SMR Development Updates for LandStar Series

Wang Xujia

Director of General Technique Department
SNERDI

知识产权声明

本文件的知识产权属国家电力投资集团公司及其相关产权人所有，并含有其保密信息。对本文件的使用及处置应严格遵循获取本文件的合同及约定的条件和要求。未经国家电力投资集团公司事先书面同意，不得对外披露、复制。

Intellectual Property Rights Statement

This document is the property of and contains proprietary information owned by SPIC and/or its related proprietor. You agree to treat this document in strict accordance with the terms and conditions of the agreement under which it was provided to you. No disclosure or copy of this document is permitted without the prior written permission of SPIC.

Contents

Contents

SMR Potential Market in China

The future development of China has raised **higher requirements** for energy:

- ✓ Clean heating demand in the north
- ✓ Electricity demand along southeast coast

→ The Most urgent

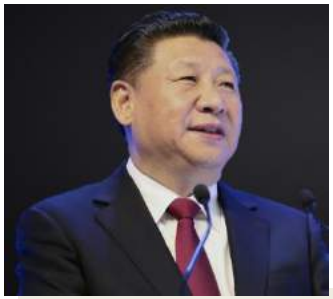
Southeast

Economic developed	→	Electricity demand
Wind power is instability	→	Nuclear power
Site resources are limited	→	Extends to the ocean
Size constraints on ocean sites	→	SMR

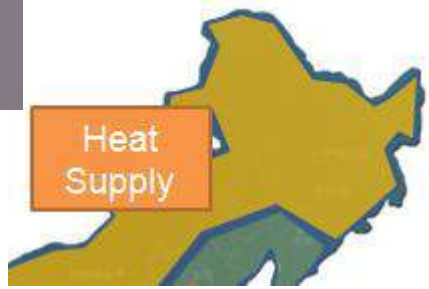
- ✓ Local power supply and the retirement of aging thermal power in the southwest

SMR has the potential to **meet these Requirements**

SMR Potential Market in China



Coal heating in northern China causes severe smog in winter and Massive CO_2 emissions



Defend the blue sky

- *Government work report 2019:*
  - Promote clean heating in northern China
- *Planning for clean heating in northern China*
  - Clean heating rate reached 70% by 2021

Coal to gas → **High cost**

Coal to electricity → **Low efficiency Heavy load to grid**

Nuclear energy, clean and affordable.

Heat load demand in Northeast

Jiamusi in Heilongjiang

- **Civil heating：**
  Heating area 33,260,000m^2，18,000,000m^2 increased by 2025
- **Industrial heating ：**
  Maximum demand for steam 620t/h，Temp 144℃~195℃，Pressure 0.6MPa~1.2MPa

Tonghua in Jilin

- **Civil heating ：**
  Heating area 25,000,000m^2，26,000,000m^2 increased in 5 years
- **Industrial heating ： ：**
  Maximum demand for steam 235t/h，Temp 170℃~190℃，Pressure 0.8MPa

SMR Development Updates

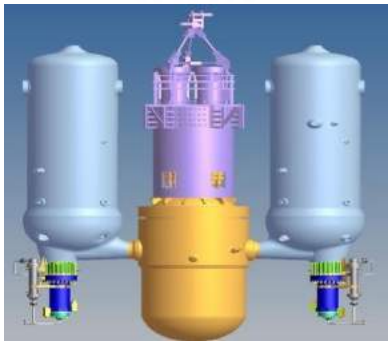
Technical Route and Development Basis of SMR by SNERDI

NPP : Design、Equipment supply chain、R&D system

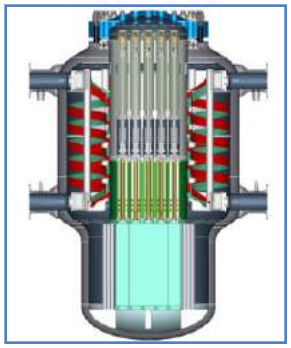
2008 → **2019**

SMR : Model serialization, technology platform

2009 → **2019**



- Small
- Light
- Intelligent
- High reliability
- Maintenance - free



SNERDI compact design

- Mature direct connection
- Less welds
- High natural circulation ability

SNERDI integrated design

- More efficient OTSG
- All main equipment internally installed——save more space
- Full natural circulation ability

Typical SMR reactor types and responding progress

Field	Small grid power supply Industrial power supply	Civil heating Industrial steam
Type	LandStar-5 (LS-5)	LandStar-1 (LS-1)
Technical route	Compact design	Integrated design
Design progress	Conceptual design completed	Preliminary design ongoing
Project progress	Marketing	Feasibility study ongoing

General Introductions of LS-5

Flexible

Electric Power

Heat Supply

Desalination

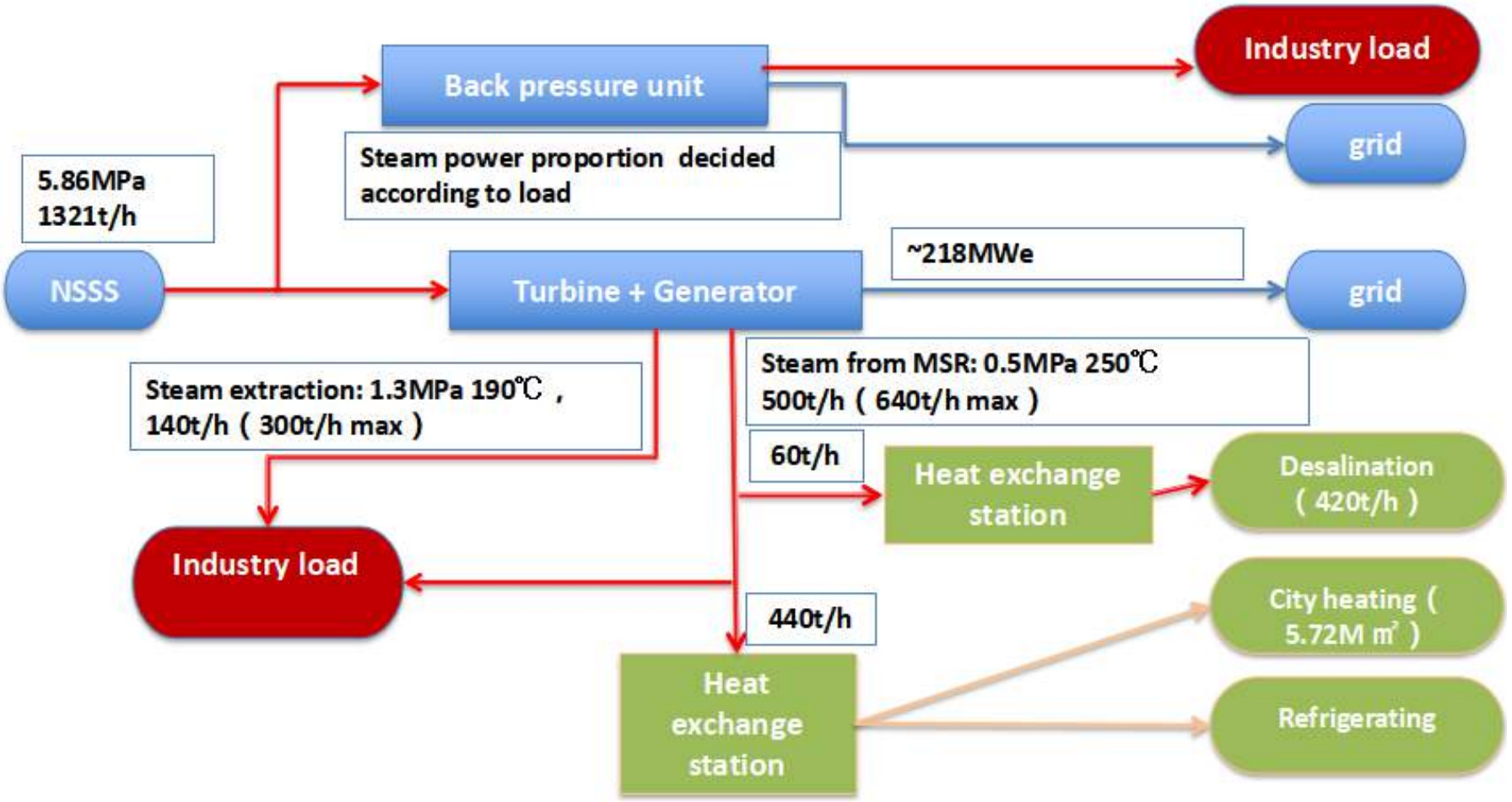
Underground

Undersea by submerged block

General Parameter		
Thermal Power	MWt	660
Electric Power	MWe	~220
RCS Pressure	MPa	15.5
RCS Loops		2
RCS Tavg	℃	301
Refueling Time	Mons	24（18~33）
FA types		17×17 RFA
FA numbers		89
Control Rods		37
CDF		$< 10^{-7}$
LRF		$< 10^{-8}$
Availability	%	> 95

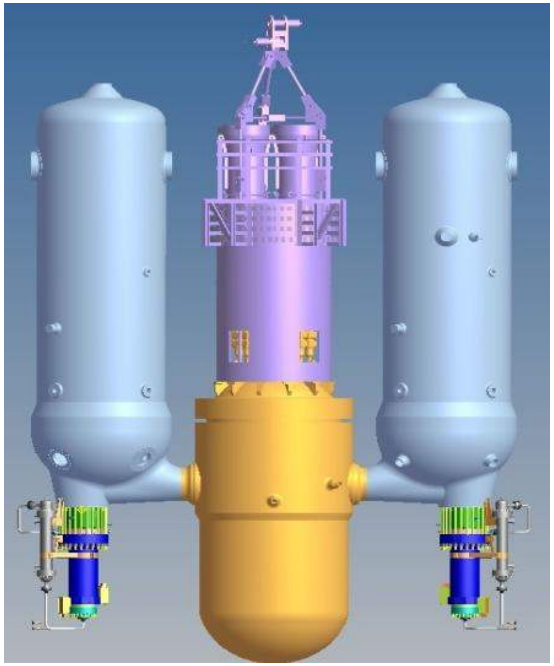
SMR Development Updates

Multi Functions of LS-5



SMR Development Updates

LS-5 Innovation



LBLOCA eliminated

Less building volume

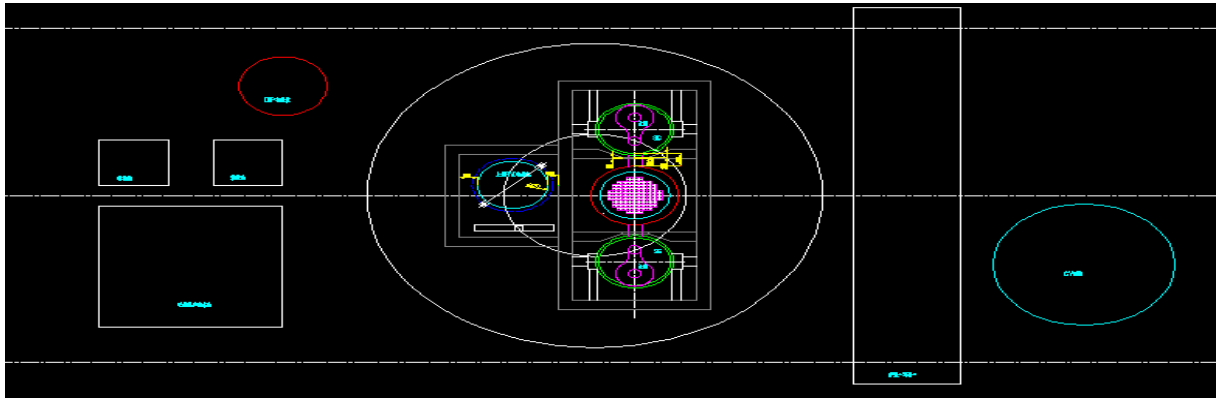
Less in-service inspection

Compact Design

- Design verification is done and the prototype is being produced.
- The support design and analysis for SG and RV.

Improved Refueling Process

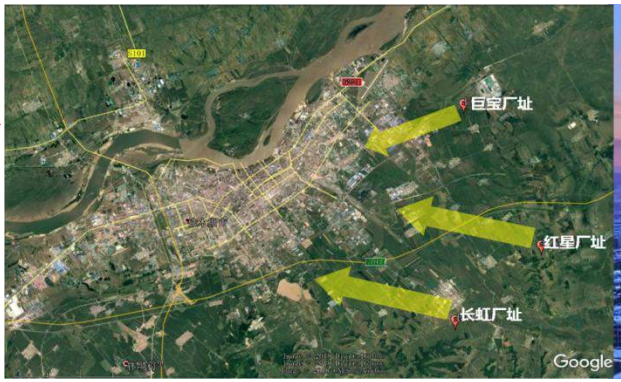
- The conventional polar crane in containment is replaced by a crane outside containment.



SMR Development Updates

Heilongjiang

Jiamusi



LS-1 Pilot Project

Finished

✓Preliminary feasibility study review

✓Get strong support from government

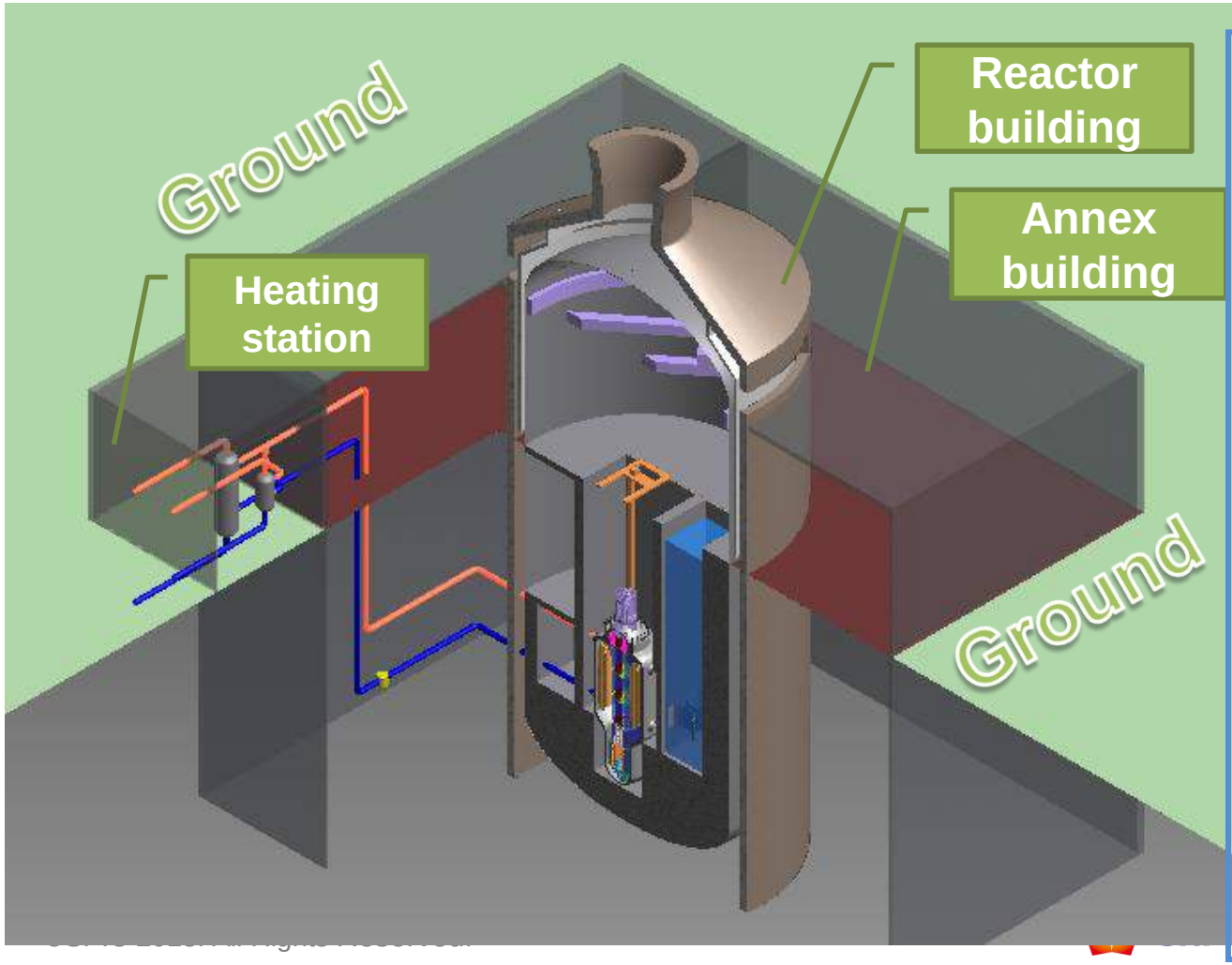
Ongoing

✓Preliminary design and Project feasible Study

■ **2 Units cover an area of 100,000m^2**

国家核电 SNPTC 上海核工程研究设计院有限公司 SHANGHAI NUCLEAR ENGINEERING RESEARCH & DESIGN INSTITUTE CO.,LTD.

LS-1 The overall configuration：3 main buildings, 3 Circuits



Reactor building

- Deep underground
- Steel Containment Vessel

Heating station

- Heat exchanger and load regulation for multi-function

Three circuits

- Higher pressure for intermediate circuit
- Isolate the potential radioactive matter from primary circuit to heating circuit

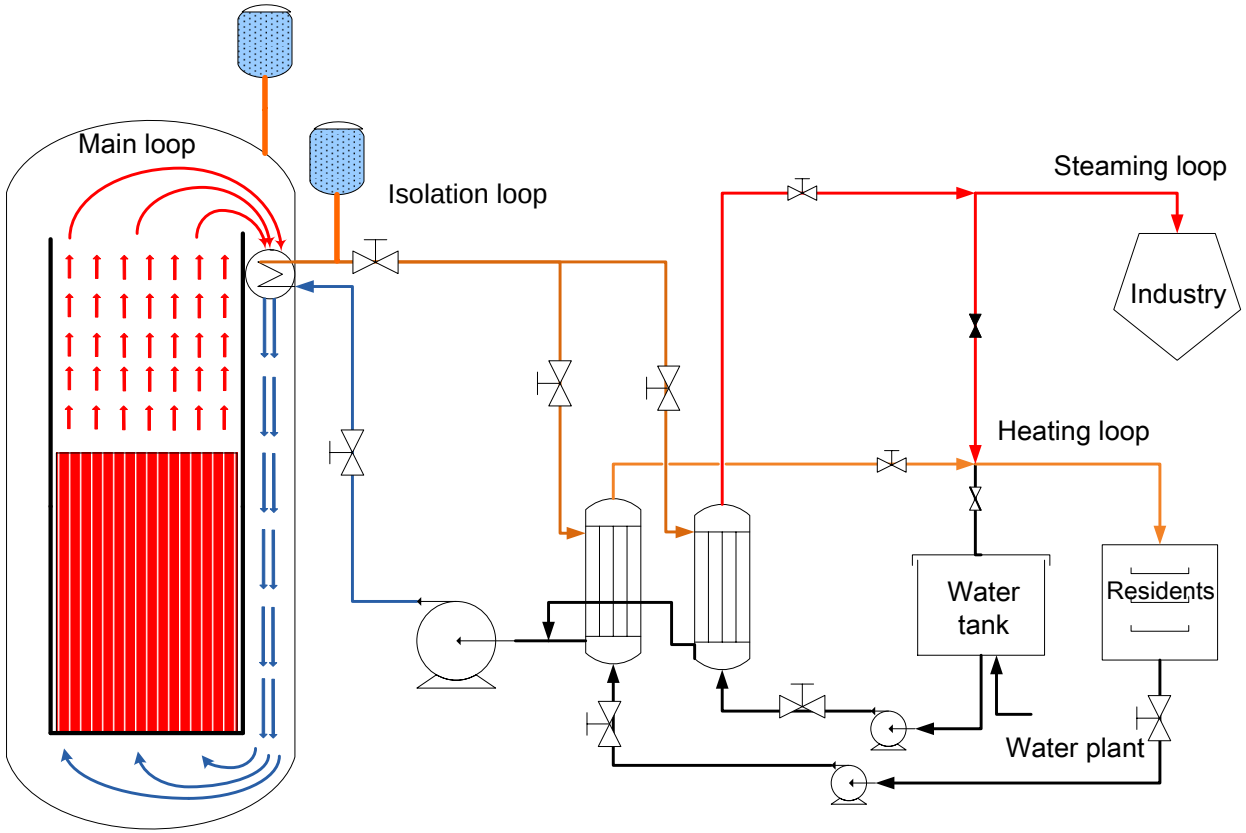
SMR Development Updates

LS-1 Multi-function: civil and industrial heating

Compatible & Extensible & Standardized

1 unit

Heating 3,640,000m²
or Steam 260t/h



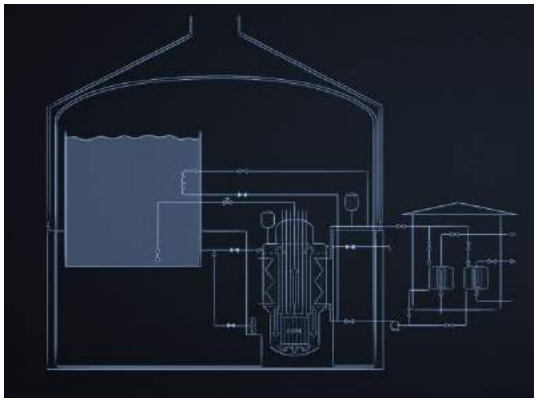
General Parameter	
Thermal Power	200MWt
RCS Pressure	9.0MPa
RCS Tin	200℃
RCS Tout	270℃
Design life	60years
Availability	95%
CDF	< 1×10-7
LRF	< 1×10-8
Refueling Cycle	24Mons

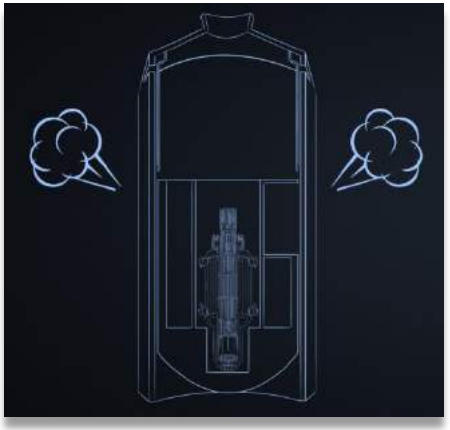
SMR Development Updates

■ LS-1 uses simplified passive design to improve inherent safety and harmonize

● Nearly zero risk

- S-PRHR
- Emergency core cooling
- Air cooling of containment

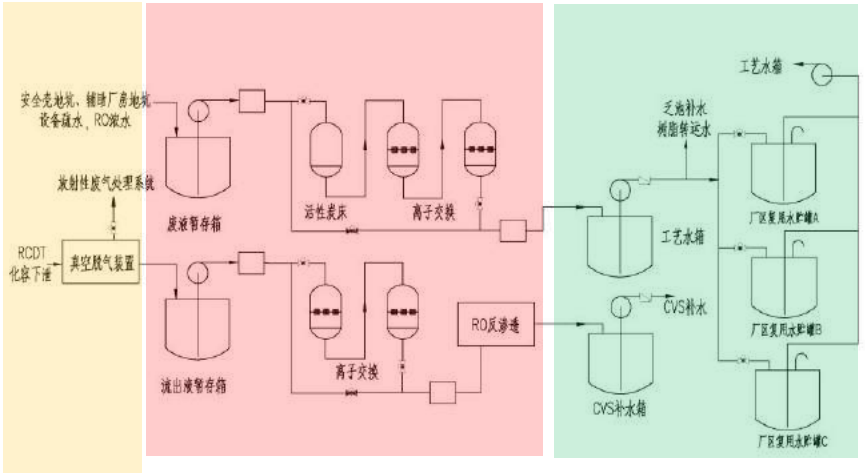




- Almost eliminate the risk of radioactive release and reduce the size of emergency planning zones

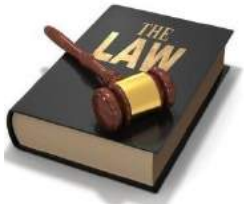
● Nearly zero rad-effluent

- Waste liquid is disposed and reused in the plant during operation , and stored after accident



3 Challenges and Consideration for SMR Development

Regulations & Standards
- Simplification of licensing process
- Reduction of EPZ



Regulations & Standards
- ✓ Positive communication with regulation authorities;
- ✓ Enhance the inherent safety of SMR

Economy
- Economy of Design: SMR is expensive, for its smaller scale with higher cost per KW
- Reduction of personnel on site
- How to improve economic models

Economy
- ✓ Accurate market positioning
- ✓ Simplification of Design
- ✓ Standard Design and batch construction
- ✓ Get close to the users
- ✓ Intelligent technique, remote support to reduce the operator
- ✓ Unified O&M team for reactor groups in a region
- ✓ High reliability for equipment

3 Challenges and Consideration for SMR Development

Operational flexibility

- How to response rapid change of load from users.

Operational flexibility

- ✓ Better fuels and better performance of equipments
- ✓ To better integrate with other renewable energy

Public acceptance

- The issue of public acceptance is extremely important for SMR because of it tends to be closer with users

Public acceptance

- ✓ Better performance with innovation in all areas including site type
- ✓ Propaganda and popularization, better communication

Despite the challenges, SMR especially multipurpose reactors are still viable in the market, the core issue is a breakthrough from zero to one, that requires joint efforts. SNERDI will be committed to SMR development, to promote the use of clean and stable energy and technological progress.

THANK YOU !