Korea-Australia Nuclear Cooperation Program

NUCLEAR ENERGY STUDY TOUR

Latest Tour January 13-17 2025

Original Tour, April 17-20 2018

Seven Sites throughout Korea

Korea - Australia Nuclear Cooperation Programme

January 2025 Study Tour -

Follows on from the Study Tour carried out in April 2018

1. Introduction and Study Tour Locations

This report focuses on the January 2025 Delegation which toured of the South Korean Nuclear Industry. It was led by Ted O'Brien MP and accompanied by Mike Newman, Stephen Wilson, Helen Cook, Jasmin Diab and Robert Parker.

Our thanks go to Mike Newman from Ginga Vale who brought his expertise in the North Asian business sector to the fore in organizing an excellent round of meetings and tours.

The report has been integrated with the report of a 2018 tour which increases the knowledge of all aspects of the South Korean Nuclear industry including waste disposal and proliferation issues.

The 2025 tour covered meetings with:

- Hyundai E&C
- Samsung C&T
- MicroURANUS SMR
- Hyosung Heavy Industries/Hyosung Goodsprings
- KHNP Head Office
- KINGS - Kepco International Nuclear Graduate School
- DOOSAN Enerbility
- DAEWOO E&C

Figure 1 – With KHNP Team, Mike Newman, Jasmin Diab, Robert Parker, Ted O'Brien MP, Stephen Wilson and Helen Cook (L to R) in front of Saeul Units 3 and 4.

The previous tour made to South Korea in April 2018 by Mr. Barrie Hill, Mr. Robert Parker and Dr Robert Barr was hosted by the Korean Nuclear Association and toured facilities at:

- KEPCO nuclear fuels
- KINAC Korean Institute of Nuclear Nonproliferation and Control
- KORAD - Korean Radioactive Waste Agency
- KHNP Saeul Nuclear Power Plant Visit
- KINGS - Kepco International Nuclear Graduate School
- Doosan Heavy Industries
- KAERI - Korean Atomic Energy Research Institute

The earlier 2018 tour focused on a larger group of sites and technologies. The later 2025 tour focused more on detailed exchanges with the key “Team Korea” organisations to examine key issues that need to be addressed when Australia adopts nuclear energy.

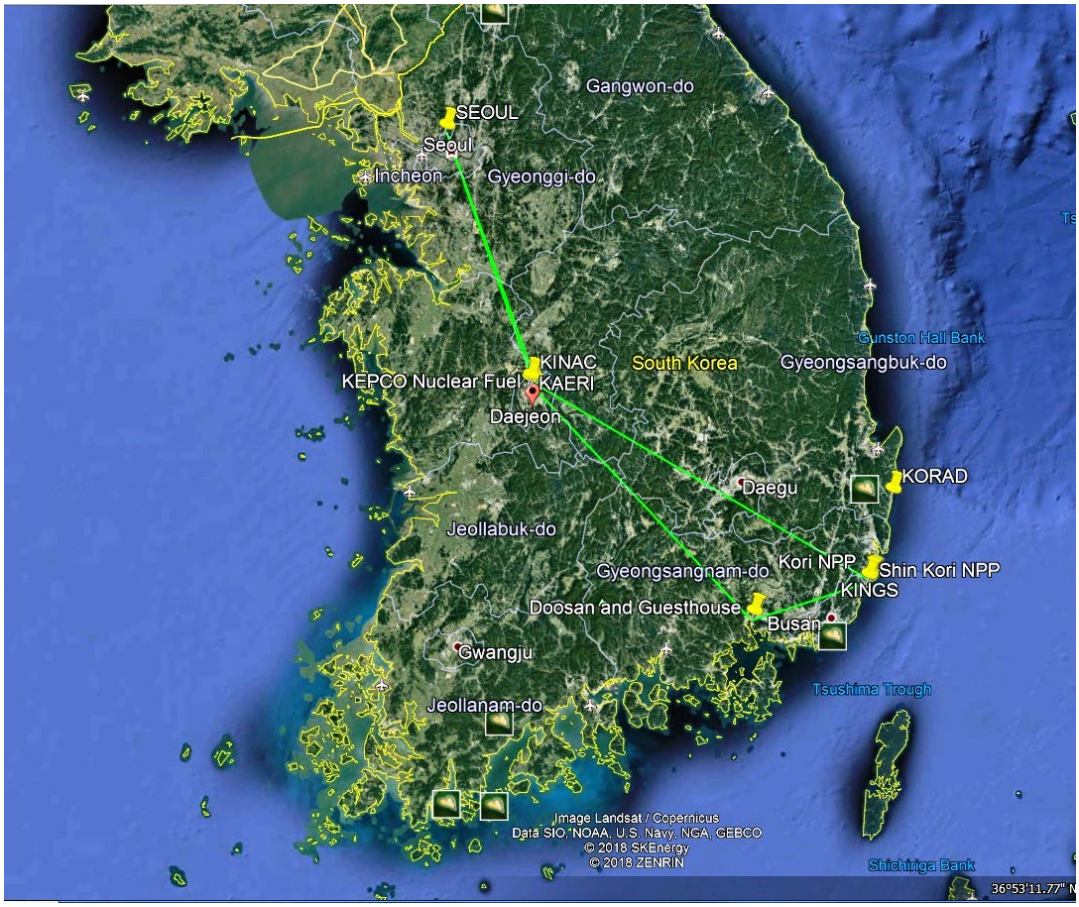

Figure 2 - Localities visited in South Korea

2. Tier 1 Contractor meetings (2025)

- Hyundai E&C
- Samsung C&T

1. Daewoo E&C

2.1 Hyundai E&C (2025)

Delegation met with Young Chio, Young Gun Parker, Changee Yun, Kyeongsoo (John) Kim, Yang Hee Lee and Sheena Kim. Mr. Yun articulated the nuclear issues very well.

Company founded in 1947, has 14,000 employees.

Has been involved in construction of 26 nuclear power plants and lead contractor on four at Kori, two at Wolsong and four at Barakah.

Hyundai noted:

- Barakah – on time and on budget and no liquidated damages
- New growth – SMR's, - Holtec, Sodium Cooled fast reactors and Molten Salt reactors
- Holtec offering 300MW SMR teaming with Hyundai

Ted O'Brien asked: What is your advice as to the key issue to get thigs right with new nuclear in Australia?

Reply:

1. Who is the Contractor? Ensure the roles and responsibilities are clearly defined,
2. Contractor and subbies need to be experienced,
3. Staffing with suitably skilled labour and line management – hard issue to resolve,
4. Ensure visa problems don't prevent importation of skilled labour – especially for certified welders, mechanical and electrical labour,
5. Resolve issues of financing and consider contractor/vendor finance,
6. Hyundai have been in discussion with CPB (ex-Leighton) in Australia,

Will modularization resolve labour issues?

1. SMR's have a significant on-site civil component – possibly proportionally larger than large plants
2. AP1000 has a larger proportion of off-site fabrication than other large plants – a possible benefit.

Hyundai plays a pivotal role (Helen Cook):

1. Sweden wants AP1000 – leads to Hyundai,
2. Bulgaria using Hyundai in EPC role for 2 x AP1000's,
3. KEPCO/KHNP use Hyundai – Barakah,
4. "Team Korea" become default deliverer of AP1000's.

Quality suppliers:

1. Korean's have confidence in home grown suppliers,

2. Less confidence in Chinese suppliers,
3. Safety is a big issue and integrity of Korean supply chain underpins this.

2.2 Samsung C&T (2025)

Delegation met with David Namgoung, Se Chul Oh (CEO and President) and Jung E. Kim (ex-Westinghouse).

Involved in large scale Nuclear Power plant construction as well as RE and Transmission projects plus Nuclear plants in Korea, UAE and now Romania with NuScale.

Involvement and observations regarding Renewable Energy:

- Focusing on RE in Australia and "green Hydrogen",
- EPC on current green projects,
- Favourable outlook for nuclear in Australia – RE at 100% is not possible – need baseload,
- Nuclear is the only option for baseload if coal and gas are denied due to emissions constraints.

Ted O'Brien advised:

- Nuclear will be required in medium and long term to replace coal on grid,
- AUKUS sets the precedent in terms of public acceptance and technology,
- We have nuclear now with OPAL reactor – Nuclear energy will happen in Australia regardless of next election.

Ted O'Brien's Question:

What is the thing to get right for nuclear to be successful in Australia?

- Social Licence is key – must get popular support,
- Having well designed nuclear policy and regulation,
- Choosing the right technology,
- Select sites and get on will site characterization e.g. Geology, hydrology etc.,
- Integrate process with IAEA pathway and have a clear plan for nuclear waste disposal,
- Govt must take lead on waste and regulation around plant operations.

Other issues for Australia:

- Lack of skilled labour – Korea can help with skills like high quality welding,
- Immigration challenges,
- Industrial opposition,
- High labour costs.

Samsung role:

Samsung not a nuclear technology company (like Westinghouse) – they are a constructor.

Partnered with Hyundai in Barakah – project too large for one company in the time frame.

On UAE project:

- Barakah required 16,000 people from 30 different countries,
- Training was not a problem,

Timelines for Australia:

- Current objectives are SMR by 2035 and large plant by 2037,
- Samsung referred to issues of environment planning, court obstruction, public hearings, permitting,
- Consider 7 year construction period for large plant.

Romania – NuScale project discussed

- Doosan building RPV now for Romania,
- 6 x 77 MW units = 462 MW total,
- FEED funded $200 million by DOE.

Rolls Royce – 470MW units – start construction 2028 in Czech Republic.

2.3 Daewoo (2025)

Met with Eung-Jae Lee (Overseas Nuclear), Sangwoo Kim, Seung-Il Cho, Suk Jong Yoo and Bong Ha KIM.

Nuclear construction started 1992. Constructed Woolsong CANDU plants and KORAD mid and low level nuclear waste store.

Ted O'Brien asked what are the key issues for a new entrant nation to nuclear energy like Australia?

Response:

- Need to obtain social license throughout nation,
    - Czech Republic has 70-80% support,
    - Coal to nuclear transition - 50-60% can transition – maybe as high as 70%. Extending working life of plant workers by moving to nuclear.
- Need to maintain constancy of policy throughout changes in political cycles,
- Set-up financial model and address financing during construction.

Who would Daewoo Partner with for Australian Projects?

Response: We don't talk to other companies.

Daewoo sits as a major contractor under KHNP.

Divisions of work in Safety Classes:

- Safety Grade by Daewoo,
- Non-safety grade by others within country.

3. KHNP (2025)

Met with Seung Yeol Lim, Geun Park, Bongjun Choi, Cha-Seop Kim

1. KHNP opened up by confirming project delivery "On Time and On Budget". They are looking forward to delivery of 2 x APR1000 units to Czech Republic.
2. Ted O'Brien wants to understand capability of KHNP as part of Team Korea to deliver nuclear power plants to Australia. The Federal opposition has nuclear energy as part of its policy for the next Federal Election – voting is compulsory in Australia – if successful at the election no further referendums are needed.

   KHNP advised that Australia must achieve social licence.
3. Ted O'Brien noted:
   - Australia already is a nuclear nation with the OPAL reactor and AUKUS submarine deal,
   - Regardless of the outcome of the next election – nuclear energy in Australia is inevitable,
   - The Opposition has identified 7 former and current coal plants as sites for new nuclear power plants – they are being entirely up front with the Australian people,
4. Helen Cook noted that our research reactor meets all IAEA safety standards and we have signed up to necessary protocols. Australia has an existing regulator with a long and established international reputation in ARPANSA.
5. Discussion moved to other issues:
   - Human resource management was difficult at Barakah,
   - Australia should start as early as possible on this key issue,
   - Check existence of relevant local supply chain ASAP and look to localization. Note however that placing too much emphasis on early localization could delay the project,
   - KHNP undertook in depth studies of Czech and Polish supply chains very early on and this has taken two years,
6. Training and Localisation - Geun Park advised training of operators and workers proved difficult in UAE – not enough local operators – Emiratis not attracted to the work. Supply chain in Korea has taken time, 20 years ago Korea did not have the large factories that now exist. Collaboration will need to develop in Australia with local contractors. Rob Parker observed that Australia has a very well developed and skilled Civil Engineering sector that can be enhanced. Doosan can help to increase Australian localization.

   Concept of a collective localization "roadmap" outlined – Kazakhstan and Romania already involved. Localisation started in Korea in 1970's and proceeded quickly and lifted the whole industrial base of the nation with human resource development, education, supply chain, safety culture and localisation.
7. KHNP endorsed the IAEA milestones approach and 19 critical factors.

8. How can project go wrong in Aust? – lack of social licence.
9. What was impact of nuclear phase out under Moon Govt? – a backlash, the public want energy security and industrial progress. Korea has high levels of energy use and industry – shipbuilding was badly affected. Nuclear phase out drove up energy prices with increased levels of fuel importation. Nuclear provides price stability and is carbon free.
10. Stephen Wilson raised issue of life extensions of existing plants – not adequately responded to.
11. KHNP advised the nuclear fleet will remain under government ownership for energy security and maintenance of safety – (a lesson here for Australia in selling off its coal fleet).
12. NPP construction period addressed – 86 months duration (KHNP) = 7 years
13. Standardisation of NPP design and construction – some jurisdictions take time and regulators don't always listen to contractors and constructors. – Czech Republic has taken time. Attempts to standardise design are welcomed.
14. Australian Grid Study – KHNP would cooperate in such a study with respect to large reactors
15. iSMR – Innovative Small Modular Reactor project – Korea is starting late on this concept – design is ongoing and centers on a 4 unit plant built underground. Consists of 4 x 170MW units = 680MW. Design to be completed by 2028 with first unit to be grid connected in Korea by 2030. Demand for technology is seen as being AI dominated.

4. Hyosung (2025)

Met with Takeshi Yokota, Byoung Min (Benny) Lee, Tae Hyeong Kim, Dang Chai (Albert) T Y Park, Anne Injung Yu and Ki Yeoung Kweon.

1. Hyosung are a major supplier of pumps, motors, switchgear, transformers and power system equipment to the Korean nuclear power industry. They also provide GIS – gas insulated switchgear. They supply both safety and non-safety related equipment and are the sole supplier to the nuclear sector. Hyosung were very enthusiastic participants and it's clear that they are very interested in the future of nuclear energy in Australia.
2. Hyosung serve a diverse range of energy industries including hydrogen manufacture, wind and solar generation and the chemical industries.
3. Hyosung provide motors for nuclear plant pumps and 80% of the pumps at the Barakah NPP.

   They are the first Korean company involved in the exports of equipment to the nuclear power sector.

4. Ted O'Brien stated that Australia needs a balanced energy mix and he outlined the Coalition's policy and the benefits of proceeding with the help of South Korea.
5. Hyosung have an interest in both water cooled at gas cooled SMR's – this probably relates to Triso fueled plants such as those to be built at Dow Chemicals plant in Texas.
6. Comment made that all Korean NPP's must use Korean equipment.

5. KEPCO Nuclear Fuels (2018)

Met with Mr. Jin-Seok LEE on Tuesday 17th April, 2018

Kepco NF was founded in 1982. An introductory video presentation gave an excellent overview of the importance and operation of the facility

We inspected the reactor models which were the best we had ever seen - all stainless steel and very detailed with lots of well-lit flow paths.

Figure 3 - KEPCO NF main building

Discussion of the System integrated Modular Advanced Reactor (SMART) reactor fuel design

As at 2018, the SMART's PSAR - Primary Safety Analysis to be completed in 2018 with FSAR - Final Safety Analysis to be completed by 2020. FOAK construction start 2020 + 5 years for completion at the earliest. Made note of planned commercial operation in Saudi Arabia by 2030. Fuel for SMART uses same 17 by 17 grid as large reactors but only half as long. Large reactor has 177# x 4.2m assemblies, SMART has 37# x 2.1m assemblies.

As at 2025 there has been no start of construction.

Figure 4 - Fuel rod assembly racks at KEPCO

Figure 5 - Helium insertion and sealing

We inspected the fuel fabrication plant from observation galleries unlike to Columbia facility in the US where direct access was allowed. The fabrication and assembly are highly automated. For PWR's the manufacture starts with enriched UF6 being imported into Korea.

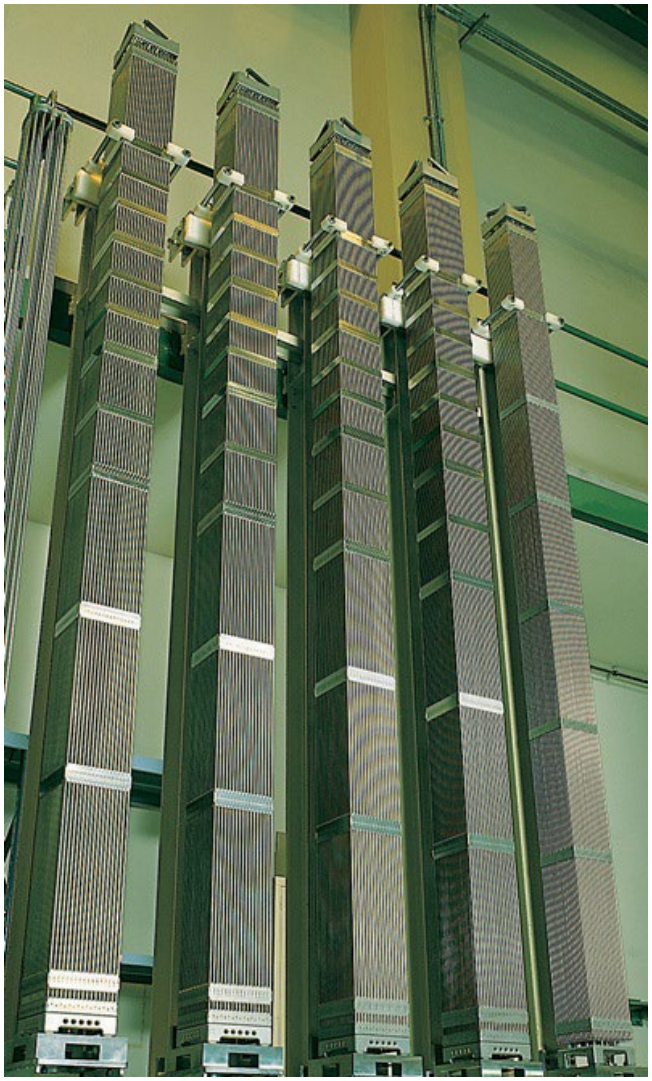

Figure 6 - Manufactured PWR fuel assemblies at KEPCO

The KNF site also has extensive research facilities aimed at fuel utilisation improvements and the development of accident tolerant fuels. Part of the strategy is to eventually have a fully developed Korean fuel. We did not inspect the research facilities.

6. KINAC - Korean Institute of Nuclear Nonproliferation and Control (2018)

Visited on Tuesday 17th April, 2018

Met with Mr. Hosik Yoo, Vice President, Mr Hyun-Chul KIM, Director General and Mr Young Wook Lee, Communications and Cooperation Division Director.

KINAC was founded in 2006 and has 140 staff.

The organisation is one of three making up to the Nuclear Safety and Security Commission. A full presentation of all the activities and responsibilities has been provided that presentation is separately available. The KINAC site has extensive training facilities both classroom and full-scale security hardware for hands-on training experience.

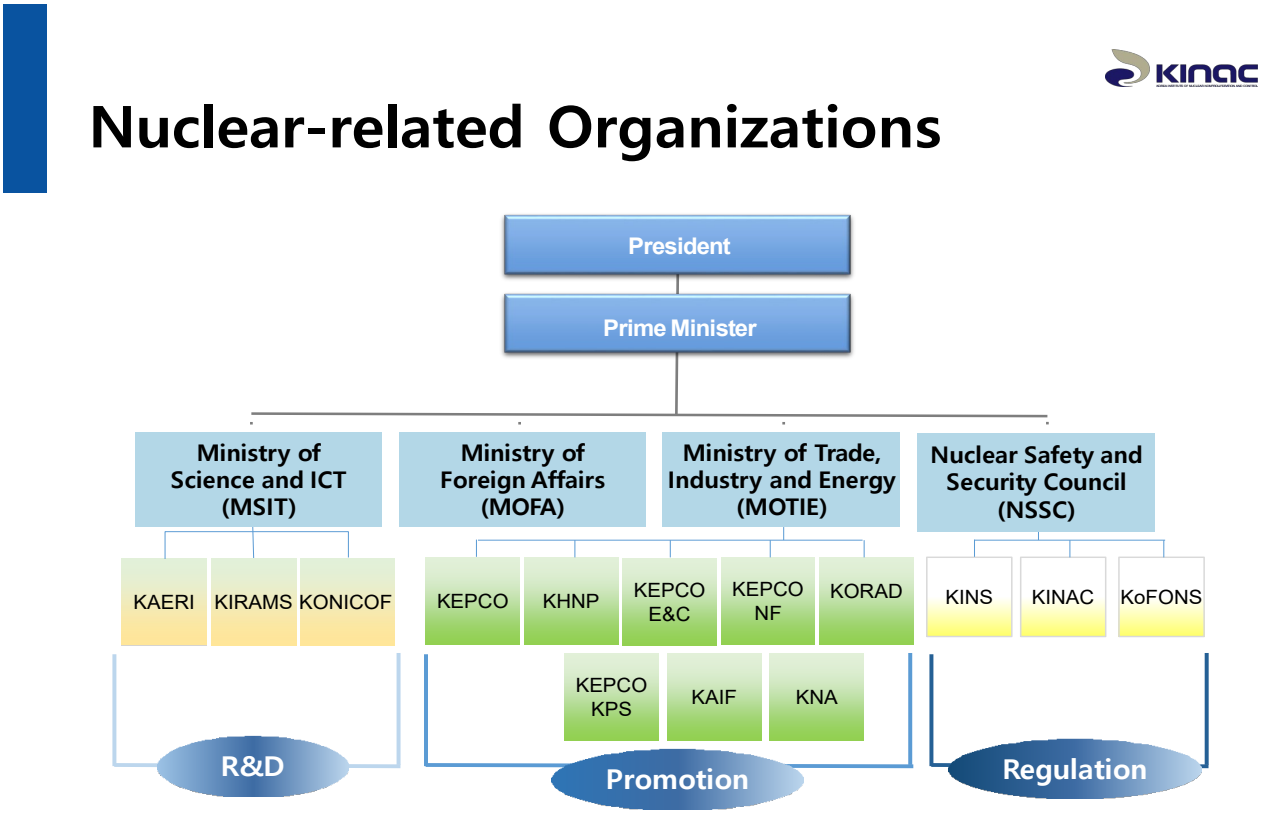

Figure 7 - Korean Nuclear related organisational structure

Regulatory Framework

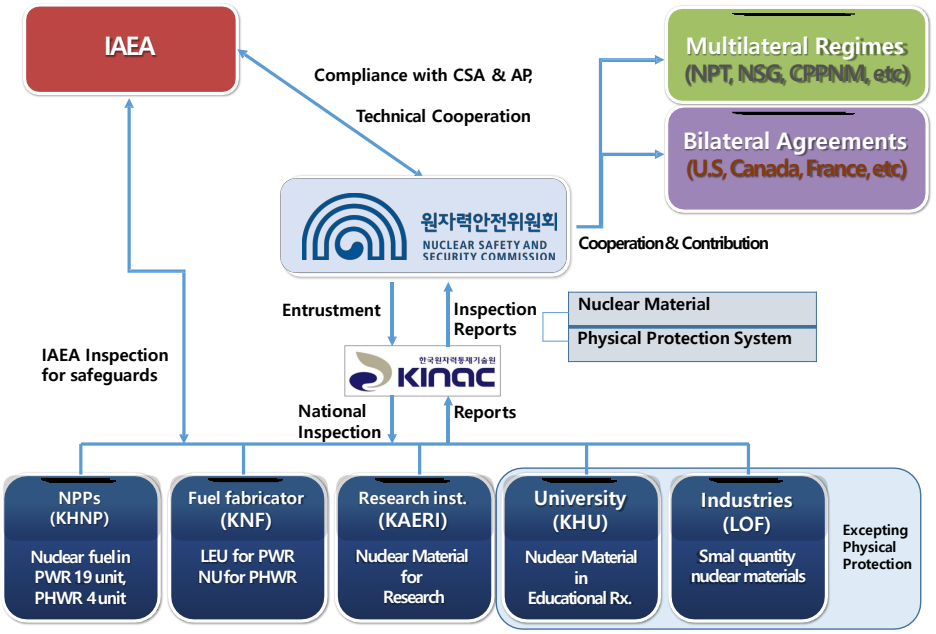

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Figure 8 Korean Nuclear Industry Regulatory Framework

KINAC Organizational Structure

Objectives

KINAC contributes to the peaceful uses of nuclear energy by implementing core measures including:
Safeguards, Export Control, Physical Protection, Cyber Security

Preventing nuclear materials and technologies from being used for purposes other than peaceful uses
Complying with the international obligations on nuclear nonproliferation
Strengthening the national nuclear transparency
* Legal ground : Nuclear Safety Law Article 6 (Establishment of KINAC)

Functions

- Safeguards, Export Control
- R&D on Nuclear control
- Support for International cooperation
- Physical Protection, Cybersecurity
- International & domestic Training
- Policy development

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Figure 9 - KINAC Organisational Structure

7. KORAD - Korean Radioactive Waste Agency (2018)

Visited on 18th April, 2018 in Gyeongju City.

Leader of the tour was Ms. Boram PARK.

The KORAD facility near Wolsong NPP is shown in Figure 2. It is intended to be a permanent storage for intermediate and low level nuclear waste.

The reporting structure for KORAD is shown in Figure 10

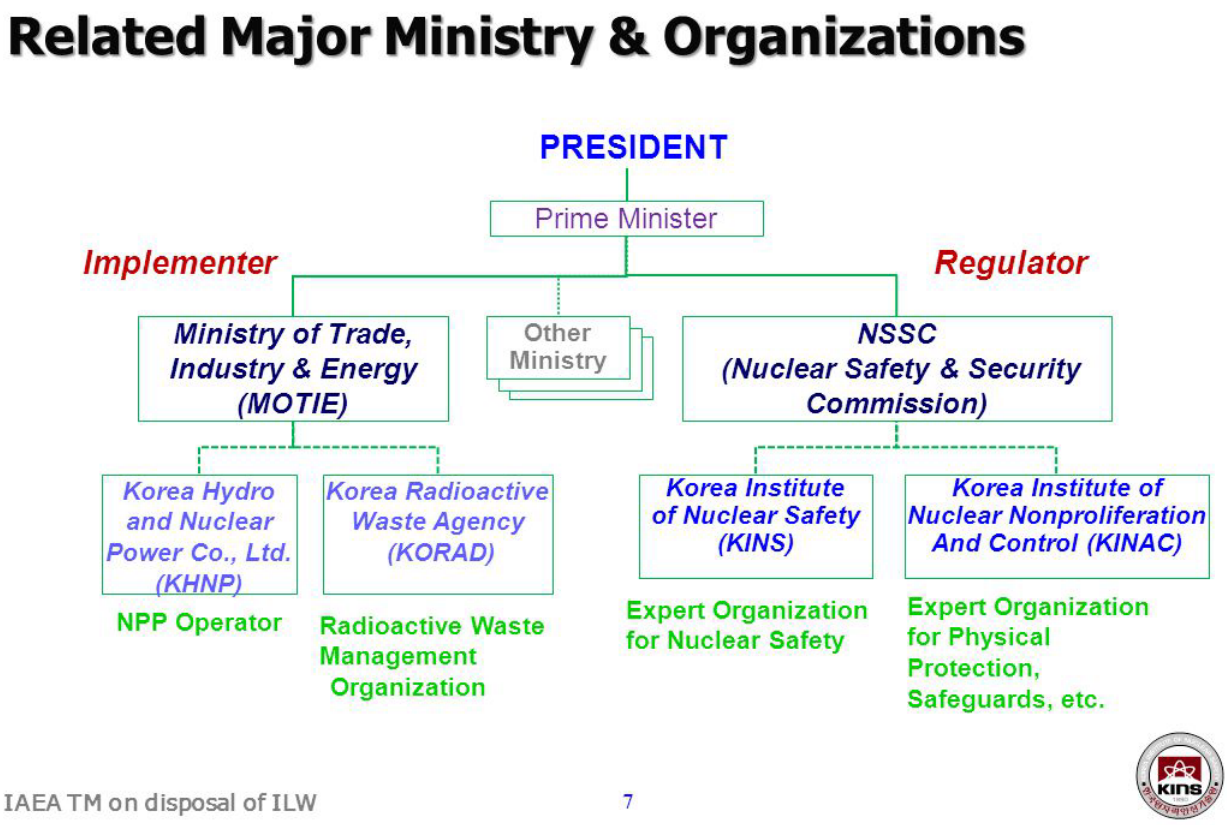


Figure 10 - KORAD reporting structure

Figure 11 shows the cross section for the underground facility and the location of the operating and construction tunnels. Figure 12 is a combined aerial photograph and schematic of its location in the regional terrain. The inspection and storage preparation buildings are at ground level and shown in the middle of the image.

The site has been engineered to withstand a 0.2g ground acceleration in a seismic event in Stage 1 while stage 2 will be designed for 0.3g.

As currently constructed the facility will house 100,000 x 200 litre drums of waste however the future Stage 2 expansion will take this to 800,000 drums over 60 years. Much of the material is unloaded at a local wharf and is transshipped in structural steel containers as shown in Figure 14 and Figure 15.

The facility has cost US$1.5 billion to get to stage 1. The standard of engineering detail and construction is very high.

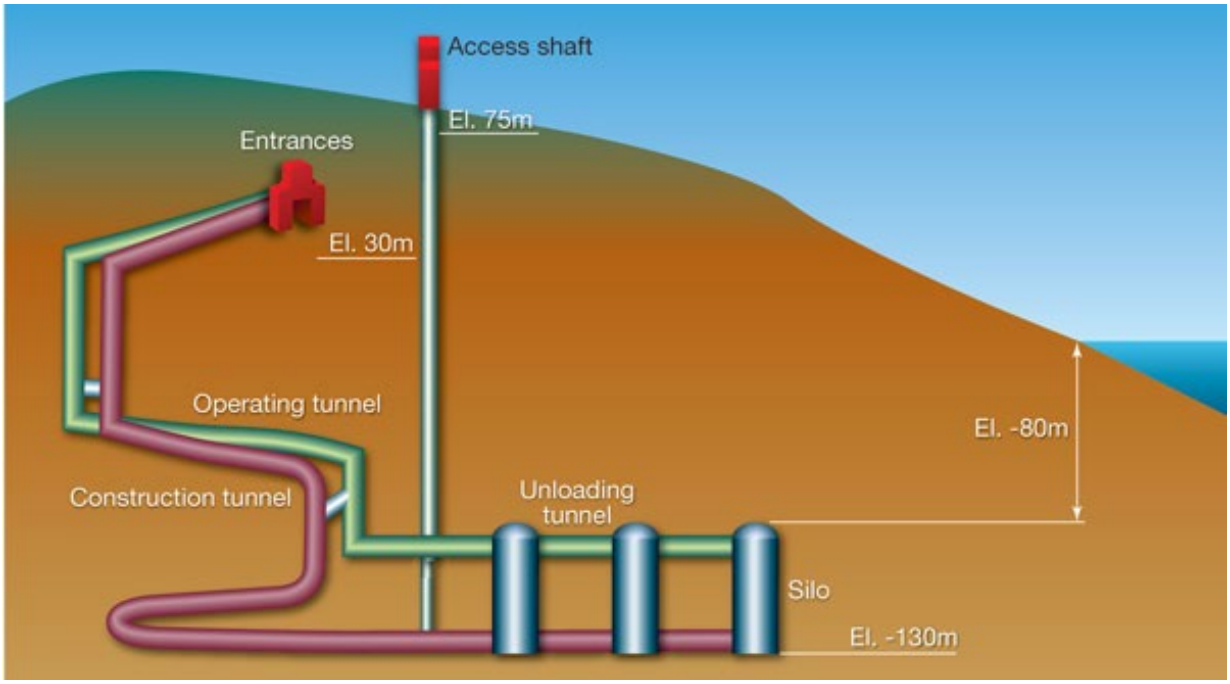


Figure 11 - KORAD sub-surface cross section

Figure 12 - Schematic of KORAD facility

The vessel used to bring the waste to the facility is the **Hanjin Cheojeong Nuri**, a radioactive waste transport ship which was built to safely transport radioactive wastes generated from each nuclear power plant and nuclear-related facilities to the disposal facility.

FEATURES

Length and Width : 78.60M / 15.80M
Draft : 4.0 M
Total Tonnage : 2,600 Tons
Total Deadweight (DWT) : 1,365tons
Speed : 12.0 Knots
Engine : Double Diesel Engine (1,632 HP each)
Max. Capacity : 190 Containers (1,520 Drums)

Figure 13 - Nuclear waste transport ship

Characteristics of Hanjin Cheongjeong Nuri

- It is designed and built with double-hull and double engine structure to prevent leakage in case of an accident.
- An accident is prevented by state-of-the-art electronic equipment such as Automatic Identification System (AIS) and Automatic Radar Plotting Aids (ARPA).
- The radiation level in the ship is automatically monitored by radiation monitoring system.
- Radiation protection and emergency response plans are established to prepare for an unexpected accident.
- Safety is further guaranteed by prominent sailing personnel and radiation safety officers on board.

Figure 14 - Structural steel transhipping containers

Figure 15 - Containers on haul trucks

At the facility the waste is packed into permanent concrete disposal containers (2.7m x 2.7m x 1.4mH) of the type shown in Figure 16. These take 16 x 200 litre drums.

Figure 16 - Permanent concrete disposal containers

Inspection of up to 64 drums per day takes place in the packing facility where workers carry out an eight-hour shift.

Seven parameters are checked on each drum:

1. Weight
2. Visual integrity
3. Surface dose rate
4. Surface contamination
5. X-ray inspection
6. Radionuclide analysis
7. Compression strength

Up to 44 containers can be disposed of per day in 1 to 27 layers

The concrete filled disposal containers are then trucked to the silos via the operations tunnel shown in Figure 17.

Figure 17 - Operations tunnel

The operations tunnel shown in Figure 17 is 1415 metres in length, 7.2m wide and 6.5m high.

The construction tunnel is 1950m in length, 7.2m wide and 6.5m high

Figure 18 - Storage Silos

The storage silos are constructed by mining out the granite, rock bolting the faces for stability and then lining the faces with a permanent waterproof membrane. The silos walls are then constructed with reinforced concrete approximately 1 metre thick.

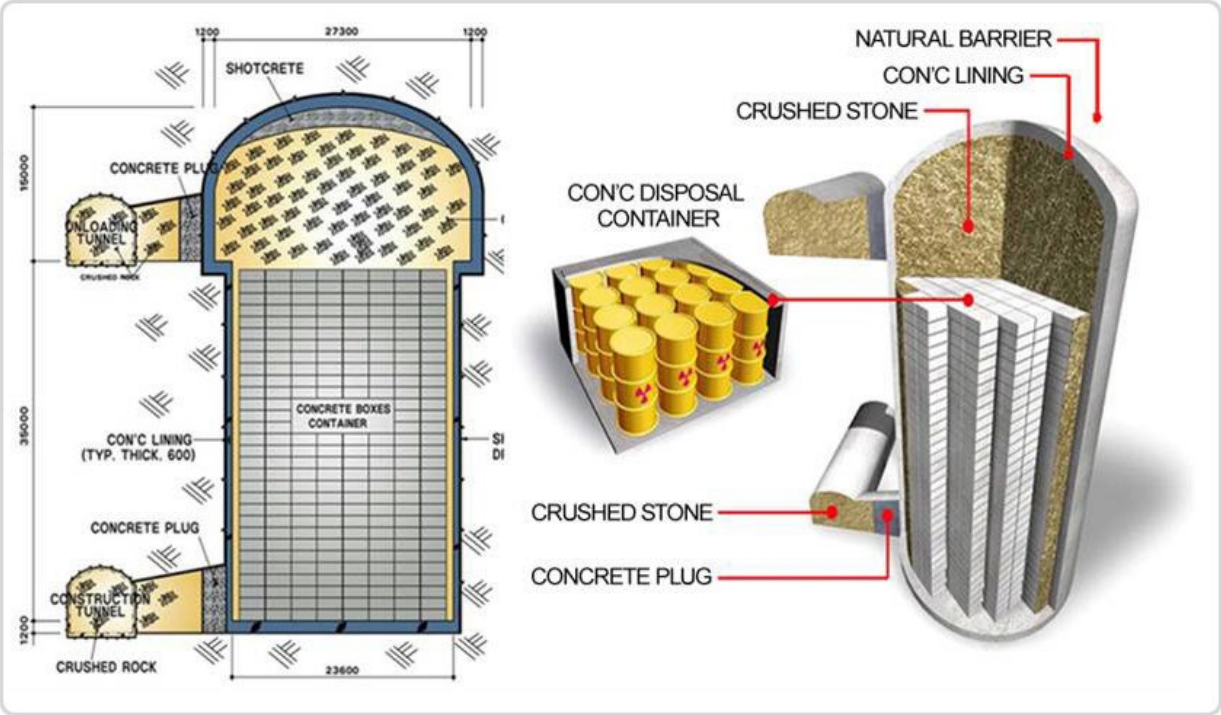


Figure 19 - Arrangement of containers in silos.

The packing arrangement in the silos is shown in Figure 19. There are six silos in Stage 1. Each is 50m high and 24m in diameter and hold 17,500 drums each. They extend from 80 to 130m below sea level in granite bedrock

10% of the material stored is intermediate waste and the facility will be monitored for 100 years

Figure 20 - Silo loading with gantry crane

On the day of inspection, the radiation intensity in the packing facility was 1.893 micro sieverts per hour. For personnel entering that environment this represents about 4 millisieverts per year working an eight hour shift, five days per week. This is well below the acceptable level of 20 mSv per year for radiation workers

Inside the observation room the level of 0.113microsieverts per hour represents about 0.24 mSv (millisieverts) per year on the same shift rotation or less than a typical terrestrial background radiation of around 1.5 mSv per year. It would seem that there is a good basis for Korea and Australia to work together on the storage of a used nuclear fuel facility. We have suitable locations they have the need, the technology, and the capital.

8. KHNP Saeul Nuclear Power Plant Visit (was Shin Kori) (2018 and 2025)

Inspected on 18th April, 2018 and January 14th 2025

Ten nuclear plants collectively make up the Kori, Shin Kori and Saeul nuclear plant complex.

Eight are operating, two over 95% complete, one awaiting commissioning and one laying idle awaiting decommissioning. They are located with 3.2 kilometers of each other on the shoreline 3 km south of Ulsan City as shown in Figure 21. The operating record shows very high utilisation some years up to 100% a reflection of the very high engineering standards utilised.

Figure 21 - Kori and Saeul NPPs with KINGS in centre

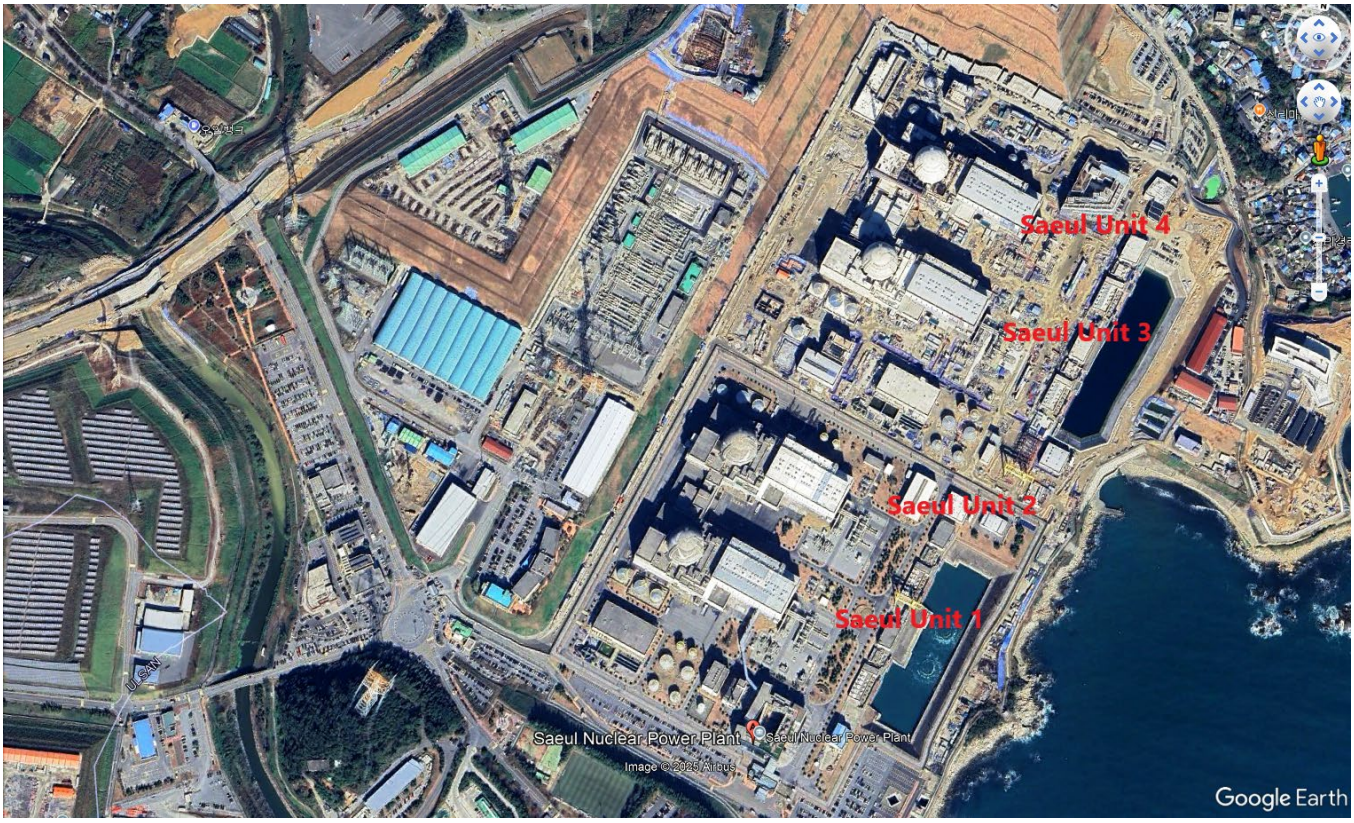


Figure 22 – Saeul Units 1,2,3 & 4

In Figure 22 we see Unit 1 through to 4. Units 1 and 2 are operating, Unit 3 is undergoing hot testing and unit 4 cold testing. The Saeul units are all APR 1400's. We were able to carry out an inspection of Unit 2 which, on the day was generating 1,495MW – possibly due to improved turbine performance in very cold weather.

We were surprised to learn that while the “house” loads of the APR1400 plants in Korea is about 100MW, those of the units operating at Barakah in the UAE are about 300MW. This 21% loss is due to high sea water temperatures, additional pumping and other measures needed to improve the cooling condenser performance.

Units 1&2 were costed at $US6.8 billion while Shin Kori 3&4 are costed at US$8.6 billion due to revisions in design required following the Fukushima events. This has included increases in containment wall thicknesses (1.7m vs 1.2m) and a multitude of other safety-related improvements. The containments have been designed to resist the impact of a Boeing 767.

Construction of Units – 3 & 4-time line:

- Excavation in granite bedrock started in July 2016
- 1st Concrete in April 2017
- Reactor vessel May 2019

Hot functional testing, fuel loading and operations were all delayed by the election of the Moon Government with its anti-nuclear policies. These were subsequently reversed. The containments

are 50.75m in diameter 71.57m high above ground level and 16.35m in ground and founded on granite.

Figure 23 – Saeul Units 1 and 2 in 2018

Other notes include:

1. Safety measure - Cavity flooding from In containment refuelling water storage tank,
2. Walls increased in thickness for aircraft impact - reo up to 67mm dia. size and vertically and circumferentially post tensioned,
3. In containment uses air tight and water proof doors,
4. Contain passive autocatalytic hydrogen recombiners, keep H2< 10%. Also have hydrogen igniters,
5. Backup batteries. Units 1&2 have 4,200 AH - 8hr, Units 3&4 have 7,200 AH - 24 hr backup,
6. Seawater coolant tunnels - intake is 750m, discharge is 380m,
7. Power conveyed via 765kV lines and 24kV local distribution, SF6 gas used to insulate underground lines,
8. Turbine hall - 70m shaft length, 24kV output, 1,800rpm, moisture separators and re-heaters, all by Doosan. Lifting gantry crane 310T/70T,
9. Operators - each reactor has 6 teams with 11 operators per team, total staffing per reactor unit is approx. 500.
10. All digital controls but safety console is not digital - uses manual operator controls.
11. Shifts = 3 x 8hrs. Day shift 3 days on, 1 day off, Night shift 3 days on, 2 days off.

Figure 24 – Saeul 3 and 4 construction in 2018

6. KINGS - KEPCO International Nuclear Graduate School (2018 and 2025)

- 2025 met with Professor Hak Kyu Lim, Dean of Academic Affairs and Chang Lak Kim, Executive Dean and Professor.
- 2018 Met with Professor Chang Choong-koo, Dean of Academic affairs and Director Lee Tong-Seung, Planning and Management (see also section 1 presentation notes on KINGS).

Figure 25 - Australian Delegation meets with Deans and Professors of KINGS

KINGS is a post graduate school training students from around the world in nuclear power plant engineering. It runs a two-year course primarily at its campus located between the Kori and Saeul nuclear powers plants near Busan. The course outline is shown in Figure 26 and leads to the award of a Masters of Engineering though the option of a Doctor of Technology also exists. The course provides education in all aspects of the nuclear fuel cycle and additionally addresses the economics of nuclear. It does not provide a nuclear plant operators certificate which falls under the responsibility of the nuclear utility.

Areas of study include Gen IV plants, SMR's, nuclear safety, energy economics and nuclear physics.

Details of the school are provided at this link:

https://www.kings.ac.kr/home.do

Entry is open to students with a Bachelor's degree in Engineering and 1 to 3 years industrial experience.

English is the language used for all tuition. KINGS started in 2009 and has over 300 graduates from 34 countries. Currently a third of students comes from Poland, Czech Republic and Eastern Europe

In recognition of the expanding tole of nuclear energy the School now has Professorial exchanges with Warsaw University and Universities in the Czech Republic

The programme steps as described in 2018 are:

1. 1st Trimester (3 mths) - BOOT CAMP provides core knowledge of nuclear power engineering
2. 2nd Trimester (3 mths) - APR familiarisation and Systems Engineering
3. 3rd Trimester (3mths) - APR intensive and Systems Engineering II
4. 4th - 6th Trimester - Specialisation programme

The course is run in conjunction with George Mason University and San Jose State University for system subjects.

Figure 26 - KINGS Course Outline

The course aims to produce people who can meet three key roles:

- **Technical experts** capable of identifying and resolving problems in NPP systems and overall engineering processes,

- **Engineering managers** capable of systematically integrating, controlling and managing complex and diverse NPP technologies and technical trends,
- **Project managers** capable of managing NPP projects occurring in the total NPP lifecycle of design, manufacture, construction, O&M etc.

The tuition is sponsored by KEPCO with full scholarships, tuition and accommodation. Entrants to the course would normally be under the age of 40 years old. There are 18 faculty heads (2018).

The opportunity to move from the classroom and walk to reactors in all states of play from construction to decommissioning for hands-on practical experience is one of the very unique opportunities that KINGS offers.

We discussed options for the possible training of Australian engineers and program management staff. In addition there is the potential to link up with Australian Universities running nuclear courses such as ANU, UNSW or Flinders University.

7. Doosan Enerbility (2018 and 2025)

Inspected at Changwon City:

- 15th January 2025 – met with Jiho Jang (Director Sales), Youngsik Kim (Sales) and HongkyuKang (SVP design and manufacturing))
- 19th April 2018 with Hong Kyu Kang General Manager Nuclear Sales and Marketing

We visited the turbine shop, forging shop and the nuclear machining shop after an initial presentation on the full range of the Doosan Heavy Industries business.

Doosan Enerbility manufacture a wide range of products for the power, water, and transport industries

In May, 2017 Doosan celebrated the installation of their new 17,000-ton forging press – the world's largest to date – at the forging plant of its manufacturing complex in Changwon, the new press is 29 meters tall and 9 meters wide. Commercial operation of the press was initiated in April 2017

Doosan also expanded the size of its forging plant by nearly 34% to 73,748 m² for the new large-scale machine, replacing the existing 13,000-ton forging press that was operated for the past 35 years. The company's forging plant is now capable of producing 80,000 tons of forged materials a year with the new forging press. Doosan plans to expedite efforts to develop and deliver supersized forged products for power generation and industrial facilities such as the next-generation advanced nuclear power reactors.

Doosan Enerbility has a total of three forging presses (2018) – 17,000 ton, 4,200 ton, and 1,600 ton – enabling the company to produce a total of 140,000 tons of forged steel products annually.

Figure 27 - 17,000 tonne forging press

At the site steel ingots up to 650 tons in weight are produced in electric arc furnaces at temperatures of 1200 degrees C and loaded out to the forging shop where we viewed a range of products shown in the following images. These are forged at around 500 degrees C before being reheated. The ingots are manipulated and fed into the forge using a Dango and Dienenthal 750 ton manipulator.

Figure 28 - Dango and Dienenthal 750-ton manipulator

Figure 29 - Integrated Steam Generator head with nozzles (2018)

From the forging shop we moved to the machining and winding shop where we viewed the Steam generators, turbine shafts and generator rotors and windings for the new Saeul "4" NPP plus a

number of other components including reactor pressure vessels for a number of future NPP's. We then inspected the steam generator and reactor pressure vessel welding and assembly facilities.

This facility has produced 34 reactor pressure vessels and 134 steam generators to January 2025. Doosan have transitioned to the use of INCO 690, or Alloy 690. This is a nickel-chromium alloy specifically manufactured to address stress corrosion cracking in nuclear power plants.

In the machining shop we viewed (in 2018) replacement steam generators for Watts Bar in the US and existing OPR 1000 NPP's

The inlets and outlets of the steam generator nozzles are lined with stainless steel grade 309 and topped with a second layer of grade 308 steel. The main steel forgings are manufactured using a low alloy grade SA508 steel.

Figure 30 - Completed steam generators

Figure 31 - Reactor pressure vessel shell in forging press

Figure 32 - Completed RPV

Figure 33 - Turbine Rotor shaft

8. KAERI - Korean Atomic Energy Research Institute (2018 only)

Visited on 19th April 2018 in Daejeon

During our visit we met with Mr Kyun S Zee, who has developed the SMART reactor concept from day one and is now retiring. Mr Keung Koo Kim who is Vice President of the SMART development and Mr Ji Han Chun who is the Principal Researcher. They gave an excellent presentation.

After the presentation and wide-ranging discussions we visited the SMART reactor thermal test rig which has evaluated most of the design parameters and the reactor control room simulator

The SMART or **S**ystem integrated **M**odular **A**dvanced **R**eac**t**or is a small integral pressurised water reactor (PWR) with a rated power of 330 MW_{th} and 100MW_e developed by the Korean Atomic Energy Research Institute - KAERI. The design aim is to achieve improvement in the economics through system simplification, component modularization, reduction of construction time and high plant availability. The design incorporates inherent safety features and passive safety systems by introducing a passive residual heat removal system (PHRS), and an advanced mitigation system for loss of coolant accidents (LOCA). The design has also low power density with a slightly enriched 5wt% UO2 fuel to ensure a thermal margin of higher than 15%. SMART has been fully licensed in South Korea and the standard design of SMART was approved by the Korean Nuclear Safety and Security Commission in July 2012.

Weighing in at 1,000 tons fully assembled it's more a small reactor made of modules than a readily transported small modular reactor (SMR) although the internal modules can be shipped separately and assembled at site.

As at 2018 Doosan were preparing a facility to assemble the reactors however at this stage they have not finalised the module arrangements for site delivery and assembly.

Likely first of a kind cost to be around US$10,000/kw or US$1 billion total

SPC, the marketing company was founded with the investment of capital and manpower from 6 corporations, including POSCO E&C, PONU Tech, and DAEWOO E&C. Currently the EPC is a JV between KAERI and the Saudi Govt who have invested circa US$40 million in the venture. The first two are planned to be built north of Medina in Saudi Arabia. The timing has not been disclosed however in 2018 we gained the impression that construction could start in about a year. There are 45 Saudi personnel at KAERI.

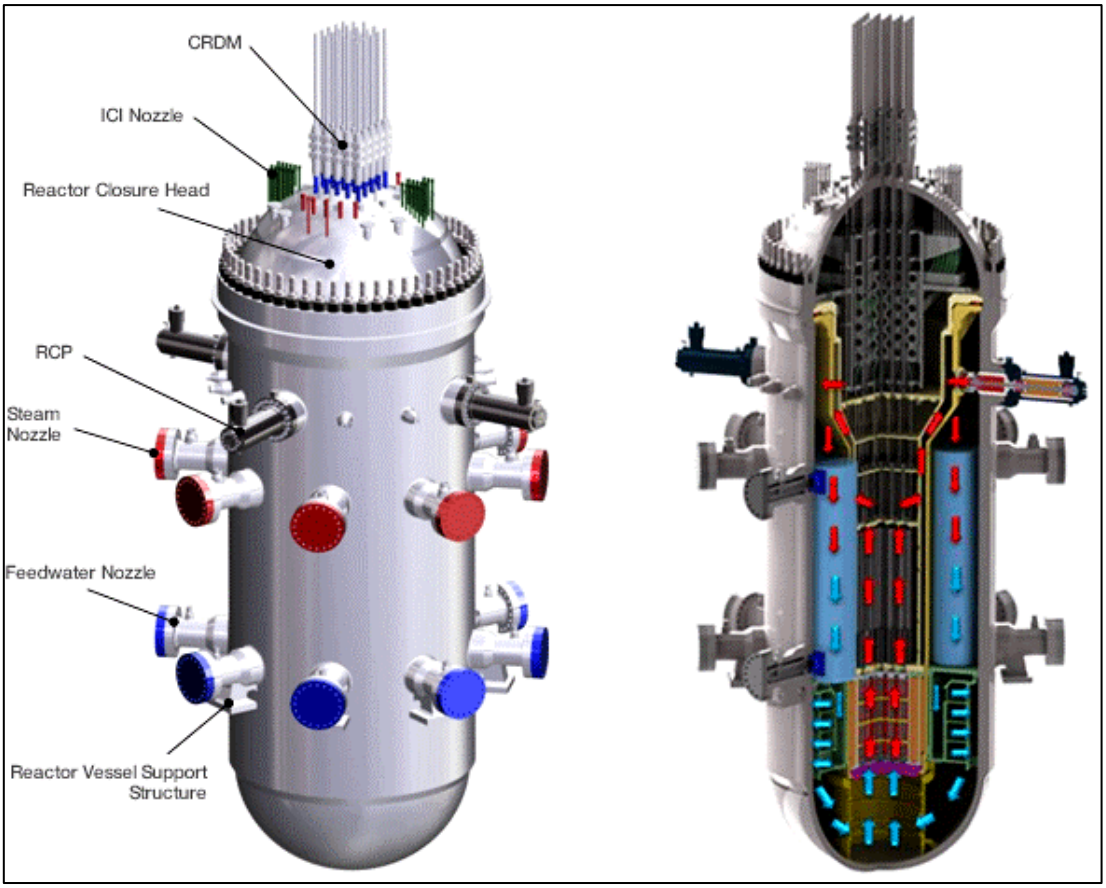


Figure 34 - SMART reactor and containment vessel

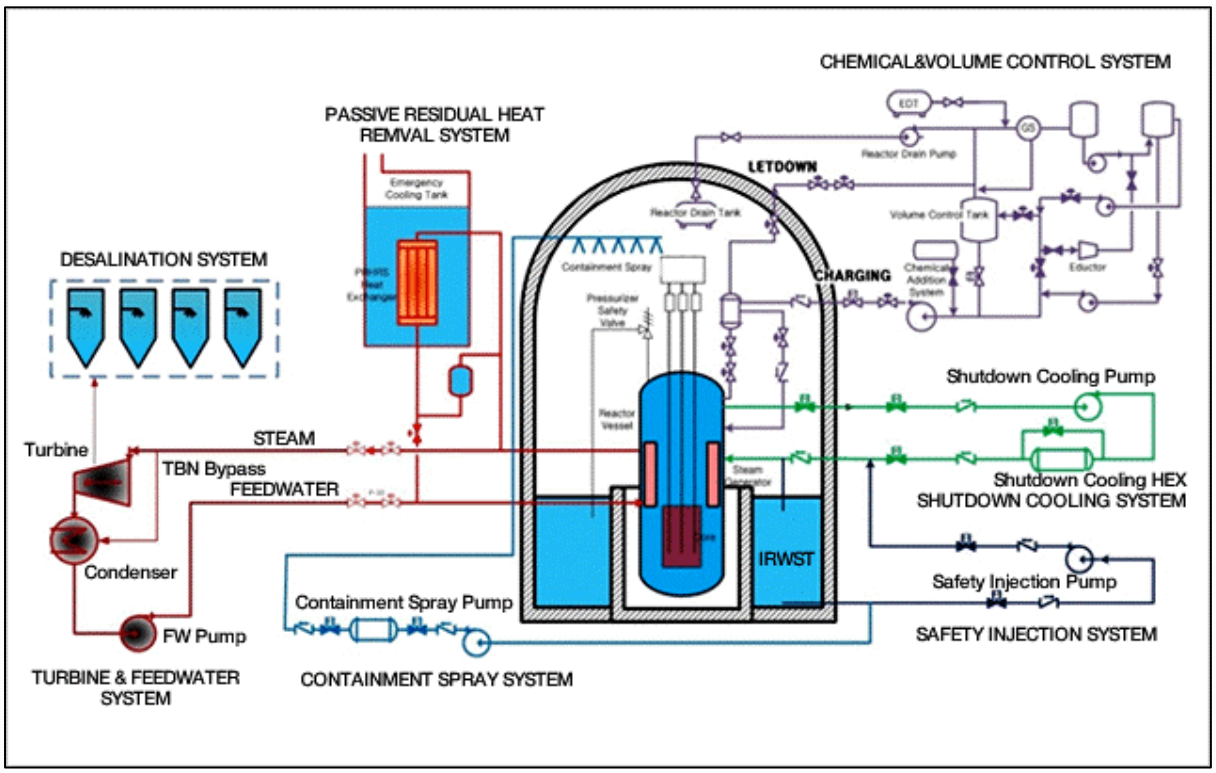


Figure 35 - SMART Schematic

The SMART reactor fits with the structure and layout of a conventional though small NPP containing elements such as a concrete containment, spent fuel pools, In-containment refuelling water storage tank IWRST, turbine building and control centre.

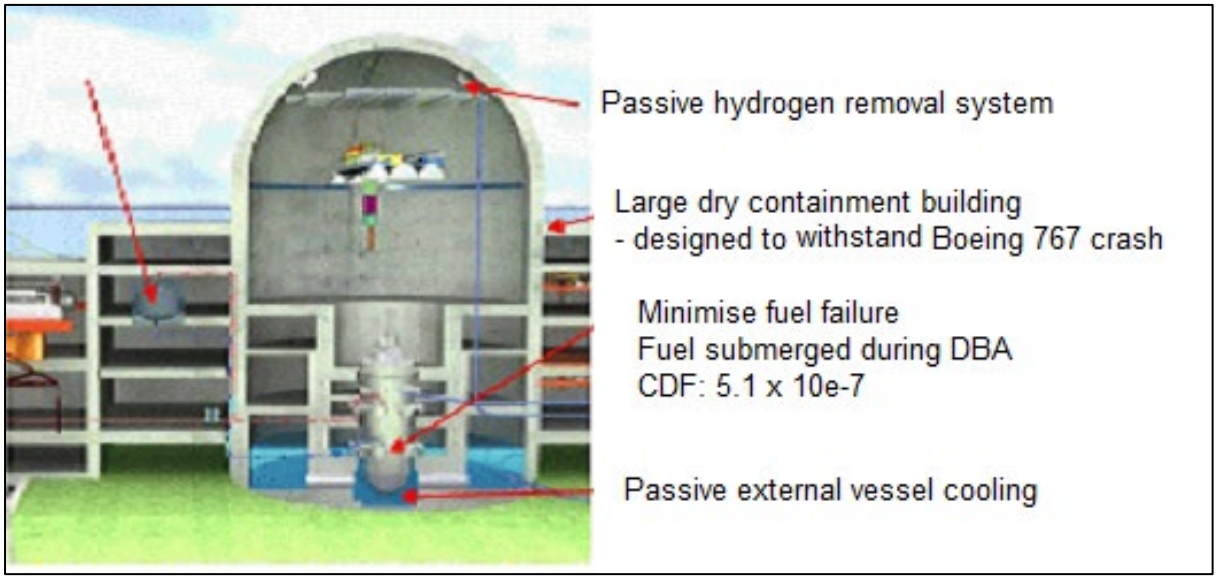


Figure 36 - SMART NPP section

9. Micro URANUS

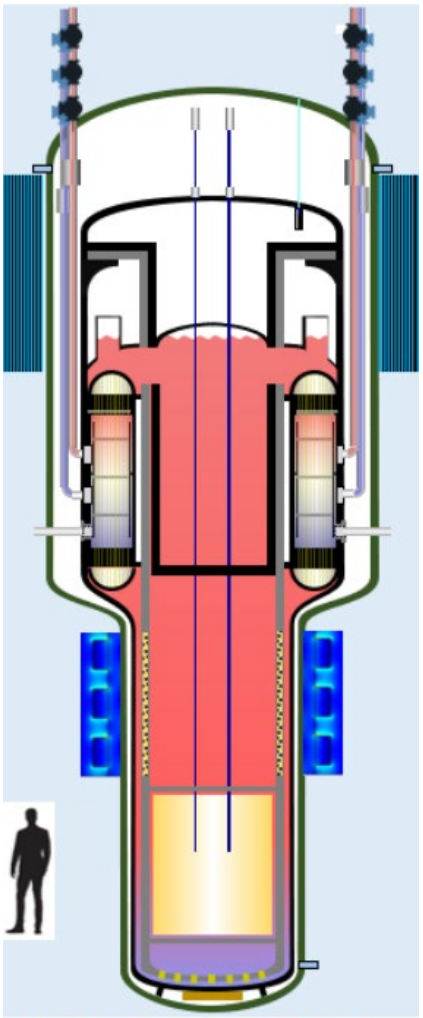
Met with Prof Il Soon HWANG, Suk-Sig LIM and Kibum KIM

1. MicroURANUS technology proposes a 20 – 30MWe Lead-Bismuth cooled Lead cooled fast reactor (LFR) which operates without refuelling for a 40 year life.

   MicroURANUS state that refuelling of small modular reactors can undermine safety, security, environment, economy as well as public acceptance. MicroURANUS is the world's first civilian nuclear reactor that can run for a full 40-years life only on its initial low enriched uranium LEU (12.4%) fuel.
   The hermetically-sealed design with no refuelling is essential to ensuring proliferation-resistance and nuclear security for use in remote or maritime environments.

2. Remote inspection and maintenance are designed to work through leak-tight ports. The lack of reactor opening during operation thus eliminated the radiological risk of polonium-210.
3. Uses average 12.5% enrichment with a range in the reactor of 14% at perimeter to 9% in centre.

   Burnup is 65 GWd/tonne with max. reactor temperature of 1000 deg C and steam generator operating at 340 degrees C. It has 1/3rd the power density of a PWR
   Module mass is 1000 tonnes – presumably stripped of coolant, fuel and mechanicals to facilitate shipment and handling.


MicroURANUS- 20 MWe Micro Reactor

4. Upon decommissioning, MicroURANUS including spent nuclear fuels is recycled at a dedicated recycling center, based on pyroprocessing. Recovered uranium and trans-uranic (TRU) elements are fabricated into new fuel for MicroURANUS reactors. All high-level wastes (HLW) from pyroprocessing will be decontaminated into low- and intermediate-level wastes (LILW) by PyroGreen technology for economic and sustainable waste management
5. Like other fast spectrum reactors, load following is readily achieved.
6. A 10MW trial plant is proposed at Bristal in the UK in concert with the ONR. It is anticipated that the design requires 4 years to complete licensing and 2 years to build.

10 Australian Embassy Briefing (2018).

- 2018-On Friday, 20th of April we attended a meeting at the Australian Embassy in Seoul where we briefed Mr James Choi - Australian Ambassador to South Korea, Mr Rodney Commerford - Trade Commissioner and Counsellor and Mr Sam Baker - Second Secretary (Economist)

  Our initial conference on Monday 16th April was attended by Ms. Amanda Hodges, Senior Trade and Investment Commissioner

  We described our tour in detail and outlined our significant concerns with increasing electricity prices in Australia and the general state of the Australian electricity sector.

- 2025 – Ted O'Brien briefed to current Australian Ambassador to South Korea - Jeff Robinson, Alexandra Dawes (Counsellor) and Simon List (2nd Secretary) on the activities of the delegation.

11 Delegation and Study Tour Participants

Participants for both the 2018 and 2025 delegations are shown.

1. **Ted O'Brien MP** (2025)- Member of the Liberal National Party of Queensland (LNP). Represents the seat of Fairfax in the House of Reps. Sits with the Liberal Party in Federal Parliament. Shadow Minister for Climate Change and Energy from June 2022. Holds an MBA(IntBus)(Hons) (UMelb), BA (UQ) and MEc (IntPolEc) (LSE).
2. **Helen Cook** (2025). Recognised as a nuclear law expert by the IAEA and author of the legal text book, "The Law of Nuclear Energy" published by Sweet & Maxwell. Helen is an Adjunct Associate Professor, School of Global and Public Law, Faculty of Law, at UNSW and a former Chair of the World Nuclear Association's Law Working Group.
3. **Stephen Wilson** (2025). Adjunct Professor in the School of Mechanical and Mining Engineering at UQ, provides advisory services through Cape Otway Associates. He is an energy economist with 30 years' experience on assignments in over 30 countries. During that time, he has been involved in most parts of the wider energy sector along the value chain from primary energy to end users, in electricity, gas and the transport sector.
4. **Jasmin Diab** (2025) Jasmin has a Master of Nuclear Engineering from UNSW and is the Australia Managing Director of Global Nuclear Security Partners and President of Women in Nuclear Australia. In addition to her nuclear work, she is a keen creative and a former servicewoman in the Australian army.
5. **Mike Newman**. (2025) Founder of Ginga Vale, has been in investment banking for over two decades. Most recently Mike was the NSW Government's Senior Trade & Investment Commissioner, North Asia where he led the Japanese and Korean offices for Investment NSW. Mike has lived in Japan for 25 years and has a deep lived experience of business culture and trust-building in the region.
6. **Robert Barr AM** (2018) is a consulting engineer, director of his company Electric Power Consulting Pty Ltd and previous National President of the Electric Energy Society of Australia. Robert has over 42 years' experience in the field of power systems and

electricity distribution, is a FIEA. Robert is an Honorary Professorial Fellow at the University of Wollongong and was awarded the title of Australian National Professional Electrical Engineer of the year in 2012. Dr Barr became a Member of the Order of Australia in 2013.

7. **Robert Parker** (2018 & 2025) is a civil engineer with over 35 years of experience in project management and the economic evaluation of projects. He is the former President of the Australian Nuclear Association which is tasked to carry out the investigation of current advances in nuclear fuel cycle for power generation. He holds a Masters in Nuclear Science from the Australian National University.
8. **Barrie Hill** (2018) is an engineer with over 45 years' experience in the design, construction, commissioning, and operation of mineral processing plants and power stations for the mining and energy sectors in New Zealand, United Kingdom, and Australia. He is currently Managing Director of SMR Nuclear Technology Pty Ltd. Experience in the nuclear engineering field includes design, commissioning, and operation of nuclear power stations in the United Kingdom and seven years as Director of Engineering for ANSTO over the period of construction of the research reactor OPAL