KWh cost management in complex long-lead equipment design - examples and prospects

Atomexpo 2014
June 9-11 2014

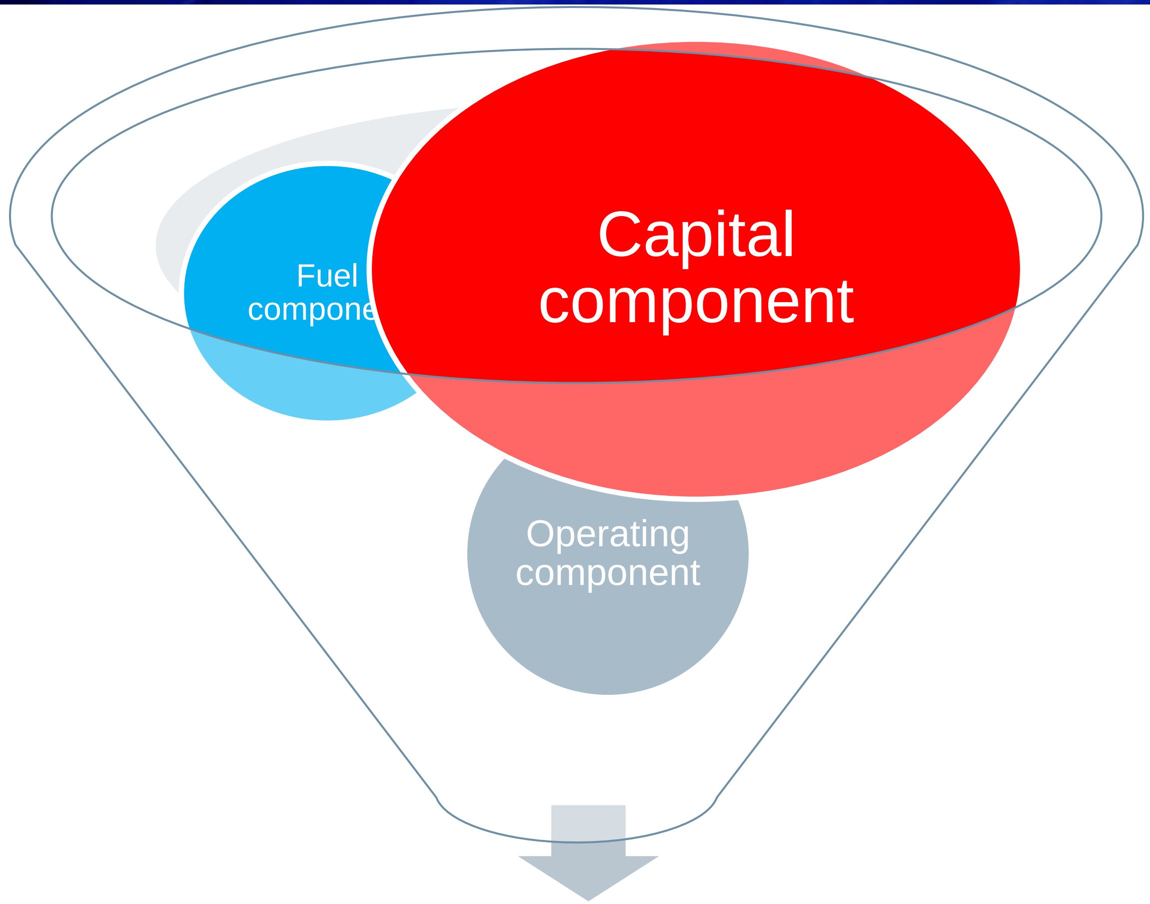
I. A. Vergizaev
General Director
AAEM LLC

AAEM
ALSTOM ATOMENERGOMASH

Foreword

- Investor's goal is to select the most efficient economic solution, while supplier's goal is to offer it.
- The electricity generation cost is one of the most important factors that influence the investment choice.
- Supplier can assist investor in achieving maximum efficiency of capital expenditures through optimizing the technical solutions for long-lead equipment.

Main components of electricity generation cost



ELECTRICITY GENERATION COST

AAEM
ALSTOM ATOMENERGOMASH

Main components of electricity generation cost

C_K

- CAPITAL COMPONENT FOR A SPECIFIC NI SIZE
- C_K ~ COST OF CONSTRUCTION / (EFFICIENCY X AVAILABILITY FACTOR)

C_{fuel}

- FUEL COMPONENT FOR A SPECIFIC NI SIZE
- Cfuel ~ 1 / (EFFICIENCY X AVAILABILITY FACTOR)

C_{oper}

- OPERATING COMPONENT FOR A SPECIFIC NI SIZE
- Coper ~ COST OF MAINTENANCE / (EFFICIENCY X AVAILABILITY FACTOR)

AAEM
ALSTOM ATOMENERGOMASH

Share of the turbine island equipment supplier in the capital component of the cost of electricity generated by NPP

SHARE OF THE CAPITAL COMPONENT IN THE ELECTRICITY GENERATION COST ≈ 70%

↑

SHARE OF THE TURBINE ISLAND EQUIPMENT IN THE CONSTRUCTION COST ≈ 15 %

↑

SHARE OF THE LONG-LEAD EQUIPMENT IN THE TURBINE ISLAND EQUIPMENT COSTS ≈ **70** %

Managing the electricity generation cost through optimizing the design & engineering solutions for the turbine island

The technical characteristics of the long-lead equipment greatly influence the NPP performance with a specific NI type

Relatively low share of the long-lead TI equipment cost in the NPP cost (≈ 8-10 %)

OPTIMIZING THE DESIGN SOLUTIONS FOR THE TURBINE ISLAND IS ONE OF THE KEY FACTORS IN OPTIMAL ELECTRICITY GENERATION COST MANAGEMENT

Managing the capital component of the electricity generation cost = managing fixed costs

1. The cost of capital investments in NPP construction is redeemed by including it in the electricity cost through depreciation.

2. The depreciation costs are fixed costs

3. Managing the capital component of the electricity cost = managing fixed costs

Productivity growth

\+

Reducing investment costs

→ Fixed cost management methods

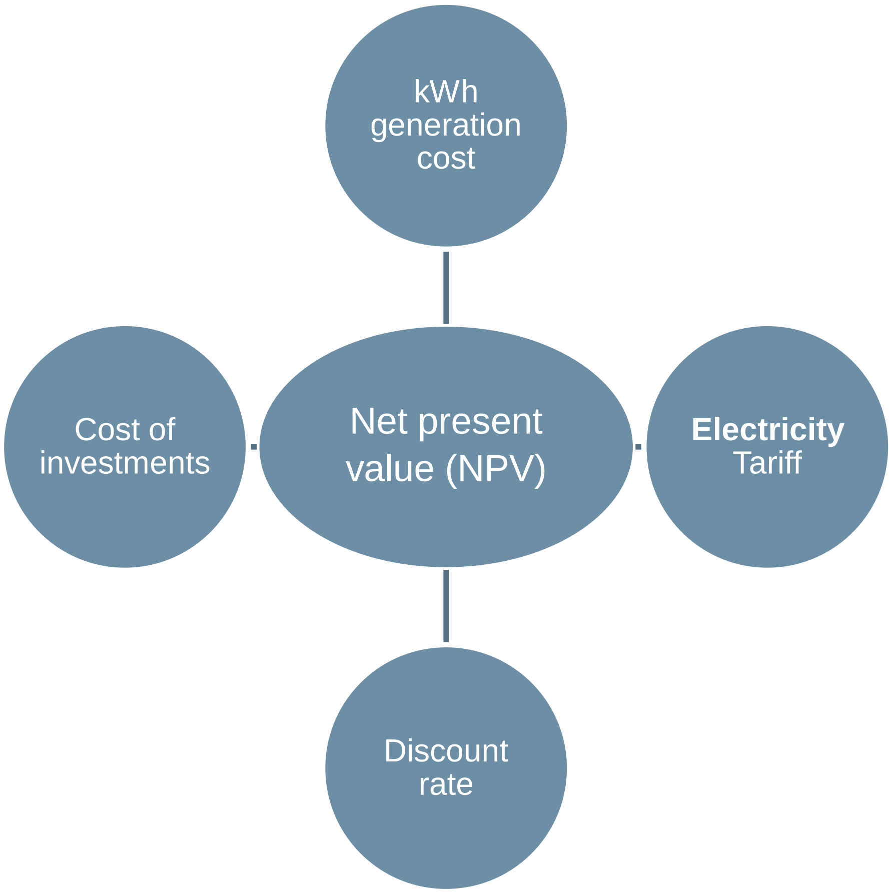
Taking into account:

- relatively low share of the long-lead TI equipment cost in the total NPP cost and
- significant impact of the technical characteristics of the long-lead equipment on the NPP performance with a specific NI type

it is obvious that such factor as productivity growth plays even greater role in managing the capital component of the electricity cost.

From kWh generation cost management to economic efficiency management

- Net present value (NPV) is a universal measure of economic efficiency of investments.
- NPV is the difference between all cash inflows and outflows adjusted to the current time (the time of investment project evaluation).
- Change in NPV (Δ NPV) is an indicator that helps assess the impact of design solutions for the turbine island on the economic efficiency of NPP construction.



ALSTOM ATOMENERGOMASH

Basic steps in selecting design solutions for long-lead TI equipment

Step 1

- Technical study of possible options to meet customer requirements

Step 2

- Calculation of ΔNPV for different options
- Ranking the options based on the economic attractiveness for the customer
- Blocking off projects that are inefficient for the customer

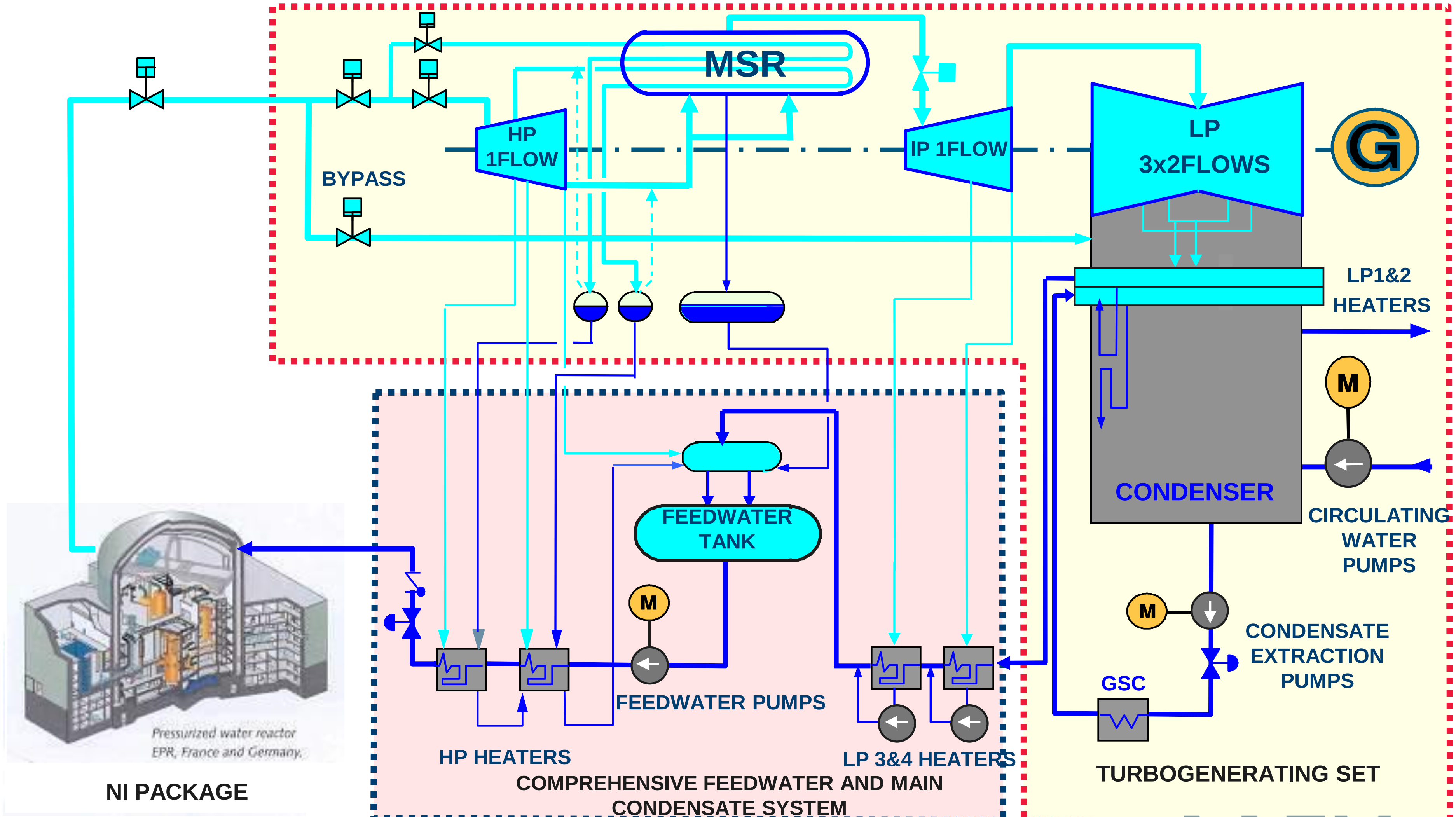
Step 3

- Picking optimal design solutions with account for economic efficiency under the conditions specified by the customer

AAEM
ALSTOM ATOMENERGOMASH

Flow diagram of the NPP steam-water cycle

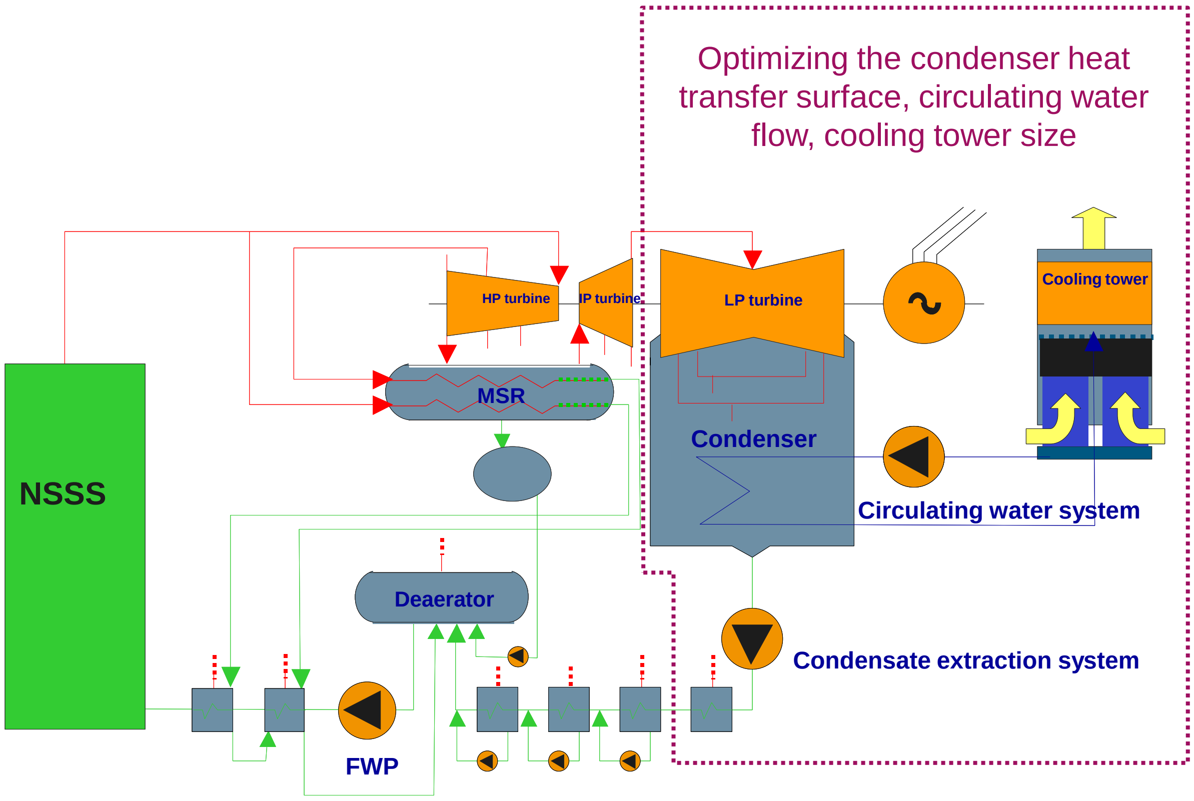
Maximum effect of coherent integration



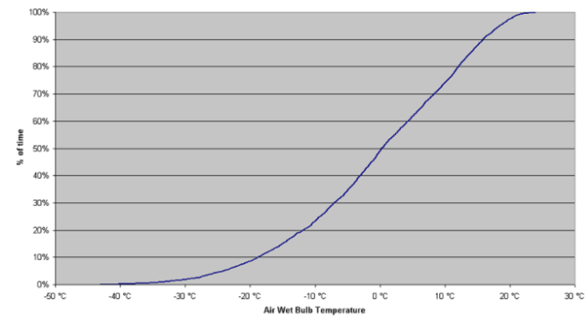
AAEM
ALSTOM ATOMENERGOMASH

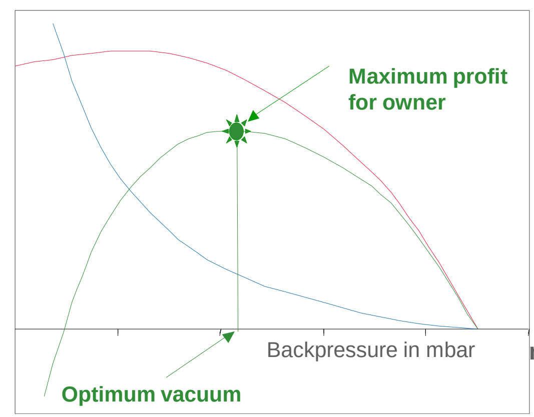
ARABELLE™ turbine generator set
Optimizing low-potential part of steam-water cycle

- Optimizing the low-potential part of the turbine generator set is a key factor in reducing the cost of kWh generation



Year climatics



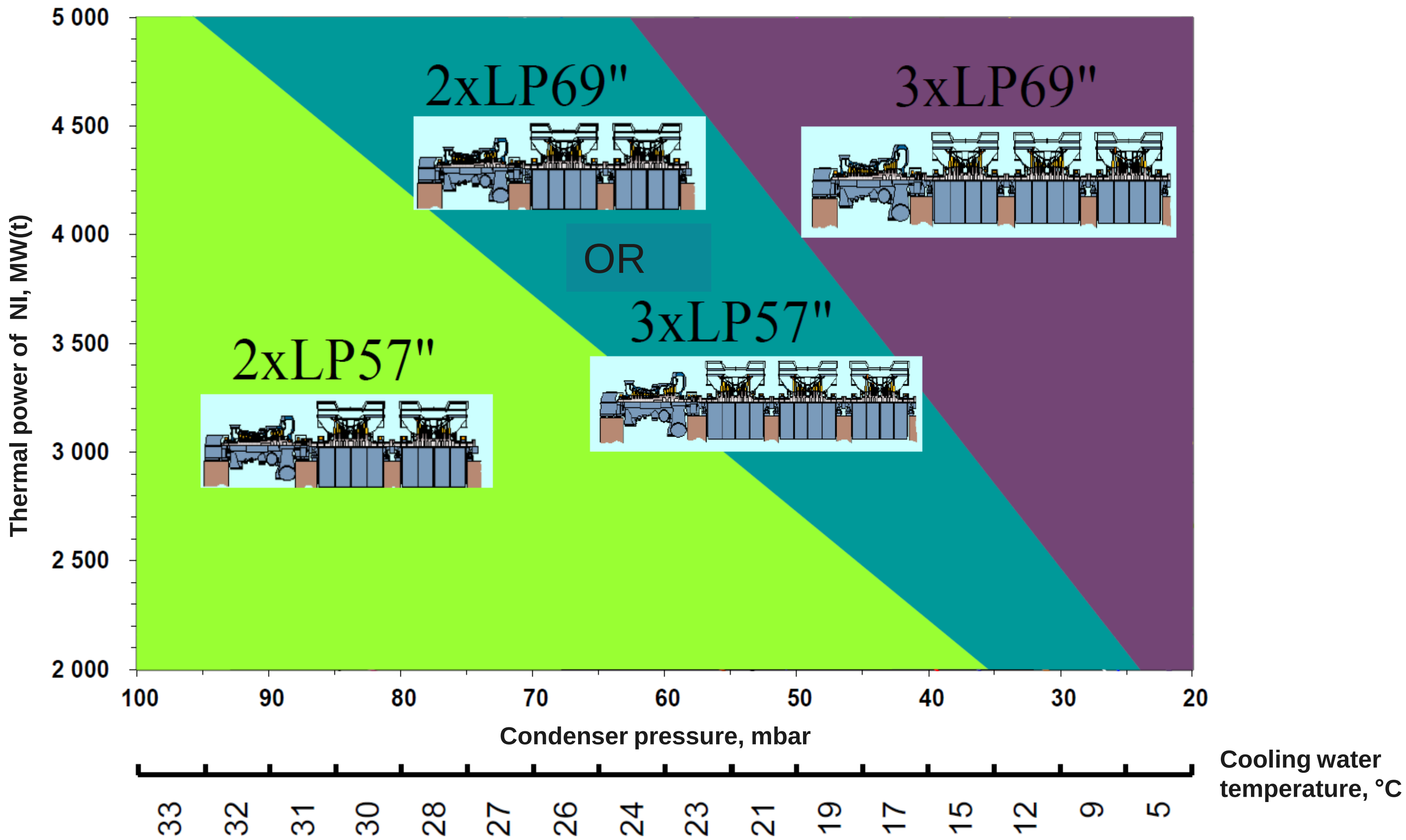


Estimated electric power
Change in net power
Investments
by cost method
Benefit for owner
net present value

Atomexpo 2014, Moscow, June 9-11, 2014, pp. 11
KWh cost management in complex long-lead equipment design. examples and prospects

AAEM
ALSTOM ATOMENERGOMASH

EXAMPLE: FLEXIBILITY OF ARABELLE™ TECHNOLOGY
Broad coverage of any NIs and cooling conditions: possible turbine configurations



Atomexpo 2014, Moscow, June 9-11, 2014, pp. 12
KWh cost management in complex long-lead equipment design. examples and prospects

AAEM
ALSTOM ATOMENERGOMASH

Assessing the impact of the main characteristics of the long-lead turbine island equipment on the economic efficiency of the NPP

Performance (efficiency)

$$\Delta NPV_{PERF} = \sum_{t=0}^{n}[(1+i)^{-t} * (1+t*r) * C_{EL}^{0} * Q_{NI} * \Delta EFF * k_{AVA} * k_{LOAD} * 8760]$$

Where n – target period (usually 40 years); t – number of target year; i – discount coefficient; t=0 – reference starting year; r – inflation factor for electricity tariff; C_{EL}^{0} – electricity tariff for a year t=0, €/(MW*h); Q_{NI} – capacity of nuclear island, **MWth**; Δefficiency – difference in **reference level of efficiency** compared to a rival; k_{AVA} – directive **availability** factor; k_{LOAD} – directive loading factor.

Reliability (FOH)

$$\Delta NPV_{REL} = \sum_{t=0}^{n}[(1+i)^{-t} * (1+t*r) * C_{EL}^{0} * N_{EL}^{NET} * \Delta FOH]$$

Where N_{EL}^{NET} – Net electric power of unit, **MWel**; ΔFOH – difference in the reference level of **reliability** compared to a rival, **forced outage hours**/(unit/year).

Availability (k_{AV})

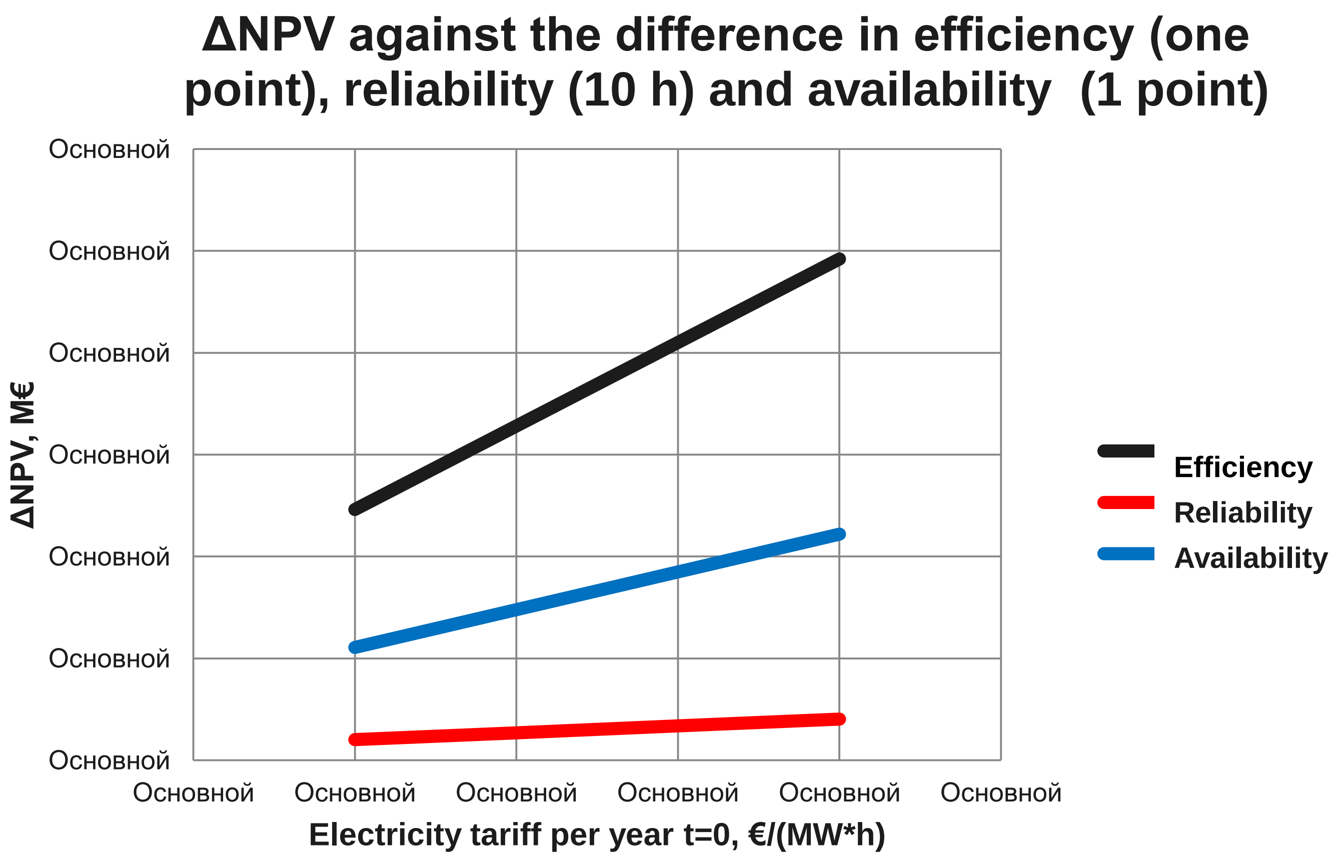
$$\Delta NPV_{AVA} = \sum_{t=0}^{n}[(1+i)^{-t} * (1+t*r) * C_{EL}^{0} * 8760 * N_{EL}^{NET} * k_{LOAD} * \Delta k_{AVA} * k_{UT}]$$

Where ΔkUT – difference in the **reference utilization level** compared to a rival.

Atomexpo 2014, Moscow, June 9-11, 2014, pp. 13
KWh cost management in complex long-lead equipment design. examples and prospects

AAEM ALSTOM ATOMENERGOMASH

Example of calculating the impact of the main characteristics of the long-lead turbine island equipment on the economic efficiency of the NPP



Q_{NI} = 3212 MWth; N_{EL}^{NET} = 1110 MWel; n = 40 years; i = 8 %/ year; r = 4 %/ year; k_{AVA} = 0.92; k_{LOAD} = 0.9

Conclusion

An optimal choice of design and engineering solutions for the long-lead TI equipment can help the NPP plant owner obtain maximum technical and economic benefits from its operation during the entire life through reducing the share of the capital component in the cost of kWh of electricity.

Bigger positive discounted cash flow due to better technical characteristics as compared to the negative cash flow associated with the investment makes it possible to reduce the share of the capital component in the kWh cost.

AAEM
ALSTOM ATOMENERGOMASH

Thank you for your time!