7th International Conference on WWER Fuel

Dukovany Power Uprate

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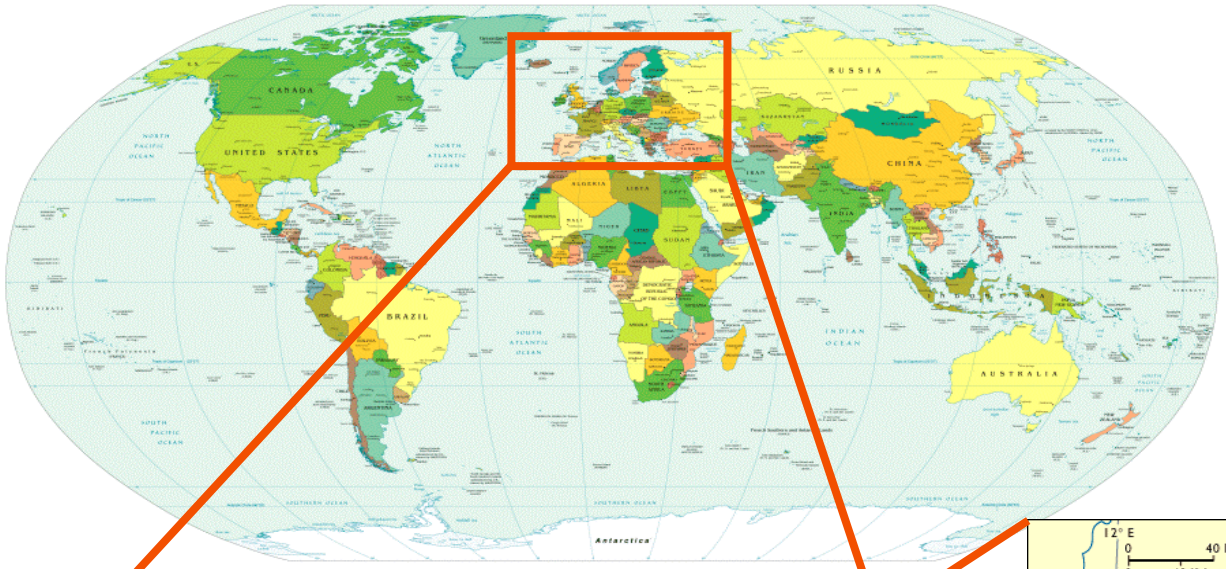
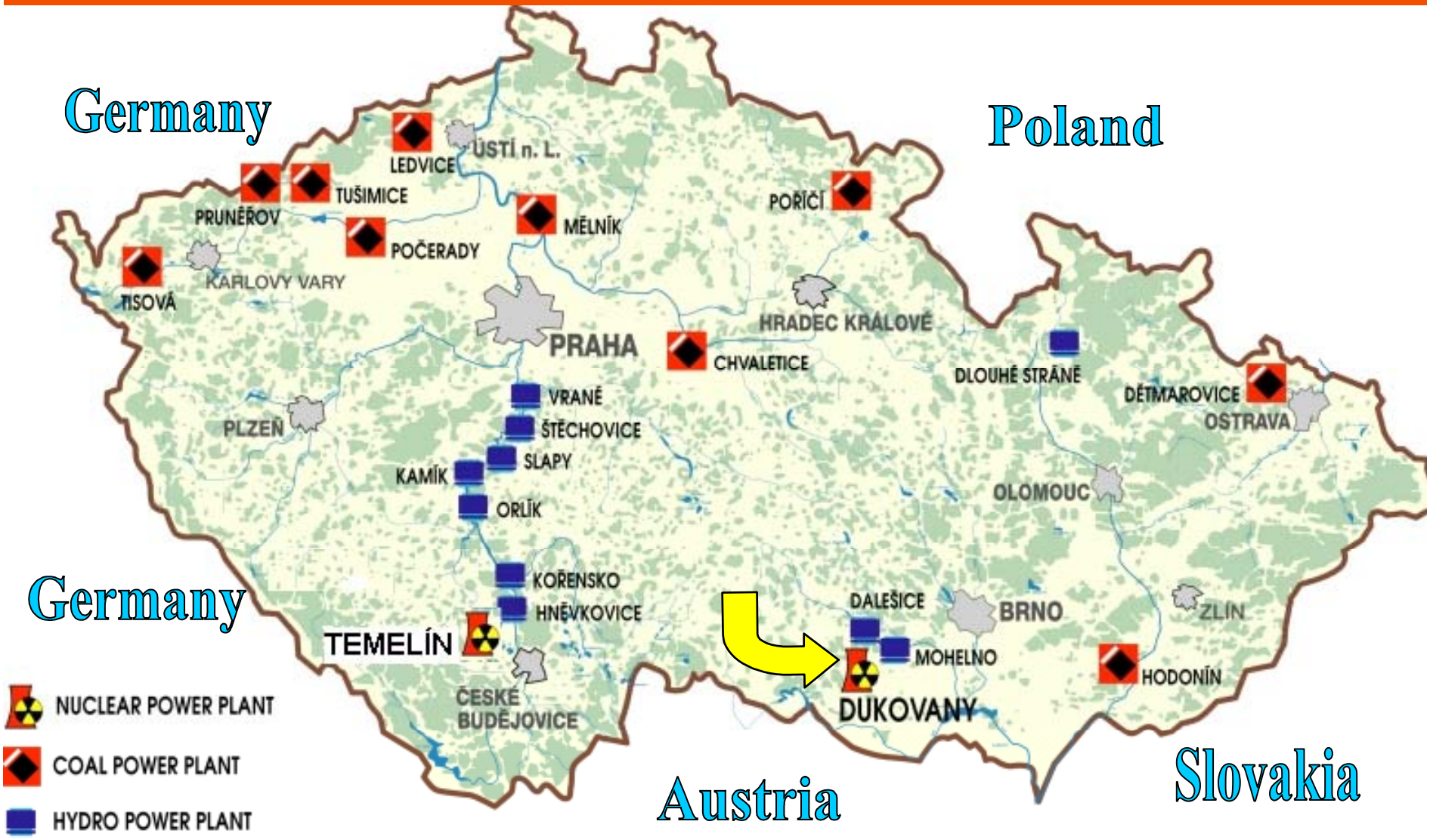
Dukovany - location of the NPP



Power Plants in the Czech Republic



The Power Uprate to 113% in Dukovany consists of two main components:

- Thermal reactor power increasing to 105%

2. Higher thermal efficiency of Unit due to upgrade in Secondary Circuit and in Electricity part

> + 3,6 % from new Low Pressure Turbine Rotors
> + 2 % from new High Pressure Turbine Rotors
 + 2,5 % due to innovation of Steam flow Measuring Orifices, Steam traps, Transformers, plus other minor changes

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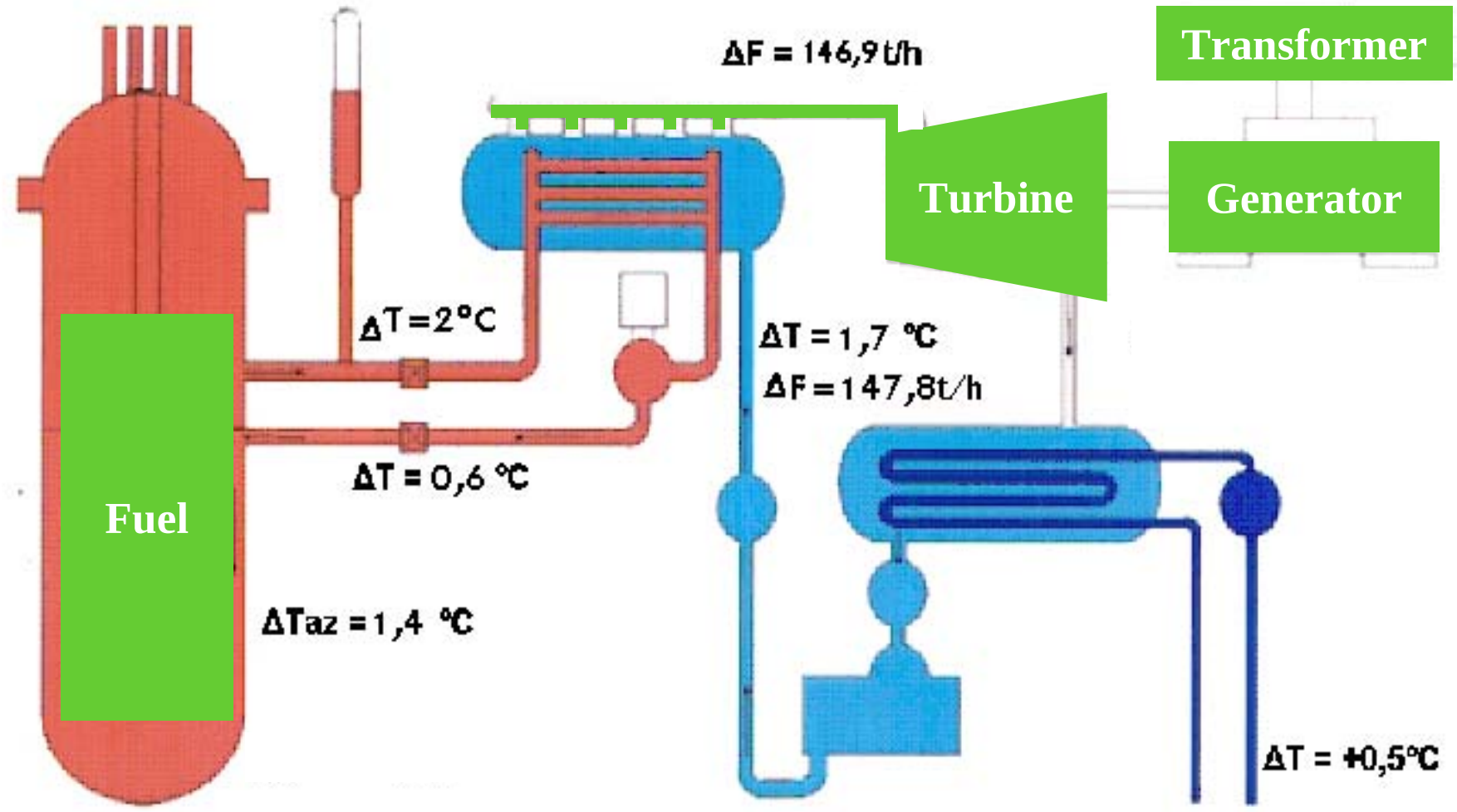
S + 13 % in electric output at the Dukovany Units,

totally minimally 113%

Dukovany VVER440 Unit will be uprated to 500 MWe

Systems with major changes (green colour)
Increments in Unit parameters



Economical and technical evaluation – - the basis for final decision

(1) After more than 20 years of operation many major Unit components are nearly at the end of their planned lifetime: turbine low and high pressure rotors, Generators, Transformers, etc. They must be replaced or modernized.
It´s useful to upgrade their efficiency in parallel with power uprate

(2) All necessary investments were estimated including their depreciation

(3) Relative fuel cycle costs were evaluated for various reactor power uprates + 2%, 5%, 7%, 9%....

(4) Production Costs (including the Fuel Cycle Costs) were evaluated for various scenario

(5) Requested extension of NPP Dukovany life time was taken into account. Special attention was devoted to reactor vessel degradation

Why only 105% in reactor power ?

Main reasons:

(1) To preserve the full Low Leakage Loading Pattern (LLLP) scheme with substantial positive effect in fuel cycle economy (relative fuel cycle costs)

(2) To save the LLLP for the lowest fluence on reactor pressure vessels not to jeopardize an extension of their life-time and long term operation

(3) To take into account a limited reserve to coolant flow Design Limits. The 5% (+2% uncertainty) increase in thermal reactor power is the value which does not need increase in coolant flow high limit (and consequently replacement of all Main Cooling Pumps or their parts)

(4) It was the more favourable case in the total economic evaluation and the result of final optimization study.

Pre-design and Pre-licensing process

(1) The process of Primary part screening has started in cooperation with the General Designer of VVER reactors (OKB GIDROPRESS Podolsk, Atomenergoprojekt Petersburg)

(2) The process of the complete units screening (mainly secondary part) has started in cooperation with the Original General Designer of NPP Dukovany (ENERGOPROJECT Prague)

(3) Replacement/modifications of major innovated systems and components (low and high turbine rotor, generator – rotor winding reisolation, stator rewinding , transformer rewinding,..) are evaluated in cooperation with original suppliers

Pre-design and Pre-licensing process

Main evaluated SSC

Primary part - Reactor, main coolant pumps, pressurizer, steam generator, primary part (OKB + original suppliers)

Secondary part - Turbine, condensate line, feedwater line, steam lines, circulation water line, essential water (Energoproject + original suppliers)

Electrical part – generators, transformers, excitors,.. (Energoproject + original suppliers)

I&C - SSC control algorithms - functional logics, setpoints (OKB, Energoproject)

Pre-design and Pre-licensing process

Analyses, calculations, evaluations for PU

(samples - finished or performed)

Reactor physical and thermohydraulic analysis and calculations

Core coolant flow determination

Reactor internal parts vibrations

Steam generator (SG) thermohydraulic and separation calculations

SG and pressurizer thermostress calculations

Determination core safety limits

Gadolinium percentage optimization calculations for fuel assemblies

Fuel charges variant projects

Pre-design and Pre-licensing process (cont.)

Analyses, calculations, evaluations for PU

(samples - finished or performed)

Analysis of critical PIE

Preliminary safety analysis

Calculations of generator warming on PU and determination of modifications

Evaluation of main transformer state and determination of modifications

Exciters evaluation

High pressure turbine rotor for increased steam flow

Steam measuring orifices accuracy calculation

Scope of physical and power commissioning tests

Pre-design and Pre-licensing process

(4) New fuel Contract was signed with Russian fuel supplier TVEL (type Gd2M)

(5) The technical direction of the whole licensing process is provided by ENERGOPROJECT Prague. The complete revision of the SAR will be accomplished.

(6) Preparing of „Power Uprate Quality assurance program “ for starting of official communication with Regulatory body (2006)

Communication with Regulatory Body has started in 2004
Licensing process starts in 2007

General approach to licensing safety analyses for Dukovany Power Uprate

Two complete set of analyses of PIU 15.1 – 15.6 (RG 1.70)

First set is prepared by fuel supplier and its subcontractors (Russian organizations)

Second set is prepared by national organizations, mainly by NRI Rez

Both set of analyses should be done by validated computers codes (validation should be done in the Czech Rep.) and they should follow the Procedure for licensing analyses and the database of input data.

The main principle of the Procedure: single failure in safety systems and consequential failures (as a result of single failure and/or as a consequence of IE) are applied; LOSP (when leads to more conservative results); equipment for normal operation are assumed to fail unless its operation leads to more conservative results; conservative deviations of measured uncertainties; conservative time delays of safety system actuation.

Analyses worked out by national organization are incorporated into chapter 15 of SAR, analyses done by Russian organizations are used as topical reports

Fuel types at Dukovany

Year ⇒	2002	2003	2004	2005	2006	2007	2008	2009	2010
UNIT 1						IaC			
UNIT 2							IαC		
UNIT 3				IαC					
UNIT 4								IαC	

- *fuel for 4-year cycle*
- *The first generation of Gd-1 fuel*
- *Advanced Gd-2 fuel*
- *Advanced Gd-2M fuel*

IαC - *Upgrade of IaC systems*

New fuel for uprated power

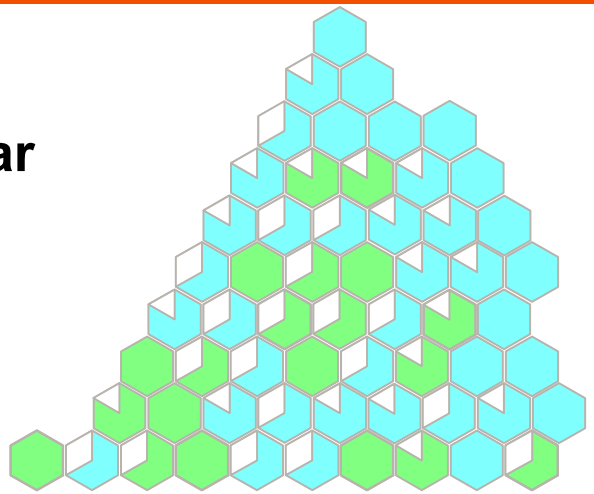
Fuel Cycle Strategy for Power Uprate

- Annual cycle with average cycle lengths 335 FPDs, stretch-out 20-30 days
- Advanced type of VVER440 fuel with Gadolinium as burnable absorber
- Existing 5-year cycle maintained, BU < 72 MWD/Kg (fuel pin limit)
- Existing limits of power distribution maintained (F_Q, F_{dH}, $T_{satur.}$ in hot channel)
- LLLP preserved, eldest fuel assemblies at the core boundary
- Existing extent of power control maintained
- Only two FA enrichments in fuel batch : 4.38wt% U235(working assemblies, 4.25 wt% (control assemblies)
- Resident time for FAs 5-6 years (to 6-7 years scheduled after 2010)

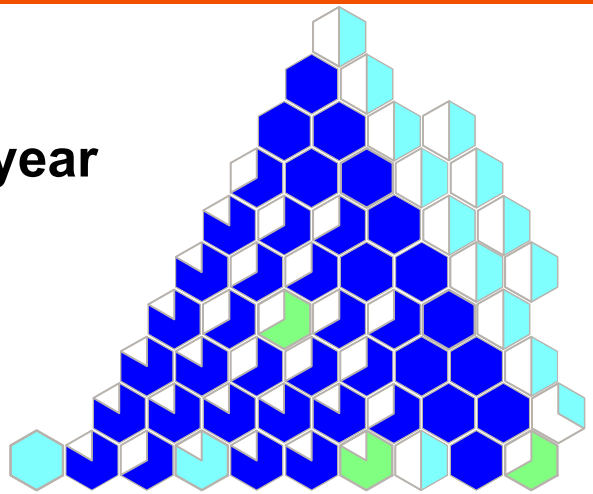
This strategy minimizes the losses in fuel cycle economy due the reactor power uprate to 105%

Development of Dukovany Fuel Cycle 1985 - 2005 . The typical reload schemes and enrichments.

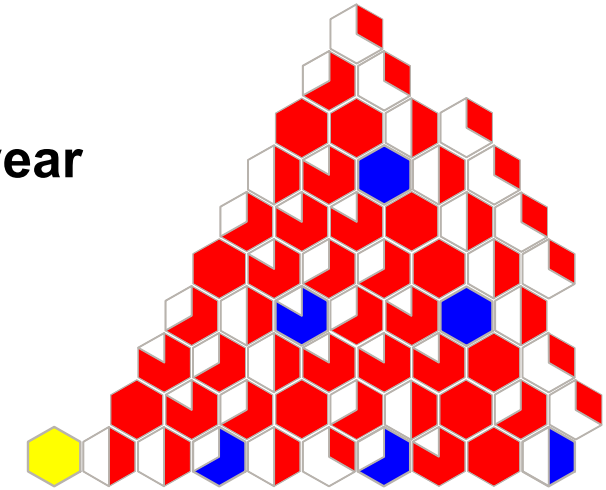
3 year

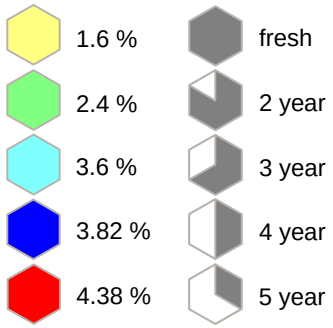


4 year



5 year





Power uprate increases the relative fuel cycle costs

*) working assemblies and control assemblies

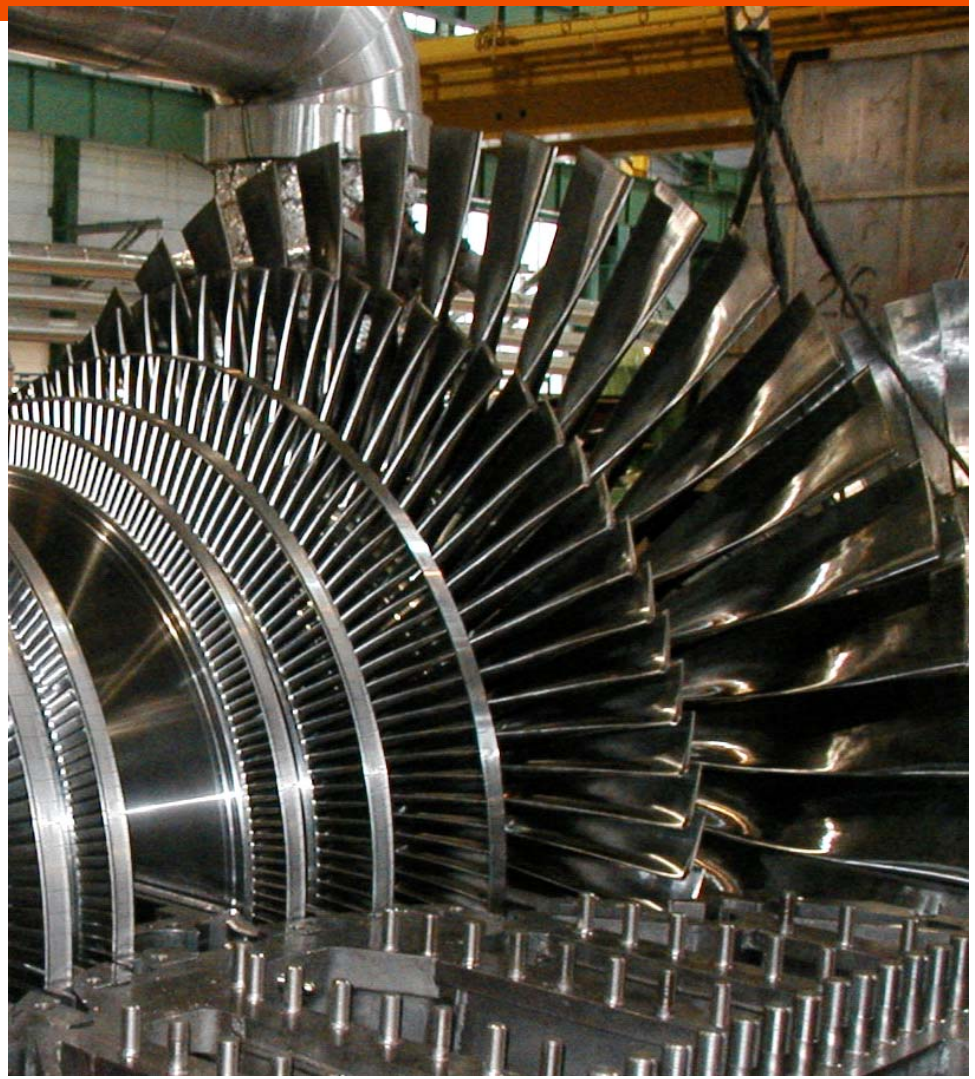
Fuel type :	Old type	Gd-1	Gd -2	Gd -2M Power 105%
Enrichment [wt% U235] *)	3,82 / 3,82	4,38 / 3,82	4,25 / 3,82	4,4 / 4,2
Cycle length [FPDs]	310	320	330	330*1,05
U consumption [kg/MWd]	0,204	0,193	0,191	0,192
Enrichment [SWU / MWd]	0,117	0,116	0,113	0,115
Relative fuel cycle costs [%]	100	92	84	85-86

Newly designed flow parts of LP turbines. The first step to power uprate was accomplished

New LP rotors at Unit 3 and 4 have increased the electric rated power by 3,6% in 2005 and 2007 (without any reactor thermal power increase)

New LP rotors are designed for 105% of rated steam-flow

<u>After LP rotors replacement the rated power of Unit 3 and 4 has increased to 460 MWe</u>



Time schedule

- Contract with General Designer of VVER reactors (GIDROPRESS, Moscow), signed 2005
- Contract with fuel supplier Tvel, Moscow, signed 2005
- Pre-design, Pre-licensing analyses, evaluations, calculations 2004-2007

(4) Investments was agreed by CEZ in May 2006

(5) Contracts preparing with suppliers 2006 - 2008

(6) Licensing process 2006 - 2008.
(Approval given by the State Regulatory Body expected in December 2008)

(7) The first reload with new fuel with reactor power uprate to 105% at Unit 3 - January - March 2009
Other units subsequently in 2010 - 2012

Dukovany Power Uprate

Thank you for your attention!