ALSTOM Atomenergomash LLC developing ARABELLE™ based Turbine Islands for newly constructed and retrofitted nuclear power plants.

26.10.2011

A.M. Tsvetkov, ALSTOM Atomenergomash LLC

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ALSTOM Atomenergomash LLC (AAEM)

ALSTOM atomenergomash

49 %

51 %

2007

AAEM ALSTOM ATOMENERGOMASH

ARABELLE™

- manufacturing of half-speed turbines and generators rated 1000 – 1800 MW for NPP
- integrated turbine hall equipment supply for nuclear applications
- turbine hall equipment retrofit solutions for nuclear industry
- emergency diesel generators packages supply for nuclear applications
- service maintenance of NPP turbine hall

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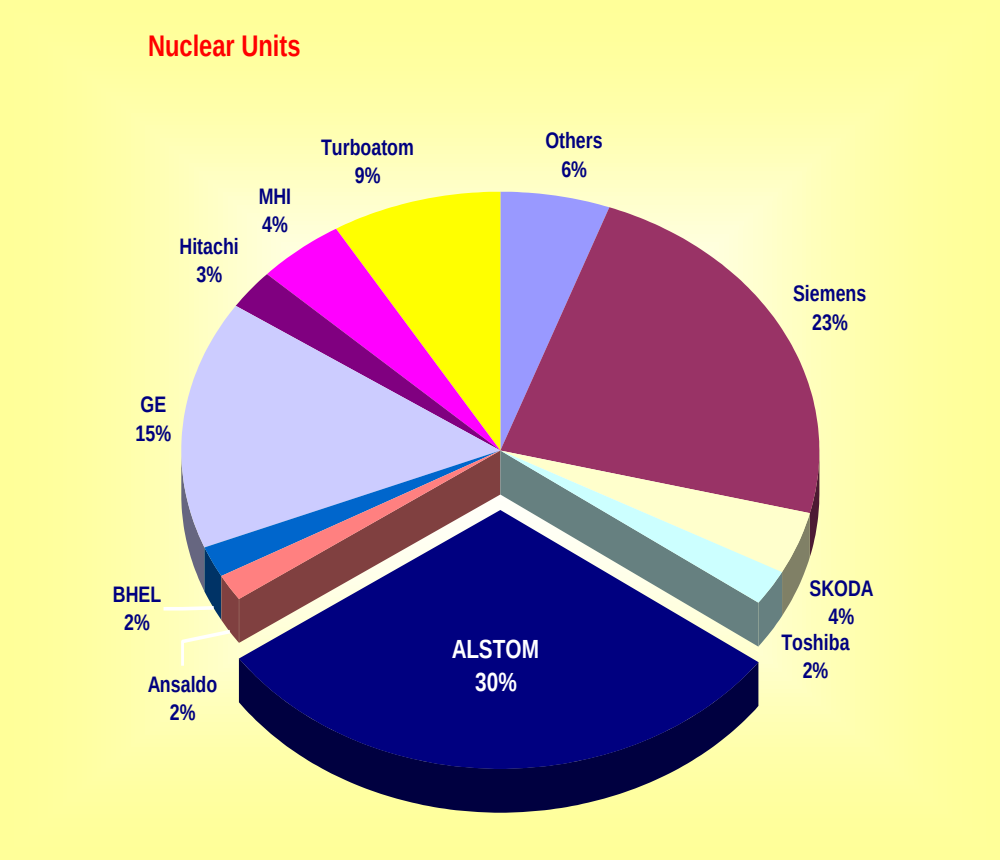
ALSTOM nuclear reference



26 ARABELLE™ are now under construction or operation worldwide

Calvert Cliffs 3
1 x 1700 MW
(engineering & long lead time item reservation)

Chooz B
2 x 1550 MW
Civaux
2 x 1550 MW
Flamanville 3
1 x 1750 MW

Ling Ao 3+4
2 x 1100 MW
Hong Yan He
4 x 1100 MW
Ningde
4 x 1100 MW
Tianwan 5+6
2 x 1100 MW

Taishan
2 x 1750 MW
Fangjiashan
2 x 1100 MW
Fuqing
4 x 1100 MW

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Participation in the new generation NPP projects

Distinctive features of new generation NPPs:

- increased thermal output of the reactor - up 3300 MW
- increased electric output – not less than 1255 MW
- increased efficiency of turbine generator unit – up to 38 %
- application of ARABELLE™ turbine generator unit with 2 LPC with LSB 1730 mm (69”)
- application of HEAS and district heating 500 MW
- 3D model of the turbine hall

Main objectives:

- maximum fleet standardization of equipment
- reduced construction period
- reduced cost of construction and maintenance

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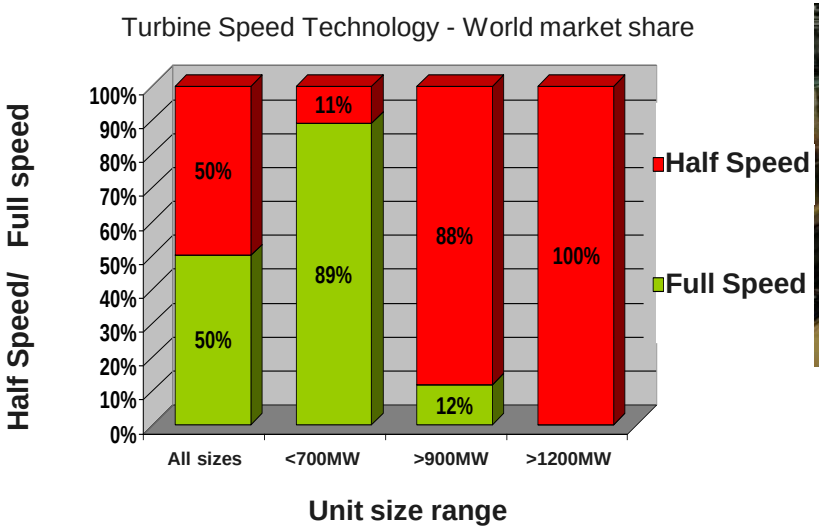
ARABELLE™ - technology for advanced NPP



Ling Ao Unit 1 (3000 rpm)

Ling Ao Unit 3 (1500 rpm)

The Customer's extra income in terms of reliability, availability, efficiency and installation and commissioning costs of the ARABELLE™ equipment versus full-speed equipment: from 360 M€ до 430 M€.

Parameter	Ling Ao 1	Ling Ao 3	Comment
Turbine speed	3000 rpm	1500 rpm	ARABELLE™ is half-speed
Machine room size	99 x 59 m	99 x 59 m	Same footprint
Reactor thermal output	2904 MWth	2904 MWth	Same reactor conditions
Cooling water temperature	23 °C	24 °C	+ 1°C warmer for unit 3
Feedwater pumps drive	Turbine	Motor	Motor driven is nowadays standard
Output (net of feed-water pumping power)	Ref .	Ref . + 81 MWe	ARABELLE™ architecture allows to boost the output by more than 8%

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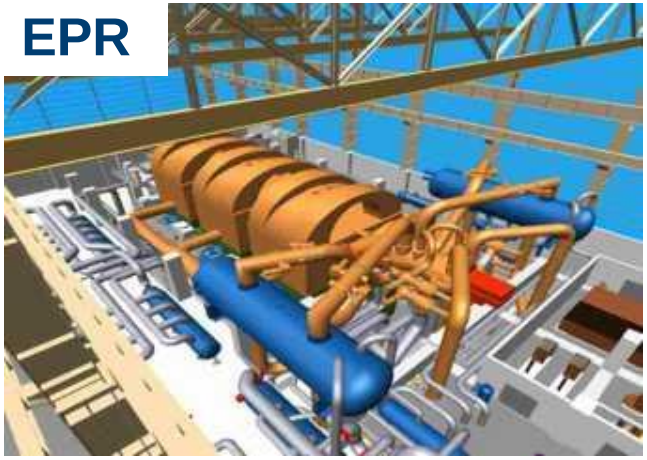
ARABELLE™ - standardized technical solutions

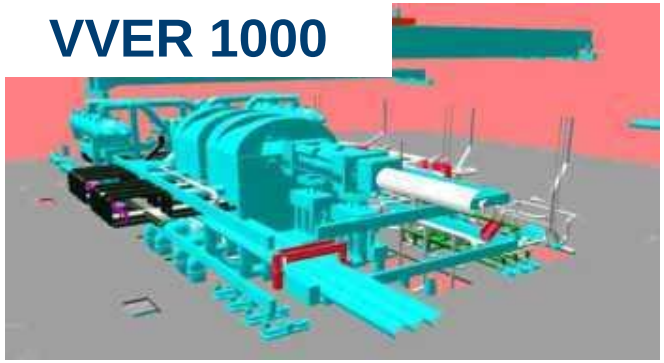
To Match Any Commercially Available Reactor

EPR



ESBWR/ABWR

VVER 1000



AP 1000

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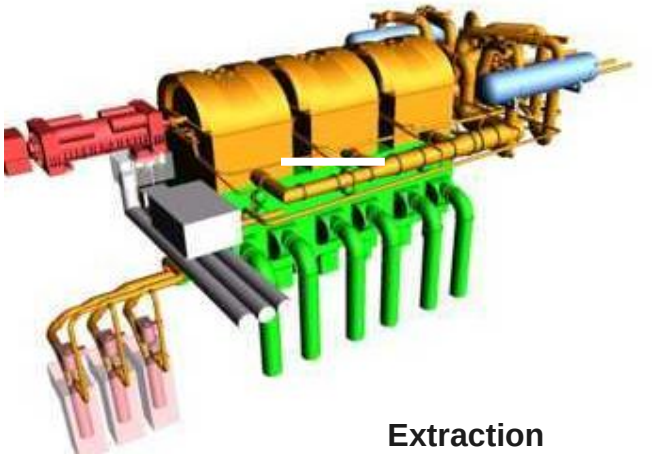
AAEM LLC – integrator of turbine hall



4-Pole generator

Extraction pumps

HP&LP Feedheaters

Circulating water pumps

LP Rotor

Condenser

MSR assembly

- **Maximum unit output:**
  - **1550MW in operation**
  - **1750MW under construction**
- **Longest last stage blade:**
  - **L = 1750mm**
- **Maximum steam turbine efficiency:**
  - **Gross efficiency > 37 %**
- **Maximum Steam turbine safety and reliability:**
  - **Reliability 99,97%**
- **Low construction costs thanks to compact design**
- **Low total operation cost**
- **The largest reference list**

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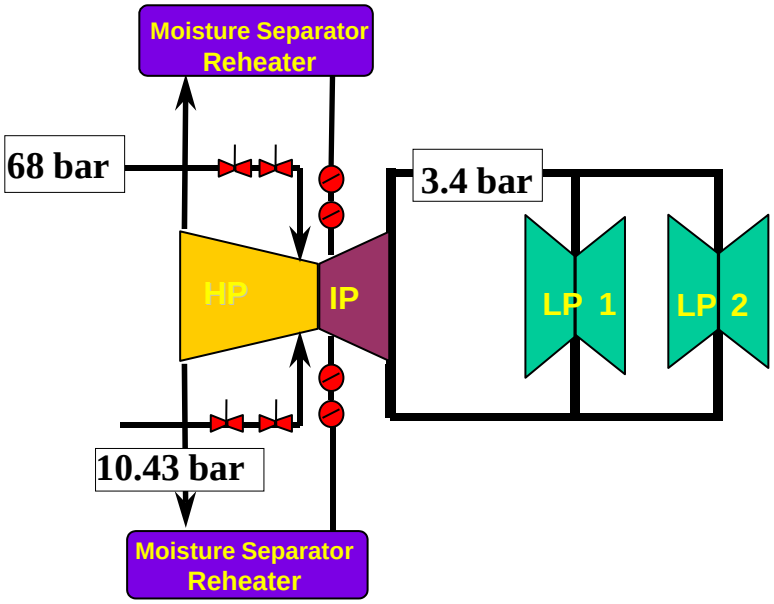
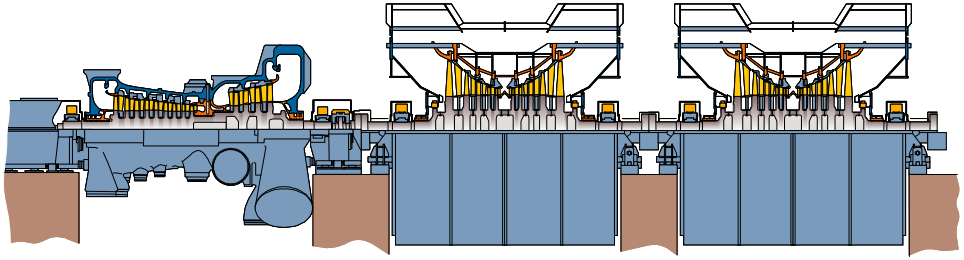
ARABELLE™ - compact design





Length of turbine set – 37,5 m

Weight of turbine set – 1880 t

HIP turbine section

LP with LSB 1730 mm

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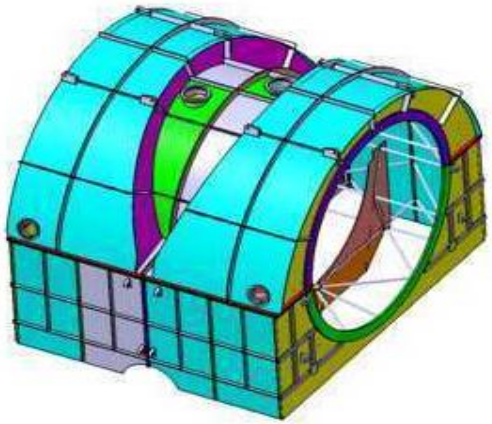
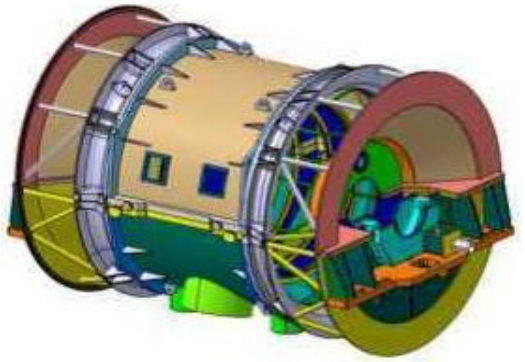
ARABELLE™ - design features

IP Exhaust

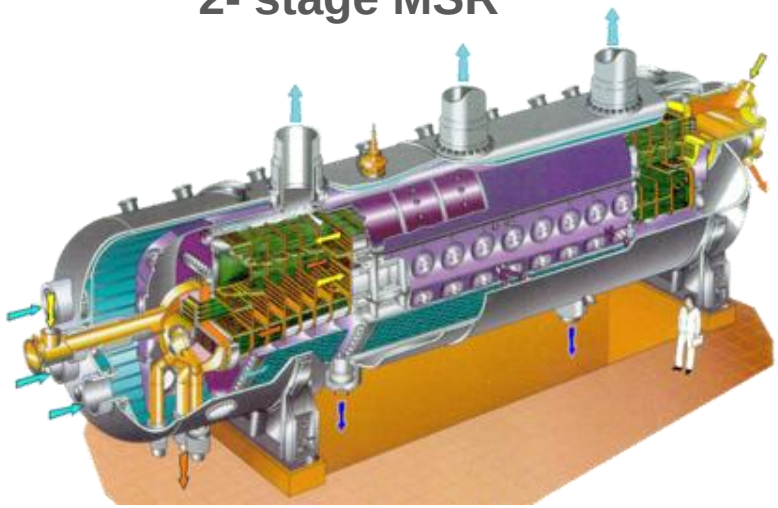
Independent LP module





The 4-pole generator

2- stage MSR



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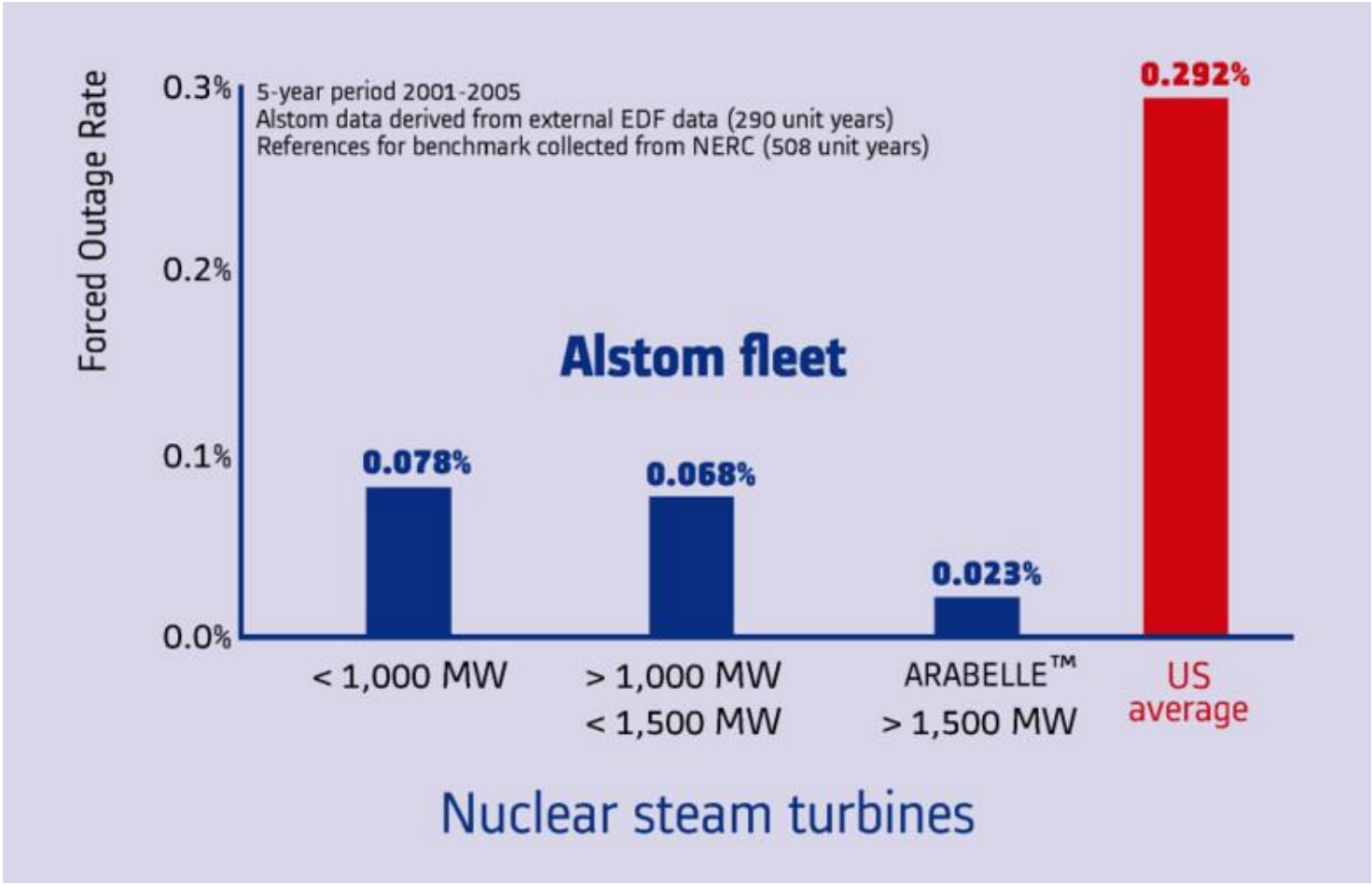
High reliability indicators

ARABELLE™ - Extensive positive feedback of experience



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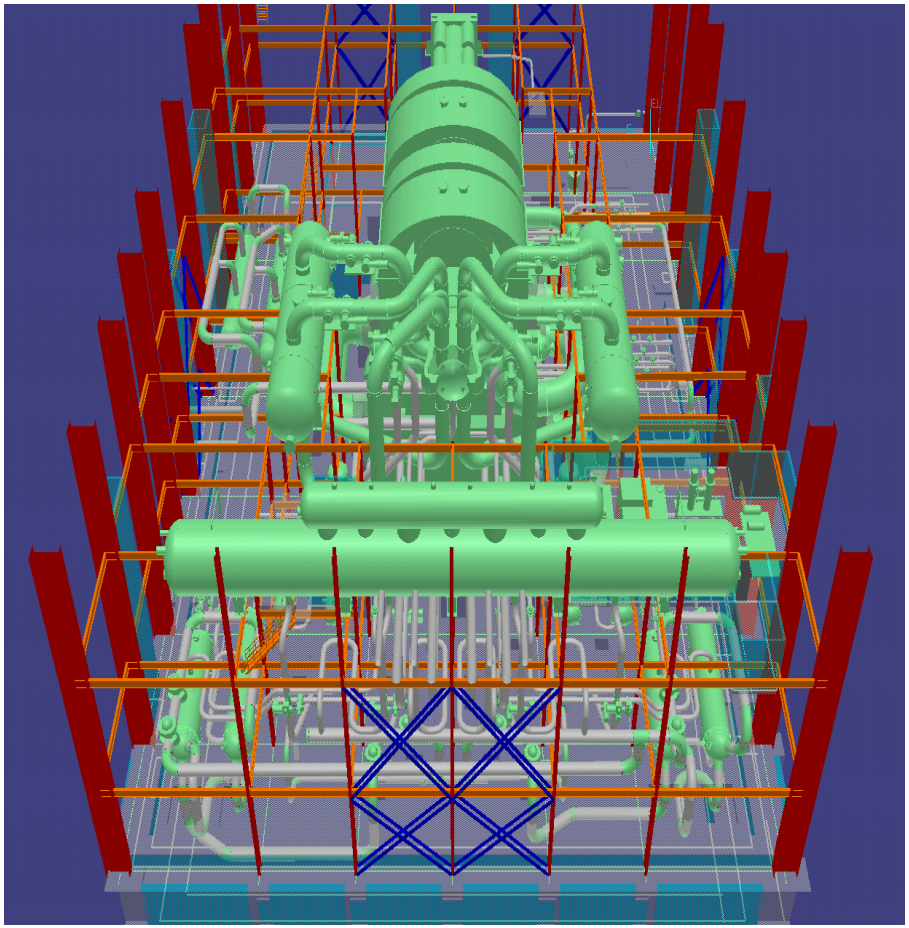
General view of ARABELLE™ based Turbine Island for new generation NPPs



The main properties:

- MSR installation 2 x 50%, Horizontal
- LP1/2 duplex heaters 2 trains, Horizontal
- LP3/4 heaters 1 train, horizontal.
- HP6/7 heaters 2 trains, horizontal.
- Turbine building footprint : Length = 91.9 m, Width = 57.2 m, Building height ~ 50 m.
- District heating heaters 3, located inside the TH building.
- Main cooling water pumps - 2 x 50%.
- Condensate extraction pumps - 3 x 50%.
- Main FW pumps - 4 x 33%.
- Start-up FW pump - 1 x 5%

Operation and maintenance indicators:

- **Availability - 97.5 %**
- **Reliability indicators - 99.7 %**
- **Capability - 1256 MW**

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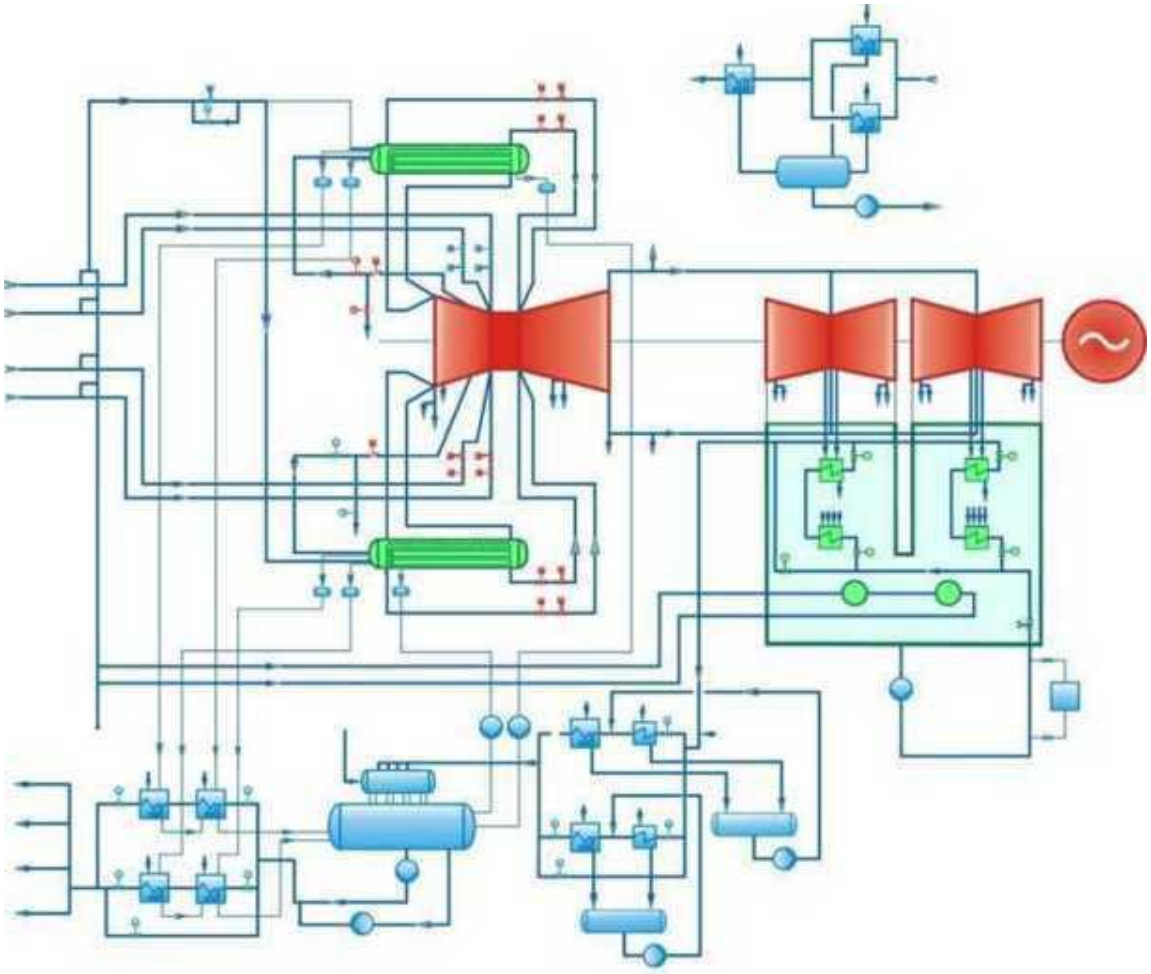
Outsourcing foreign manufacturers of NPP Turbine Hall equipment

AAEM –Plant Integrator



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Outsourced manufacturers

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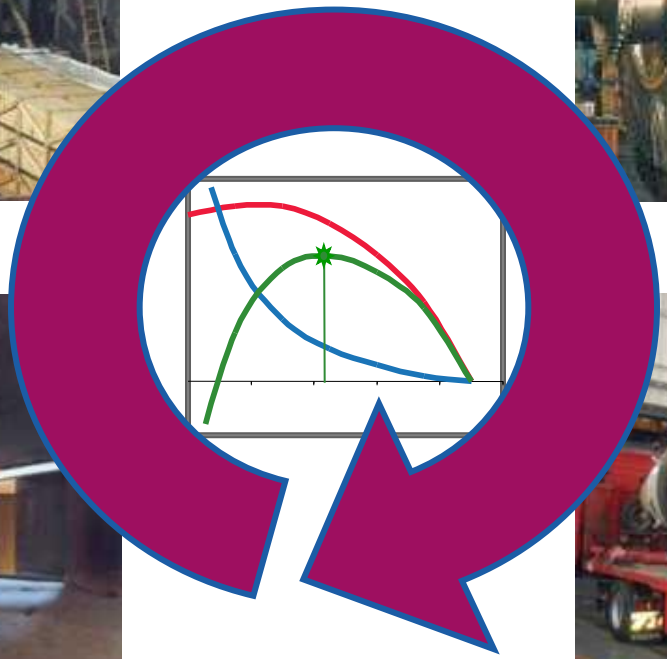
Heat sink, district heating and HEAS optimisation

Modular condenser

LP turbine selection



Main circulating water pump

Condensate pump

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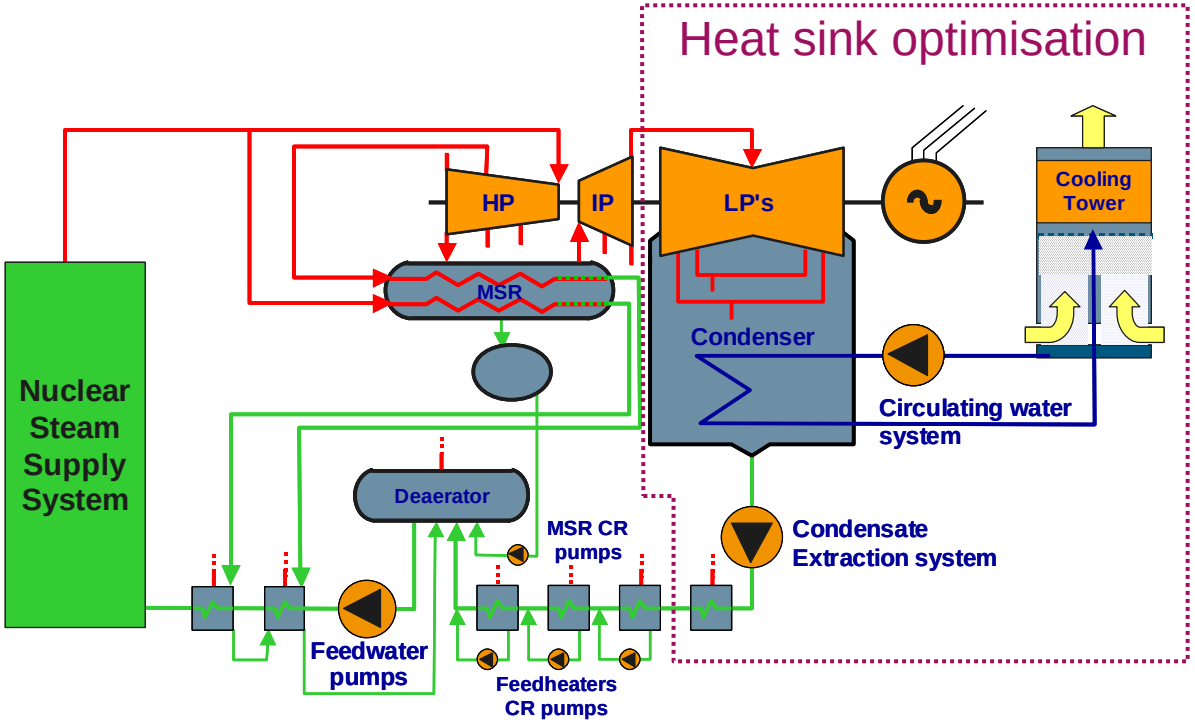
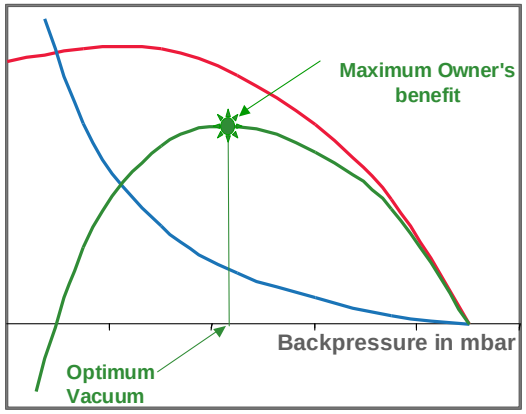
Heat sink optimisation effects
Turbine hall integration for nuclear applications

Make the Best Use out of the Nuclear Reactor

- Cold-End optimising is key for plant economic performance
  - Direct impact on Cost of Electricity





— Evaluated MWe
Extra net MW * Evaluation factor

— Investment Cost
Investment total cost based

— Owner's Benefit
Net present value

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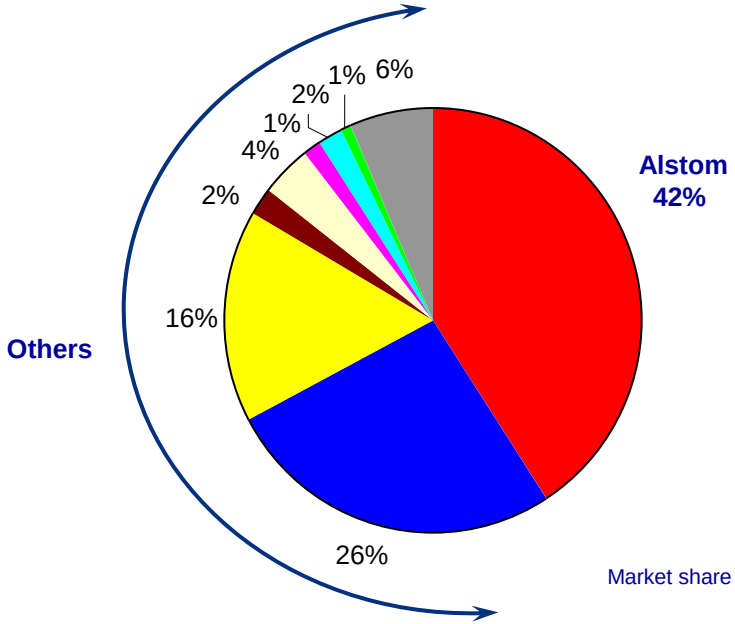
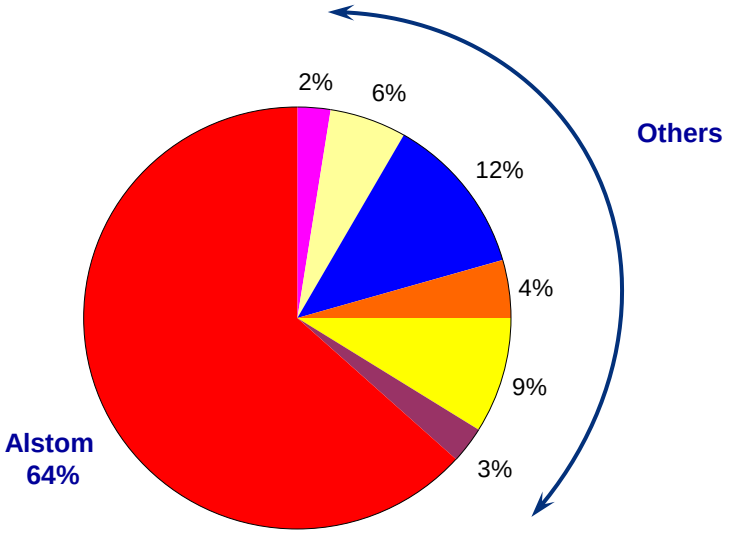
ALSTOM's experience in conventional island equipment retrofit

World leader in component and integrated retrofits

Component retrofits



Integrated retrofits



Market share analysis represents period FY04-FY08.

Source: Internal

780 cylinders retrofitted (320 retrofits of third party machines)
Leading the concept of integrated retrofits for turbine island

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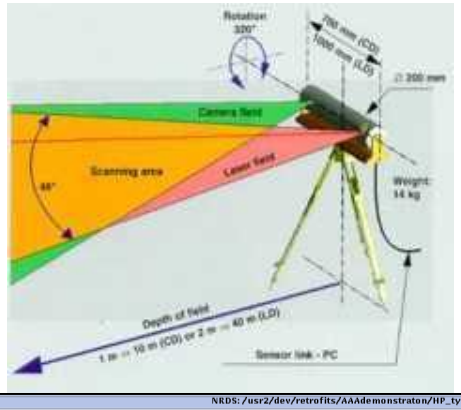
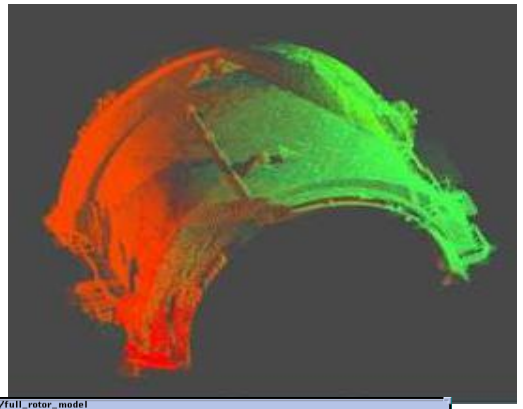
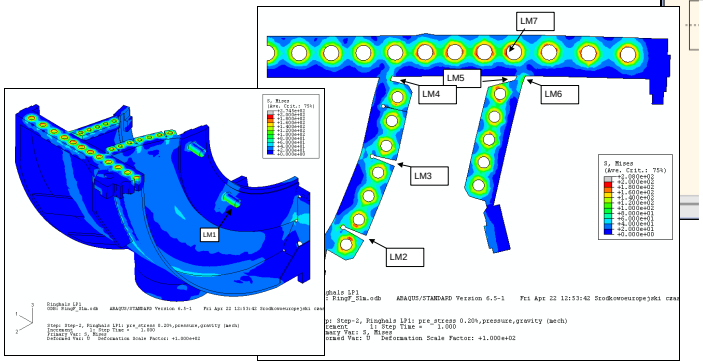
Retrofit. Design procedure

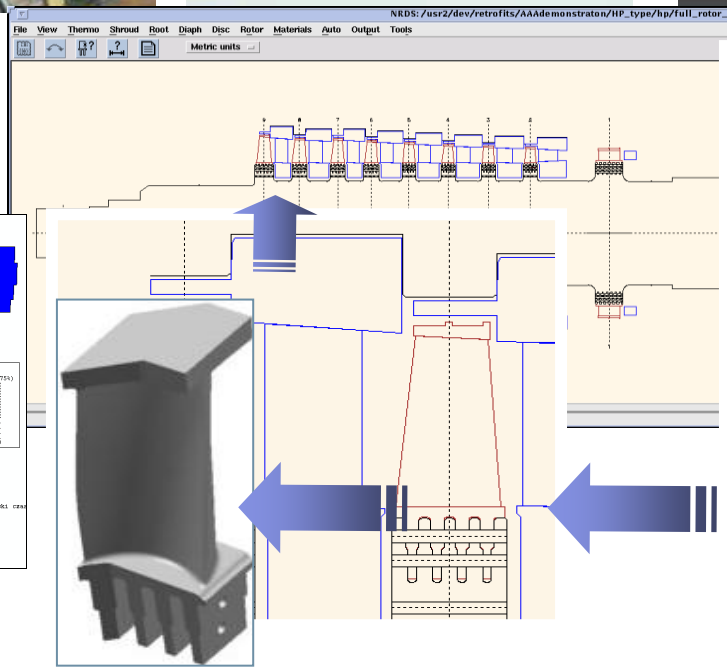
Lazer equipment utilization at site

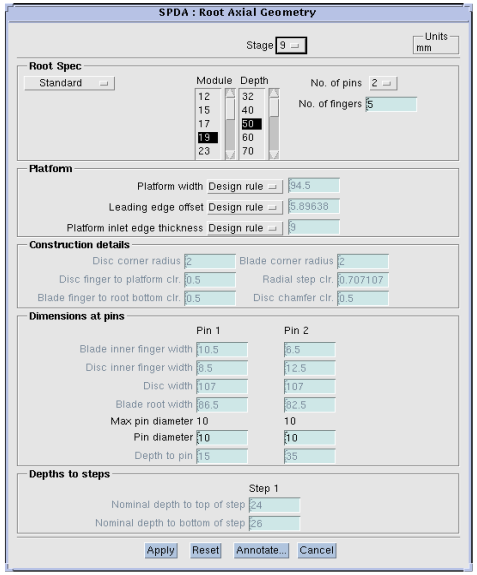




Integrated instruments for design and calculations







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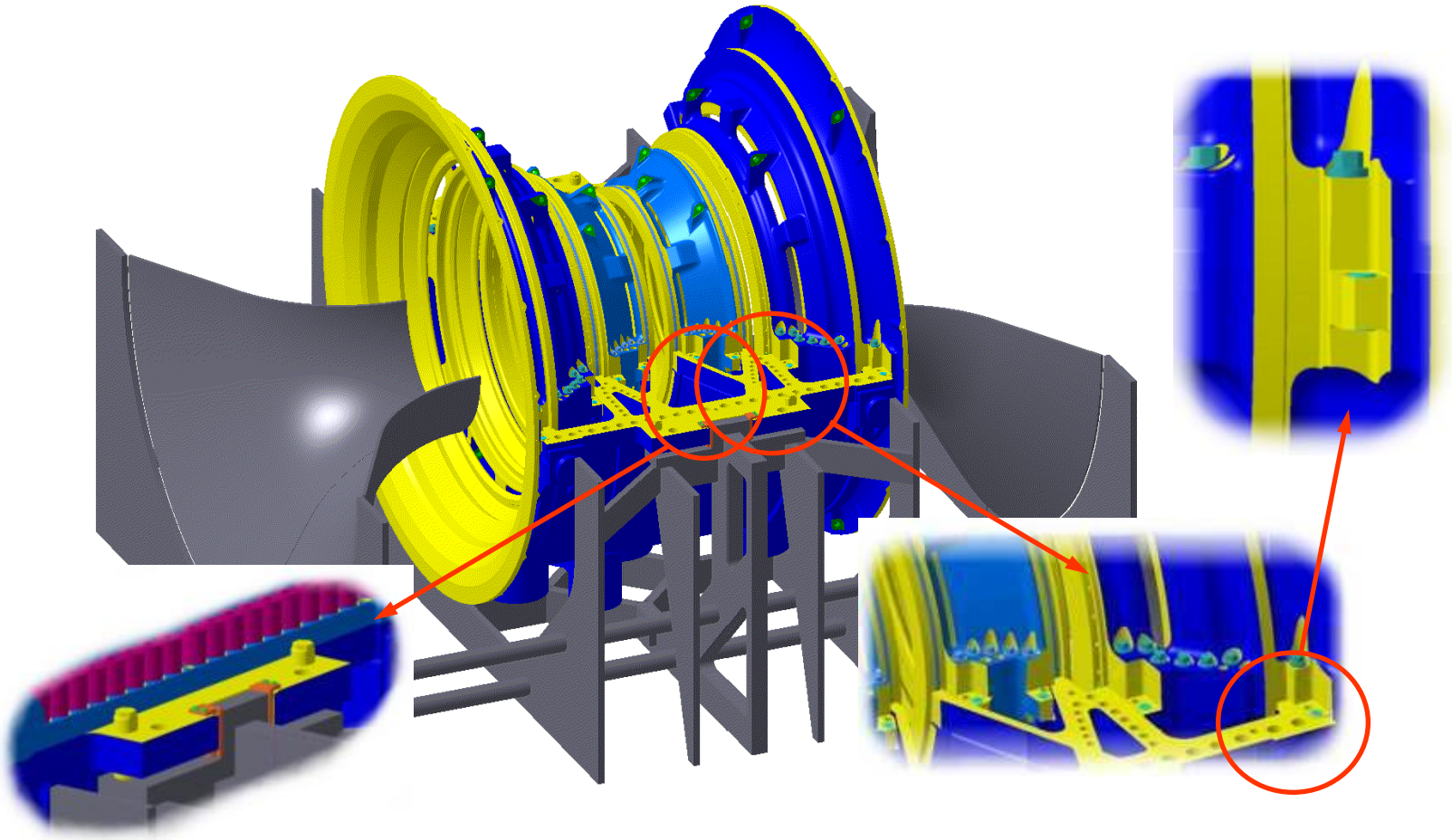
Retrofit. Design procedure

Interface analysis for steam turbines of the other manufacturers



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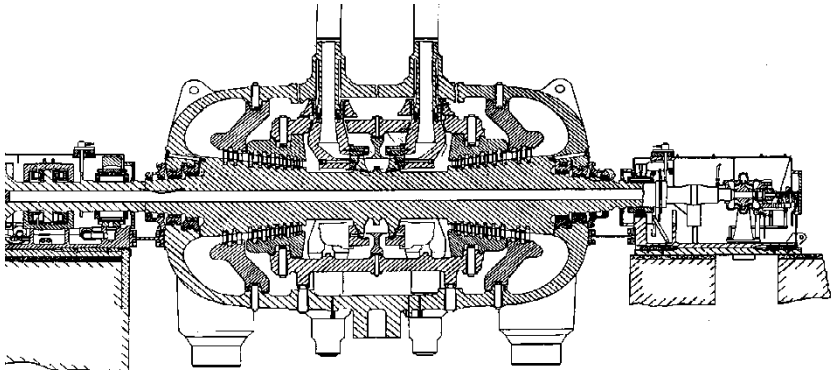
Turbine retrofits. Technical options

Original design

Double flow cylinder
- reactive type blading

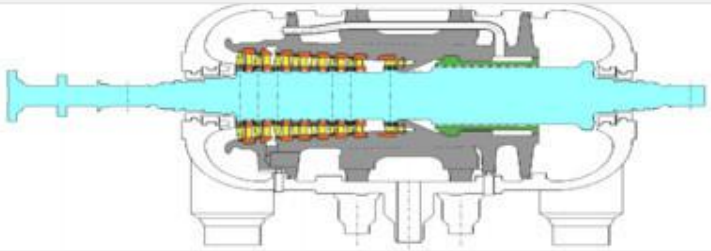


Various retrofit options implemented

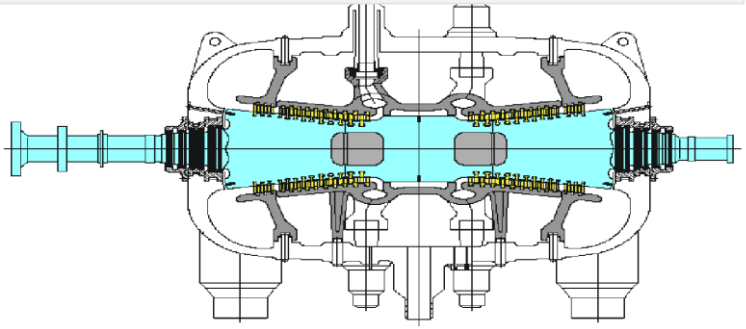
Turbine producer not involved

Targeted output achieved and turbine problems cured thanks to the selected technical retrofit options

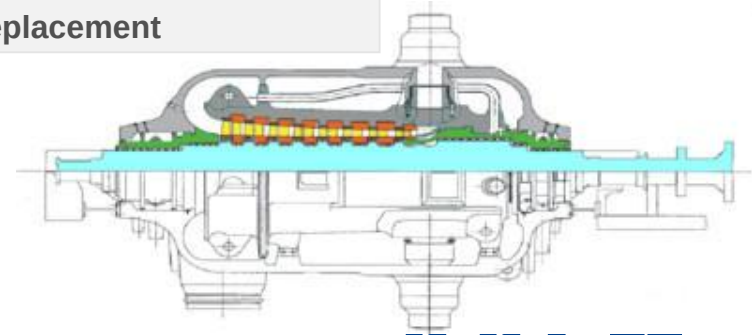
Single flow cylinder – reactive type blading



Inner casing components optimization



Cylinder replacement



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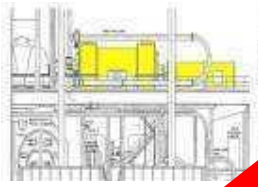
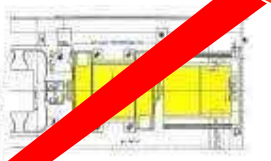
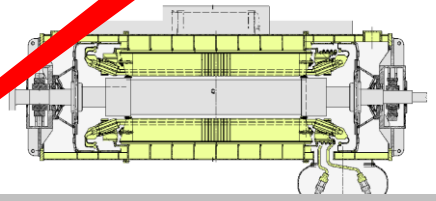
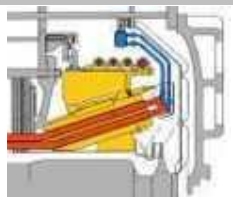
Generators retrofit
Nuclear Rewind, Upgrade & Retrofit

Capability

Performance (MVA, MVAR, efficiency, reliability …)
Outage time
Extended life time

Replacement Generators	  	Integrated solutions to fit new generators within existing environment, requalification of auxiliaries, new excitation systems, functional scope
Generator Mid-Sections	 	“Plug and operate” solutions : stator replacement, rotor replacement or rewind, new excitation systems, requalification of auxiliaries
Generator Rewinds / Upgrades	 	Stator rewinds, rotor rewinds, new excitation systems, technology changes, additional loops (water)
Maintenance		Parts and Field Services

Solution depending on customer need.

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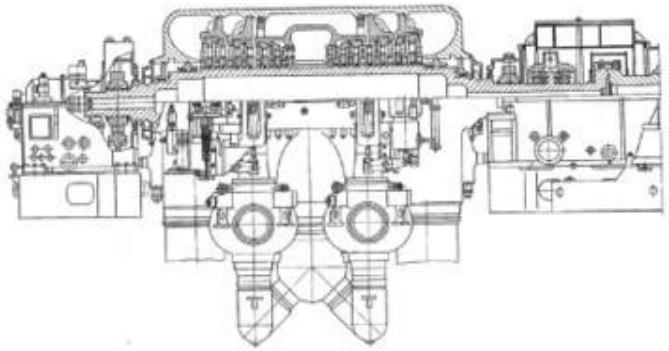
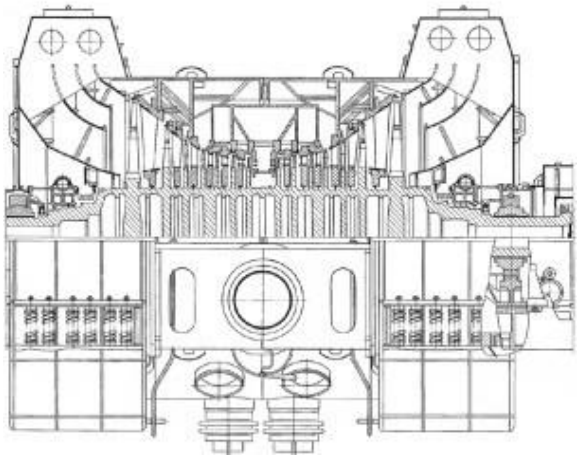
Retrofit. Consolidated data for the operated turbine

- K-1000-60/1500-2 - 1500rpm
- 1 x HP double flow module
  - 2 x 7 stages
  - Active type blading
    - Disc-and-diphragm design
    - Welded rotor
  - Полный подвод пара
- 3 x LP double flow module
  - 2 x 7 stages
  - Active type blading
    - Disc-and-diphragm design
    - Welded rotor





Last stage blade: 1450mm (57”) на ϕ2700mm – 18,9m^2

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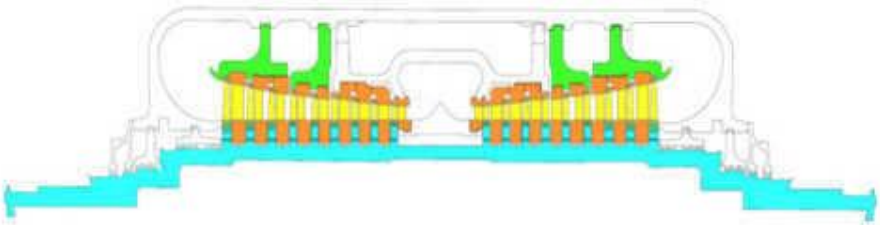
Balakovo NPP Retrofit
HPC and LPC scope options

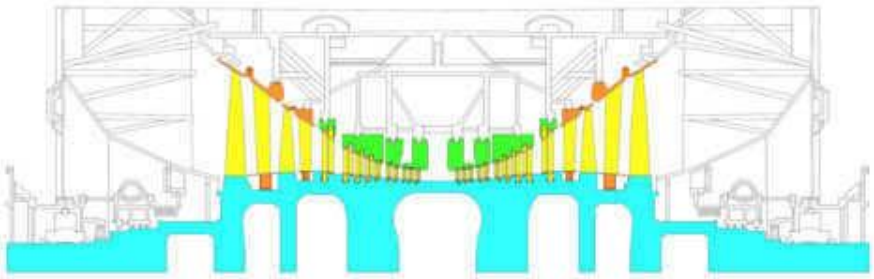
New HP cylinder

- Active type blading (disc-and-diaphragm design)
  - Finalization of the blading type active versus reactive depends on ratio expenses-profit
- 9 stages per flow
- Preliminary scope of works includes:
  - Bladed rotor
  - Diaphragm
  - Diaphragm sockets for 4-9 stages (operated 1-3 stage sockets of diaphragms remain unchanged)
- Welded rotor
- Full arc admission

New LP cylinder

- Reactive blading
- 12 stages per flow
- Preliminary scope of works includes:
  - Rotor
  - Stationary and moving blades
  - New sockets of blades – inner casing shall remain unchanged (subject to additional estimation)
- LSB 57”
- Drum type welded rotor





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Conclusion

1. Currently 33 out of 38 nuclear units rated 900 MW and over are equipped with low speed turbines. 26 of them are based on ARABELLE™ technology.
2. Tests of the 1000MW ARABELLE™ Half-Speed Turbine Plant conducted in the 3rd power unit at Ling-Ao NPP (China) in 2010 have shown an electric power increase of above 8% versus full-speed double-flow turbine design given the same conditions on-site.
3. According to Alstom/AAEM research, the Customer's extra income in terms of reliability, availability, efficiency and installation and commissioning costs of the ARABELLE™ equipment versus full-speed equipment would vary in the following range: € 360 million per unit at the rate of € 25/MWh, or € 430 million per unit at the rate of € 30/MWh.
4. 2011 agreement is reached to involve AAEM with ARABELLE™ technology for the participation in new nuclear units to be constructed in Russia and abroad.
5. Basing on Alstom engineering solutions, AAEM adds value to its competence in retrofitting equipment for nuclear power plants in operation.

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Thank you for your attention!

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