TOMSK POLYTECHNIC UNIVERSITY

NPP ECONOMIC EFFICIENCY

ECONOMIC INDICATORS

- NPP capital costs

- Generating electricity and heat costs

- **Total cost**

- Capacity factor

SPECIFIC CAPITAL COSTS
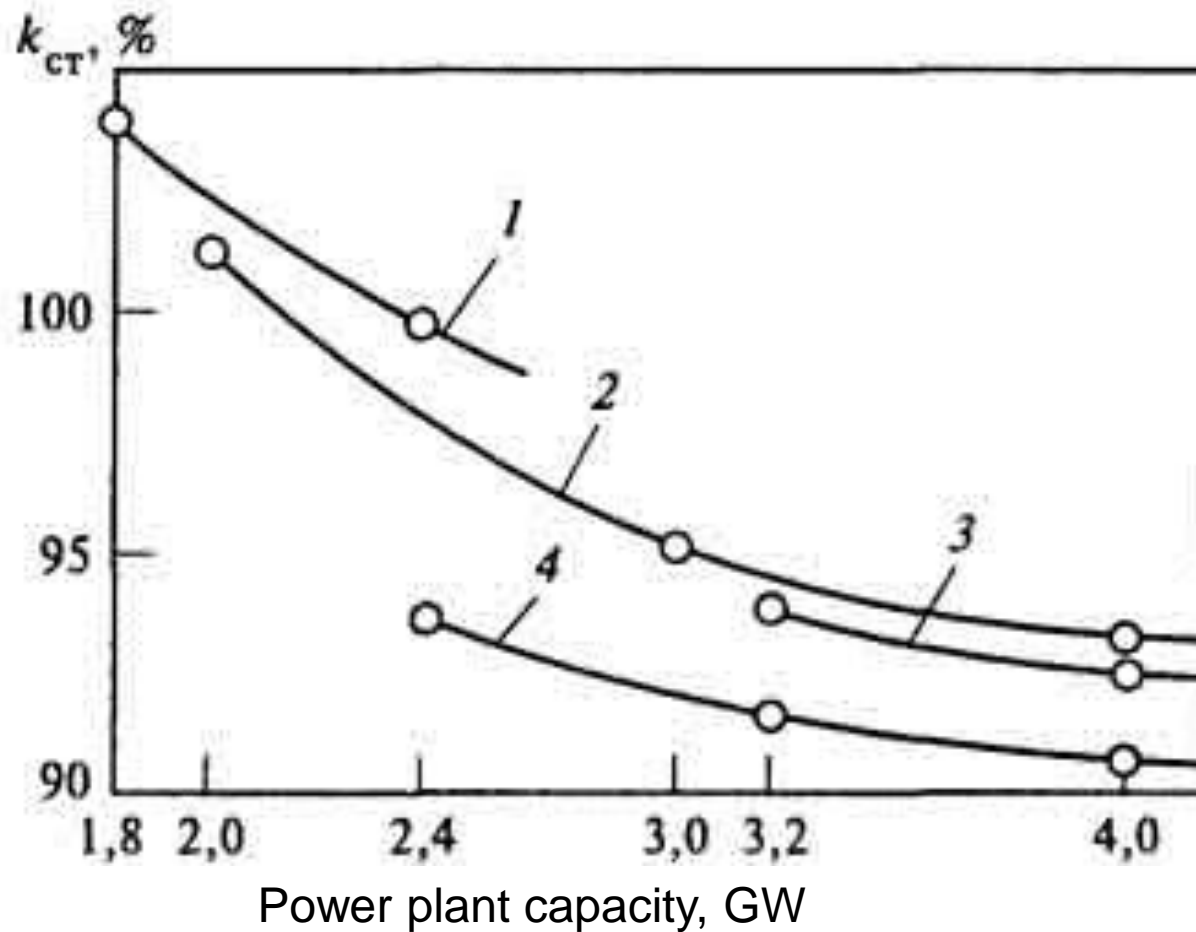
$$k_{sp} = K/N_{el}^{inst} , rub / kW$$

- **K** - capital costs, [rub]

- **Nel** - installed electrical capacity, [kW]

SPECIFIC CAPITAL COSTS DEPENDS ON

- Type of power plant

- Working fluid properties

- Type of coolant-moderator and properties

- Electrical capacity of the NPP and single power unit

DEPENDENCE OF SPECIFIC CAPITAL COSTS ON CAPACITY

Power plant capacity, GW

INCREASE OF SPECIFIC CAPITAL COSTS

- Additional capital investments in NPP
  - Plant safety system
  - Nuclear waste dump
  - Decommissioning of the nuclear power plants

POWER PLANT'S SPECIFIC CAPITAL COSTS WORLDWIDE, [US$ / KW]

- NPP   4610–7550
- Coal Power plant   1870–4090
- Gas turbine   540-1000
- Combined-cycle plant   880-1600
- Combined-cycle plant (coal gasification)   2860-4770
- Geothermal power plant   2570-3580
- Wind power plant   1340-2700
- Solar power plant   3080-5100

SPECIFIC ELECTRICITY AND HEAT GENERATION COSTS

$$c_{el} = C_{el} / Э$$

$$c_{heat} = C_{heat} / Q$$

- C_{el} и C_{heat} - generating electricity costs, [Rub], or heat costs, [Rub]

- Э – power generation, [kWh]

- Q – heat production for the consumer, [GJ]

TOTAL ELECTRICITY GENERATION COST

$$C_{el} = C_{fuel} + C_c + C_{O\&M}$$

■ The cost per kWh is determined by:

- Fuel costs

- Construction cost (depreciation, repairs, safety systems modernization etc.)

- Operation and maintenance (O&M) costs (salaries and wages, taxes, consumable materials etc.)

SPECIFIC ELECTRICITY GENERATION COST

$$c_{el} = C_{el}/Э = C_f/Э + C_c/Э + C_{O\&M}/Э =$$

$$= c_f + c_c + c_{O\&M}$$

SPECIFIC CONSTRUCTION COST

$$c_c = E\, K\, /\, (N_{el}^{inst} \cdot \tau_{inst})$$

$$c_c = p_a k_{sp} / \tau_{inst}$$

WORLDWIDE ELECTRICITY GENERATION COSTS, [CENT / KWH]

- Coal Power plant   2,4–3,3
- Combined-cycle plant   1,6–2,55
- NPP (VVER-1000)   1,8–3,24
- Cogeneration plants   1,2–2,8

SPECIFIC ELECTRICITY / HEAT GENERATION COSTS

- Cost depends on amount of generated electricity or heat (generating equipment performance)

ELECTRICITY TARIFFS

- Prices may exceed generating electricity cost by 1.5 times

- Fraction of tariff goes to decommissioning fund of NPP

CAPACITY FACTOR

$$CF = Э_{yr} / (N_{yr}^{inst} \cdot \tau_{yr}) \cdot 100 \ \%$$

$$Э_{yr} = N^{mean} \cdot \tau_{yr}$$

- $Э_{yr}$ – amount of electricity generated during the year

- Generally, $N^{mean} < N_{yr}^{inst}$

- Power reduction is due
  - planned and unplanned shutdowns of equipment
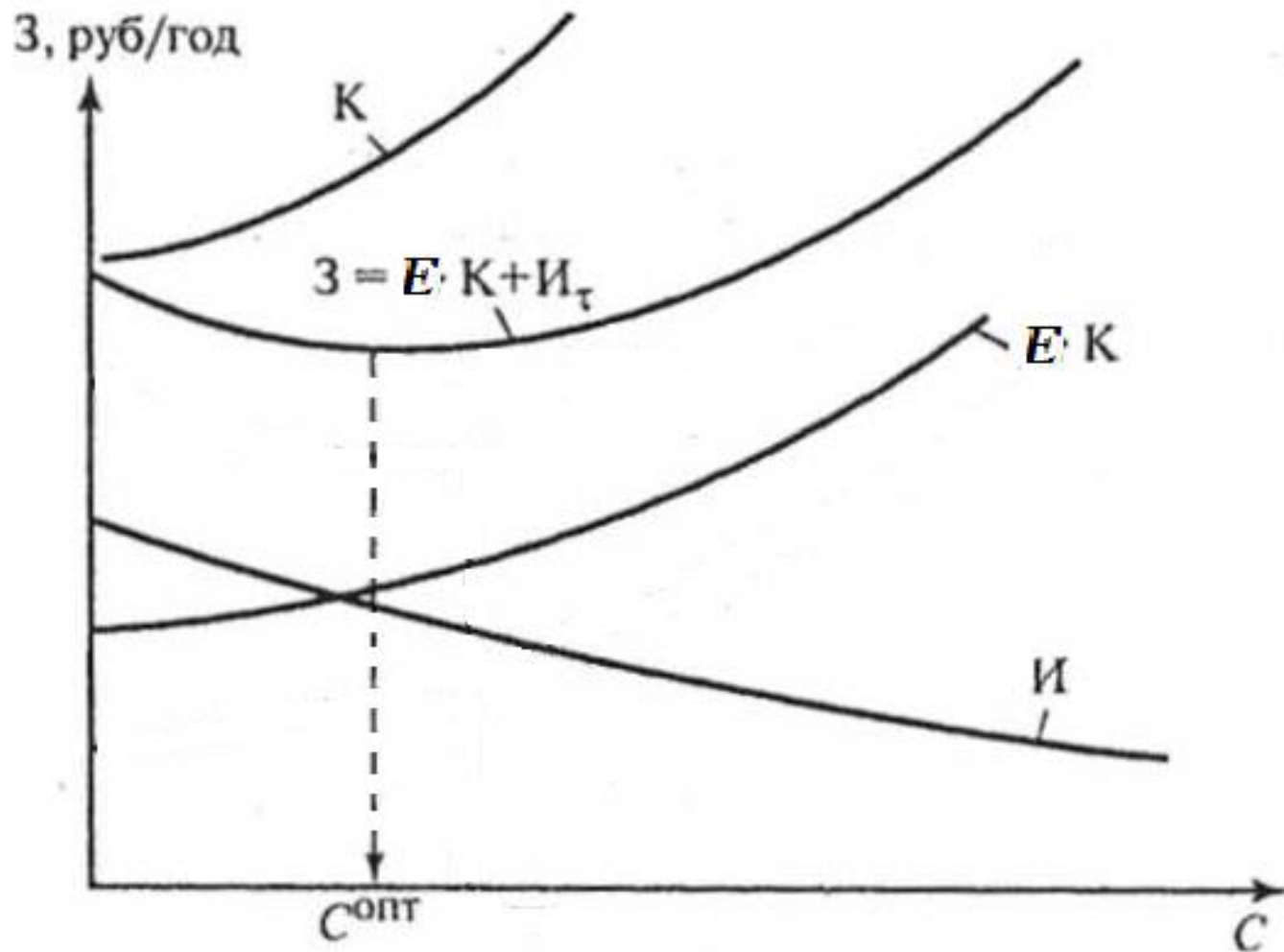 - load limits in accordance with the dispatch load schedule, etc.

ANNUAL NUMBER OF HOURS OF USE OF INSTALLED CAPACITY

$$\tau_{inst} = Э_{yr} / N_{el}^{inst} = CF \cdot \tau_{yr}$$

CAPACITY FACTOR

- Global average CF – 87 %

- Finnish NPP "Loviisa" (VVER-440)

  □ CF - 95 – 96 %

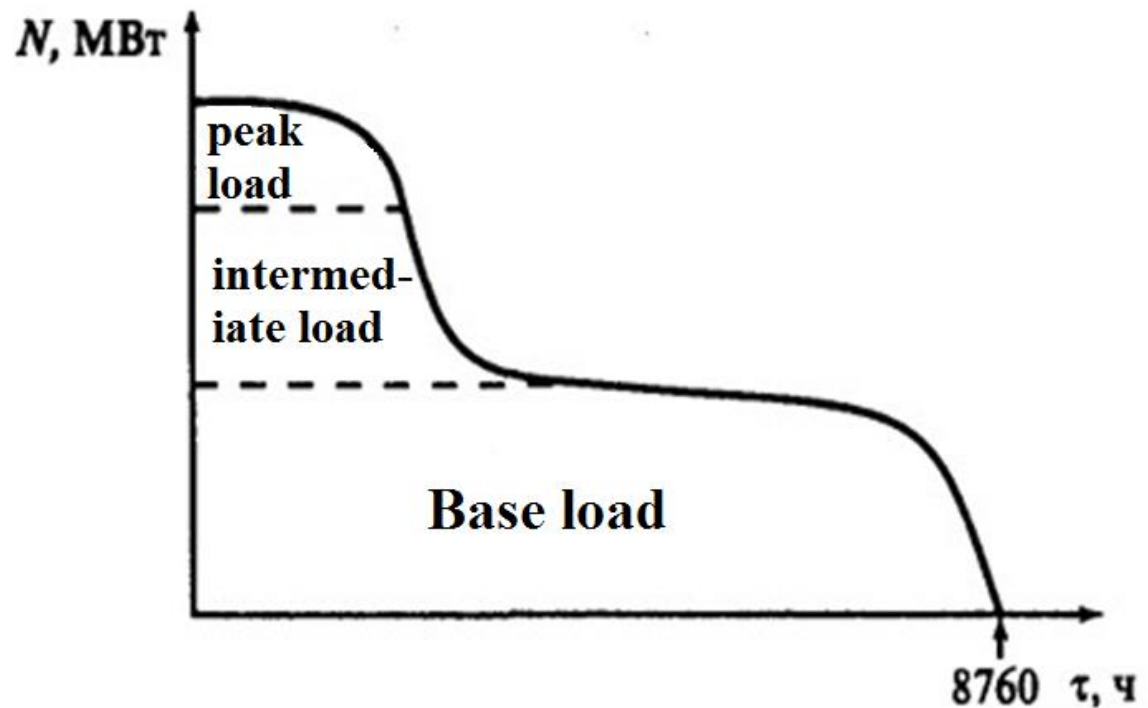# OPTIMIZATION CRITERION

NPP CLASSIFICATION

- Base load
  - $T_{Inst.} > 5000$ h / year
- Intermediate load
  - $T_{Inst.} = 3000\text{-}4000$ h / year
- Peak load
  - $T_{Inst.} < 1500$ h / year

THANK YOU FOR YOUR ATTENTION