Co-generation and Desalination Options: Experience of Russian Organizations' Assistance in Creation of Nuclear Engineering and Infrastructure

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АТОМСТРОЙЭКСПОРТ

Nuclear Power Middle East & North Africa 2010

VIENNA, september 28-29

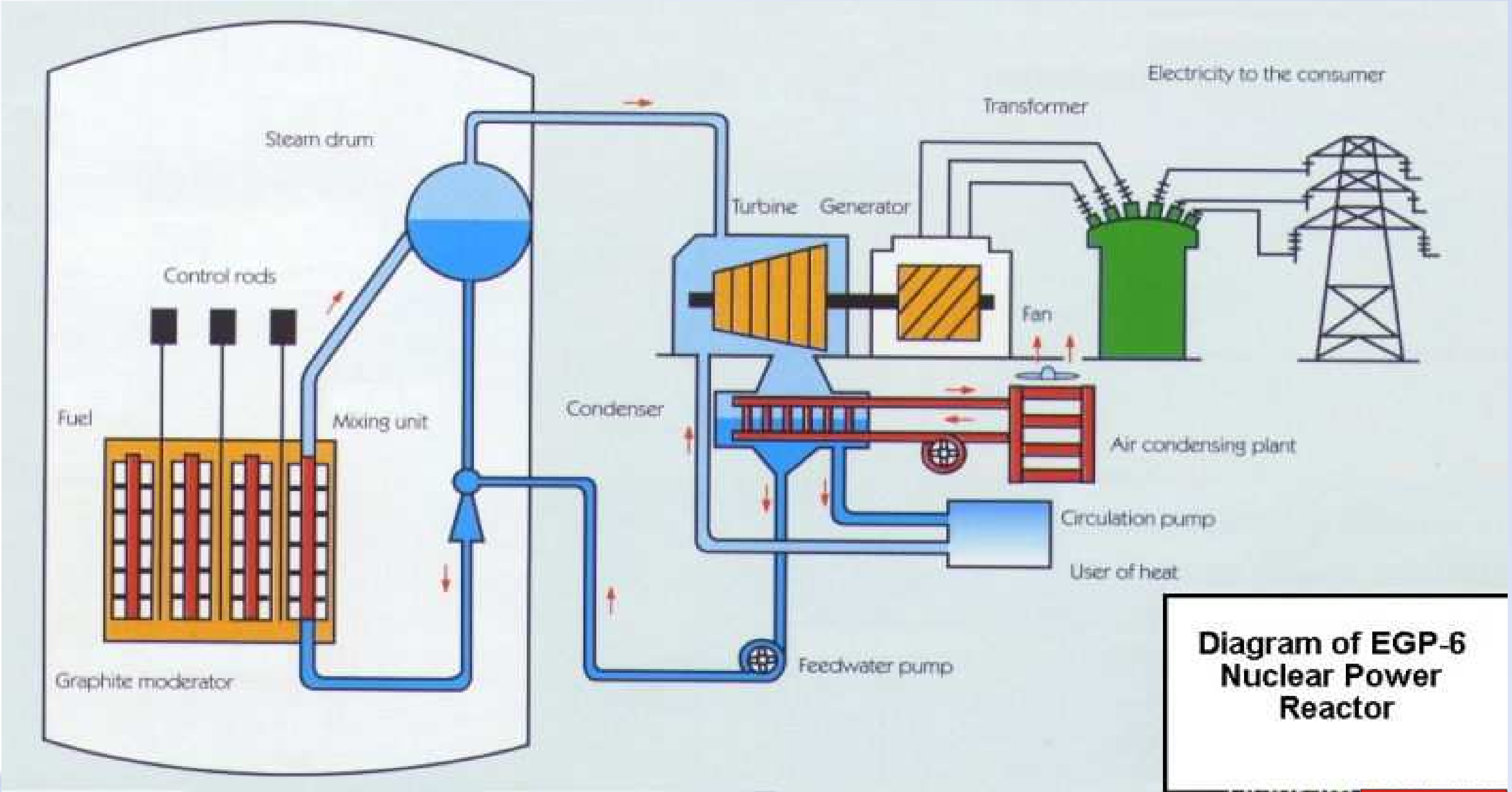
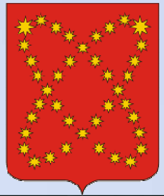


Diagram of EGP-6 Nuclear Power Reactor

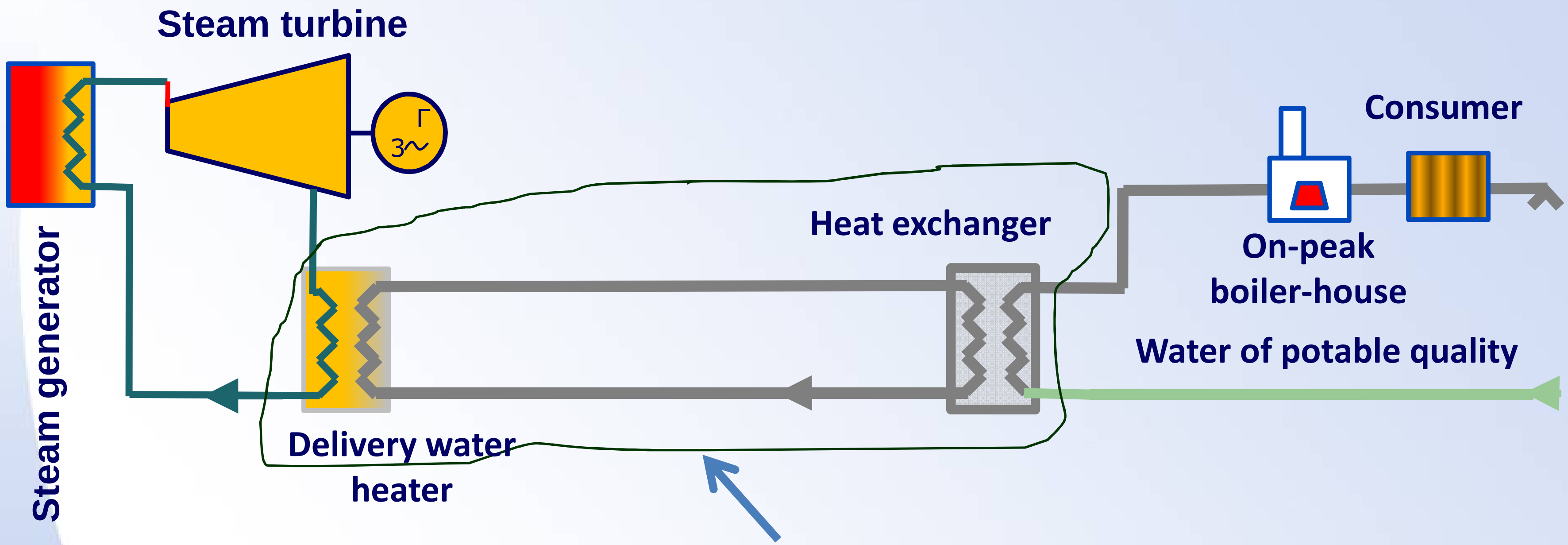
All NPPs are potentially co-generative



- **Bilibino nuclear thermal power plant (NTPP) at Chukotka, near the city of Anadyr, was commissioned in 1976**
- **NTPP includes 4 reactors, everyone with thermal capacity of 29 MW and electric capacity of 12 MW**

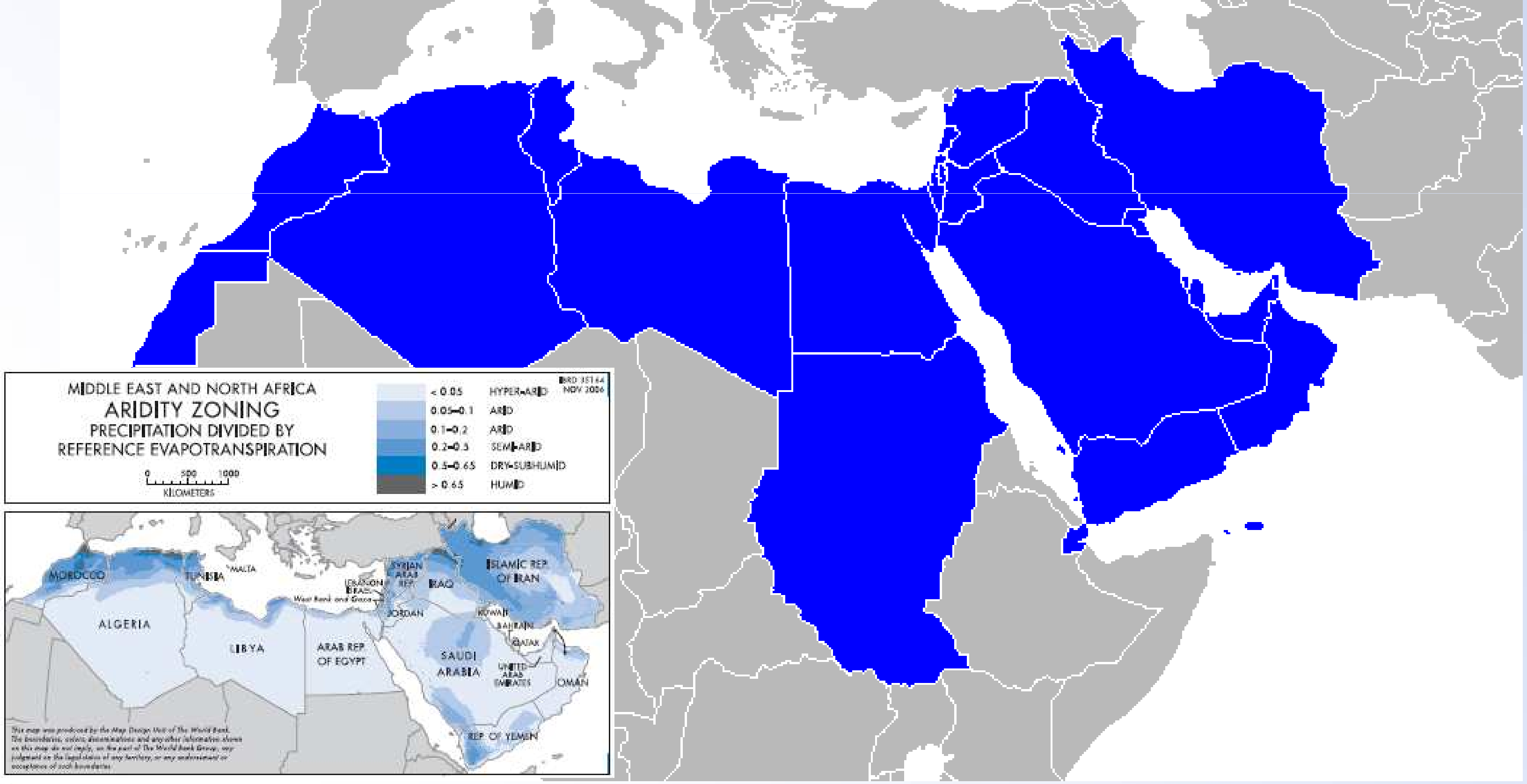
- **Unique in every respect: geographic location, design and applicability**
- **Supplies with electricity and heat an adjoining industrial complex and residential houses of Bilibino**

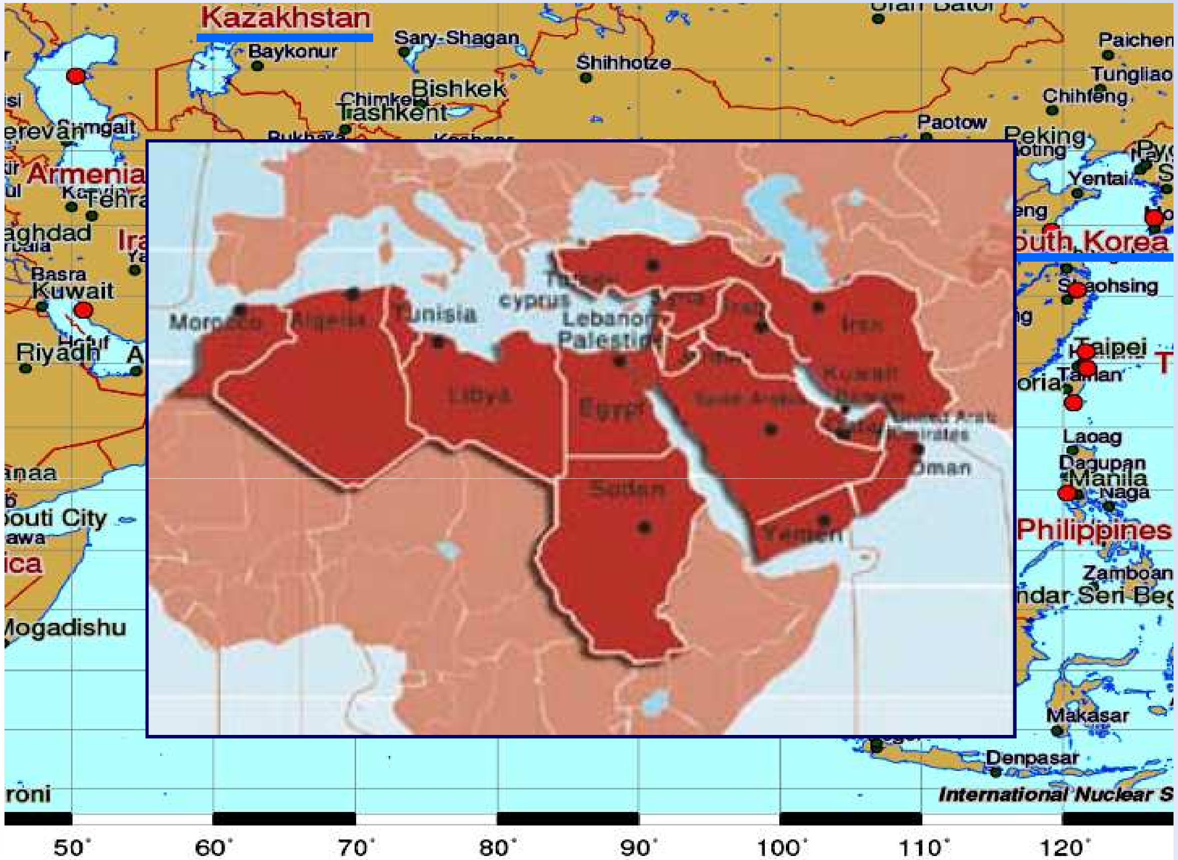
Technical option of a heat supply of city of St. Petersburg with use of hot water of NPP LENINGRAD-2



Contour 30 km
Consumption 11300 t / h
Head 220 m
Pump capacity 8 MW

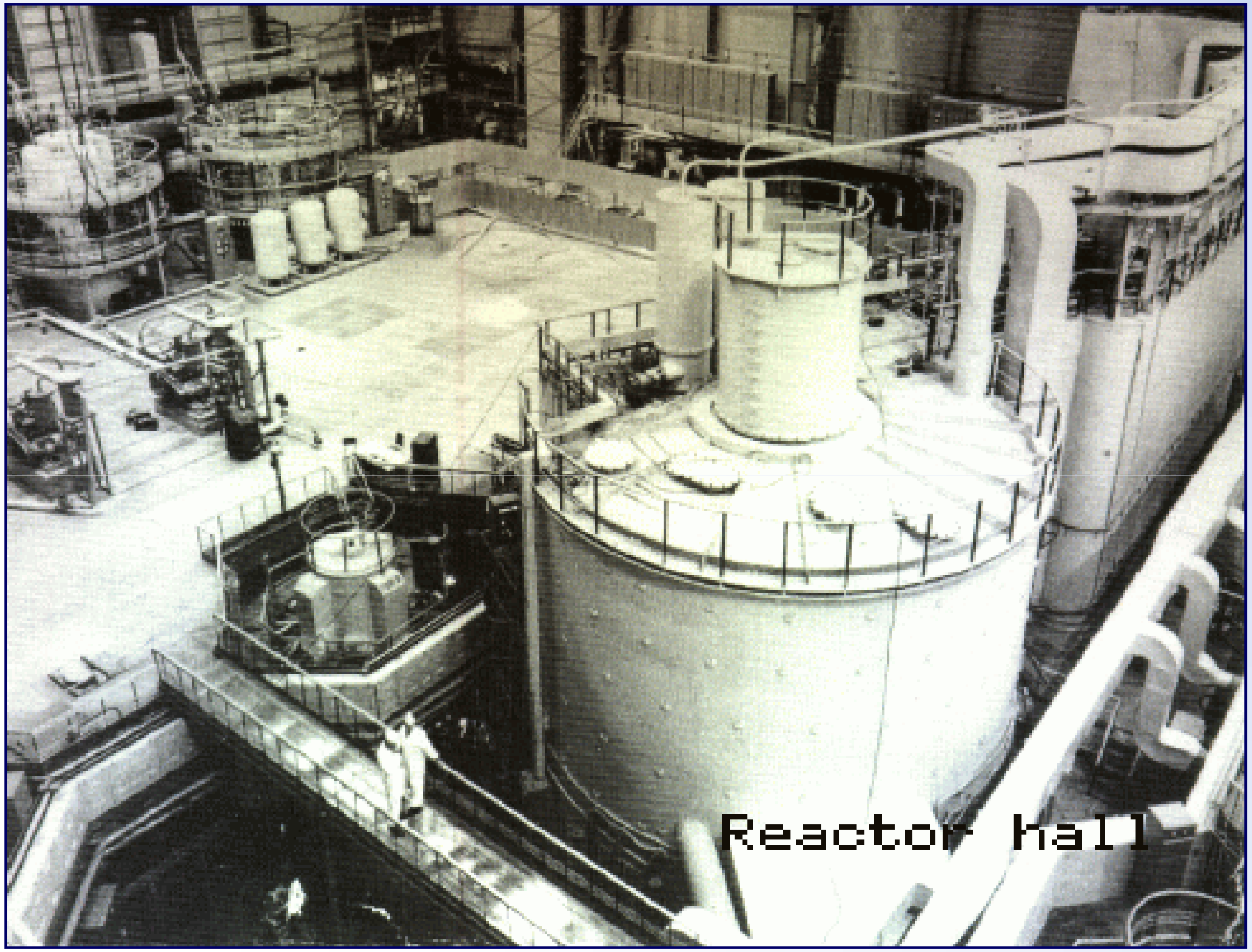
In regions with a hot droughty climate with an increasing deficiency of the fresh water, menacing to sustainable economic development, **co-generation** could be applied in the mode of **nuclear desalination**



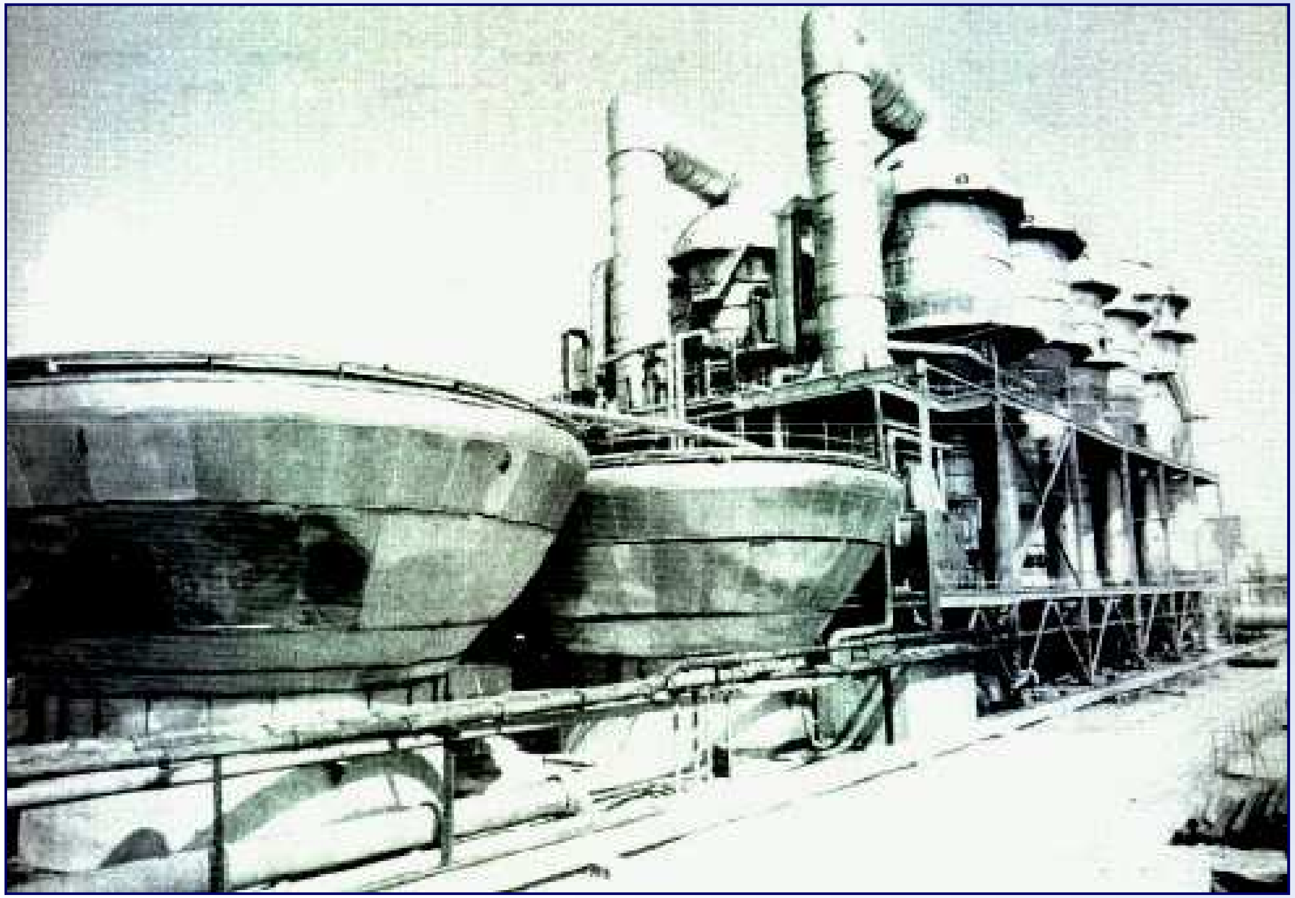


Nuclear desalination will be attractive if two conditions are satisfied simultaneously

- **Lack of fresh water**
- **Ability to use nuclear power**

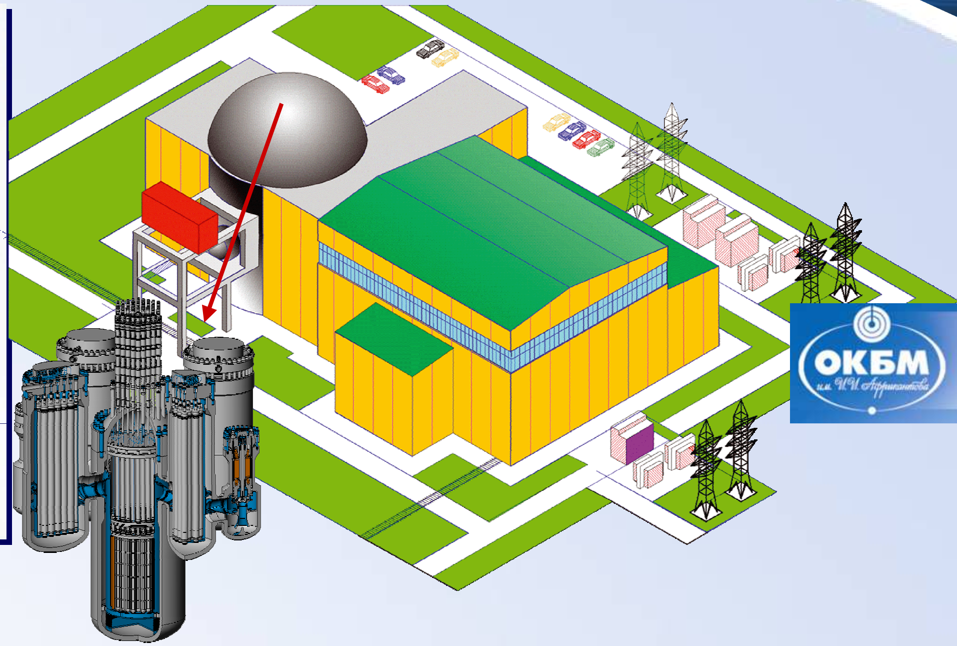


THE NUCLEAR POWER COMPLEX WITH SODIUM-COOLED FAST BREEDER REACTOR BN-350 OF 350 MW INSTALLED CAPACITY USED FOR PRODUCING ELECTRICITY, STEAM AND FRESH WATER



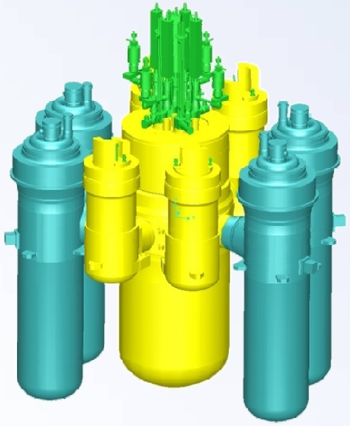
THE COMPLEX, EQUIPPED WITH DISTILLATORY DESALINATION PLANTS COULD SUPPLY FRESH WATER FOR CITY SHEVCHENKO (AKTAU) IN VOLUME UP TO 120 000 M^3/DAY

MAEC STILL REMAINS UNSURPASSED IN SCALE USE OF NUCLEAR ENERGY TO PRODUCE POTABLE WATER

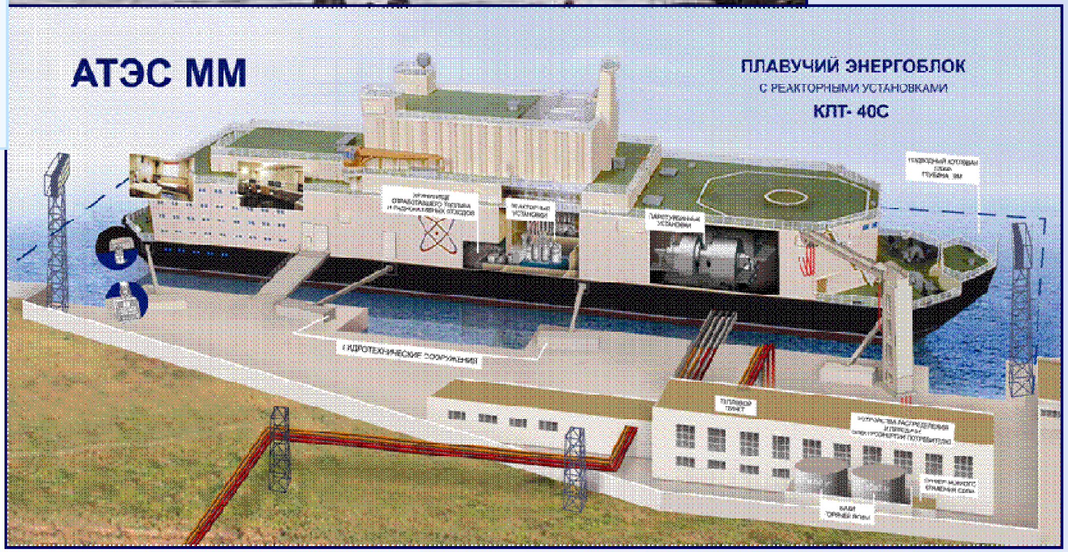


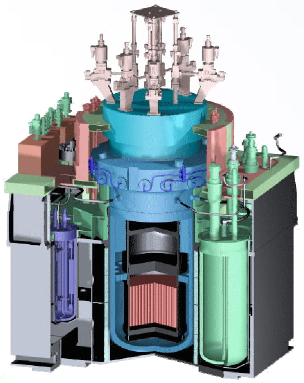
KAZAKH-RUSSIAN COMPANY ATOMIC STATIONS JSC

- **DEVELOPS A NEW PROJECT OF NUCLEAR POWER PLANT WITH REACTORS VBER-300, DESIGNED BY OKBM AFRIKANTOV JSC**
- **LIKE KLT-40S REACTOR, IT IS CONSIDERED AS ONE OF THE MAIN PRIMARY ENERGY SOURCES FOR FUTURE CO-GENERATIVE NPP**



MODERN RUSSIAN PROJECTS OF FLOATING NUCLEAR POWER PLANTS BASED ON LOW-POWER REACTORS KLT-40S, AND ABV-6



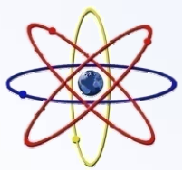


NUCLEAR POWER REQUIRES ESPECIALLY CAREFUL

- **PLANNING,**
- **PREPARATION,**
- **TIMELY INVESTMENT & HUMAN RESOURCES**
- **POSSESSION AND HANDLING OF NUCLEAR MATERIALS**

MEETING THESE REQUIREMENTS DEMANDS SUSTAINABLE NATIONAL INFRASTRUCTURE

THE CREATION AND SUBSEQUENT DEVELOPMENT OF NATIONAL INFRASTRUCTURE IS THE MAIN TASK FOR COUNTRIES EMBARKING ON NUCLEAR POWER



THE REGION OF EAST EUROPE IN THE MID 50-IES OF XXth CENTURY

1956 - FIRST AGREEMENTS ON TECHNICAL ASSISTANCE OF SOVIET UNION IN A CONSTRUCTION OF PILOT (experimental-industrial) NUCLEAR POWER PLANTS

NPP Rheinsberg

NPP Bohunice-A1

DIRECTIONS OF INTERNATIONAL COOPERATION :

- establishment of research-and-development centers
- construction of production facilities
- construction of pilot nuclear power plants
- scientific and technological experience exchange
- foundation of Joint Institute for Nuclear Research as a ground for teamwork of Soviet/Russian and foreign experts
- nuclear personnel training

1975 - THE OBJECTS CONSTRUCTED WITH THE SOVIET/RUSSIAN ORGANIZATIONS' ASSISTANCE:

IN TOTAL

9 research reactors with capacity ranging from 2MW to 10MW, including

- **6 water-cooled water-moderated reactors,**
- **2 pool type reactors with ordinary water**
- **1 with heavy water**

6 cyclotrons with energy up to 25 MeV

7 radiochemical

7 physical laboratories

The next phase of international cooperation – the Soviet/Russian organizations provided technical assistance in the construction of nuclear power plants

- **Multilateral cooperation within the framework of COMECON has risen on higher level**
- **In 1973 international economic association "INTERATOMENERGO" with the participation of Bulgaria, Hungary, East Germany, Poland, Romania, USSR and Yugoslavia was created in the framework of COMECON**
- **Agreement on multilateral international specialization, co-operation and mutual supplies of equipment for nuclear power plants was signed in June 1979**
- **In 1987 Cuba joined the agreement**

THE SPECIALIZATION OF COUNTRIES-MEMBERS OF AGREEMENT

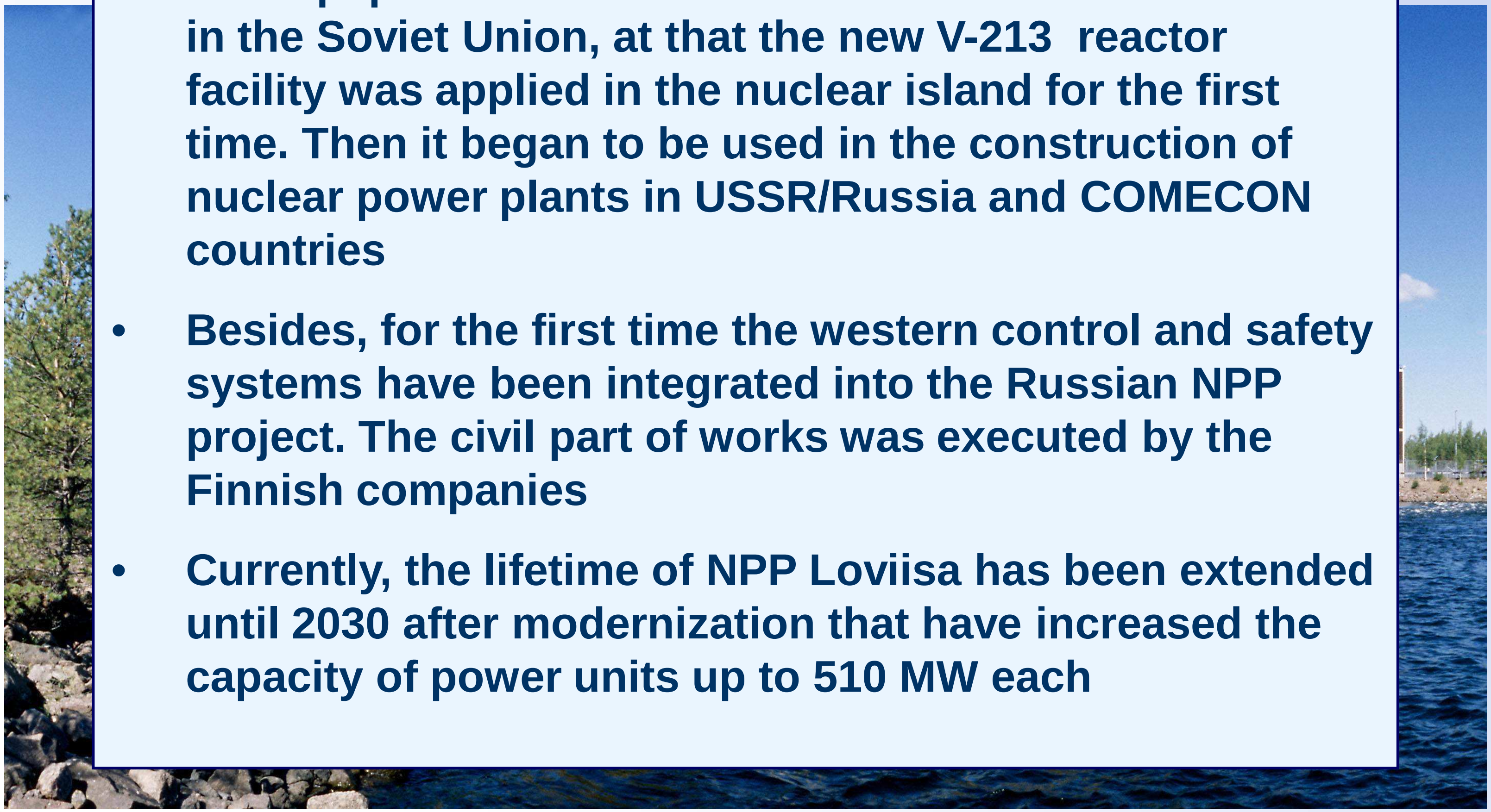
- By the end of 1978, the total capacity of nuclear power plants in Bulgaria, Czechoslovakia, East Germany and the USSR amounted to 11,870 MW. In five years it has grown almost in 2 times
- In 80-ies of XXth century a nuclear power in COMECON countries became self-dependent and confidently developing energy production industry

EDUCATION AND TRAINING OF EXPERTS

- **1971 – 1984. Over 5000 professionals for the nuclear power industry of COMECON countries have been trained in the USSR**

- **Many of them worked in positions of leadership of under construction or operated nuclear power plants, in the leadership of the committees and ministries of their countries**

NPP LOVIISA IN FINLAND - NEW APPROACHES TO COOPERATION



- The equipment of nuclear and turbine islands was made in the Soviet Union, at that the new V-213 reactor facility was applied in the nuclear island for the first time. Then it began to be used in the construction of nuclear power plants in USSR/Russia and COMECON countries
- Besides, for the first time the western control and safety systems have been integrated into the Russian NPP project. The civil part of works was executed by the Finnish companies
- Currently, the lifetime of NPP Loviisa has been extended until 2030 after modernization that have increased the capacity of power units up to 510 MW each

NPP TIANWAN - THE CONSTRUCTION IN THE POST-SOVIET PERIOD

- **The continued cooperation of the Russian organizations with the Finnish company Fortum OY - the owner of NPP Loviisa, bore fruits in the form of AES 91 (91/99) project**
- **This project was proposed for construction of a new power unit at Olkiluoto site in Finland and implemented with some changes at Tianwan site in China**

INFRASTRUCTURE DEVELOPMENT IN SURROUNDING REGION

Implementation of the first stage of NPP Tianwan project has given

a stimulus for the development of transport and communications,

the creation of new jobs and new educational institution, increasing standards of living in the surrounding region

The importance of the region across the country has increased

The nearby small fishing town of Lianyungang turned into a fashionable megapolis

31 VVER NUCLEAR POWER UNITS IN 7 COUNTRIES
12 NUCLEAR RESEARCH CENTERS IN 12 COUNTRIES

More than 50 years Russian experience of

successful international cooperation

shows that

attention to all issues of infrastructure,

from the earliest phase of construction of nuclear power plants,

promotes to resolving many problems in the future and

significantly affects the successful introduction of nuclear power

Atomstroyexport JSC Today

- **Exclusive distributor of Russian nuclear technologies and services on the world market since 1998**



Atomstroyexport JSC Today

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- **Modern EPC/EPCM-company with more than 1300 employees**



Atomstroyexport JSC Today

- **Subordinate to State Atomic Energy Corporation ROSATOM**



Our Partners

Our Partners

Considerable cooperation with the leading Russian and foreign companies in the field of engineering, machine-building, construction and electricity sales, with the maximum possible involvement of local companies

Our Projects

JSC ASE performs contracts as General supplier for construction of 5 nuclear power units worldwide – in India, Iran and Bulgaria

2 units VVER-1000
Under construction

1 VVER-1000
Under construction

2 VVER-1000
Under construction
Commissioning in 2010/11

First NPP in Turkey

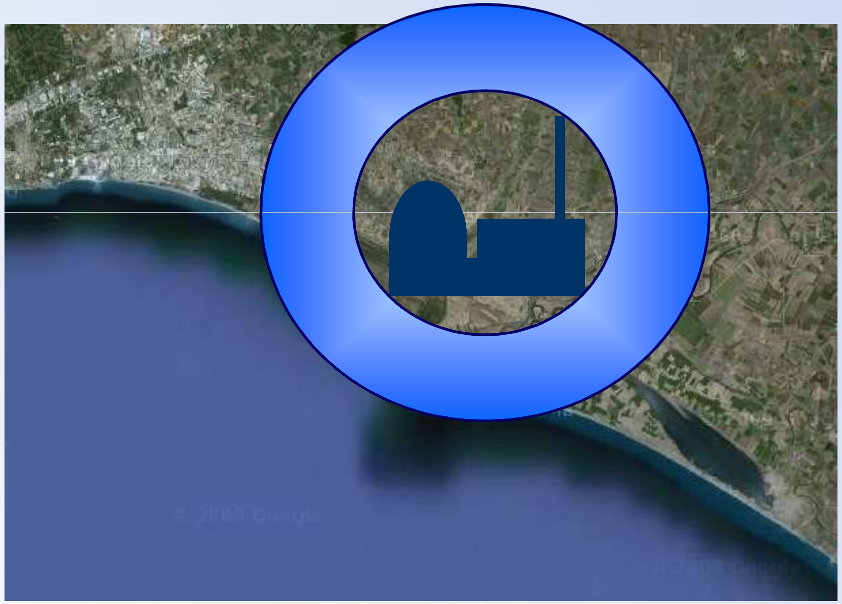
- **In 2007 the Turkish Government made a strategic decision on diversification of the country's electric-power industry and on development of nuclear generation (NPP at Akkuyu site in Antalya and in Sinop on the Black Sea)**

First NPP in Turkey

- **In March 2008 there was invited the bid on construction of Turkey's first nuclear power plant at the Akkuyu site at “Build-Own-Operate” model**

First NPP in Turkey

- **The Russian-Turkish Intergovernmental agreement on cooperation in relation to the construction and operation of a Nuclear Power Plant at the AKKUYU site in the Republic of Turkey was signed in May 2010**



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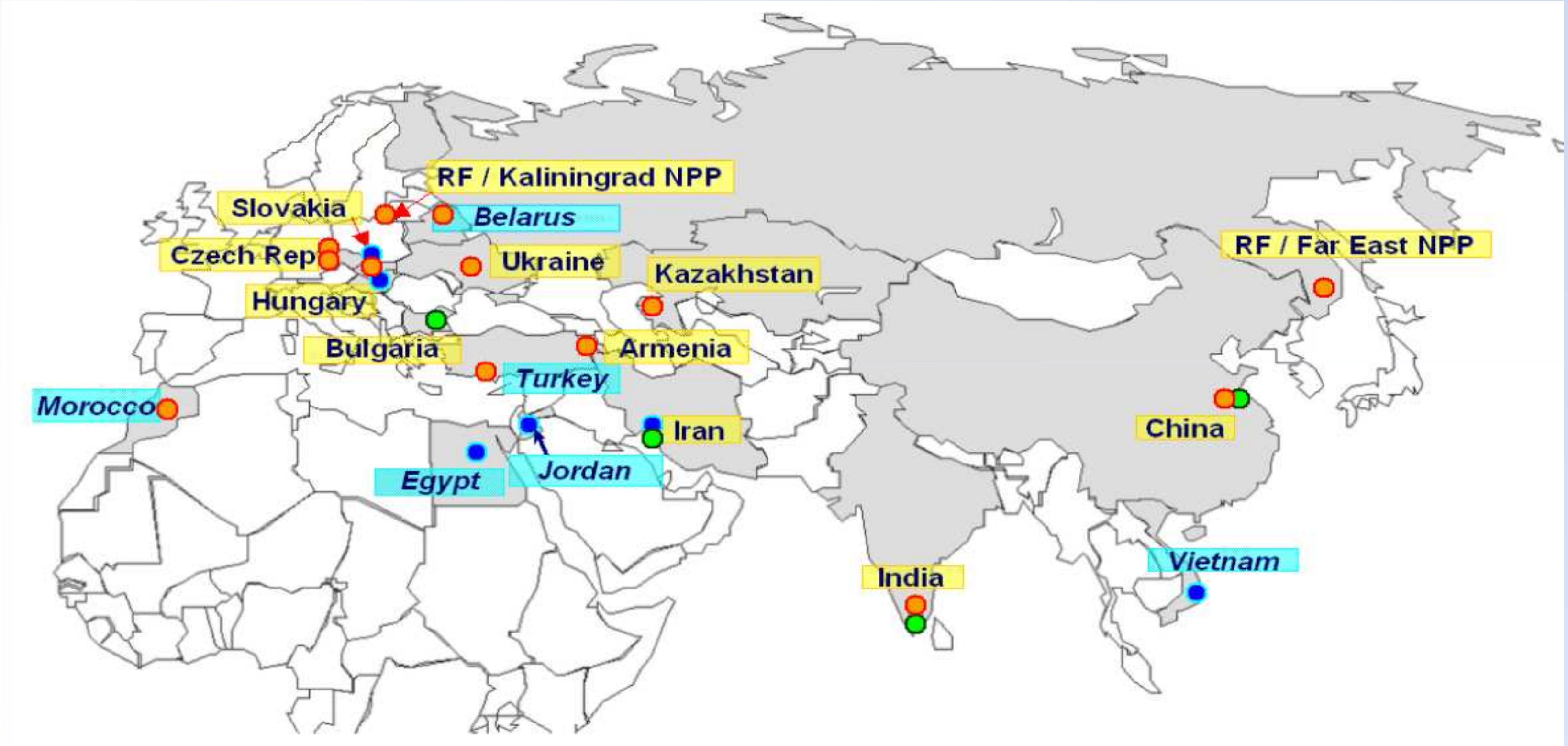
ASE AT THE WORLD MARKET



NPP commissioning, units

- Projects implementation
- Bidding / negotiations participation
- Perspective vision

– countries with well-developed nuclear power infrastructure

– countries with developing infrastructure or new-comers of the "nuclear club"

PROSPECTIVE PROJECTS

China
Tianwan NPP, units 3-4
(Construction)

India
Kudankulam NPP,
units 3-6
(Construction)

Belarus
NPP, units 1-2
(Construction)

Armenia
NPP, 1 unit
(Construction)

Slovakia
Mochovce NPP,
units 3-4
(Completion)
Bohunice NPP, unit 5
(Construction)

Czech Republic
Temelin NPP, units 3-4
Dukovany NPP
(Construction)

Libya
Nuclear Research Center
(Modernization)

Jordan
Nuclear Power Plant
(Construction)

Ukraine
Khmelnitskaya NPP,
units 3-4
(Construction)

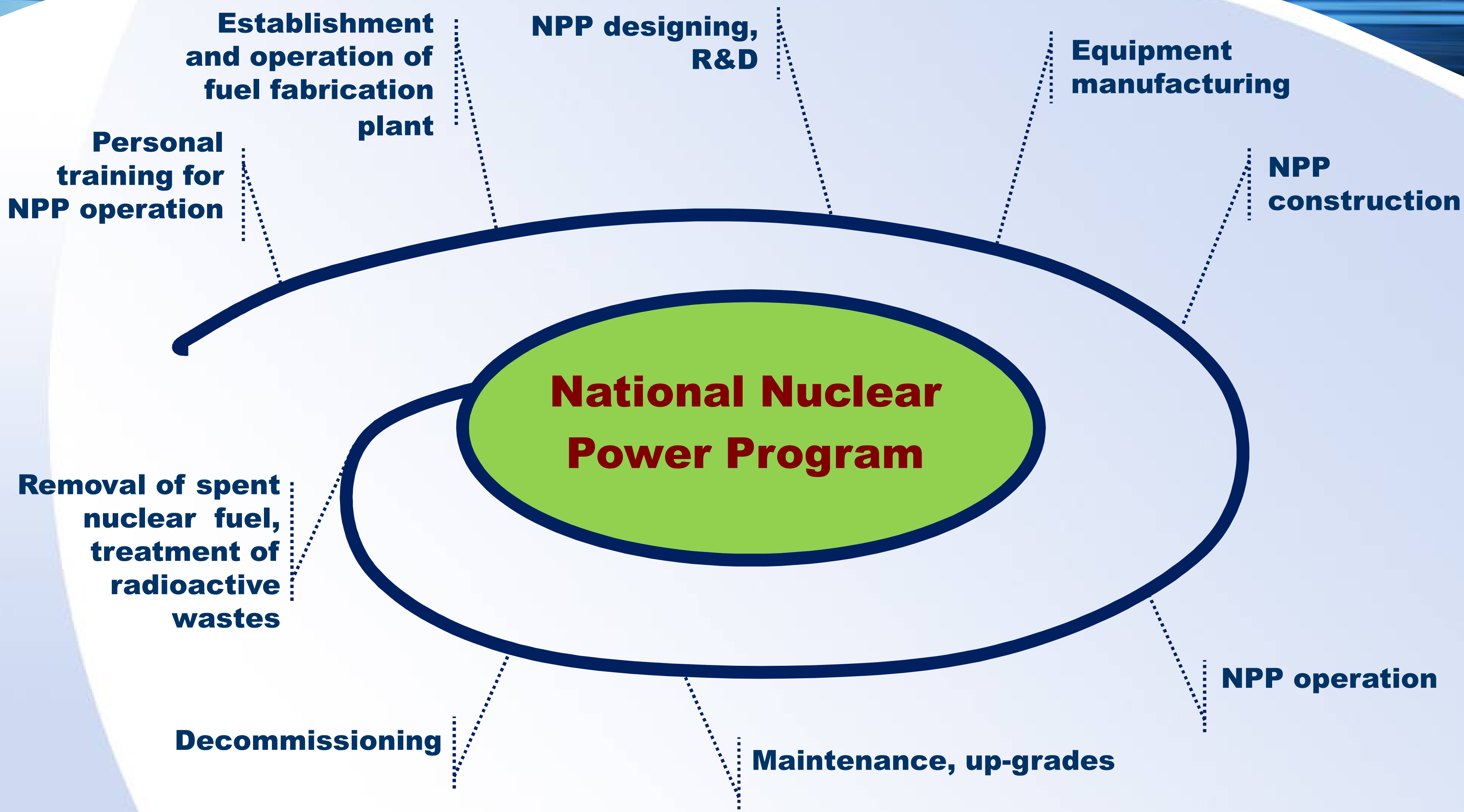
Hungary
Paks NPP, units 1-4
(Modernization)
units 5-6
(Construction)

Vietnam
NPP, 4 units
Nuclear Research
Center
(Construction)

Bulgaria
Belene NPP
(Construction)
Kozloduy NPP
(Modernization)

PROSPECTS FOR COOPERATION

- Construction of NPPs with VVER type reactor plants
- Construction of multipurpose Nuclear Research centers
- Construction of NPPs with fast neutron reactors
- Personnel education and training for national nuclear industry


National Nuclear Power Program
Establishment and operation of fuel fabrication plant
NPP designing, R&D
Equipment manufacturing
Personal training for NPP operation
NPP construction
Removal of spent nuclear fuel, treatment of radioactive wastes
NPP operation
Decommissioning
Maintenance, up-grades

FORMS OF COOPERATION

In the frame of Intergovernmental Agreements

Tianwan NPP, China

2 Units
with VVER-1000

Bushehr NPP, Iran

1 Unit
with VVER-1000

Kudankulam NPP, India

2 Units
with VVER-1000

TENDERS and BOO

Open partnership and international cooperation

Belene NPP, Bulgaria

2 Units
with VVER-1000

“Build – Own – Operate” Project

Akkuyu NPP, Turkey

4 Units
with VVER-1200

Personnel Education and Training

ASE JSC provides training and education of all categories of personnel, and for various phases of a nuclear facility life cycle (including construction, commissioning, operation and decommissioning)

TRAINING PURPOSES

- educating in general nuclear technology or nuclear physics
- gaining experience in research or power reactor operators
- training researchers at scientifically used research reactor
- educating people working with radiation at facilities other than reactors
- training experts on licensing of nuclear facilities of all kinds

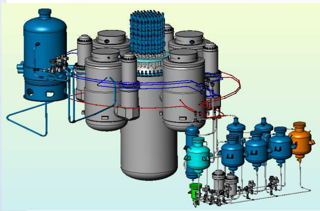
Design Developments

nuclear power installations of various capacities

- **L A R G E**
  - VVER-1000 MW (AES-91,92)
  - VVER-1200 MW (MIR.1200)

52 Russian-designed NPP units with VVER successfully operated in 10 countries (29 VVER-1000 units)

The VVER-640 NPP concept meets the international trends in development of nuclear power and refers to the evolutionary VVER designs with passive safety systems



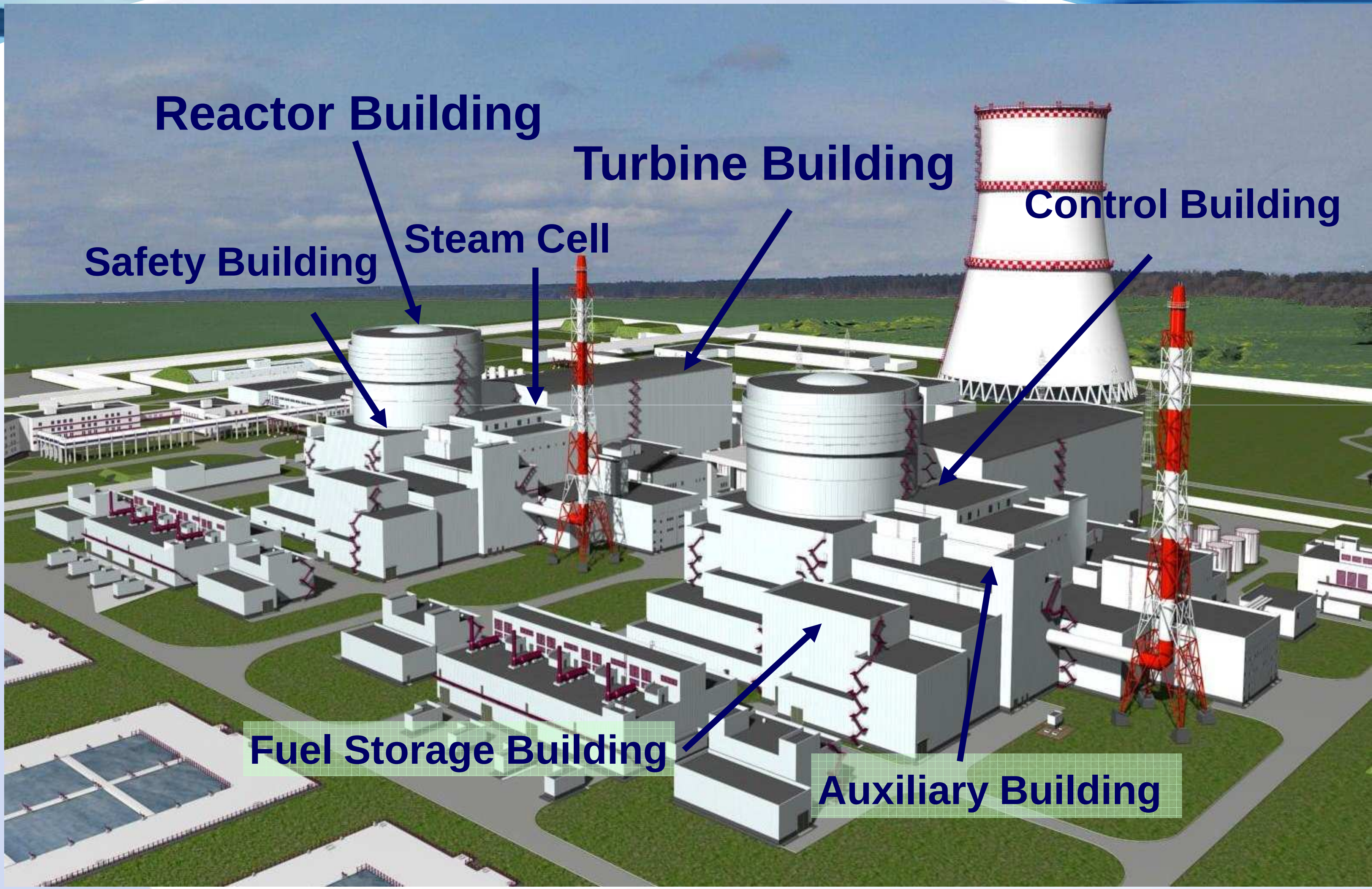
- **M E D I U M**
  - VVER-640 MW
  - VVER-600 MW
  - VVER-300 MW
  - VBER-300 MW

VBER-300 NPP design options confirm the possibility of creating ground-based and floating NPP for electricity and heat generation, and sea water desalination

- **S M A L L**
  - VBER-150 MW
  - KLT-40C 35 MW

About 460 SMALL SIZE reactor units have been constructed for atomic fleet and have proved high reliability.
Russian safety experience of ship reactors operation exceeds 7000 reactor-years

A New Name for a New Partnership



A New Name for a New Partnership

MIR.1200
MODERNIZED INTERNATIONAL REACTOR

MIR is at the same time a NPP design as well as a cooperation model

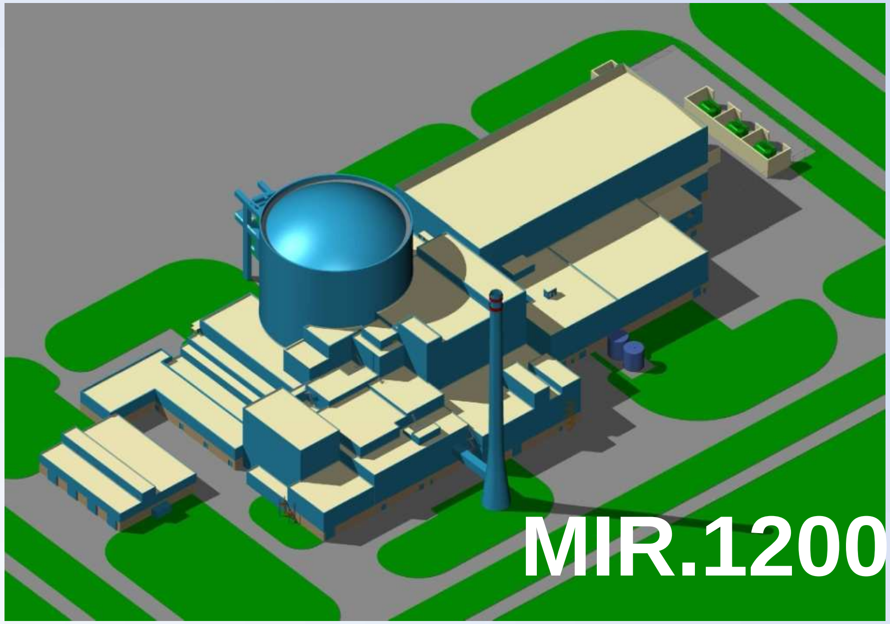
- The proposed design provides capacity of 1200 MW
- Reference plants are already being constructed in Russia
- MIR-1200 is proposed for implementation in
  Kaliningrad region, Turkey, Czech Republic, Slovak Republic, Hungary
- Russia provides services through the whole NPP's life-cycle including but not limited to

  qualified personnel training,
  designing – construction – operation of NPPs,
  up-grades,
  nuclear spent fuel and radwastes management,
  decommissioning

Evolutionary design

MIR-1200 design is grounded on the following evolutionary technologies:

- **Optimized safety system configuration with active and passive elements**
- **Digital Instrumentation & Control system**
- **Higher fuel utilization**



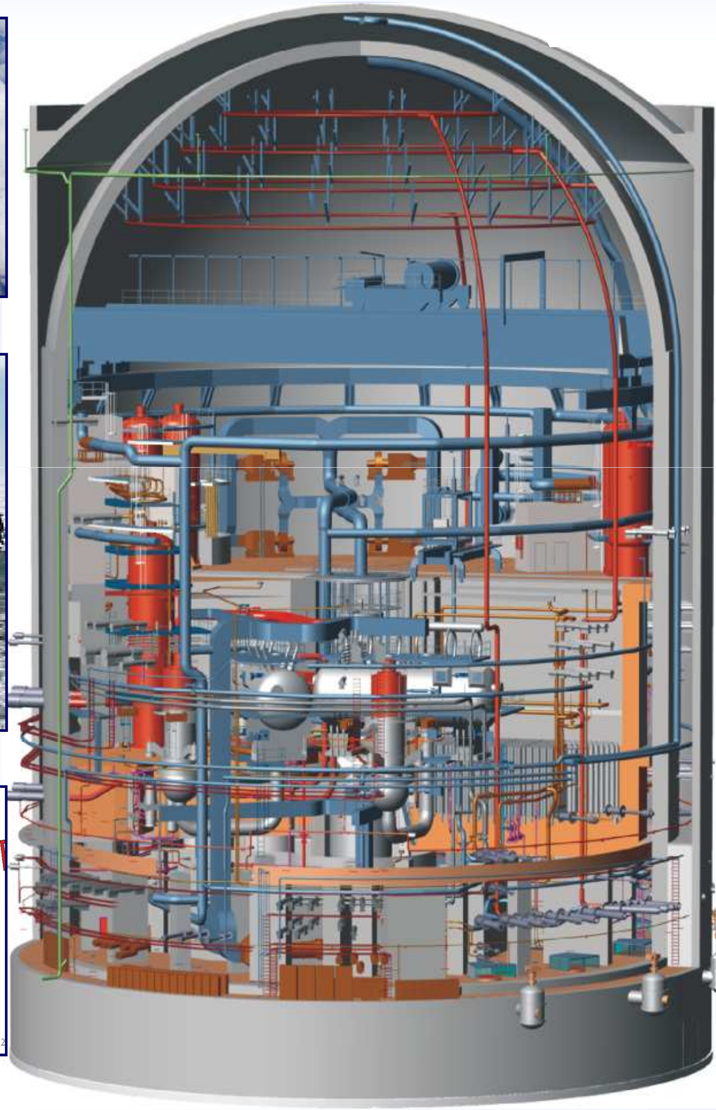
Evolutionary design

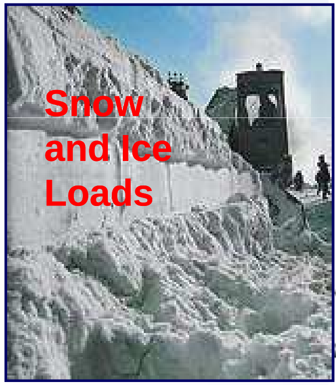
High performance of MIR.1200 is achieved due to the following advantages:

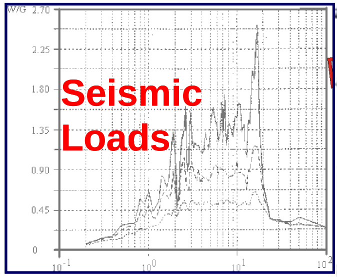
- **Finalized design in full compliance with European rules and standards (the design integrates NPP life cycle management with equipment data base, 3D CAD, schedules, etc.)**
- **Construction and schedule management enabling 54 month on-site works from the first concrete till the start-up**
- **Life cycle up to 60 years with the extension possibility**
- **Serial and experience-proved equipment integration**
- **Overall repairs – once in 8-10 years and replacement of equipment according to its actual condition**

MIR.1200

Protection Against External Hazards of MIR.1200

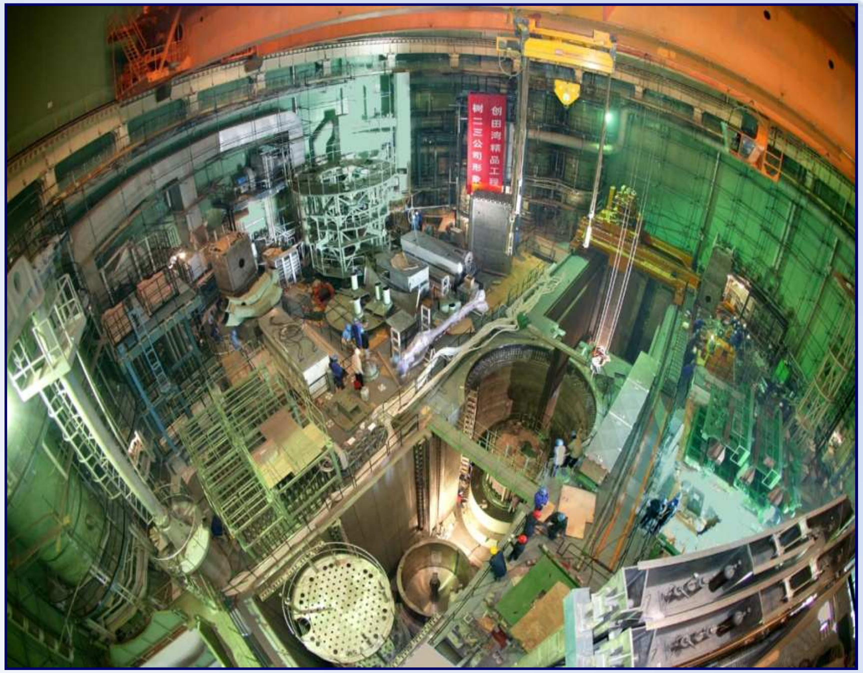






MIR Design Solutions

- Design simplicity and equipment standardization enables reduced number of equipment range to be procured and possibility of serial manufacturing
- Passive safety systems integration contributes to NPP reliability increase
- Block and modular construction and installation techniques spread
- Simplicity in operation and maintenance through use of proven referent systems and components, as well as man-machine interface advancements



Enhanced safety, competitive economics of NPP construction and operation

MIR Design Characteristics

Name of the characteristic	Value
Lifespan: - steam-generating nuclear equipment	60 years
Power unit output, MW: - electric (gross) - electric (net) - thermal	1.158*) MW_E 1.078 MW_e 3.200 MW_t
Unit heat extraction output	<300*) MWt
Minimum coefficient of installed output utilization	> 90%
Number of operating staff (nominal), workers/MW	0,35
Maximum calculation depth of fuel burn-out, average per fuel assembly, for the stationary fuel reload mode	60 MWd/kgU

MIR Design Characteristics

Name of the characteristic	Value
Number of operating staff (nominal), workers/MW	0,35
Maximum calculation depth of fuel burn-out, average per fuel assembly, for the stationary fuel reload mode	60 MWd/kgU
Duration of fuel campaign	4 years
Period of refueling	12 months
General probability of: - core damage - excess of the limit environmental impact criteria in case of serious accidents - total frequency of conditions resulting in serious damage to fuel and containment tightness	 $<5,8x10^{-7}$ $<2,0x10^{-8}$ $<3.7x10^{-9}$

“ Coming together is a beginning.
Keeping together is progress.
Working together is success.”

Henry Ford

Together - to a New Clear Energy

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