POWER UPRATES AT NPP TEMELÍN VVER-1000

PARAMETERS AND PERSPECTIVES

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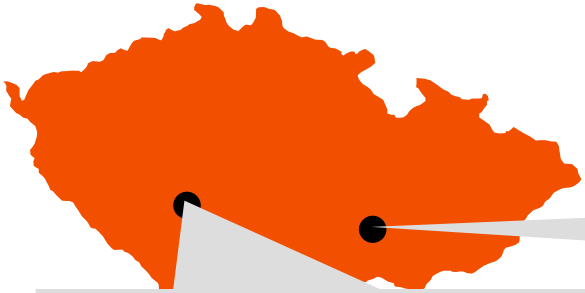
ČEZ NUCLEAR FLEET



Temelín

- *PWR, 2xVVER-1000 V320*
- *U1 startup: 2000*
- *Thermal Power: 3120 MWt (104% of original)*

Dukovany

- *PWR, 4xVVER-440 V213*
- *U1 startup: 1985*
- *Uprated Thermal Power: 1444 MWt (105% of original)*

TEMELÍN REACTOR POWER UPRATE (104%, IMPLEMENTED 2013) – NUMBERS

- **Reactor rated thermal power**: **3000 MWt => 3120 MWt**
- **Generator electric output**: **1018 => 1062 MWe** (*) **= +88 MWe total** (2 units)
- **Project total costs**: **16 mil. EUR** (431.5 mil. CZK) *(20÷40x lower inv. costs per installed MWe than new builds)*

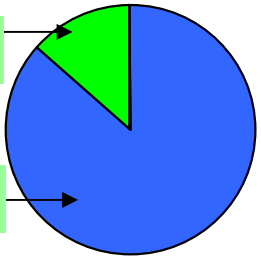
(*) *Reference heat balance diagram – without district heating, T_{CW} = 18,5 °C*

+88 MWe / 16 mil. EUR

+ ca. 0.66 TWh/year (with considered LF of 85%), **pay back < 2 years**

2,2 mil. EUR: equipment modif's

13,8 mil. EUR: analytical part, tests



Utilization of VVER-1000, V-320 reserves => minimum equipment modifications

… we constructed cheapest new clean power source …

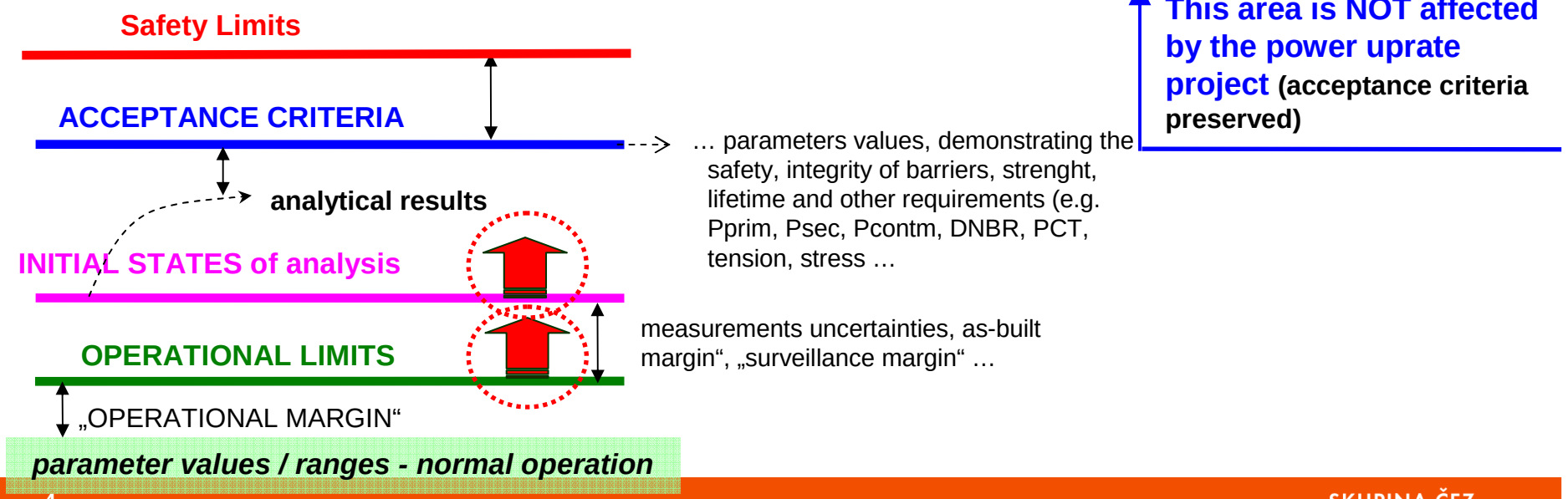
TEMELÍN REACTOR POWER UPRATE – TIMELINE

- **2010÷12:** **analytical part -**
  - **- NRI Řež**
  - **- JSC TVEL** (fuel vendor)
  - **- OKB-GP** (original designer)
  - **- equipment manufacturers**
- **2012/13:** **implementation of equipment modifications** (during refuel. outages)
  personnel training
- **22.4.2013:** **regulatory body permission**
- **18.8.2013:** **unit 2 at 3120 MWt**
- **22.9.2013:** **unit 1 at 3120 MWt**

TEMELÍN REACTOR POWER UPRATE – BASIC PRINCIPLES

PRESERVATION OF ...

- **fuel system design**
- **technological safety system's characteristics / parameters** (flow rates, volumes …)
- **SG secondary side pressure (i.e. T_{CL})**
- **power limits** (abs. values) **for operation with N-1 / N-2 loops in operation**
- **safety analysis acceptance criteria**
- **limits / acceptance criteria of other types of analysis / proofs** (strenght, lifetime, EQ, …)



TEMELÍN REACTOR POWER UPRATE – PROJECT SCOPE – ANALYTICAL PART, EQUIPMENT MODIFICATIONS

ANALYTICAL PART

- **SAFETY ANALYSES**
- **Update of methodologies for reload design and reload safety evaluation**
- **Operational modes, update of OPERATIONAL PROCEDURES**
- **STRENGHT, LIFETIME, EQ evaluations**
- **EQUIPMENT PERFORMANCE at uprated power (design functions, limits)**
- **Chemistry, radiation monitoring**
- **Environmental impact**

PERMITS

- **SONS** (nuclear regulatory body)
- **Ministry of Industry**

PERSONNEL TRAINING

- **classroom, simulator**

EQUIPMENT MODIFICATIONS

- **Electric equipment** (generator, output conduits)
- **I&C**
- **Technological systems**

STARTUP TESTS

96 → 98 → 100%

- **Standard reactor physics tests, protection system calibrations**
- **Evaluation of parameters, Equipment diagnostics tests**
- **Test of 1 abnormal transient**

TEMELÍN REACTOR POWER UPRATE – EQUIPMENT MODIFICATIONS

ELECTRIC EQUIPMENT

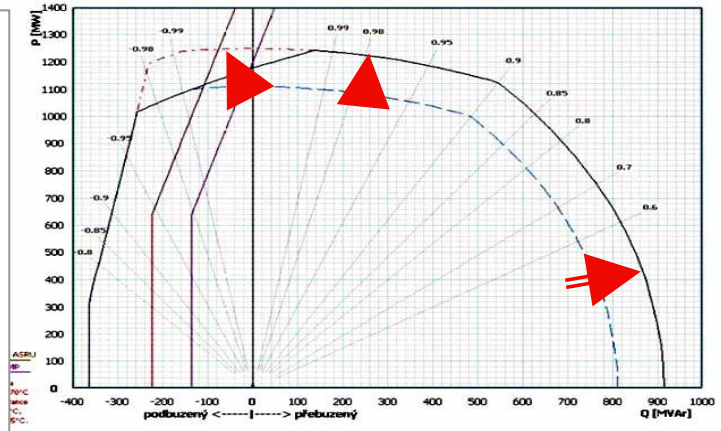
- **Uprate of generator Sn (1111 MVA => 1250 MVA) … new PQ diagram, modification of „zero conjunction“ (cooling)**
- **Modification of generator breaker cooling system**
- **Adjustment of protection settings, excitation system limiters, ASRU SW, etc. …**

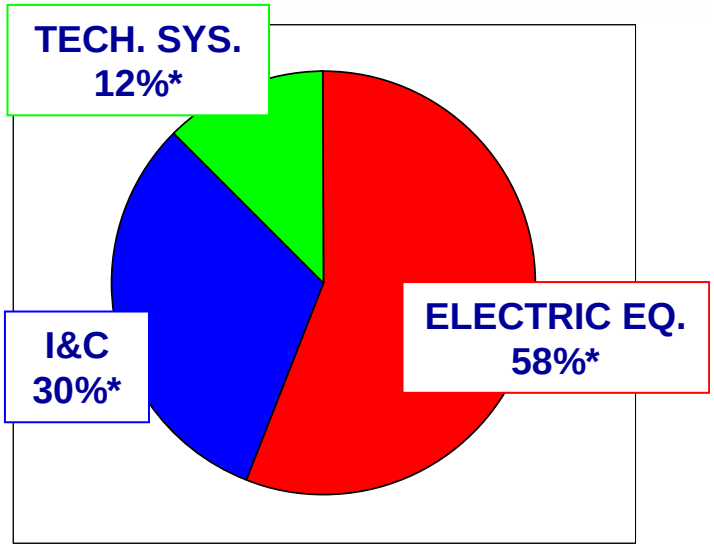
I&C

- **Modification of RTS and LS setpoints** (N-flux based setpoints, DNB protections)
- **Expansion of instrument span of several measuring channels** (Fsteam, Fconden., Fhpr)
- **Modifications of settings: main controllers, specific applications (NAPs, Beacon)**

TECHNOLOGICAL SYSTEMS

- **Increase of hydraulic head of condensate pumps**

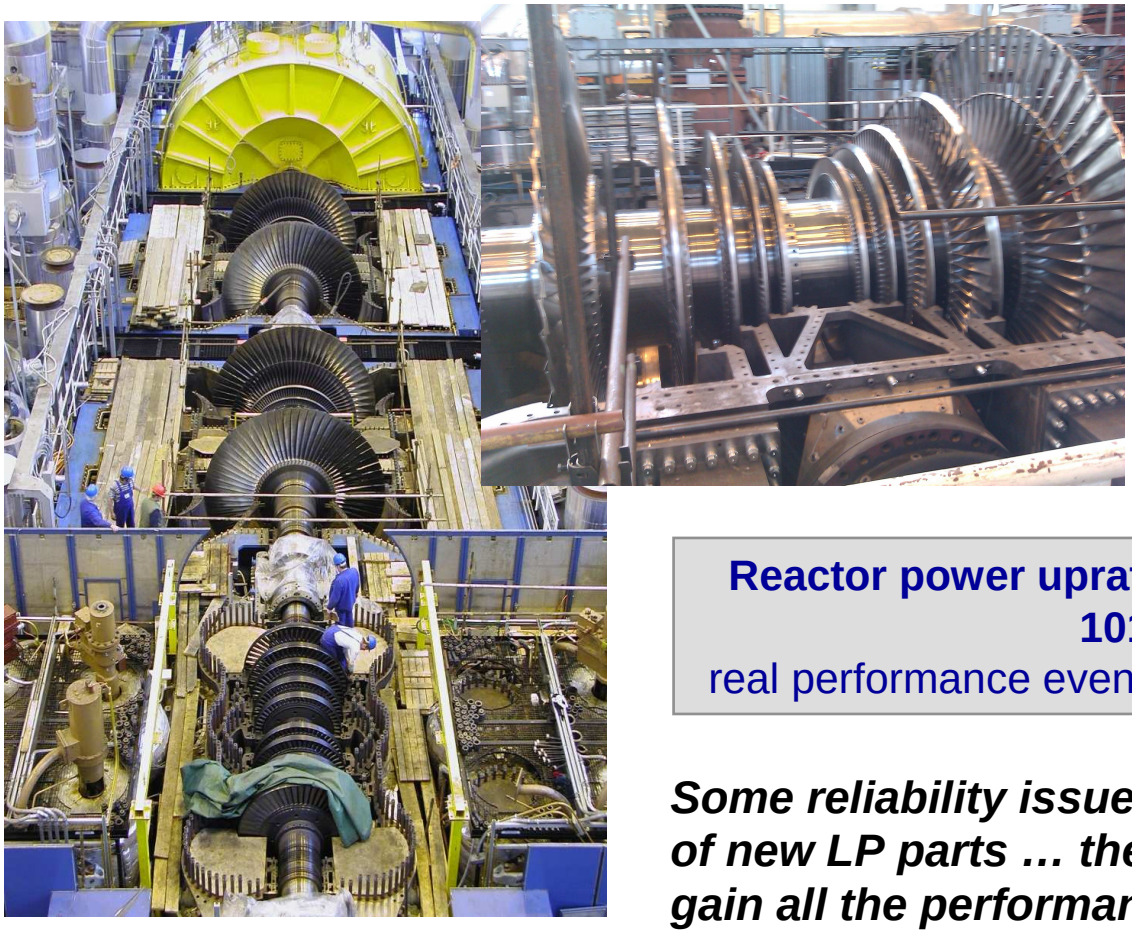




** % of total costs for equipment modifications*

FURTHER UPRATE STEPS – INCREASE OF UNIT EFFICIENCY / EL. OUTPUT

New turbine low-pressure parts (2014/15)



Increase of termodynamic efficiency = increase of MWe output (> +22 MWe/unit (*)**)**

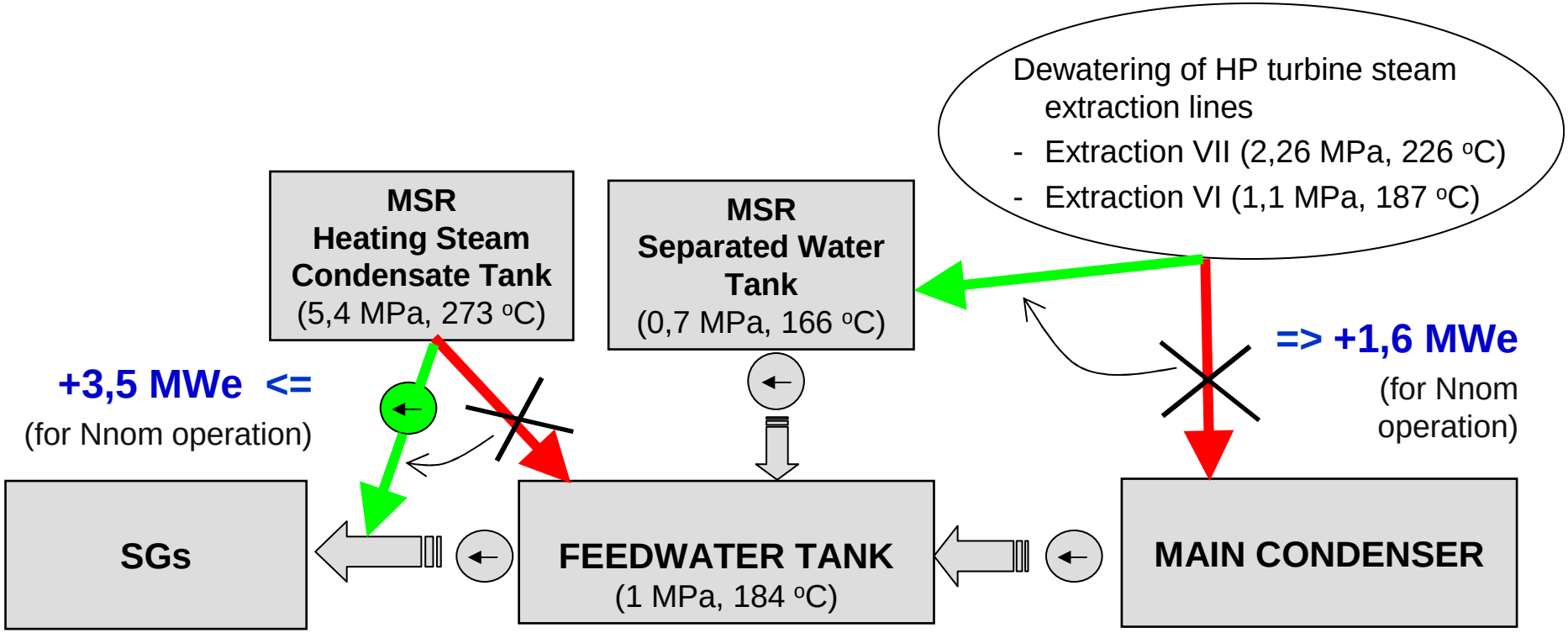
(*) *Depending on external conditions*

Reactor power uprate + new LP parts = +66 MWe/unit
1018 => 1084 MWe
real performance even better based on external conditions)

Some reliability issues during first 2 years of operation of new LP parts … their resolution is current priority to gain all the performance benefits

FURTHER UPRATE STEPS – INCREASE OF UNIT EFFICIENCY / EL. OUTPUT

Increase of energy conversion efficiency (unit power output) through optimization of secondary side design



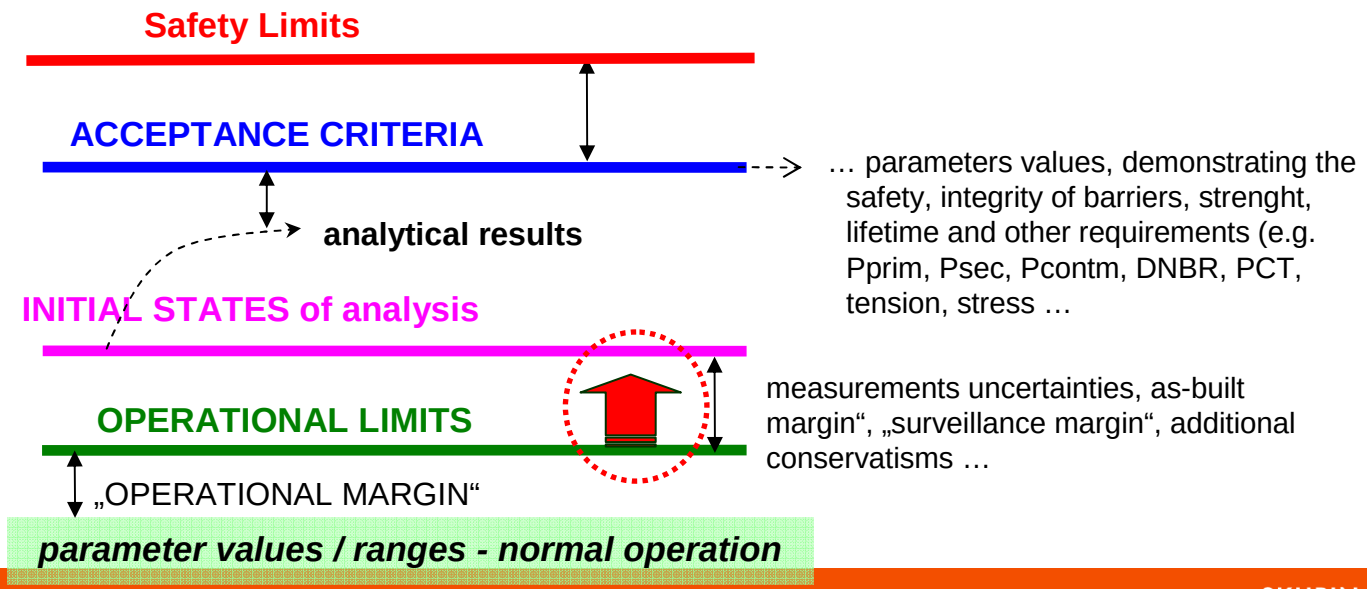
Implementation planned for 2017÷18

ADDITIONAL POWER UPRATE AT TEMELÍN VVER-1000 – PERSPECTIVES, VIABILITY

Limits of additional „safe“ and „low-cost“ power uprate:

- **New (uprated) operational state (parameters) remain covered (encountering uncertainties) by initial states of safety analyses and equipment analyses (strenght, lifetime, …) … *„mini-uprate“ principle => no need for repeated extensive analytical work***
- **Equipment can operate on increased parameters w/o attacking its limits … *=> no need for extensive equipment modifications***

… met for +1% reactor power as a maximum for existing Temelín VVER-1000 design



ADDITIONAL POWER UPRATE AT TEMELÍN VVER-1000 – PERSPECTIVES, VIABILITY

UPCOMING YEARS …

- **ČEZ will continue with modifications to increase energy conversion efficiency**
- **Additional reactor power uprate – not a current priority**
- **Outage lenghts – currently negatively influenced by repeated inspections of weld-joints and other factors – are at present the factor with most dominant effect on operational results of ČEZ NPPs**

THE END

QUESTIONS ?