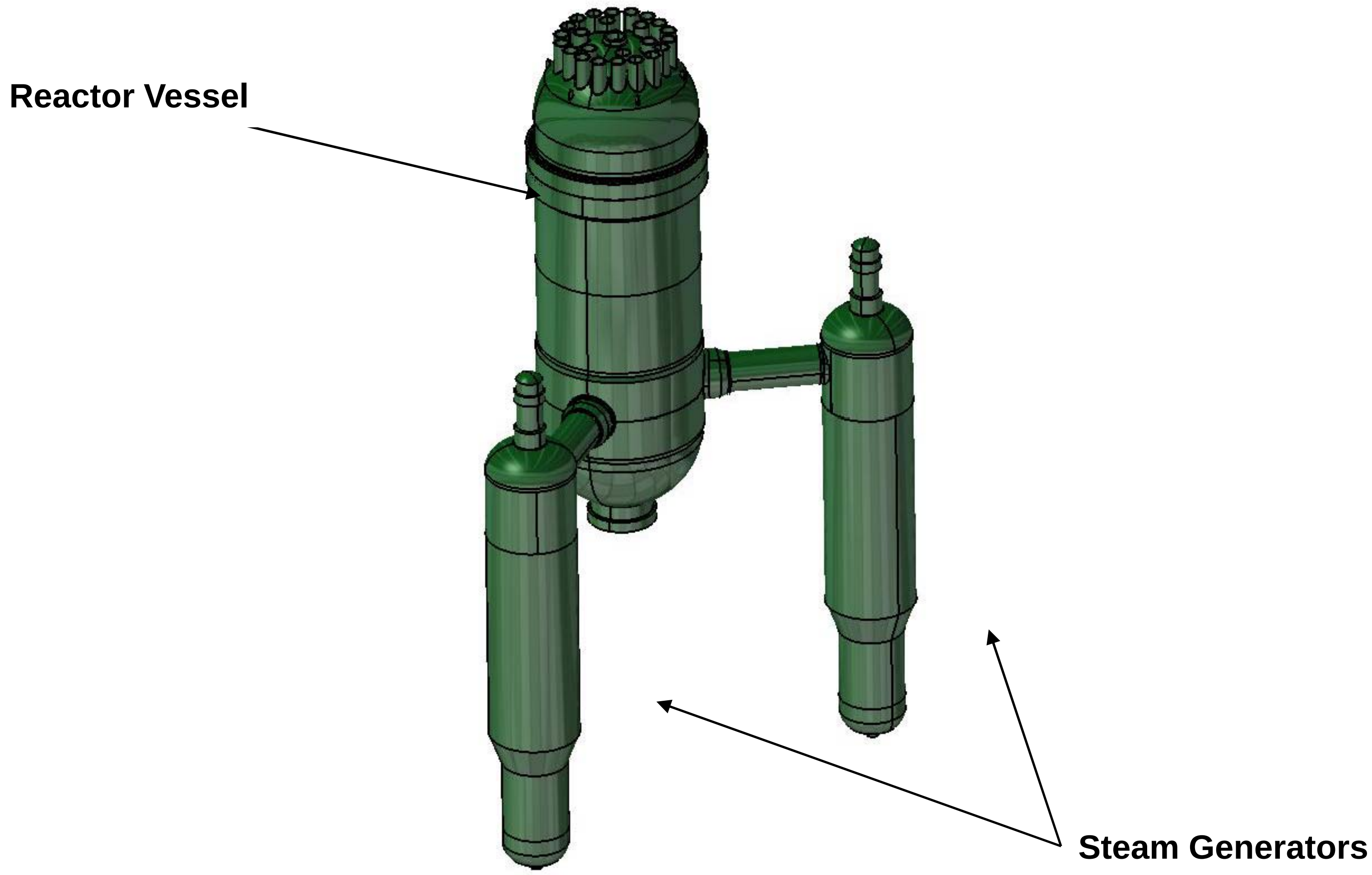
Conventional Steam Cycle NGNP Arrangement, AREVA



Commercial Process Heat Cogeneration Facility, AREVA



Commercial HTR Arrangement for Conventional Steam Nuclear Heat Source, AREVA



NEXT GENERATION NUCLEAR PLANT PROJECT INFORMATION INPUT SHEET

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