

Kiev Institute of Energy Projects



“Experience of Ukraine in the design, construction and operation of nuclear power plants, in the context of diversification of equipment and service suppliers”

Presented by Yurii Sapozhnykov

INTERNATIONAL NUCLEAR CONFERENCE

“STATE-OF-THE ART SMALL MODULAR REACTORS TECHNOLOGIES AND THEIR PREPAREDNESS FOR THE MARKET OF SOUTHEASTERN EUROPE”

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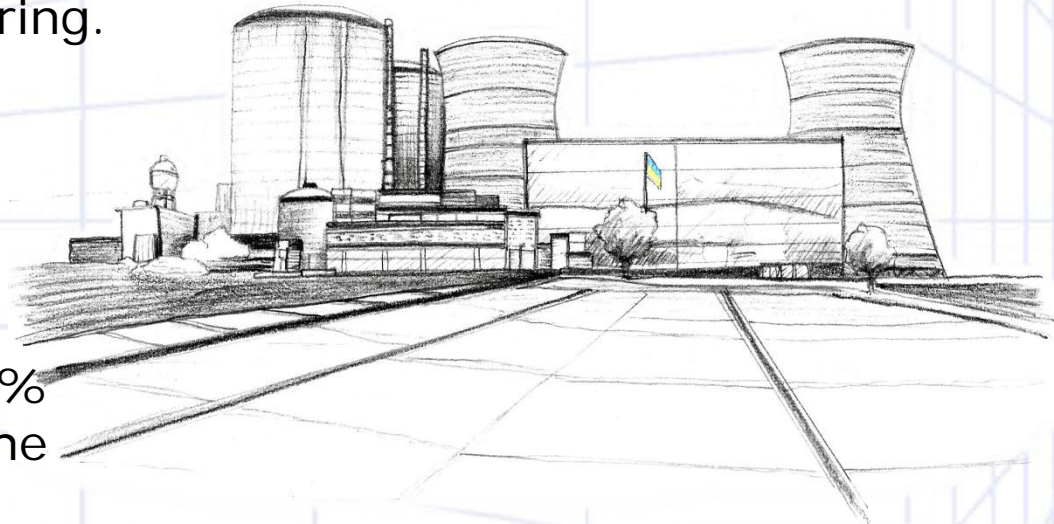
Our Company

Joint-Stock Company “Kyiv Research and Design Institute “Energoprojekt” (KIEP) counts its history since 1933.

Throughout the entire time the KIEP has been occupying a leading position in Ukraine in projects development and implementation in a nuclear field, thermal and renewable energy, and in other branches of industrial and civil engineering.

More than 100 thermal and nuclear power plants have been constructed upon the project of KIEP worldwide.

KIEP is JSC, Ukraine owns 25% of shares, that managed by the Ministry of energy



Joint-Stock Company Kyiv Research and Design Institute «Energoproject»

General information:

Established: 1933

Registered office: Peremohy

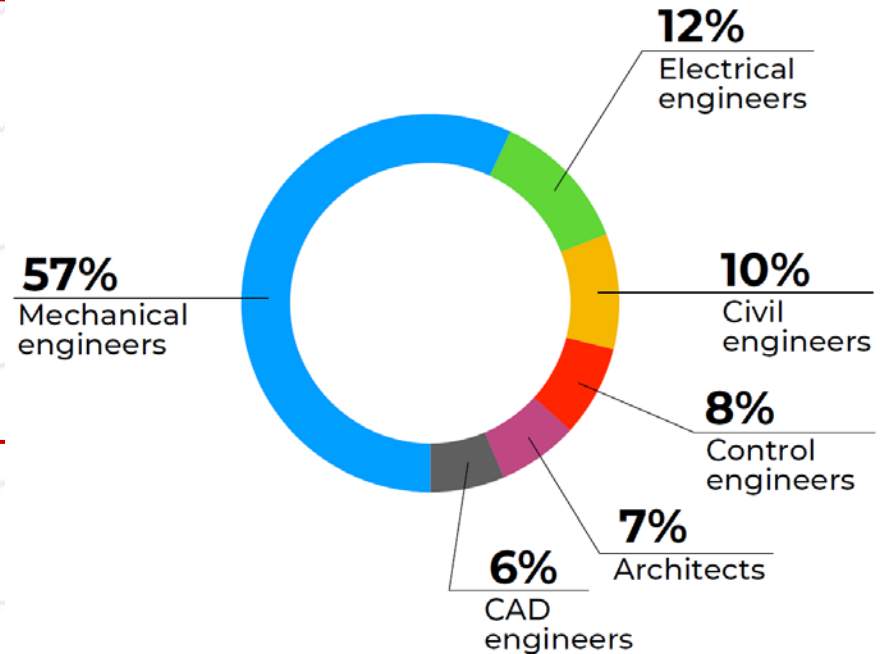
Ave, 4, Kyiv, Ukraine, 01135

Overall staff as of August 1st,
2022: 400 employees

www.kiep.ua

Licenses and certificates:

JSC KIEP holds all necessary licenses and permissions issued by Regulatory Authorities of Ukraine to perform design and engineering activity.



Main Types of Activity

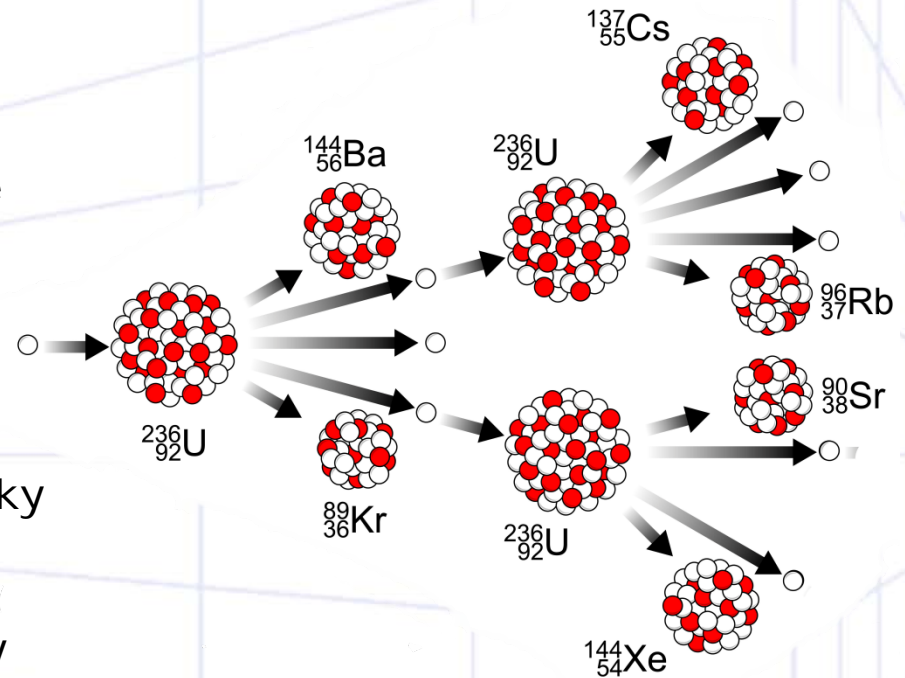
Comprehensive Design at Various Stages of NPP and Nuclear and Radwaste Facilities Design and Engineering support of their Operation:

- Design of NPP from site selection
- Designer supervision at facilities construction
- Develop feasibility studies for investments in power facilities
- Perform feasibility analyses, assessments and forecasts
- Perform Environmental Impact Assessments (EIA)
- Prepare and issue Sanitary Legislation Compliance Reports
 - Perform works associated with power facilities selection and justification
 - Perform Client's Engineer - Employer's engineering consultancy functions







Main activities currently performed by JSC KIEP for NPP's Projects

- Engineering support of current operation of the Ukrainian NPPs
- Development of Feasibility Study for optimization of RAW Management at Ukrainian Nuclear Power Plants
- Design of Ukrainian National Centralized Spent Nuclear Fuel Storage Facility for Rivne NPP, Khmel'nitsky NPP and South-Ukrainian NPP
- Development of Cadastre of a new NPP's site in Ukraine
- Development of feasibility study of construction the units 3,4 of Khmel'nitsky NPP
- Design of the RAW management comprehensive facilities at Khmel'nitsky NPP and Rivne NPP








KIEP has been designing nuclear power facilities for more than 40 years

Main Nuclear Power Plants Designed by KIEP


Country	Name of NPP	Quantity of Units and Capacity (MW)	KIEP Activity
 Hungary	NPP Paks	4x VVER-440 2x VVER-1000 (B-320)	General Designer
 Bulgaria	NPP Belene	2x VVER-1000 (B-320)	General Designer
Bulgaria	NPP Belene	2x VVER-1000 (B-466)	Developer of Design and Detailed documentation of the Turbine Building
 Russia	Balakovo NPP	2xVVER-1000	General Designer
Russia	Kostroma NPP	2xRBMK-1500	Designer of the Turbine Building
Russia	Beloyarsk NPP	1xБН-800 1xБН-1200	Designer of the Turbine Building
Russia	Kalinin NPP	1xVVER-1000	Designer of the Turbine Building
Russia	VVER-TOI	1xVVER-1200	Designer of the Turbine Building
Russia	Siberian Chemical Combine	BREST-OD-300	Developer of the pre-design of Turbine Building
 India	NPP Kudankulam	2x VVER-1000	Developer of Technical specifications for the reactor installation and Technical specifications for NPP Design

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Main Nuclear Power Plants Designed by KIEP

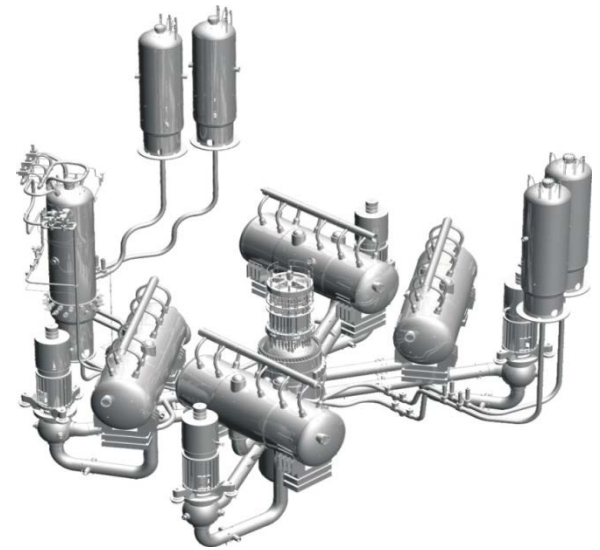
Country	Name of NPP	Quantity of Units and Capacity (MW)	KIEP Activity
 Moldova	Moldovan NPP	4x VVER-1000 (B-320)	Development of the Feasibility Study and NPP site selection
 Lithuania	Ignalina NPP	2xRBMK-1500	Designer of the Turbine Building
 Belarus	Belarusian NPP	2xVVER-1200 (NPP-2006)	Development of the Feasibility Study and NPP site selection
 Vietnam	NPP Ninh Thuan-1	4xVVER-1200 (NPP-2006)	Development of the Feasibility Study and NPP site selection
 Ukraine	Chigirinskaya NPP	4x VVER-1000 (B-320)	General Designer
Ukraine	Rivne NPP	2xVVER-440 2x VVER-1000	General Designer
Ukraine	Khmelnitsky NPP	2xVVER-1000 (B-320) 2xVVER-1000	General Designer
Ukraine	Zaporizhzhya NPP	6xVVER-1000	Responsibly Designer of safety enhancement measures
Ukraine	South-Ukrainian NPP	4xVVER-1000	Responsibly Designer of safety enhancement measures
Ukraine	Chernobyl NPP	3xRBMK-1000	General Designer since 1987. Designer for the NPP decommissioning Project

Design works at Chernobyl exclusion zone

Country	Name of Object	Name of Facility	KIEP Activity
 Ukraine	Chernobyl NPP	Liquid Radwaste Treatment Plant	General Designer
Ukraine	Chernobyl NPP	Industrial Complex for Solid Radwaste Management	Local Designer in partnership with NUKEM, Germany
Ukraine	Chernobyl NPP	Facility for removal of trans-uranium elements and organics from process water and liquid Radwaste	Local Designer in partnership with NUKEM, Germany
Ukraine	Chernobyl NPP	Object "Shelter"	General Designer (operation support, NSC enclosure perimeter)
Ukraine	Chernobyl NPP	New Safe Confinement (NSC)	Main Ukrainian Designer in partnership with consortium NOVARKA, France
Ukraine	Chernobyl NPP	Interim Storage Facility for Spent Nuclear Fuel (ISF-2)	General Designer in partnership with Holtec, USA
Ukraine	Exclusion zone of Chernobyl NPP	Centralized Storage Facility for Spent Nuclear Fuel of Ukrainian NPPs	General Designer in partnership with Holtec, USA
Ukraine	NAEC "Energoatom"	Nuclear Fuel Fabrication Plant	Designer of the facility physical protection
Ukraine	Exclusion zone of Chernobyl NPP	"Vektor" Industrial Complex. Technological Building for Radwaste Treatment	Local Designer in partnership with EMPRESARIOS AGRUPADOS, Spain

Diversification of supplier and canceling monopoly

- In general necessity for diversification of supplier of equipment and services for nuclear industry of Ukraine was initiated directly after country got independence in 1991. As soon as main part of nuclear industry of former Soviet Union had been concentrated in RF, we put a lot of efforts for development of own nuclear infrastructure in amount necessary for design, operation support and maintenance of own nuclear fleet which consists from 15 VVER units with total electric output about 13,88 GW, equal to 55% of national grid consumption



Diversification of supplier and canceling monopoly

Stage 1 (1/1)

As whole diversification process had several main phases with different driving forces:

- **Stage 1** (2000 AC). Construction of construction and commissioning of Khmelnytsky NPP Unit 2 and unit 4 of Rivne NPP. Necessity for diversification was identified after receiving economical proposal from russian companies. Completion of construction had been done using local resources with replacing many non-local companies by native. For example automated processing complex and I&C had been completely designed, manufactured, supplied and commissioned by Ukrainian companies with support of international community. JSC KIEP attended to the project as General Designer of both units
- During this period of time three complex programs for safety enhancement of operating units had been implement for all units

Diversification of supplier and canceling monopoly

Stage 2 (1/4)

- Stage 2 (2014 AC). Russian invasion to the Crimea and East Ukraine.

Political decision of RF led to significant decrease of russian companies in participation in service and supply contracts to Ukraine. Due to the decision of National Security Counsel companies related to rosatom had been included in national sanction list, which required significantly increase the internal capability of national utility SE NAEK “Energoatom” and his local suppliers. Since that time Ukraine successfully performed lifetime extension projects for more than 10 units (see next slide). This stage also included ageing management and assessment of primary circuit and rector vessel including internal structures

Diversification of supplier and canceling monopoly

Stage 2 (2/4)

At stage 2 had been implemented national program “Measures provided by the comprehensive (consolidated) program for improving the safety of power units” it includes:

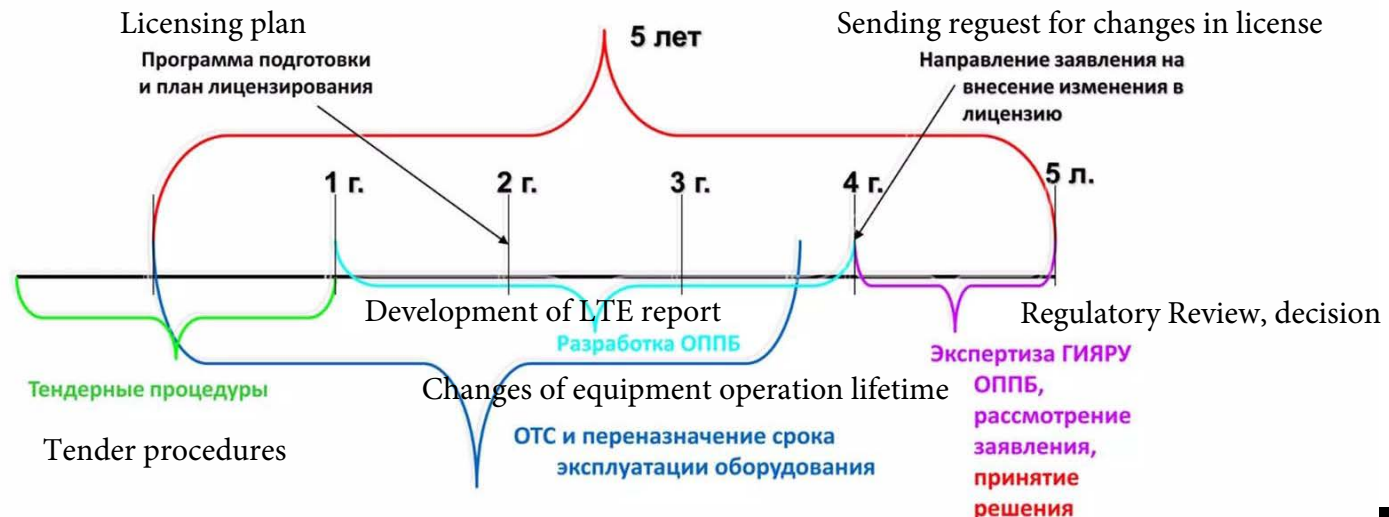
- 1. Measures aimed at increasing the safety of power units with VVER-1000 reactor installations (B-320, B-302, B-338);
- 2. Additional measures aimed at improving the safety of power units with VVER-440 (B-213) reactor installations
- 3. Activities for the preparation of reports on the safety analysis of NPP power units;
- 4. Activities aimed at increasing the operational readiness of NPP power units.
- After the accident at the Fukushima Daiichi NPP, additional measures based on the results of an extraordinary in-depth reassessment of the safety of Ukrainian nuclear power plants ("stress tests") and additional fire safety measures were included in the CSPPB.

Diversification of supplier and canceling monopoly

Stage 2 (3/4)

At stage 2 also had been implemented lifetime extension program:

- lifetime extension program of nuclear power units is a priority direction of the national utility, provided for in the "Energy Strategy of Ukraine for the period until 203"
- Works on extending the operation of power units are carried out according to: "Comprehensive program of works to extend the operating life of existing NPP power units"
- Duration for lifetime extension project is 5 years and scheduled as:



Diversification of supplier and canceling monopoly Stage 2 (4/4)

Current status of lifetime extension in Ukraine

NPP	Unit	Power output, MW	Type of VVER	Commissioning date	End of design lifetime	Lifetime extension, Until
ZNPP	1	1000	B-320	10.12.1984	23.12.2015	23.12.2025
	2	1000	B-320	22.07.1985	19.02.2016	19.02.2026
	3	1000	B-320	10.12.1986	05.03.2017	05.03.2027
	4	1000	B-320	18.12.1987	04.04.2018	04.04.2028
	5	1000	B-320	14.08.1989	27.05.2020	27.05.2020
	6	1000	B-320	19.10.1995	21.10.2026	
SUNPP	1	1000	B-302	31.12.1982	02.12.2013	02.12.2023
	2	1000	B-338	09.01.1985	12.05.2015	31.12.2025
	3	1000	B-320	20.09.1989	10.02.2020	10.02.2030
RNPP	1	420	B-213	22.12.1980	22.12.2010	22.12.2030
	2	415	B-213	22.12.1981	22.12.2011	22.12.2031
	3	1000	B-320	21.12.1986	11.12.2017	11.12.2037
	4	1000	B-320	10.10.2004	07.06.2035	
KhNPP	1	1000	B-320	22.12.1987	13.12.2018	13.12.2028
	2	1000	B-320	07.08.2004	07.09.2035	

Diversification of supplier and canceling monopoly Stage 3 (1/1)

- **Stage 3** (2022 AC). Full scale russian aggression against Ukraine. It completely interrupt all possible connection with russian companies or international companies affiliated to russian stockholders. At present, it is clear that we have no choice and it is necessary to completely replace all equipment which might have unique supplier affiliated to RF. Implementation of this phase cannot be possible if we are going to continue usage of russian fuel assemblies. Fortunately, country was completely ready for replacement of supplier of fuel assemblies and this can be represented as example of persistent and fruitful international cooperation between US Government and Westinghouse from one side and Ukrainian Government and SE NAEK “Energoatom” from other side. Details provided in description of last stage.

Diversification of nuclear fuel supply

Stage 4 (1/3)

- **Stage 4 (1996 - 2022 AC).** Complete replacement of russian fuel assemblies

1996	US Department of Energy (DOE) and the Ministry of energy of Ukraine on the basis of Intergovernmental agreement in the field atomic Energy experts approved the draft qualification nuclear fuel for Ukraine
1998	Power unit No. 3 of the South Ukrainian NPP was chosen as a pilot project for planned loading with American fuel, as logistics became an objective and important component in the selection of a nuclear power plant
2000	The Center for the Design of Active Zones was established at the Scientific and Technical Complex "Nuclear Fuel Cycle" of the National Scientific Center "Kharkiv Physical and Technical Institute" for scientific and technical support of the Westinghouse company in the development of fuel rods and assemblies for reactors of the VVER-1000 type installed on NPP of Ukraine
2005	For the first time, Ukrainian nuclear workers loaded six Westinghouse-produced TVZs at the South-Ukrainian NPP
2006-2008	Plans introduction of nuclear fuel at NPPs of Ukraine new ones modifications , in particular TVZA-12 and TVZ- WR , for the first time declared by the document " Energy strategy of Ukraine on from 1 to 2030" (CMU Resolution No. 436-p dated 27.07.06), Decree of the President of Ukraine No. 156/2008
2008	NAEK " Energoatom " and Westinghouse concluded the first commercial contract for supply nuclear fuel in 2011-2015
2010	42 FA manufactured by Westinghouse were loaded at the third power unit of the South-Ukrainian NPP

Diversification of nuclear fuel supply

Stage 4 (2/3)

- **Stage 4 (1996 - 2022 AC).** Complete replacement of russian fuel assemblies

2011	84 Westinghouse-produced FA were loaded at the second and third power units of the South-Ukrainian NPP
2012	Have arisen difficulties testing American nuclear fuel through it approval in mixed zone from TVZ produced in the Russian Federation
2014	The beginning of the aggression of the Russian Federation. State inspection nuclear regulation of Ukraine approved modified nuclear fuel Westinghouse for further use on a larger quantity nuclear power plants . The contract between NAEK " Energoatom " and company Westinghouse for the supply of nuclear fuel for Ukrainian nuclear power plants until 2020, according to which fuel collections will be loaded on two power units of the South-Ukrainian NPP and one unit of the Zaporizhzhia NPP
2018	Power unit No. 3 of the South -Ukrainian NPP is operating exclusively on TVZ production Westinghouse is signed Addition dated 27.01.2018 No. 22 to the contract between by the company Westinghouse and SE "NAEK " Energoatom ", which provided for supply of TVZ- WR for the period until 2025
2019	Power Unit No. 5 of the Zaporizhzhya NPP became the second power unit in Ukraine that operates exclusively on nuclear fuel from the American company Westinghouse Ukraine the only one in the world country, which succeeded realize nuclear fuel diversification project for VVER - 1000 type reactors

Diversification of nuclear fuel supply

Stage 4 (3/3)

- **Stage 4 (1996 - 2022 AC).** Complete replacement of russian fuel assemblies

2020	<p>In the period from 2014 to 2019 , 24 batches of 42 production FAs were delivered Westinghouse for power units South Ukrainian and Zaporizhzhya NPPs</p> <p>In 2020, it is planned to supply six batches of FA manufactured by Westinghouse (four batches – for the Zaporizhzhia NPP, two – for the South-Ukrainian NPP)</p>
2020	<p>An agreement was signed between NAEK " Energoatom " and the company Westinghouse on the supply of nuclear fuel for reactors of the VVER-440 type of the Rivne NPP. Supply of FA for VVER-440 is planned in 2024</p>
2021	<p>The goal of diversifying the supply of fuel assemblies for operating reactors has been achieved in accordance with the energy development strategy of Ukraine until 2035, which provides for the availability of an alternative supplier with a share of at least 40%</p>
2022	<p>After the start of a full-scale aggression against Ukraine, the government of Ukraine decided to completely exclude the supply of FA from companies of the Rosatom corporation , and all power units of operating nuclear power plants should be transferred to the operation of FA produced by Westinghouse</p>

Future of nuclear energy in Ukraine

- Actual Strategy of development of energy sector in Ukraine assume that percentage of nuclear energy in total energy mix will not decrease in the future
- This means that we need to ensure lifetime extension for operating nuclear units at least to 60 years
- Completion of construction of Khmelnytsky NPP Units 3,4 is the main priority taking into account existing level of construction readiness. The main trouble in this regard is absence of nuclear island equipment. Currently Ukraine is seeking for possible options of supply the equipment of nuclear island for VVER-1000 reactor units
- SE NAEK “Energoatom” signed memorandum for construction from five to nine power units AP-1000 designed by Westinghouse Electric. At the present process postponed due to military aggression
- SMR also considered as options, especially for purposes different from electricity generation. Moreover 1980-s our company has experience for design of NPP units with capacity 200 MWe to provide district heating in

Kyiv and Odessa

Experience in the field of small modular reactors

- Starting from 2021, KIEP is a **partner of the FIRST program - Foundational Infrastructure for Responsible Use of Small Modular Reactor Technology for Ukraine** - capacity-building program designed by U.S. DEPARTMENT of STATE to deepen strategic ties, support energy innovation, and advance technical collaboration with partner nations on secure and safe nuclear energy infrastructure. Such cooperation includes supporting the deployment of advanced nuclear technologies, including small modular reactors (SMRs), in a manner consistent with the International Atomic Energy Agency's Milestones Approach for implementing a responsible nuclear power program

During this time many proposals concerning SMR offered by KIEP have been successfully approved. Among them are projects related to:

- Selection of SMR technology useful for UA
- site selection for SMR development
- Examining SMR possibilities for district heating
- safety and security problems considering





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