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ECONOMY AND MANAGEMENT IN POWER ENGINEERING

4th lecture

Content

- Fixed assets – FA
  - dividing
  - life time (service life), depreciation
- Business costs
  - division
  - recalculation of investment costs
- Optimization of FA
  - cost and revenue flows
  - updating of economic variables (simple and compound interest, discounting, acceleration of revenues)
  - saving (accumulating), repayment (amortization)

3

Fixed assets - FA

- = productive resources **which repeatedly participate** in the business process, **they aren't consume** in it, they only wear out
- It concerns independent subjects or object (transformer), groups of subjects or object or technological and building wholes which contain:
  - independent technical-economic determination (they can work separately)
  - service life longer than 1 year
  - purchase price exceeding the set limit
- They also included land, buildings, structures, flats, non-residential premises, a herd of animals, draft animals, and permanent crops land regardless of the purchase price

4

Fixed assets are not

- reserves (stock, sub-delivery, incompletion production, animals)
- tangible assets that cannot be valued (watercourse, deposits of raw materials, works of art, if they are not part of buildings)
- capital spending on development of company

5

Dividing of FA

- According to pertinence to definite sphere of the business process:
  - **production** - be instrumental towards realization productive process of the company (machinery and arrangement carrying out production, building, through which the production passes)
  - **non production** – means which servant for non-productive purposes (living, food, health provision)
- According to character participation in production process:
  - **active** - acting directly on the product (industrial machine, arrangement, apparatus, production construction, vehicles)
  - **passive** - not directly connected with the production, but make possible it (shop, stores, head-office building)

6

Theory of renewal

- During time FA waer out:
  - physical – depend upon the using way, life, environment, influence may constitute material such as rust, increase the possibility of failure FA
  - technical-economic (moral) – depends whether running of FA is more expensive than new install oneself like function
- **=>** FA must be keep in repair or replace by new ones – those processes with deal with theory of renewal
  - it relates to finding the optimal recovery method, i.e. maintenance and reproduction of FA
  - exploitation of mathematic models (stochastic programming and deterministic)

7

Service life (lifetime) of FA

- FA use is limited by their lifetime, i.e. the time that depends on the physical or technical economic (moral) wear of FA
- Definition of service life:
  - physical – time when FA is able to fulfil its function when used for longer life may be more expensive than the operation of the new features at the same time
  - moral – time that the operation of FA is more effective than operation of newly acquired resources

optimal – have to be identified under physical and moral

8

Depreciation (1)

- Lifetime is important for the depreciation of FA
- Depreciation is economic expression of the physical and moral FA wear, it is part of FA, in money, which for a fixed period of time (year) will go into production resources, the production of which involved in the FA
- The equipment must be paid within economic life, finding the optimal set of lifetime, have to be deprecated during **economic service life of facilities,** it is fixed term which start from judgment optimum service life
- Depreciation are financing arrangements reproduction of FA

9

Depreciation (2)

- Value of the annual depreciation C_{DEP} [money]

$$C_{DEP} = c_{PP} \cdot \frac{p_{DEP\%}}{100} = c_{PP} \cdot p_{DEP} = \frac{c_{PP}}{T_{LT}}$$

  - c_{PP} - purchase price of investment [money], as well notation C_{IC} - investment costs
  - $p_{DEP\%}$ - allowance for deprec. from purchase price [%]
  - p_{DEP} - relative depreciation [-], $p_{DEP} = 1/T_{LT}$
  - T_{LT} - lifetime of FA [years]

Rem.: Energy production through FA may represent a high level of investment cost, which is the reason why their optimization must be evaluated in detail

10

Business costs

- Means represented by production technique that is associated with the consumption of articles of working groups, resources for work and labor
- Costs (obligation) are monetary expression of consumption stuff, means wear out for work, and other resources which you need on production
- It can be defined according to various criteria
- For purposes of determining the economic effectiveness of capital variants (will lecture in the other) it is necessary to express them according to various criteria

11

Business cost division

- For calculation in power engineering is important cost division **according to their dependence on production**
  - **stable (fixed)** – depending on the installed power
  - **variable** – depending on the quantity of energy production
- Division **by the way of expending**
  - **one-time** – associated with one-time expenditure of investment costs
  - **repetitive (lasting)**, typically varying in height every year throughout the manufacturing process are linked to the operation of FA

12

Investment costs

- C_{IC} [money]
- These are the costs of the investor associated with the acquisition of the object
- They are spent once for the duration of the investment
- Their value is transferred to the product in parts

- **Examples:**
  - costs of the project
  - costs on construction of the object
  - costs on machinery, arrangement, instruments
  - costs on supply and assembly machines and arrangement

13

Recalculation of investment costs

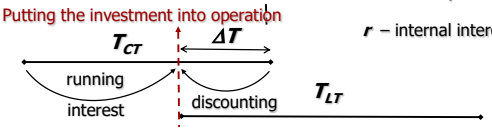
- In economic calculations, where investment costs are spent in each year of construction, the conversion of investment costs to the first year of lifetime are used, so called comparative costs. C_{ICC} .

$$C_{ICC} = \sum_{t=1}^{T_V} c_{IC}\, r^{T_{CT}-\Delta T-t}$$

c_{IC} – investment costs in the year t

r – internal interest

Putting the investment into operation



T_{LT} – life time
T_{CT} – construction time

They can overlap =>
=> ΔT – time of overlap

14

Ex. - Recalculation of investment costs

- Build-up power station proceed 7 years, after 4 year come into operation 1st block. Indicate progress of investment costs recalculation on start of lifetime.

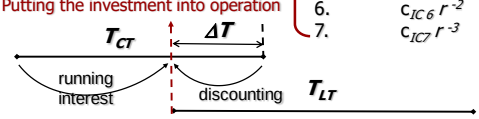
T_{CT} = 7 years
ΔT = 3 years

Cost expenditure in years

$$C_{ICC} = \sum_{t=1}^{T_V} c_{ICt}\, r^{T_{CT}-\Delta T-t}$$

1. year $c_{IC1}\, r^{7-3-1} = C_{ICC\,1}\, r^{3}$
2. $c_{IC2}\, r^{2}$
3. $c_{IC3}\, r^{1}$
4. $c_{IC4}\, r^{0}$
5. $c_{IC5}\, r^{-1}$
6. $c_{IC\,6}\, r^{-2}$
7. $c_{IC7}\, r^{-3}$

Putting the investment into operation



15

Own expense of a company

- C_{OE} [money]
- It is a monetary expression of consumption related to the operation of the company (type division)

$$C_{OE} = C_M + C_{PR} + C_{OC}$$

  - C_M - material costs [money] (not only for consumed material, but also depreciation, services, etc.)
  - C_{PR} - wages and other remuneration for work [money] (only permanent, remuneration from profit)
  - C_{OC} - other costs [money] (administrative fees, insurance premiums, social contributions, interest - not from investments) - these items change over the years

16

Operating costs

- C_{OP} [money]
- These are own costs less depreciation
- They depend on the size of production (whether the device is in operation)
- They are repeated every year during T_{LT}
- Their value is transferred to the whole product every year costs which are decrease about reduction

$$C_{OP} = C_{OE} - C_{DEP} = C_M - C_{DEP} + C_{PR} + C_{OC}$$

  - C_{DEP} - depreciation from FA [money], they are independent on operation of FA, it must be spent even in the event of liquidation of the company

17

Cost of production

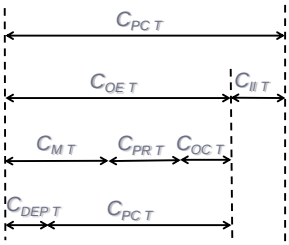
- C_{PR} [money]
- We define them as our own costs plus interest on investments
- They are a monetary expression of material consumption, wear and tear of work equipment, remuneration for work and other earmarked resources.

$$C_{PR} = C_{SC} + C_{DEP} = C_{OP} + C_{DEP} + C_{II}$$

  - C_{II} - interest from investment [money]

18

Business costs in *T* year of lifetime



$$C_{PCT} = C_{OET} + C_{IIT}$$
$$C_{PCT} = C_{OPT} + C_{DEPT} + C_{IIT}$$
$$C_{PCT} = C_{OPT} + c_{DEP}C_{ICC} + p_a C_{ICC}$$
$$C_{PCT} = C_{OPT} + \alpha_{TL} C_{ICC}$$
$$C_{PCT} = C_{CCT} + (\alpha_{TL} - c_{DEP}) C_{IIT}$$
$$\alpha_{TL} = c_{DEP} + p_a$$

α_{TL} – relative annuity over the lifetime of the investment

c_{DEP} – relative depreciation (proportional payment - see amortization)

p_a – relative interest (annuity interest rate)

19

Optimization of FA (investment)

- We want optimize exercise capital resources (FA) during definite time period
- choose from more variant solving realization definite production process, that have we have to compare and choose variant optimum (most effective, best-more economical, with biggest profit)
- We can use express by Cash Flow:

$$P = R - C \quad \text{[money/year]}$$

  - P – profit
  - R – revenue
  - C – cost

20

Cost and revenue flows

- In general, we can consider n variants, with which are associated different profits P_1 to P_n, different costs C_1 to C_n and revenues R_1 to R_n
- We are looking for a variant of
  - $P_{opt} \overset{!}{=} P_{max}$ or
  - $C_{opt} \overset{!}{=} C_{min}$
- The mentioned economic quantities are expressed for a certain period of time (usually given by T_{LT}), generally different for different variants => the need to recalculate values at one point in time

21

Recalculation (actualization) of economic variables (1)

- In order to be able to compare individual variants with each other during the optimization calculation, we must determine the place in the defined time period of FA operation, where we will recalculate the profits (costs, revenues).
- In practice, they are most often used 2 possibilities of recalculating:
  - at the beginning of T_{LT} (0-th year), from futures to the present, so-called **discounting** (using **-**)
  - at the end of T_{LT} (T_{LT}–th year), from present into the future by the help of interest running, **accumulating** (using **+**)

22

Recalculation (actualization) of economic variables (2)

- Up-dating of economic quantity is pursue with utilize so-called time factor q or internal interest r
- It is basic on assessing or devaluing of money (capital resources must bring major profit or savings, beyond we insert them in banks)
- If we recalculating from futures to the present, we have to subjective judge what situation will be in future

23

Time factor (1)

- Is ratio income companies and material resources spend on achievement hereof income.
- Definition:
  - **Absolute time factor** ratio whole income and of all going material resources in election time period. Has analytical meaning.
  - **Incremental time factor** z ratio incremental income and incremental material resources behind elect time period. Mean dynamism effectiveness resources spend in different time period.

24

Time factor (2)

- **Incremental time factor** expressed:

$$z = \frac{\Delta D_S}{\Delta P_M} [-]$$

kde:

- ΔD_s – addition income behind select time period
- ΔP_M – addition material resources spend on achievement incremental income ΔD_s

It can set relative clean income of company, possible reach for in a given period in political economy.

25

Time factor (3)

- If ***1+z = q*** is **time factor**, than we can count revenues achieved in different years for one common arbitrarily selected year for the purpose of their comparison or summarization (see e.g. the so-called acceleration of revenues - below)
- These counts are identified by **method of compound interest running** which is use in banks, where rate of interest signed like ***p*** has the same function like ***z*** (here)
- Interest bearing ***r = 1 + p*** **<=>** ***q = 1 + z***

26

Acceleration of revenues

- It is recalculation of revenues from ***k-th year*** to ***j-th year*** for example:
  - about ***1*** year we get ***R´= R (1+z)***
  - about ***2*** years ***R´´= R(1+z)²***
  - ⋮
  - about ***n*** years ***R´´´= R (1+z)ⁿ***
- For example: Acceleration of revenues ***R*** about ***1*** year mean increase of this income for this year to ***R (1+z)***
- Acceleration of revenues ***R*** from ***k-th*** year to ***j -th*** year mean, that this income has in ***k-th year*** valuefrom ***k to j*** (about ***k-j*** year)

$$R_{kj} = R_j (1+z)^{k-j}$$

27

Acceleration of revenues

- Likewise for costs and profits we can set:

$$C_{kj} = C_j \, q^{k-j} \qquad P_{kj} = P_j \, q^{k-j}$$

- **At finish:**
  - If subject reach acceleration of revenues (delay of costs) ***1*** monetary unit about ***1*** year, it can invest with efficiency ***z***, this monetary unit will bring profit in height of ***z*** monetary unit
  - At delay of sales (forward costs) ***1*** monetary unit, it will lose possibility to valorize it

28

Calculus of interest

- It is instrumental to set interest from some sum of money and use interest rates.
- In economy it has generally function like implement to formulation dynamism of development.
- At calculation economic investment efficiency we using method of constitution interest running
- Descending reduction of flow come out from method of interest running

29

Method of interest running

- We have 2 basic methods:
  - Simple interest running – in every period the interest count is calculated from primary amount
  - Compound interest running – in every period the interest count is calculated from present-day amount
  - Attribution of interest is periodically in put term, usually at the end of the year

30

Example: Simple interest running

- $K_0 = 1\ 000\ 000$ CZK, interest rate $p = 6\ \%$, i.e. interest of every year is 60 000 CZK
  - 1. year is debt $K_0(1+p)$ 1 060 000 CZK
  - 2. year is debt $K_0(1+2p)$ 1 120 000 CZK
  - 3. year is debt $K_0(1+3p)$ 1 180 000 CZK
  - . . .
  - n year is debt $K_0\ (1+n.p)$

31

Example: Compound interest running

- $K_0 = 1\ 000\ 000$ CZK, interest rate $p = 6\ \%$ or $r = 1{,}06$
  - 1. year is debt $K_0 . r$ 1 060 000 CZK
  - 2. year is debt $(K_0 . r).r = K_0 . r^2$ 1 123 600 CZK
  - 3. year is debt $[(K_0 . r).r].r = K_0 . r^3$ 1 191 016 CZK
  - . . .
  - n year is debt $(K_0 . r).r^{n-1} = K_0 . r$

32

Utilization of compound interest running to count economic variables to another time

- It is financial operation which allow us to count what value takes economy quantity by time T (e.g. n years) at interest rate p
- **Example:** we want to know debt [CZK] in n-*th* year

  Presume:
  - K_0 - loan amount (credit), current value of debt [CZK]
  - p - interest rate [%, -], it is amount which we pay to bank
  - r - internal interest [-], $r = 1 + p$
  - K_n - height of debt after n years [CZK]

  than $K_n = K_0(1+p)^n = K_0 r^n$

33

Example of compound interest running

- How big will be costs reduction in the end time economic service life $T_{LT} = 20$ **years**, if opening value of costs is $C_1 = 150\,000$ **CZK** and internal interest is $r = 1{,}1$?

$$C_{20} = C_1 \cdot r^{20} = 150\,000 \cdot 1{,}1^{20} = 1\,009\,125 \text{ CZK}$$

34

Discounting

- Is opposite operation to interest running
- it will often exploitation at up-dating on contemporary appreciate different-time quantity in calculation of economic investment efficiency
- We count present-day value of quantity (e.g. debt). From value in ***n-th*** year [CZK]

$$K_0 = K_n(1+p)^{-n} = K_n r^{-n}$$

  - K_0 - loan amount (credit) = debt [CZK]
  - K_n - height of debt after n years [CZK]

35

Example: Discounting

- Count a present-day value of costs, if they are $C_{15} = 560\,000$ **CZK** in 15-th year and internal interest is $r = 1{,}07$.

$$C_1 = C_{15} \cdot r^{-15} = 560\,000 \cdot 1{,}07^{-15} = 202\,970 \text{ CZK}$$

36

Amortization

- **Goal:** Pay off debt (credit) so that at the term of expiration end was amount with interest is paid
- **Task:** Determine, how big amount to we have to in every period (year) pay
- Amount, which with this way regularly pay, can be either constant (in every period same) – simple amortization, or it can change – amortization of uncertain sums

37

Simple amortization (1)

- We pay **constant** amount ***A*** every payment period, this amount has include not only relative part of debt, but interest too
- amount ***A*** is **annuity**
- **=> Task:** Find annuity which is constant and covers interest running of lent money

38

Simple amortization (2)

- We will discount, i.e. recalculating from future to present-day
  - At the end of 1. year $A \cdot r^{-1}$
  - At the end of 2. year $A \cdot r^{-2}$
  - :
  - At the end of **n** year $A \cdot r^{-n}$

  Recalculating to 0. year
- Sum has to be same as borrowed sum K_0

$$K_0 = A \cdot r^{-1} + A \cdot r^{-2} + \cdots + A \cdot r^{-n} =$$
$$= A \sum_{T=1}^{n} r^{-T} = A \cdot \left(r^{-1} + r^{-2} + \cdots + r^{-n} \right)$$

39

Simple amortization (3)

- We want to know sum of geometric progression which is define: $s_n = a_1 \cdot \frac{1-q^n}{1-q}$
- where:
  - a_1 - 1. member of progression (for us $a_1 = 1/r$)
  - q - quotient (for us $q = 1/r$)
- i.e.

$$\sum_{T=1}^{n} r^{-T} = \frac{1}{r} \cdot \frac{1-\left(\frac{1}{r}\right)^n}{1-\frac{1}{r}} = \frac{1}{r} \cdot \frac{r^n-1}{r^n} \cdot \frac{r}{r-1} = \frac{r^n-1}{r^n(r-1)}$$

$$\Rightarrow A = K_0 \frac{r^n(r-1)}{r^n-1} \qquad A = K_0 \cdot \alpha_n \qquad A = \frac{K_0}{n} + p_a \cdot K_0$$

proportional annuity | proportional interest

40

Example: simple amortization

- Count amount of year annuity, if time of amortization is ***20 years*** and amortization amount is ***100 000 CZK*** interest rate is ***p = 0,04*** .

$$A = K_0 \cdot \alpha_n = 100\,000 \cdot \alpha_{20} = 100\,000 \frac{r^n(r-1)}{r^n-1} =$$
$$= 100\,000 \frac{1{,}04^{20}(1{,}04-1)}{1{,}04^{20}-1} =$$
$$= 100\,000 \cdot 0{,}0736 = 7360\ KCZ$$

41

Amortization of uncertain sum (1)

- Basic on compound interest, we pay every period part of debt + interests, but amortization **is not constant**
- we discount on beginning of payment period (begin of 1. year), i.e. every part payment (in ***T-th year***, ***T = 1*** to ***n***) multiply r^{-T}

42

Amortization of uncertain sum (2)

T–th year	part payment	discount
end of 1. year	$\frac{K_0}{n} + p \cdot K_0 = K_0\left(\frac{1}{n} + p\right)$	$.r^{-1}$
end of 2. year	$\frac{K_0}{n} + p \cdot \left(K_0 - \frac{K_0}{n}\right) = K_0\left[\frac{1}{n} + p\left(1 - \frac{1}{n}\right)\right]$	$.r^{-2}$
end of 3. year	$K_0\left[\frac{1}{n} + p\left(1 - \frac{2}{n}\right)\right]$	$.r^{-3}$
. . .		
end of **n-th** year	$K_0\left[\frac{1}{n} + p \cdot \left(1 - \frac{n-1}{n}\right)\right]$	$.r^{-n}$

43

Amortization of uncertain sum (3)

Sum of yearly payment must be same as borrow amount.

$$\sum_{T=1}^{n} K_0\left[\frac{1}{n} + p \cdot \left(1 - \frac{T-1}{n}\right)\right] \cdot r^{-T} =$$

$$= \frac{K_0}{n}\sum_{T=1}^{n} r^{-T} + pK_0\left(1 + \frac{1}{n}\right)\sum_{T=1}^{n} r^{-T} - \frac{pK_0}{n}\sum_{T=1}^{n} Tr^{-T} = \quad \textit{on next page (*)}$$

sum payment by *n* years

Sum of interest from remain of debt by *n* years

$\sum_{T=1}^{n} Tr^{-T}$ … combination of geometric and arithmetic series, their sum is define:

$$\sum_{T=1}^{n} Tx^T = x + 2x^2 + 3x^3 + \ldots + nx^n = \frac{x}{1-x}\left(\frac{1-x^n}{1-x} - nx^n\right) \quad ,$$

where $x = r^{-1} = 1/r$ … quotient geom. p.

44

Amortization of uncertain sum (4)

(*)

$$= \frac{K_0}{n}\frac{r^n - 1}{r^n(r-1)} + pK_0\left(1 + \frac{1}{n}\right)\frac{r^n - 1}{r^n(r-1)} - \frac{pK_0}{n}\frac{\frac{1}{r}}{1 - \frac{1}{r}}\left[\frac{1 - \left(\frac{1}{r}\right)^n}{1 - \frac{1}{r}} - n\left(\frac{1}{r}\right)^n\right] =$$

$$= \frac{K_0}{n}\frac{r^n - 1}{r^n(r-1)} + pK_0\left(1 + \frac{1}{n}\right)\frac{r^n - 1}{r^n(r-1)} - \frac{pK_0}{n}\frac{1}{r-1}\left[\frac{r(1 - r^{-n})}{r-1} - nr^{-n}\right] =$$

$$= \frac{K_0}{n}\frac{r^n - 1}{r^n p} + pK_0\left(1 + \frac{1}{n}\right)\frac{r^n - 1}{r^n p} - \frac{pK_0}{n}\frac{1}{p}\left[\frac{r(1 - r^{-n})}{p} - nr^{-n}\right] =$$

$$= \frac{r^n - 1}{r^n p}\left[\frac{K_0}{n} + pK_0\left(1 + \frac{1}{n}\right)\right] - \frac{K_0}{n}\left[\frac{r(1 - r^{-n})}{p} - nr^{-n}\right]$$

45

Accumulating

- We count sum of profits on the end of ***n-th*** year [money]

$$R_n + R_{n-1}r^1 + R_{n-2}r^2 + \cdots + R_1 r^{n-1} = \sum_{T=1}^{n} R_T r^{n-T} =$$
$$= r^n \sum_{T=1}^{n} R_T r^{-T} = r^n \left(R_1 r^{-1} + R_2 r^{-2} + \ldots + R_n r^{-n}\right)$$

- We make sum of geometric progression:
  $V_T = V_n$ = konst.
  - generally
    $$S_n = a_1 + a_2 + \ldots + a_n = a_1 + a_1 q + \ldots + a_1 q^{n-1} = a_1 \cdot \frac{1-q^n}{1-q}$$
  - $a_1 = 1/r$, $q = 1/r$
    $$r^n \sum_{T=1}^{n} R_T r^{-T} = R_n r^n \sum_{T=1}^{n} r^{-T} = R_n r^n \frac{r^n - 1}{r^n (r-1)} = R_n \frac{r^n - 1}{r - 1}$$

saver

(mark like h_n or h_T)

46

Example: Accumulating

- Count sum of profits at the end of service life ***$T_ž$ = 25 years***, if they are constant ***R_1 = 5 000 CZK***. Internal interest is ***r = 1,05.***

$$\sum_{T=1}^{25} R_1 r^{25-T} = R_1 \frac{r^{25} - 1}{r - 1} = 5000 \frac{1{,}05^{25} - 1}{1{,}05 - 1} =$$

$$= 338\,635{,}5 \text{ KCZ}$$

47