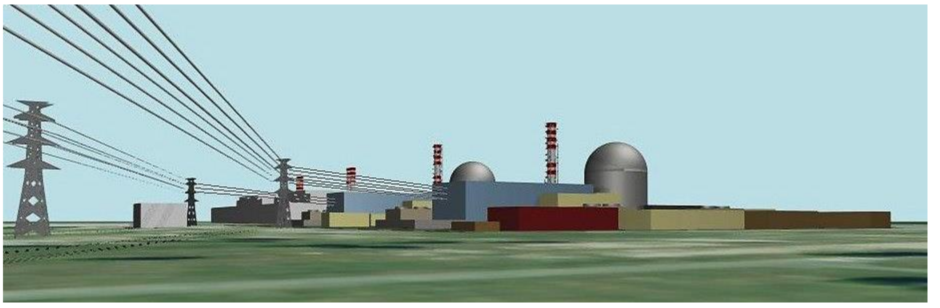


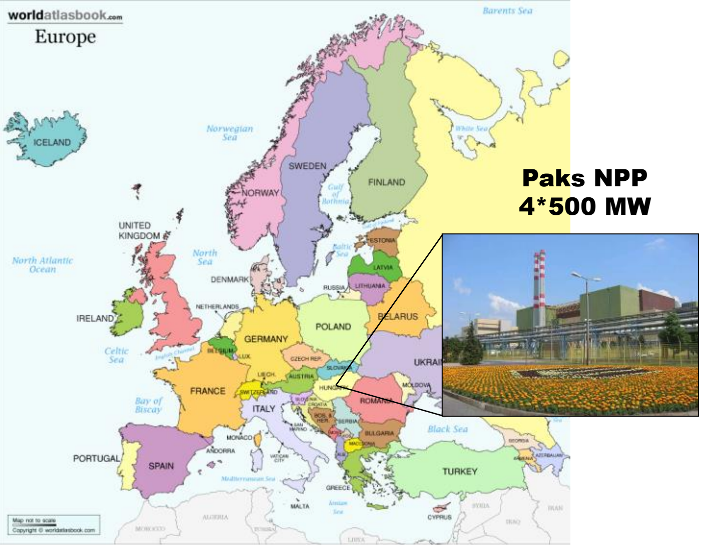
New units at the Paks NPP – environmental licensing

Prof. Dr. Attila Aszódi
Government Commissioner, Paks-II project
Prime Minister's Office, Hungary
Member of the Board of Directors, Paks-II Plc.

Vienna, 23 September 2015

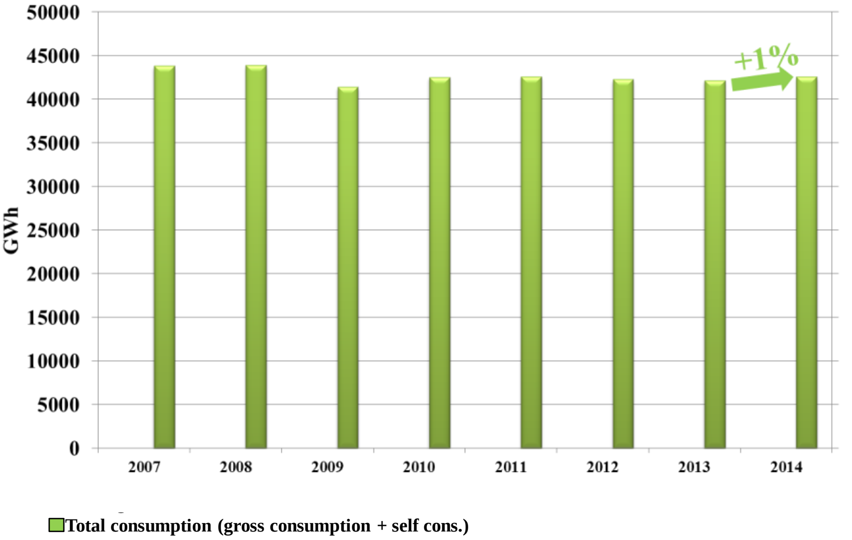
ENERGY POLICY

Hungary



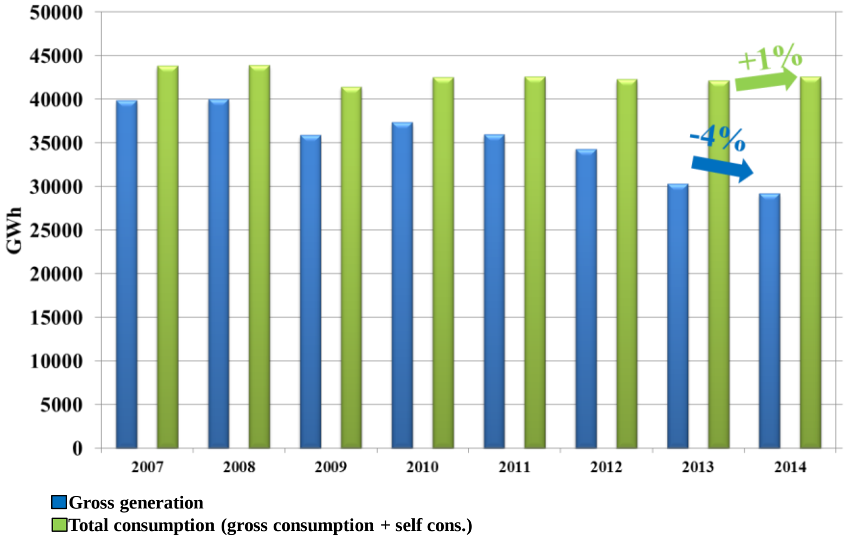
- Hungary:
  - Population: 10 million
  - Area: 93 030 km²
  - Nuclear share in electricity production 51%
  - Nuclear share in electricity consumption 36%

Trends of previous years (2007-2014)



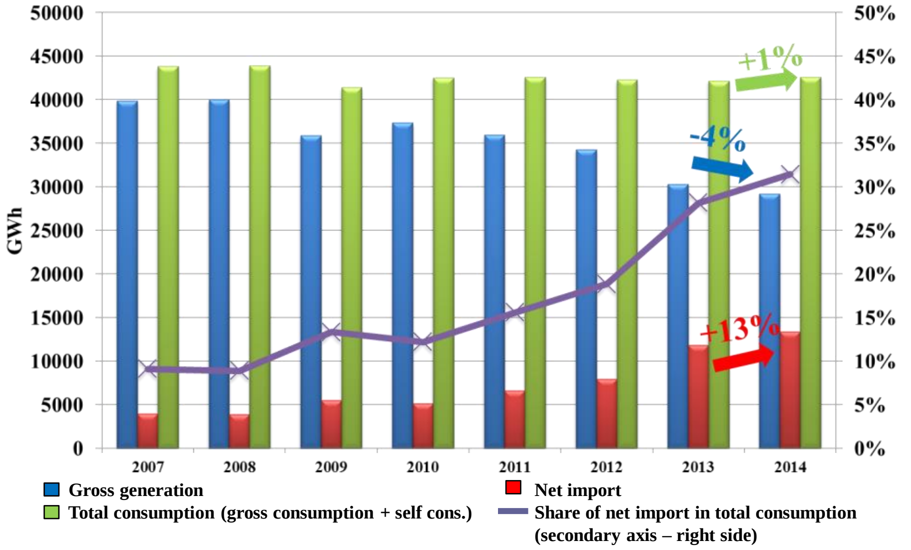
Source: Mavir: „Statistical data of the Hungarian electricity grid", 2013 and MAVIR statistics 2014

Trends of previous years (2007-2014)



Source: Mavir: „Statistical data of the Hungarian electricity grid", 2013 and MAVIR statistics 2014

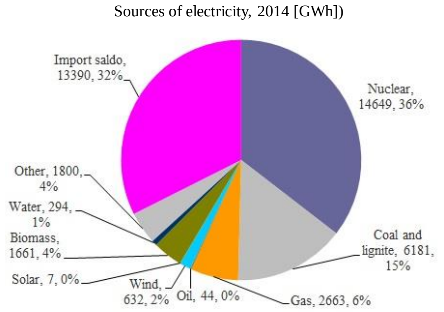
Year	Peak load (MW)	Domestic production (MWh)	Export-import balance (MWh)	Total (MWh)	Import share (%)
2013	6307	30 311 469	11 877 704	42 189 173	28,15
2014	6461 **(+2,44%)**	29 200 924	13 388 078	42 589 002 **(+0,95%)**	31,44

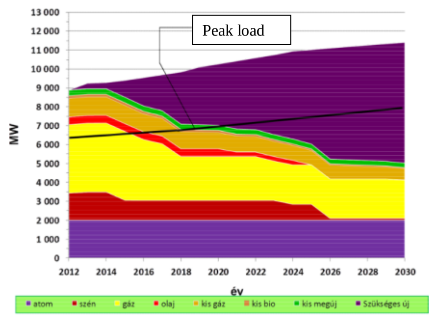


Source: Mavir: „Statistical data of the Hungarian electricity grid", 2013 and MAVIR statistics 2014

The Hungarian electricity consumption

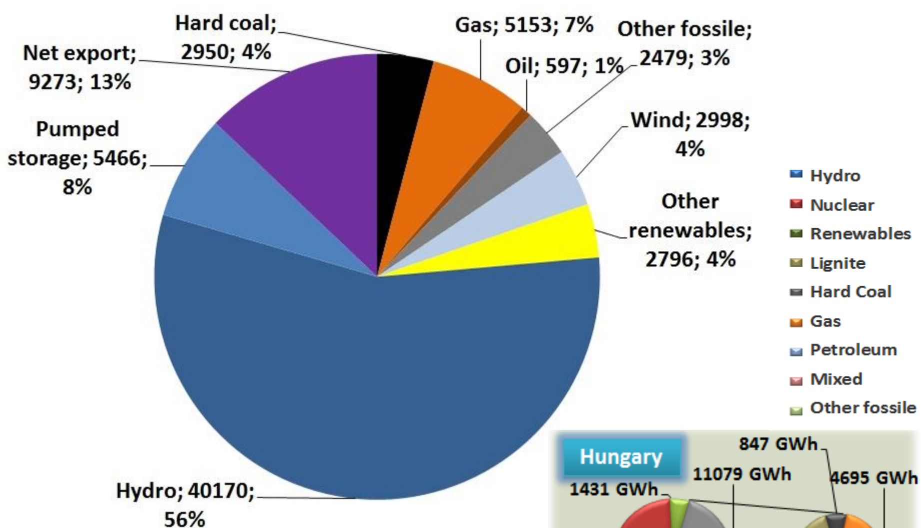
- 2014: Total gross electricity consumption: 42 589 GWh
  - Domestic production: 29 201 GWh
  - Imported electricity: 13 388 GWh
- Expected rate of growth: 1,3%/year (later 1%/year)
- Until 2030 roughly 7300 MW new capacity has to be built
  - Within this, 3100-6500 MW can be large PPs (e.g.: nuclear), 1600 MW small PPs on renewable sources



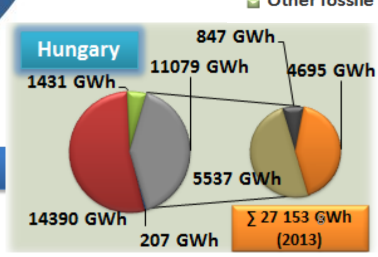


 Source: ENTSO-E

Source of Electricity Production (2014)

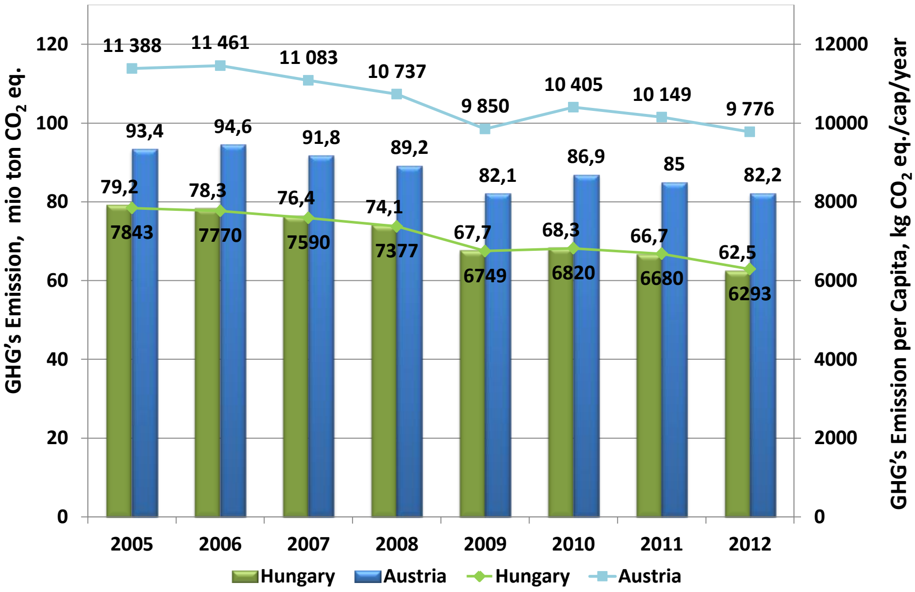


∑ : 71882 GWh



Source of data: www.apg.at

GHG's Emissions

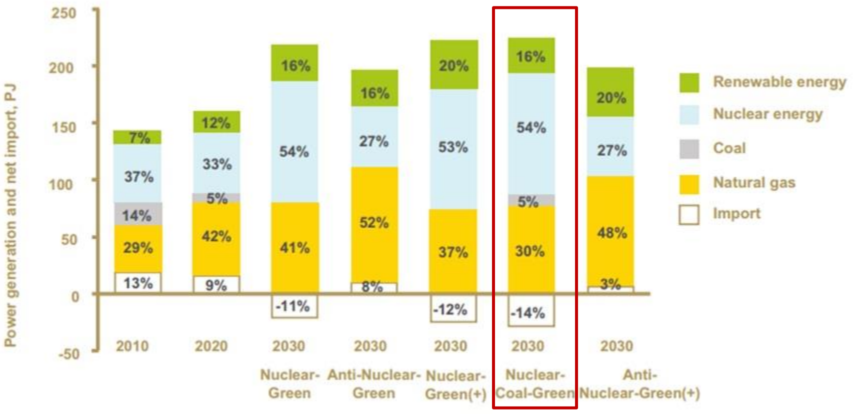


Source of data: EU-28: Energy datasheets

National Energy Strategy - 2030

- Nuclear-Coal-Green scenario

„the long-term maintenance of nuclear energy in the energy mix…"

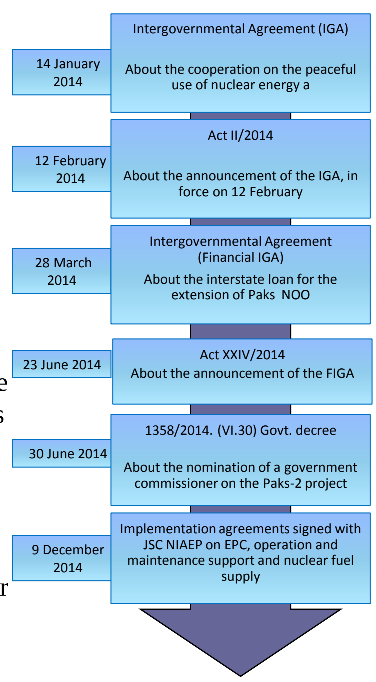


Source: Nemzeti Energiastratégia 2030 (National Energy Strategy 2030)

BACKGROUND OF THE PROJECT

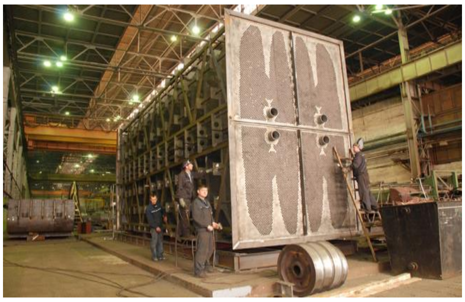
New units at Paks NPP

- Paks NPP: extension on the agenda since the 80's
- 30th March, 2009: decision-in-principle of the Hungarian Parliament about new units
- 2012: establishment of MVM Paks II. Nuclear Power Plant Development Ltd
- January 2014: Intergovernmental agreement on the peaceful use of nuclear energy by Russia and Hungary
  - Two VVER-1200 type reactors at the Paks site
  - Russian loan for the 80% of construction costs
  - Key point of the IGA: 40% localization level (share of domestic suppliers)
  - Nuclear fuel supply is available from the Russian party
  - Spent fuel management (interim storage or reprocessing in Russia), while the spent fuel or the residual waste (in case of reprocessing) will be transferred back to Hungary



VVER-1200/V491

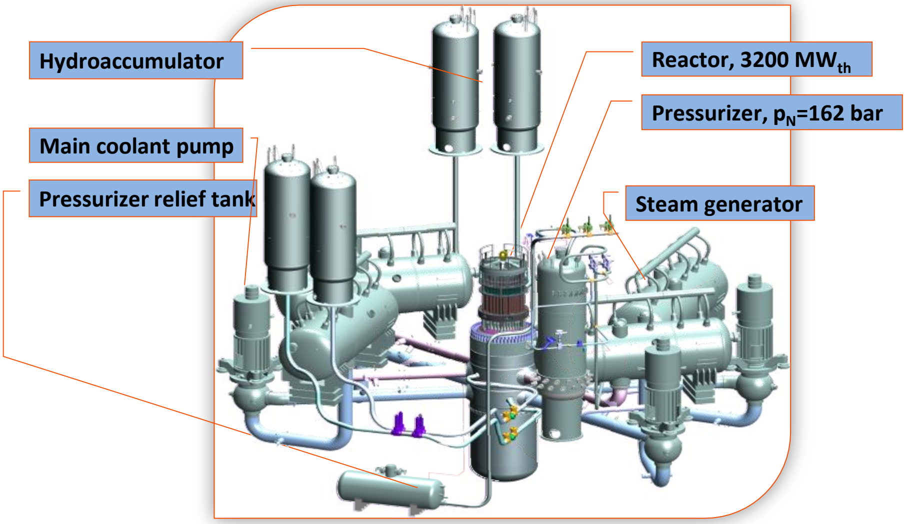
- The design of the units to be constructed at Paks site: VVER-1200/V491
- Pressurized water reactor type, developed by the Atomenergoproekt, based on VVER-1000 (evolutionary reactor design)
- Same type as offered for Finland (Pyhäjoki site, owner: Fennovoima Oyj)
- Reference unit: Leningrad II-1 and -2
  - Start of construction: 2008 (unit 1), 2010 (unit 2)
  - Start of operation: 2016, 2018



Condenser of Leningrad-II-1

Steam generator installation at Leningrad-II-1

Nuclear island



Net Efficiency: >34%	Availability: >90%
Expected lifetime: 60 years	Gross electric power: 1198 MW$_e$

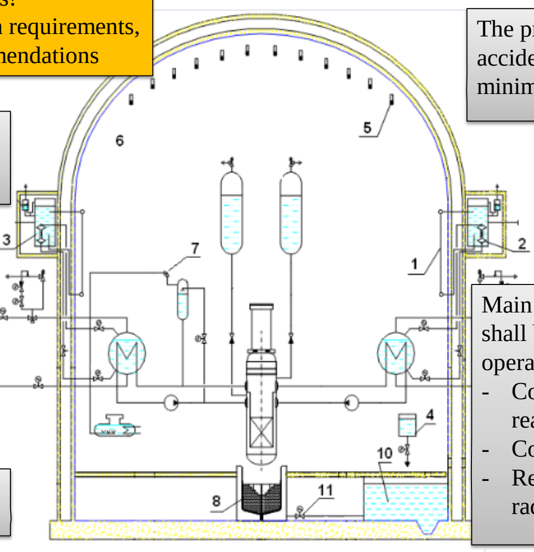
Hungarian requirements

Special requirements!
Based on Hungarian requirements, EUR, IAEA recommendations

Nuclear safety is the main priority!

The reactor has to comply with the Hungarian requirements (NBSZ) and the international standards

Feedback of the Fukushima lessons

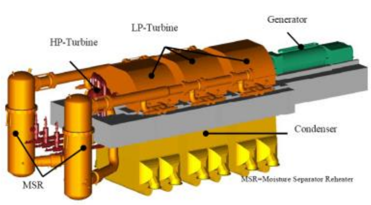


The probability of accidents shall be minimized

Main safety functions shall be met in all operational condition:
- Control of chain reaction
- Cooling of the fuel
- Retaining radioactivity

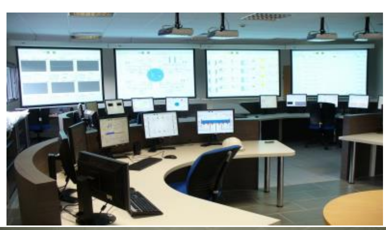
Open issues / tendering

- <u>Supplier of the turbogenerator systems</u>?
- Hungarian requirement: 1500 rpm turbine
- Real European possibilities:
  - Alstom Arabelle turbine
  - Siemens SST5-9000 turbine



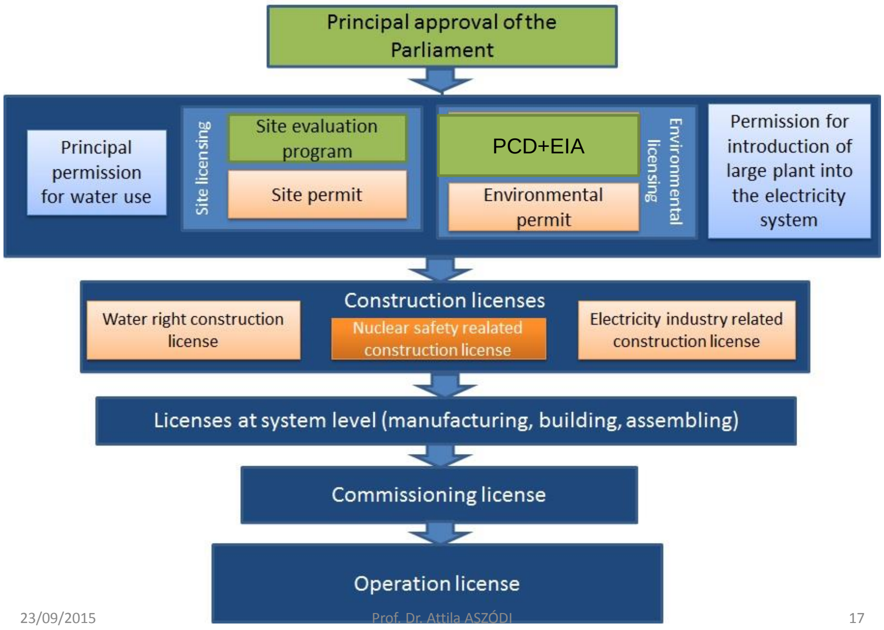
Siemens turbine (up) and Alstom turbine (down)

- <u>Supplier of the instrumentation and control (I&C)?</u>
  - Digital
  - Reliable



Corys at FL-3 (up); Tianwan (down)

The licensing process



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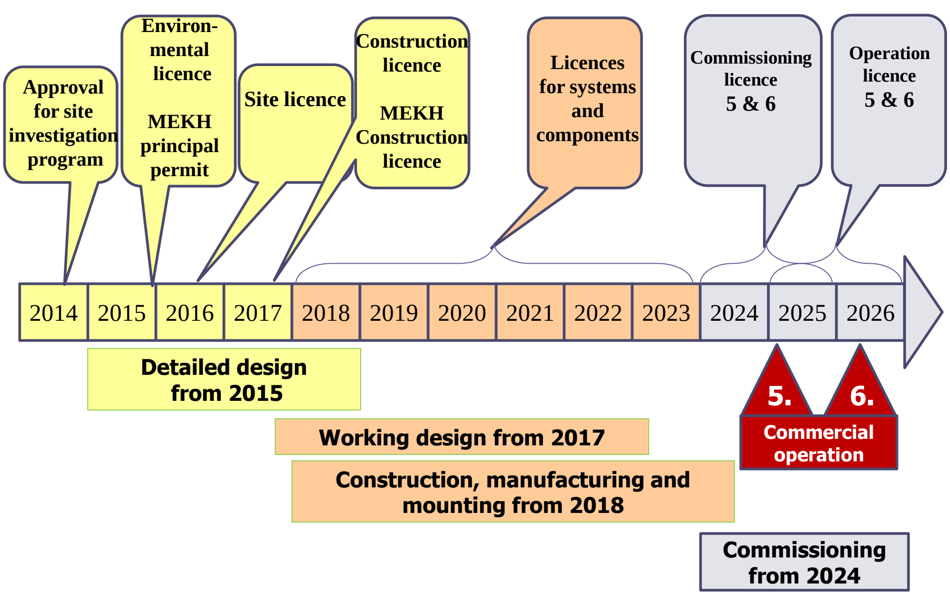
Planned milestones of the Paks-2 project



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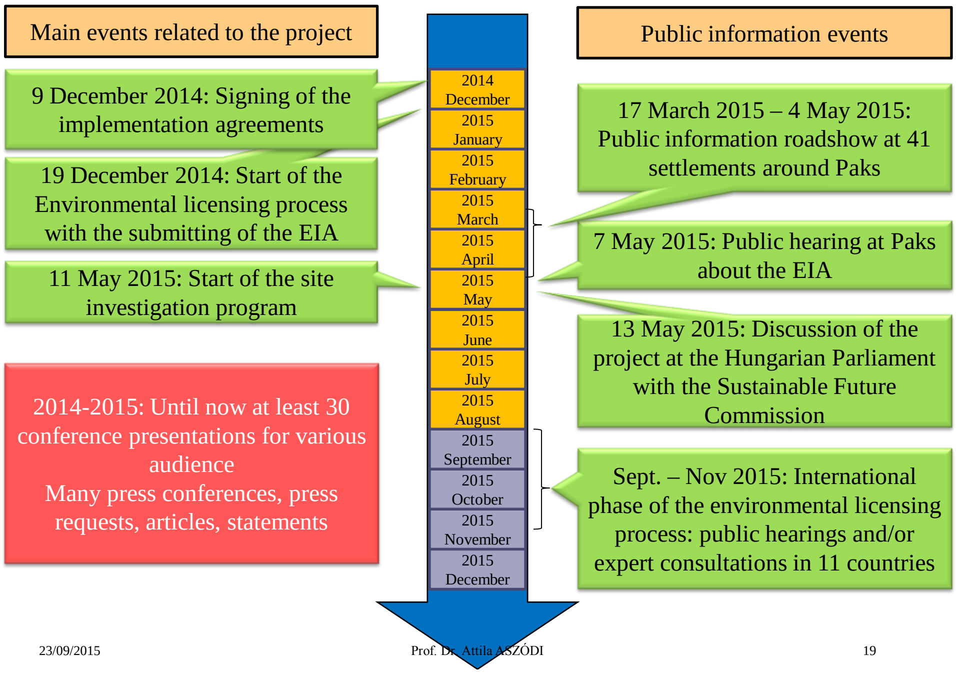
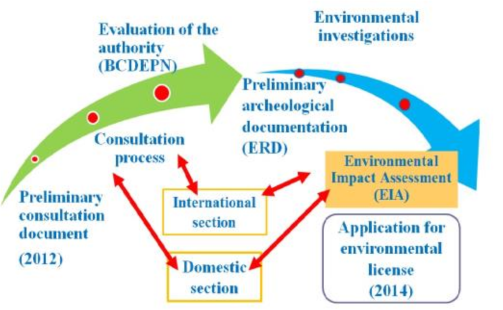
Extension of Paks NPP – the progress of the project and communication

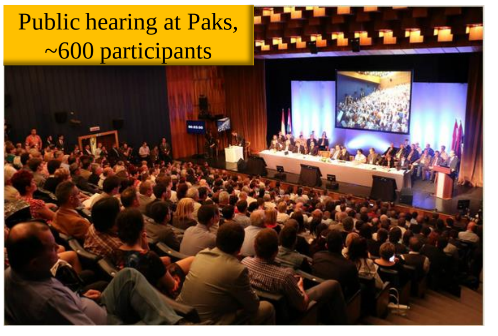


ENVIRONMENTAL IMPACT ASSESSMENT

Environmental Impact Assessment (EIA)

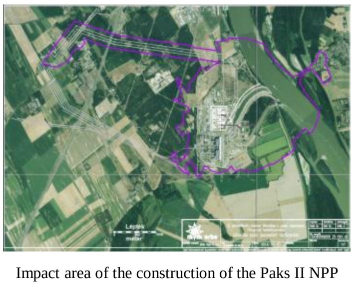
- The preliminary environmental consultation document was submitted to the authority in 2012
- EIA submitted to the competent authority on 19th December 2014
- Public hearing held in Paks in May 2015
  - Plus 41 presentations during the public information roadshow
- International public hearings according to the Espoo Convention
  - EIA was sent to 30 countries
  - 11 countries have been registered in the licensing process (Austria, Czech Republic, Greece, Croatia, Malta, Germany, Romania, Serbia, Slovak Republic, Slovenia, Ukraine)



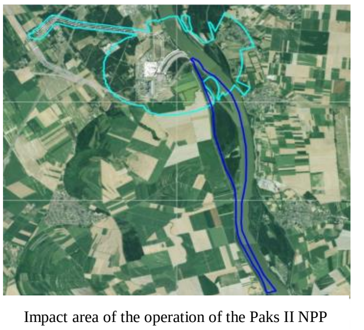


Results of the Environmental Impact Assessment

- The main contents of the EIA:
  - Basic information about the project
  - Impact of the discharged cooling-water into the River Danube (heat plume)
  - Water and air quality assessments
  - Noise- and vibration assessment
  - Radioactive and conventional waste management
  - Flora and fauna analysis
  - Environmental radiation, and radiation exposure of the population living near the site
  - The economic and social effects of the project



Impact area of the construction of the Paks II NPP



Impact area of the operation of the Paks II NPP

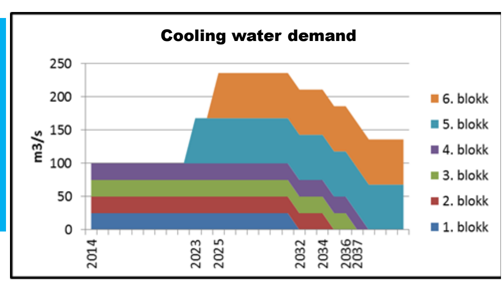
Environmental effects of the construction

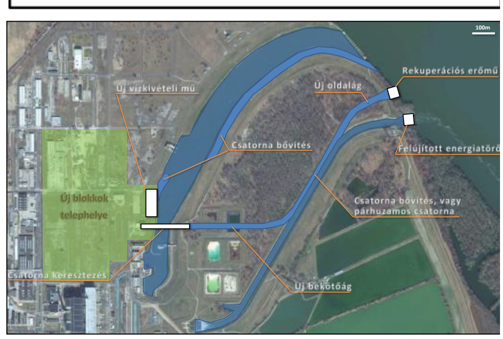
Tianwan, China, 2015
(Photo: Attila Aszódi)

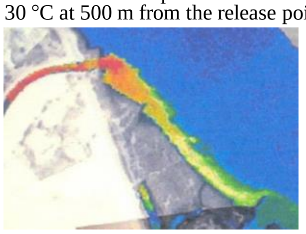
Cooling of the new units

- The most important impact is the discharging of the warmed-up cooling-water into the River Danube.
- The cooling of the NPP can fulfil all regulatory constraints even in extreme conditions (low water-level, high temperature).

- Regulatory limits:
  - Difference between inlet and outlet water temperature shall be below 14 or 11 °C (depending on the Danube water temperature)
    <u>Design requirement: 8 °C</u>
  - Danube water temperature can't exceed 30 °C at 500 m from the release point







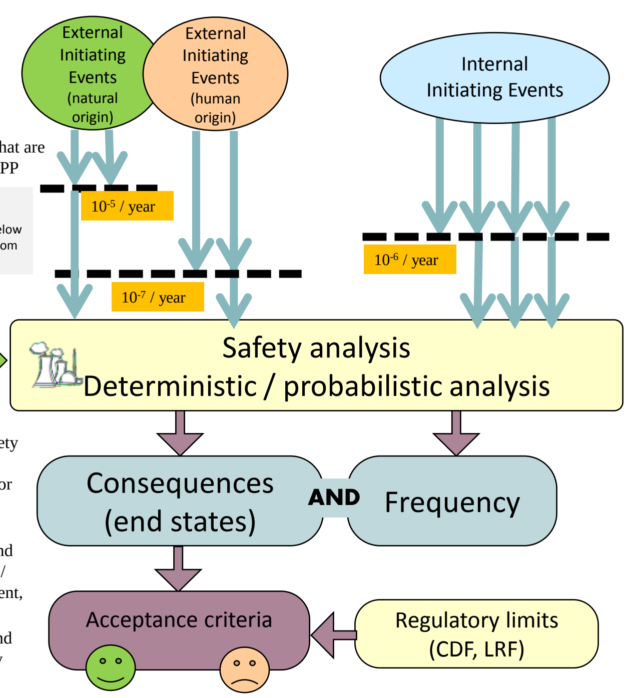
SAFETY OF THE NEW UNITS

Design basis of new reactors

- Postulated Initiating Events: events that are able to jeopardize the safety of the NPP

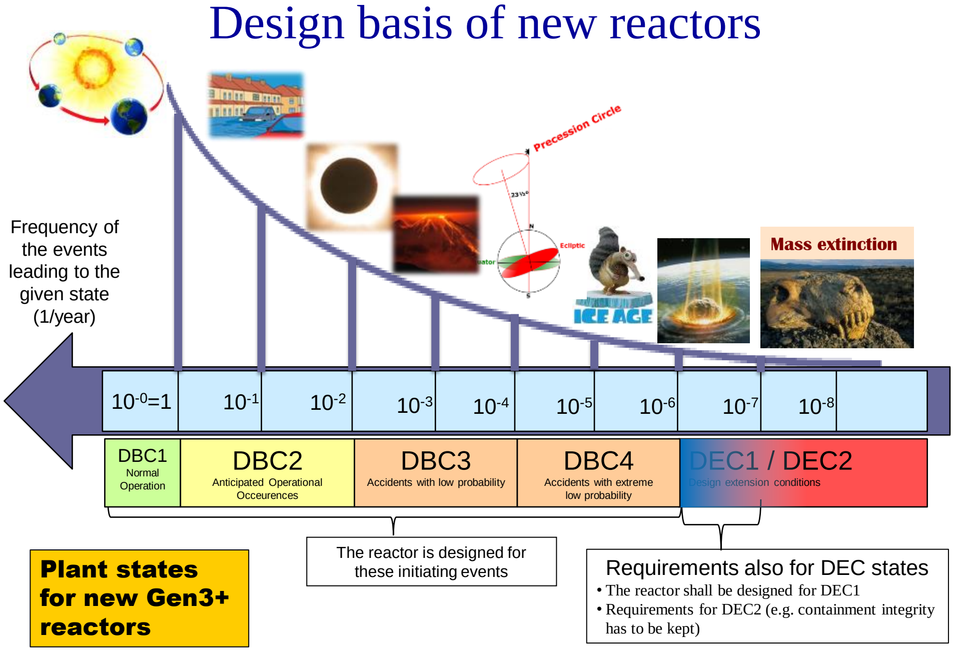
Screening
(events without safety significance or below the regulatory limits can be excluded from the safety analysis)

Inputs: initial conditions, operator actions, safety systems, other failures, etc.



- The consequence of a PIE on the safety depends on the plant initial state, the availability of safety systems, operator actions, etc.
- Many different chain of the events is possible, which results in different end states (e.g. no damage / fuel damage / radioactivity release to the environment, etc.)
- The safety analysis determines the end states and their calculated probability

Design basis of new reactors



Safety of VVER-1200 – Fukushima-proof design

- Experiences from the Fukushima accident built into the design
- Design for external hazards
  - Seismic resistance
  - Extreme weather conditions (snow pressure, wind load, precipitation, floodings, etc.)

Further requirements based on the site specific data (available data + site investigation results)

- Preparation for severe accidents
  - Application of passive systems
  - Handling of generated hydrogen or melted core

Fukushima-proof design!

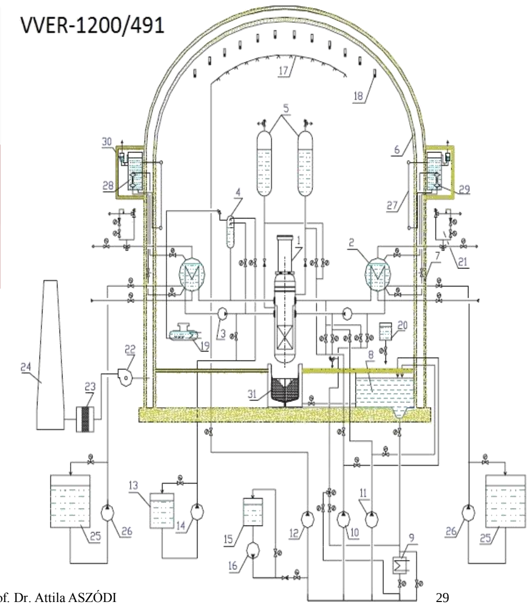
Safety of the VVER-1200/491

What happened in Fukushima?

- Loss of cooling and electric supply because of an extraordinary earthquake and tsunami

Design solutions to cope with external events

- Conservative design
- Resistance against external hazards
- Elevation of the site
- Double-wall containment



Safety of the VVER-1200/491

What happened in Fukushima?

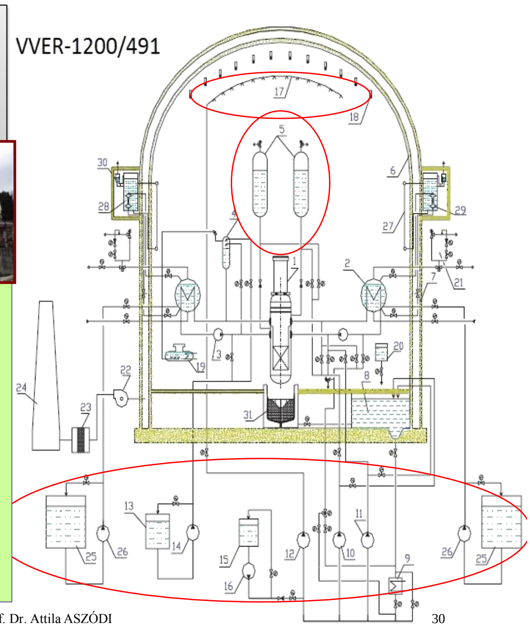
- Loss of cooling and electric supply because of an extraordinary earthquake and tsunami

Design solutions to maintain core cooling

Emergency core cooling systems:

- Active HP-ECCS + LP-ECCS:
  - o 4x100% redundancy
  - o Physically separated
  - o Resistance against external events
- Passive:
  - o Hydro accumulators

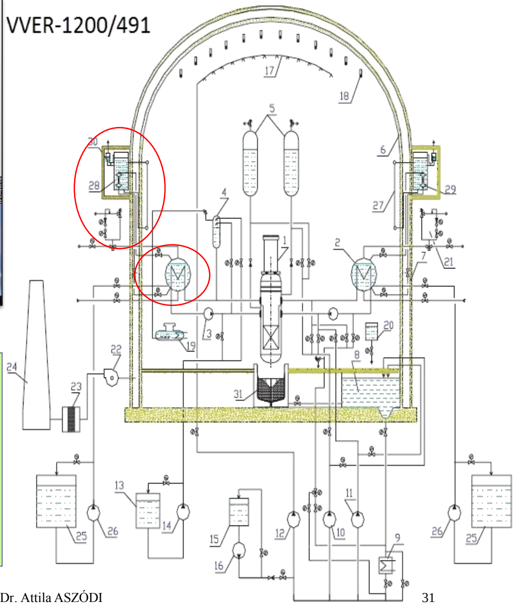
Active sprinkler system for containment cooling



Safety systems of the VVER-1200/491

What happened in Fukushima?

- Total loss of electric supply (SBO, station blackout) because of the flooding of the emergency diesel generators (EDGs)
- Loss of ultimate heat sink (loss of the seawater pumps)



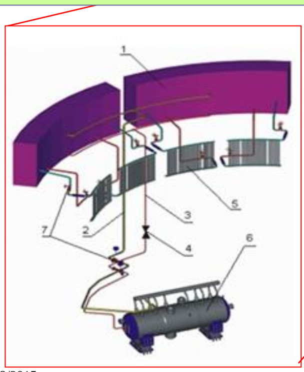
Design solutions to cope with SBO and LUHS

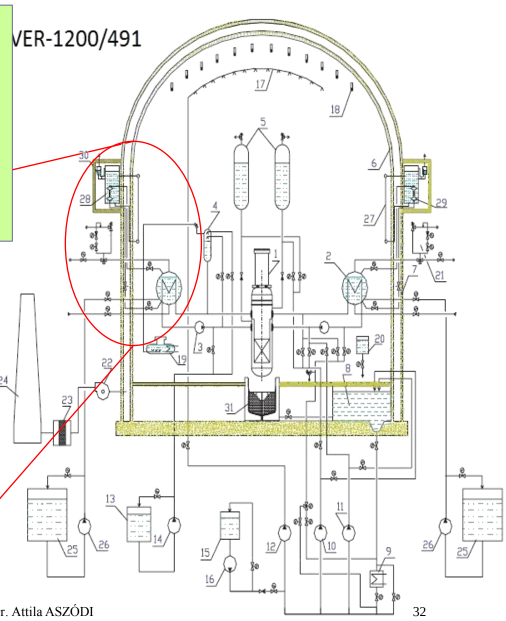
- Physically separated EDGs
- Passive cooling systems to cope with events with SBO
  - Passive SG cooling
  - Passive containment cooling

Safety systems of the VVER-1200/491

Passive heat removal from the primary circuit in case of loss of ultimate heat sink

- Heat removal directly from the steam generators
- Passive, no need of external power
- 4x33% redundancy

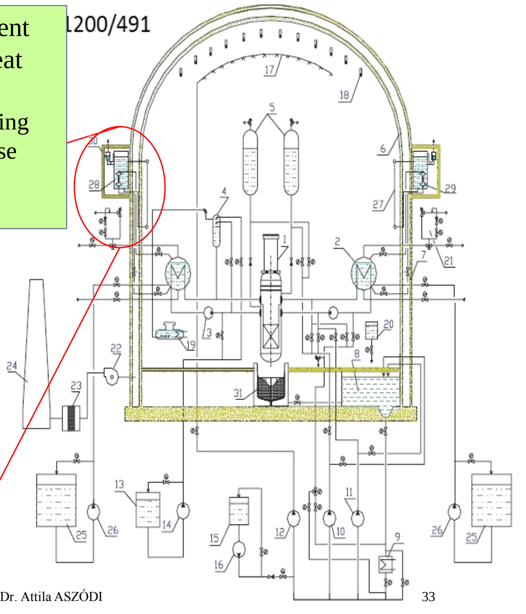


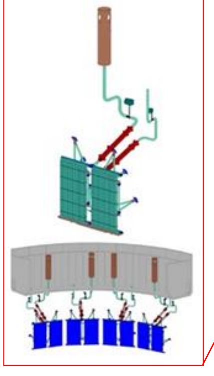


Safety systems of the VVER-1200/491

Passive heat removal from the containment atmosphere in case of loss of ultimate heat sink

- Heat removal from the containment building
- Containment cooling and pressure decrease
- Passive, no need of external power
- 4x33% redundancy





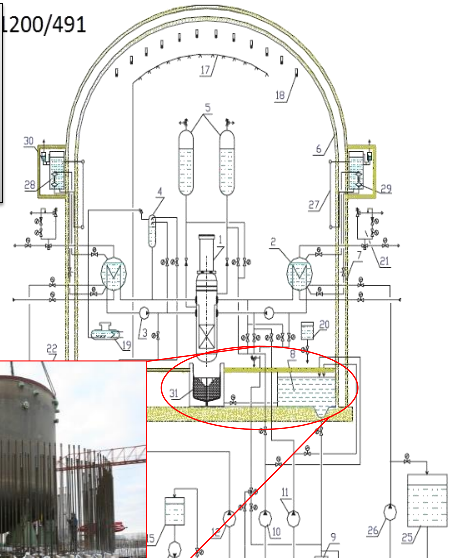
Safety systems of the VVER-1200/491

What happened in Fukushima?

- Core melting because of loss of cooling
- Uncontrolled flow of melted core
- No information available about the state of melted core

Design solutions to prevent large release to the environment

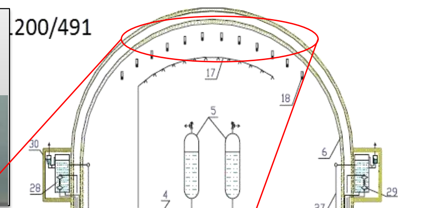
- In case of core melting: **core catcher** – retention of corium, controlled corium management and cooling
- Severe accident monitoring system



Safety systems of the VVER-1200/491

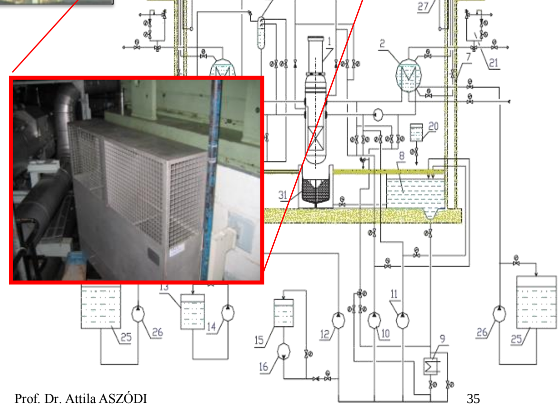
What happened in Fukushima?

- Failure of the containment buildings because of hydrogen explosions and containment overpressure



Design solutions to prevent large release to the environment

- Hydrogen recombiners designed for DBC and DEC states as well
- Containment pressure protection with passive containment cooling



Radiation situation near the site – worst case scenario

Impact areas in case of the Design Extension Conditions (DEC) with the biggest release in this situation (DEC-1: total loss of external power supply; DEC-2: severe accident)

Scenario	Isotope	Xe-133	I-131 (all form)	Cs-137
DEC-1	Release at 35m (TBq)	2.4	0.26	7.2E-5
	Release at 100m (TBq)	190	0.028	3.2E-7
DEC-2	Release at 35m (TBq)	2400	56.2	5.2
	Release at 100m (TBq)	57000	5.47	0.073

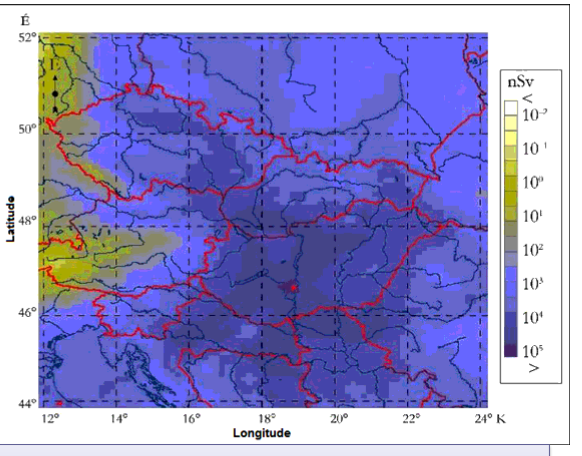
TAK1-2 (DEC1-2)

According to the Hungarian Nuclear Safety Code

- **Over 800m:** no need for urgent emergency response
- Over **3000m:** no need for temporary evacuation
- **Over 800m:** no need for late permanent evacuation

International impacts of the Severe Accidents (DEC2)

- For normal operation and Design Basis Accidents: **there are no transborder effects or impacts** of the new NPP in any phase of the project
- For severe accidents comprehensive calculations based on **real meteorogical database** and the emission database were performed
- The worst case scenario arose in case of considering inhalation doses for children, DEC2 event and late release



The results show that in case of DEC2 event the highest radiation impact with maximum of **~10 µSv inhalation dose** can be obtained at the southern borders. The dose **never reaches** the impact threshold level (**90 µSv/year**), the dose limit constraint defined by the authority. **In other words the impact is neutral.**

Transboundary effects of DEC 1-2 accidents

Calculated annual inhalation dose rates for children from DEC1 releases

Settlement	Model coordinates		Inhalation effective dose nSv	
	Width	Length	TAK1 (DEC1) - early	TAK1 (DEC1) - late
Graz	15.50	47.1	3.296E+00	3.343E+00
Zagreb	15.95	45.8	1.133E+02	1.146E+02
Vienna	16.40	48.2	5.559E+01	5.669E+01
Bratislava	17.15	48.2	1.022E+02	1.043E+02
Novi Sad	19.85	45.3	1.105E+02	1.132E+02
Beograd	20.45	44.8	8.203E+01	8.448E+01
Arad	21.35	46.2	**1.232E+02**	**1.250E+02**
Kosice	21.35	48.7	6.886E+01	6.979E+01
Oradea	21.95	47.0	5.615E+01	5.673E+01
Uzhgorod	22.25	48.6	3.758E+01	3.815E+01

Calculated annual inhalation dose rates for children from DEC2 releases

Settlement	Model coordinates		Effective inhalation dose nSv	
	Width	Length	TAK2 (DEC2) - early	TAK2 (DEC2) - late
Graz	15.50	47.1	2.474E+02	2.679E+02
Zagreb	15.95	45.8	8.517E+03	9.072E+03
Vienna	16.40	48.2	4.181E+03	4.625E+03
Bratislava	17.15	48.2	7.681E+03	8.559E+03
Novi Sad	19.85	45.3	8.307E+03	9.208E+03
Beograd	20.45	44.8	6.160E+03	6.969E+03
Arad	21.35	46.2	**9.260E+03**	**9.906E+03**
Kosice	21.35	48.7	5.170E+03	5.551E+03
Oradea	21.95	47.0	4.225E+03	4.456E+03
Uzhgorod	22.25	48.6	2.819E+03	3.046E+03

Radioactive waste

- Radioactive waste: radioactive material that will not be used later and that cannot be handled as a common waste due to its radiation characteristics
- Radioactive waste management is a task of the state, waste management costs are to be paid by the polluter (operator)
- Radioactive waste management: depends on the waste characteristics (activity, half-life etc.)
- Waste management phases:
  - Processing (e.g. volume reduction)
  - Conditioning (e.g. solidification)
  - Classification
  - Interim storage
  - Final disposal

Classification of radioactive waste based on its activity concentration

1. Exemption level: any material containing radioactive isotope below an activity concentration or total activity level determined by law is exempted from authority control

2. Low-level radioactive waste (based on total activity or equivalent dose rate)

3. Intermediate-level radioactive waste

4. High-level radioactive waste – requires individual waste management and special protection measures

Radioactive waste

<u>Low- and intermediate-level waste</u>

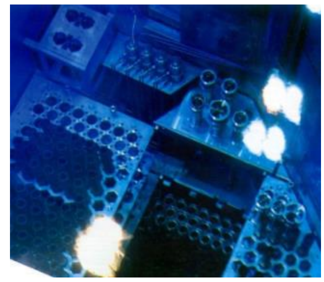
- Interim storage possibility on the site
- Final disposal: National Radioactive waste storage (NRHT), Bátaapát, HU
  - near-surface facility, in depth of 250 m
  - Current capacity: 4600 containers;
  - First near-surface storage vault is available since the end of 2012

Construction of the national radioactive waste storage facility

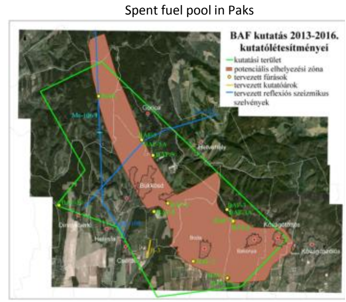
Radioactive waste

Spent fuel

- Spent fuel: during the operational period of the power plant (60 years) 3135 spent fuel elements will be produced
- Spent fuel: high activity concentration, significant heat production, long-life radioactive material
  - Not obviously waste!
- Storage under water for 3-5 years
  - Spent fuel pool, within the reactor building
- Interim storage: abroad or in a storage facility to be built on the site
- Final disposal: Hungary has established a national policy which was published on May 4, 2015 in the Official Journal. Based on this, a national program is being adopted.
- During realization of the program further Environmental Impact Assessments will be conducted, in line with the Espoo convention.



Spent fuel pool in Paks



THANK YOU FOR YOUR ATTENTION!