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ECONOMY AND MANAGEMENT IN POWER ENGINEERING

6th lecture

Content

- Economic efficiency in the electricity
  - Economic optimization
  - Economic efficiency – def.
- Economic efficiency of energy investments
  - Meaning
  - Dependence profit on investment resources
  - Used criteria

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Economic optimization and economic efficiency in the electricity

- Economic optimization = selection of such technically compliant variant of that given the limited resources leads to the achievement of economic goals.
- Economic efficiency is defined as the degree of achievement of economic goals, most often expressed in terms of money
- Methods of calculating the economic efficiency must give the most accurate and the most definite results
- The electric power calculations are complicated due to the particularities of EE system (see the lect. 1)

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Economic efficiency of energy investments (1)

- Crucial in assessing the economic efficiency in the electricity industry has problems of economic efficiency of investment
- **Reasons:**
  - Economic outcomes of energetic (power, boiler, outdoor and cable lines, distribution or transformer station) are largely predetermined by carrying out the work which has been built. Change of personnel, organization, material, etc. after the building delivers little results, or even not possible.

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Economic efficiency of energy investments (2)

- **Reasons for continuation:**
  - Physical (technical) life of power equipment is long and not even their moral obsolescence (technological progress in energy is not as fast) ➞ economic life (depreciation period) is long (25 - 40 years in hydroelectric even more) ➞ predestination economic results of operations (*see previous section*) refers to the relatively long period
  - Energy is one of the most capital-intensive sectors

=> need for the economic calculation before realization of the construction

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Dependence profit on investment resources (1)

- To explore the economic efficiency of investment is an important link between investment and other costs, if necessary profit
- For each type of production can be assembled functional dependence of profits on investment costs considered building: $P = f(C_{IC})$
- Capital costs are one-off nature **X** surplus rising during period of the building (an annual profit (+) or loss (-)) → see next page

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Dependence profit on investment resources (2)

- Then we can write:

$$P_{T\,LT} = \sum_{T=1}^{T_{LT}} P_T q^{-T} \quad [currency]$$

- Where:
  - P_{TLT} - updated (the beginning of the 1st year) earnings considered the building of lifetime
  - P_T - profit in the T-th year of operation
  - q - the time factor

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Dependence profit on investment resources (3)

- When expressed as profit from the activities considered an object in a given year as the difference in sales to production (services) and all costs incurred in connection with the production (cost), then

$$P_{T_{LT}} = \sum_{T=1}^{T_{LT}} (R_T - C_{PRT}) q^{-T} \quad [currency]$$

$$C_{PRT} = C_{OP} + C_{DEP} + C_{II} \quad [currrency]$$

- Where:
  - R_T - income at T-th year of operation
  - C_{PRT} - cost of the T-th year of operation, the annual cost can be divided into dependent operations (operations) and to depend on the amount of capital costs (depreciation, interest on investments)

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Dependence profit on investment resources (4)

- The updated sum of depreciation and interest over the life of $T_{\check{z}}$ is the total investment costs
- Substituting $C_{IC} = \sum_{T=1}^{T_{\check{z}}} (C_{DEP} + C_{II}) q^{-T}$ [currency]

$$P_{T_{LT}} = \sum_{T=1}^{T_{LT}} (R_T - C_{OPT}) q^{-T} - C_{IC} \quad [currency]$$

- Where :
  - $C_{OP\,T}$ - the operating costs considered in building T-th year
  - C_{IC} - the investment cost object
- Relationship holds for Ni incurred in one year, namely the $T = 0$ (the year before the investment in service), otherwise we will use C_{IC} instead C_{ICC} comparative investment costs (see the lect. 4)

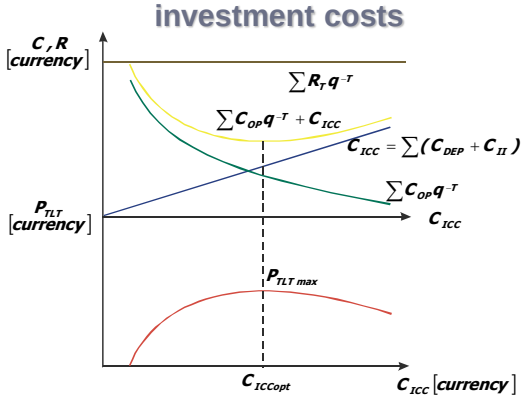
$$C_{ICC} = \sum_{t=1}^{T_{\check{z}}} c_{ICt} r^{T_{CT} - \Delta T_0 \cdot t}$$

Dependence profit on investment resources (5)

- With those obtained by specifying the relationship in the form $P_{T_{LT}} = \sum_{T=1}^{T_{LT}} (R_T - C_{OPT}) q^{-T} - C_{ICC}$ [currency]
- Furthermore, those **graphic dependence of profit** on the investment cost of the building, which is (also see link above) normally hyperbolic course
- With increasing C_{ICC} usually drop the remaining ingredients costs (see graph $\sum_{T=1}^{T_{LT}} C_{OPT} q^{-T}$ on next page), P_{TLT} grows up to max $P_{TLT\,\max}$, then with further increasing already declining C_{ICC} (C_{ICC} prevails over the increase by reducing other costs)

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Graphical dependence of profit on the investment costs



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Limitation of investment resources

- Unless the investment resources are limited, it will be the optimal solution, which ensures maximum profit (*see* [$C_{ICC\ opt}$, $P_{TLT\ max}$] *in the Fig. ahead*), investment costs $C_{ICC\ opt}$ this solution may be considered optimal
- Hypothesis of unlimited investment costs, i. e. the choice of variants with maximum profit and investment costs $C_{ICC\ opt}$, not usually considered (not real, investment resources are limited)

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Used the criteria of economic efficiency of energy investment

- Most of the criteria are used to assess the economic efficiency of energy investments is derived from two basic types:
  - Criterion updated profit
  - Criterion for internal interest rate
- In some cases it may be used *(see below)*
  - Criterion updated cost , which is a modification of criterion updated profit

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Time comparison

- One of the conditions of comparability of investment options is that they cover the same period => introduce a comparison time T_{CT}
- It's a period for which the evaluation of economic efficiency
- Selecting the right evaluation period is quite problematic and has significant impact on the evaluation results
- Selects an individual decision for each
- E.g. least common multiple of periods of the life of the options

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Criterion updated profit (Net Present Value – NPV) - (1)

- The building is economically efficient if: $P_{TCT} > 0$
- The options under consideration is the optimal one whose updated profit is maximum

$$P_{T_{CT}} = \sum_{T=1}^{T_{CT}} (R_T - C_{PRT}) \cdot r^{-T} \overset{!}{=} max \quad [currency]$$

- where:
  - P_{TCT} - updated (discounted) profit considered object (investment) for the period compared to T_{CT}
  - R_T - incomes from the investment activity in the T-th year of its operation
  - C_{PRT} - cost the investment in T-th year of operation (= operation + depreciation + interest on investments)

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Criterion updated profit (2)

- If the period of comparison time T_{CT} compared to the economic life of the T_{LT}, than

$$P_{T_{LT}} = \sum_{T=1}^{T_{LT}} (R_T - C_{PRT}) \cdot r^{-T} \overset{!}{=} max \quad [currency]$$

- If we substitute the cost C_{PRT} total operating expenses, depreciation and interest on investments, we get the most common form of this criterion

$$P_{T_{LT}} = \sum_{T=1}^{T_{LT}} (R_T - C_{OPT}) \cdot r^{-T} - C_{ICC} \overset{!}{=} max$$

- where:
  - C_{OPT} - the operating costs of the investment in T-th year of its operation

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Criterion updated profit (3)

- If $R_T - C_{OPT} = const = P_{rT}$ ... annual profit in T- th year lifetime T_{LT}

$$P_{T_{LT}} = \sum_{T=1}^{T_{LT}} P_{rT} \cdot r^{-T} - C_{ICC} = P_r \left(\sum_{T=1}^{T_{LT}} r^{-T} \right) - C_{ICC} \quad [currency]$$

supplier 0. level

const. annual profit for the period T_{LT}

$s_{TLT}^{(0)}$

- => We can go on **the annual criterion updated profit**

$$P_r = R_r - C_{PRr} \overset{!}{=} max$$

We consider here $T_{LT} = T_{CT}$

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Criterion updated profit (4)

- If $R_T - C_{OPT} = const$ introduce so-called average annual profit $P_{n\phi}$ (= const.'s annual profits, which counted for T_{LT} and discounted at the beginning T_{LT}, give the same value as profit during the T_{LT} in the normal course of sales and production costs)

$$\sum_{T=1}^{T_{LT}} P_{n\phi} \cdot r^{-T} = P_{n\phi} \sum_{T=1}^{T_{LT}} r^{-T} = \sum_{T=1}^{T_{LT}} (R_T - C_{PRT})\, r^{-T} \quad [currency]$$

supplier 0. level for the period T_{LT} $s_{TLT}^{(0)}$

$$P_{n\phi} = \frac{\sum_{T=1}^{T_{LT}} (R_T - C_{PRT}) r^{-T}}{s_{T_z}^{(0)}} \overset{!}{=} max$$

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Criterion updated factor cost (1)

- It is a special case of criterion updated profit
- You can use it when compared to the same sales options:
  - valid as the variants have the same effect of production (producing the same thing), i.e. the same technical effect defined with energy indicators (performance, production, etc.)
  - Updated costs are those given by :
  - in a comparison time $C_{PRT_{CT}} = \sum_{T=1}^{T_{CT}} C_{PRT} \cdot r^{-T}$
  - in a lifetime $C_{PRT_{LT}} = \sum_{T=1}^{T_{LT}} C_{PRT} \cdot r^{-T} = \sum_{T=1}^{T_{LT}} C_{OPT} \cdot r^{-T} + C_{ICC}$

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Criterion updated factor cost(2)

- Criterion in this case the minimum of these costs
  - in a comparison time

$$C_{PRT_{CT}} = \sum_{T=1}^{T_{CT}} C_{PRT} \cdot r^{-T} \overset{!}{=} min$$

  - in a lifetime

$$C_{PRT_{LT}} = \sum_{T=1}^{T_{LT}} C_{PRT} \cdot r^{-T} + C_{ICC} \overset{!}{=} min$$

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Criterion for internal interest rate (IRR) – (1)

- Internal interest rate = mean the interest rate at which investment option under consideration is neither profit nor loss
- At this interest rate difference between the updated sum of sales and operating costs just equal the cost of investment

$$P_{T_{LT}} = \sum_{T=1}^{T_{LT}} (R_T - C_{OPT}) \cdot r_i^{-T} - C_{ICC} = 0$$

- where:
  - r_i , p_i - internal interest, internal interest rate ($r_i = 1+p_i$)

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Criterion for internal interest rate(2)

- Investment is economically efficient if:

  $r_i > r$, where interest $r = 1+p$
  - p … force (market, prescribed) rate
- The more investment options is the optimal one whose internal rate is maximum, i. e. interest:

$$r_i > r \;,\quad r_i = max$$

  - The investment will be repaid as soon as possible
  - To assess the energy investment is not very appropriate, because the return on investment is a long-term in electricity

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Criterion for internal interest rate (3)

- Def.:
  - The repayment period of investment T_s = time at which the investment pays his profit
- The criterion of internal interest rate favors variants with the shortest repayment period

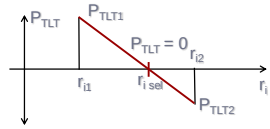
$$T_s = min \;,\quad T_s > 0$$

- T_s we determinate as r_i by gradual approximation (see next page)

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Criterion for internal interest rate (4)

- To determinate r_i for $P_{T_{LT}} = 0$:
  - We know distribution of cost and income flows (cash flow) for each year
  - We are looking for r_i what comes out $P_{TLT} = 0$, i. e. select r_i and calculate the value of P_{TLT}
  - If P_{TLT} is positive, we choose r_i more to get P_{TLT} negative (or vice versa - P_{TLT} is negative, we choose r_i smaller)
  - From 2 values P_{TLT} (positive and negative) we obtain by approximation real line r_i (see Fig.)
- In which option is r_i by zero profit more, is the better!



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Comparison criterion updated profit and for internal interest rate (1)

- The literature is often considered the optimal option with the highest interest rate. But this is contrary to the optimization according to the updated criteria of profits, when we expressed the investment costs as related to the criterion of internal interest rate

$$C_{ICC} = \sum_{T=1}^{T_{LT}} (R_T - C_{OPT}) \cdot r_i^{-T}$$

- and substitute them in relation to the criterion updated profit, it will get

$$P_{T_{LT}} = \sum_{T=1}^{T_{LT}} (R_T - C_{OPT}) \cdot (r^{-T} - r_i^{-T}) = max \qquad (*)$$

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Comparison criterion updated profit and for internal interest rate(2)

- From the previous, it is seen that the variant with maximum r_i does not satisfy the above mention (*) => maximize the internal rate of interest does not lead to maximizing updated profit for the period T_{LT}
  - increases the 2nd bracket
- Both criteria prefer variants with higher surplus
  - Internal interest rate criterion prefers higher specific profit (good for investments with shorter T_{LT})
  - Updated profit criterion prefers higher absolute profits (better for long-term energy investment)

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