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HOW OLD are NEW PLANT concepts ?

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Actual construction plans for NPP in CEE

VVER 1000 – AES 92:

BELENE: NEK Bulgaria's Electricity Company choose Atomstroyexport to build 2 VVER 1000 reactors in BELENE „AES-92“

IGNALINA: 4 countries plan to build an AES-92

CANDU-6:

CERNAVODA: Cernavoda unit 3 and 4 are planned to construct

VVER 440/213

MOCHOVCE: A construction permit exists since 1994 for 2 more Mochovce units (VVER 440/ 213)

CANDU 6 - history

CANDU: first license in the early 1980ies in Canada, Argentina and Korea:

Point Lepreau, Canada 1983

Wolsong 1, Korea 1983

Gentilly 2, Canada 1983

Embalse, Argentina 1984

Cernavoda 1, Romania 1996

Wolsong 2,3,4 Korea 1997-1999

Qinshan 1.2 China 2002, 2003

CANDU 6 - evolution

Over the years the CANDU-6 concept has not changed substantially, but some improvements were integrated:

Electricity output was increased by improveming the turbine- feedwater system's efficency, from 680 MW to 728 MW.

For later built Wolsong and Qinshan Units the airborne tritium emissions have been reduced to half of the previous units.

New Candu 6 reactors will be designed for 40 years lifetime.

CANDU 6 - safety

General safety problems of CANDU reactors:

higher risk (compared to LWR) of LOCA because of material stress due to

- large number and length of pressure tubes
- high pressure and corrosion of tubes
- on line fuel exchange

CANDU's positive void coefficient results in case of LOCA in a higher risk of power excursion

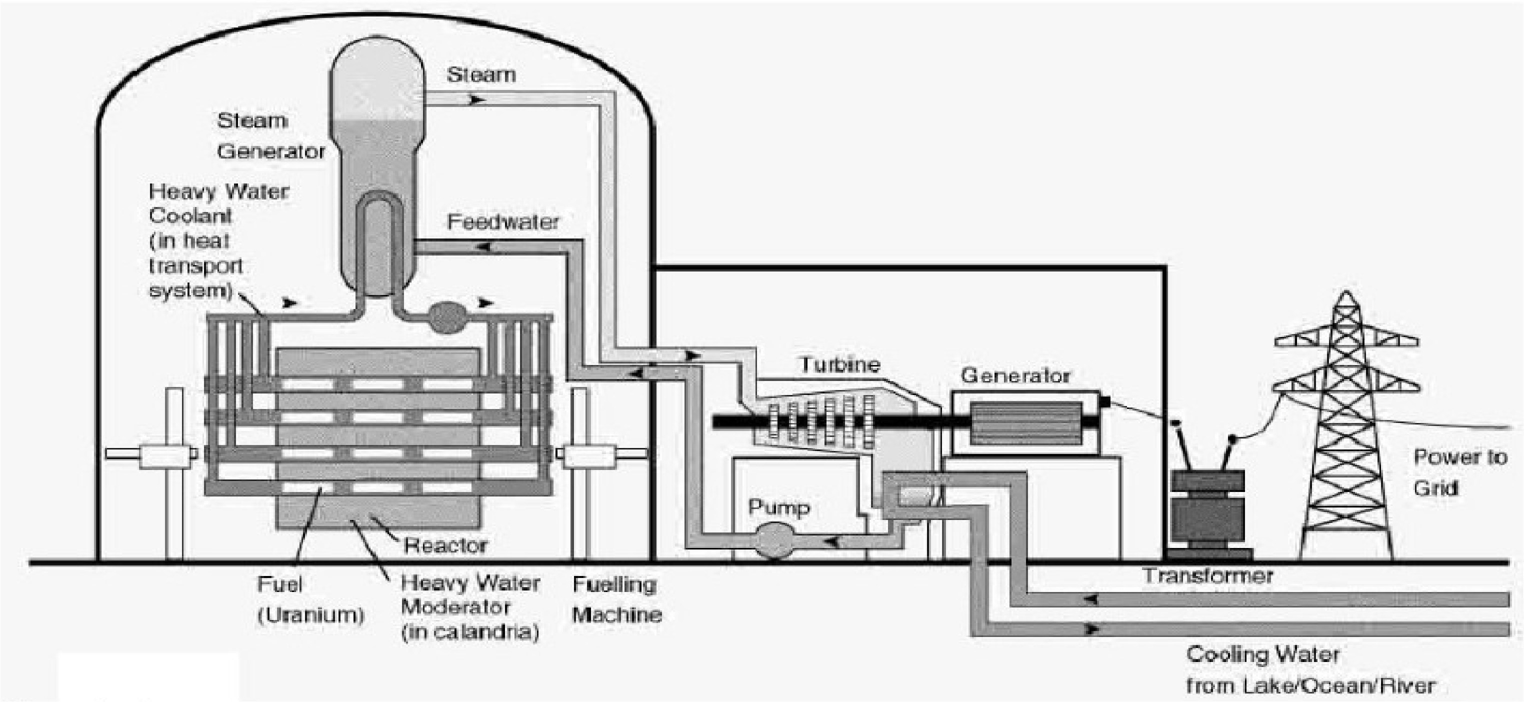


Illustration 1:

CANDU 6 - LOCA

In case of LOCA, overheating of the zircaloy cladding tube cannot be excluded.

In case of ECCS failure heat removal from the core shall be provided by the moderator circle. This capability is probably not sufficient for all LOCA scenarios.

CANDU 6 severe accidents

WENRA 2000:

Concerning severe accidents the standard CANDU safety analysis already includes scenarios with the failure of emergency core cooling in which the heat removal is provided by the moderator. For scenarios with more core degradation, the capability of the calandria to provide a spreading of the corium and sufficient heat removal area for core debris as well as the additional capability of the concrete reactor vault as ultimate heat sink are still to be analyzed and the corresponding management procedures defined.“ [WENRA 2000]

CANDU 6 - containment

The CANDU containment requires active systems for isolation in case of a severe accident (ventilation dampers and dousing system).

Thus the large release frequency of 10E-7 /year reported in the EIA doe CNPP-2 is not sufficiently proved.

In all references a core melt frequency of about 1E-5/year is reported. (RISKMAP, ENCONET 2001)

CANDU 6 – earthquake

Design Basis Earthquake (DBE) = the earthquake for which the NPP is designed so that it can still be safely shut down (re-occurrence period T > 1000 years) -

DBE for Cernavoda: (AECL 2001):
intensity = VIII MSK, acceleration=0,2g

Site Design Earthquake (SDE) = the earthquake for which the NPP is designed so that it can still be operated re-occurrence period T > 100 years).

SDE for Cernavoda: (AECL 2001):
Intensität = VII MSK, acceleration=0,1g

CANDU 6 – earthquake,2

Earthquake risk is a much discussed problem concerning Cernavoda NPP. The NPP is located in a region where severe earthquakes have occured. The data used for the design of Cernavoda NPP are from before 1992.

ICIM 2002, the EIS for NPPC-2, states that “there is a margin of 12,5% in the design in the design data for DBE (0,2 g).

Reference data for the correlation of earthquake intensity and acceleration show that the safety margin is probably not sufficient. (UBA 2000)

Intensity VII: acceleration: 0,07 – 0,25 g

Intensity VIII: acceleration: 0,18 – 0,4 g

CANDU 6 - References

AECL 2001: Cernavoda Unit 2 NPP Environmental Assessment Summary; 2001

ENCONET 2001: Nuclear Safety in Central and Eastern Europe; ENCONET Consulting, Eskonsult,NNC,NRG, April 2001 EUR 19895

HIRSCH et al 1993: The Game of Hazard: Nuclear Reactor Risk in the 1990s - Amsterdam: Greenpeace, 1993

ICIM 2002 - 2: Cernavoda 2 NPP- Environmental Impact Assessment ICIM December 2002

WENRA 2000: Western European Nuclear Regulators' Association; Nuclear safety in EU candidate countries, October 2000

RISKMAP ONLINE: http://www.umweltbundesamt.at/umwelt/kernenergie/akw/riskmap

VVER 1000 history

The VVER 1000 design was developed between 1975 and 1985.
First generation VVER 1000/V338: Kalinin 1-2, South Ukraine
Second generation: VVER 1000/ V320: Balakhovo, Rovno, Khmelnitsky, South Ukraine, Zaporoshe, Kozloduy.
VVER 91: In 1989 Finland and the Soviet Union started a development project for a VVER 1000 version that would meet stringent Finnish nuclear design requirements. *“on paper, the Soviet VVER 91 design is among the world's most advanced light water NPPs” (NEI 1997)*
VVER 92: *Development of a new VVER-1000 design, the VVER-92, was expected to be carried out with Western assistance. (NEI 1997)*

AES 92
! very cheap. very safe. very mysterious !

In contrast to the EPR constructor – Areva - the Russian nuclear industry's marketing is not very informative.

AES-92 is announced to be a VVER 1000 reactor with a modern design that has met **European Utilities' Requirement** for safety and reliabilty (nucleonics week, 14.12.2006)

"The VVER-92 incorporated what one Finnish nuclear expert called "radically simplified" plant systems that included active safety systems, a reduced-power reactor core, and a double containment structure surrounding the nuclear reactor." (NEI 1997)

European Utilities' requirements

The European Utilities' requirements contain safety and reliabilty criteria.

Accidents with limited impact: release of 0,1% of core inventory- i e. 4000 TBq I-131 Cs-137, Sr-90 ~100 TBq

Safety targets:

- **core damage frequency**: < 10 E-5,
- **frequency of release > limited impact:** 10 E-6,
- **early or large release frequency**: 10E-7

(i.e. criteria are similar to IAEA safety targets (INSAG 3, 1999) Belene should be licensed according to the Wenra reference safety levels for existing plants.

AES 91 TIANWAN NPP

The Russian AES-91 type unit is an improved concept based on the experience of design, construction and operation of WWER-1000/320 series, absorbing the advanced technologies from western PWR, conforming with the existing international requirements in nuclear and radiation safety.

The plant also adopts integrated digital I&C system of Siemens, Germany.

The construction cost per kilowatt and operation cost of the project are being kept low, while of excellent economics.

TNPP installed capacity is 2x1060 MW and design life of 40 years, the annual average load factor is no less than 80% and annual generated electricity 14 billion kWh.

AES 91 TIANWAN NPP

Construction time was planned to be 62 month. It started in 2000. Tianwan 1 became operational in January 2007- with a delay of at least 1 year.

? AES 91 = AES 92 ?

AES 92 - Belene

ASE (Atomstroyexport) offered the "new-generation" **AES-92, also with 1,000-MW-class VVER**s.

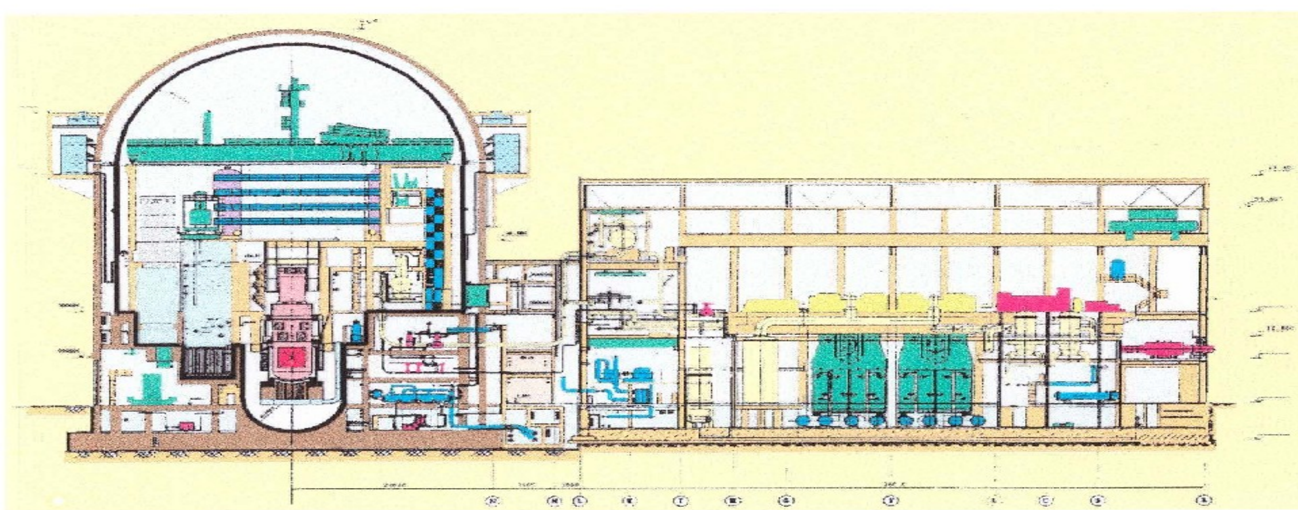
AES-92, combines active and passive safety systems, features an "economically advantageous" safety systems organization, and uses instrumentation and control (I&C) of a new generation. Framatome ANP would supply the I&C system. (Teleperm system- originally by Siemens is used also on the Tianwan AES-92)

Framatome ANP will also deliver electrical systems, heating, ventilation, and air conditioning systems, safety systems including hydrogen recombiners and monitors, and containment prestress system - also similar to Framatome ANP's scope at Tianwan. (NW 2006 No 6)

AES 92 - Belene

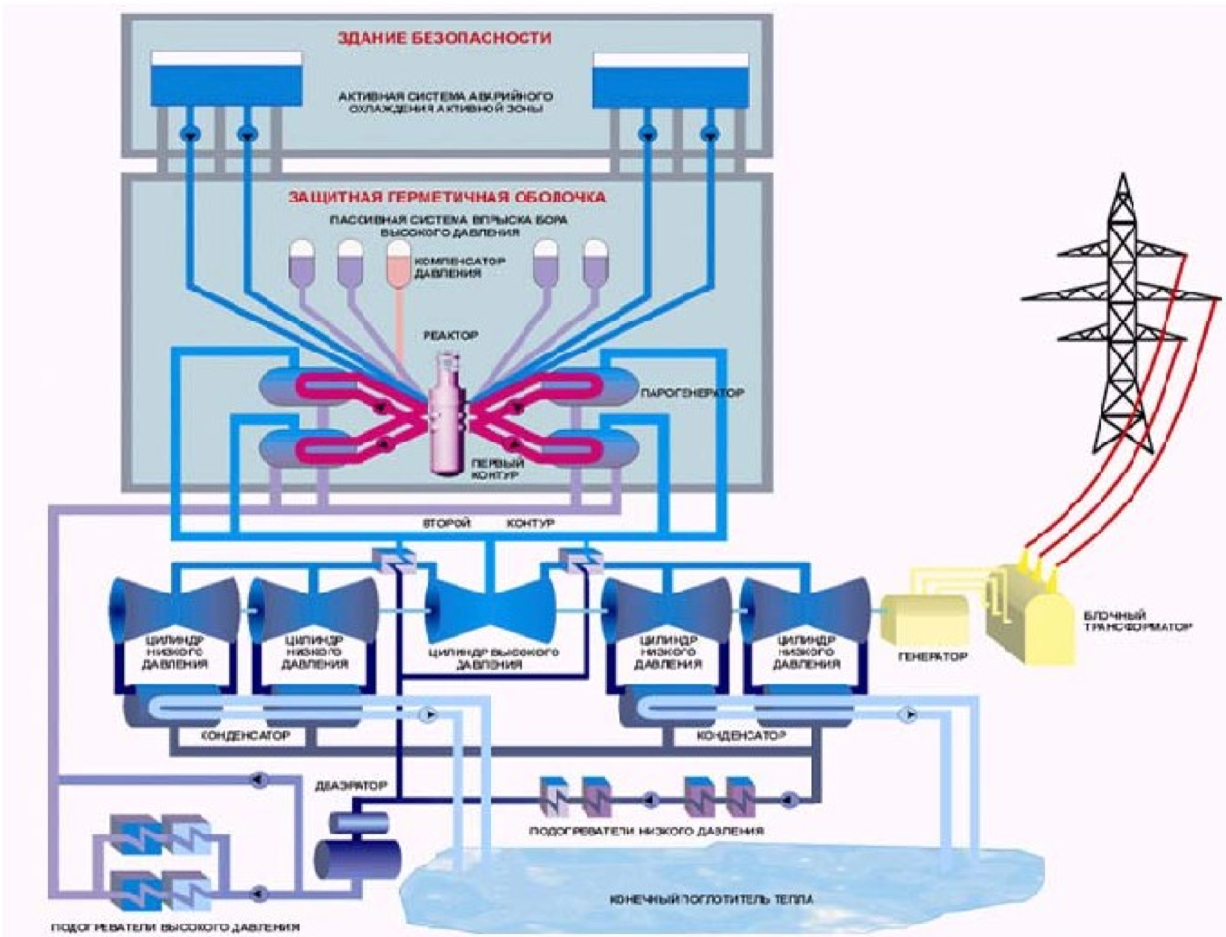
AES-92 advanced VVER have adopted a system different from the EPR core catcher: for ex-vessel core recovery a second vessel outside the main vessel is used - a simpler arrangement than the EPR's core-spreading system. Verification of the long term integrity is not proofed – thermochemical reactions

ДОВОС НА ИНВЕСТИЦИОННО ПРЕДЛОЖЕНИЕ ЗА СТРОИТЕЛСТВО НА АЕЦ "БЕЛЕНЕ" Стр. 1.2-64 от 1.2-78



Фигура 1.2-5 - Компановка на В-407

Документ № BNPP-EIA-PEC-NEK-0001-B3 март, 2004 г.



Фигура 1.2-6 - ВВЕР-1000/В-466: Главна технологична схема

AES 92 – Belene

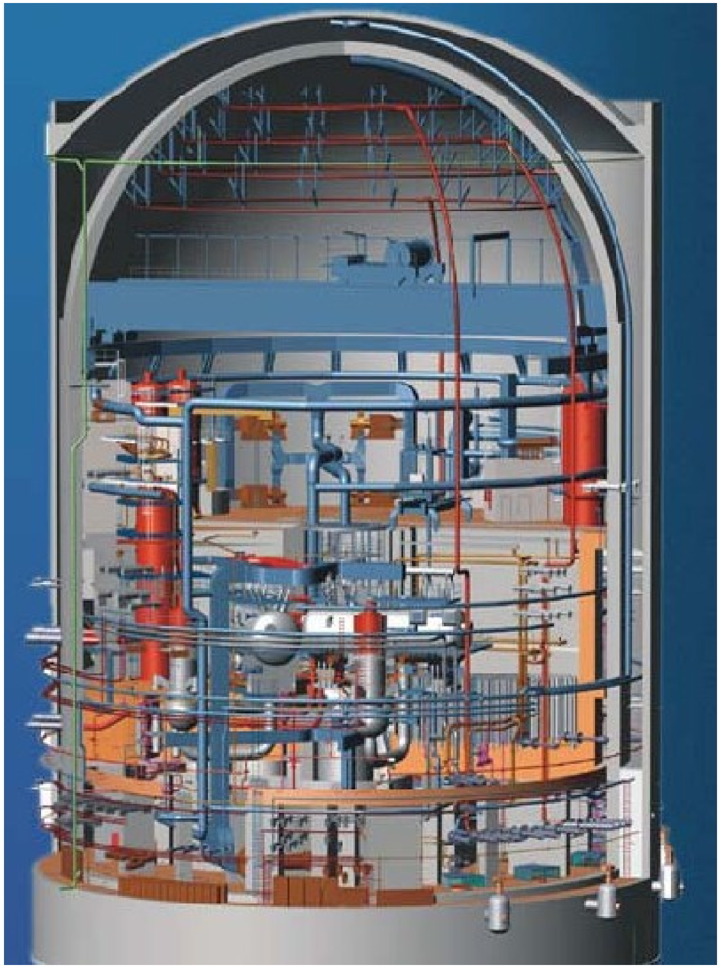
Why has Russia won the BELENE tender ?

Russian proposal for two third-generation VVERs of the V-466 model (= AES 92) provided a higher level of safety and a longer operating lifetime (60 years) than the competing bid from Skoda Alliance. The ASE bid was also cheaper, 4 billion euros compared to Eur 5 billion for Skoda Alliance.

NEK said one reason for the choice was that "a third-generation VVER" was better accepted in the European Union than the V-320, whose base design dates from Soviet times.

?? AES 91 or AES 92 ??

The power plant ASE will build at Belene is known as AES-92. So far, it has been built only in China, at Tianwan-1 and -2 A slightly different design, AES-91, is under construction by ASE at Kudankulam in India.



AES 92 PSA results

core melt frequency: < 5 E-8

limited release frequency 1E-4 – eff. dose < 0,1 mSv

large release frequency 1 E -7 – eff. dose < 50 mSv

AES 92 - References

NEI 1997: Source Book: Soviet-Designed Nuclear Power Plants in Russia, Ukraine, Lithuania,Armenia, the Czech Republic, the Slovak Republic, Hungary and Bulgaria, Fifth Edition, Nuclear Energy Institute, Washington 1997

Nucleonic Weeks, year 2006

Thank you !