NPCIL

DIRECTORATE OF PROJECTS

KKNPP SAFETY FEATURES

REMARKABLE CONTRIBUTION OF SH. S.S. BAJAJ, SENIOR EXECUTIVE DIRECTOR (SAFETY)

NPCIL

DIRECTORATE OF PROJECTS

ABOUT VVER

VVER is an acronym for Russian designed " water cooled, water moderated energy reactor". The VVER reactors belong to the family of Pressurized Water Reactors (PWRs) which are one of the predominant type in operation, world over. This type of reactor uses light water as coolant & moderator and enriched uranium (about 3.92% U^{235}) as fuel.

NPCIL

DIRECTORATE OF PROJECTS

ABOUT VVER (contd.)

The VVER reactor that is under construction at Kudankulam site is an advanced PWR i.e. VVER NSSS model Version V-412, which incorporates all the features of a modern PWR as per the current Russian, Western, and IAEA standards.

NPCIL

DIRECTORATE OF PROJECTS

Main Plant parameters

Reactor Thermal Power	MW 3120
Electrical	MW electrical 1000
Number of circulating loops	4
Working Pressure in Primary Circuit	15.7 ± .3 MPa
Rated Coolant Temperature At Reactor Inlet, At Reactor Outlet,	 291 deg C 321 deg C
Coolant Flow Rate through reactor,	80,000 cu.m/h

NPCIL

DIRECTORATE OF PROJECTS

Steam Pressure	6.2 MPa
Steam Flow	4*1470 tons/hr
Reactor coolant pipe, diameter	850 mm
Reactor Pressure Vessel	SS cladded low alloy steel

NPCIL

DIRECTORATE OF PROJECTS

Number Hexagonal Fuel Assemblies	163
Reactor internals. (Core barrel, Core basket, Protective tube assembly).	Austenitic SS
Nos. of control rods	121 positions
Life time (years),	30 Yrs (40 yrs for RPV)
Containment	Double with primary steel lined
Turbo-Generator 1000 MWe,	

NPCIL

DIRECTORATE OF PROJECTS

Purpose

Systems are designed for the following :

- Normal Operation
- Anticipated operational occurences (AOO)
- Design Based Accidents (DBA)
- Beyond Design Based Accidents (BDBA) including Anticipated Transients Without Scram (ATWS)

NPCIL

DIRECTORATE OF PROJECTS

Safety Features of Kunankulam NPP

The VVER-392 version being offered to India for the Kudankulam project has many significant safety enhancement features such as:

- Double Containment with steel liner.Interspace kept at negative pressure to reduce ground level releases significantly.
- Passive heat removal system to provide cooling during 24 hours station black out situation.

NPCIL

DIRECTORATE OF PROJECTS

Safety of VVER

- Larger number of control rods giving higher sub-criticality margins.
- Second quick acting shutdown system, quick boron injection system.
- Hydrogen recombiners.
- Modern state-of-the-art instrumentation and controls.
- Improved design of equipment.

NPCIL

DIRECTORATE OF PROJECTS

Inherent Safety Features

The VVER 1000 reactor chosen for Kudankulam is an extremely safe reactor during normal as well as abnormal conditions, as it has certain inherent safety features.

- The most important one is the "**negative power coefficient**" wherein any increase in reactor power is self terminating.

NPCIL

DIRECTORATE OF PROJECTS

Inherent Safety Features

Negative Void Coefficient.

- Another inherent characteristic is the "**negative void coefficient**" which causes the reactor to shut down, if there is loss of water from the reactor core.

NPCIL

DIRECTORATE OF PROJECTS

Safety System Classification

The Engineered Safety Systems are classified as follows :

- ***Protective safety systems***
- ***Localizing safety systems***
- ***Support safety systems***

NPCIL

DIRECTORATE OF PROJECTS

Protective Safety System

Definition

The systems (elements) are designed for prevention or restriction of damage to nuclear fuel, fuel assembly claddings, and primary coolant system containing radioactive products are referred to as protective safety system.

NPCIL

DIRECTORATE OF PROJECTS

Protective Safety Systems

- Control and protection system (JDK)
- Quick boron injection system (JDJ)
- Overpressure protection system of the reactor coolant system (JEF)
- Emergency and planned cooling down of primary circuit and fuel pool cooling system (JNA)

NPCIL

DIRECTORATE OF PROJECTS

Protective Safety Systems

- High-pressure emergency injection system (JND 10-40) and emergency boron injection system (JND 50-80)
- ECCS passive part (first stage hydro accumulators) system (JNG10-40)
- Additional system for core passive flooding (second stage hydroaccumulators) (JNG50-80)
- Emergency gas removal system (KTP)

NPCIL

DIRECTORATE OF PROJECTS

Protective Safety Systems

- SG emergency cooling down and blowdown system (JNB10-40)
- Passive heat removal system (JNB50-90)
- System for the steam generators cut-off from steam (LBA)
- System for the secondary circuit overpressure protection (LBU)

NPCIL

DIRECTORATE OF PROJECTS

Localizing Safety System

Definition

Localizing safety systems (LSS) are designed for preventing or restricting the releases of radioactive substances and limiting the radiological consequences in case of accidents beyond the design limits.

NPCIL

DIRECTORATE OF PROJECTS

Localizing Safety Systems

- Reactor compartment: double containment system (JMA).
- Sprinkler system (JMN).
- Annulus Passive Filtering System (JMC).
- Hydrogen monitoring and suppression system inside the containment.

NPCIL

DIRECTORATE OF PROJECTS

Localizing Safety Systems

- System for retaining and cooling of molten core (JKM)
- Containment isolation system

NPCIL

DIRECTORATE OF PROJECTS

Support safety system

Definition

Support systems are designed for supplying power, cooling process media to the safety systems and creating conditions for their functioning.

NPCIL

DIRECTORATE OF PROJECTS

Support safety systems

- Component cooling system of reactor building (intermediate circuit) (KAA)
- Sea water supply system for reactor and diesel generator building (PEB)
- Emergency power supply system

NPCIL

DIRECTORATE OF PROJECTS

Design Concepts

The general design concepts of Safety Systems :

- Each active safety system has four trains, each capable to perform completely the intended safety function.

NPCIL

DIRECTORATE OF PROJECTS

Design Concepts

- Number of the trains is chosen proceeding from implementation of the single failure principle;
- Each protective safety system comprises active and passive parts, each capable to perform the intended safety function;

NPCIL

DIRECTORATE OF PROJECTS

Design Concepts

- The safety system trains are separated physically in space and the trains are protected by the structural arrangement;
- The design of control safety systems is such that a failure in the system causes actions directed to ensure safety;

NPCIL

DIRECTORATE OF PROJECTS

Design Concepts

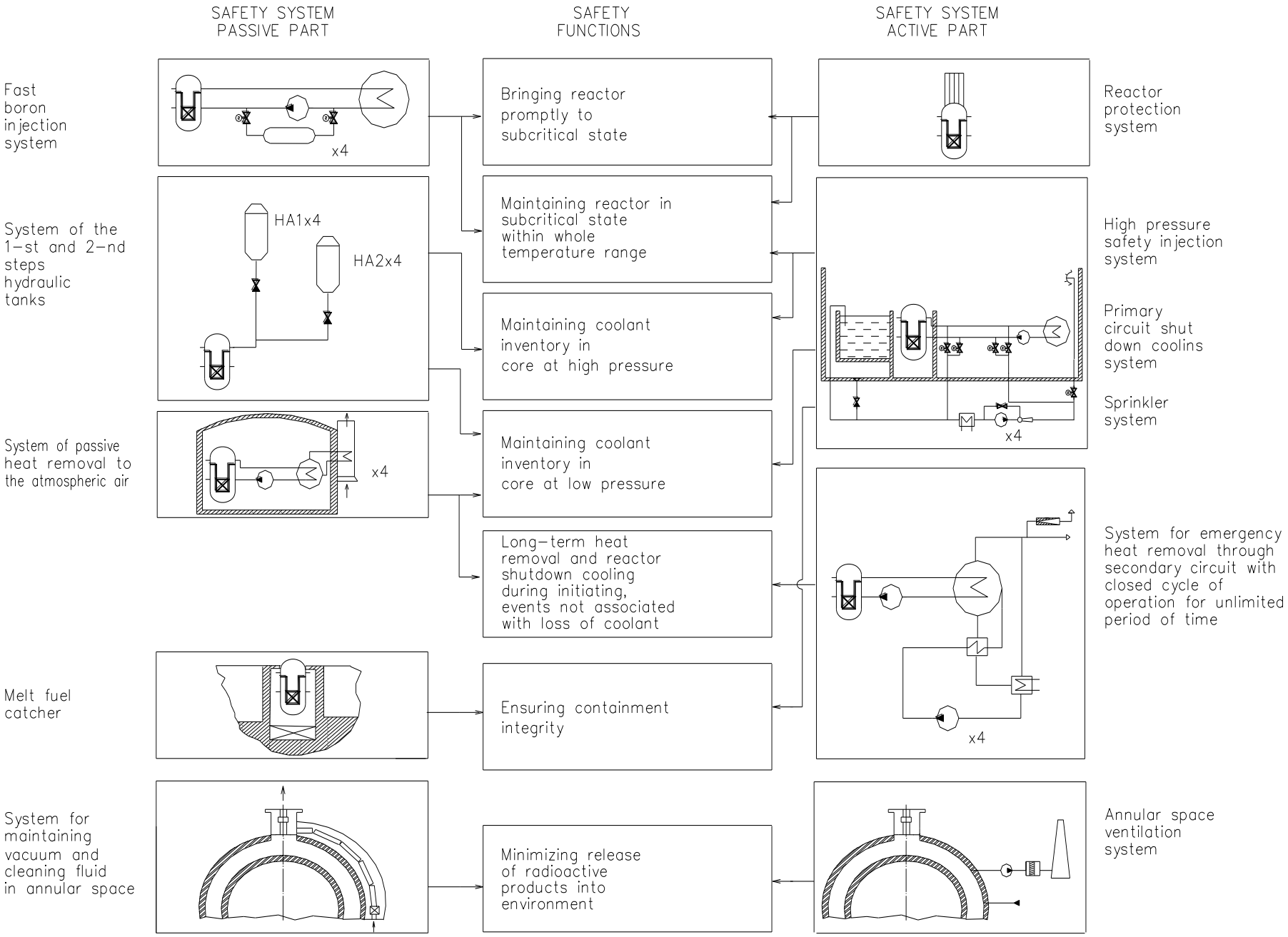
- The safety system actuates on demand automatically and operators actions are blocked in the first 30 minutes to exclude personnel error;
- All safety systems are supplied with power from independent sources (Dedicated Diesel Generators), designed in accordance with the requirements to the protective safety systems.

NPCIL

DIRECTORATE OF PROJECTS

Design Concepts

- Full redundancy of active safety systems by passive safety systems has been implemented in the design for realization of these principles. In this case the passive safety systems provide safety functioning independent of the active safety systems.



Active Safety Systems and Passive Safety Systems

NPCIL

DIRECTORATE OF PROJECTS

Design Concepts

- Safety approach adopted in the design of "Kudankulam" NPP ensures required level of safety characterized by core damage frequency of 10^{-5} /reactor-year. This approach involves different principles of operation of safety systems (active and passive) and excludes practically common-cause failure.

NPCIL

DIRECTORATE OF PROJECTS

Design Concepts

- When designing systems included into the safety system active part, with a view to increase functional reliability, a method for combining safety and normal operation functions was adopted. In this case the design provides such schematic solutions, which carries out for safety function without switch over in general, or with minimum number of changes of valves positions only.

NPCIL

DIRECTORATE OF PROJECTS

Design Concepts

- Number of actuations, as shown by analyses, is considerably less than the traditional safety systems not engaged for normal operation functions. Such a principle permits to reduce number of undetected failures considerably.

NPCIL

DIRECTORATE OF PROJECTS

Engineered Safety Features for Design Basis Accident

E.C.C.S.

- High Pressure Emergency Injection System (JND10-40).
- First Stage Hydro accumulators (JNG 10-40).
- Emergency and Planned cool down of primary circuit and fuel pool cooling system (JNA).
- SG Emergency cool down and blow down system (JNB10-40).

NPCIL

DIRECTORATE OF PROJECTS

Engineered Safety Features Designed for Beyond Design Basis Accident

1 Second stage hydro accumulators (JNG 50-80).

2 Passive heat removal system (JNB 50-90).

3 Annulus passive filtering system.

4 Molten core retaining and cooling system.

NPCIL

DIRECTORATE OF PROJECTS

Engineered Safety Features for ATWS

- **Active System**

  Emergency Safety Boron Injection System(JND 50-80)

- **Passive System**

  Quick Boron Injection System. (JDJ)

Other Safety Systems

- Life Support System(control room habitability).
- Emergency gas removal system.
- Fission products removal and control system(containment atmosphere).
- Stand by Emergency diesel generator sets.
- Secondary circuit overpressurization protection system.
- Component cooling system of reactor building (KAA).
- Sea Water cooling system of reactor building and emergency diesel generators.

VVER-1000 and **AP1000**

– A COMPERATIVE STUDY

JULY 24, 2007

ELEMINATION OF SYSTEMS
LEADING TO SIMPLIFICATION

PHRS,

QBIS,

HPIS(JND10-40),

EBIS(JND50-80),

JMN,

Emergency Power Supply

&

MINIMUM REDUNDANCY

REDUCTION OF PIPING,VALVES &PUMPS :

Piping=80% less
Valves=50% less
Safety Pumps=35% less

REDUCTION OF CABLE

85% less cable due to use of digital system and multiplexing

CONTAINMENT PENETRATION

50% less penetration

CONCRETE , M3

<100 000 m3 (OL3 - 400 000 m3 ; Sizewell B - 520 000 m3)

REBAR, METRIC TONS
<12,000 tons (Sizewell B - 65 000 m3)

- SIGNIFICANT REDUCTION IN TOTAL BUILDING VOLUME
- DRAMATIC REDUCTION IN ‘SAFETY GRADE’ STRUCTURE AND SYSTEM
- CONSTRUCTION WITH PREFABRICATED MODULES
- USE OF LIMITED NUMBER STRUCTURAL STEEL PROFILE, REBAR, PIPING AND VALVES
- DEVELOPMENT OF LEVEL 3 PRIMAVERA CONSTRUCTION SCHEDULE AND LINKAGE TO 3D MODEL
- CONSTRUCTION SCHEDULE: 36 MONTHS

NPCIL

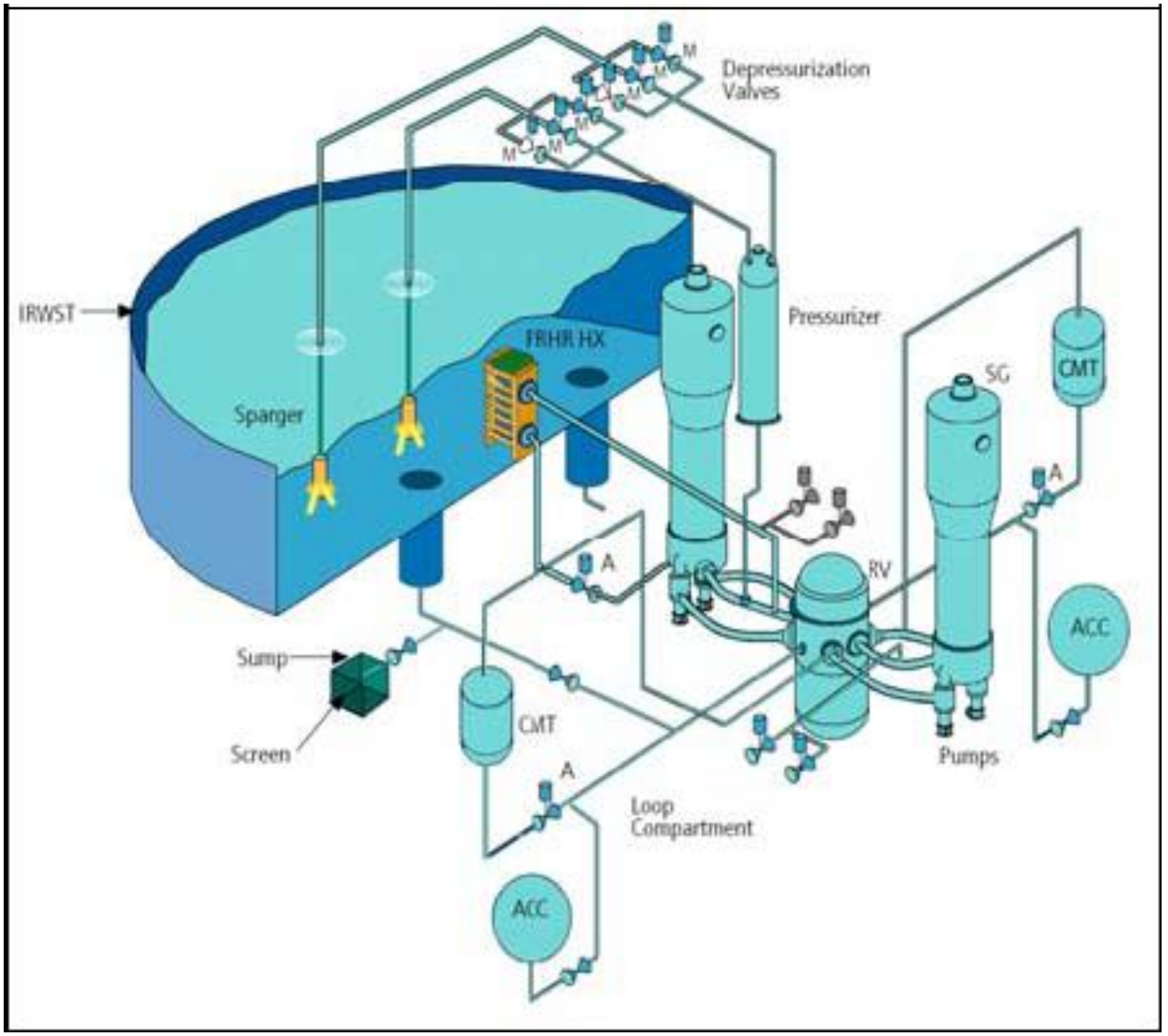
DIRECTORATE OF PROJECTS

FUTURISTIC DESIGN OF PWR

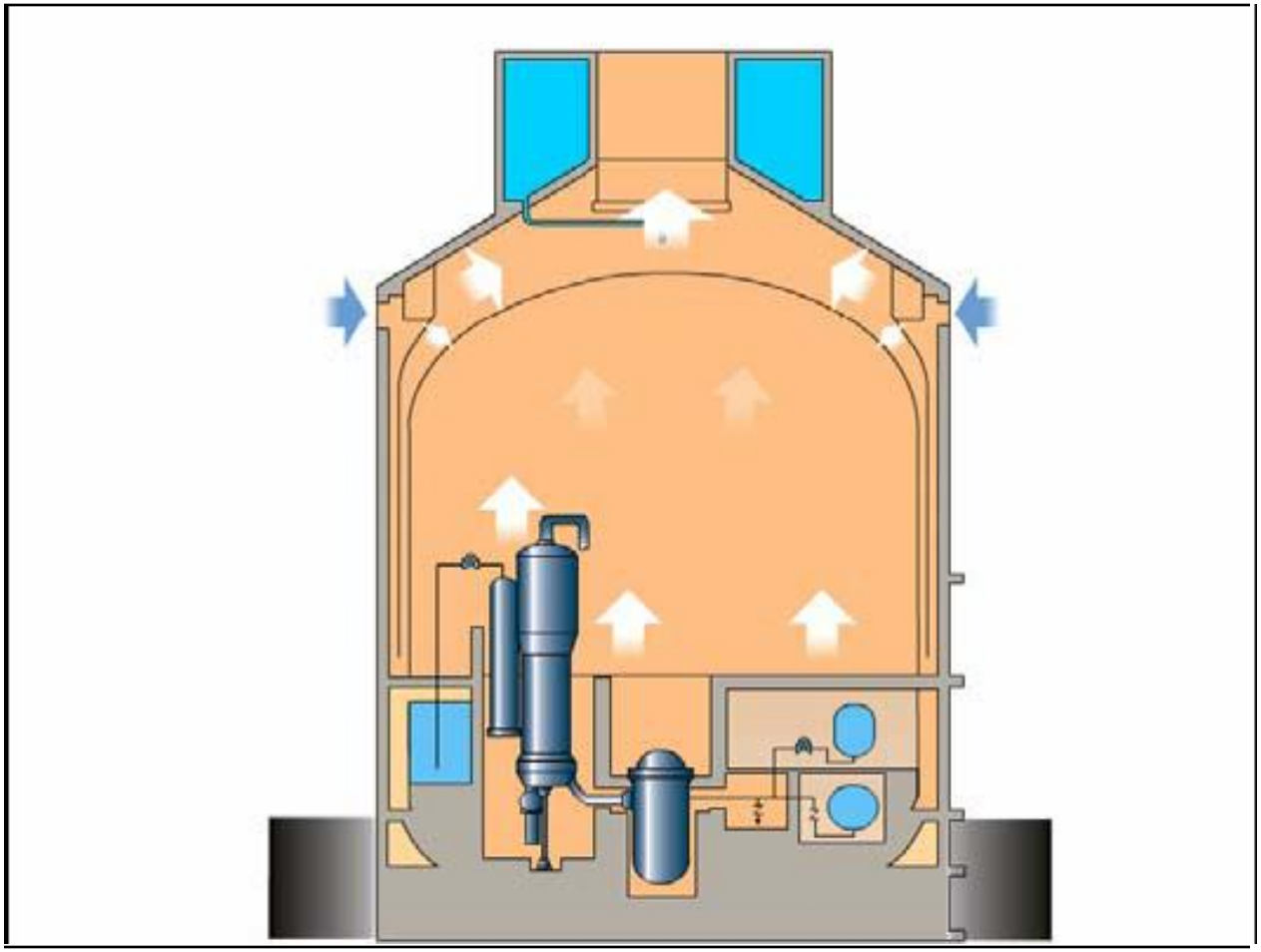
FEATURES:

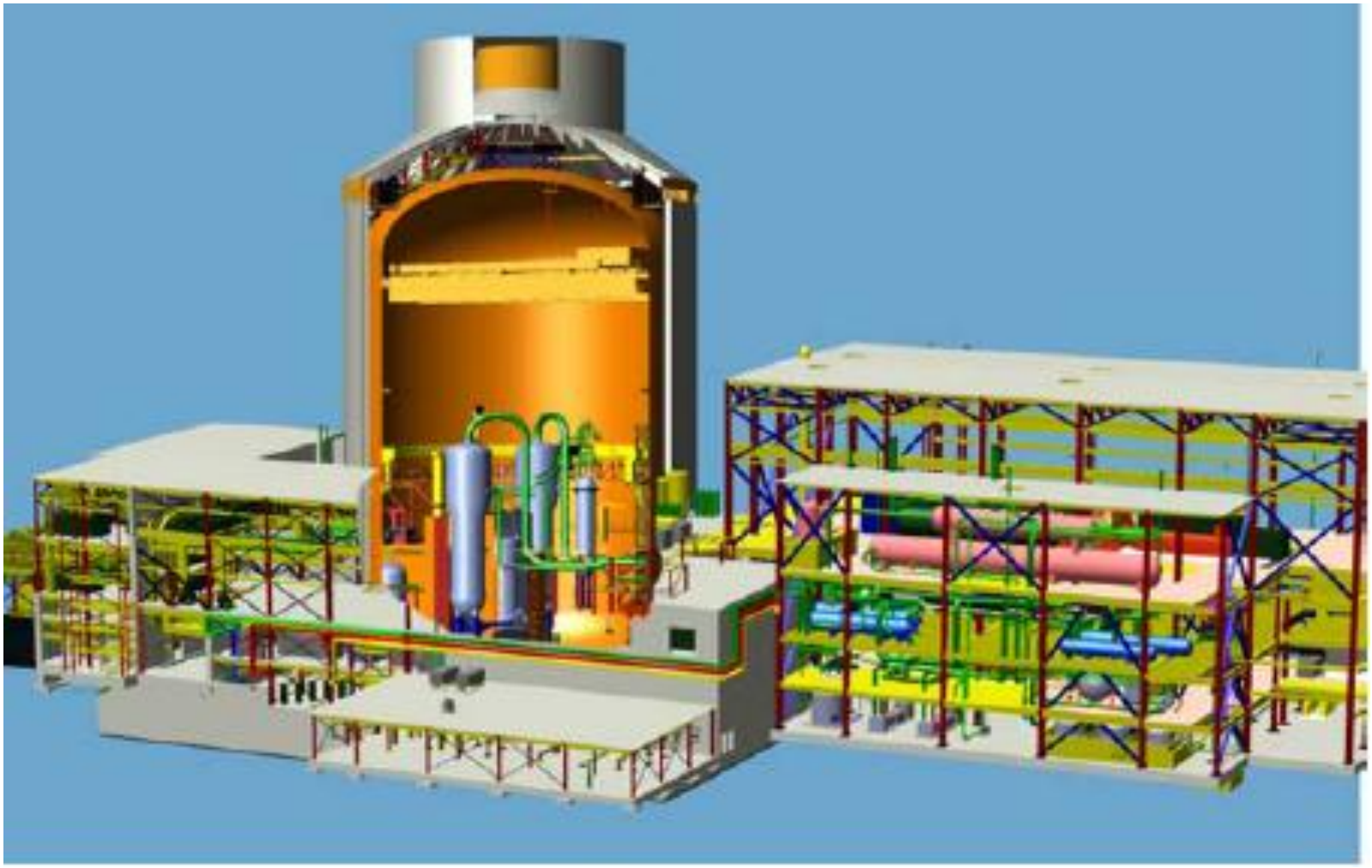
- **FUTURISTIC DESIGN CALLS FOR OPTIMIZATION IN DESIGN FEATURES OF VVER-1000: FROM MAXIMUM TO OPTIMISED DESIGN FEATURES. THIS CALLS FOR REDUCTION OF SYSTEM LIKE QBIS ETC.**
- **OPTIMUM MIX OF PASSIVE AND ACTIVE SYSTEMS**
- **USE OF BREAK PRECLUSION CONCEPT / LBB**
- **SIMPLE BUT INHERENTLY SAFE DESIGN**
- **DETERMINISTICALLY SAFE**

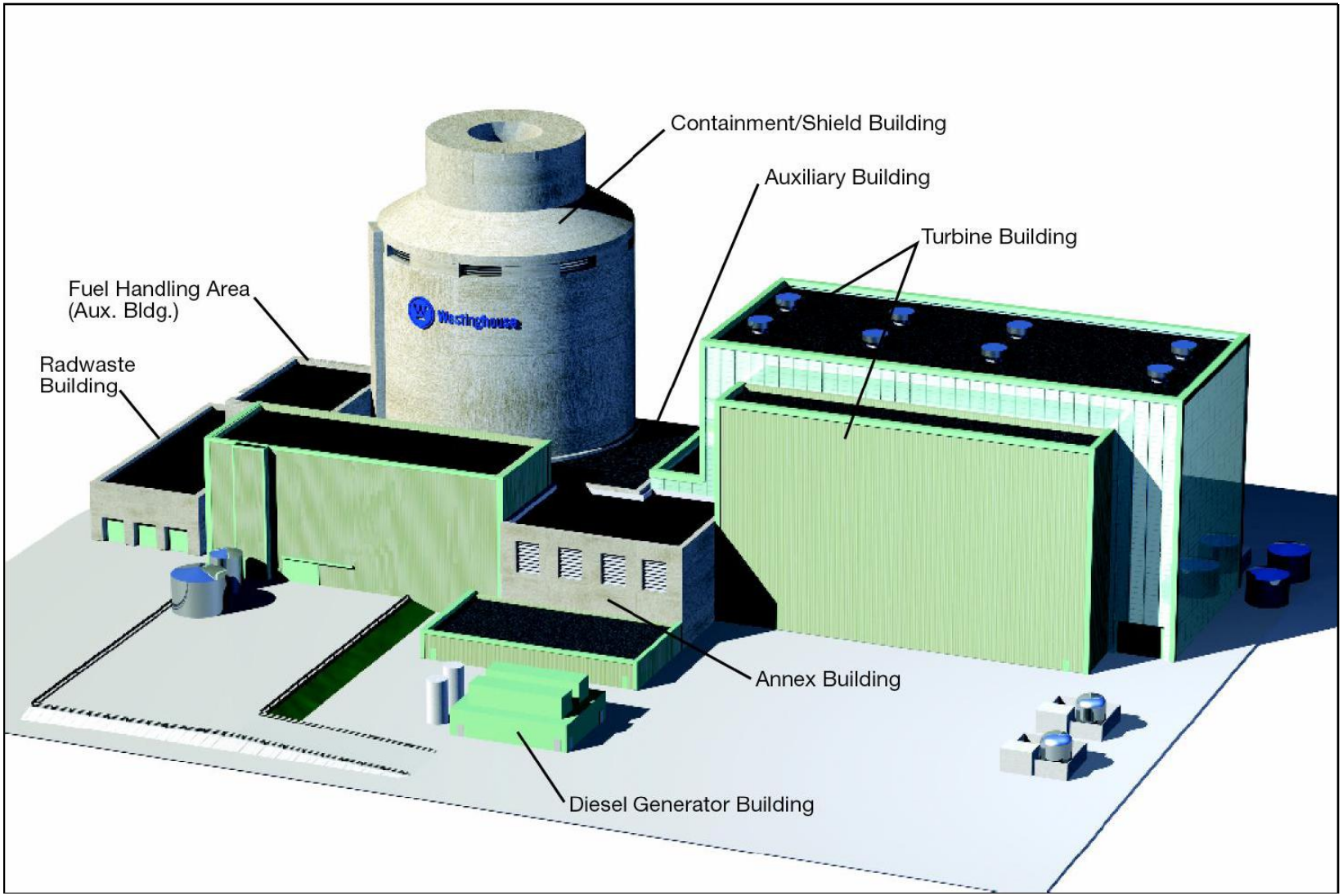
Passive Core Cooling System



Passive Containment Cooling






Containment/Shield Building
Auxiliary Building
Turbine Building
Fuel Handling Area
(Aux. Bldg.)
Radwaste
Building
Annex Building
Diesel Generator Building

NPCIL

DIRECTORATE OF PROJECTS

THANK YOU