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THE ROLE OF NUCLEAR IN DECARBONISATION

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***Abstract**: Nuclear plays a crucial role in the Hungarian electricity system. More than half of the domestic electricity generation came from nuclear in the first half of 2020. Besides this, the Hungarian nuclear power plant generates 36% of the domestic electricity consumption, renewable energy (mainly PV) generates another 11%, and Hungary has an electricity import share of approximately 30%. The electricity consumption in Hungary has a growing tendency, between 2013-2019, the annual average growth rate was 1,3%. The peak load also increases, the records were broken several times last year. The current maximum peak load (7105 MW) was reached on 5th of December 2019. Until 2033 about 2500 MW capacity from the current power plant fleet will go offline, but the electricity demand will grow by approx. 1000MW. To meet electricity demand in a low carbon way, nuclear power will be inevitable for the electricity system. When looking at European examples we see that low-carbon electricity generation is reached in countries with high nuclear and/or hydro share in the electricity-generation mix. The Hungarian example shows that with nuclear power generation more CO_2 emission can be avoided, than the amount absorbed by forests. Half of the EU Member States rely on nuclear energy. Currently 9 EU Member States are building or planning to build new nuclear units. Hungary is one of them. Paks II. is a capacity replacement project, the two new nuclear units (2x 1200MWe) will on the long run replace the aging units currently in operation. Paks II. is Hungary's biggest project with a capital expenditure of 12,5 bn euro. It includes an outstanding technical solution as the Russian primary circuit is paired with a Western European turbine-generator set from GE-Alstom and an also Western European I&C system from the Siemens-Framatome consortium. In the summer of 2019 construction works of the project started on the construction and erection base (so called CEB). This area contains about 80 buildings, such as complex for assembly works, concrete batching facilities, office buildings. Until the end of September 2020 the Paks II. Project has already obtained 478 licenses, among them major ones like the environmental license and the site license (both effective). With the submission of the Implementation License Application (ILA) to the Hungarian Atomic Energy Authority on 30th June 2020 the most important licensing procedure started. The main tasks of the next months are to continue with the construction of the CEB buildings and to carry out soil improvement works and to construct the slurry wall.*

Nuclear plays a crucial role in the Hungarian electricity system

More than half of the domestic electricity generation came from nuclear in the first half of 2020. Besides this, the Hungarian nuclear power plant generates 36% of the domestic electricity consumption, renewable energy (mainly PV) generates another 11%, and Hungary has an electricity import share of approximately 30%. (Figure 1)

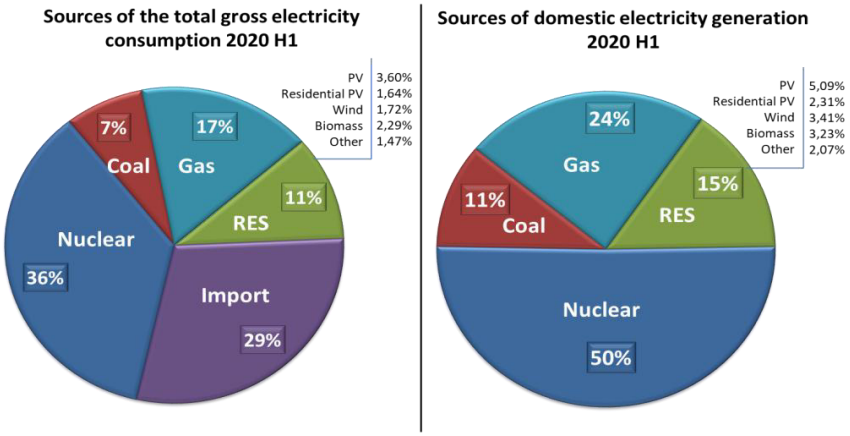


Figure (1) Nuclear plays a crucial role in the Hungarian electricity system
Source: MAVIR database 2020

The electricity consumption in Hungary has a growing tendency

- The total gross consumption of electricity (Figure 2) continues to grow and is reaching new records every year.
- Between 2013 and 2019, the annual average growth rate was 1.3%.
- The main reasons for the increasing demand for electricity were GDP growth and continuing electrification.

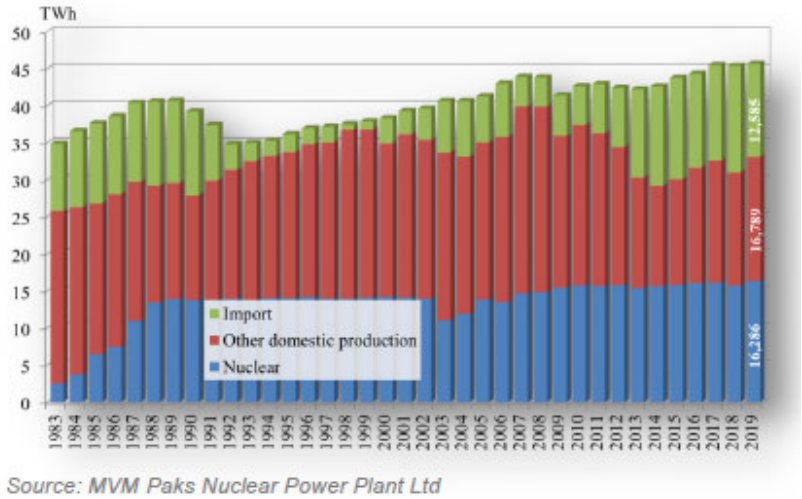


Figure (2) The electricity consumption in Hungary has a growing tendency

Development of gross peak load

The peak load also increases, the records were broken several times (Figure 3):

- 2019.12.05. – 7105 MW
- 2019.12.04. – 7099 MW
- 2019.01.23. – 6926 MW
- 2019.01.08. – 6884 MW
- 2018.12.19. – 6869 MW

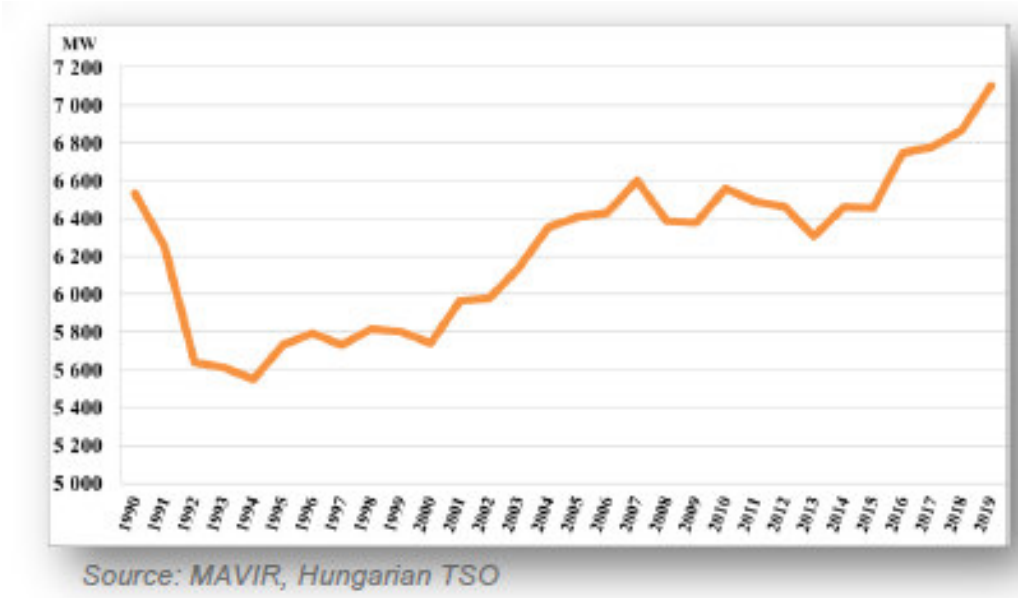


Figure (3) Development of gross peak load

The electricity consumption in Hungary has a growing tendency, between 2013 and 2019; the annual average growth rate was 1.3%. **The peak load also increases, the records were broken several times last year.** The current maximum peak load (7105 MW) was reached on 5th of December 2019. Until 2033 about 2500 MW capacity from the current power plant fleet will go offline, but the electricity demand will grow by approx. 1000MW. **To meet electricity demand in a low carbon way, nuclear power will be inevitable for the electricity system.**

Electricity import share in 2019 was 27.56% on average (Figure 4)

- The yearly import share in electricity consumption in 2019 was 27.56%.
- There were periods, when it was above 50%.
- Hungary has one of the largest electricity import-share in Europe.
- The cross-border electricity transmission capacity exceeds the required level by far.

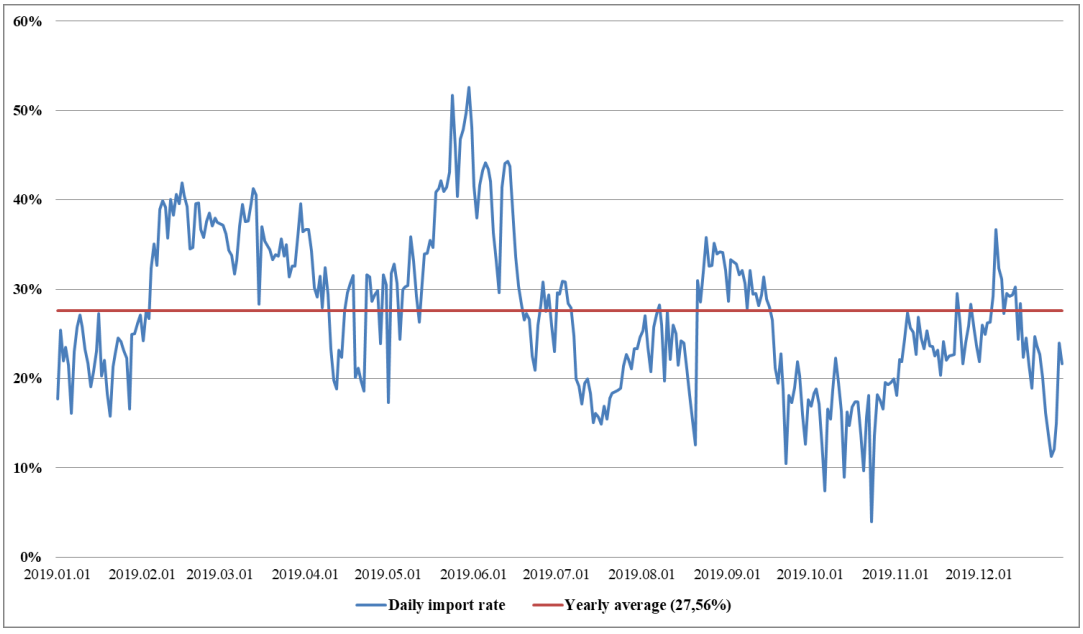
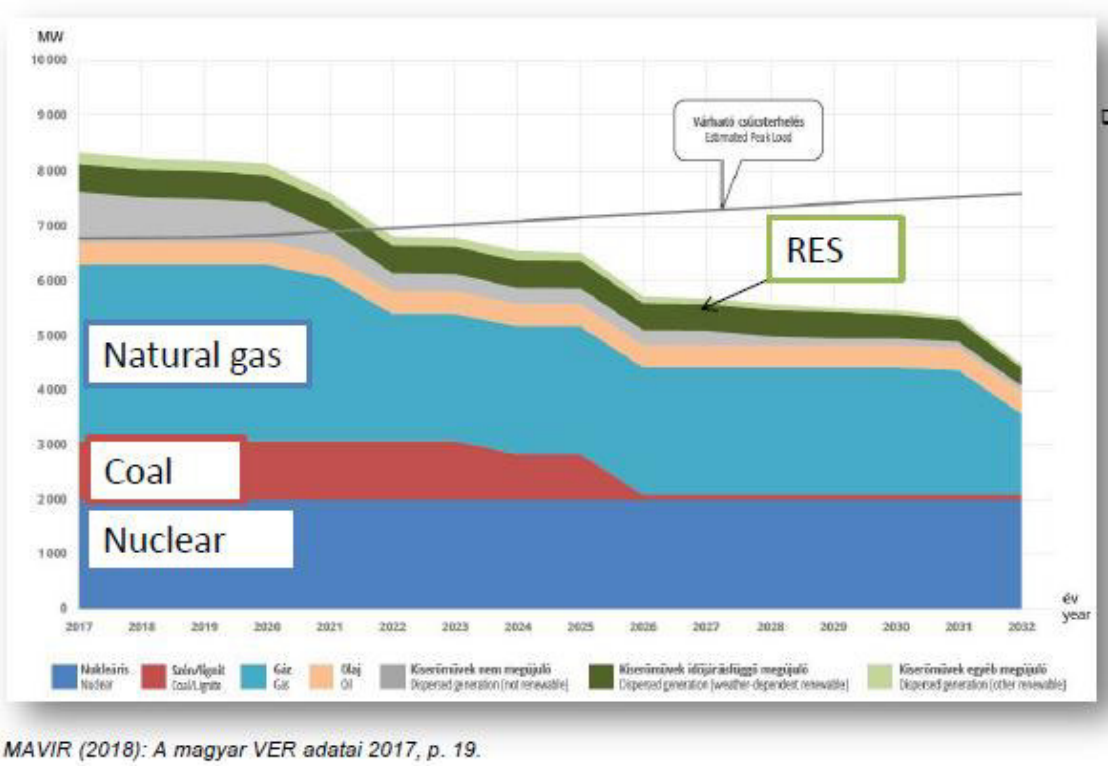


Figure (4) Share of electricity import in electricity consumption in 2019 (daily data)

Future of the current power plant capacities

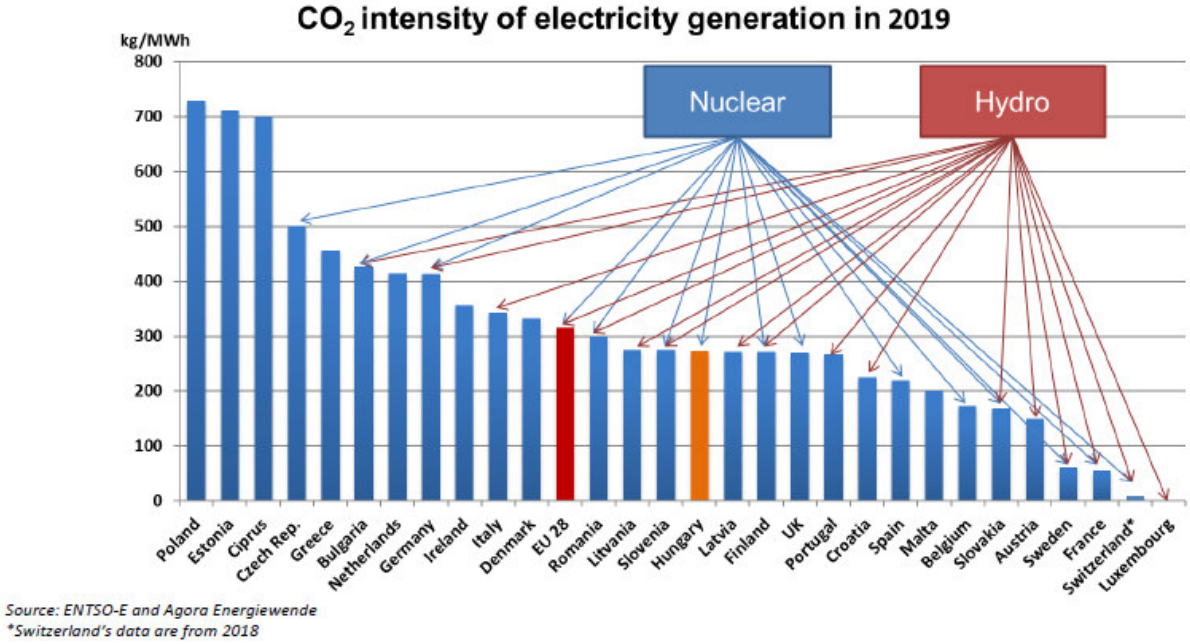
Figure (5)



MAVIR (2018): A magyar VER adatai 2017, p. 19.

Figure (5) Nuclear power will be inevitable for a low carbon emission electricity system

Low-carbon electricity generation in Europe is reached in countries with high nuclear and/or hydro share in the mix



Source: ENTSO-E and Agora Energiewende
*Switzerland's data are from 2018

Figure (6) Main objective: decarbonisation

Means to achieve: nuclear, renewables and energy efficiency

Installed electricity generation capacities in Hungary and their envisaged future

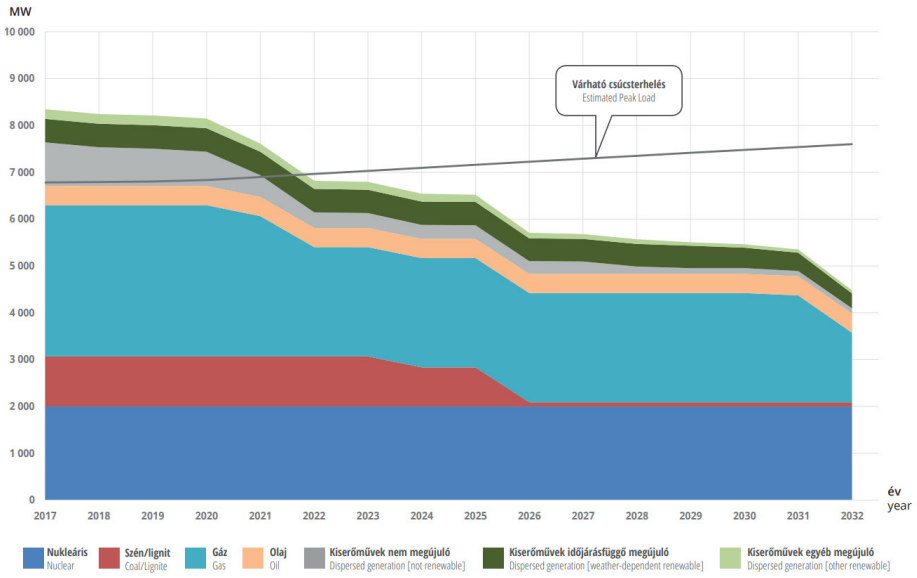


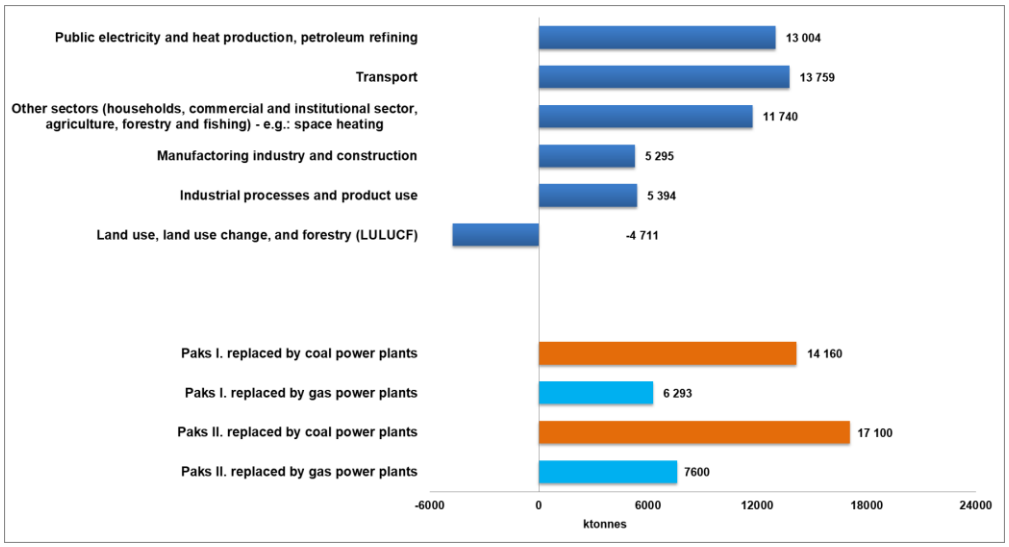
Figure (7) Data of the Hungarian electricity system Source: MAVIR, 2018: Data of the Hungarian electricity system

When looking at European examples we see that **countries reach low-carbon intensity of the electricity generation with high nuclear and/or hydro share in the electricity-generation mix.** The Hungarian example shows that with nuclear power generation **more CO_2 emission can be avoided, than the amount absorbed by the Hungarian forests** (covering more than 20% of the territory of the country)**.**

Until 2033:

- ~2500 MW capacity will go offline
- Demand up by ~1000MW
- ~5000 MW would be missing between peak load and available capacity

With nuclear power, Hungary avoids more CO_2 emissions yearly, than the amount absorbed by forests



Source: Hungarian Meteorological Service: National Inventory Riport 1985-2018

Figure (8) Total CO_2 emission of Hungary by sectors, 2018

Without nuclear power in Hungary CO_2 emissions of the domestic power plants fleet could be two times higher.

Half of the EU Member States rely on nuclear energy. Currently 9 EU Member States are building or planning to build new nuclear units. Hungary is one of them. **Paks II. is the capacity replacement project, the two new nuclear units (2x 1200MWe) will on the long run replace the aging nuclear units currently in operation.** Paks II. is the Hungary's biggest project with a capital expenditure of 12,5 bn euro. **It includes an outstanding technical solution as the Russian primary circuit will be paired with a Western European turbine-generator set from GE-Alstom and an also Western European I&C system from the Siemens-Framatome consortium.** In the summer of 2019 construction works of the project started on the construction and erection base (so called CEB). This area contains about 80 buildings, such as complex for assembly works, concrete batching facilities, office buildings.
Until the end of September 2020, the Paks II Project has already obtained 478 licenses, among them major ones like the environmental license and the site license (both effective). With the submission of the Implementation License Application (ILA) to the Hungarian Atomic Energy Authority (HAEA) on 30th June 2020 the most important licensing procedure started. Meanwhile, on 20th of November 2020 the Hungarian Energy and Public Utility Regulatory Authority issued the Implementation License (a license that differs from the one to be issued by the HAEA). The main tasks of the next months are to continue with the construction of the CEB buildings, with the detailed design and to carry out soil improvement works and to construct the slurry wall.

Nuclear in Europe

Figure (9) Location – Paks I. site

Half of EU Member States rely on nuclear energy

Member States building / considering new units: France, Slovakia, Finland, Hungary, Czech Republic, Bulgaria, Poland, Slovenia, Romania (UK, Turkey, Belarus)

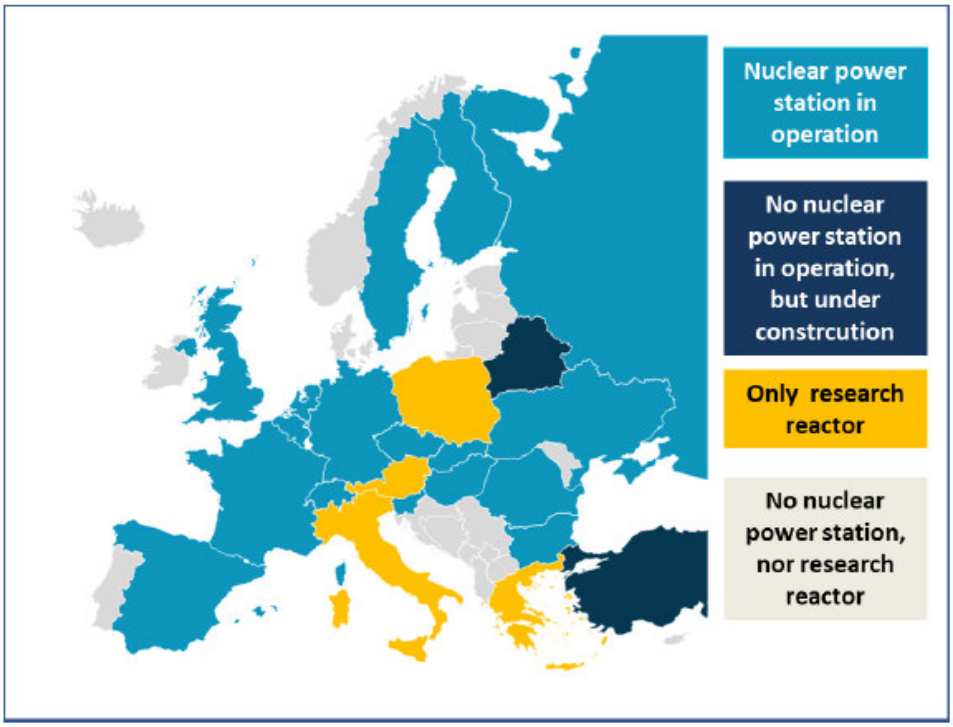


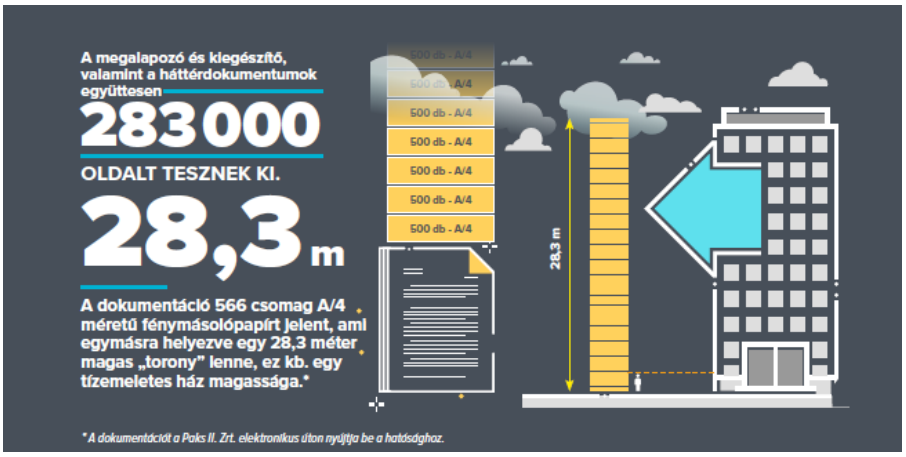
Figure (10) EU Member and nuclear energy

Paks II., a capacity replacement project

Paks II. – Hungary's biggest project, also unique in Europe

- Two new nuclear units, 2x VVER-1200
- 12.5 bn EUR investment
- Separate minister responsible for the project
- Advanced safety systems
- Load-following capability
- High annual load factor

Implementation License Application (ILA) – submitted on 30/6/20



- Submitted to the Hungarian Atomic Energy Authority on **30 June 2020**
- ILA: 283 000 pages
- Until 30th September 2020, the Paks II. has already obtained 478 permits

Key characteristics of the III+ Gen VVER-1200 power unit

Reactor type	Pressurized water reactor
Thermal output	ca. 3220 MW
Electrical output	ca. 1200 MW*
Fuel	U-235, max. enrichment 4.95%
Number of primary loops	4
Number of steam-generators	4
Coolant temperature at reactor outlet	328.9°C
Coolant temperature at reactor inlet	298.2°C
Primary pressure	16.2 Mpa
Secondary pressure	7 Mpa
Safety systems	active and passive safety systems
Designed lifetime	min. 60 years
Availability factor	>90%
Plant efficiency	37%
House load consumption	7.1%
Time required for maintenance (for a 7-year cycle)	4 x 16 days; 2 x 24 days; 1 x 30 days
Demand for operating personnel (in terms of electrical output)	0.42 person/MWe

*Based on the turbogenerator system planned for use, the rated electrical output of new Paks units will be 1262 MW

Source: Implementation Licensing of the new nuclear power unit, comprehensible summary

An outstanding technical solution

- Russian primary circuit is paired with a Western European turbine-generator set and I & C system
- a turbine-generator set from GE-Alstom
- main and upper-level I & C from Siemens-Framatome

www.ge.com

framatome

PRESS RELEASE

RASU JSC and Framatome-Siemens consortium sign contract to supply automated process control systems for Hungarian Paks-2 Nuclear Power Plant

MOSCOW, Oct. 23, 2019 – Rusatom Automated Control Systems JSC (RASU JSC), a subsidiary of Rosatom State Corporation, and the Franco-German consortium Framatome-Siemens signed an agreement to manufacture, deliver and commission automated process control systems for the Paks Nuclear Power Plant Units 5 and 6, located in central Hungary. This award was based on the results of a competitive call for bids.

The document was signed by CEO of RASU JSC Andrei Butko, Managing Director of Framatome GmbH Carsten Haferkamp, Vice President Sales Nuclear I&C of Siemens AG Jens König, and Commercial Sales Director Nuclear I&C of Siemens AG Jens Bostelmann.

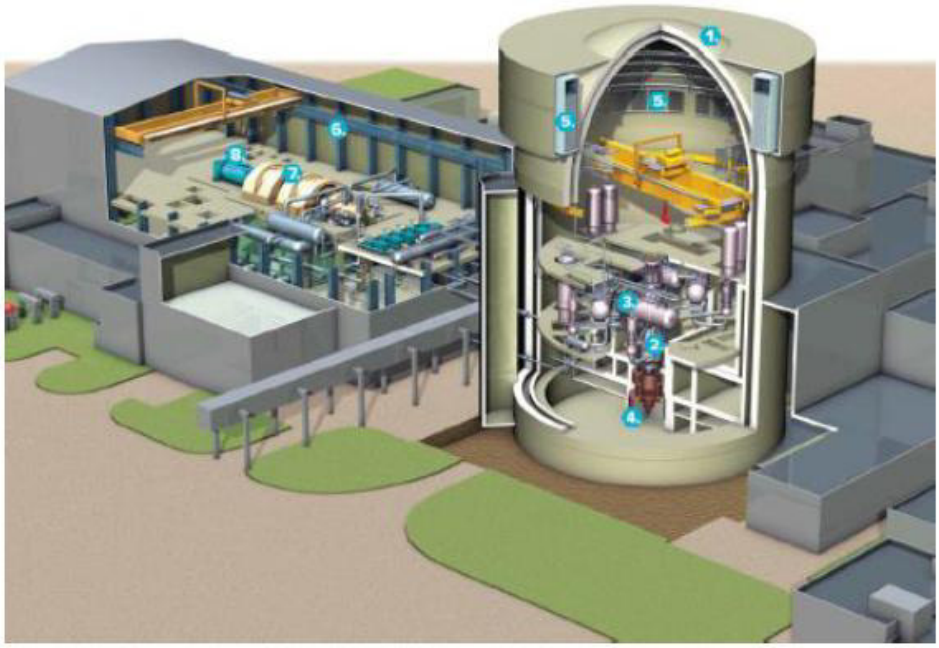
According to the signed agreement, the Framatome-Siemens consortium will manufacture and supply the equipment for automated process control systems, as well as conduct its certification and qualifications, including compliance with information security requirements.

"Framatome is proud to provide automated process control systems for Paks-2 in conjunction with our partner, Siemens," said Frédéric Lelièvre, senior executive vice president in charge of Sales, Regional Platforms and the Instrumentation and Control (I&C) Business Unit at Framatome. "Our high-performing people have been commissioning automation systems at nuclear power plants in Russia for many years. With Paks-2, we are delighted to use our expertise in I&C for VVER reactors in Europe, and add to a long list of successful projects with Rosatom."

www.framatome.com

Schematic design of VVER-1200

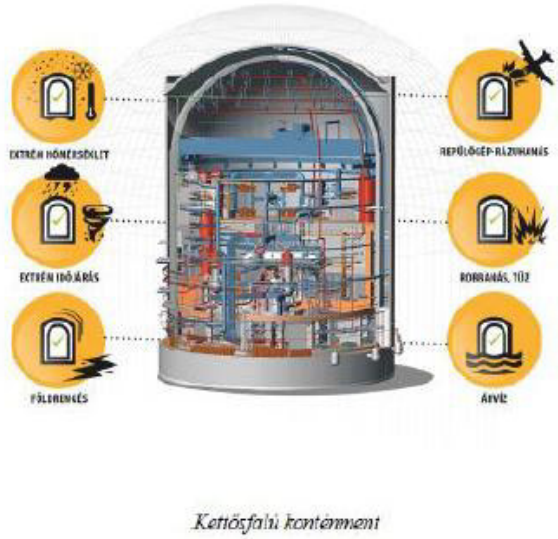
1. Containment
2. Reactor pressure vessel
3. Steam generator
4. Core catcher
5. Passive heat removal system of the containment
6. Turbine building
7. Turbine
8. Generator



Source: Paks II. Ltd.

Safety systems – 1

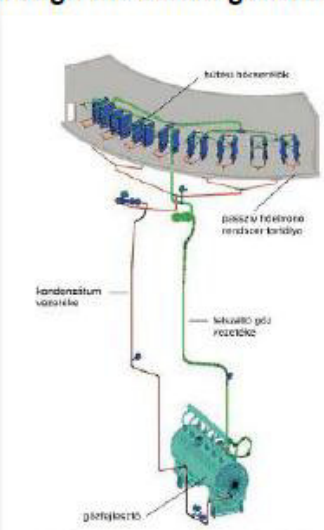
Double-walled, full hermetic containment



Kettősfalú konténment

Inner containment: retaining radioactivity
Outer containment: protection against external hazards

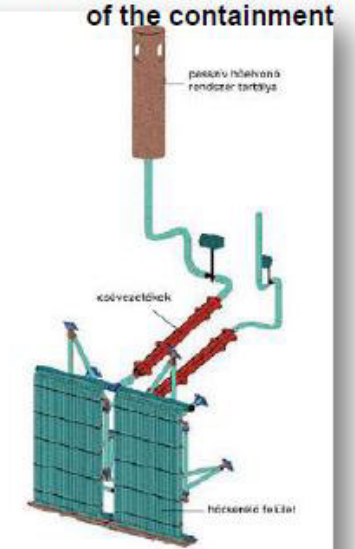
Passive heat removal system through the steam generator



A gőzfejlesztő passzív hőelvonó rendszere

Residual heat dissipation

Passive heat removal system of the containment



A konténment passzív hőelvonó rendszere

Controls the temperature and pressure increase in case of accident

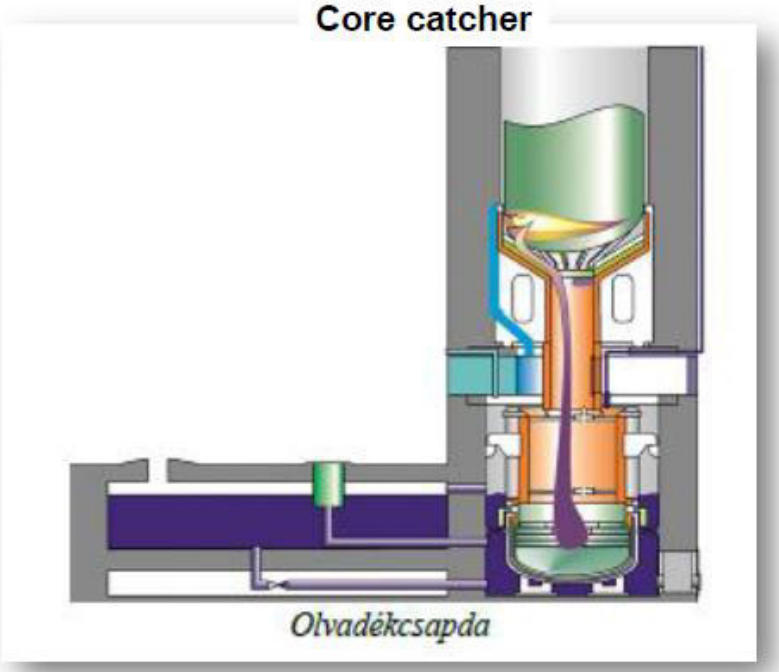
Source: Paks II. Ltd.

Safety systems – 2

Hydrogen combiner

In case of an accident they keep hydrogen concentration low

Core catcher



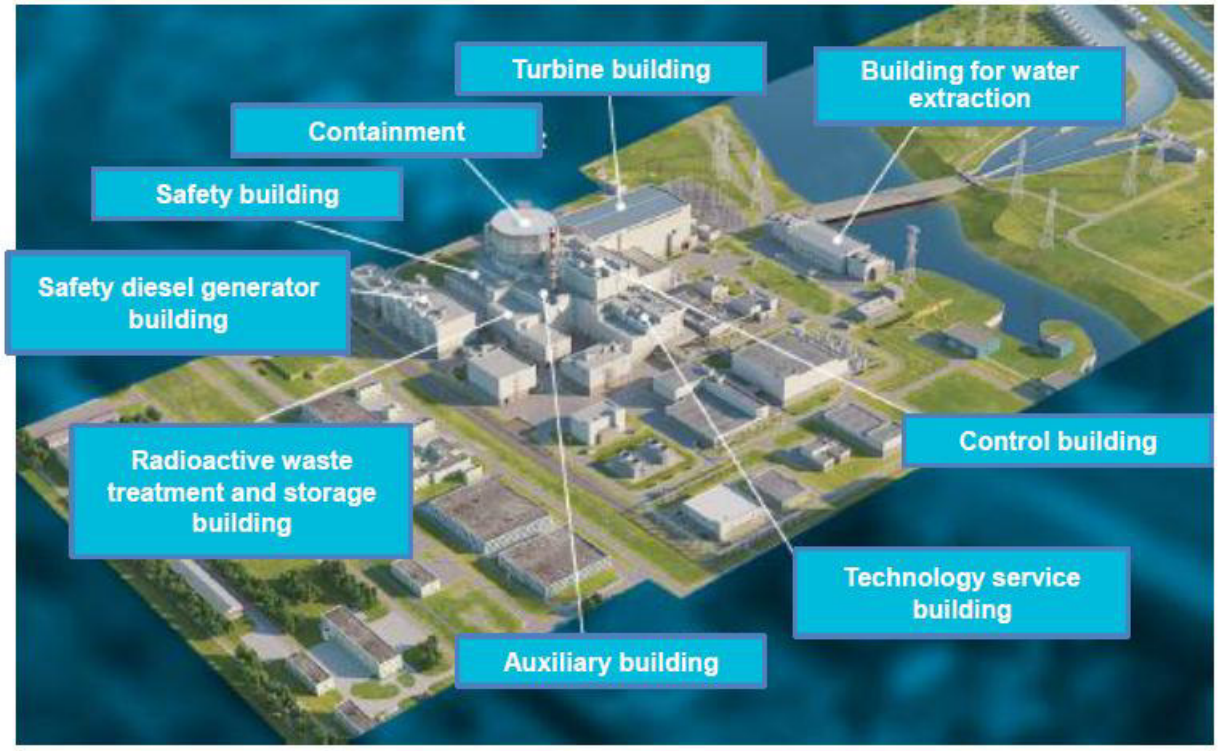
In case of a severe accident it protects the base plate from the molten core

Source: Paks II. Ltd.

Site, CEB and visualization of the new and old units

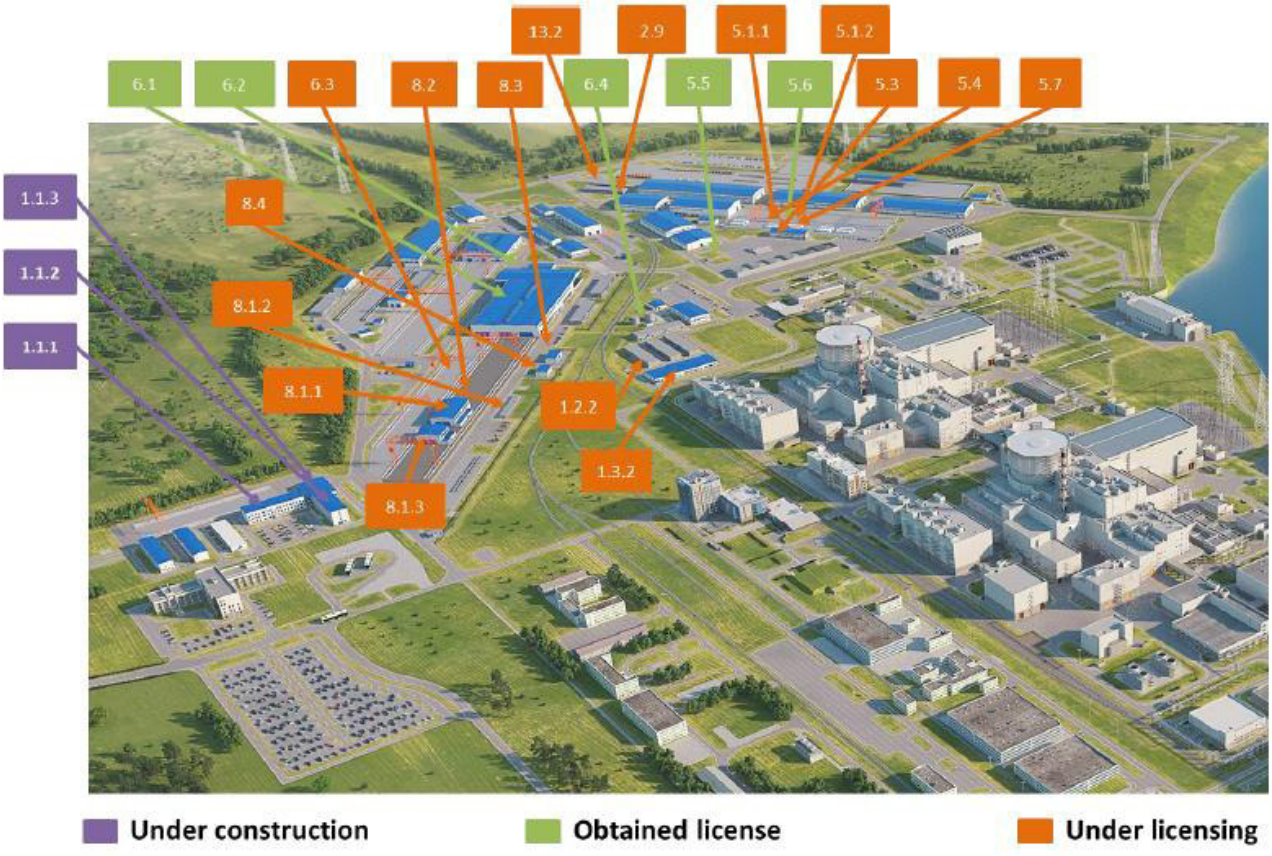
Source: Paks II. Ltd

VVER-1200 unit – main buildings



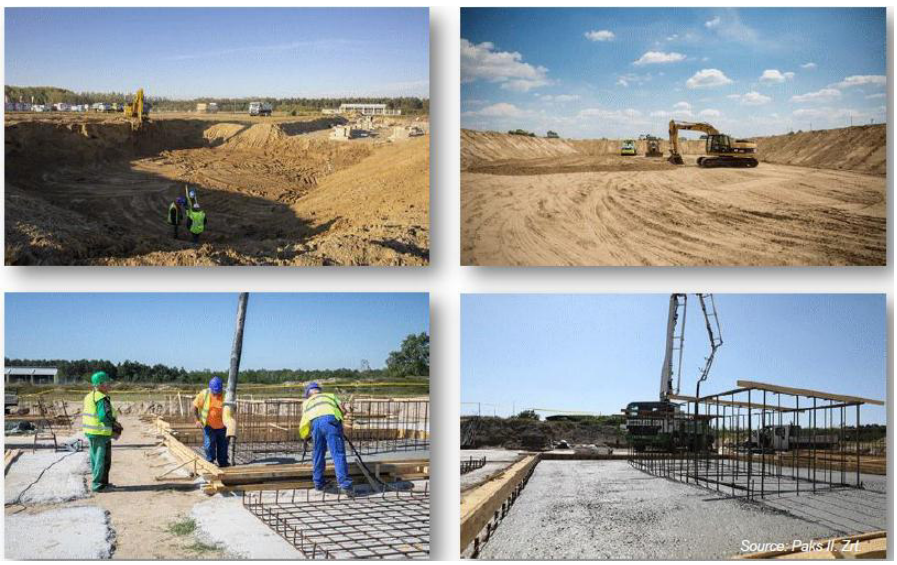
Source: Paks II. Ltd.

Construction and erection base (CEB) buildings status



Building construction starting date: 20th of June 2019

Building construction works



Most recent pictures - 1

Visualisation of the concrete testing laboratory

Visualisation of the metal structure and storage workshop

Figure (11) Buildings 6.1, 6.2, 5.5 and 5.6

Figure (12) Buildings 8.1.1, 8.1.2 and 8.1.3

Visualisation of the solvents and paints storage Visualisation of the material storage

Figure (13) Buildings 8.3 and 8.4