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Present Status and Near-Term Plans of the Nuclear Power Program in the Czech Republic

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14TH INTERNATIONAL CONFERENCE OF THE CROATIAN NUCLEAR SOCIETY

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OUTLINE OF THE PRESENTATION

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The presentation describes the current status and future plans for implementation of nuclear power in the Czech Republic and discusses the practical steps associated with implementation of the plans. It includes summary of the existing nuclear units, preparation for construction of new large power units, as well as development and plans for implementation of small modular reactors.

- Overall situation in nuclear sector
- Nuclear power in the Czech Republic
- New build plans in the Czech Republic
- SMR deployment in the Czech Republic
- Development of SMRs in the Czech Republic
- Summary

Acknowledgment: The presentation was prepared with significant inputs from colleagues of CEZ, a. s.

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OVERALL SITUATION

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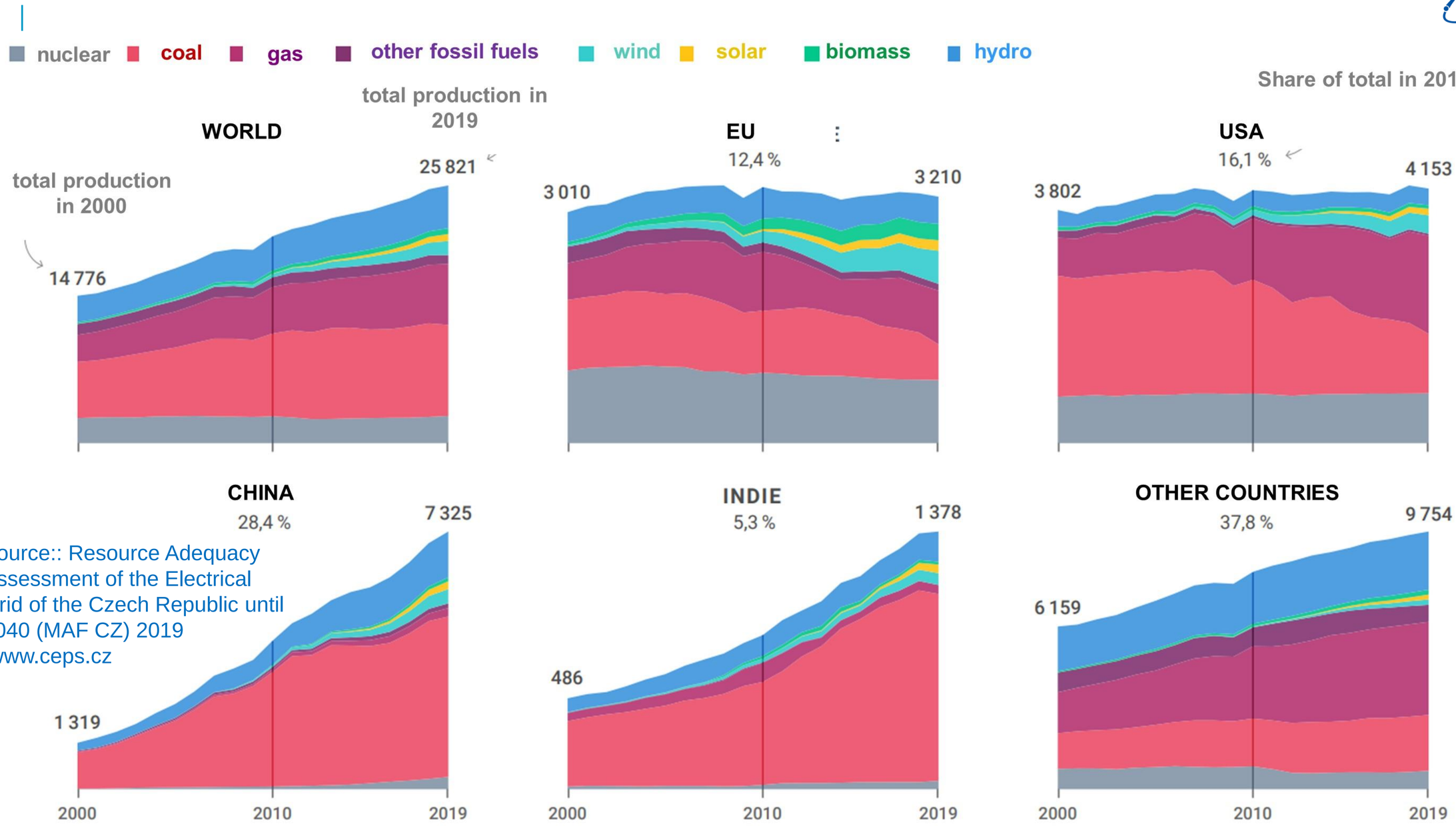
WORLDWIDE ELECTRICITY PRODUCTION IN TWH (2000-2019)

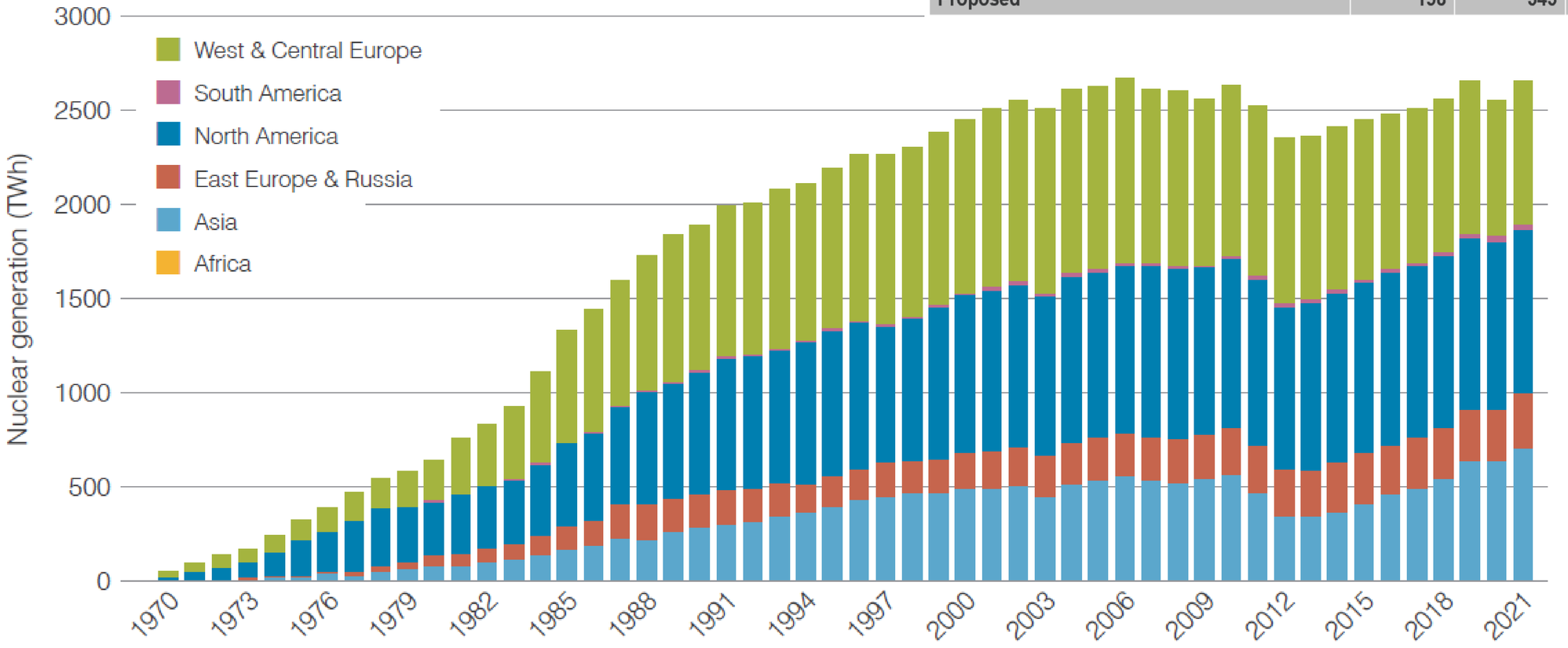


Source:: Resource Adequacy Assessment of the Electrical Grid of the Czech Republic until 2040 (MAF CZ) 2019 :www.ceps.cz

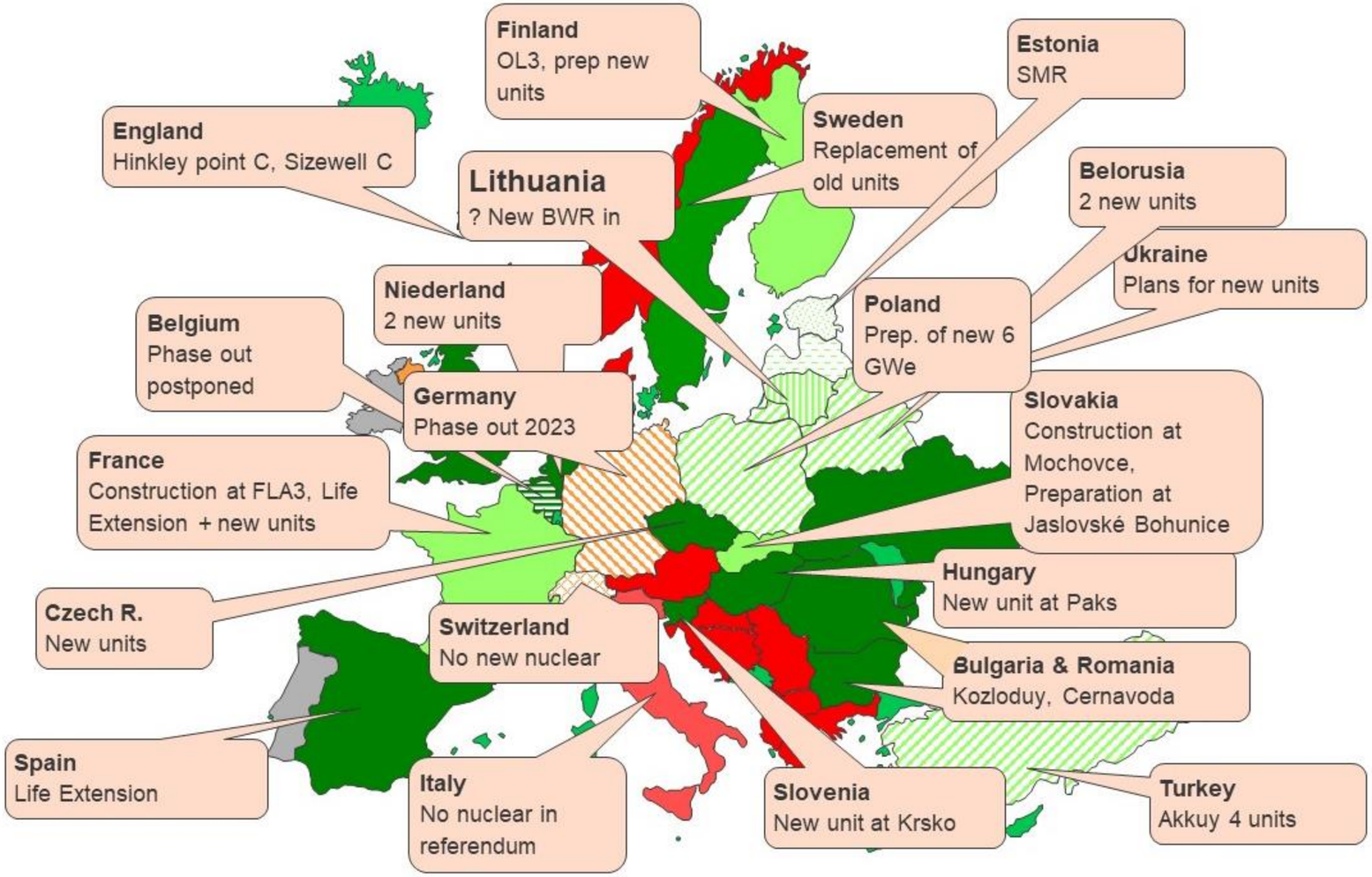
NUCLEAR POWER IN THE WORLD – CURRENT SITUATION (2023)

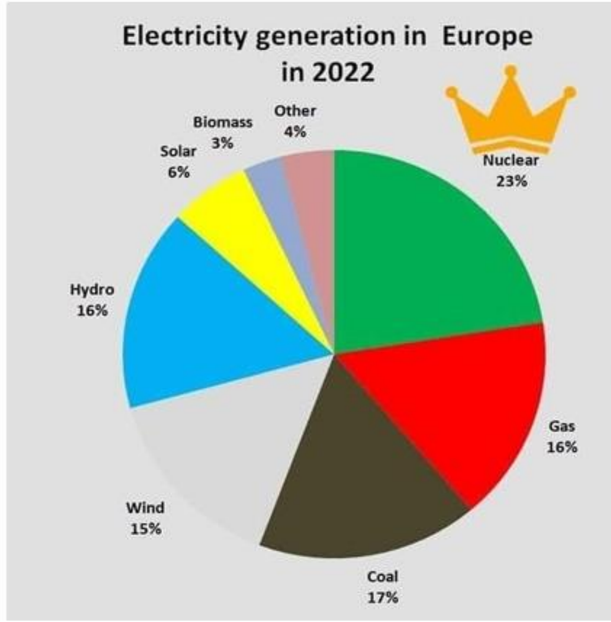
- Number of units: 436
- Installed power: 393 GWe
- Under construction: 59 units 66 GWe
- The nuclear share of electricity production is slightly over 10 %

	2006	2011	„Today“*
Units in commercial operation	435	434	436*
Installed power GWe	368	370	393
Ratio of nuclear power in overall production	16%	13,8%	10%
Under construction	28	61	59
On order or planed	64	156	100
Proposed	158	343	323



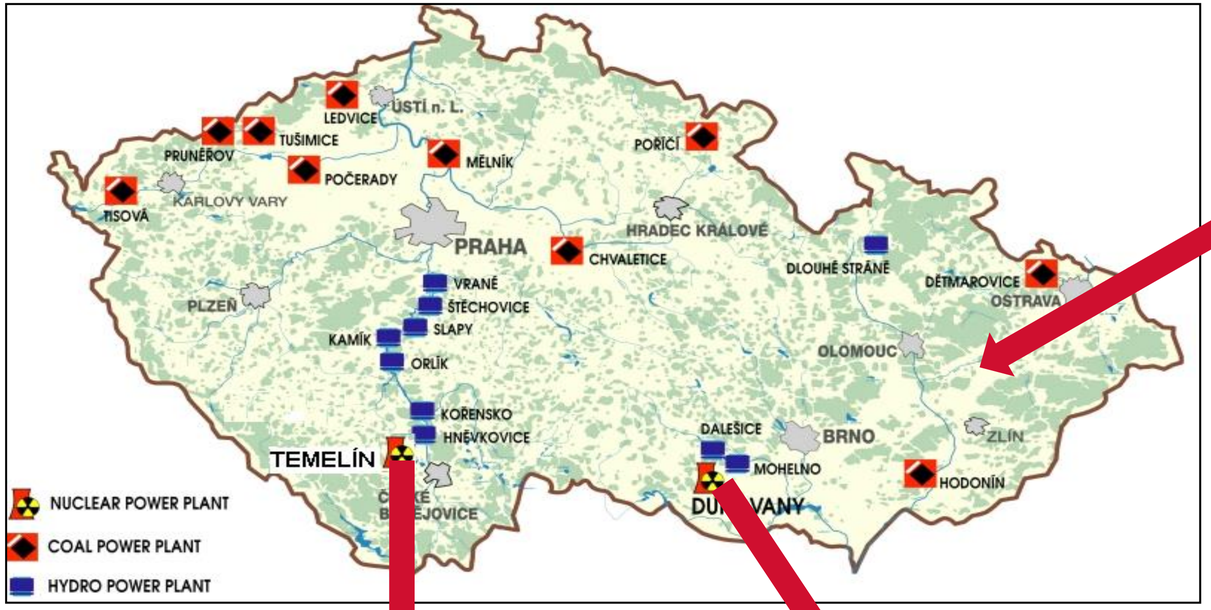
PLANS FOR NUCLEAR NEW BUILDS IN EUROPE

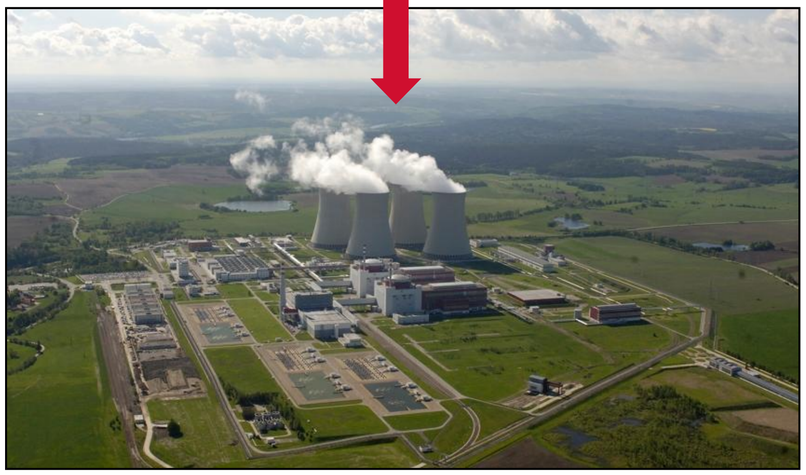




NUCLEAR POWER IN THE CZECH REPUBLIC

NPPs IN THE CZECH REPUBLIC





Temelin NPP

- 2 Units VVER 1000/V320
- Unit 1 - 2002
- Unit 2 – 2003
- Power upgrade to 104 %
  (3000 MWt => 3120 MWt)

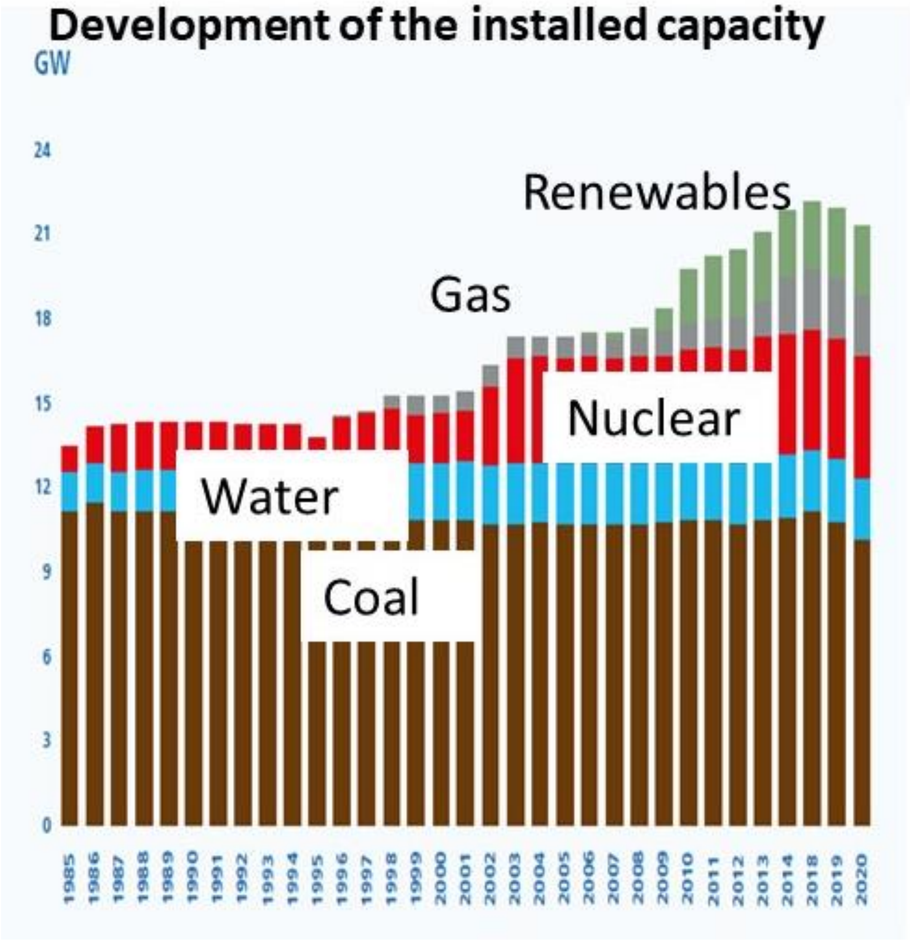
Dukovany NPP

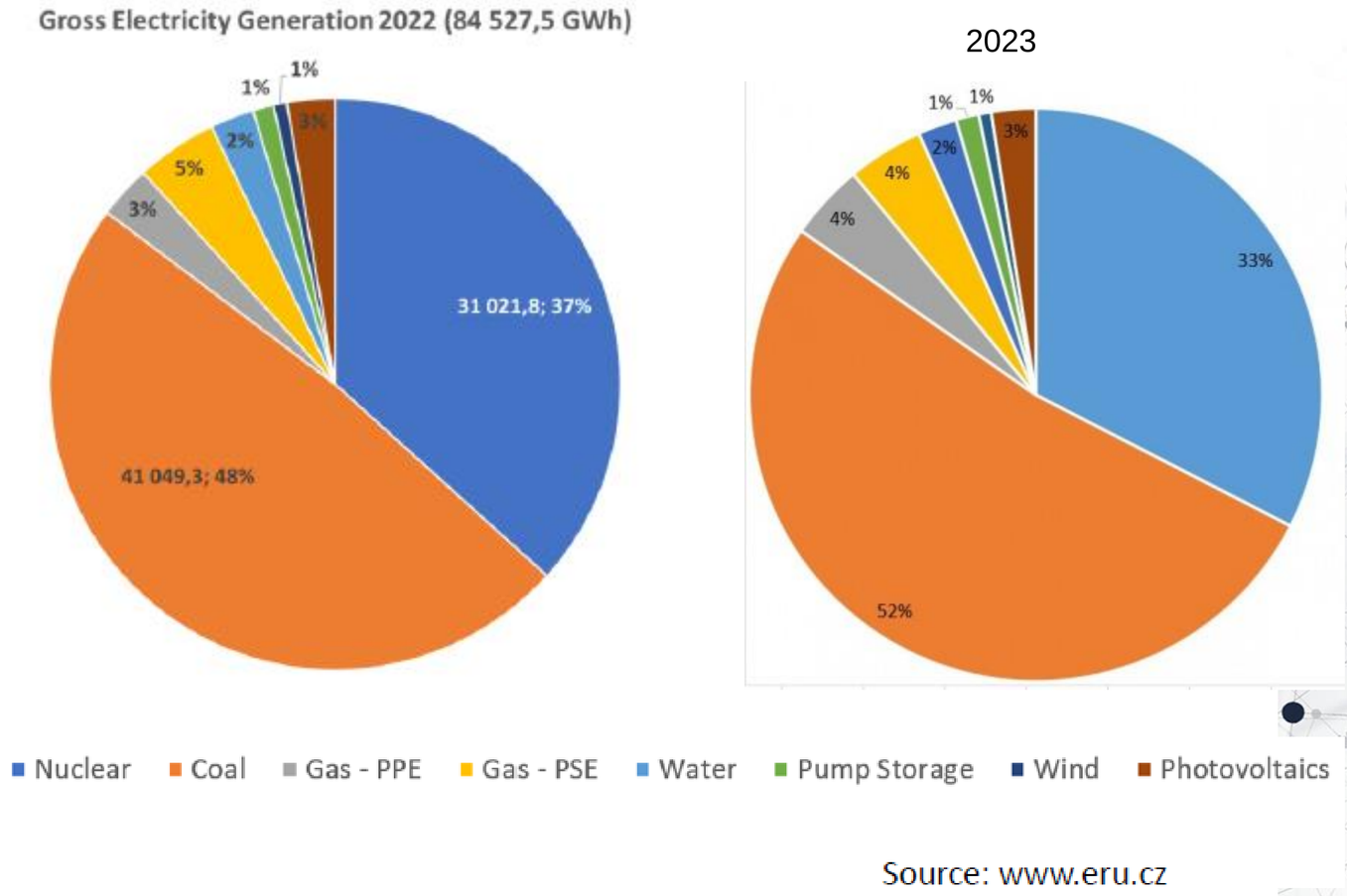
- 4 Units VVER 440/V213
- Unit 1 - 1985
- Unit 2 - 1986
- Unit 3 - 1986
- Unit 4 - 1987
- Power upgrade to 105 %
  (1375MWt =>1444 MWt)

NUCLEAR FACILITIES

Site	Nuclear installation	No. of units	Type	Commis-sioning	Operator
Dukovany	NPP	4	VVER 440/213	1985-1987	CEZ
	Interim Spent Fuel Storage Facility	1		1995	CEZ
	Spent Fuel Storage Facility	1		2006	CEZ
	Radioactive Waste Disposal Facility	1		1995	SURAO
Temelin	NPP	2	VVER 1000/320	2000-2002	CEZ
	Spent Fuel Storage Facility	1		2010	CEZ
	Fresh Fuel Storage Facility	1		2000	CEZ
Rez	Research Reactor	1	LVR 15	1972	RC REZ
	Research Reactor	1	LR-0	1995	RC REZ
	Spent fuel and high level waste storage facility	1		1997	UJV REZ
Prague	Training Reactor	1+1	VR-1	1992	CVUT
Litomerice	Radioactive Waste Disposal Facility RICHARD	1		1964	SURAO

ROLE OF NUCLEAR POWER IN THE CZECH REPUBLIC





Ambition: All coal units to be closed until 2033

DEVELOPMENT OF ELECTRICITY PRODUCTION AND CONSUMPTION (TWh) IN THE CZECH REPUBLIC (CEZ ESTIMATE)

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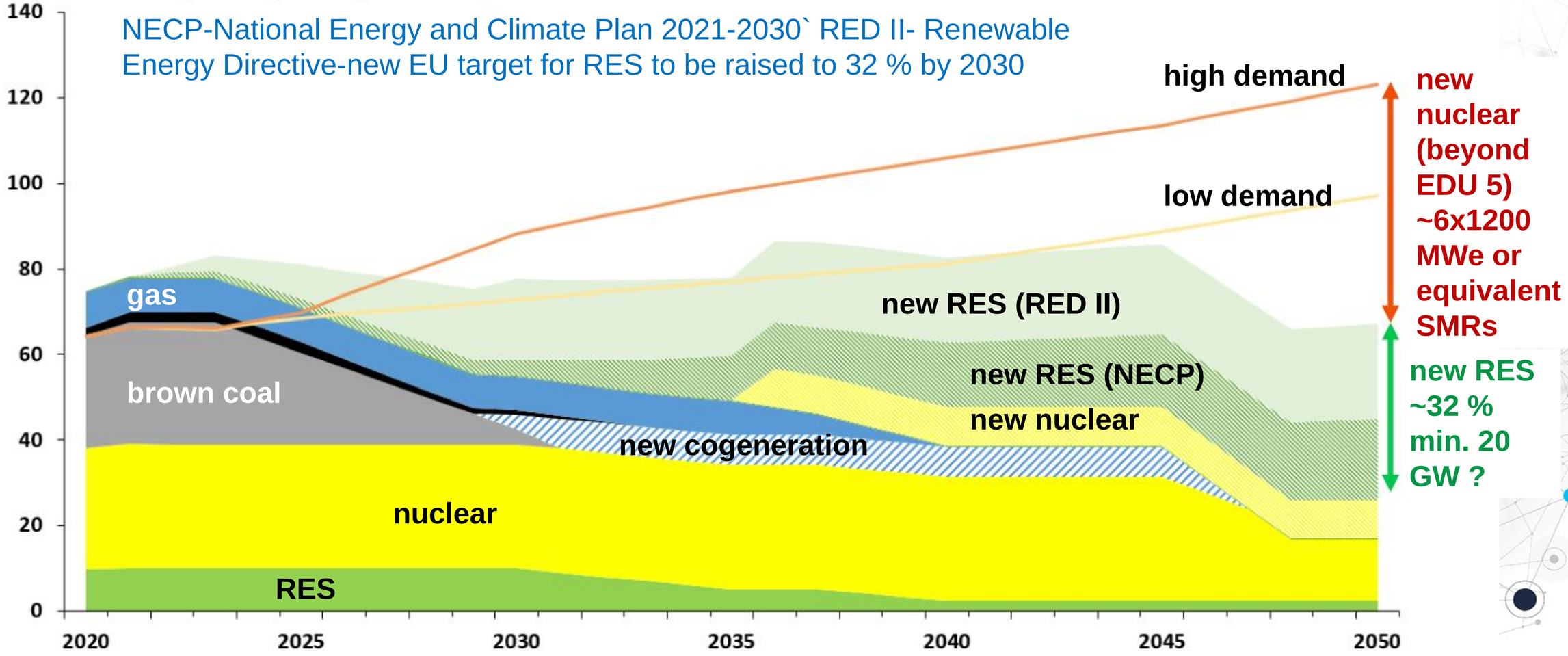
NECP-National Energy and Climate Plan 2021-2030` RED II- Renewable Energy Directive-new EU target for RES to be raised to 32 % by 2030



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DEVELOPMENT OF GENERATING CAPACITY AND GENERATION IN CR (REFERENCE CASE)

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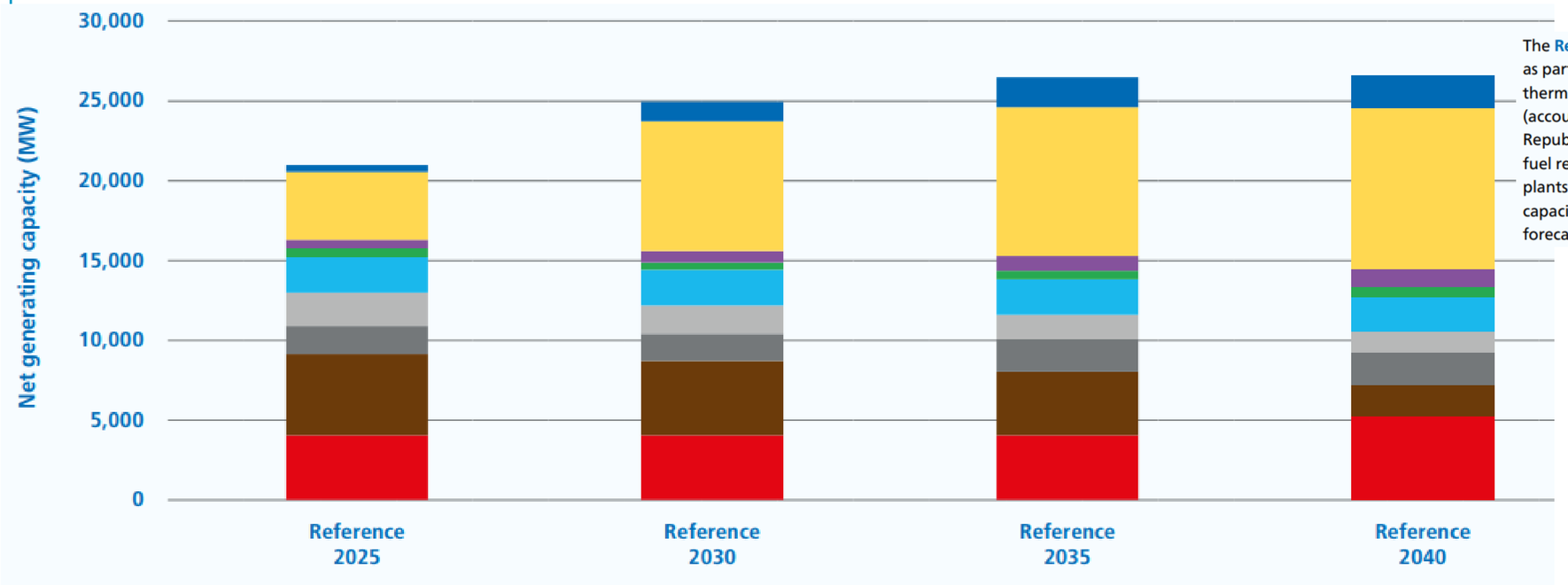
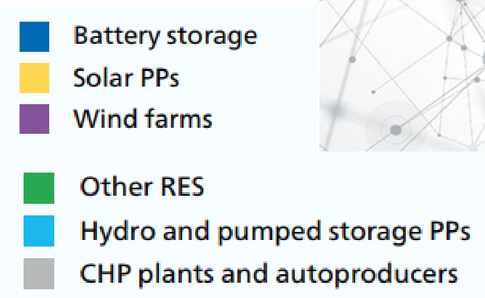
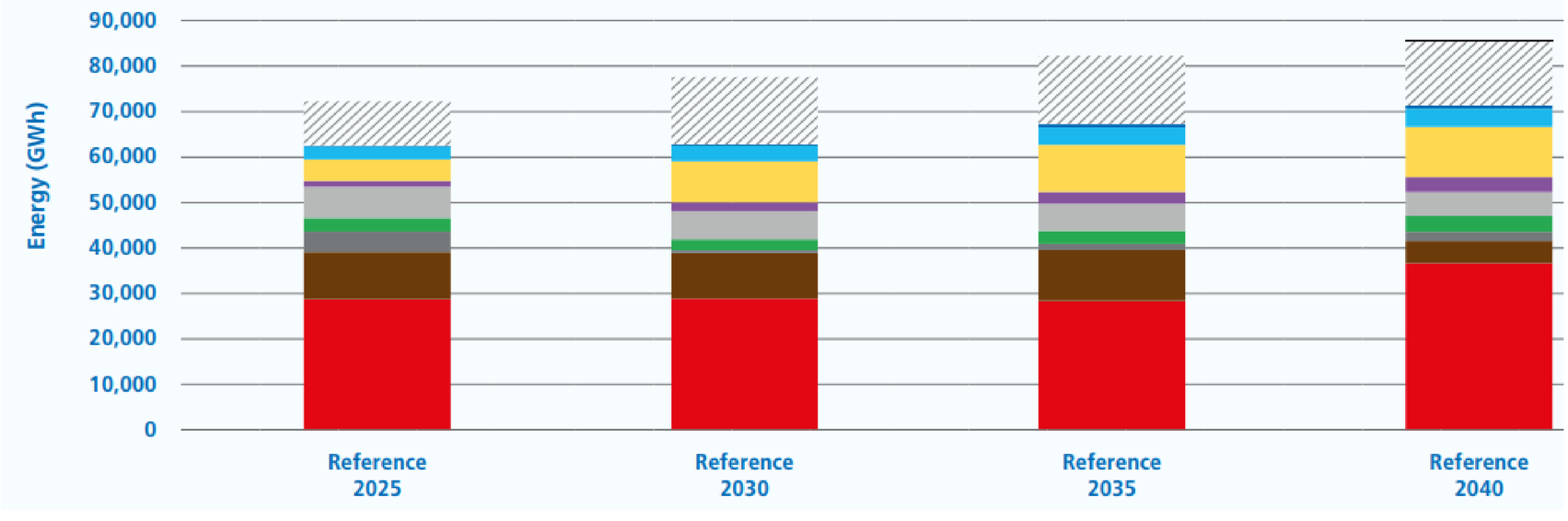
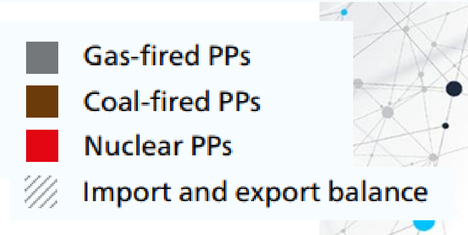


The **Reference scenario** is based on primary data collected from electricity producers as part of the CEPS questionnaire survey conducted in 2021 which includes all thermal and hydro power plants with a net installed capacity above 10 MWe (accounting for 79% of the installed capacity of the electrical grid of the Czech Republic). The data collection indicates a slower decline of currently operating fossil fuel resources which will be partially replaced by gas-fired sources in coal-fired power plants, CHP plants, and autoproducers. The future development of the installed capacity of wind and photovoltaic power plants is in accordance with the realistic forecast of the Conservative scenario.







Source:: Resource Adequacy Assessment of the Electrical Grid of the Czech Republic until 2040 (MAF CZ) 2021 :www.ceps.cz

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ELECTRICITY BALANCE OVERVIEW IN EUROPEAN COUNTRIES IN 2024 FOR ONE OF THE SCENARIOS

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- To achieve long-term energy d security of the Czech Republic, it will be necessary to build new low carbon sources -especially nuclear and RES, and to strengthen energy savings.
- Demand for electricity will grow significantly due to electrification, especially in transport, industry and heating.
- Future demand will not be met and an electricity shortage of 20 TWh per year is expected already in 2030. Electricity shortages are also expected in many other EU countries and therefore relying on imports is not an option.
- Nuclear power should consist of a combination of large units and SMRs. SMRs are not a substitute for large units, but complementary sources for replacement for coal-fired sources, including

Year 2040

Source: Resource Adequacy Assessment of the Electrical Grid of the Czech Republic until 2040 (MAF CZ): 2019 www.ceps.cz

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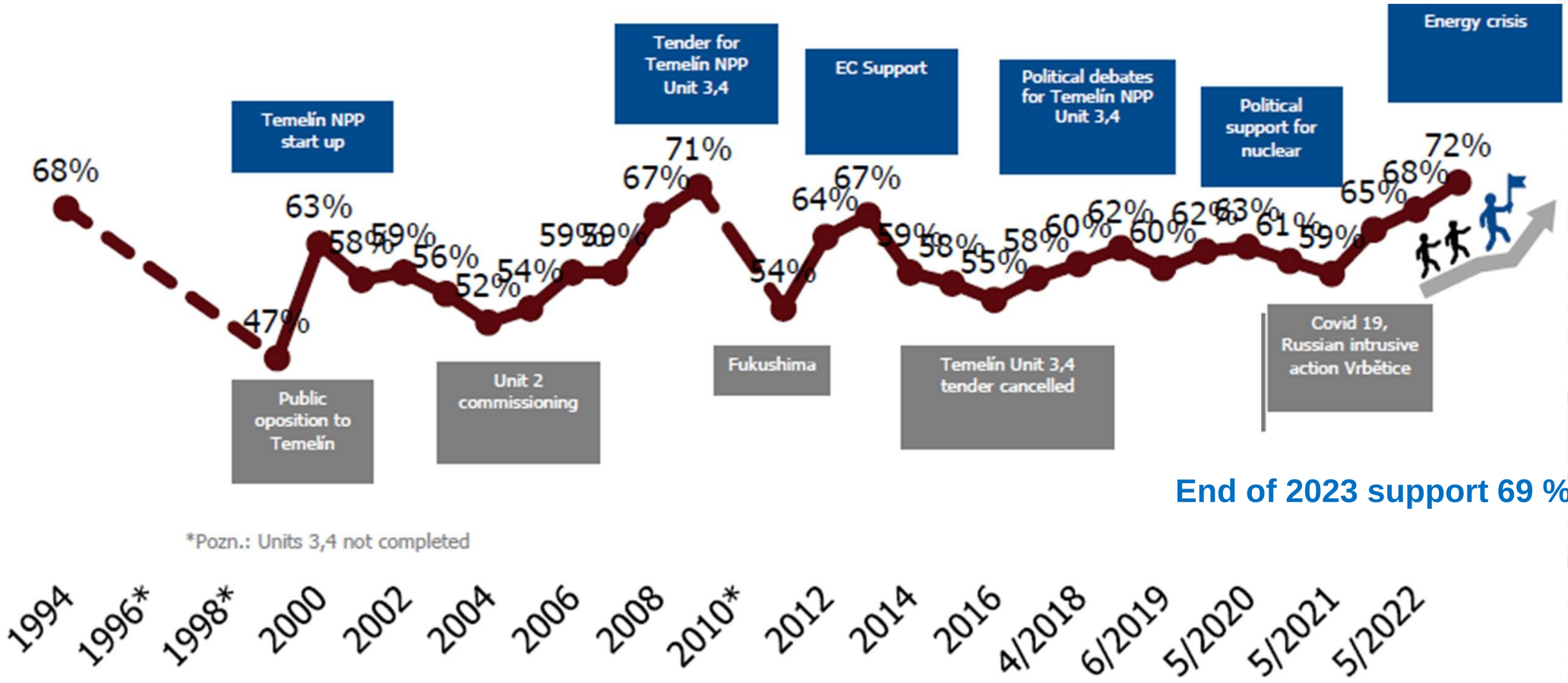
PUBLIC SUPPORT TO NUCLEAR POWER IN CR



PROGRAM STATEMENT OF THE GOVERNMENT (END OF 2021)

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- **Future energy mix – nuclear + decentralized renewables**
- **Long term operation of the current units**
- **Construction of the new nuclear unit in Dukovany**
- **Construction of more new units at Dukovany and Temelin site**
- Strengthening of R&D, international cooperation in the nuclear field
- Strategy for implementation of SMRs
- Continued works on deep geological repository

NEW ENERGY PLAN OF THE GOVERNMENT (18 OCT 2023)

- Estimated increase in electricity consumption till 2030 ~ 10 %
- End of coal burning for electricity 2033
- Increase of renewable sources in total consumption from current 18 % to 30 % till 2030: 10.1 GW in PV, 1.5 GW in wind plants
- Till 2040, increase of nuclear in electricity production from 40 to 60 %: 2 large units in Dukovany, 2 in Temelin
- Temporarily, increased share of electricity production from the gas, and from the import
- Use of nuclear power for heating of large cities (Ceske Budejovice, Brno)
- Needed investment till 2030 ~20 mld EUR to energy sources

NEW NUCLEAR BUILD

Elektrarna Dukovany II, a. s. (EDU II)

- subsidiary company of CEZ, a. s.
- established in 2015
- at present 165 employees

100 % ←

CEZ, a. s. (CEZ Group)

Elektrarna Temelin II, a. s. (ETE II)

- focus on new large reactors at Temelin

Development of SMR

- SMR – Temelin + new sites

DUKOVANY 5 PROJECT DEVELOPMENT

Year	Step	Note
2010-2011	Feasibility Study	Atmea 1000, Kepco APR1400, Mitsubishi EU APWR 1700, Westinghouse AP 1000, Areva EPR1600 and ASE MIR 1200
2012-2014	Site related studies	raw water consumption, transportability, or power grid connection max. power output set up to 1200 MW
2017	EIA	Environmental Impact Assessment documentation was submitted to the Ministry of the Environment of the Czech Republic
2019	EIA Statement	Ministry of Environment issued Binding Statement
2015	Site License Documentation	EDU II obtained the License for the siting of two units of the new Nuclear Power Plant at Dukovany Site from the State Office for Nuclear Safety on 8th March 2021.
2019-2021	Site Permit Documentation	Application for site permit to Ministry of Regional Development was submitted by CEZ in May 2021 – Decision obtained in October 2023, appealed, new decisions expected in November 2024
2020-2021	BIS	Preparation of Bid Invitation Specification. 3 bidders (EDF, Westinghouse, KHNP)
2022-2024	Tender process	Final bids November 2023 Preferred bidder selection 15 July 2024
2024	Contract signature	March 2025

DUKOVANY 5 PROJECT DEVELOPMENT

Year	Step	Note
2025-2027	Construction License Documentation	According to Atomic Law.
2028	Construction License	Application to the State Office for Nuclear Safety
2026-2028	Construction Permit Documentation	According to Building Act.
2029	Construction Permit	Application for construction permit to Ministry of Industry and Trade
2030	Construction Start	First Concrete
2035-2036	Active testing & commissioning	**Additional Licenses** First physical start-up of a nuclear installation with nuclear reactor; - First power-generation start-up of a nuclear installation with nuclear reactor; - Commissioning of a nuclear installation without nuclear reactor: - Operation of a nuclear installation
2036	Commercial Operation	

TENDER FOR EPC SUPPLIER

- Bids submitted by November 30, 2022, 3 original bidders
- Negotiation with WEC interrupted by decision of Government
- Updated offers to build 4 units 15.4.2024
- Statement of the government on the bid evaluation 07/2024
- Contract negotiations with the preferred bidder 07/2024 - 03/2025
- EPC contract ready for signing 03/2025

Bidder	Country of origin	Type	Installed capacity
~~Westinghouse Electric Company LLC~~	~~USA~~	~~AP 1000~~	~~970 MW~~
Korea Hydro & Nuclear Power Company	Korea	APR 1000+	1100 MW
Électricité de France	France	EPR 1200	1200 MW

CANDIDATE DESIGNS – APR 1000+

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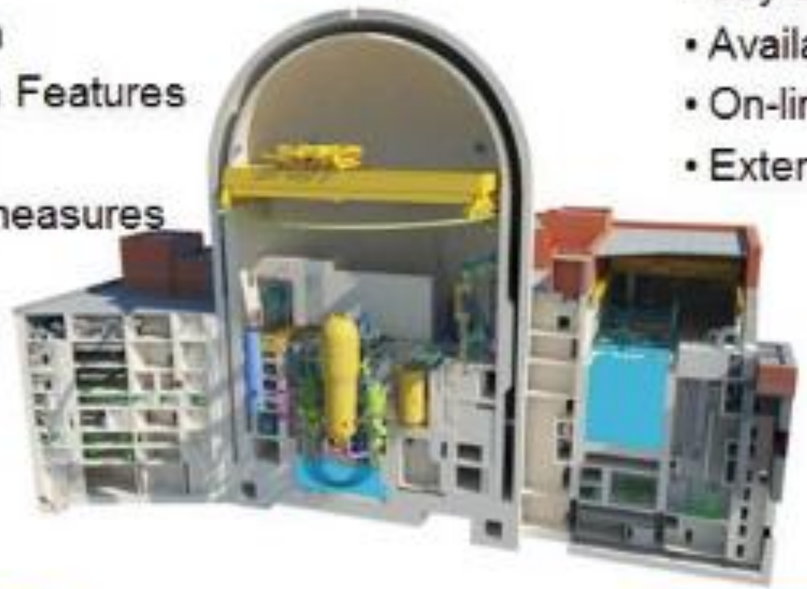
Ultimate Safety

- Improved Safety System
- Enhanced Seismic Design
- Severe Accident Mitigation Features
- Aircraft Crash Resistance
- Post-Fukushima Countermeasures



Outstanding Performance

- 60yrs Plant Lifetime
- Availability over 92%
- On-line Maintenance
- Extended Refueling Period

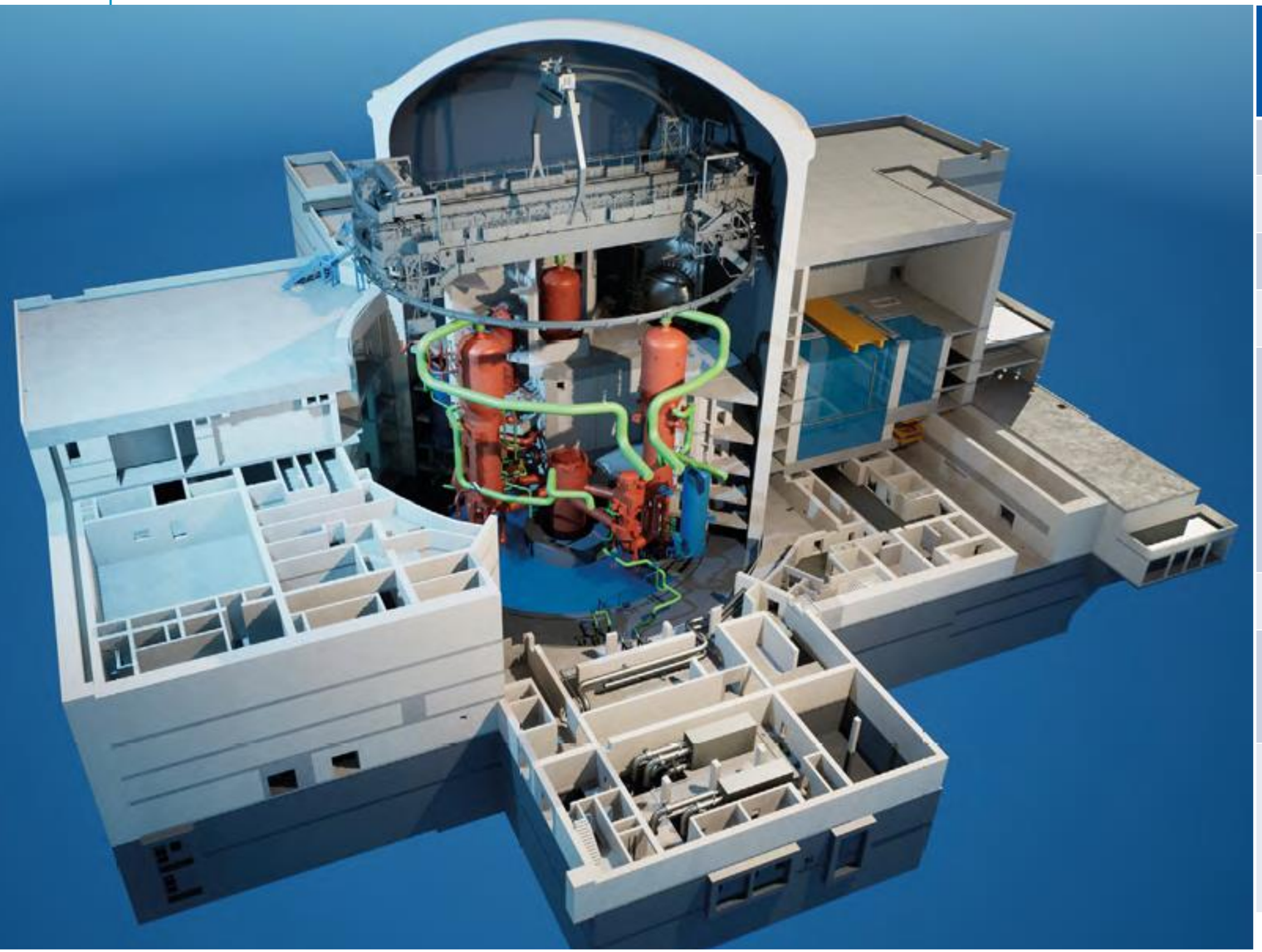
Proven Design

- OPR1000/APR1400 Feedback
- Operating Experience over 85 RY
- Continuous Construction
- International Reviews

Advanced Technology

- Passive Safety Features
- Diverse Design against CCF
- Fully-digitalized MMIS
- Grid-Following Capability

CANDIDATE DESIGNS – EPR 1200



EPR KEY CHARACTERISTICS	
Electrical net output	Up to 1200 MWe
Fuel cycle	18 to 24 months
Availability factor	91 %
Design lifetime	At least 60 years
Fuel	UO2 enriched up to 4.2% Possibility for up to 30% MOX
Fuel assemblies	177 assemblies
Primary coolant system	3 loop configuration
Load follow flexibility	25% to 100% nominal power in 30min

AGREEMENTS WITH STATE – IN PREPARATION
KEY PRINCIPLES AGREED

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Key transaction elements which will govern the rights and obligations of the parties in relation to the Project and, if agreed by the parties, will replace the First Implementing Agreement and the Master Agreement concluded on 28 July 2020 among the State, ČEZ, a. s. (CEZ) and Elektrárna Dukovany II, a. s. (EDU II):

A. Power purchase agreement ("**PPA**") between the Czech Republic represented by the Ministry of Industry and Trade (the "**State**") as off-taker and Dukovany II as supplier;

B. Investor agreement ("**IA**", "**Investor Agreement**") among the State, CEZ and EDU II;

C. Repayable financial assistance ("**RFA**") granted by a decision of the Ministry of Industry and Trade to EDU II.

Notification of State Aid needed (European Commission):

- Prenotification started in August 2020
- Notification started in June 2022
- Notification received 30 April 2024

The PPA, the Investor Agreement and the RFA will be signed/issued on or around the same date and none of them will enter into effect unless and until each of them are signed/issued.

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SMR DEPLOYMENT IN THE CZECH REPUBLIC

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NUCLEAR IN UPDATED STATE ENERGY POLICY

Updated the State Energy Policy (SEP) and National Action Plan of Nuclear Energy (NAP)

- Plan to include construction up to 4 large reactors for electricity generation
- Plan to include SMRs for electricity, heat, and H_2 generation

SMRs are not substitution of large reactors

- Supplementation of energy mix to substitute coal power plants and large central heating plants

Regions are interested to include SMRs in their regional energy policy

- South Bohemian Region (“South Bohemian Nuclear Park”), Moravian-Silesian Region, North Bohemian (Usti and Labem) Region

Objectives

- Operation of SMR ETE in 2034
- Additional units in non-nuclear sites after 2038

CEZ SMR IMPLEMENTATION PROGRAM

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SMR Designs under evaluation

BWRX-300 (USA, 300/870 MWe/MWt), BWR GE Hitachi

Nuward (2 x 170/ 2 x 540 MWe/MWt), PWR

EdF

SMART100 (Korea, 2x107/2x365 MWe/MWt), PWR

KHNP

SMR-160 (USA, 1x160/525 MWe/MWt), PWR

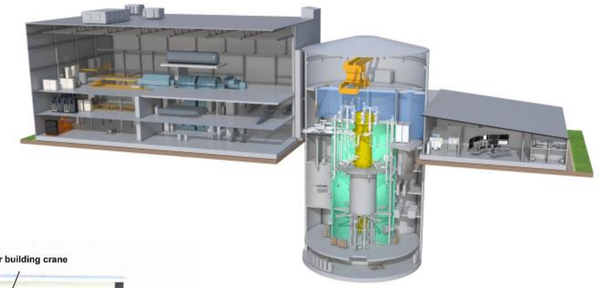
Holtec

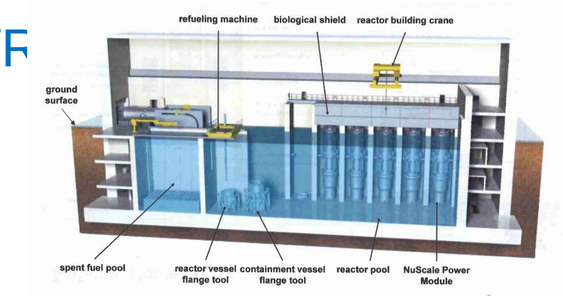
UK SMR (UK, 470/1276 MWe/MWt), PWR

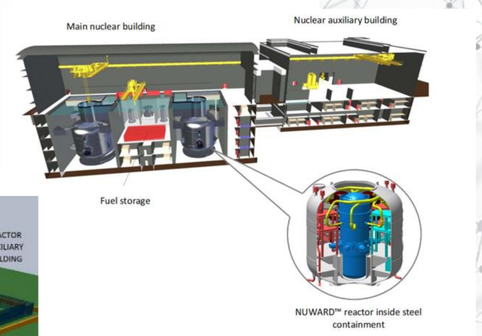
Rolls Royce

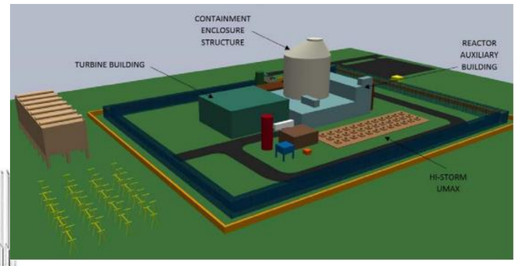
WEC SMR (USA, 1 x 300/900 MWe/MWt), PWR

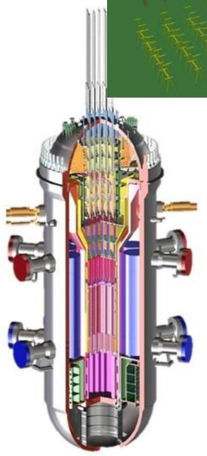
Westinghouse

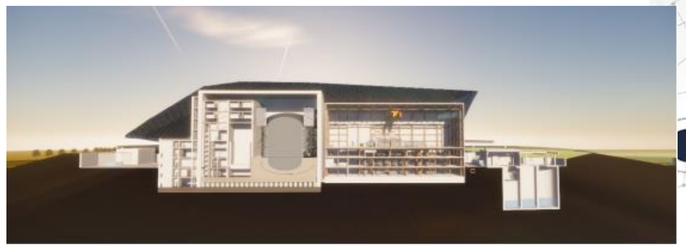












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BASIC TECHNICAL DATA OF PRESELECTED DESIGNS

Parameter	BWRX300	UK SMR	WEC	NUWARD
Type of reactor	BWR	PWR	PWR	iPWR
Reactor in containment	Single	Single	Single	Double
Thermal output [MWt]	870	1276	900	2 x 540
Gross electrical output [MWe]	270-290	470	300	2 x 170
Circulation	Passive	Active	Active	Active
Primary circuit pressure [MPa]	7,2	15,5	15,5	15
Secondary circuit pressure [MPa]	-	7,6	7,1	4,5
Steam generator input T_{in} [°C]	270	296	291	280
Steam generator output T_{out} [°C]	287	327	327	307
Fuel arrangement	UO2/10x10	UO2/17x17	UO2/17x17	UO2/17x17
Enrichment	< 5 %	< 5 %	až 7%	< 5 %
Fuel cycle [months]	12-24	18-24	až 48	24
Safety systems	Passive	Active + Passive	Passive	Passive
Plant lifetime [years]	60	60	100	60
Design basis earthquake	0,3 g	0,3 g	0,3 g	0,25 g
Pressure vessel weight [t]	485	220	240	310

CEZ SMR DEVELOPMENT PROGRAM

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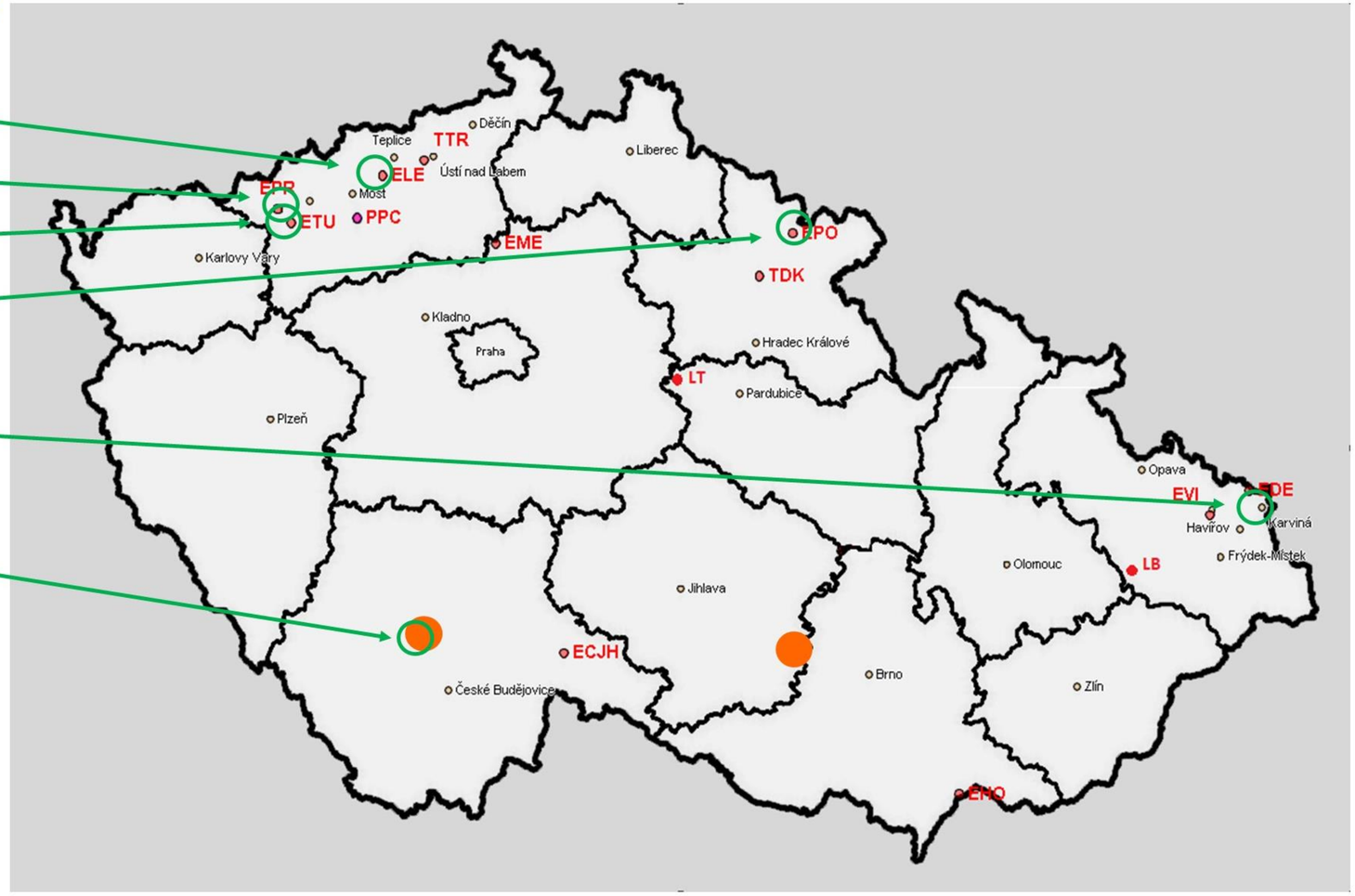
Pre-selected sites for SMRs

- Ledvice
- Prunéřov
- Tušimice
- Poříčí
- Dětmarovice
- Temelin



Current NPPs

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INTENDED SCHEDULE FOR IMPLEMENTATION OF SMR

Advanced planning stage for SMR ETE (up to 500 MWe), and SMR ETU and EDE up to1500 MWe), all deadlines are indicative

Case „1 Unit in Temelin”

Site	Units	Start of operation
Temelín		2034
Tušimice	(+)	2038 + 2040 (TBD)
Dětmarovice	(+)	2044 + 2046 (TBD)
Other sites	(+)	TBD

www.cez.cz

TEMELIN SITE FOR SMR CONSTRUCTION

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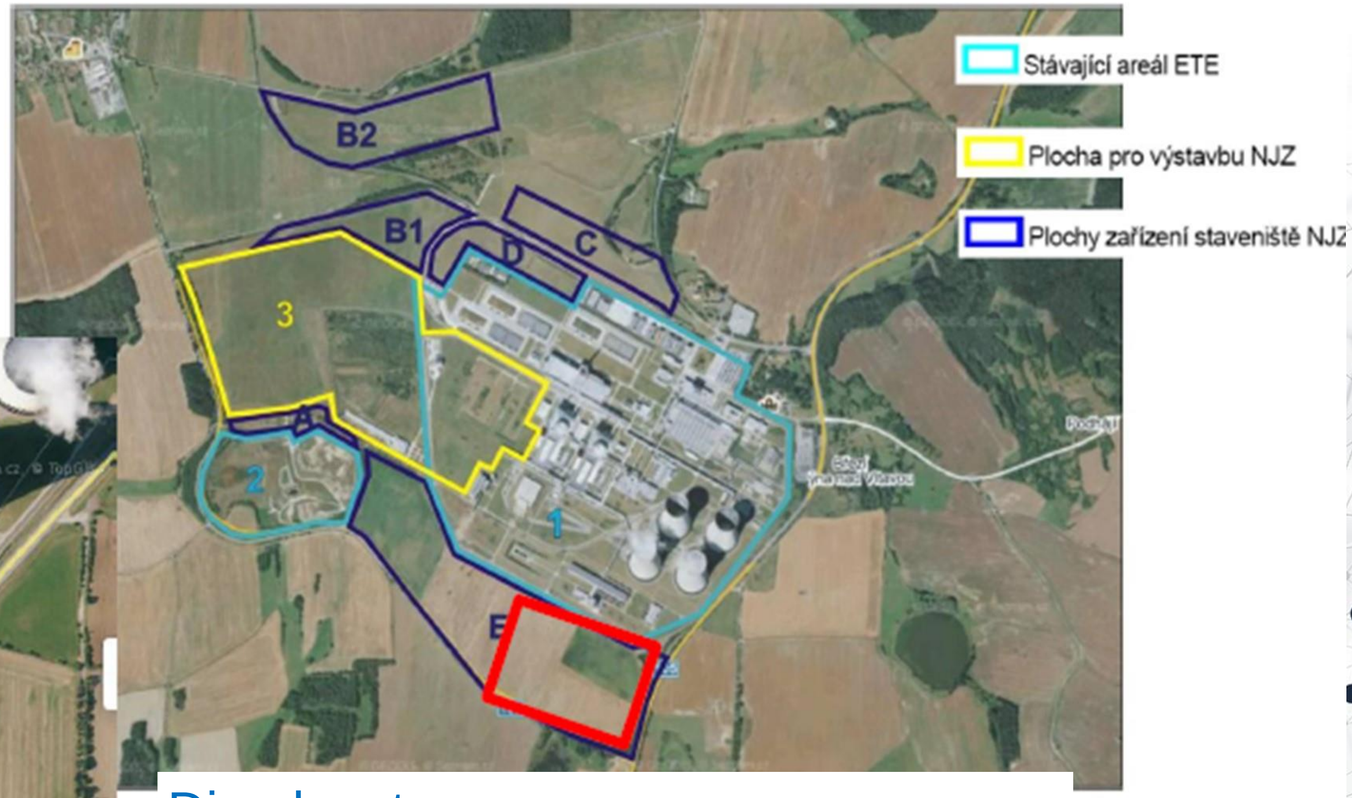
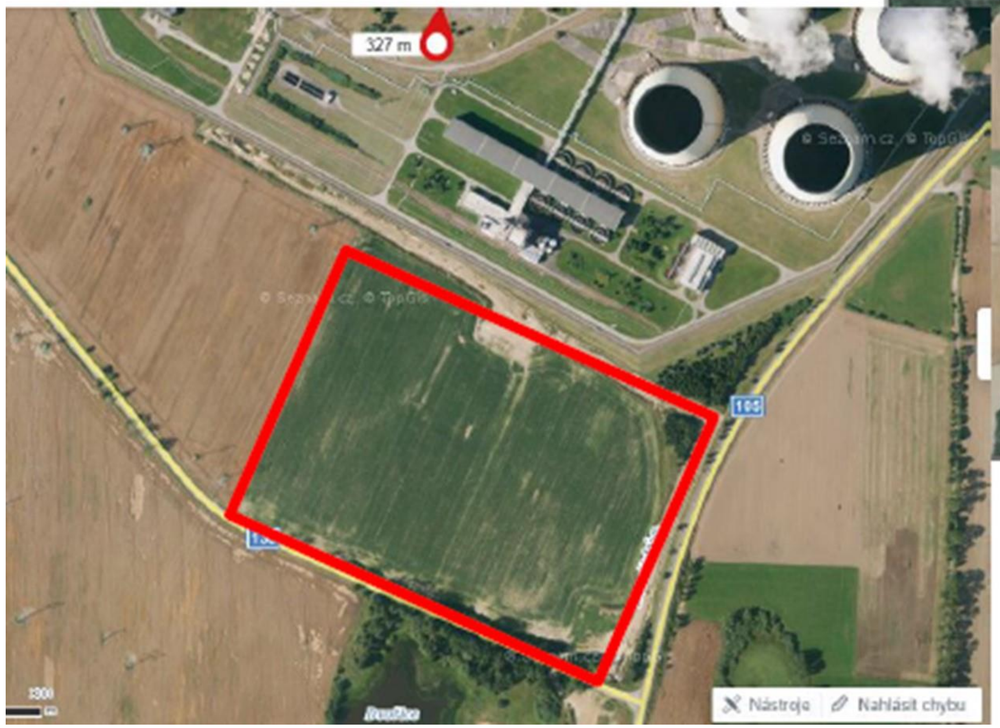
Advantages:

- Close vicinity to existing NPP
- Available area 19 ha
- Convenient geological conditions
- Public support





Disadvantages:

- Potential collision with construction of ETE 3,4
- Limited area

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DEVELOPMENT OF SMR IN THE CZECH REPUBLIC

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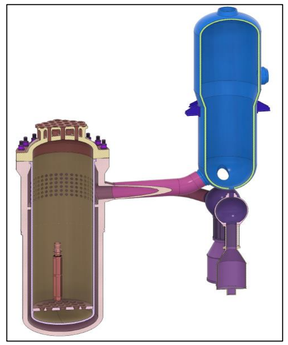
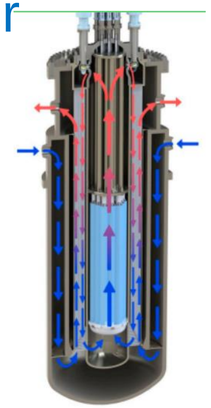
Activities on development of Czech own designs of SMR ongoing

- **PWR projects**
  - DAVID (Witkovitz Group), PWR, 175 MW, vessel-in-vessel ,off-site refueling
  - CR-100 (UJV Group), 100 MWt, SMR based on VVER fuel
- **HWR project**
  - TEPLATOR (West Bohemia University), 200 MW, only heating source, heavy water reactor (use also spent fuel assemblies)
- **Advanced Reactors**
  - Energy Well (CV Rez), 20 MW, cooling by liquid salt, solid fuel
  - ALLEGRO / HeFASTo (V4G4 CoE – UJV Rez + CV Rez), 75 / 200 MW, fast helium cooled reactor



CR-100



DAVID

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DEEP GEOLOGICAL REPOSITORY ROADMAP –NATIONAL POLICY AND GOVERNMENT RESOLUTIONS

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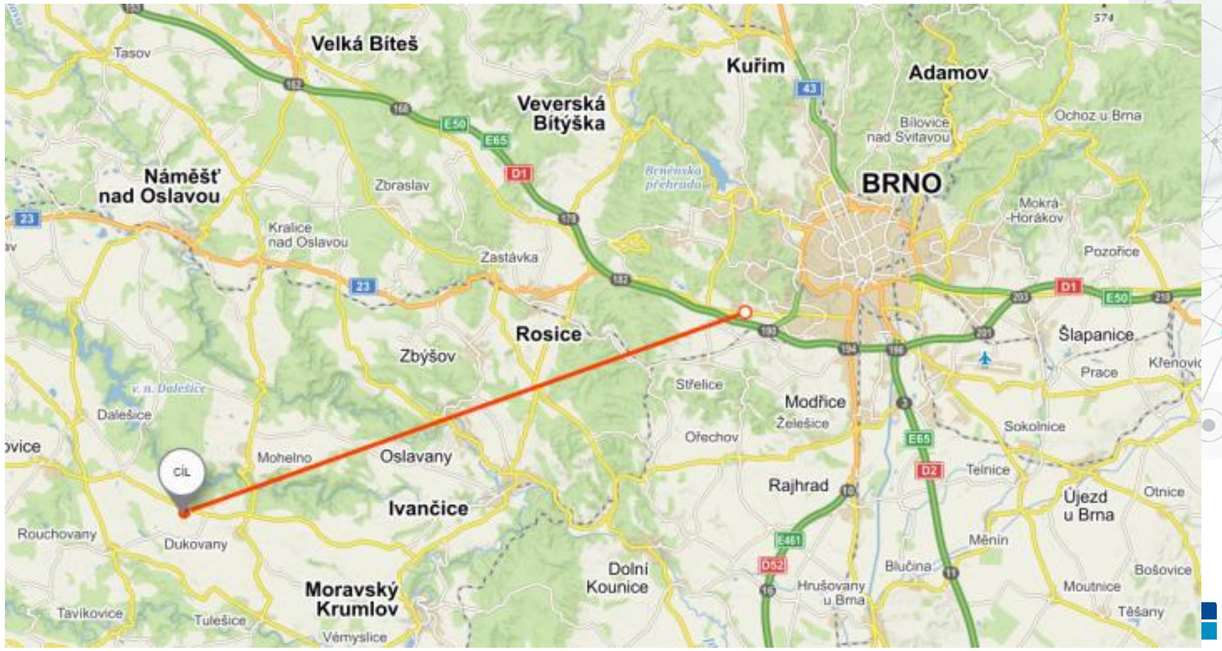
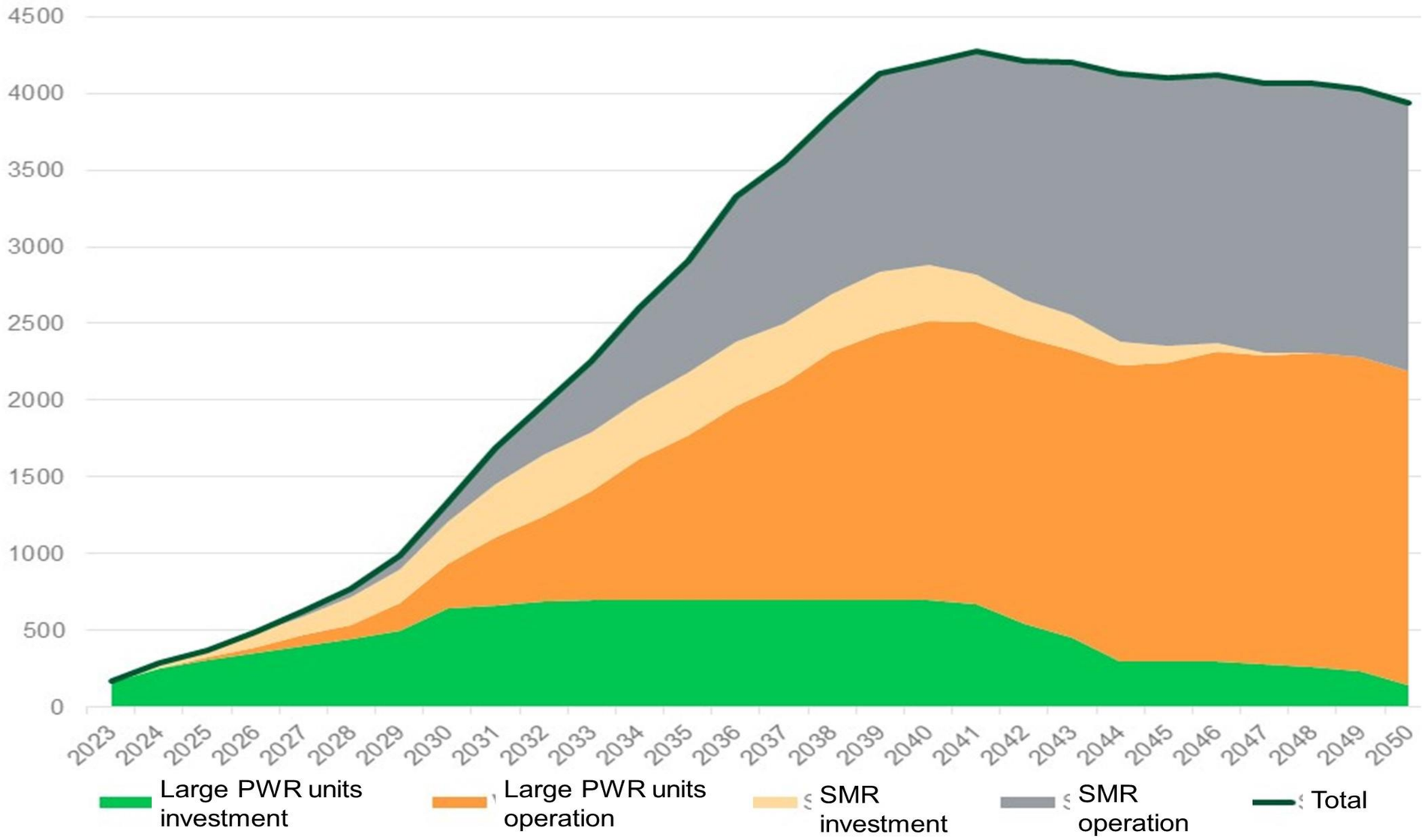
- 4 studied sites,
- Key milestones (National policy, Government Resolutions):
  - 2025+: update of the National Policy
  - 2021-2028: site characterization & site selection (transparent through Advisory Board of Experts of SURAO)
    - ✓ Biological monitoring ongoing+ Geological survey (proposal)
  - 2030+: Site characterization at depth
  - 2040: construction permit
  - EU Taxonomy (proposal by Government): available 2050

NPP DUKOVANY DISTRICT HEATING OF BRNO

- Central heating plants in Brno use natural gas
- The current energy situation led to renewed interest in the possibility of heating from EDU (1st mentioned in 1980s)
- Main engineering works begin in 2024 and the project should be completed by 2030.
- Benefits for climate policy and EDU II political support
- Complicated route (about 40-50 km)



STAFFING FOR NEW NUCLEAR



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SUMMARY

- Nuclear power has essential role in the Czech electricity sector and its role should be further strengthened
- Without nuclear power transition from fossil fuels is not feasible
- The current updated energy concept of the CR envisages roughly half share of nuclear power in electricity production, construction of several large nuclear units are needed
- SMRs have significant potential to complement energy mix mainly due to their multipurpose applications
- SMRs are not considered in CR as a replacement for large units, but complementing the energy mix as a suitable replacement for coal units and for large central heating plants

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THANK YOU FOR YOUR ATTENTION

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