The Status and Prospect of SMR in Chinese Mainland

ZHANG Qinghua
China Nuclear Energy Association

2022.07

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01 The Status of SMR in Chinese Mainland

1 The Status of SMR in Chinese Mainland

In order to expand the application scope of nuclear energy, ensure energy security and meet the needs of low-carbon energy development, over the past more than ten years, several investment groups and their subsidiary institutes have being actively developed the small reactor technologies with its own characteristics to satisfy the different purposes and market demands. Most of the SMRs are still in the stage of research and design, and a few have entered or will enter the stage of demonstration project construction.

中国大陆小型模块化反应堆现状和前景

The Status and Prospect of SMR in Chinese Mainland

中国核能行业协会 CHINA NUCLEAR ENERGY ASSOCIATION

1 The Status of SMR in Chinese Mainland

序号	堆型号/Name	堆型/Type	开发单位/Design Company	功率/Power	进展阶段/Status
水冷小堆（陆基）（Land Base）					
1	ACP100	压水堆/PWR	中核集团/CNNC	125MWe	工程示范/Demonstration
2	DHR-400	常压轻水堆/Pool Type LWR	中核集团/CNNC	400MWt	详细设计/Detailed Design
3	NHR-200	压水堆/PWR	中广核-清华/CGN-THU	200MWt	详细设计/Detailed Design
4	和美一号	压水堆/PWR	国家电投/SPIC	200MWt	详细设计/Detailed Design
水冷小堆（海基）（Sea Base）					
5	ACP100S	压水堆/PWR	中核集团/CNNC	100 MWe	详细设计/Detailed Design
6	ACP25S	压水堆/PWR	中核集团/CNNC	25MWe	初步设计/Basic Design
7	ACPR50S	压水堆/PWR	中广核集团/CGN	50MWe	详细设计/Detailed Design

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序号	堆型号/Name	堆型/Type	开发单位/Design Company	功率/Power	进展阶段/Status
高温气冷小堆					
8	HTR-PM	高温气冷堆/HTR	清华-华能/THU-HUANENG	2×100MWe	工程示范/Demonstration
9		车载气冷微堆/GCR(mobile)	中核集团/CNNC	5MWt	概念设计/Concept Design
第 4 部分：快中子小堆					
10	CL-100	铅铋快堆/LFR	中核集团/CNNC	100MWe	总体设计/General Design
11	CLEAR	铅铋快堆/LFR	中科院/CAS		概念设计/Concept Design
12	CLFR-100	铅铋快堆/LFR	中广核/CGN	100 MWe	概念设计/Concept Design
13	BLESS-D	铅铋快堆/LFR	国家电投/SPIC		概念设计/Concept Design
第 5 部分：熔盐小堆					
14	TMSR-LF1	熔盐堆/MSR	中科院/CAS	2MWt	工程示范/Demonstration

02 Prospect of Market Applications

2 Prospect of Market Applications

(1) Replace the outdated thermal power capacity

In reaching low-carbon energy economy, SMRs have a wide of needs and prospect in various areas, and play an important role potentially.

During "*the Thirteenth Five-Year Plan*" period, 150 GW of coal-fired power capacity will be suspended or postponed nationwide, and over 20 GW of outdated capacity will be eliminated. In particular, it is necessary to eliminate and shut down coal-fired power generating units below 300MW that do not meet the requirements, and include the enterprise's coal-fired self-provided units into the scope of elimination;

At this stage, the use of SMR technology to replace small thermal power technology on site is basically mature, and the prospects is promising. As this kind of replacement is a very new, affected by the factors of economics, public concerns, etc., its' market exploration will be pushed.

- **适用堆型/Candidate reactor: ACP100（玲龙一号）、HTR-PM-200等。**

2 Prospect of Market Applications

(2) Living and industrial heating

Based on statistics, the total heating supply continued growing during 2013-2019. In 2019, the steam heating supply amounted up to approximately 0.651 billion GJ, an increase of 12.71% over 2018; the total amount of hot water heating was approximately 3.275 billion GJ, an increase of 1.18% over 2018;

	2013	2014	2015	2016	2017	2018	2019
蒸汽供热总量（亿吉焦）	5.32	5.56	4.97	4.15	5.80	5.77	6.51
热水供热总量（亿吉焦）	26.65	27.65	30.21	31.80	31.03	32.37	32.75
蒸汽供热总量同比增速（单位：%）		4.46	-10.63	-16.50	39.72	-0.44	12.71
热水供热总量同比增速（单位：%）		3.78	9.24	5.27	-2.43	4.31	1.18

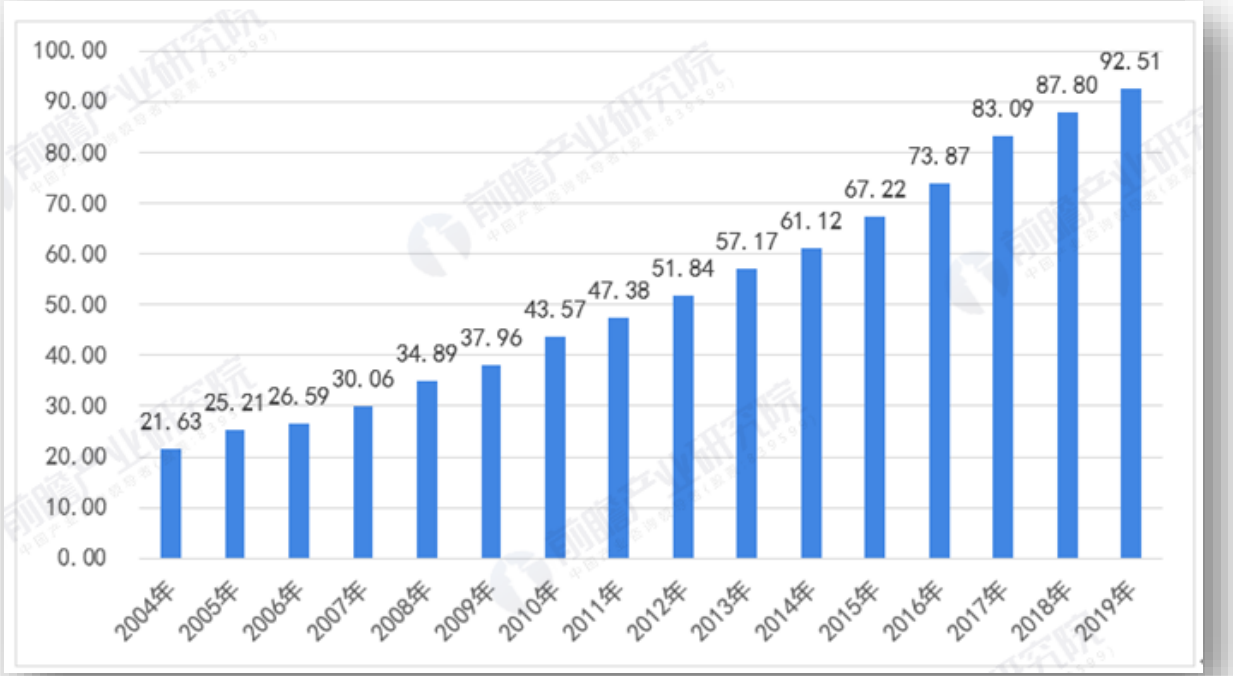
China Heating Supply 2013-2019 (10^9GJ)

2 Prospect of Market Applications

(2) Living and industrial heating

❑ Heating area

- The existing central heating area in northern region is about 13.1 billion square meters, about 11 billion square meters in urban areas, the central heating ratio is about 85%.
- the residential building area is 8.2 billion square meters, accounting for 75%; the public building area 2.8 billion square meters, accounting for 25%;
- With the trend of urbanization, the areas needing heating in northern region is increasing.



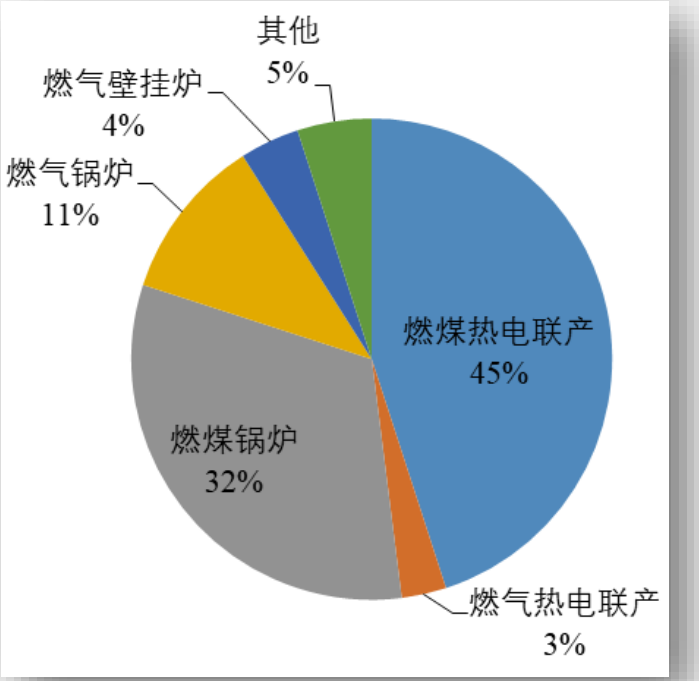
Change of City Central Heating Area in China 2004~2019 (10^9GJ)

2 Prospect of Market Applications

(2) Living and industrial heating

❑ Heating source

- The heating source of urban central heating in my country has basically formed a pattern in which cogeneration is the mainstay, the regional boiler room is supplemented, and other heat sources are supplemented.
- 80% of the heat source charcoal uses coal as the main fuel, and coal-fired boilers, gas-fired boilers and coal-fired cogeneration are the main heating methods.
- coal-fired combined heat and power accounting for 45%, coal-fired boilers for 32%, gas-fired boilers for 11%, and the rest from other sources.
- Over 50% of outdated production capacity with high pollution and low efficiency;



Heating source structure in Northern China in 2016

2 Prospect of Market Applications

（2） Living and industrial heating

❑ Heating source

Nuclear energy heating technology is mature and has a broad market. It has broad application prospects in the field of low-carbon heating, but whether it can be adopted depends on many factors, such as public safety concerns, price acceptance, and the attitudes of governments at all levels are the main challenges.

➢ 适用堆型/Candidate reactor： Hemei One和美一号、 NHR200-II、 DHR-400等。

2 Prospect of Market Applications

（3）Seawater desalination and hydrogen production

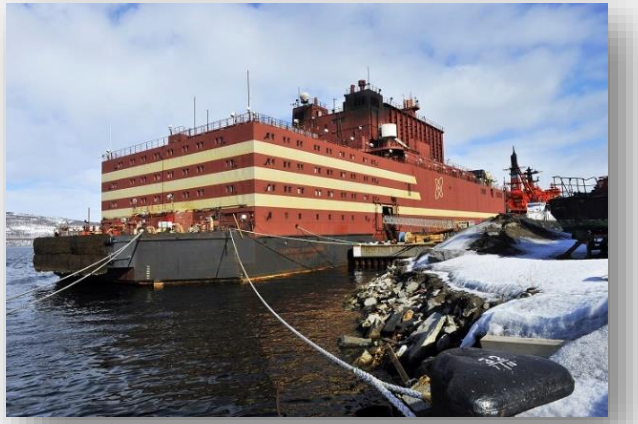
- Water resources in Northern China and some coastal areas are seriously insufficient, mainly in Northern China, some coastal and provincial capital cities and industrial cities. Six provinces and autonomous regions have water resources per capita below 500 cubic meters.
- Desalination market room is very large, and the technology is mature;
- Hydrogen production has a outstanding prospects at home and abroad, and hydrogen will be widely used in the future energy market. HTR(VHTR) has advantages in this respect, but is expected to be after 2030 in China;

➢ **适用堆型/Candidate reactor: HTR-PM-200、ACP100、和美一号Hemei One等。**

2 Prospect of Market Applications

(4) Ocean development energy supply

- China has a large number of islands, with a total area of over 6,600 square kilometers and a population of over 7.4 million. The state has formulated policies on Hainan development, to efficiently explore the sea island resources.
- Small on-land reactors and offshore floating nuclear power platforms are important options for energy supply to achieve the above goals. They can provide both electricity and process steam, and also be used for desalination, with advantages of small investment scale, flexible configuration, no need for off-site power supply, safe, suitable for isolated island operation;



➢ 目前正在开发的堆型Under Design：ACPR50S、 ACP100S等。

03 SMRs started or planned

3 SMRs started or planned

(1) ACP100

At present, the Hainan Changjiang multi-purpose SMR technology demonstration project ACP100 has started construction in last July. The reactor has a power of 125 MWe and a construction period of 58 months. It can be used for power generation, combined heat and power, etc.

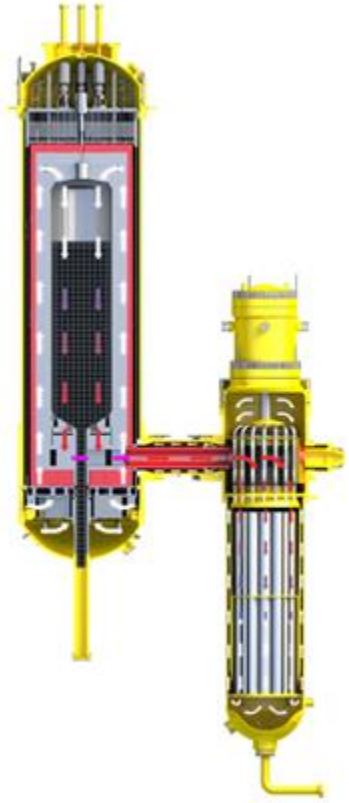
Main Parameter

MAJOR TECHNICAL PARAMETERS	
Parameter	**Value**
Technology developer, country of origin	CNNC(NPIC/CNPE) China
Reactor type	Integral PWR
Coolant/moderator	Light water / light water
Thermal/electrical capacity, MW(t)/MW(e)	385 / 125
Primary circulation	Forced circulation
NSSS Operating Pressure (primary/secondary), MPa	15 / 4.6
Core Inlet/Outlet Coolant Temperature (°C)	286.5 / 319.5
Fuel type/assembly array	UO_2/17x17 square pitch arrangement
Number of fuel assemblies in the core	57
Fuel enrichment (%)	<4.95
Core Discharge Burnup (GWd/ton)	<52 000
Refuelling Cycle (months)	24
Reactivity control mechanism	Control rod drive mechanism (CRDM), Gd_2O_3 solid burnable poison and soluble boron acid
Approach to safety systems	Passive
Design life (years)	60
Plant footprint (m^2)	200 000
RPV height/diameter (m)	10 / 3.35
RPV weight (metric ton)	300
Seismic Design (SSE)	0.3g
Fuel Cycle Requirements or Approach	Temporarily stored in spent fuel pools
Distinguishing features	Integrated reactor with tube-in-tube once through steam generator, nuclear island underground
Design status	Detailed design

3 SMRs started or planned

(2) HTR-PM-200

Huaneng Shidao Bay High-temperature Gas-cooled Reactor Demonstration Project was launched in Rongcheng, Shandong province with the installed capacity of 200 MW(2*250MWt) in Dec. 2012. Adopted a pebble-bed modular high-temperature gas-cooled reactor, the primary heat carrier is helium, the core inlet temperature is 250 ℃, and the outlet helium temperature is 750℃. Mature superheated steam turbine failure cycle scheme is adopted on the conventional island, with two reactors and one machine.



主要参数/Main Parameter

项目/Items	参数/Parameter
热功率/Thermal capacity	2*250MWt
电功率/Electrical capacity	211MWe
堆芯直径/Core Diameter	3m
堆芯高度/Core Height	11m
氦气压力/N2 Pressure	7MPa
堆芯出口温度/Core Outlet Temperature	750℃
堆芯进口温度/Core Inlet Temperature	250℃
主蒸汽温度/Main Steam Temperature	500-570℃
主蒸汽压力/Main Steam Pressure	11-13.5MPa

3 SMRs started or planned

Research on large-scale steam supply or combined heat and power supply of multi-module High Temperature Gas-cooled Reactor

latest progress

- 2021.8.21 Started the first loading
- 2021.9.12 Unit 1 reached the first criticality
- 2021.9.28 Completed the first criticality under normal working medium helium atmosphere
- Grid-connected power generation)
- put into commercial operation)

3 SMRs started or planned

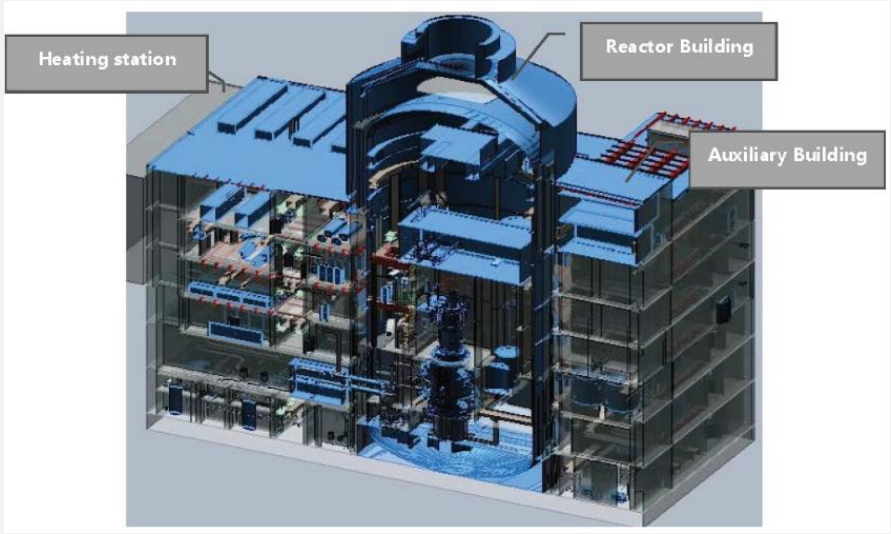
Research on large-scale steam supply or combined heat and power supply of multi-module High Temperature Gas-cooled Reactor

- In recent years, China Nuclear Energy Technology Co., Ltd. has carried out research on high-temperature gas-cooled reactor heating plan based on the technology verified by HTR-PM.
- A multi-module High-temperature Gas-cooled Reactor heating technology plan that can be used for project implementation and meet independent operation and maintenance requirements has been preliminarily formed, which can be used for large-scale steam production and supply or combined heat and power.
- Multi-modules are used to meet the requirements of independent operation and maintenance of load and heating modules, as well as failure backup, etc., to achieve high-reliability and uninterrupted high-temperature steam supply.

3 SMRs started or planned

(3) Hemei One

参数		单位	数值
堆芯额定功率/Core Power		MWt	200
电厂设计寿命/Design Life		年/a	60
换料周期/Refuelling Cycle		月/month	24
堆芯损伤频率/CDF		1/堆年	$< 1\times10^{-7}$
大量放射性物质释放频率/LRF		1/堆年	$< 1\times10^{-8}$
反应堆冷却剂系统正常运行压力/RCS Operating Pressure		MPa(a)	9.0
堆芯出口温度/Core Outlet Temperature		℃	272
堆芯入口温度/Core Inlet Temperature		℃	202
供热回路/Heating Supply Circuit	供汽出口温度/Steam Supply Temperature	℃	240
	供汽出口压力/Steam Supply Pressure	MPa(a)	1.3
	供水出口温度/Water Supply Temperature	℃	120
	供水出口压力/Water Supply Pressure	MPa(a)	1.2

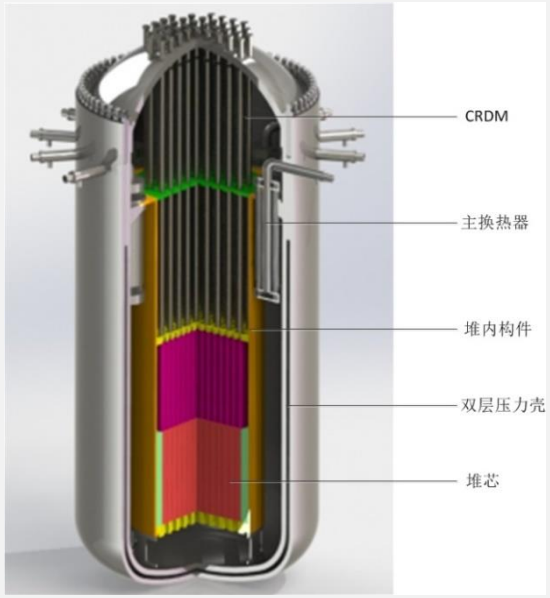


The Hemei One, as a nuclear heating demonstration project in Jiamusi, is progressing smoothly. It is planed to build a 4×200 MWt integrated heating reactor, 2×200MWt per phase, the maximum heating capacity is 8 million square meters, or the gas supply 500 tons/hour, with a construction period of 36 months.

3 SMRs started or planned

(4) NHR200-Ⅱ

NHR200-II, its preliminary work of low-temperature heating reactor demonstration project in Guizhou, is progressing actively and orderly. It is planed to build 6 NHR200-II units, 2 units per phase. The first one is scheduled to start construction in Dec. 2022, will be the first commercial application of comprehensive nuclear energy utilization and low-temperature heating technology.

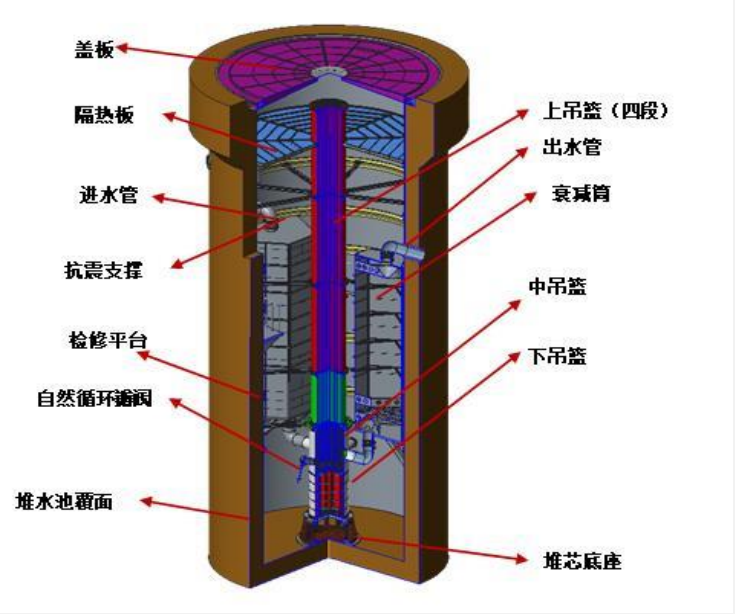


参数名称	单位	数值
热功率/电功率 Thermal & Electrical Capacity	MWt/MWe	200/50
反应堆设计寿期 Design Life	a	60
反应堆冷却剂工作压力/RCS Operating Pressure	MPa	8.0
堆芯入口/出口温度 Core Inlet/Outlet Temperature	℃	232/280
中间回路工作压力 Middle Circuit Pressure	MPa	8.8
蒸汽发生器出口蒸汽压力 SG Outlet Steam Pressure	MPa	1.6
蒸汽发生器出口蒸汽温度 SG Outlet Steam Temperature	℃	201.4
蒸汽产量（额定工况） Steam Flowrate(normal operation)	t/h	323
燃料组件总数 Number of Fuel Assemblies	盒	208

3 SMRs started or planned

(5) DHR-400

DHR-400 demonstration project is being carried out in Liaoyuan, Jilin Province. The heating area of a single unit is about 10 million square meters. It is planned to achieve FCD in 2022 and be completed and put into operation in 2024.



MAJOR TECHNICAL PARAMETERS	
Parameter	**Value**
Technology developer, country of origin	China National Nuclear Corporation (CNNC), China
Reactor type	Pool type reactor
Coolant/moderator	Light water / light water
Thermal/electrical capacity, MW(t)/MW(e)	400 / *does not produce electricity*
Primary circulation	Forced circulation
NSSS Operating Pressure (primary/secondary), MPa	0.3 (Core inlet pressure)
Core Inlet/Outlet Coolant Temperature (°C)	68 / 98
Fuel type/assembly array	UO_2 pellet / 17x17 square
Number of fuel assemblies in the core	69
Fuel enrichment (%)	< 5.0
Core Discharge Burnup (GWd/ton)	30
Refuelling Cycle (months)	10
Reactivity control mechanism	Control rod drive mechanisms
Approach to safety systems	Inherent safety features with large water volume in the reactor pool
Design life (years)	60
Plant footprint (m^2)	40 000
Pool depth/diameter (m)	26 / 10
Seismic Design (SSE)	0.3g
Distinguishing features	Coupling with desalination and radioisotope production
Design status	Basic design

04 Challenges

4 *Challenge*

1) Laws and Regulatory

At present, a relatively complete set of regulations and standards applicable of SMR development and user requirements has not been established, including:

1 SMRs safety requirements and permit approval;

2 Industry standard for SMR design;

3 SMR emergency policy and source term and emergency area determination;

4 Safeguard and Security Policies for SMR.

4 Challenge

2) Safety and Economics

□ Safety

SMR ‘s safety features can offer better protection for the public and the investors. Safety must be ensured to avoid radiation effects on the general public and losses for the investors to dampen their enthusiasm for investment. SMR’ s advanced safety features can effectively prevent and mitigate severe accidents, reducing, if not eliminating the needs for external interventions. SMR is a new technology in close proximity to the public, so it’ s only natural that people are more concerned with and tend to have higher requirements for their safety.

4 Challenge

2) Safety and Economics

□ Economics

Improve its economics to compete with other zero-carbon electricity and heat generations. Still challenging, but can be improved with technological innovation, simplification of the system, standardization, scaled development, modularization, factory pre-fabrication and on-site assembly.

□ Service and Support from Supply Chain

SMR suppliers can offer excellent and effective services to the owners to ensure excellent and safe O&M.

More efforts are needed to improve the acceptance of SMRs by the public and by the market. A successful demo project is key.

4 Challenge

3) Increase R&D investment

- Fuel, esp. for long refueling cycles
- High temperature and radiation resistance fuel
- Software for design and safety analysis and V&V
- Application of AI and other advanced technologies in SMRs

The SMRs in China will Have Good Opportunities to Contribute in Clear Energy of China's Zero Carbon Economy

Thanks for your Attentions

CAREM PROJECT
DESIGN AND STATUS

Ignacio de Arenaza
ignaciodearenaza@cnea.gob.ar

CAREM Management / National Atomic
Energy Commission of Argentina

CAREM25

April 2022
Buenos Aires, Argentina

Comisión Nacional
de Energía Atómica

NUCLEAR GENERATION IN ARGENTINA

CAREM SMR PROTOTYPE
32 MWe gross

EMBALSE: 648 MW

CANDU

ATUCHA I: 347 MW

ATUCHA II: 745 MW

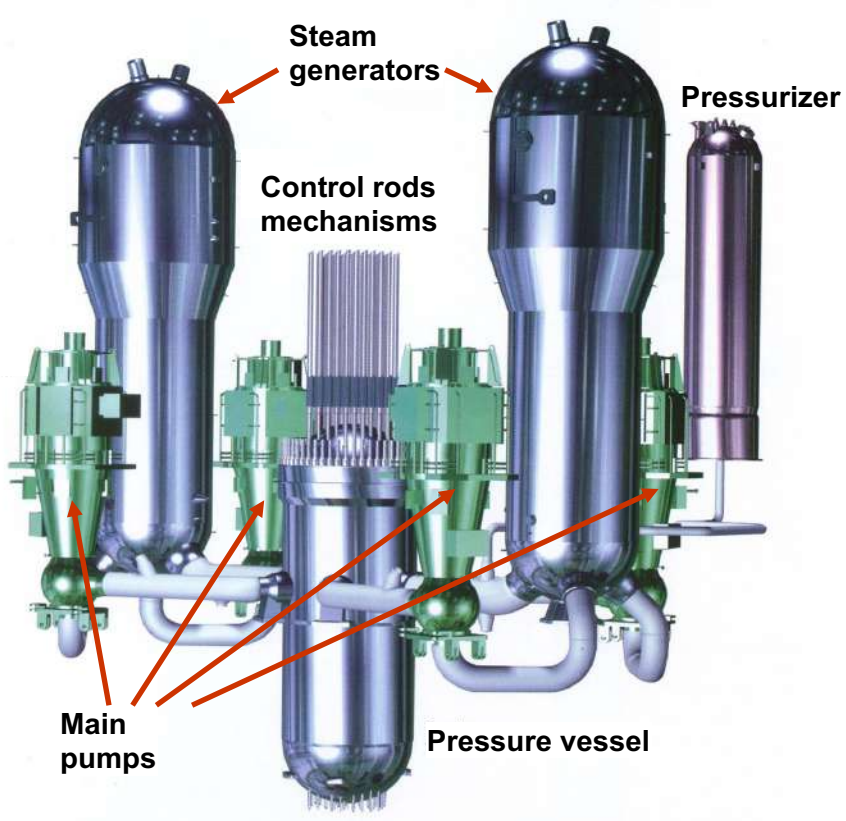
PHWR
type

CAREM: THE ARGENTINIAN SMR

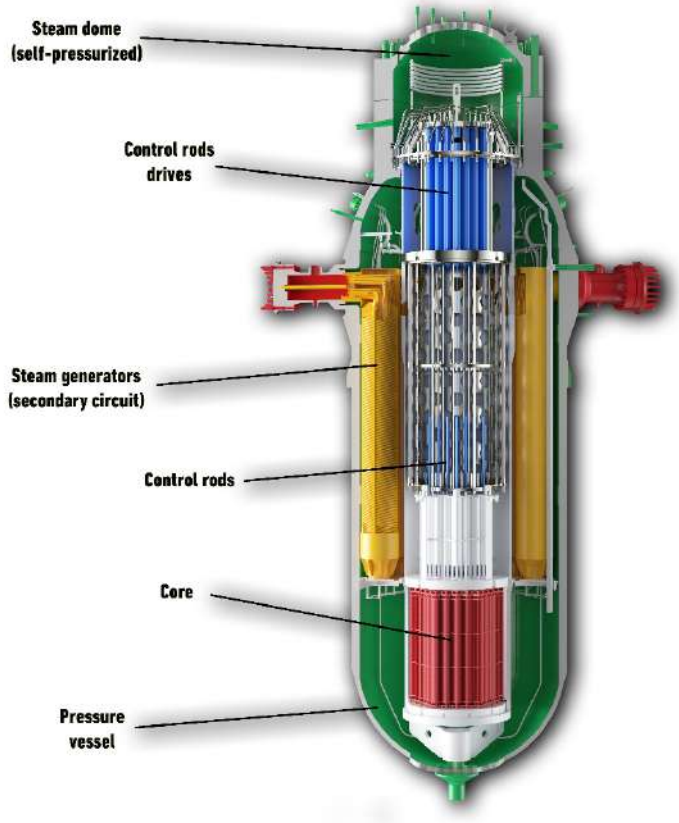
Aims of the prototype

- ✓ To qualify the concept and all the systems
- ✓ To develop capabilities within the CNEA and the national companies.
- ✓ To repeat the success obtained with the Research and Multipurpose Reactors exportation
- ✓ To include NPPs designed and built in Argentina in the national electrical grid.

COMPARISON: CLASSIC PWR / CAREM



CLASSIC PWR

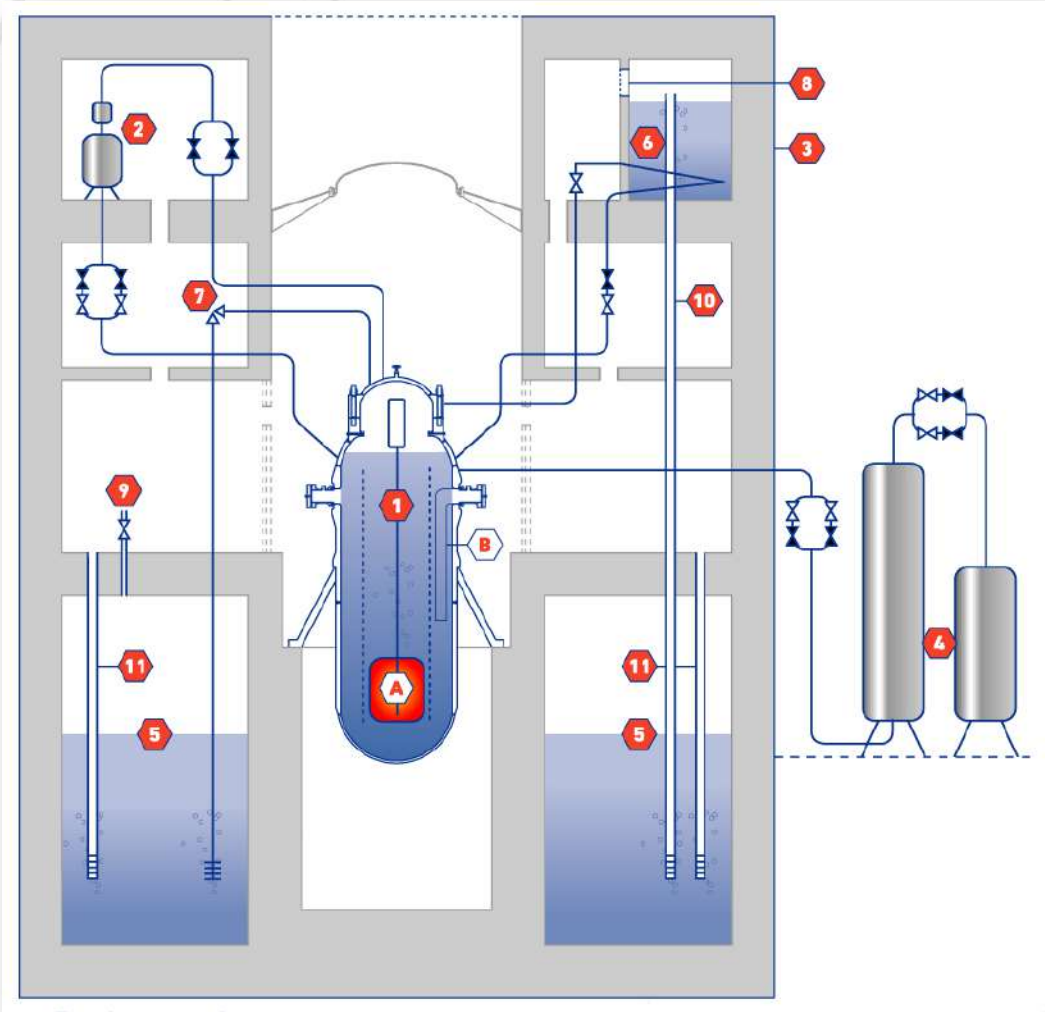


CAREM

CAREM Prototype

- ✓PWR type (32 MWe)
- ✓Passive safety systems
- ✓Integrated Primary System
- ✓Natural circulation
- ✓Self-pressurized
- ✓Enriched UO2 fuel (3,1 and 1,8%)

PASSIVE SAFETY SYSTEMS

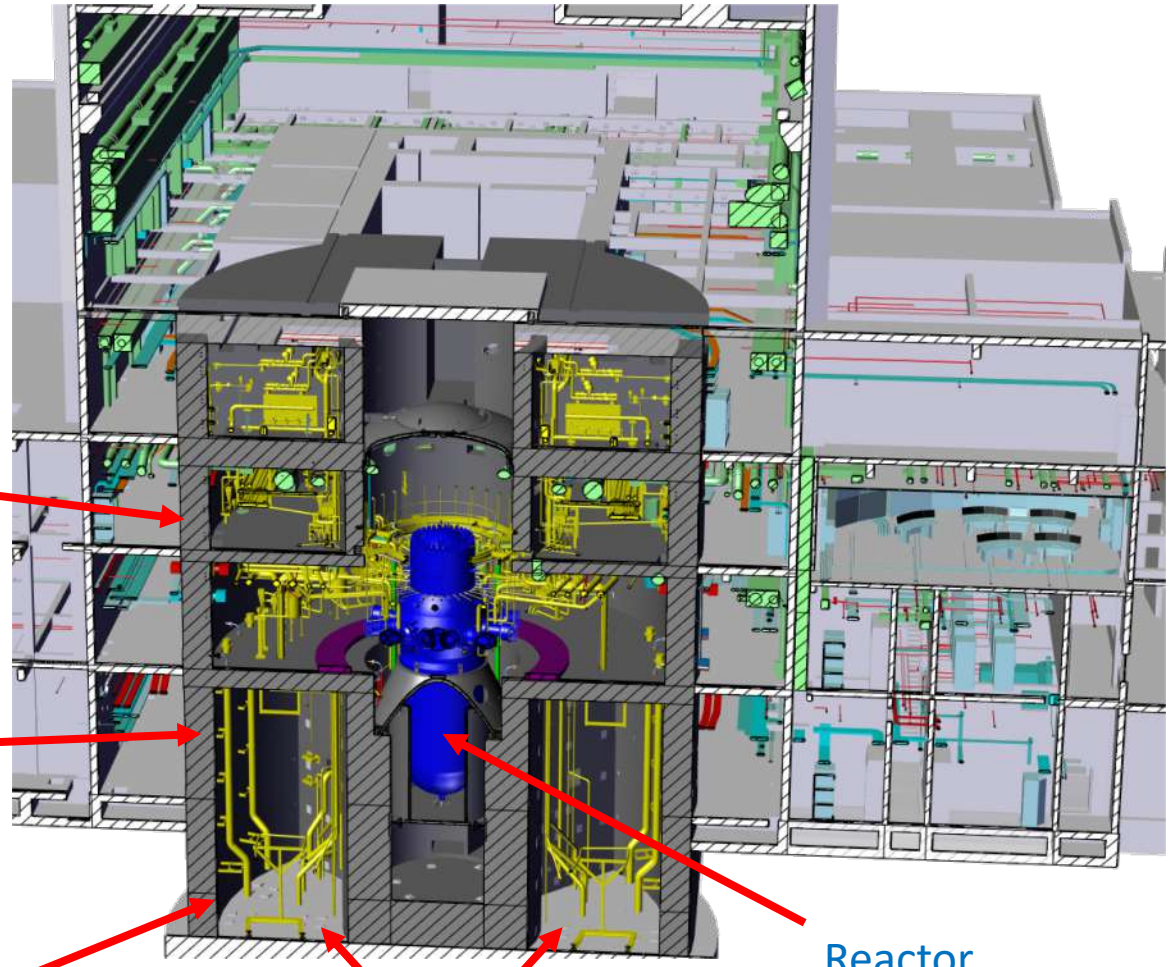


A) Core (hot source)
B) Steam generators (cold source)

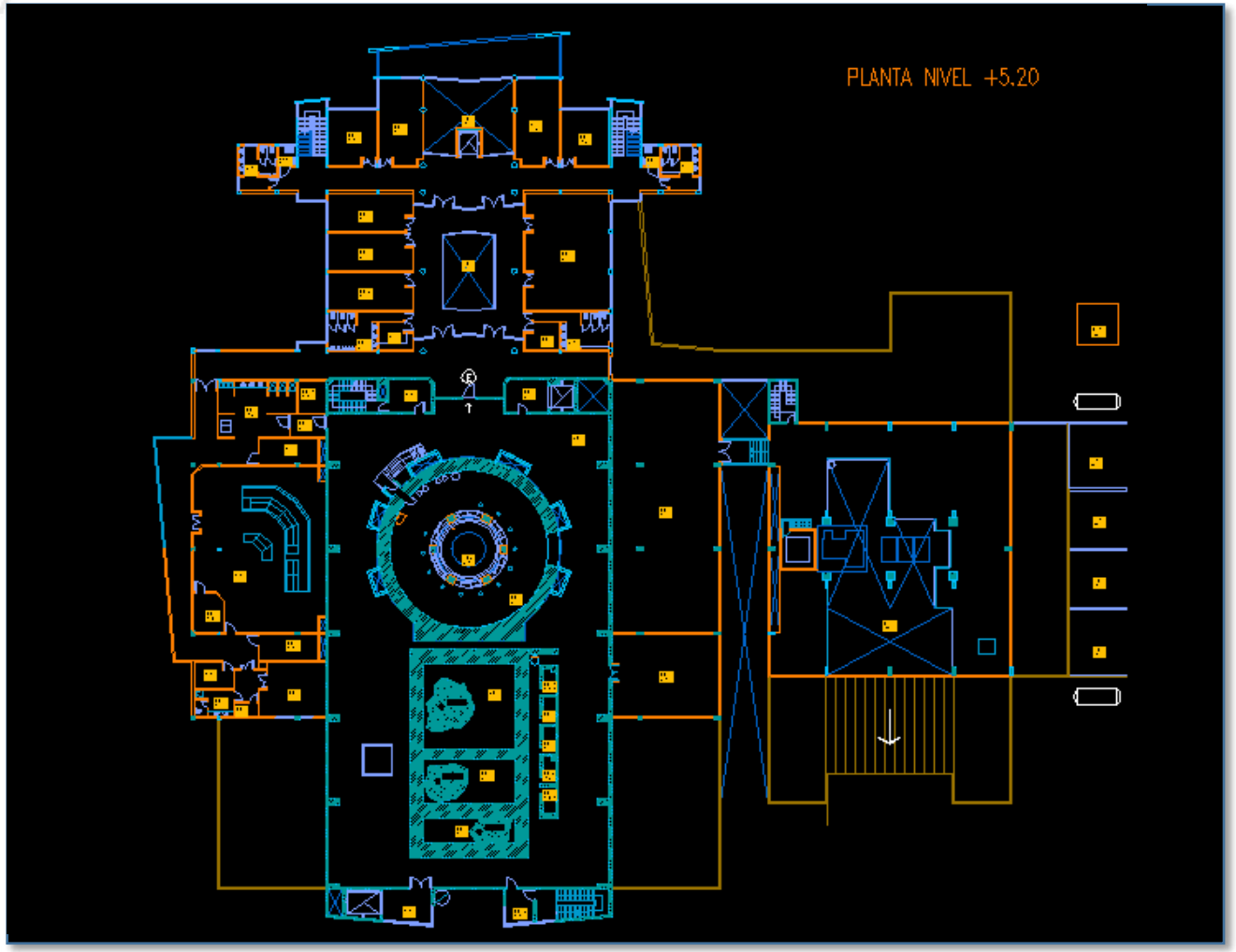
1) Safe Shutdown System
2) Diverse Shutdown System
3) Containment building
4) Medium Pressure Injection System
5) Pressure Suppression Pool
6) Removal Heat Decay System
7) RPV relief valve
8-11) Containment building pressure equalizer

≥ 36HR PASSIVE CAPABILITY

REACTOR BUILDING AND CONTAINMENT

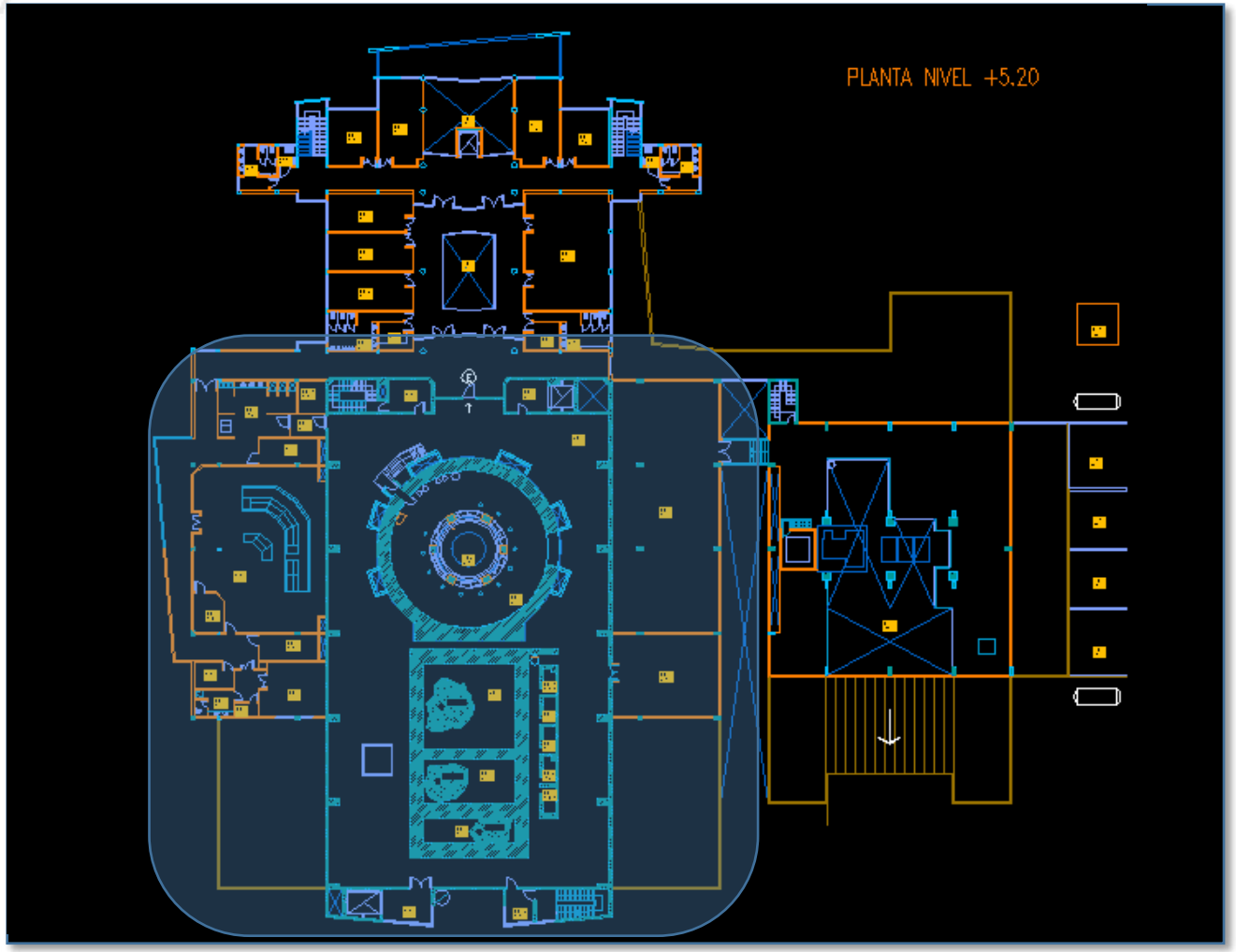


CAREM PROTOTYPE BUILDING LAY OUT



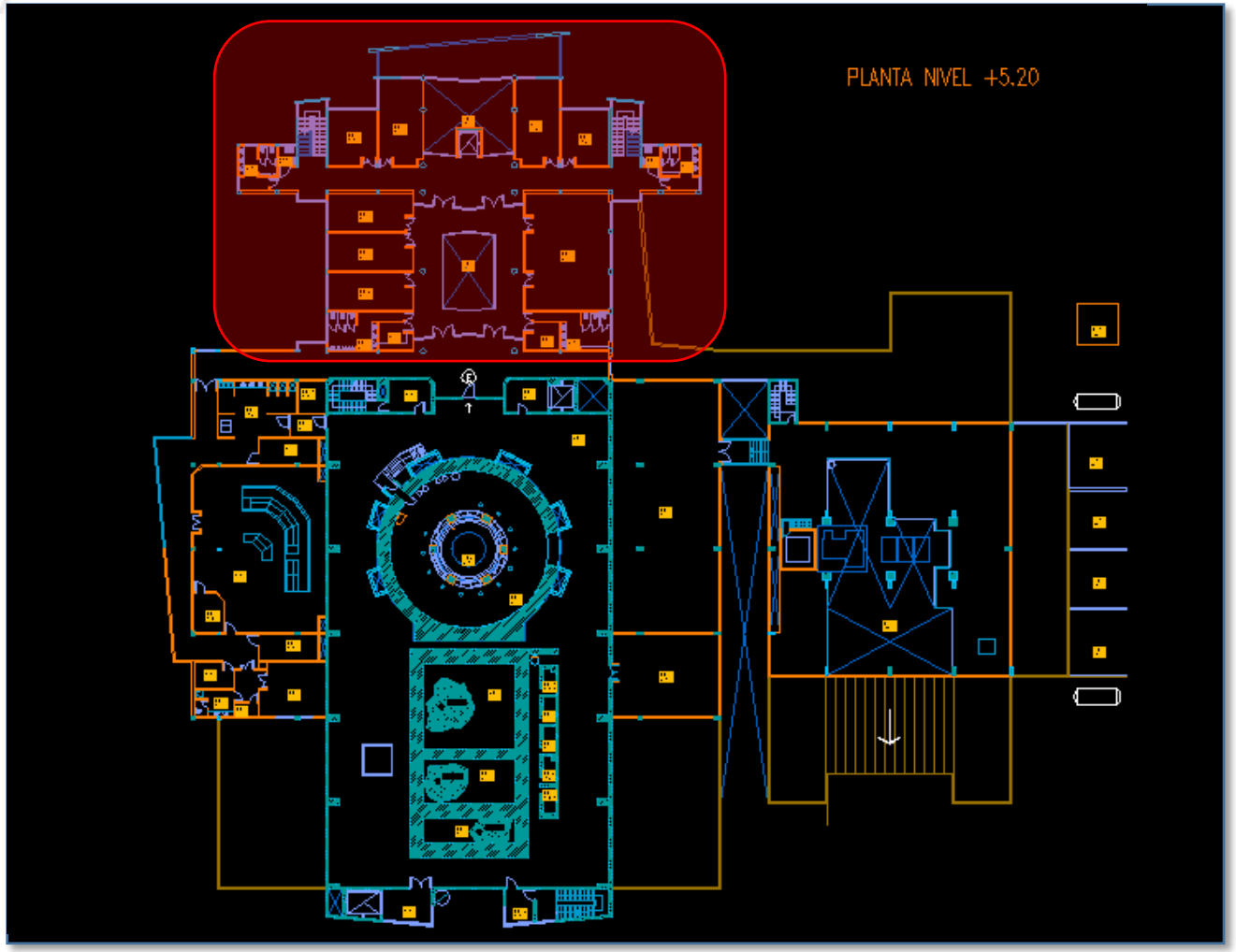
CAREM PROTOTYPE BUILDING LAY OUT

- **Reactor Building**
  - Containment
  - Spent Fuel Pool
  - Safety & Process Systems
  - Control Room



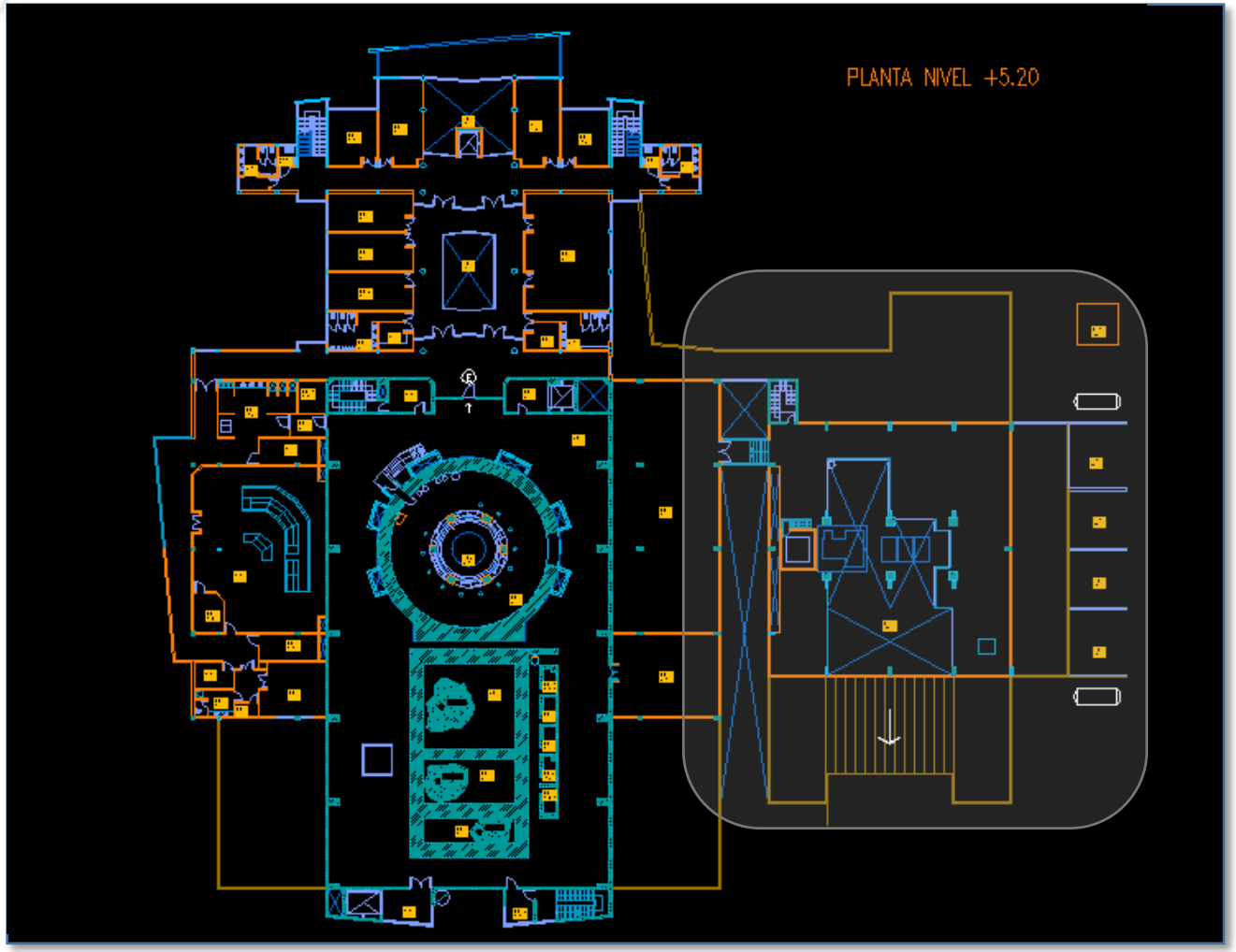
CAREM PROTOTYPE BUILDING LAY OUT

- **Service Building**
  - Offices
  - Changing rooms
  - Emergency Control Room
- **Reactor Building**
  - Containment
  - Spent Fuel Pool
  - Safety & Process Systems
  - Control Room



CAREM PROTOTYPE BUILDING LAY OUT

- **Service Building**
  - Offices
  - Changing rooms
  - Emergency Control Room
- **Reactor Building**
  - Containment
  - Spent Fuel Pool
  - Safety & Process Systems
  - Control Room



- **Turbine Building**

BALANCE OF PLANT:
- Turbine
- Electric generator
- Condenser

Main contractors

CNEA is in charge of the project, performing all the basic engineering, the detailed engineering inside the containment, leading the civil works and the complete administration.

NUCLEOELÉCTRICA ARGENTINA S.A.	Civil Works on the nuclear building
CONUAR FAE	Reactor internals including steam generators and control rod drives. Fuel assemblies
IMPSA	Reactor Pressure Vessel Other qualified metal-mechanical components
INVAP	Reactor Protection System Detailed engineering of some process systems

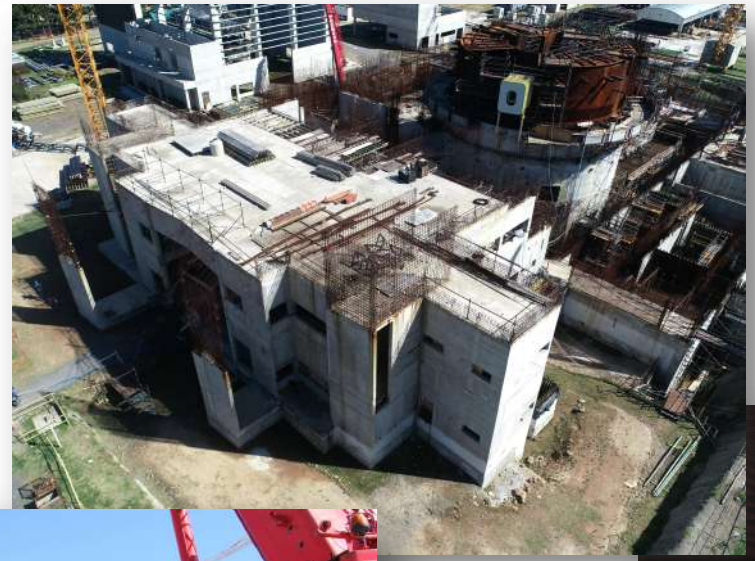
- ✓ Over 1000 Argentinean companies have provided engineering, services and components.
- ✓ Today we have 120 ongoing contracts. 800+ people working overall.
- ✓ Goal of 70% of national integration in Argentina for the prototype.

CAREM PROTOTYPE STATUS: REACTOR BUILDING

CAREM PROTOTYPE STATUS: REACTOR BUILDING

CAREM PROTOTYPE STATUS: REACTOR BUILDING

ESTIMATED PROGRESS: 70%



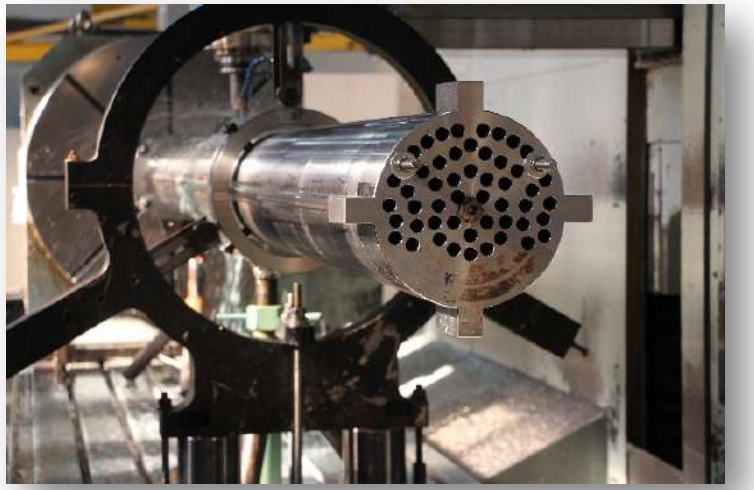
CAREM PROTOTYPE STATUS: CONTAINMENT LINER

ESTIMATED PROGRESS: 90%

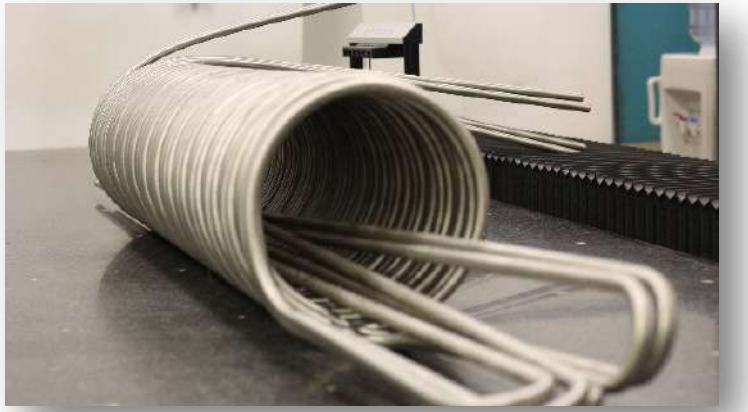
CAREM PROTOTYPE STATUS: REACTOR PRESSURE VESSEL

ESTIMATED PROGRESS: 65%

CAREM PROTOTYPE STATUS: STEAM GENERATORS

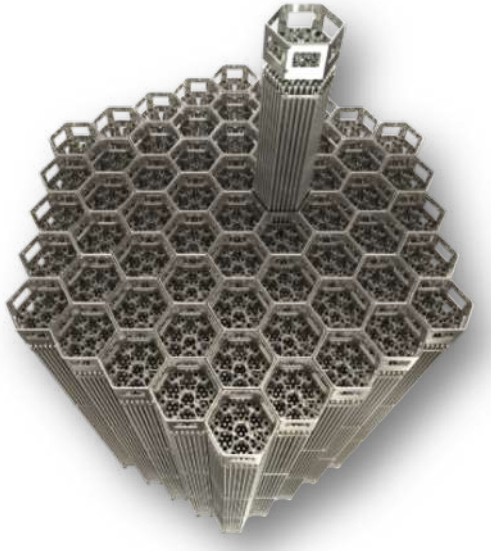


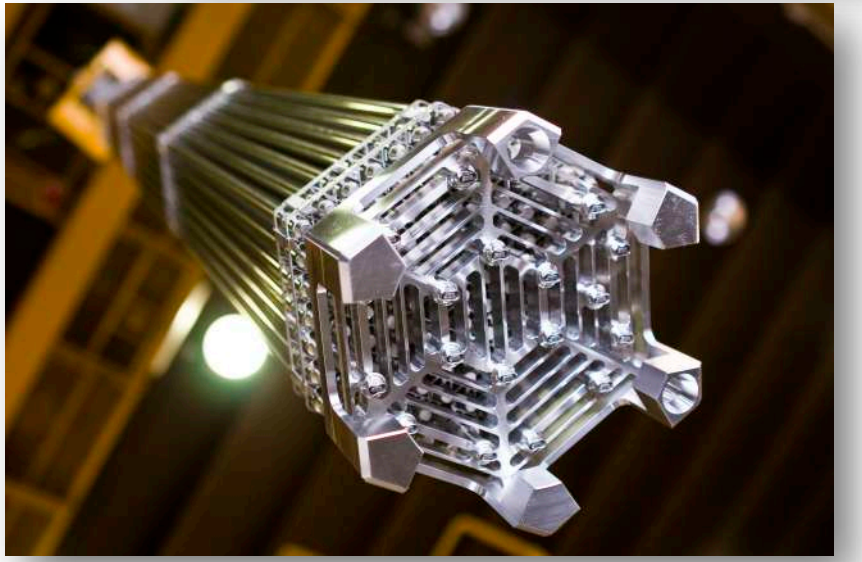
ESTIMATED PROGRESS: 52%



CAREM PROTOTYPE STATUS: FUEL ASSEMBLIES

ESTIMATED PROGRESS: 56%





CAREM PROTOTYPE STATUS: OVERALL PROGRESS

Phases	Accumulated physical progress (%)
CNEA facilities	100,00%
Site preparation	100,00%
Design	93,42%
Supplies	58,06%
Construction	73,46%
EM assembly	0,67%
Start up	0%
TOTAL	**59,79%**

** Updated 2021_12-31*

THANK YOU!

Comisión Nacional
de Energía Atómica

argentina.gob.ar/cnea

proyectocarem@cnea.gov.ar

ACP100 Design and Project Progress

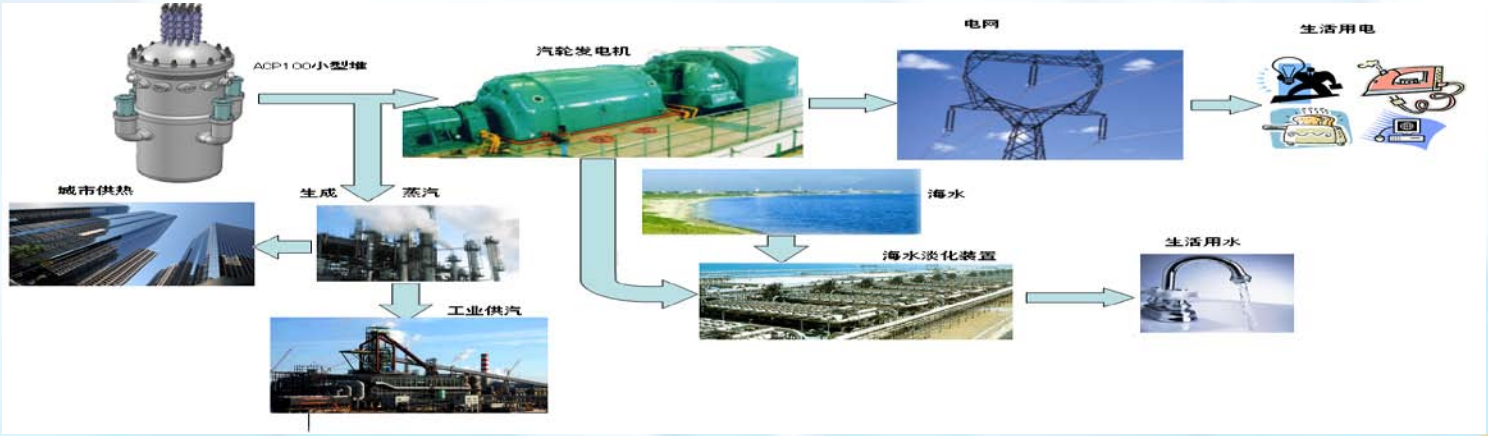
Nuclear Power Institute of China

7/12/2022

CONTENTS

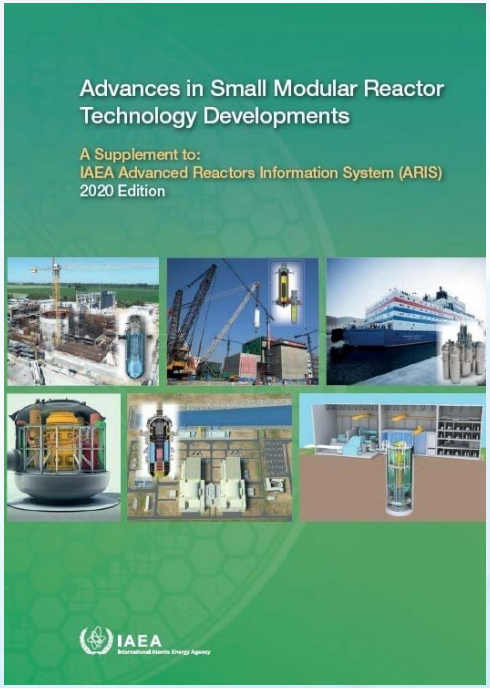
Background

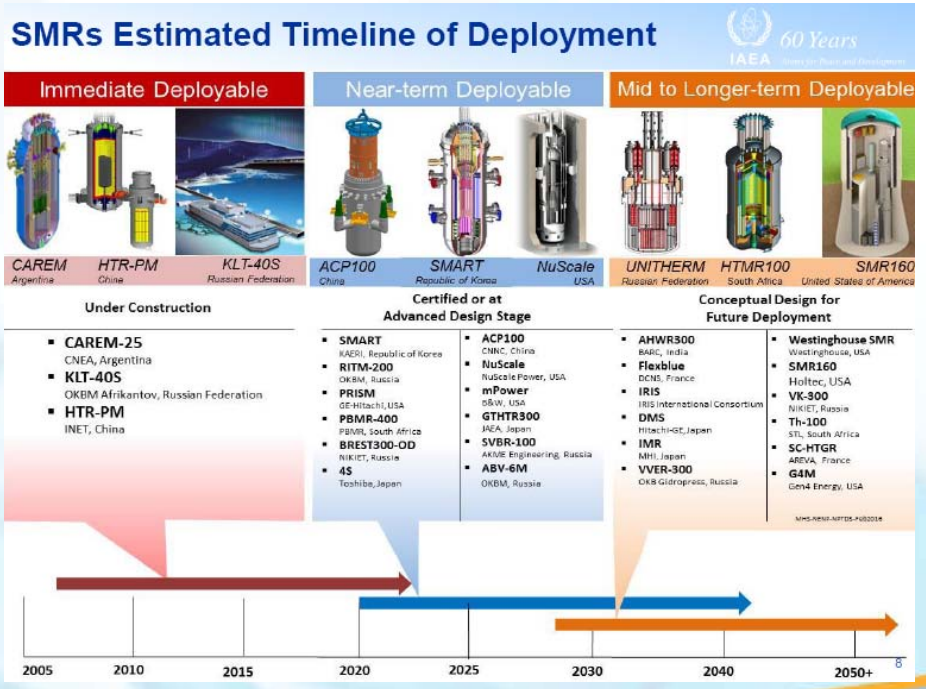
- *SMR is suitable for small electricity grid, district heating, process heating supply, seawater desalination. According to different condition, different countries have different goals.*



Background

- **Main developed and innovated SMR in different countries**
  - **2020 SMR book gives 72 reactors in 18 countries, 1/3 are PWR, and most of them are integrated reactor**





Introduction of ACP100

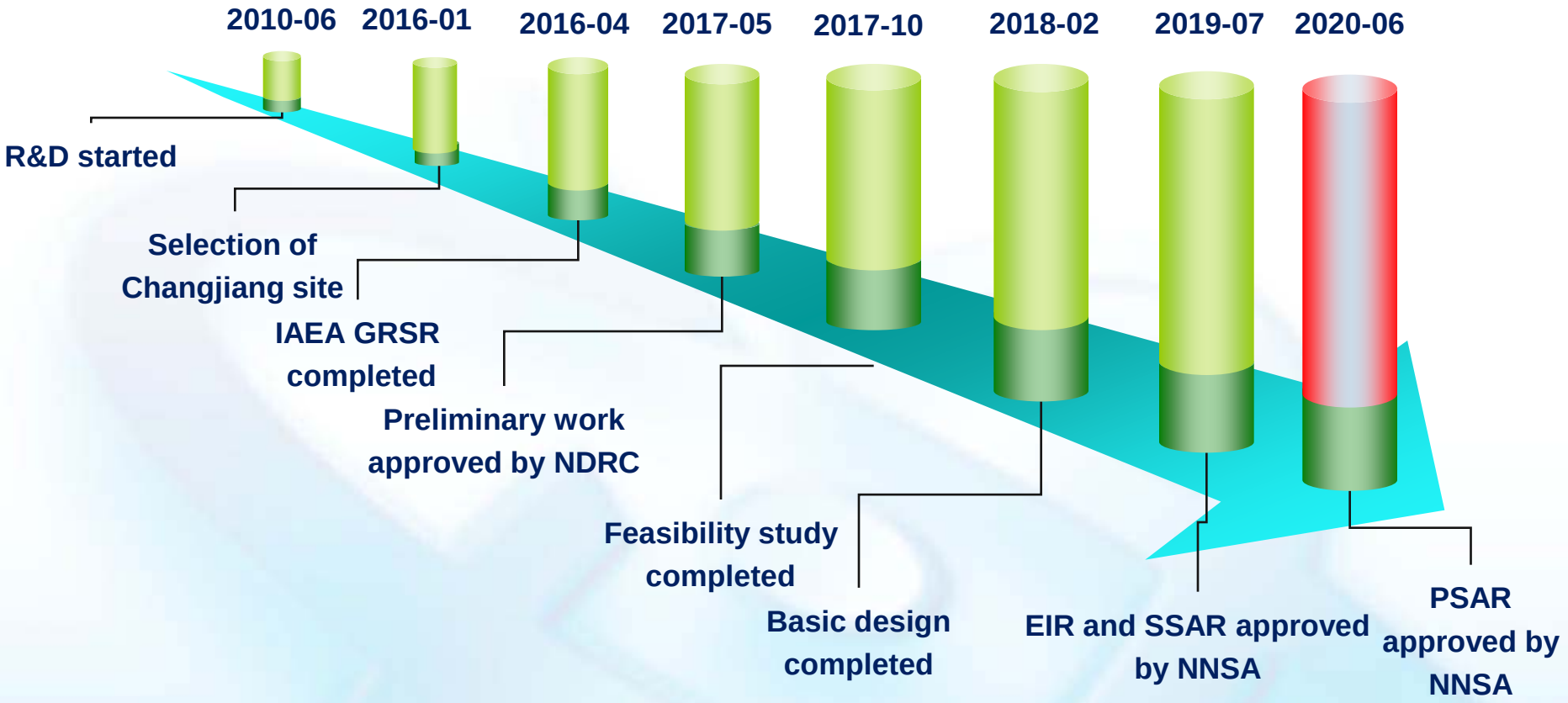
- *CNNC SMR, named ACP100, is an innovative PWR based on existing PWR technology , adapting "passive" safety system and "integrated" reactor design technology*

- *CNNC stared R&D on ACP100 from 2010*

- *The modular design technique is used to control the product quality and shorten the site construction period.*

Introduction of ACP100

Roadmap of ACP100 development



Design parameters of ACP100

Main design parameters

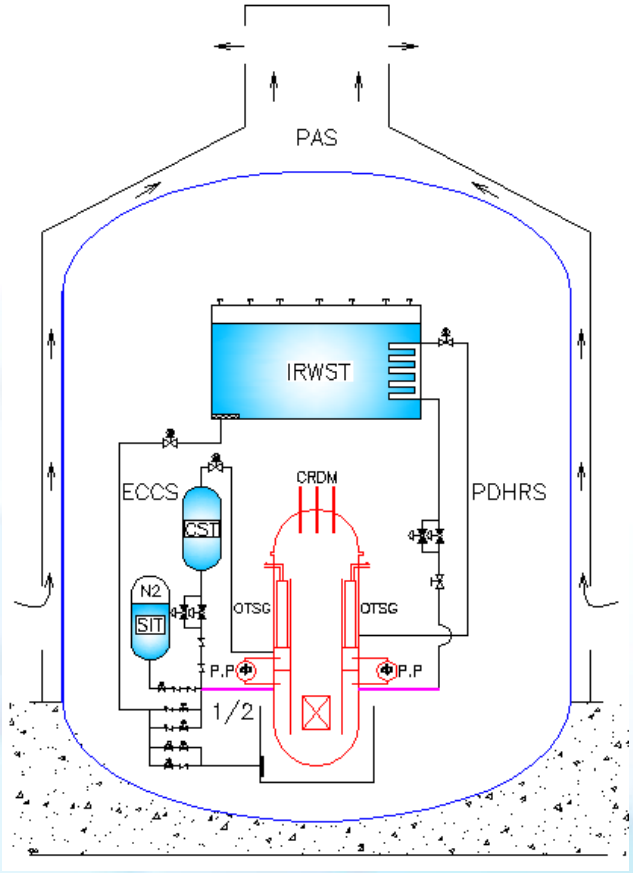
ACP100

Thermal power	385MWt
Electrical power	~125MWe
Design life	60 years
Refueling period	2 years
Coolant inlet temperature	282 ℃
Coolant outlet temperature	323 ℃
Coolant average temperature	303 ℃
Best estimate flow	10000 m^3/h
Operation pressure	15MPaa
Fuel assembly type	CF3 shortened assembly
Fuel active section height	2150 ㎜
Fuel assembly number	57

Design parameters of ACP100

Main design parameters

Fuel enrichment	*4.45%*
Drive mechanism type	*Magnetism lifting*
Control rod number	*25*
Reactivity control method	*Control rod、solid burnable poison and boron*
Steam generator type	*OTSG*
Steam generator number	*16*
Main steam temperature	*>290 ℃*
Main steam pressure	*4.5MPaa*
Main steam output	*560t/h*
Main feed water temperature	*105 ℃*
Main pump type	*canned pump*
Main pump number	*4*



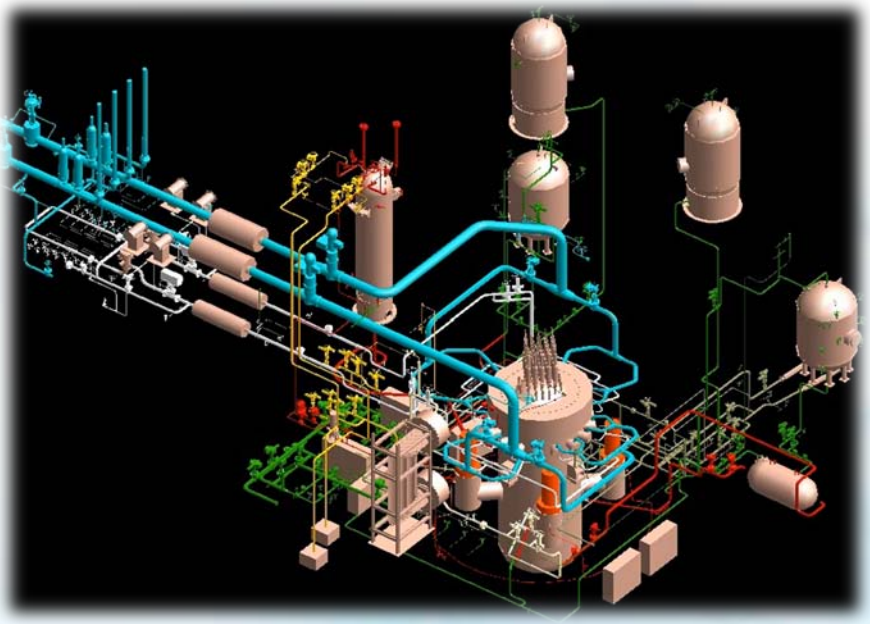
Design parameters of ACP100

Main design parameters

Reactor power-control operation program	primary constant average temperature
Thermal power plant operation model	Base load operation（Mode-A)
Plant design life	60 years
SSE level ground seismic peak acceleration	0.3g
Predicted Core Damage Frequency (CDF)	＜1E-7 Per reactor year
Predicted Large Release Frequency (LRF)	＜1E-8Per reactor year

Design parameters of ACP100

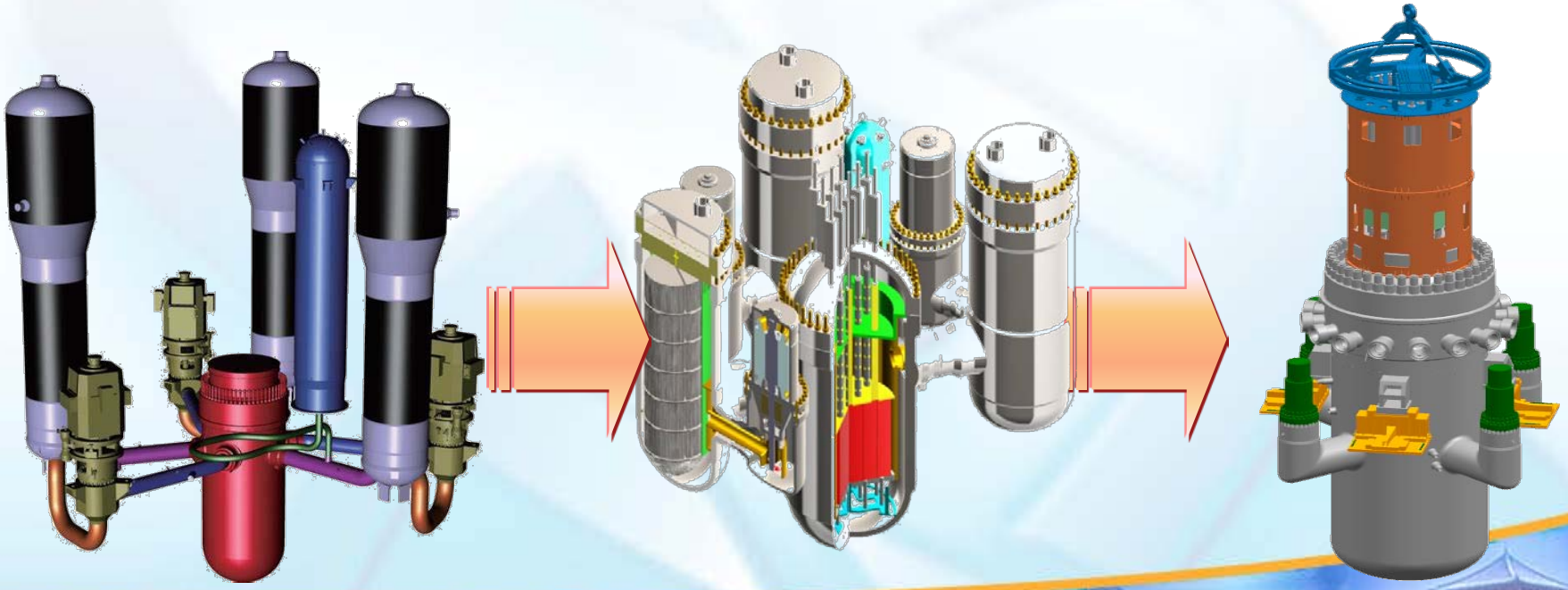
- One reactor with one turbine



Technical Aspects

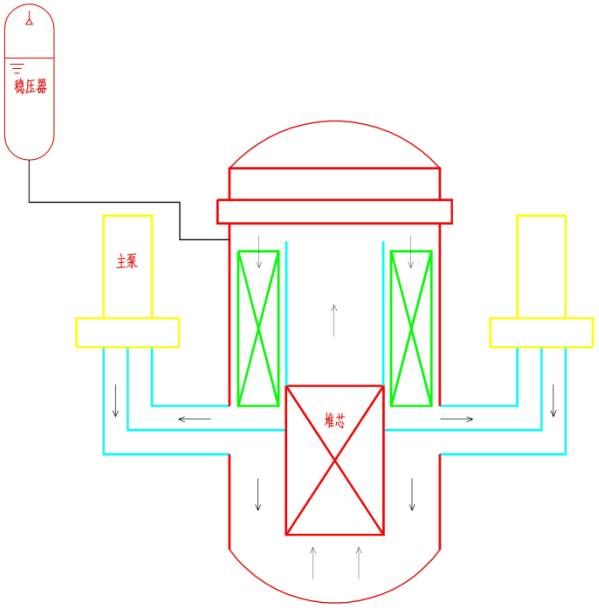
Integral reactor module

- *The reactor coolant system has been integrated reactor module. The reactor module is consisted of reactor vessel, once-through steam generators, canned motor pumps, reactor internals and integrated reactor head package.*



Technical Aspects

Reactor coolant system



反应堆冷却剂系统

– ***system function and composition***
  - *4 main pumps*
  - *16 OTSG*
  - *1 pressurizer*

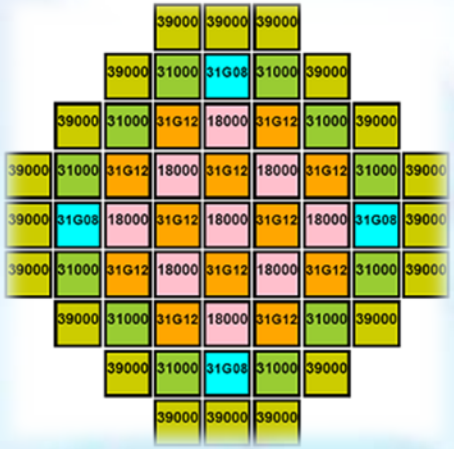
– ***system description***
  - *operation pressure 15.0MPa*
  - *core exit temperature 325℃*

Technical Aspects

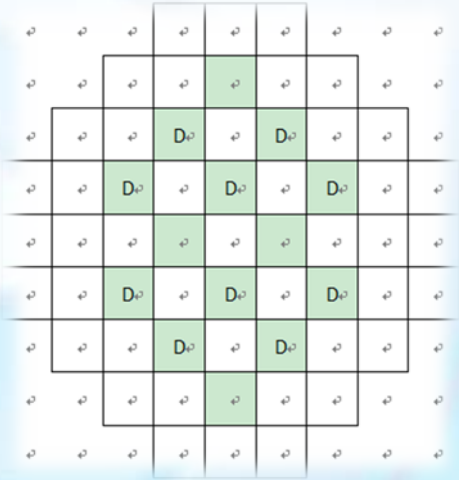
Reactor Core

57 17X17 square fuel assembly with Gd2O3 solid burnable poison

Refueling period 24 months.



Core layout

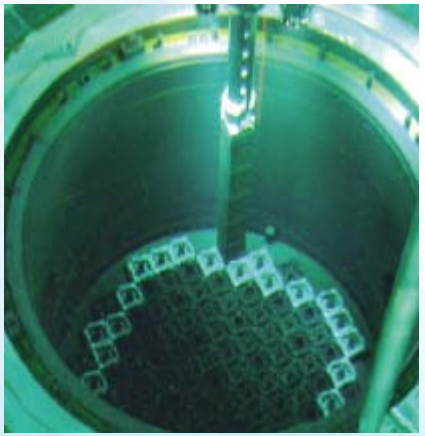


Advanced core detection system

Technical Aspects

Fuel assembly

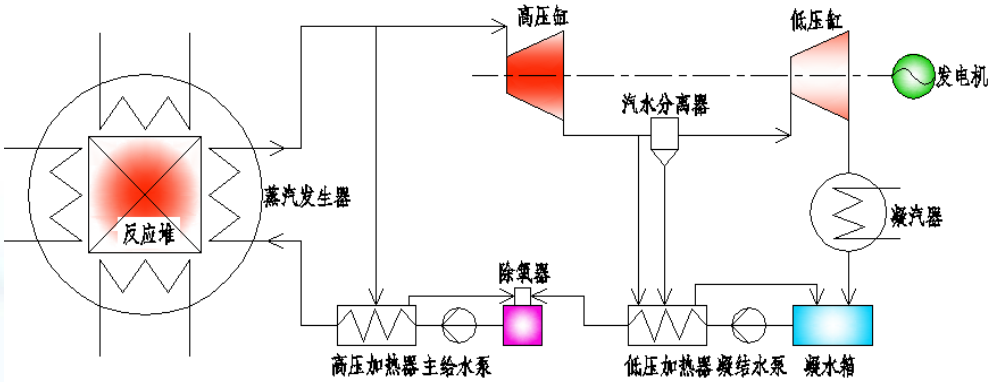
- 17×17 square arrangement
- Fuel rod：264
- guide tube： 24
- instrumentation tube： 1
- total height: ～2500mm
- active length: 2150mm



Technical Aspects

Main steam system

– **system function and composition**
  - main steam system
  - bypass system
  - moisture separator reheat system



– **system description**
  - operation pressure 4.5MPa
  - Temperature 285℃

Technical Aspects

I&C system

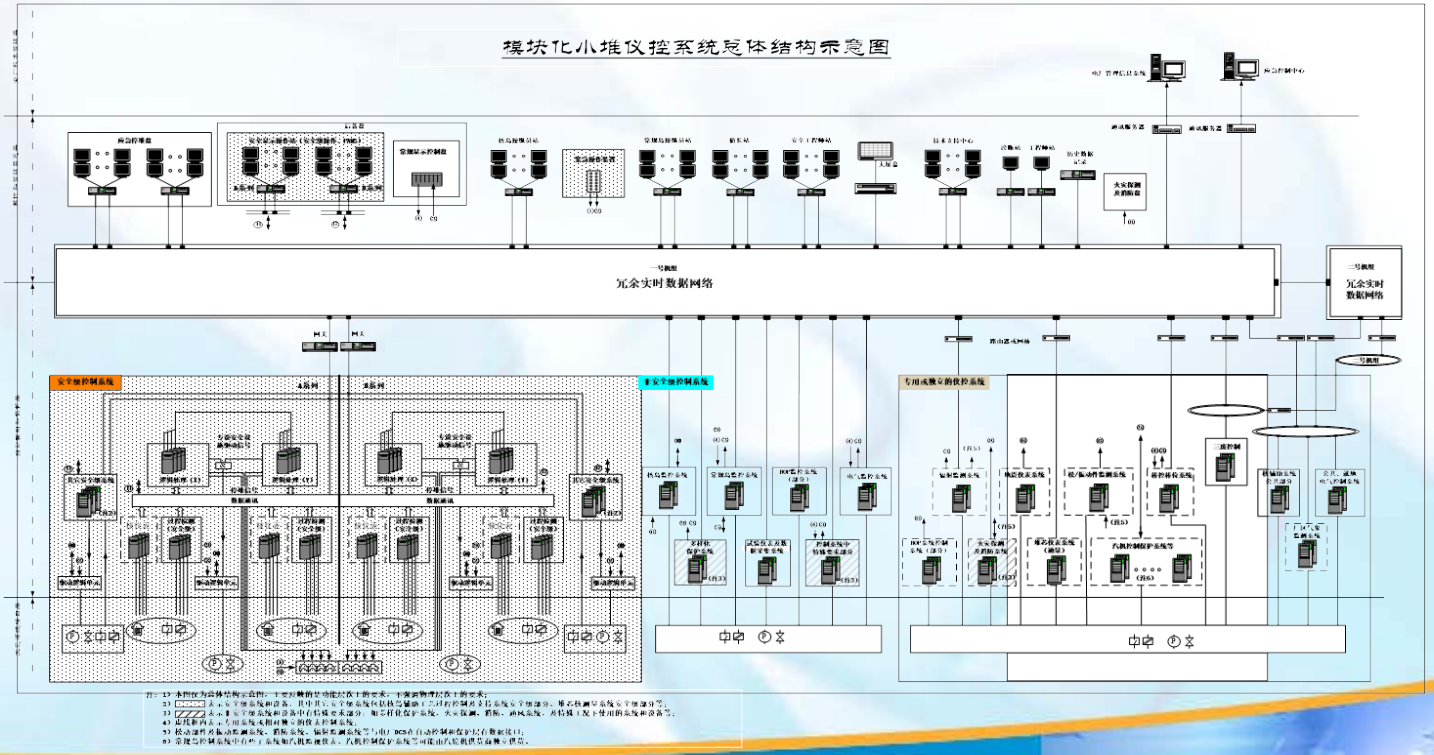
Functionally divided into 4 layers：

0. Interface layer；

1. Auto control and covering layer；

2. Operation and management information layer；

3. Plant technical management layer.

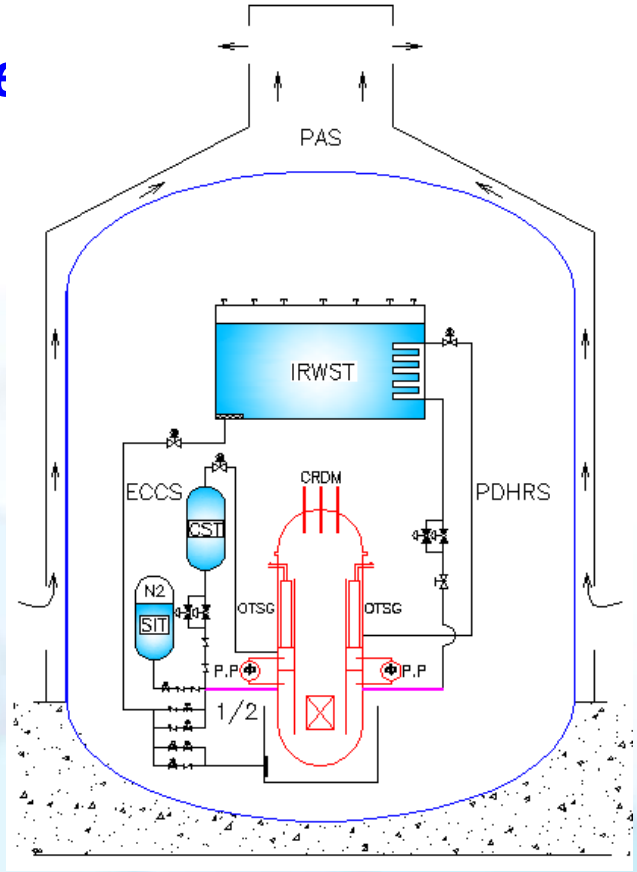


Technical Aspects

Fully passive safety system

ACP100 adopts fully passive safe illustrated in Figure:

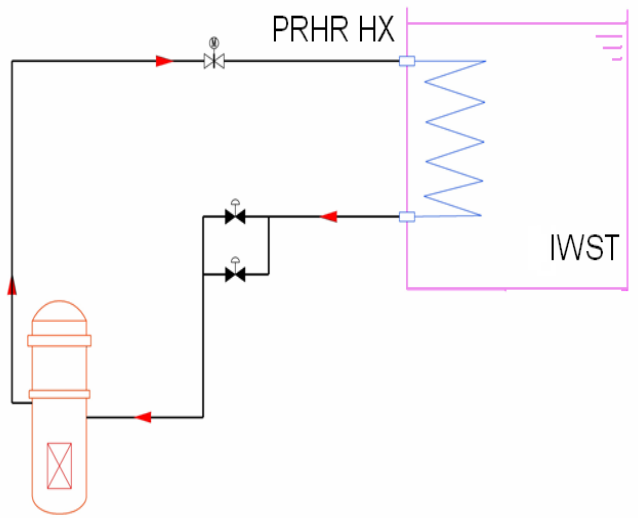
passive core cooling system,
passive residual heat removal system,
passive containment heat removal system,
passive inhabitation system,
automatic depressurization system,
passive hydrogen control system.



Technical Aspects

Passive residual heat removal system

- *The heat exchanger is mounted in the IWST. HX is usually filled with coolant.*
- *Natural Circulation or, if RCPs running, forced flow through the HX.*
- *Flow through the HX-tubes from the RCS transfers heat to the IWST contents.*

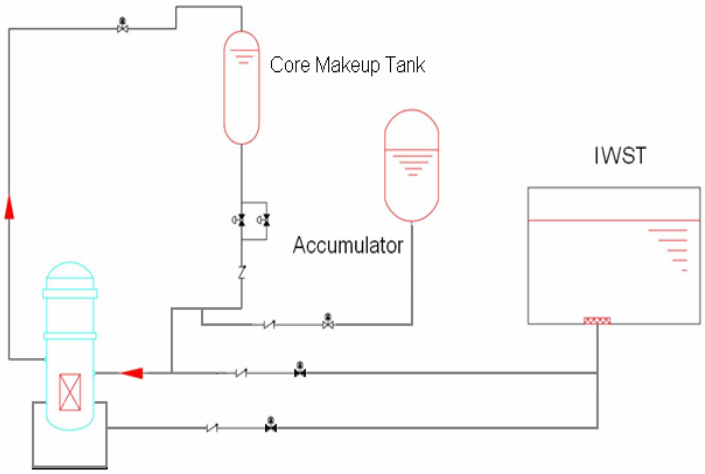


Passive Residual Heat Removal system

Technical Aspects

Passive core cooling system

- *Provides the Reactor coolant system emergency makeup.*
- *Safety injection: Provide adequate core cooling for the SBLOCA (i.e. SGTR) by:*
  - *CMTs*
  - *Accumulators*
  - *IWST*
- *After CMTs, Accumulators, & IWST have injected, containment is flooded sufficiently to provide recirculation flow.*

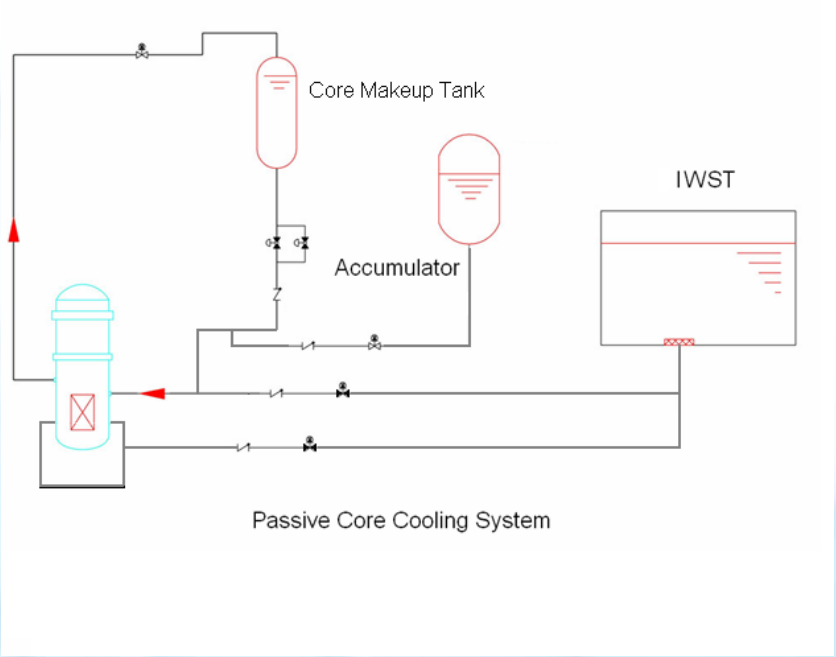


Passive Core Cooling System

Technical Aspects

Passive Reactor Cavity Flooding System

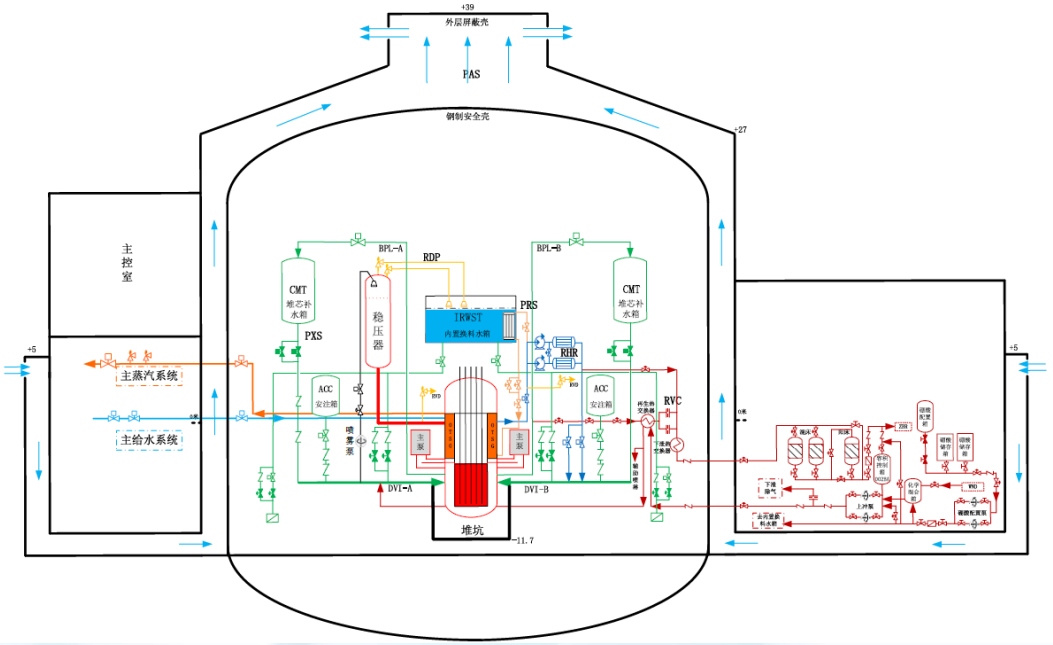
- *Provides a means of external reactor vessel cooling under assumed severe accident condition.*
- *Prevent the core molten.*



Technical Aspects

Passive containment cooling system

- *Provides Long-term heat removal from the containment in the case of any DBA & BDBA including those associated wit blackout and spray system failure; Steam condenses on containment HX.*
- *Condensate collects in IWST/Sump via gutter arrangement.*
- *And transfer the core heat ultimately through the containment HX into the surrounding atmosphere by natural circulation.*



Technical Aspects

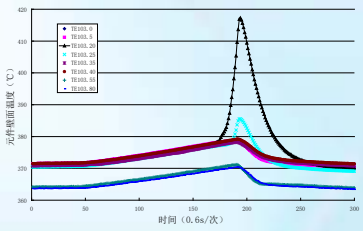
Other safety systems

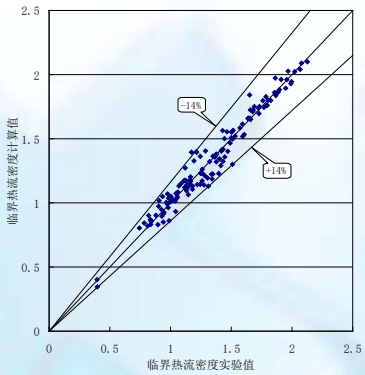
- Provide automatic depressurization (ADS) in the event of a SBLOCA
- Passive combustible gas control in containment

Deterministic and Possibility Safety analysis

Deterministic Safety analysis

- 7 categories incldluing 50 kinds of incidents and accidents
- 15% of thermal margin achieved

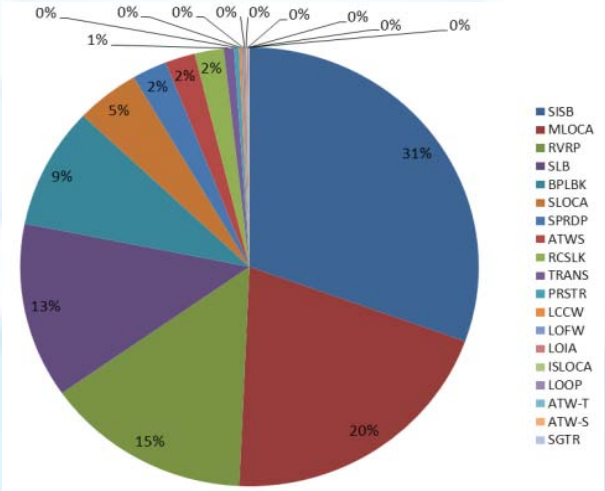




Possibility Safety analysis (PSA)

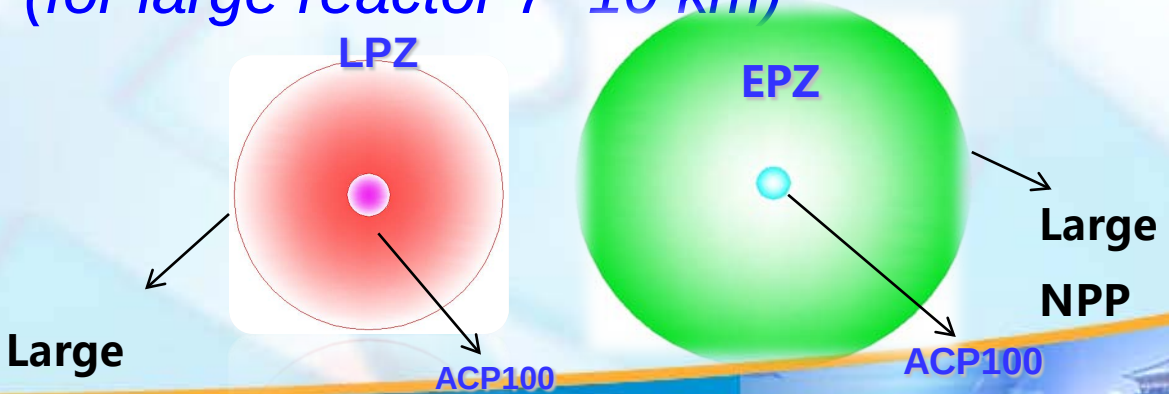
CDF：1.91×10^{-7}

LRF: 10^{-8} level



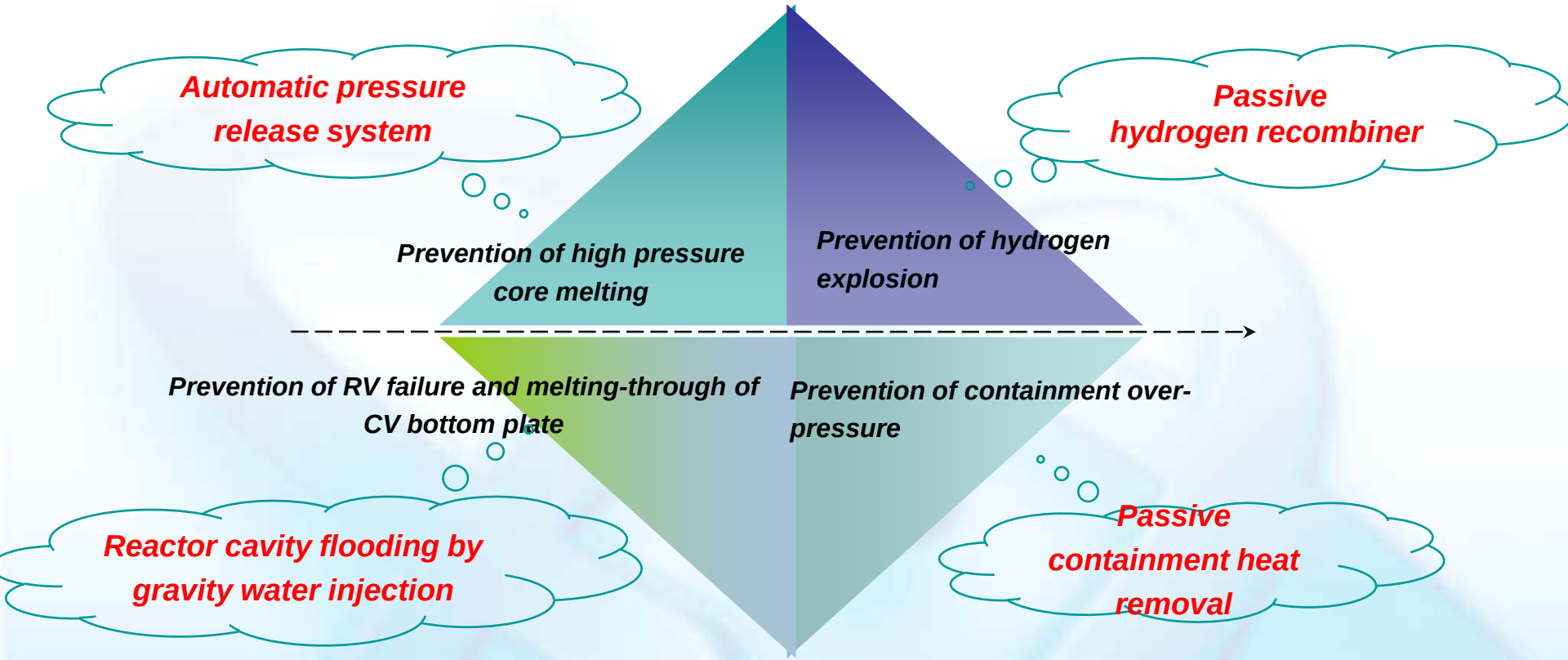
Non-residential Area and Planned Restricted Zone Study

- *Non-residential area (EAB): Less than 300 m; (for large reactor 500m)*
- *Planned restricted zone (LPZ): Less than 500 m; (for large reactor 5km)*
- *Eemergency plan zone (EPZ): Internal zone Less than 500 m; (for large reactor 3~5 km) External zone Less than 600 m. (for large reactor 7~10 km)*



Safety and licensing strategy

Severe accident prevention and Mitigation measures



Safety and licensing strategy

Third party verification

- *IAEA gave the review comments on ACP100 Generic Reactor Safety Review （GRSR）report on April 22, 2016, the 1st SMR completion of GRSR in the world.*

Safety and licensing strategy

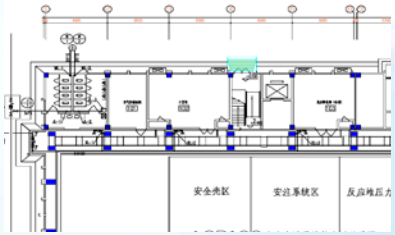
Third party verification

"According to the safety documentation, the ACP100 plant is an innovative design that belongs to the SMR class of NPPs and deploys passive safety features. It can be expected from new designs that they are capable of dealing with extreme environmental conditions and multiple failures to assure that early or large radioactive releases are practically eliminated. "

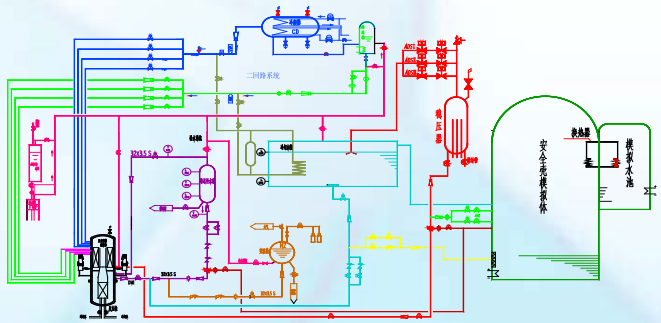
Testing & Verification

Seven test research

- Control rod drive line cold and hot test
- Control rod drive line anti-earthquake test
- Internals vibration test research
- Fuel assembly critical heat flux test research
- Passive emergency core cooling system integration test
- CMT and passive residual heat removal system test research
- Passive containment heat removal testing



Thermal hydraulic testing hall



Passive emergency core cooling system

Testing & Verification

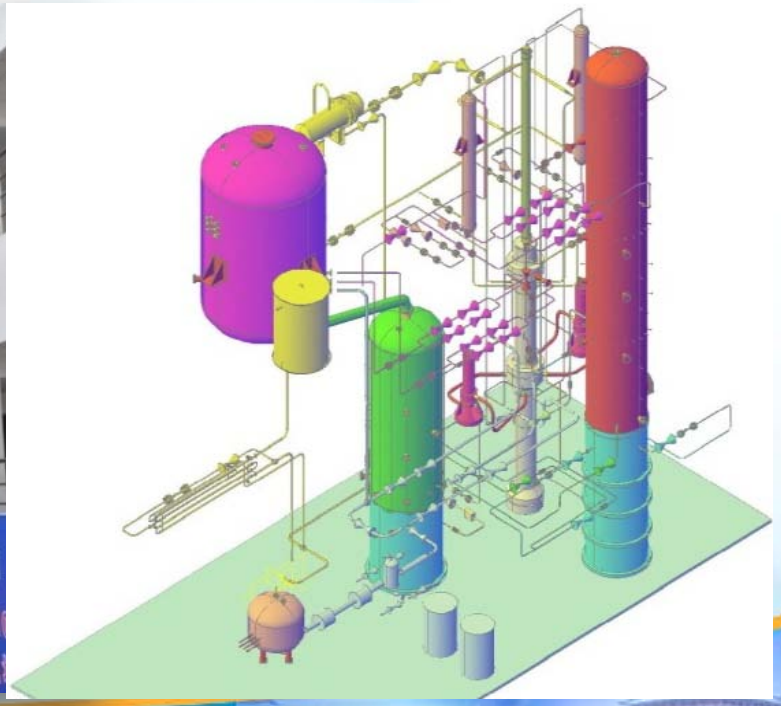
Seven test research

- Control rod drive line cold and hot test
- Control rod drive line anti-earthquake test

Testing & Verification

Seven test research

- *Passive emergency core cooling system integration test*
  - ✓ *Over 3 years, CNNC had constructed the most comprehensive passive engineering safety system testing facility. Core cooling system integration testing, Passive residual heat removal system testing had finished on this facility*

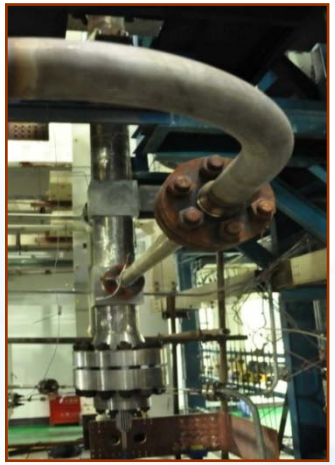


Testing & Verification

Seven test research

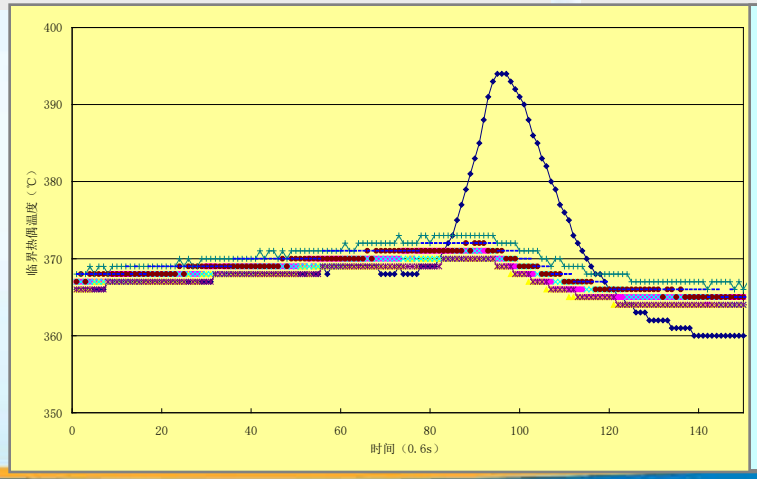
- *Fuel assembly critical heat flux test research*

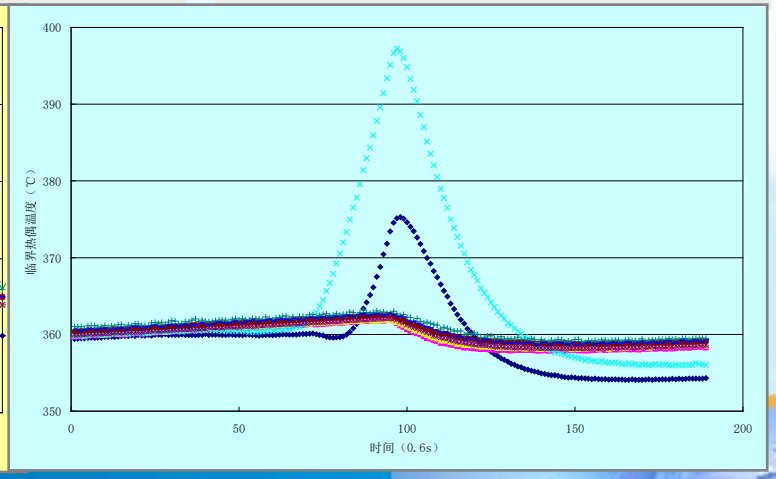
CHF testing facility



CHF testing tube

CHF heating assembly

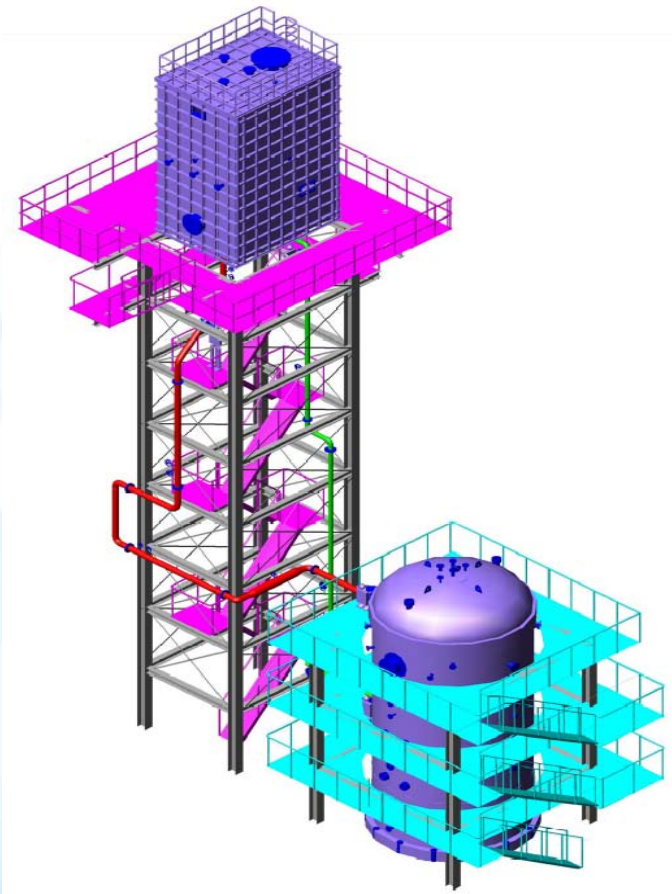




Testing & Verification

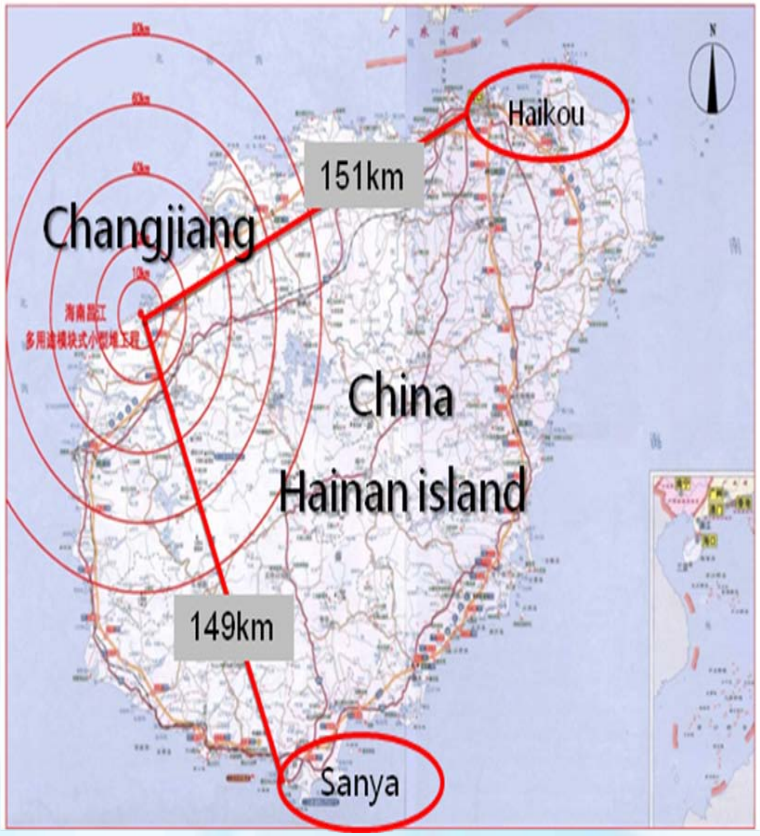
Seven test research

- *Passive containment heat removal testing*
  - ✓ *The results of the testing indicate the passive containment heat removal system is sufficient to conduct the heat to the ultimate heat sink*

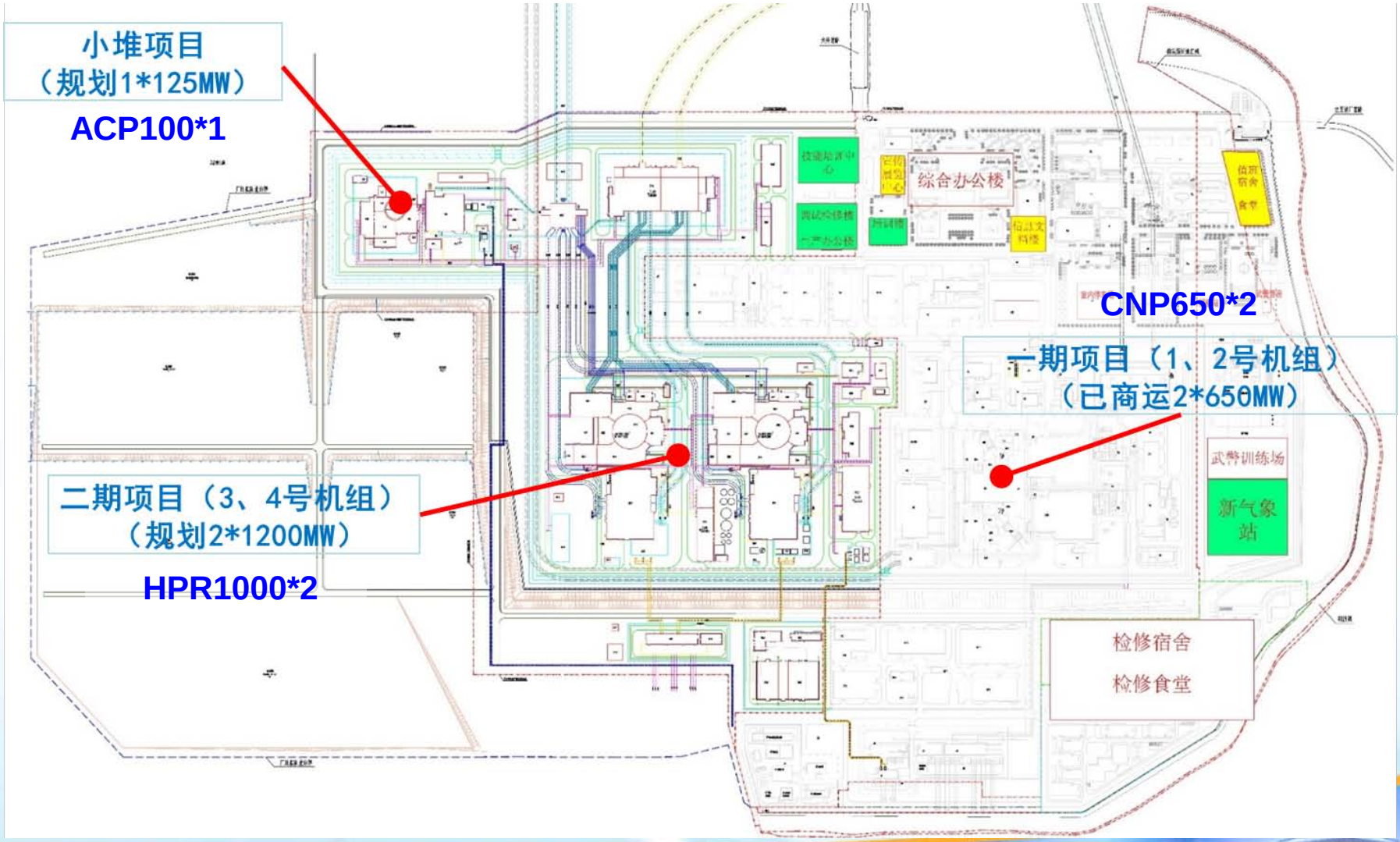


Demonstration project of ACP100

- *Changjiang nuclear power site, Hainan, China, as illustrated in Figure, was chosen to build the first of a kind (FOAK) ACP100 demonstration project.*
- *FCD in July, 2021.*
- *Construction period of FOAK 55 months, target commercial operation in 2026*



Demonstration project of ACP100



Demonstration project of ACP100

- ***Major equipment, such as Reactor Pressure Vessel, Steam generator and Tubine Generator already in manufacturing stage.***

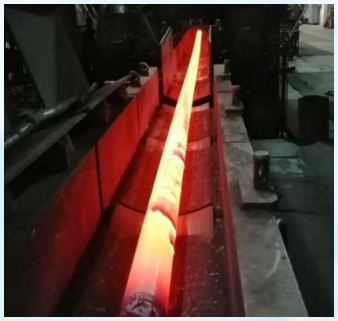
RPV主泵接管锻件

RPV支承段筒体堆焊

RPV容器法兰堆焊

RPV主泵接管待堆焊

主泵试验回路



SG钛管热轧

主泵电机组装

Demonstration project of ACP100

- **Site preparation on 18 July, 2019**

小堆施工现场

Demonstration project of ACP100

- Site preparation on 31 December, 2019




Demonstration project of ACP100

- **Site preparation on 30 June, 2020**

Demonstration project of ACP100

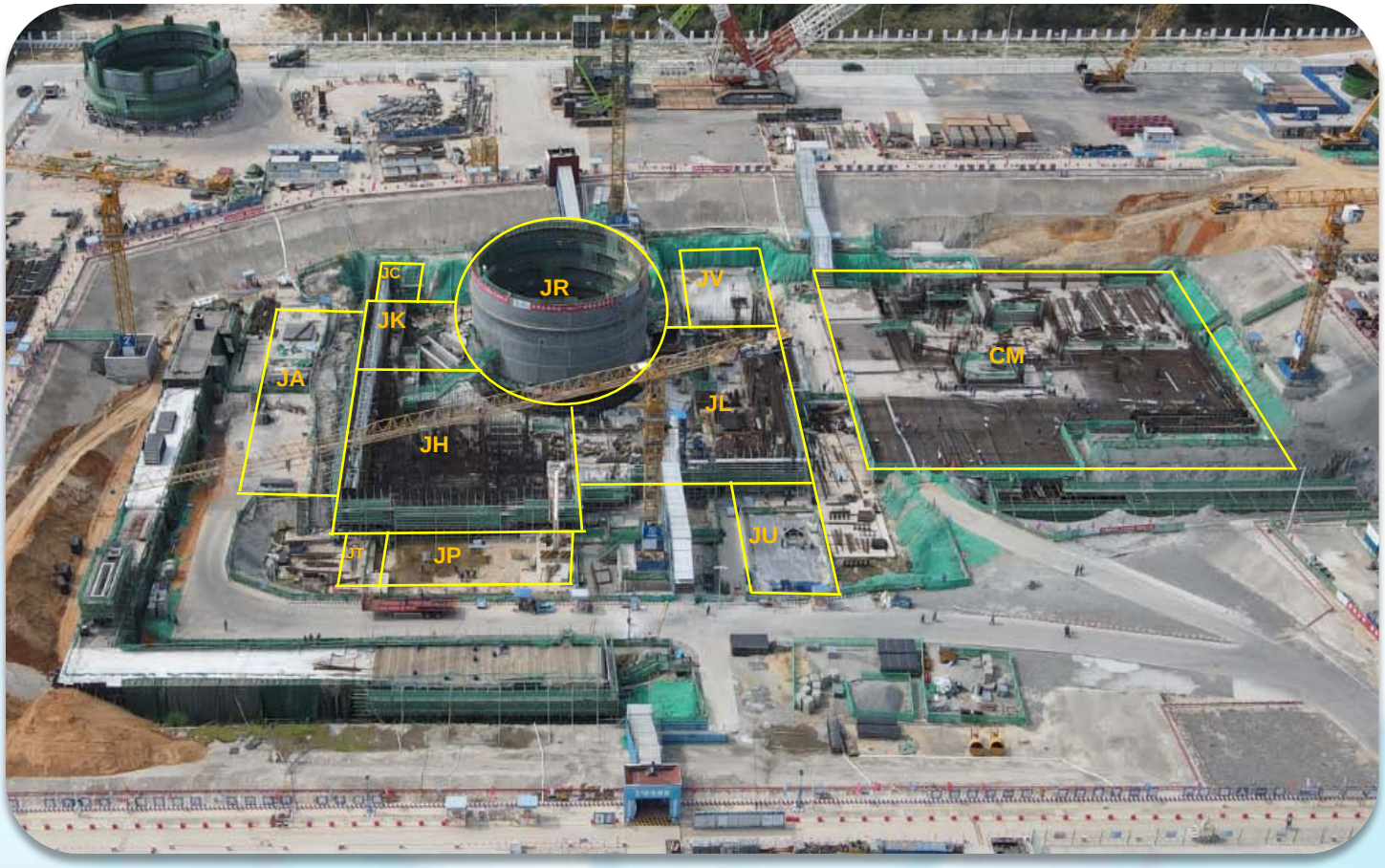
- **Site preparation on 26 February, 2021**

Demonstration project of ACP100

- **FCD on 13 July, 2021**

Demonstration project of ACP100

- *Site photo on 06 July, 2022*



Thanks and Questions

Status of the RA-10 Research Reactor Project

Herman Blaumann
National Atomic Energy Commission
Argentina

Introduction

- The requirements and initial design of the RA-10 reactor were established by CNEA in 2010.
- The project is supported by the National Administration.
- CNEA is the responsible for the design, construction and commissioning.
- CNEA is the holder of the Construction License.

RA-10 Multipurpose Research Reactor

- Replacement for the RA-3 Reactor, currently used for Moly production
- Support future radioisotope demand becoming a potential supplier for the regional and global market
- Provide an irradiation facility for testing NPP fuel rods
- Provide cold and thermal neutron beams for basic research and technology

RA-10 Multipurpose Research Reactor

- Replacement for the RA-3 Reactor.
- Radioisotope production.
- Fuel and material testing.
- Basic research
- Industrial applications

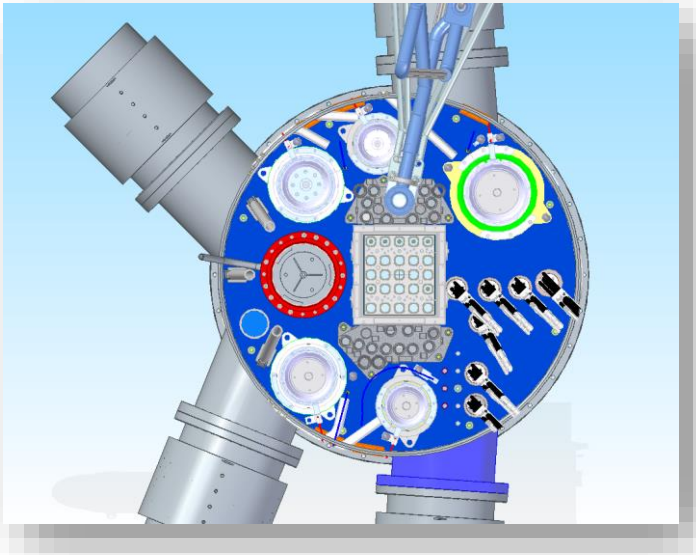
.

Associated projects:

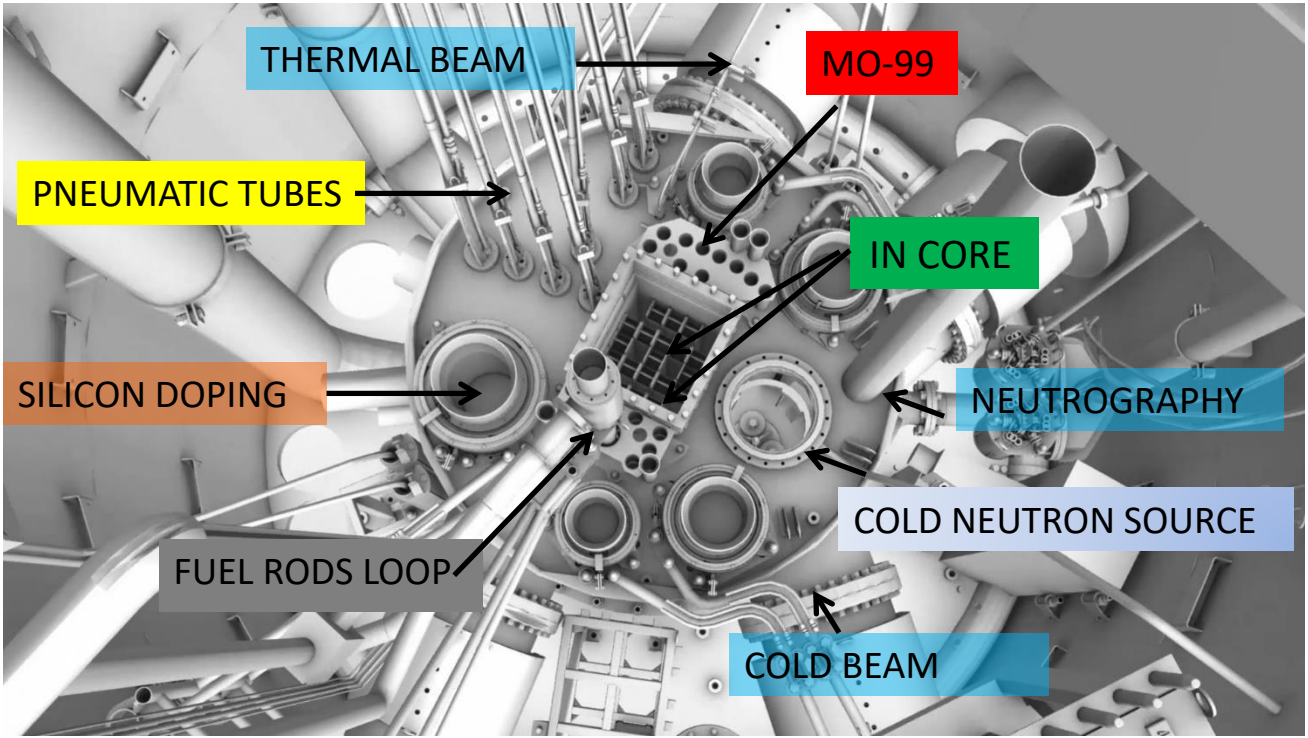
- Radioisotopes production plant.
- Fuel elements production plant.
- Irradiated material testing laboratory
- Neutron beams laboratory

The RA-10 Reactor

- Type : Open pool
- Operating power : 30 MWth
- Operating regime: 300 days per year
- Cycle length : 29.5 days
- Fuel : MTR, LEU, 19.8% ^{235}U
- Coolant : Light water
- Reflector: Heavy water
- Site: Ezeiza Atomic Center

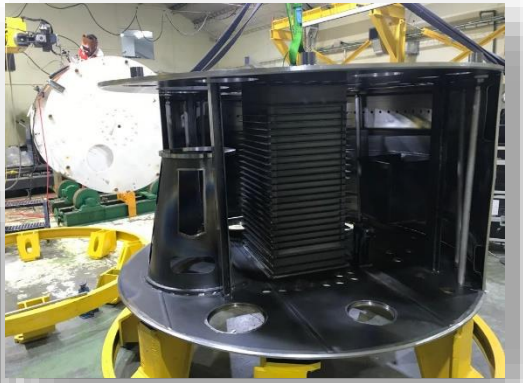


RA-10 Reflector Tank



Civil Work Status

RA-10 Reflector Tank



Project Status

- The Construction License was obtained in October 2014.
- The Environmental Assessment Study was approved in March 2016.
- The civil work was initiated in February 2016. The advance is 97%.
- The SSCs supplying and installation was initiated on February 2016. The main components have already been installed. Contracts for main systems installation are on going.
- A contract for the provision of the fuel rods irradiation facility is under discussion
- First operation team has been undergoing training since February 2016.
- The project advance is 70% .
- Commissioning is planned for 2024.

Relevant contracts

- Civil work construction.
- Fuel elements, nuclear instrumentation and reactor protection system supplying.
- Supplying and mounting of SSCs.
- Heavy water supply.
- Fuel rods irradiation facility supplying and mounting.

Users management

- In order to assure the fully exploitation of the reactor, several projects are being promoted involving **new facilities design and construction**, **equipment supplying**, and **human resources development:**
  - New radioisotopes plant
  - Neutron beams national laboratory
  - Irradiated material testing laboratory
  - Silicon doping production
  - Fuel rods irradiation facility utilization
  - New NAA applications
- In order to manage the relationship with these associated projects, a USER´S COMMITTEE was created.

The RA-10+ Center

- A program that includes related project for building a **“Complex for medical radioisotopes, science and nuclear technology”** (facilities but also capacities)
- Opportunity for a **national multidisciplinary laboratory** that cross the scientific and technological regional system around a world class facility
- With strategic impact on health, basic research, technology and services

Radioisotopes production and Silicon doping

Purpose (no. of positions)	Required	Calculated	Production
Mo-99 * (x 10)	1-1.5 E14 n/cm2 s	1.5 E14 n/cm2 s	4000 Ci/week (a)
Ir-192 (med.) (x 4)	>1.8 E14 n/cm2 s	2.5 E14 n/cm2 s	34400 Ci/cycle
Lu-177 (x 4)	>1.8 E14 n/cm2 s	2.5 E14 n/cm2 s	1.85 Ci/mg cycle
Ir-192 (ind) (x 4)	1-1.5 E14 n/cm2 s	1 E14 n/cm2 s	12600 Ci/cycle
Other RI (x 4)	1-1.5 E14 n/cm2 s	1 E14 n/cm2 s	-
Silicon doping	1-4 E13 n/cm2 s	1.2 -2.3 n/cm2 s	80 ton/year

*) Without considering radiochemical process efficiency (about 60%)

Materials and fuel testing

Purpose	Required	Calculated
Irradiation device under fast spectrum (x 2). (e.g. Corrosion and hidruration studies)	>3E14 fast n/ cm2 s	5 E14 fast n/ cm2 s
Irradiation device under reactor spectrum (x 4): (e.g. MTR plates, neutron damage, etc.)	1 E14 n/cm2 s (integral)	3 E14 n/cm2 s (integral)
NPP fuel rods LOOP Steady state Ramps	 200-600 W 4-100 W/cm min	 200-600 W 4-100 W/cm min

"fast"> 0.1 MeV

Science Research

Purpose	Required	Computed
Pneumatic * (NAA, other)	1-20 E13 n/cm2 s 2 < T/F < 500	1-20 E13 n/cm2 s 2 < T/F < 500
Thermal beam at Reactor Face	>1 E10 n/cm2 s	2.9 E10 n/cm2 s
Thermal beam at Guide Hall	>1 E9 n/cm2 s	2.5 E9 n/cm2 s
Cold beam at Reactor Face	> 4 E9 n/cm2 s	1.4 E10 n/cm2 s
Cold beam at Guide Hall	> 1 E9 n/cm2 s	5.4 E9 n/cm2 s

Thank you!

Comisión Nacional
de Energía Atómica

LAHN: The Argentine Neutron Beam Laboratory

Eng. Karina Pierpauli

Executive Director

LAHN | LABORATORIO ARGENTINO DE HACES DE NEUTRONES

LAHN: The first large-scale research infraestructure for neutron science in Latinamerica

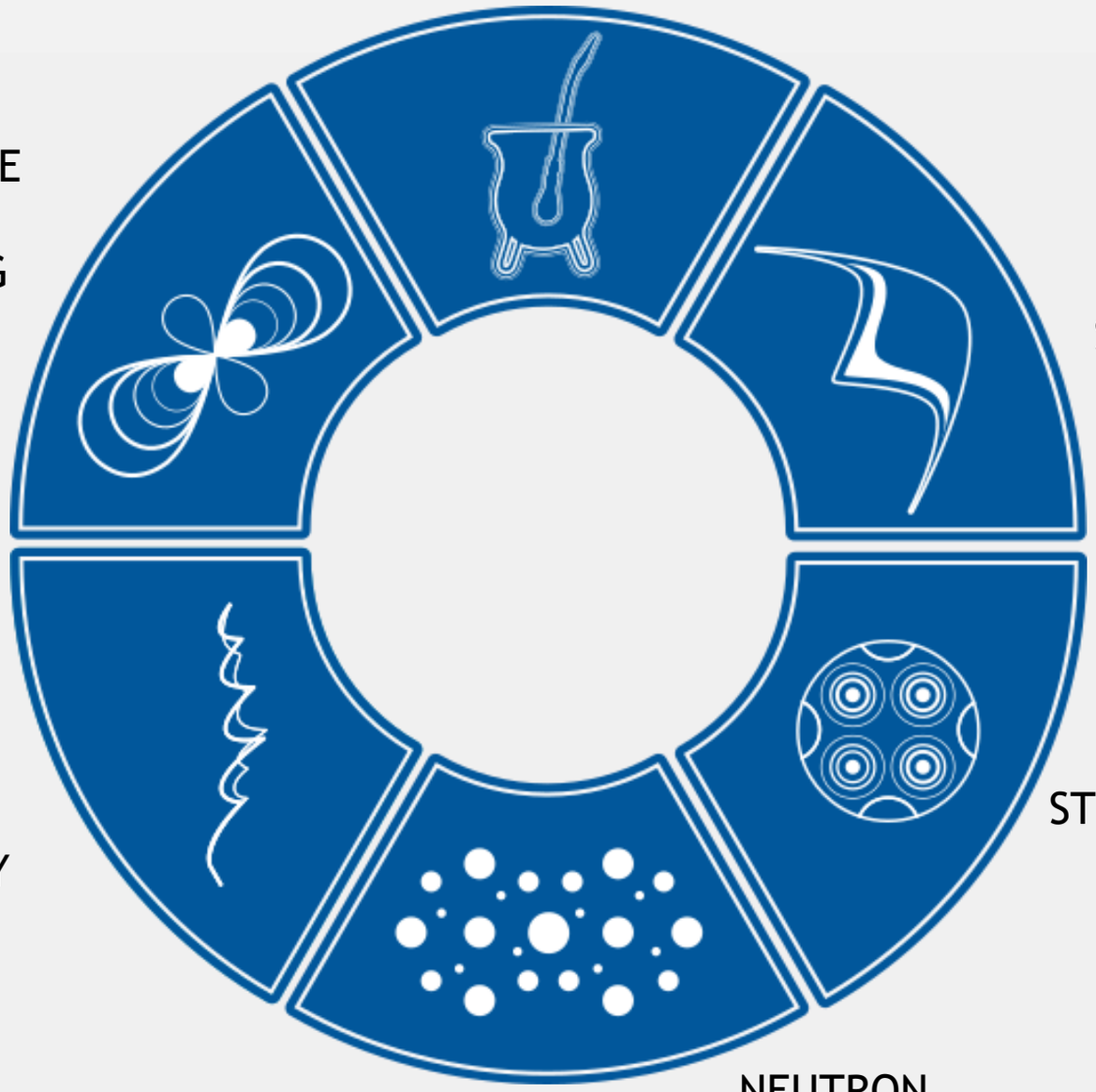
A Research Center for the development and use of neutron beam techniques for the study of matter.

THE SITE


Centro Atómico Ezeiza,
Buenos Aires, Argentina
RA-10 commissioning
2024

But not only the site is a grand challenge

NEUTRON SCIENCE TO ADDRESS THE MAJOR CHALLENGES OF SOCIETY

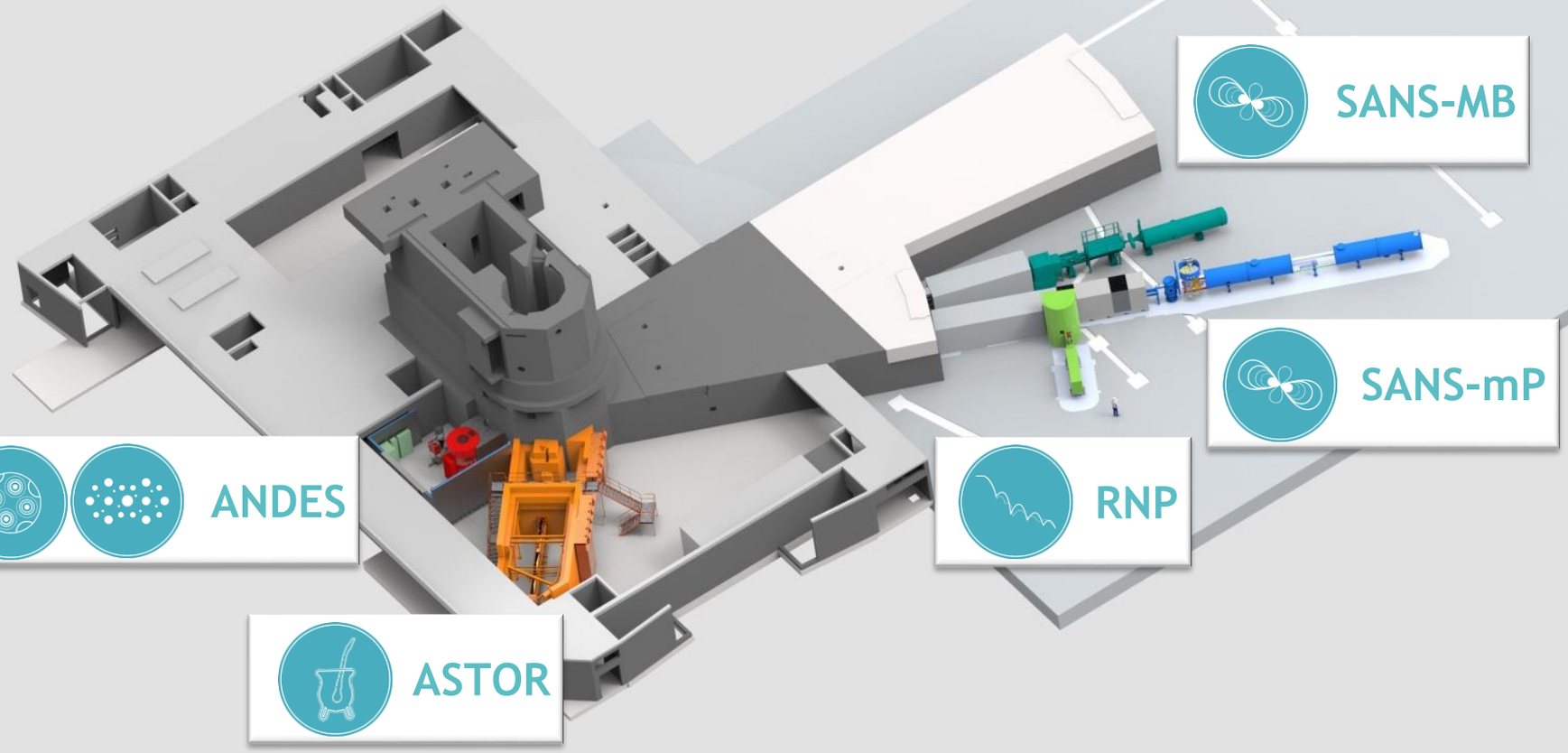


SCOPE OF LAHN

LN

LAHN
LABORATORIO ARGENTINO DE HACES DE NEUTRONES

THE NEUTRON BEAMS SHALL BE OUR MAIN TOOL, BUT NOT THE ONLY ONE!



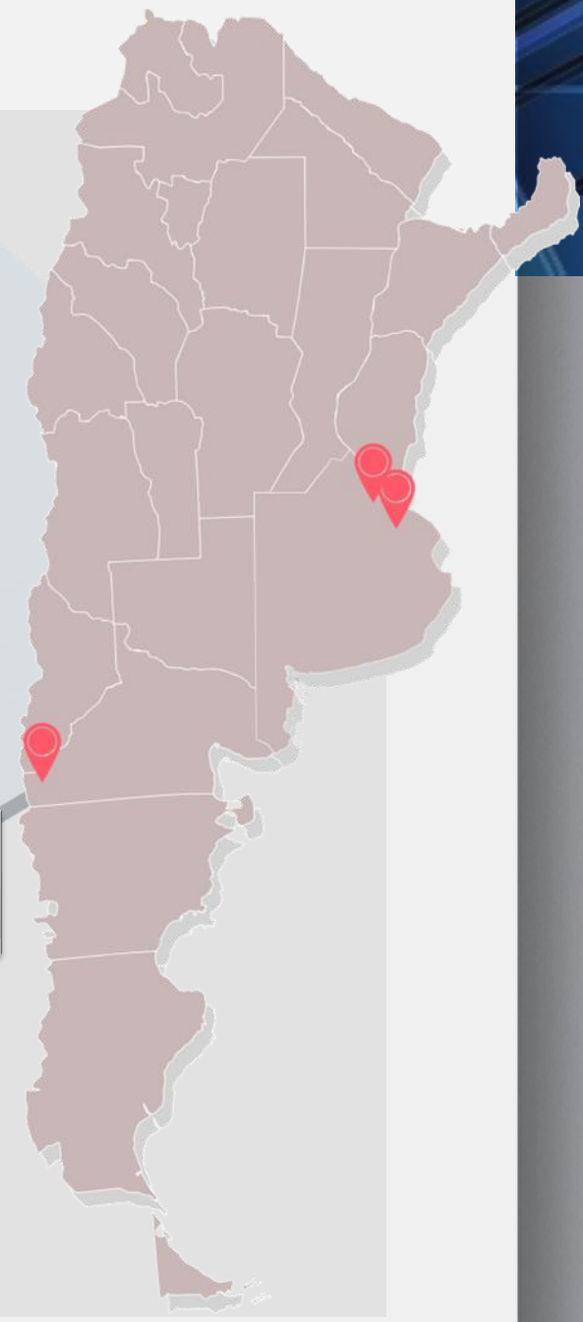
SANS-MB

SANS-mP

ANDES

RNP

ASTOR



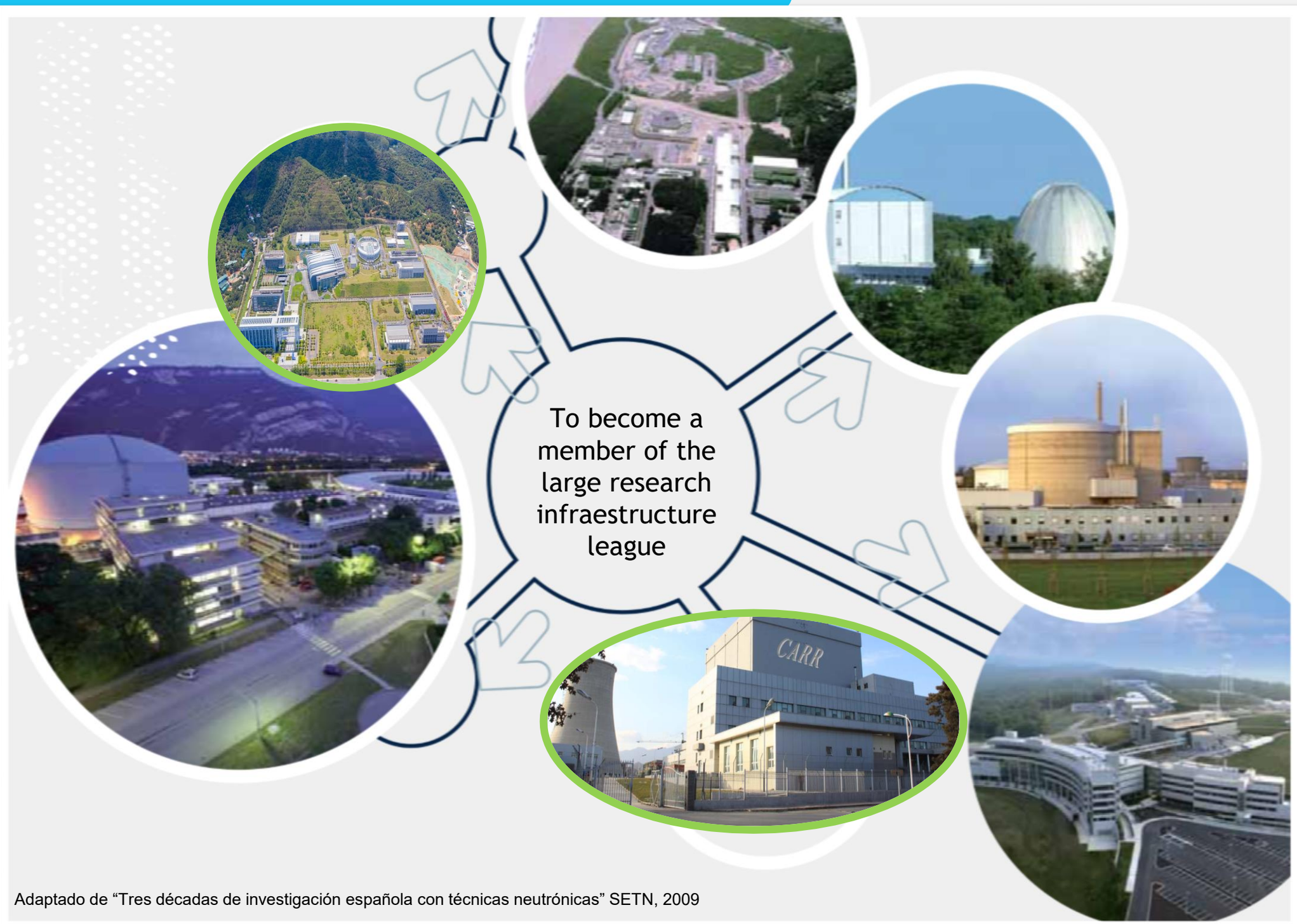
LABs FOR MAGENTIC MEASUREMENTS

LABs FOR TOMOGRAPHIC RECONSTRUCTION

LABs FOR X-RAY CHARACTERIZATION

LABs FOR SAMPLE PREPARATION AND SAMPLE ENVIRONMENT

OUR CHALLENGE



Adaptado de “Tres décadas de investigación española con técnicas neutrónicas” SETN, 2009

STRATEGY


CU
To build a solid user community
To train the people for the development and operation of LAHN
CI
LN
To create a Large-scale National Laboratory
LAHN´s STRATEGIC GOALS
To become a reference in the Latinamerican region
RE

BACKGROUND OF COOPERATION WITH US

CU

To build a solid user community

To train the people for the development and operation of LAHN

CI

LN

To create a Large-scale National Laboratory

LAHN´s STRATEGIC GOALS

To become a reference in the Latinamerican region

RE

SCOUPE

Keypoints for a common agenda on large-scale research infraestructure

- Improvement of benefits of joint collaboration in training of HHRR
- Integration with Chinese Association of Neutron Scattering
- Common research projects for scientific collaboration and instrument development
- Experience in running national facilities – large-scale research infraestructure / user-oriented

Comisión Nacional
de Energía Atómica

THANKS

www.lahn.cnea.gov.ar

Topics of collaboration interest for training, exchange of staff, joint projects and meetings

Interest of the Nuclear Fuel Cycle Management

Zirconium Alloys Technology

Processing development
Microstructural Issues
Hydrides in zirconium alloys, Diffraction techniques, Scanning electron microscopy plus Electron backscatter diffraction (SEM and EBSD), Finite element analysis (FEM), Transmission electron microscopy (TEM), Post irradiation studies, Training-Exchange Staff Members

Materials Management (Constituyentes Atomic Center)

Materials Characterization (Zr based alloys, structural steels, Ag-In-Cd alloys, Ni alloys, etc.):
Phase transformation behavior under manufacturing processes and accident conditions, microstructure, Grain size, Crystalline texture, Dislocation density, Corrosion behavior and oxide adhesion, Hydrogen solubility, Delay Hydrogen Cracking and KIH determinations, Mechanical properties and thermal physical properties, Post irradiation experiments (PIE), Standards and/or guidelines along with references values, Melting and solidification.

Nuclear Energy Area Management

Ageing Management

Low levels of Hydrogen/deuterium detection by Hot Vacuum Mass Spectroscopy. Equipment Qualification for normal and accident conditions. Dry storage of spent Fuel.
Nuclear fuel Critical heat flow (CHF) tests in Freon loops. Neutron beam sources (other than research reactors) and related physics. Advanced and accident tolerant Fuel materials. Probabilistic and deterministic safety analysis of CANDU reactors.

Beninson Nuclear Technology Institute

Radiation Detectors

Fission chambers, wide-range neutron detectors, self-powered neutron detectors, boron-lined ionization chambers, gamma area monitors etc.

Nuclear Technology Applications Management

Radioisotopes – radiochemistry, Study and applications of nuclear reactions, Development of radiopharmaceuticals for diagnosis and/or therapy, Radioisotope metrology

Nuclear analytical techniques. Environmental, forensic and science and technology analytical applications, Radiobiology, Development of applications and new materials by irradiation, Dosimetry of ionizing radiation. Calibration and certification of equipment and dosimeters, Irradiation of foods, medical devices, polymers, cosmetics, etc.
Development of nuclear, medical, industrial, agricultural and livestock applications.
Hydrogen technology. Production, purification, storage. Energy vector. Fuel cells.

Non-Nuclear Research and Applications Area Management (GAIyANN)

INSTITUTE OF NANOSCIENCE AND NANOTECHNOLOGY- INN CNEA/CONICET
Design and development of nanomaterials and devices for health, energy and environment research and applications management – GiyA, Accelerator technology for Boron Neutron Capture Therapy and other medical and nuclear applications, -Photovoltaic technologies for terrestrial and space applications, -Supercapacitors applications for energy storage in space and terrestrial use. Nanostructured materials for applications in Lithium batteries, fuel cells, CO_2 reduction and hydrogen production, Nanoscale heat transfer: Applications to heat exchangers and cryogenics, Materials for magnetocaloric and electrocaloric energy conversion.
TECHNOLOGICAL DEVELOPMENT AND SPECIAL PROJECTS MANAGEMENT - GDTyPE
-Characterization of composite materials in hostile environments, -Analysis of the replacement of metallic components by others made of composite materials in hostile environments.

Controlled Nuclear Fusion

Fusion Plasma Physics, Energetic particles physics, Development of software for plasma control, Theoretical and numerical calculation of MHD equilibrium, 3D, nonlinear resistive MHD simulations, Lithium compounds for tritium production, Lithium titanate has been synthetized using Li from Argentina´s resources.