Enclosure 2

Presentation Materials about Construction Permit Application for the KP-FHR

(Non-Proprietary)

(Note that the enclosed information is preliminary and pre-decisional and is subject to change during detailed planning and project execution. It is provided for planning and familiarization purposes in support of pre-application discussions with the NRC Staff.)

Kairos Power

Non-Power Reactor (Hermes) Construction Permit Application

Pre-Application Meeting with NRC, January 27-28, 2020

Kairos Power’s mission is to enable the world’s transition to clean energy, with the ultimate goal of dramatically improving people’s quality of life while protecting the environment.

Agenda

Day 1 (January 27)

Public Session

- 10:00EST / 7:00PST - Introduction
- 10:15EST / 7:15PST -Licensing Strategy
- 10:45EST / 7:45PST - Design Overview

Closed Session

- 11:30EST / 8:20PST - Safety Analysis
- 12:00EST / 9:00PST - Lunch Break
- 12:45EST / 9:45PST - Safety Analysis
- 13:15EST / 10:15PST - Reactor System
- 14:30EST / 11:30PST - Heat Transport Systems
- 15:00EST / 12:00PST - Decay Heat Removal System
- 15:30EST / 12:30PST - Overview of Remaining PSAR Chapters

Day 2 (January 28)

Public Session

- 10:00EST / 7:00PST – Site Selection
- 10:20EST / 7:30PST – Environmental Report Requirements and Approach

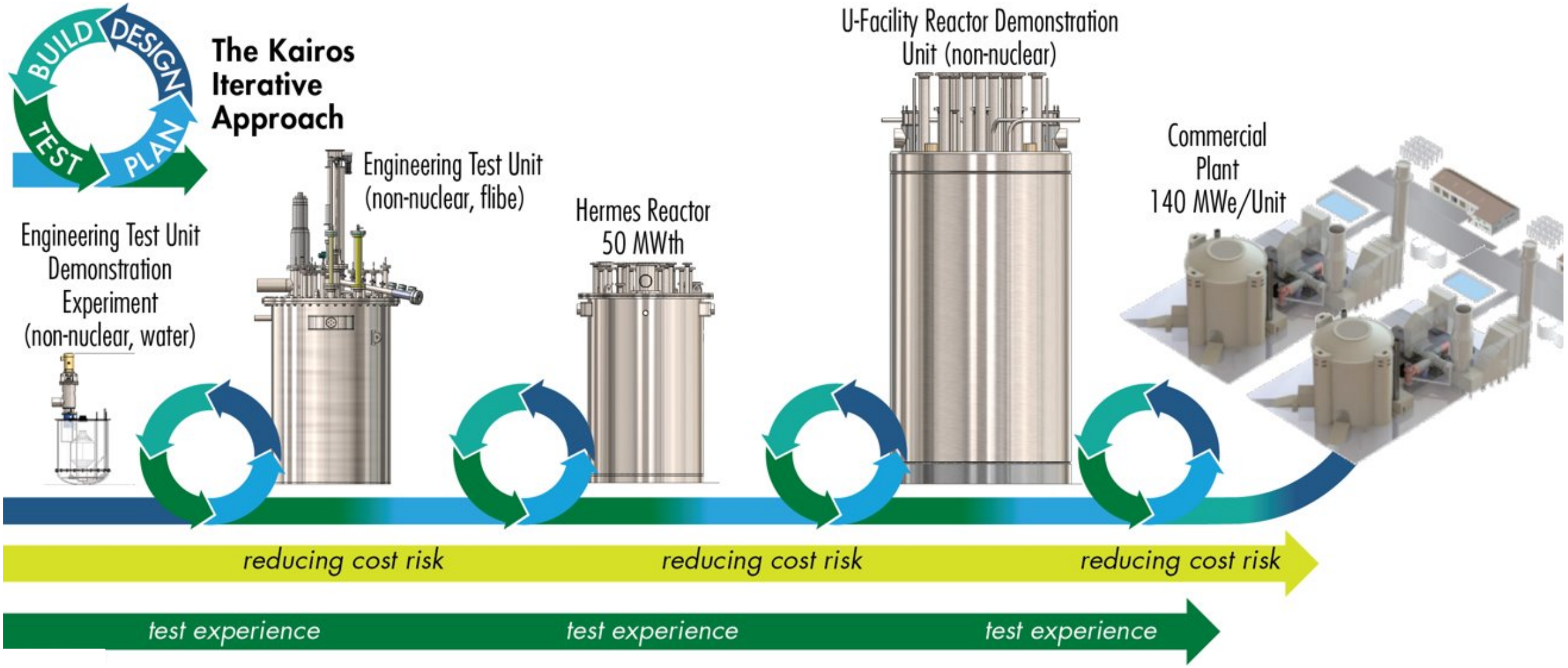
Closed Session

- 10:45EST / 7:45PST – Site Data Sources and Collection
- 11:30EST / 9:30PST – NRC Staff Feedback

Licensing and Development Strategy

DARRELL GARDNER – SR. DIRECTOR, LICENSING

Development Strategy - Iterative Development Approach



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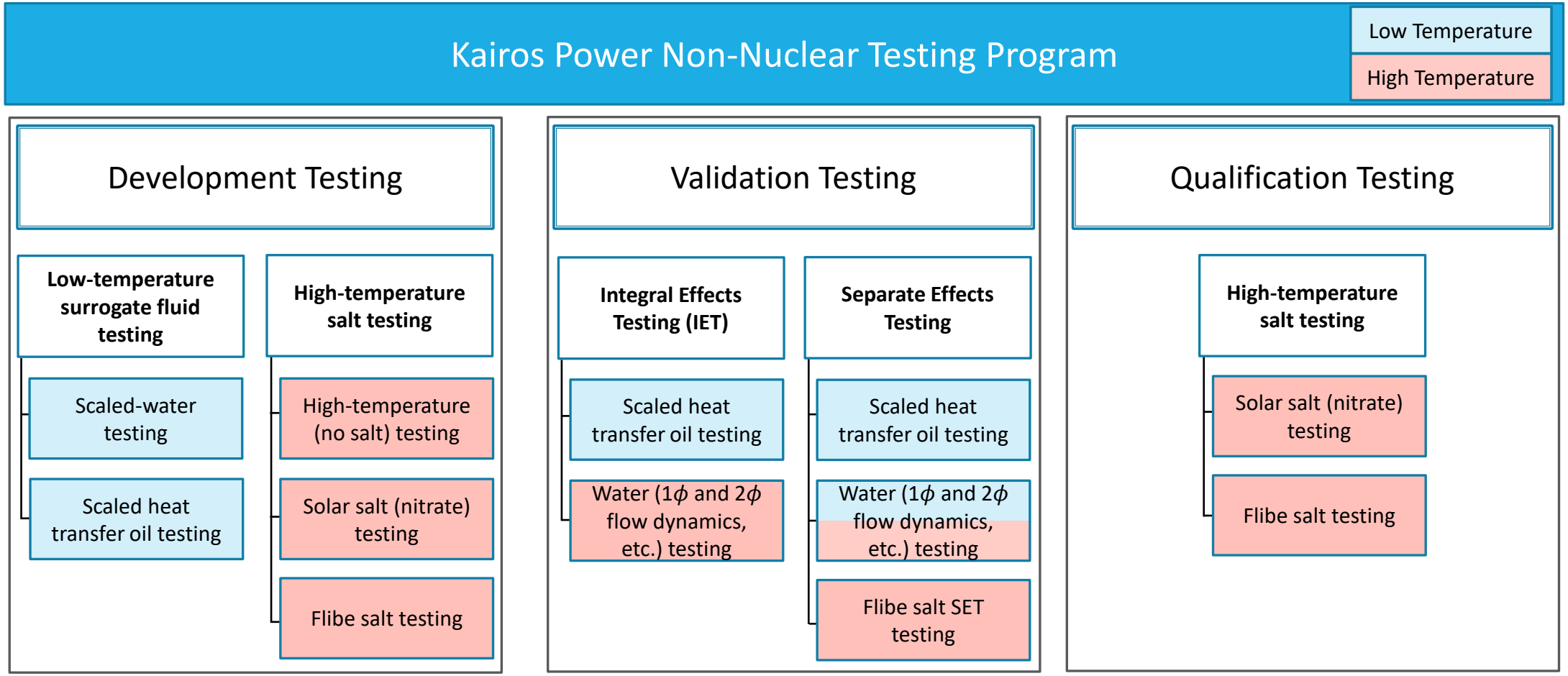
Development Strategy - Non-Nuclear Testing Program



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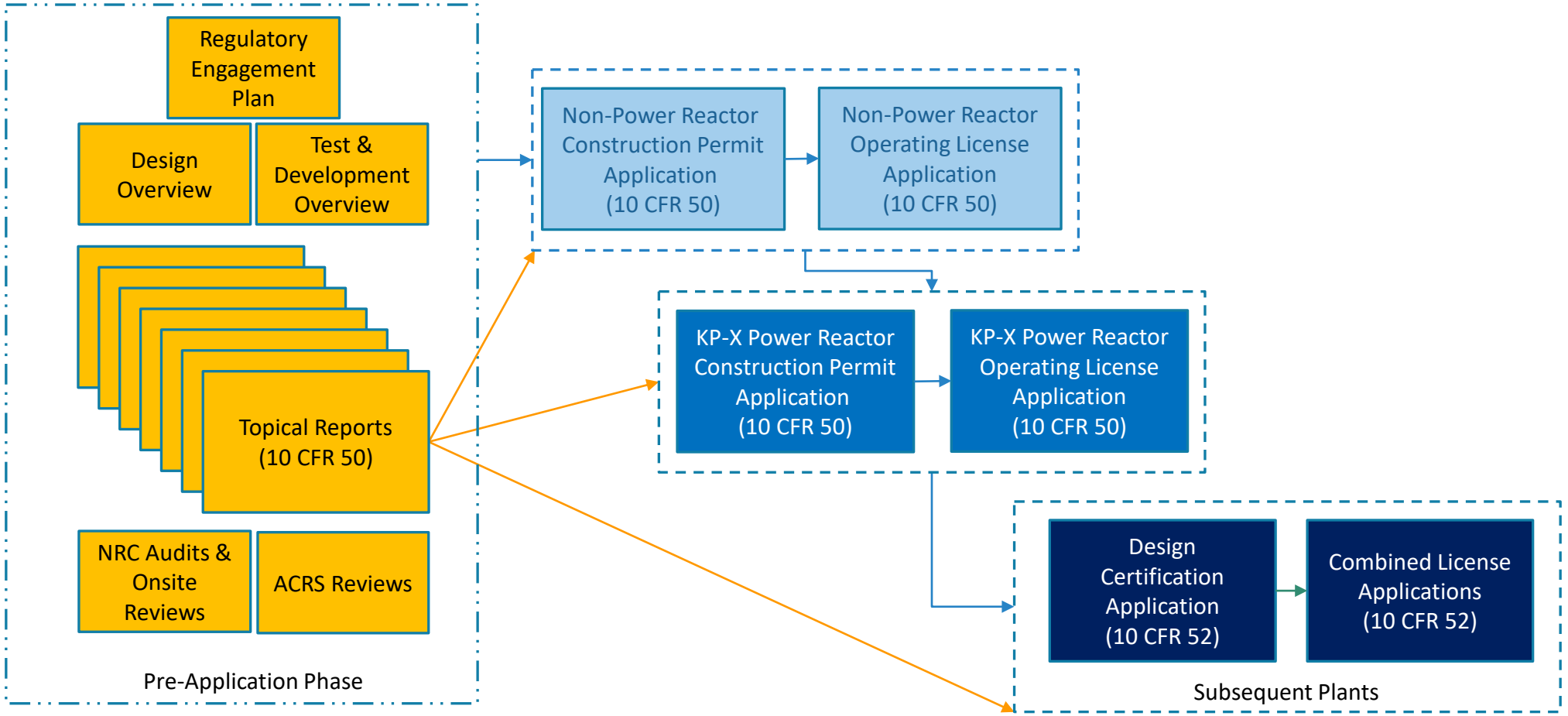
Development Strategy – Licensing Approach



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Non-Power Reactor Construction Permit Application

- Kairos Power intends to submit a construction permit application for a non-power reactor pursuant to 10 CFR 50.21(c):
  - *(c) A production or utilization facility, which is useful in the conduct of research and development activities of the types specified in section 31 of the Act, and which is not a facility of the type specified in paragraph (b) of this section or in § 50.22*
- The regulatory requirements related to the contents of a Non-Power Reactor Construction Permit Application are found in:
  - 10 CFR 50.30 (f) - **submittal of an Environmental Report (ER)** (consistent with Subpart A of Part 51)
  - 10 CFR 50.33 - general information requirements
  - 10 CFR 50.34(a) - **submittal of a Preliminary Safety Analysis Report (PSAR)**
  - 10 CFR 50.34 (g) - address Combustible Gas Control
- The basis for NRC issuing a construction permit is included in 10 CFR 50.35(a):
  - ...the Commission may issue a construction permit if the Commission finds that:
    - (1) the applicant has **described** the proposed design of the facility, including, but not limited to, the **principal architectural and engineering criteria** for the design, and has **identified the major features or components incorporated therein for the protection of the health and safety of the public**;
    - (2) such **further technical or design information** as may be required to complete the safety analysis, and which can reasonably be left for later consideration, **will be supplied in the final safety analysis report**;
    - (3) safety features or components, if any, which require **research and development have been described** by the applicant and the applicant has identified, and there will be conducted, a research and development program reasonably designed **to resolve any safety questions** associated with such features or components; and that
    - (4) on the basis of the foregoing, there is **reasonable assurance** that, (i) such **safety questions will be satisfactorily resolved** at or before the latest date stated in the application for completion of construction of the proposed facility, and (ii) taking into consideration the site criteria contained in part 100 of this chapter, the proposed facility can be constructed and operated at the proposed location without undue risk to the health and safety of the public.

PSAR Requirements for Non-Power Reactor – 10 CFR 50.34(a)

- (i) **A description and safety assessment of the site** on which the facility is to be located, with appropriate attention to features affecting facility design. Special attention should be directed to the site evaluation factors identified in part 100 of this chapter. The assessment must contain an analysis and evaluation of the major structures, systems and components of the facility **which bear significantly on the acceptability of the site** under the site evaluation factors identified in part 100 of this chapter, assuming that the facility will be operated at the ultimate power level which is contemplated by the applicant. […]
- (2) A **summary description and discussion of the facility**, with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations.
- (3) The **preliminary design of the facility** including:
  - (i) The **principal design criteria for the facility**.
  - (ii) The **design bases and the relation of the design bases to the principal design criteria**;
  - (iii) Information relative to **materials of construction, general arrangement, and approximate dimensions, sufficient to provide reasonable assurance that the final design will conform to the design bases with adequate margin for safety**.
- (4) A **preliminary analysis** and evaluation of the design and performance of structures, systems, and components of the facility with the objective of **assessing the risk to public health and safety** resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents. […]
- (5) An identification and justification for the selection of those variables, conditions, or other items which are determined as the result of preliminary safety analysis and evaluation to be **probable subjects of technical specifications for the facility,** with special attention given to those items which may significantly influence the final design: […]
- (6) A **preliminary plan for the applicant's organization, training of personnel, and conduct of operations**.
- (7) A **description of the quality assurance program** to be applied to the design, fabrication, construction, and testing of the structures, systems, and components of the facility.
- (8) An **identification of those structures, systems, or components of the facility, if any, which require research and development to confirm the adequacy of their design**; and identification and **description of the research and development program which will be conducted** to resolve any safety questions associated with such structures, systems or components; and a schedule of the research and development program showing that such safety questions will be resolved at or before the latest date stated in the application for completion of construction of the facility.
- (9) The **technical qualifications of the applicant** to engage in the proposed activities in accordance with the regulations in this chapter.
- (10) A discussion of the applicant's **preliminary plans for coping with emergencies**. Appendix E sets forth items which shall be included in these plans.

PSAR Guidance – NUREG 1537 Standard Review Plan

- NRC guidance for developing a PSAR for non-power reactors is provided in NUREG-1537 (Part 1 and 2) and associated Interim Staff Guidance for medical isotope facilities
- Kairos Power intends to generally follow the basic chapter format and content outlined in NUREG-1537 with some exceptions.
  - NUREG 1537 does not provide explicit differentiation in the expected content for a preliminary and final safety analysis reports
    - The available recent precedent PSAR is for medical isotope facilites (Shine and Northwest Medical Technologies) neither of which is a reactor.
    - The CPA for the non-power reactor will focus on those topics specifically required by 10 CFR 50.34(a) for a PSAR.
      - Kairos Power notes that the Shine and Northwest Medical PSARs included content not required at the PSAR stage (e.g., Part 20)
    - NUREG-1537 does not provide a consistent approach to organization of material.
      - Kairos Power intends to generally address the content expectations while presenting the material in a consistent manner from system to system
    - Kairos Power does not expect to request review and approval for any portions of the safety system design at the time of CPA.
      - Such a request is "optional" in the regulations and is not being pursued at this time

PSAR Organization for the Non-Power Reactor

- PSAR Organization follows NUREG-1537 at "X" and "X.Y" with exceptions as noted below:
  - Chapter 1 The Facility (no change)
  - Chapter 2 Site Characteristics (no change)
  - Chapter 3 Design of Structures, Systems, and Components (no change)
  - Chapter 4 Reactor Description
    - Minor title changes to subsections. Additional subsections added to align with the reactor architecture
  - Chapter 5 Heat Transport Systems
    - Title changed to match design architecture. Reactor coolant auxiliary systems moved to Chapter 9
  - Chapter 6 Engineered Safety Features
    - KP-FHR uses a functional containment and does not include ECCS. ECCS section replaced with Decay Heat Removal System
  - Chapter 7 Instrumentation and Control Systems
    - 1st two sections reorganized into subsequent system-based sections. Rad monitoring moved to Chapter 11
  - Chapter 8 Electrical Power Systems
    - Added initial summary section and changed "emergency power" to "backup power"

PSAR Organization for Non-Power Reactor (continued)

- Chapter 9 Auxiliary Systems
  - Added reactor coolant auxiliary systems from Chapter 5 resulting in renumbering
- Chapter 10 Experimental Facilities and Utilization (no changes – not applicable)
- Chapter 11 Radiation Protection Program and Waste Management
  - Added radiation monitoring from Chapter 7
- Chapter 12 Conduct of Operations
  - Environmental Report moved to separate stand-alone report
- Chapter 13 Accident Analysis
  - Summary and conclusions section incorporated into prior section consequence discussions.
- Chapter 14 Technical Specifications (no specific structure required for PSAR)
- Chapter 15 Financial Qualifications
  - Sections on foreign influence and insurance added consistent with Interim Staff Guidance Document
- Chapter 16 Other License Considerations (no changes – not applicable)
- Chapter 17 Decommissioning and Possesion-Only License Amendments (no changes)
- Chapter 18 Highly Enriched to Low-Enriched Uranium Conversions (no changes – not applicable)

PSAR Organization for Non-Power Reactor (continued)

- As noted, NUREG-1537 does not always specify nor provide for a consistent organization of material across Chapters at the "X.Y.Z" subsection levels. The text narrative in NUREG-1537 does tend to discuss similar "themes."
- Kairos Power intends to follow a generally consistent organization for system-based sections with the intent to address the common "themes" identified in NUREG-1537:
  - **Description** – provides a description of the overall system design and concept of operation. Materials of construction, overall process flow diagram, and a table of key parameters is provided for those portions of the system affecting safety.
  - **Design Bases** - identifies the specific Principal Design Criteria and regulations applicable to the design
  - **System Evaluation** - provides a discussion of how the specific system design satisfies the applicable Principal Design Criteria and regulations. The evaluation addresses hazards presented by the system and relevant design codes and standards for those portions of the system affecting safety.
  - **Testing and Inspection** – provides a discussion of the inspection plans and the testing to confirm the operability of the system. Generally deferred to FSAR.
- The level of detail will vary based on the importance to the safety analysis or system relationship to implementation of principal design criteria or regulations.
- Programmatic-based sections of the PSAR will generally follow NUREG-1537 for those programs are "technology neutral" and relevant to the KP-FHR design.

Topical Report Applicability

- The following Topical Reports addressed both power and non-power reactors. No departures are anticipated at this time
  - Regulatory Analysis Topical Report
  - Fuel Performance Topical Report
  - Fuel Qualification Topical Report
  - Graphite Materials Topical Report
- The following Topical Reports did not specifically address a non-power reactor but are considered sufficient. No departures are anticipated:
  - Scaling Methodology Topical Report
  - Reactor Coolant Topical Report

Topical Report Applicability (continued)

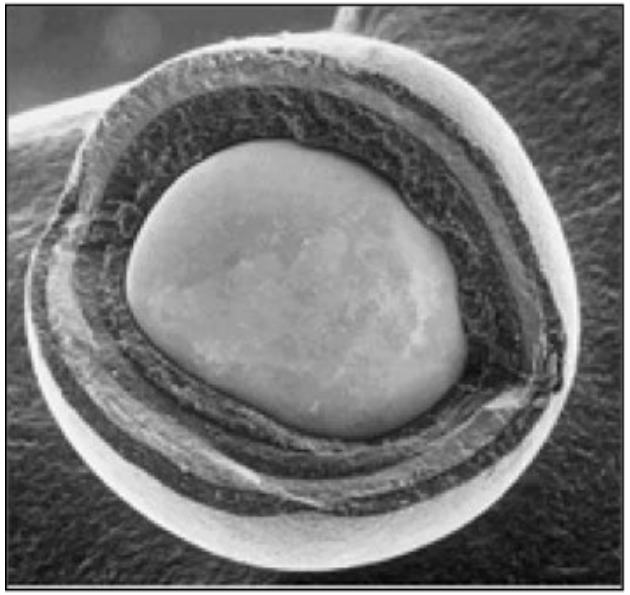
- Other reports are dispositioned as follows:
  - Principal Design Criteria Topical Report
    - Some departures are anticipated for implementation on the non-power reactor. Example: safety-related SSCs vs safety-significant SSCs.
  - Risk Informed Performance Based Licensing Basis Methodology Topical Report
    - The non-power reactor will evaluate a maximum hypothetical accident . A formal LMP implementation is not anticipated.
  - High Temperature Materials (Metallics) Topical Report
    - This report is under NRC review. A revision is planned during the review to include an appendix specific to the non-power reactor.
  - Quality Assurance Topical Report
    - A non-power reactor specific technical report will be submitted with the PSAR to implement an ANSI 15.8 QA program, consistent with NUREG-1537.
  - Mechanistic Source Term Methodology Topical Report
    - This report is under NRC review. Some departures are anticipated for implementation on the non-power reactor.
  - Core Design and Analysis Topical Report
    - This report has not been prepared and is anticipated to initially focus on the non-power reactor.

Design Overview

ODED DORON – DIRECTOR, ENGINEERING DESIGN

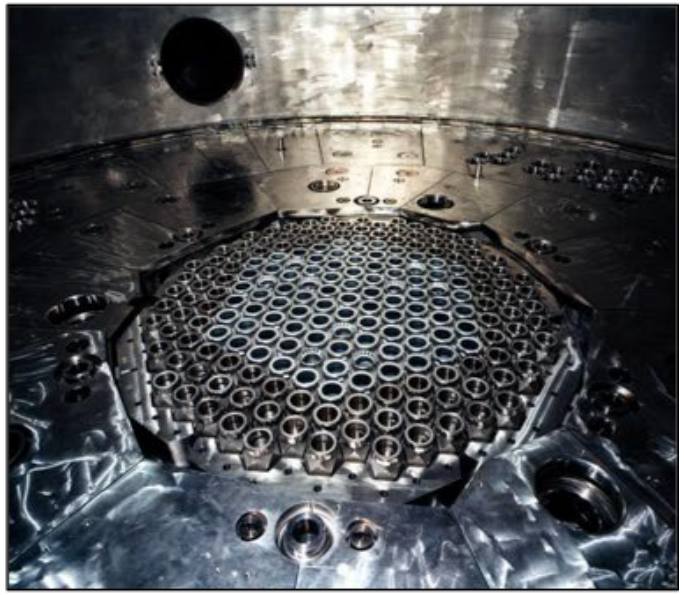
Fluoride Salt-Cooled High-Temperature Reactor (FHR) Technology Basis

Coated Particle Fuel
TRISO



Liquid Fluoride Salt Coolant
Flibe ($2LiF\text{-}BeF_2$)

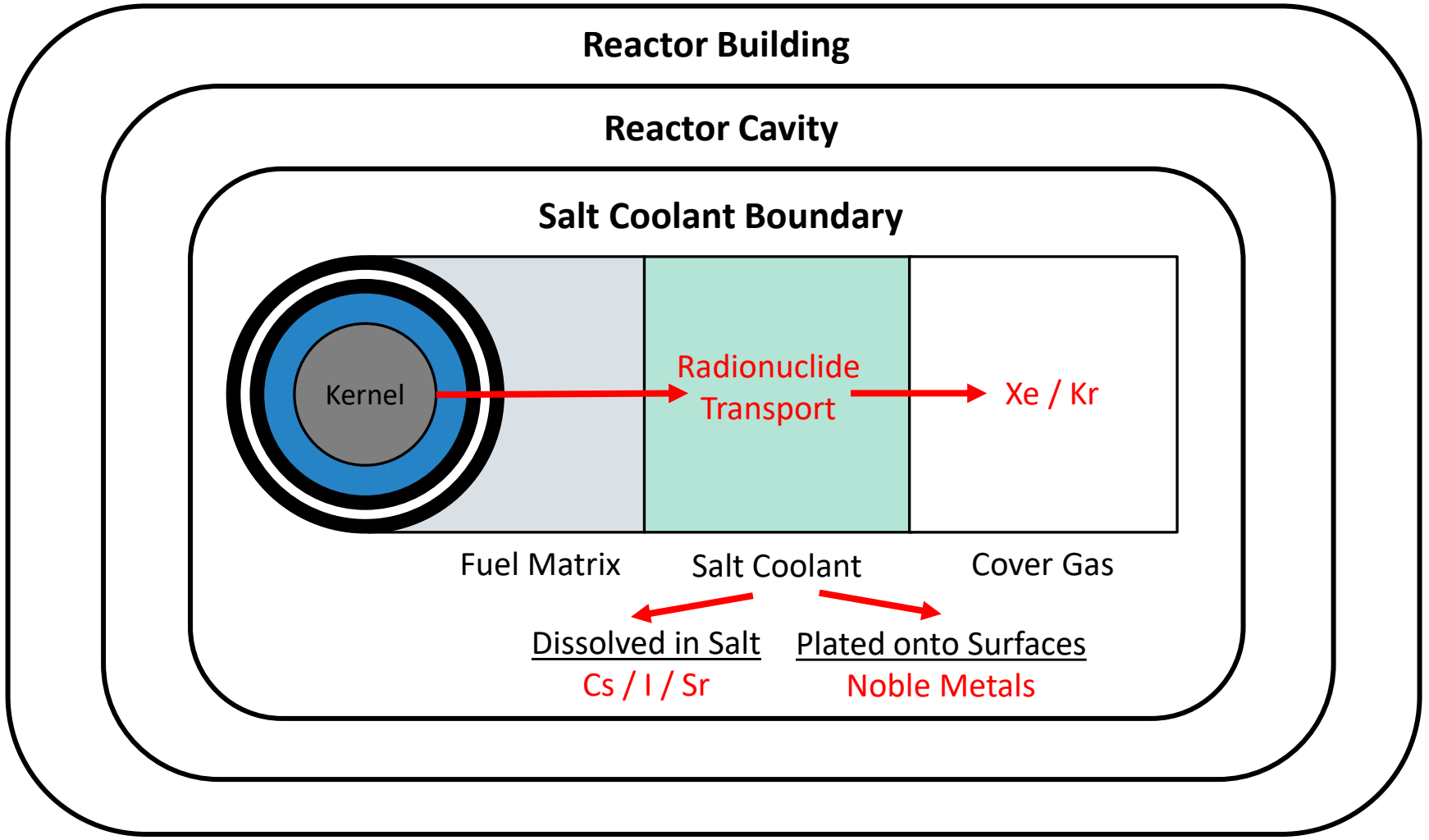
Low-Pressure Reactor Vessel
(FFTF core shown)



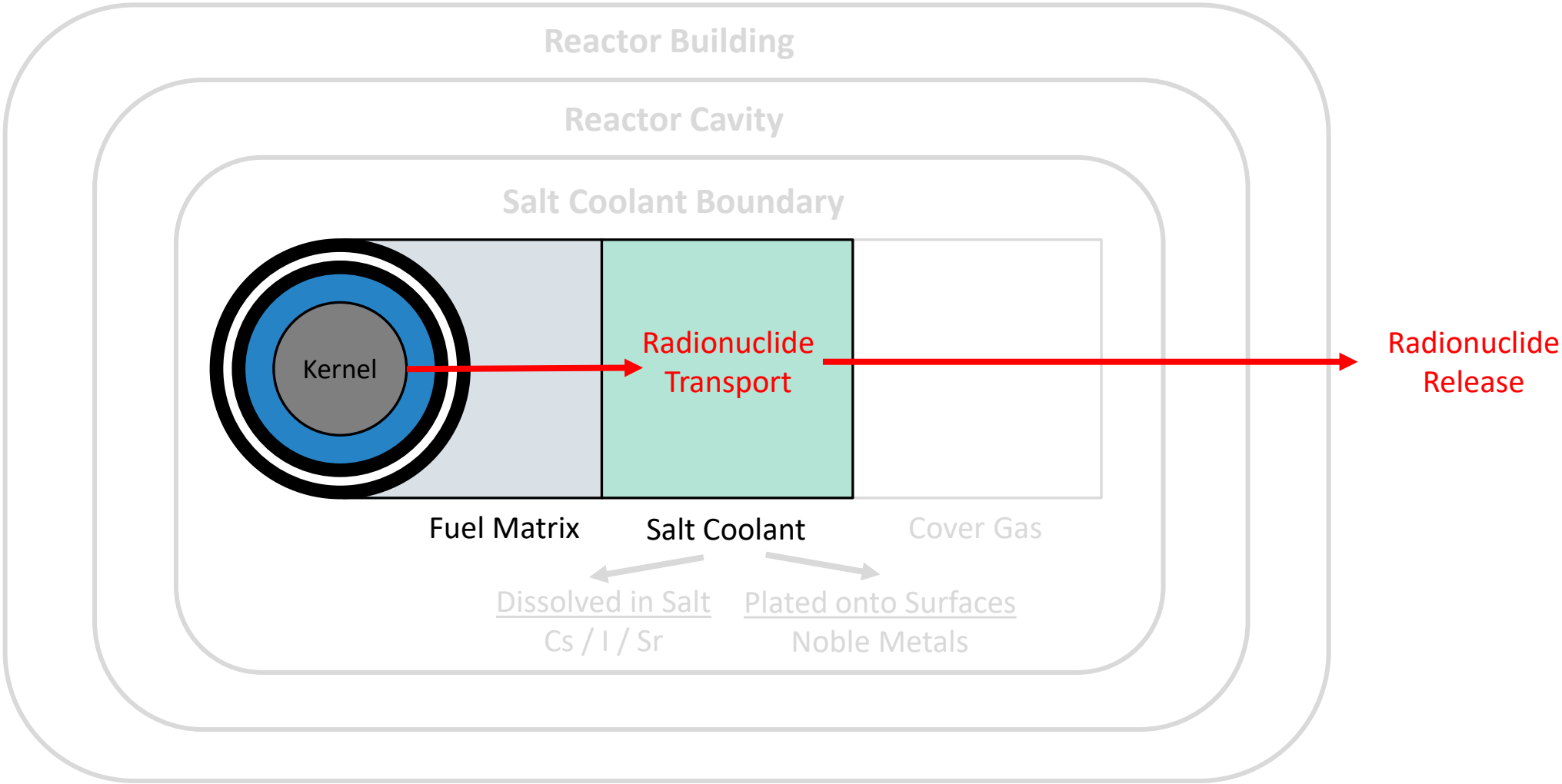
KP-FHR Inherent Safety Features

- **The fundamental safety case for the KP-FHR is rooted in the robust intrinsic safety characteristics of fuel and reactor coolant**
- **Tri-structural Isotropic (TRISO) Fuel**
  - Demonstrated fission product retention up to 1600°C
  - FHRs can operate with uniquely large fuel temperature margins
  - No incremental fuel failure expected during credible postulated events
- **Reactor Coolant - Flibe ($2LiF\text{-}BeF_2$)**
  - Demonstrated retention of solid fission products including cesium and iodine in Molten Salt Reactor Experiment (MSRE)
  - No exothermic reactions between the primary Flibe salt coolant and air or water
- **Low Pressure Primary System**
  - Primary heat transport system does not perform a “pressure boundary” function like traditional LWR designs
  - Loss of “reactor coolant boundary” does not result in large pressure related energy releases

KP-FHR Safety Case – Barriers to Release



KP-FHR Safety Case – Barriers Credited in Safety Case



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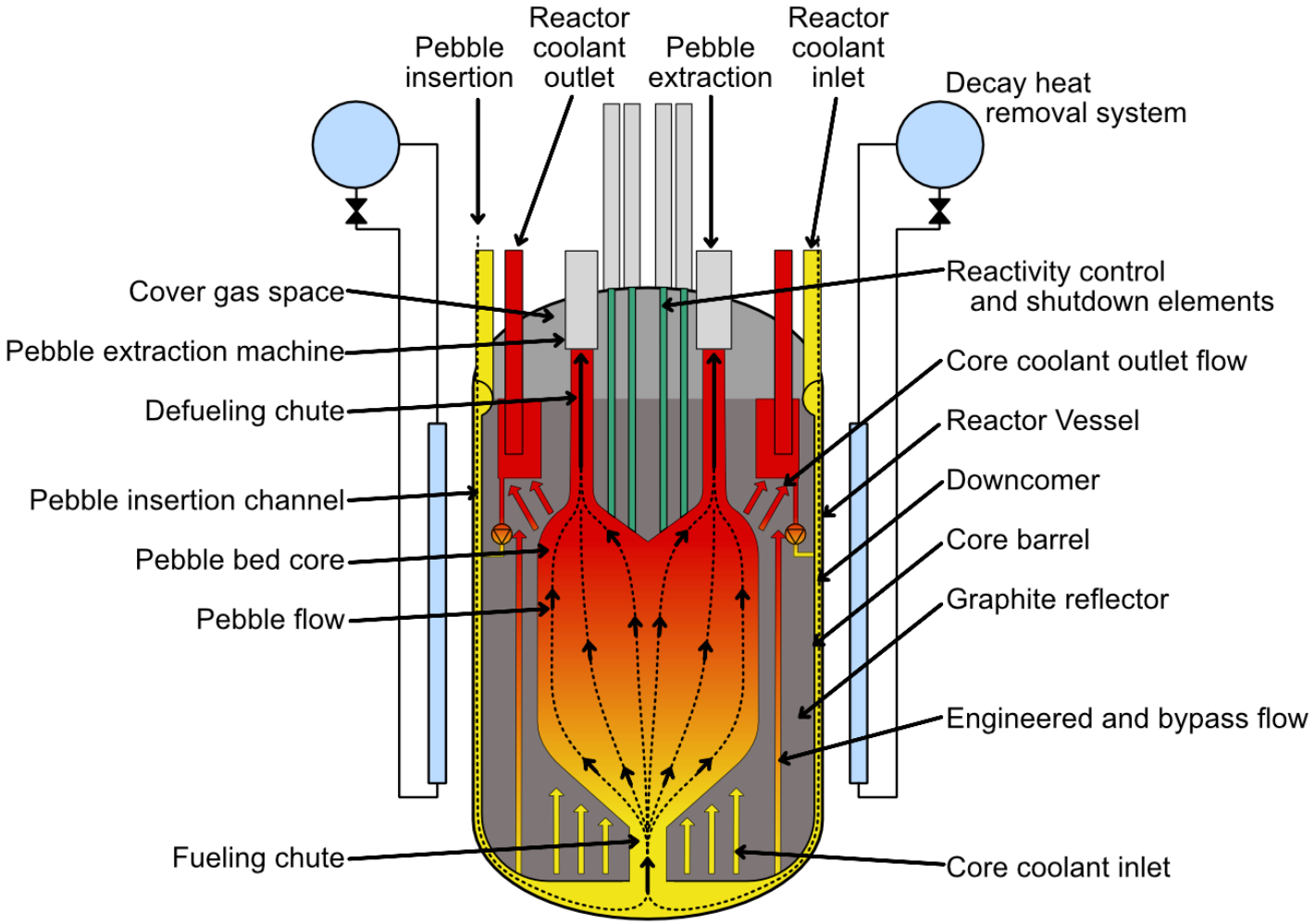
Reactor Systems - Nominal Parameters & Materials

Parameter	Value/Description
Reactor Type	Fluoride-salt cooled, high temperature reactor (FHR)
Core Configuration	Pebble bed core, graphite moderator/reflector, and enriched Flibe molten salt coolant
Reactor Thermal Power	<50 MW_{th}
Core Inlet and Exit Temperature	550˚C / 600-650˚C
Reactor Coolant Flow Rate	3200-8576 gal/min
Reactor Vessel Dimensions	10 ft diameter, 16 ft height
Material for: Reactor Vessel, Internal Structures, PHTS Piping, IHTS HX	316H, ASME Section III, Division 5, conforming to 2019 composition specification requirements
Graphite Reflector	ETU-10 (Ibiden)

Design Temperature Limits	Value
Primary Salt (Flibe) Freezing and Boiling Temperatures	459°C / 1430°C
Maximum ASME Section III, Division 5, SS316 Temperature	816°C
Accelerated Creep Rupture of SS316	~1000°C
SS316 Melting Temperature	~1400°C
Peak Fuel Temperature Limit	1600°C

Passive safety features are designed to protect the reactor vessel and fuel integrity – will not exceed demonstrated performance limits of these systems.

Reactor Systems - Core Configuration & Reactor Vessel



Highlights

- Pebble bed fuel, salt coolant, and graphite structures provide large thermal inertia, slow transient response, and ensure that design limits are not exceeded
- SS316H vessel, with targeted service life of 10 years
- Graphite reflector designed to match the vessel service lifetime

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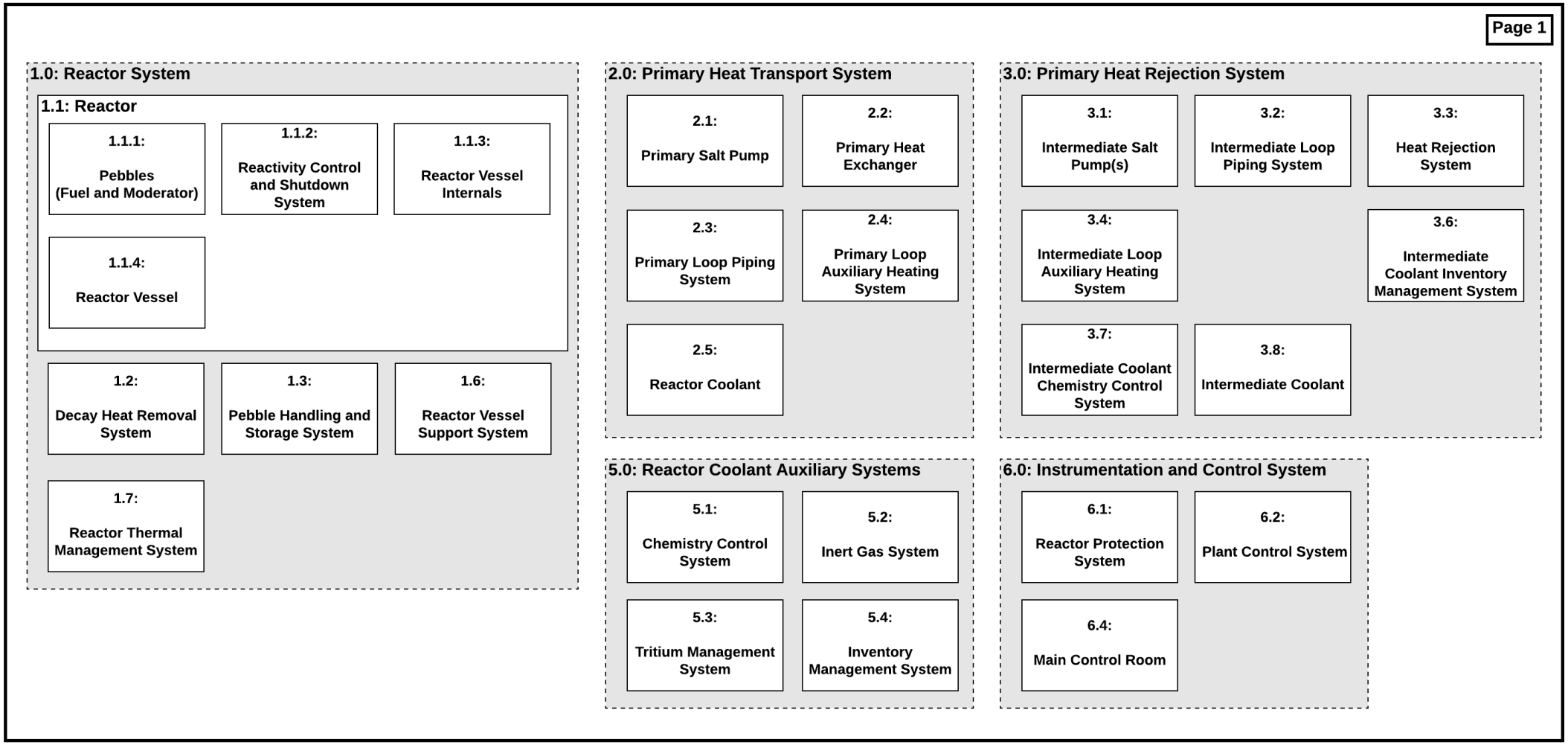
Non-Power Reactor System Architecture Diagram



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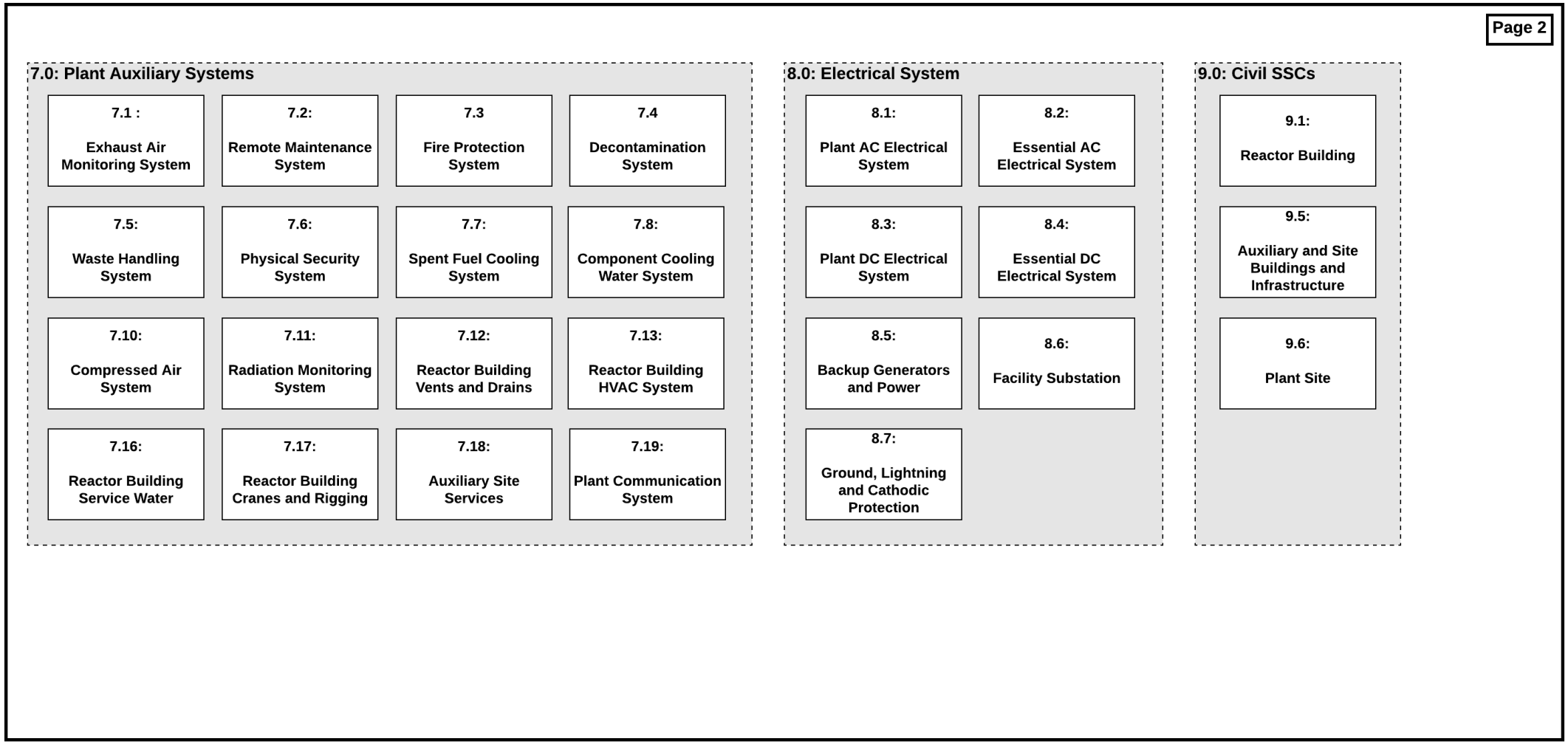
Non-Power Reactor System Architecture Diagram (cont'd)



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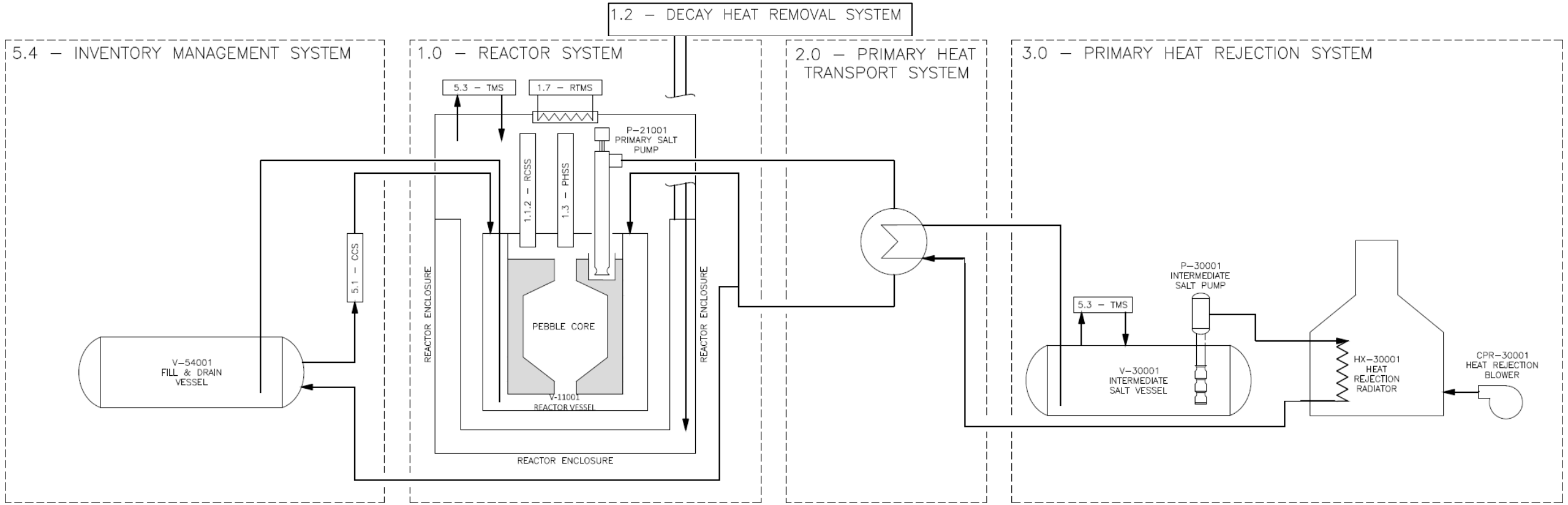
Plant Systems Overview - Basic System Configuration



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Questions

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Non-Power Reactor Construction Permit Application

Day 2 of Pre-Application Meeting with NRC, January 27-28, 2021

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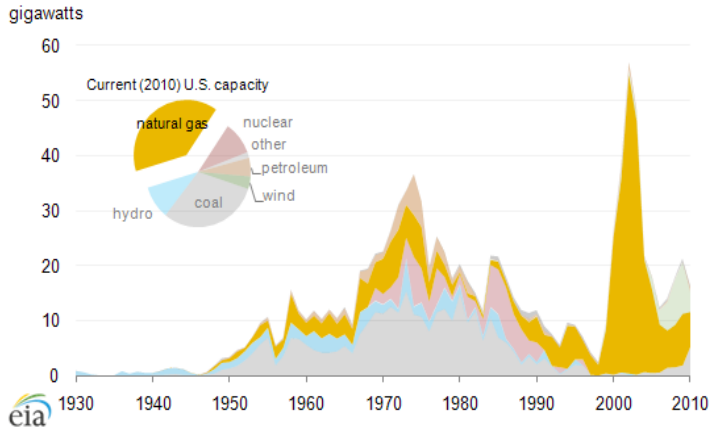
Siting and Environmental Report

MARGARET ELLENSON - SR. ENGINEER, LICENSING

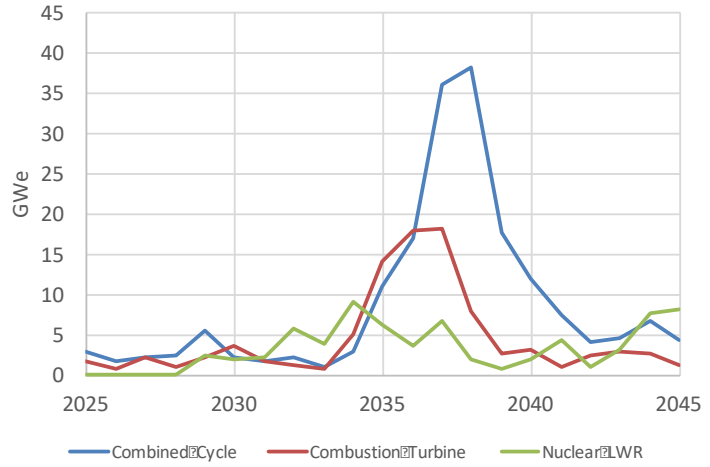
Protecting the Environment

- Kairos Power's mission is to enable the world's transition to clean energy *while protecting the environment*.
  - Replace carbon-emitting energy sources
  - Minimize environmental effects of construction and operation
  - Enable economic revitalization, including beneficial reuse of industrial sites where possible
    - Kairos headquarters located on former Naval Air Station, Alameda, California
    - Hermes Reactor selected location on former K-33 gaseous diffusion plant site, Eastern Tennessee Technology Park
  - Target market is to replace existing U.S. natural gas generation in the 2030's

U.S. Electricity Generation by Initial Year of Operation and Fuel Type



Annual U.S. Generation Retirements



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Siting Requirements and Guidance

- 10 CFR 100.10 provides siting factors:
  - a) Characteristics of reactor design and proposed operation
  - b) Population density and use characteristics of the site environs, including the exclusion area, low population zone, and population center distance
  - c) Physical characteristics of the site, including seismology, meteorology, geology, and hydrology
  - d) Any compensating engineering safeguards (paraphrased)
- NRC guidance for describing siting information in the Construction Permit Application is generally provided in Chapter 2 of NUREG 1537 Standard Review Plan
  - Chapter 2 format and content addresses the information expectations in 10 CFR 100.10 for non-power reactors

Site Selection Process

- The site selection process considered several sites within the continental United States
  - Idaho, Tennessee, North Carolina, Ohio
- Only sites with a low risk of exposure to the public were included in the initial screening, so down-selection focused on business factors.

The Selected Site: East Tennessee Technology Park

- Former Dept of Energy K-33 Gaseous Diffusion Plant site

view from the southeast

aerial view

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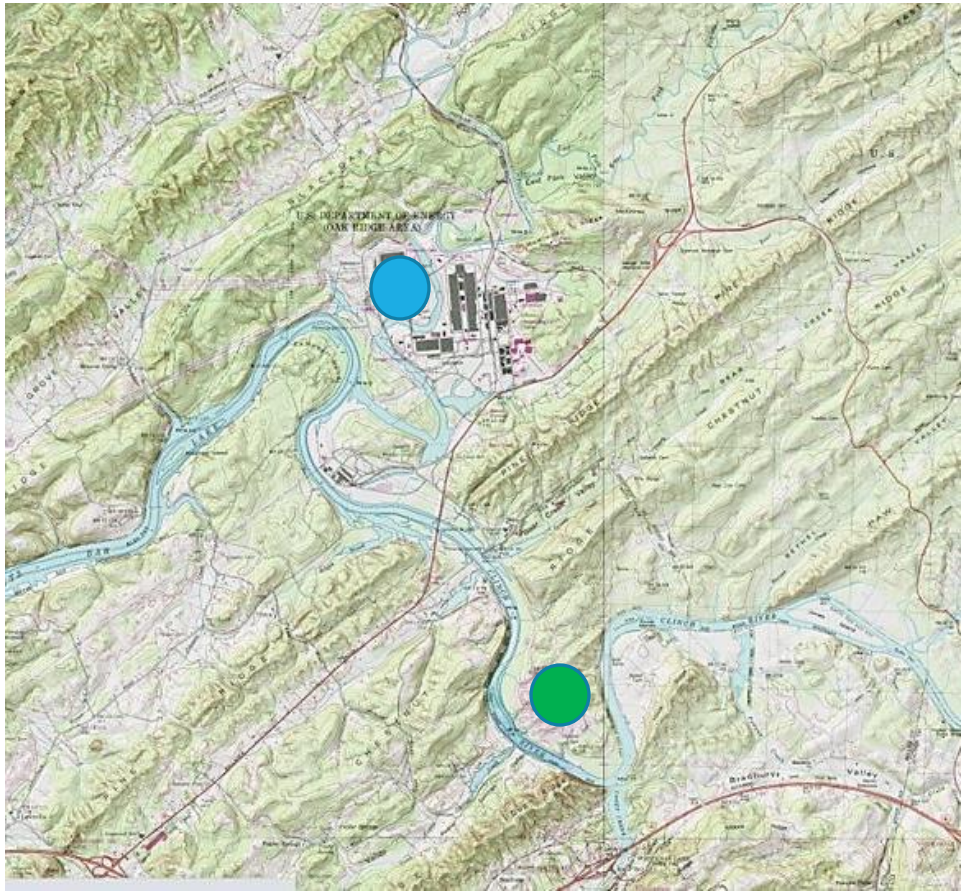
Site Vicinity

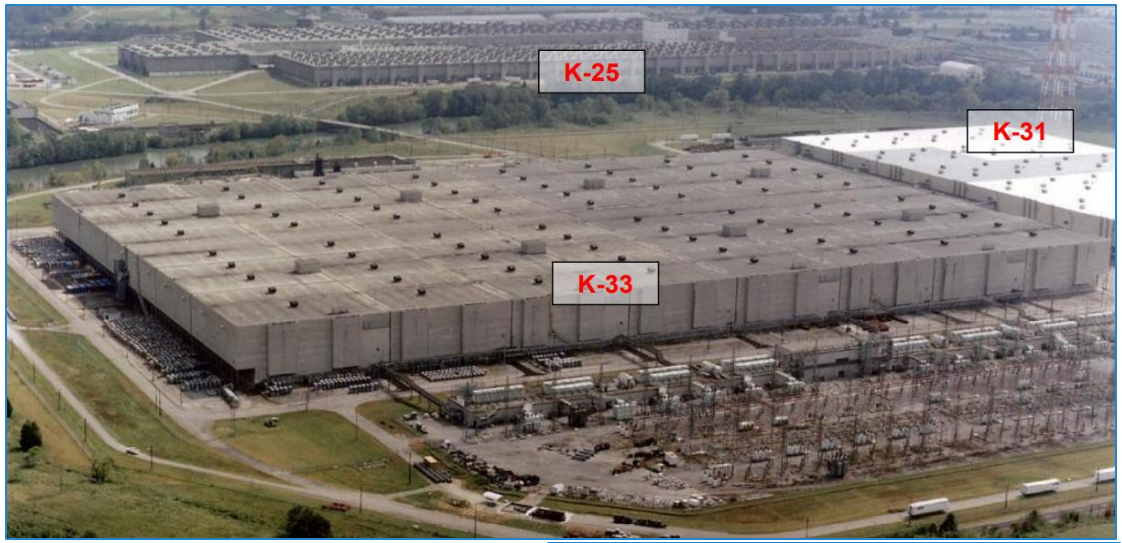


- Oak Ridge is located between the Smoky Mountains and Walden Range.
- Poplar Creek curves around the site, on the east (northeast at its nearest point)
- The Clinch River is to the south of the site (southwest at its nearest point)
- The Clinch River nuclear site is roughly 3 miles to the southeast.

Kairos Power test reactor site

Clinch River nuclear site

Site Historical Use



For more historical information: http://www.k-25virtualmuseum.org/

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Environmental Report Requirements – 10 CFR 51

- 10 CFR 51.50 requires applicants for a construction permit to submit an Environmental Report.
  - The section points to §§ 51.45, 51.51, and 51.52 which describe the specific categories of information to be provide in the environmental report.
  - The section also discusses reporting and recordkeeping procedures as well as environmental license conditions in accordance with 10 CFR 50.36b.
- 10 CFR 51.45 specifies the core information to be provided in an Environmental Report including:
  - (b) Environmental considerations. The environmental report shall contain a description of the proposed action, a statement of its purposes, a description of the environment affected
  - (c) Analysis. The environmental report must include an analysis that considers and balances the environmental effects of the proposed action, the environmental impacts of alternatives to the proposed action, and alternatives available for reducing or avoiding adverse environmental effects…
  - (d) Status of compliance. The environmental report shall list all Federal permits, licenses, approvals and other entitlements which must be obtained in connection with the proposed action and shall describe the status of compliance with these requirements.

Fuel Cycle, Fuel Transportation and Waste

- 10 CFR 51.51 requires light water reactor applicants to use Table S-3 as the basis of an evaluation of the uranium fuel cycle on the environment.
  - Table S-3 does not apply to advanced reactors
- 10 CFR 51.52(b) requires construction permit applicants to evaluate the environmental effects of the transportation of fuel and waste.
  - Table S-4 is referenced by 10 CFR 51.52(a)) and it does not apply to advanced reactors
- The environmental report for the non-power reactor construction permit application will discuss the effects on the environment related to the fuel cycle, transportation of fuel, and waste. The contents of the discussion will implement the guidance from NUREG-1537.
- Other references:
  - PNNL-29365, "Non-LWR Fuel Cycle Environmental Data," March 2020
  - PNNL-29367, "Environmental Impacts from Transportation of Fuel and Wastes to and from Non-LWRs," March 2020

Environmental Report Guidance – NUREG 1537

- NRC guidance for developing an Environmental Report for non-power reactors is provided in Chapter 12 of NUREG-1537 (Part 1 and 2) and was updated in the associated Interim Staff Guidance for medical isotope facilities (Chapter 19)
- Kairos Power intends to generally follow the basic chapter format and content outlined in the ISG by submitting a stand-alone Environmental Report (not an Appendix to Chapter 12 nor Chapter 19 of PSAR)
- ER Organization
  - Chapter 1 Introduction of the Environmental Report
  - Chapter 2 Proposed Action
  - Chapter 3 Description of the Affected Environment
  - Chapter 4 Impacts of Proposed Construction, Operations, and Decommissioning
  - Chapter 5 Alternatives
  - Chapter 6 Conclusions

End of Public Session