Travel Report – Scandinavia

Safety, Young Generation 2025

During our year in the networking program Young Generation, we had the opportunity to visit Finland in early June and the Czech Republic in October of 2025. In Finland, we visited the Loviisa Nuclear Power Plant and the VTT Technical Research Centre, with focus on reactor safety, simulation tools, and materials research. In the Czech Republic, we visited the Temelín Nuclear Power Plant, with focus on fresh and spent fuel storage, and the ÚJV Řež research center, where we observed Hot Cells and the LVR-15 research reactor. Together, these visits provided valuable insights into European nuclear technology and safety practices in different operational contexts.

Text written by Federico Barbano, Morgan Didriksson, Julia Hägerström, Ellen Ståhl and Olivia Winestedt.

Finland - Guided Tours at Loviisa NPP and VTT

In early June 2025, we traveled to Finland to explore and learn from the country's unique approaches to nuclear power and safety. The visit centered around study trips to the Loviisa Nuclear Power Plant and the VTT Technical Research Centre of Finland.

Participants

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Purpose of the trip

The purpose of the study visits was to gain insights by learning from other companies' and organizations' approaches to safety-related questions, as well as broadening our perspectives in nuclear power and academia. The visits were planned in Finland due to the similarities to Sweden in culture and nature, but with clear differences in power plants, regulations, and geopolitical placement. The group chose Loviisa Nuclear Power Plant and VTT as their destinations. By analyzing Finland's structured approach to nuclear safety, the group wanted to gain valuable knowledge applicable to future reactor developments and international safety collaboration.

Monday 26th of May - Loviisa NPP and the Fortum Showroom

Our day began on-site at the Loviisa NPP, Finland's first nuclear facility, which today consists of two reactors: Loviisa 1, which began producing electricity in February 1977, and Loviisa 2, which started operations in November 1980. Today, Loviisa supplies approximately 10% of Finland's electricity, has produced more than 7.9 TWh of energy during 2024, and employs around 570 permanent staff on-site.

What makes the Loviisa plant unique is that it marked the first time in nuclear engineering history that East and West collaborated on a multicultural project. The reactors, turbines, generators, and other main components were supplied by the former Soviet Union, while the safety, control, and automation systems came from Western countries. This blend of technologies earned the plant the nickname "Eastinghouse". The power plant units are VVER-440 type pressurized water reactors.

In the afternoon, we had the opportunity to get to know the plant even better during a visit to their Visitor Center located in the city of Loviisa.

Loviisa NPP

On Monday morning, we drove to Hästholmen, an island outside the town of Loviisa. At the end of the road, we were met by a vehicle gate, a welcome building belonging to the nuclear power plant, a few parking spaces, and a marina.

Inside the welcome building at Loviisa Power Plant, we met Simo Kettunen, who was our guide for the day. In addition to his regular duties at the facility, he also represented the Loviisa chapter of Young Generation. We received our access badges, got a brief introduction to the history and current status of the Loviisa plant, and changed into full safety gear. After passing through the secured vehicle gate, we entered the Loviisa industrial area.

Following a security screening similar to airport controls—including an alcohol test, testing for traces of explosives on hands, and a full body scan—we were allowed into the turbine hall. The turbine hall at Loviisa was a single large building, resembling a warehouse, with windows high up along one of the long walls, quite different from Forsmark and Ringhals. Inside the hall were all four turbines, two each for Loviisa 1 and Loviisa 2. Unlike Swedish nuclear plants, there was no separation between the turbine units of the two reactors; all turbines and generators were housed in the same hall.

Many of the turbine components still had old signs in Russian, a reminder of their original suppliers. There were also signs reading "Smoking prohibited," highlighting the age of the buildings and how the working environment had evolved over the reactors' lifespans.

We also had the opportunity to visit one of their latest 3D-model projects in the testing house on-site. They had built a simulator of the large overhead crane inside the reactor containment, replicating exactly what crane operators see when working in real conditions. The simulator is called HeLiSi - Virtual Reality Heavy Lift Simulator. This allowed operators to practice heavy lifting operations and thereby speed up the process during maintenance outages. Naturally, we got to try out the simulator ourselves and could now proudly call ourselves crane operators.

Loviisa has, throughout its years of operation, continuously undergone various safety enhancements to improve the overall safety of the plant. One passive safety feature included in the original design and developed by Westinghouse is the ice condenser system integrated with the steel containment.

Following the Fukushima disaster, Loviisa was required to ensure the ability to use air as an alternative heat sink in the event of water loss, such as during an oil spill in the nearby sea. Additionally, the facility underwent seismic upgrades to enhance its resilience against earthquakes.

Efforts are underway to transition to alternative fuel suppliers that are not Russian. In 2024, the first batch of Westinghouse fuel was loaded. The change of fuel implies substantial paperwork for the authorities. Loviisa has recently secured extended licenses to operate the units until 2050.

Figure 1: This picture is taken in a picture in the showroom in the city. Shows one turbine and its generator. The windows can also be seen in the upper part of the warehouse.

Figure 2: Group picture with the Loviisa Power Plant in the background. From left: Federico, Morgan, Ellen, Julia, Olivia and our guide Simo.

Fortum showroom

Following the technical tour of the Loviisa plant, we visited Fortum's newly established showroom in the city center. Designed with a broader audience in mind, the exhibition featured interactive installations and virtual reality experiences aimed at communicating the fundamentals of nuclear energy and the operation of Loviisa NPP. One highlight was a VR simulation offering immersive views inside the containment building and a hydropower facility, which made complex infrastructure more tangible. While the content was relatively high-level for nuclear professionals, it was still insightful to see how Fortum engages the public on energy topics. For future YG groups, we'd recommend not allocating too much time here, but it's worth a brief visit for the creative presentation methods and potential outreach inspiration.

Figure 3: Looking in the VR-goggles and the interactive screens at the visitor center.

After visiting the Visitor Center and enjoying lunch with Simo in the city, we headed back toward Espoo. On the way, we took the opportunity to stop in Porvoo, Finland's second oldest city. And of course, we treated ourselves to ice cream by the Porvoo River (Porvoonjoki).

Figure 4: Ice cream by the river Porvoonjoki.

Tuesday 27th of May - VTT

We met Jenna and a passionate expert, Timo Veijola, who discussed material strength in a laboratory located 40 meters underground in Espoo. The lab conducts strength tests on materials from various stages of the "Surveillance Program," as required by STUK. Samples are taken from the NPP, but since each system component is unique and exposed to specific conditions over time (heat, radiation, cycles, etc.), only a limited amount of material is available. Initially, large samples were used, but methods have evolved to allow for smaller samples, which provides more possibilities for testing in the future. The challenge now lies in manipulating these smaller samples within the hot cell, scaling up operations, and handling active components inside the hot cell.

Additionally, small cross-sections of materials—small enough to fit on a fingertip—can be tested. This is called "small punch testing". These allow for direct analysis from systems undergoing maintenance. The facility evaluates the strength of pressure-bearing reactor components and the integrity of final disposal sites, including Sweden's method (KBS3 method).

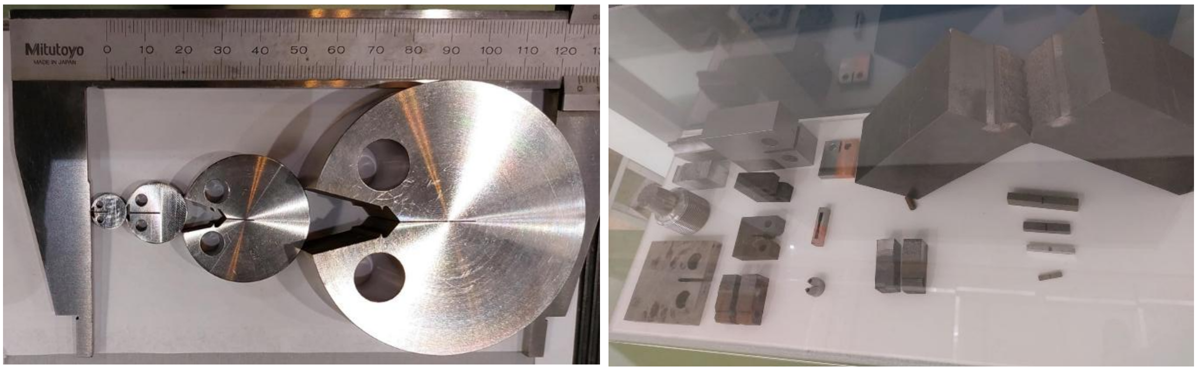

Figure 5: "Pacman" and classical specimens used for strength tests, showing how samples sizes have changed.

After the visit to the underground laboratory, we met Tuomo, who shared his research on the Fukushima accident. He had researched and theoretically modeled severe accidents for six years before Fukushima. The modeling process of the Fukushima accident includes plant data collection, establishing boundary conditions, and using MELCOR, an integral code for severe accident analysis.

Tuomo pointed out that at Fukushima, the three identical plants exposed to the same tsunami experienced drastically different event progressions. This could, for example, be considered when placing SMRs in series and arguing for joint licensing.

The last stop at VTT was a visit to the radiochemistry lab. It differed significantly from a nuclear power plant setting. Entry was via a conventional office door in an administrative building. The lab had a green floor, indicating the lowest-level lab zone for handling low-level radioactive materials.

Next, in the hot cell lab, the flooring was yellow, indicating a higher radiation zone where samples with higher dose rates were processed. With a sample located inside a hot cell, the dose rate on the external surface of the hot cell should be kept below 2 μSv/h. When handling highly radioactive samples, they are transported within the lab using a small containment vessel between the impact lab and the hot cell. Inside the hot cell, samples are manipulated via control levers to conduct strength tests. The impact lab mirrors the larger impact lab but at a smaller scale.

Exiting the hot cell lab area required passing through a full body monitor.

Figure 6: the hot cell lab, showing the individual hot cells and the handles to safely manipulate the active samples behind shielding.

Figure 7: The picture shows a projectile from the impact lab (not open for access during our visit).

Lessons learned and insights, Finland

- It was interesting to see that Loviisa has only one large turbine hall housing the turbines for both units, unlike in Sweden where the turbine halls are typically separated.
- Loviisa NPP combines Soviet reactor technology with Western safety systems. Because of this blend, it is sometimes humorously referred to as "Eastinghouse".
- VVERs are typically modified in Europe to meet Western safety standards.
- One of Loviisa's distinctive safety features is the use of borated ice within the containment structure, designed to reduce pressure in the event of a steam leak.

- Driving toward Loviisa was an experience in itself, especially heading in the direction of Russia. The road signs showing distances to Russian cities made the proximity to the border feel a bit unsettling, especially in today's geopolitical climate.
- Porvoo, Finland's second-oldest town, offered charming historic streets filled with small shops selling all kinds of trinkets. The beautiful buildings and the old church made it well worth a stop. And the ice cream by the river, of course.
- Espoo, where we stayed, was a great choice; it allowed us to avoid driving into the city center of Helsinki. The metro made it easy to get into the city.
- Tip for future travels: check restaurant opening hours and target working days. Many restaurants were closed from Sunday to Wednesday, which limited our dining options somewhat.
- The VTT laboratory, located 40 meters underground, also serves as a designated emergency shelter with capacity for 5,000 civilians and 200 researchers.
- We were lucky to meet one particularly enthusiastic researcher 40 meters underground, who proudly showed us a tiny box he always carries. Inside were small-scale punch tests, tiny metal domes that looked like miniature sombreros.

Travel Report – Europe

Safety, Young Generation 2025

In mid-October, the Young Generation Safety Group set off on their European trip, with the destination being the Czech Republic, more specifically Prague.

Over the course of two days, we had the opportunity to visit the Temelín NPP, located about two hours south of Prague, as well as ÚJV Řež, a research center situated just north of Prague.

Text written by Federico Barbano, Morgan Didriksson, Julia Hägerström and Ellen Ståhl.

Czech Republic - Temelín and ÚJV Řež

Participants

Name	Company
Federico Barbano	Blykalla
Morgan Didriksson	Westinghouse
Julia Hägerström	Ringhals
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Purpose of the trip

The purpose of this visit was largely the same as during our spring trip to Finland. The aim was to broaden our perspectives within the nuclear power industry and gain insights into different parts of the field, with an overarching focus on safety.

Monday 20th of Octobre - Temelín NPP and showroom

Our day at the Temelín NPP began with a visit to the site located in the South Bohemian Region of the Czech Republic. Temelín is the country's largest energy facility and plays a crucial role in the national energy system. The plant consists of two VVER 1000/320 type pressurized water reactors: Temelín 1, which began supplying electricity in

December 2000, and Temelín 2, which entered commercial operation in April 2003. Together, the units produce more than 15 TWh of electricity annually and employ around 1,000 permanent staff.

Originally planned in the late 1970s under the Communist regime, construction began in 1987 with a Soviet design for four reactors. In 1989, due to growing safety concerns after the Chernobyl disaster, the project was scaled down to two units. In the 1990s, the plant underwent extensive modernization led by Westinghouse. This East-West collaboration echoes the multicultural engineering seen at Loviisa, although Temelín's journey was more politically turbulent and technically ambitious.

Figure 8: left – picture of the NPP entrance and the cooling towers; right – map of the Temelín NPP site.

The introduction of the Temelín plant has allowed the Czech Republic to shut down coal-fired power plants equivalent to 2,000 MW.

The reactor core in each unit consists of 163 fuel assemblies with 312 fuel rods per assembly filled with UO_2. Previously, the fuel in the plant was produced in Russia, but work is underway to replace all Russian fuel with Western fuel (from Westinghouse). To regulate the 163 fuel cartridges, 61 control rods are mounted in the core.

The VVER-1000 reactor underwent several modifications throughout the 1990s to increase the safety and availability of the plant to meet Western standards. The IAEA and WANO have conducted extensive inspections and provided input, which was implemented during construction and commissioning.

After the Fukushima accident, several tests were carried out on the reactors to ensure their resistance to extreme weather conditions. As a result of the testing, 40 safety measures were identified and are being implemented at the site.

In case of a power failure, the Temelín plant has multiple ways of maintaining core cooling before shutting down the reactor. One of the ways is auxiliary power generators on-site. There is also the possibility to draw power from the grid it usually supplies with electricity. In the river where the plant gets its cooling water from, there is a hydroelectric pump station that can generate electricity to keep operations going.

If there is a problem with the water supply pumps from the river to the water treatment plant where the cooling towers get their cooling water from, the site has a process water storage that can be used until the supply pumps are put back online. If this is required and the plant needs to use this reserve, it would reduce the core's output and run at minimum power to conserve the amount of water needed to maintain sufficient cooling.

Fresh fuel storage

The fresh fuel and spent fuel areas are the most strictly controlled areas of the power plant, and all traffic is kept to a minimum. The fuel is delivered either by truck or train to the plant. Once inside the hall, the fuel container is positioned upright before unloading the fuel assembly.

Once unpacked, the fuel is moved into a type of storage unit where 19 fuel assemblies are stored waiting for use. Temelín has 14 storage units for unused fuel assemblies, which gives a total storage capacity of 266 fuel assemblies in the fresh fuel storage. In the storage unit, the fuel assemblies are protected with criticality-safe separation and are FME-protected by means of a large cloth bag that closes with the help of cord locking.

Figure 9: fresh fuel stored on site

Spent fuel storage

Temelín has a dry final storage facility where the fuel assemblies are loaded into a type of storage container called a castor. The castor is moved into the pool with the decayed spent fuel and loaded with up to 19 fuel assemblies. The castor is then transferred to the final storage facility, where it is drained, dried, and filled with helium gas after it has been hermetically sealed. Both temperature and pressure in the casks are monitored by the International Atomic Energy Agency.

Figure 10: spent fuel stoage to the left, and a miniature storage castor to the right.

The fuel will be stored in the casks for up to 60 years, during which it will be cooled constantly by airflow in the storage facility. Today's capacity is enough for 30 years of operation, and it is possible to build an extension of the storage facility.

Unless it is used otherwise when its storage time expires, the fuel will be declared waste and disposed of permanently in a deep geological repository, which the Radioactive Waste Repository Authority (RAWRA) plans to open in 2065.

Showroom

The showroom was situated a couple of hundred meters from the main entrance to the NPP, inside a castle. During the VR tour, you are presented with the fresh fuel storage, a walk through the reactor hall, the cooling towers (including flying up through a cooling tower), and the spent fuel storage. It gave an excellent overview of the plant. The fact that all this information, including pictures from the outside and inside of the site, is available on the internet was surprising to the group, since this is very different from how things are in Sweden.

Prague City

After the return from Temelín NPP, we visited Prague city center, including the Dancing House, crossed bridges including the Charles Bridge (Karlsbron) with its many sculptures and tourists, walked along the Vltava river, watched the astronomical clock in the Old Town Square where we got to witness "The Walk of the Apostles"—an hourly show of moving Apostle figures and other sculptures at the top of the clock tower. The day ended at a Czech brewery where we tried more local food and beer.

Figure 11: The dancing house and dinner in Prague city

Tuesday 21st of Octobre - ÚJV Řež

The visit to ÚJV Řež provided us with a deeper understanding of the Czech Republic's research efforts in nuclear technology and radioactivity. We were able to observe how their Hot Cells operations are conducted, visited their unique research reactor, and had the opportunity to discuss safety with the CEO of the research reactor.

The ÚJV Řež facility is situated outside of Prague, hidden in a valley. ÚJV Řež provides a wide range of services, including design and engineering activities in the fields of energy, industry, and health. During our visit, three of the group members visited the Hot Cells and the research reactor LVR-15, and the last group member met with employees from the Nuclear Safety and Reliability division.

ÚJV Řež is largely owned by CEZ Group (which runs the NPPs in the Czech Republic) and partially by Slovak utilities.

Figure 12: the group in front of an old oak tree on site – only picture allowed to be taken

Hot Cells

The first thing we visited was the building with their ten Hot Cells, which were completed in 2016. These ten Hot Cells are built inside an already existing building and are therefore customized specifically for this location. The Hot Cells have fixed shielding and interchangeable hermetic boxes with different equipment on the inside. The Hot Cells are designed to be movable and are modular, which provides great flexibility. This allows the Hot Cell boxes to be repositioned within the building and placed in separate compartments, isolated from the others. They can also prepare a Hot Cell for a research test outside the compartments, where the box is more accessible and free from radioactivity.

In these Hot Cells, they conduct advanced research and testing on irradiated and high-performance materials. This includes mechanical property evaluation, environmental interaction studies, aging simulations, and the development of fuel cladding materials for both current and next-generation nuclear reactors. They are also conducting research on nanomaterials for nuclear applications, for example, to improve materials used in nuclear power plants.

Research Reactor

The LVR-15 research reactor serves a wide range of experimental missions—from materials irradiation to isotope production and advanced reactor support.

The LVR-15 is a 10 MW light-water moderated, pool-type research reactor with an 80-cell core grid (71.5 mm pitch) housing 28–34 fuel assemblies during standard operation. The 600 mm active fuel is cooled by forced circulation of demineralized water at 45°C inlet and 50–55°C outlet under near-atmospheric pressure, achieving central core thermal neutron flux of $\sim 1.5 \times 10^{18}$ n/m^2·s. The reactor uses compact (~ 1 m^3) Russian 20% enriched fuel assemblies with rectangular "swirls," achieving energy density comparable to conventional reactors. Horizontal, vertical, and reflector irradiation channels accommodate experimental loops operating up to 25 MPa and

600°C for advanced materials testing and Generation IV reactor qualification. The facility serves materials irradiation and aging studies, with hot-cell examination of structural steels, claddings, and advanced materials to assess embrittlement, corrosion, and stress-corrosion cracking for nuclear plant life extension. It also provides isotope production, neutron-beam irradiation, and neutron activation analysis for academic and industrial applications. Serving external institutions, companies, and international projects, the facility enhances understanding of material behavior under irradiation, improves nuclear safety margins, and strengthens nuclear engineering research capacity.

The visit included several important stops:

- Control Room: We entered the reactor's control room, where we observed a fascinating juxtaposition of older analog panels and modern digital instrumentation. While part of the system has been renewed, a large portion of the control boards, cabinets, and dials remain "old-school". This blend of analog and digital systems is particularly interesting from a safety/operations standpoint: one sees legacy systems operating alongside modern ones, which raises questions about interface consistency, human-machine interaction, and system redundancy.
- Reactor Hall: We walked into the reactor hall and viewed the pool-type vessel, irradiation channels, test loops, and the arrangement of experimental rigs. Seeing the physical layout—core region, pool structure, adjacent infrastructure—gave us a strong spatial sense of how the reactor integrates research facilities and access/logistics for testing.


- Handling Fuel Elements: During the visit, we were given the opportunity to hold fuel assemblies (or mock elements) and take photographs. This hands-on moment grounded our understanding of the core hardware and emphasized the material and handling aspects of the reactor.

- <u>Post-Irradiation / Hot-Cell Pathway</u>: Through briefings and observation, we also learned how irradiated specimens are transferred to nearby hot-cell laboratories for detailed analysis (aging, corrosion, microstructure). We were able to trace the full chain: irradiation in the reactor → specimen removal → hot-cell examination. This chain reinforces the research-service character of the facility.
- <u>Research Infrastructure Briefing</u>: We were shown how the reactor supports advanced experimental loops (e.g., high-temperature helium loops, supercritical-water loops), isotope production, and neutron-beam applications. The flexibility of the irradiation channels and the fact that the site supports external institutions and industrial service was clearly underlined.

Presentations from the *Nuclear Safety and Reliability* Division

The first presentation from the named division introduced the work they execute for the industry, such as calculations for fuel design, CFD, calculations for safety assessments, and PSA for the NPPs. They also support the ongoing work with new builds (such as the SMR in Temelín) by helping with the license application. The department will also participate in the independent safety assessment of the planned new-build plants. The question of independence was raised (independence between the owners of the planned new builds, CEZ, with respect to ÚJV Řež, which is largely owned by CEZ), to which the department answered that the independence in question is from the power plant developers. This means that ÚJV Řež is independent from the companies developing the power plants planned to be constructed in the Czech Republic, like the SMR in Temelín.

A case study of ongoing work at the division was then presented. The study has its roots in the Fukushima accident—when zirconium alloy is exposed to high-temperature steam, the alloy oxidizes, which leads to an exothermic reaction and hydrogen production. The aim is to develop an accident-tolerant fuel. Fuel is therefore coated and studied using both the LVR-15 research reactor and then the hot cells available on-site.

The second presentation introduced HeFASTo, which is a Gas-Cooled Fast Reactor (GFR) with thermal power of 200 MW and core outlet temperature reaching 900°C. The HeFASTo has a fully passive safety system with natural convection to remove heat. The power density of the HeFASTo reactor is 100 MW/m^3, which is about 10–20 times higher than thermal water reactors. One drawback of the gas-cooled reactor was that the entire helium inventory leaks in one year of operation, meaning that it needs to be continuously refilled. The HeFASTo project is at the end of its conceptual stage and is planned to be sold in the European Union.

Lessons learned and insights, Czech Republic

- VVERs are typically modified in Europe to meet Western safety standards.
- Temelín: There are plans for expanding the Temelín site, possibly building Rolls-Royce SMRs—similar expansion projects as in Sweden.
- ÚJV Řež is a huge site with lots of history, where many buildings have been kept from the original build but emptied and repurposed for new needs.
- Dejvice, Prague: The hotel we stayed at was situated just outside the city center, which made it easier during the morning traffic, and we could get to the city center in minutes by metro.
- Cooling towers are huge. Temelín's towers are 155 m high with a base diameter of 131 m. Not a usual sight in Sweden!
- The Czech Republic operates nuclear power plants without knowing what the final repository in the country will look like.
- Trust your email contacts—we were warmly welcomed everywhere, and they were prepared for our visits with guides and presentations.
- A visit to the research reactor LVR-15 at ÚJV Řež is highly recommended because it is uncommon to get access to one.
- When searching for places to visit, make use of your internal company network (like talking to the sales department, customer service, etc.).
- The operator training center at Temelín was occupied for training during our visit, but we got to see it being used for live training.
- Suggest to not have the same type of visits on the two visits (like visiting hot cells on two different sites and countries).
- Before the trips, be as specific as possible about what you would like to visit. It could avoid visiting parts of the facilities which are of less interest and focus on the areas that are more interesting.