Engineering Economics

Principles

- During our examinations we assume a consolidated economy. (Free of extremities, such as war, hyperinflation, corruption, etc., and fundamentally operated by pure market mechanisms and by stabil legal and regulations' systems)

- Our examinations are aiming at economic comparisions of functionally equivalent technical and/or financial options. Figures resulted by any analysis of any option can not be evaluated as themselves but as values to be measured against others.

- Conclusions of our examinations are at most supporting decision makers at their work when elaborating their market policy and/or strategy, but are not substituting any decisions to be made by them.

Using External Resources Foreign Capital

Due to the fact that a typical investment in civil engineering and/or in construction industry moves huge amount of technical and financial resources, it is frequently unavoidable to invoke external („foreign”) resources and/or capital temporarily.

Liquidity:

Promp available own economic resources. („self-financing capability”)

Loan:

External economic resource temporarily let for use and to be paid back later increased by some extra fee („foreign capital”, „loan capital”).

Interest:

„Rent” („price”) of using foreign capital. Its extent is highly defined by the actual „demand versus supply” conditions.

Using External Resources Foreign Capital

Term / Pay-Back Period / Lending Period:

A time period in which a foreign capital is let for use. By the end of it the capital itself and the interest on it must be entirely paid back.

Simple Interest: *(I)*

The extent (volume) of interest is neither related to the amount of the capital itself nor to the extent of pay-back period formally.

Present Value: *(P)*

A fictive or actual value of capital let for use (lended or to be lended) at the beginning of lending period.

Future Value: *(S = Succeeding Value)*

A fictive or actual value of capital let for use (lended or to be lended and increased by the interest on it) at the end of lending period.

$$S = P + I$$

Using External Resources Foreign Capital

Rate of Interest: *(i)*

The extent (volume) of interest is formally related to the amount of capital lended.

$$I = P \cdot i \quad \Rightarrow \quad S = P \cdot (1 + i)$$

Nominal Period:

A pre-set extent of time (period) for which the periodic amount of interest (related to the amount of capital) is set in advance.
(e.g.: year, „annum”)

Compounding / Capitalization:

The movement (generally at the end of a nominal period) when the due interest on lasted period(s) is united with the capital itself and the interest for the next nominal period is calculated in proportion of this cummulated value (… as if the cummulated value was the lended capital for the next nominal period).

$$S_1 = P_0 \cdot (1 + i) \quad \Rightarrow \quad P_1 = S_1$$
$$S_2 = P_1 \cdot (1 + i)$$

Using External Resources
Foreign Capital

Discount Rate:

Inverted „value” of the Interest Rate used for „backward-” calculations, typically at Present Value calculations. („Discounting”)

$$\text{e.g.} \quad P = S \cdot \frac{1}{i}$$

Compound Amount Interest:

The extent (volume) of interest is both related to the amount of the capital itself and to the extent* of lending period formally.
*(* set as number of nominal periods: „n”)*

$$S_n = P \cdot (1 + i)^n$$

$$P = S_n \cdot \frac{1}{(1 + i)^n}$$

$$i = \sqrt[n]{\frac{S_n}{P}} - 1 \qquad n = \frac{\ln \frac{S_n}{P}}{\ln(1 + i)}$$

Further Terms in Relation with „Time-Value of Money”

Effective Rate of Interest:

To satisfy arising needs for shorter capital recovery cycles, and for lessening loss in interest in case of capital withdrawal before the end of a nominal period, banks offered a special way of interest calculation …
(t = compoundings in a nominal period; t = 4/12/365; i_n = „nominal interest”)

$$i_e = \left(1 + \frac{i_n}{t} \right)^t - 1 \quad \Rightarrow \quad Euler : „e”$$

Daily Access Rate of Interest: *(i_d)*

Regarding the „limited manner” of Effective Rate of Interest, and for to substitute the daily compounded *(t=365)* interest calculations …
(d = number of passed days within a nominal period (typically a year); number of days within a fiscal year 365 (360))

$$i_d = i_n \cdot \frac{d}{365}$$

Further Terms in Relation with „Time-Value of Money"

Substituting Mean Interest: *(i_m)*

An indicatrix characterizing a loan affair in case of rate of interest changing in time …

(k = running index of compoundings)

$$i_m = \sqrt[n]{\prod_{k=1}^{n} (1 + i_k)} - 1$$

Inflation: *(f)*

Specific loss in purchasing power of a currency within a period.

(There can be numerous reasons of it, not all of them negative phenomenon behind)

Net/Real Rate of Interest: *(i_r)*

Rate of Interest calculated taking inflation into account (indicatrix).

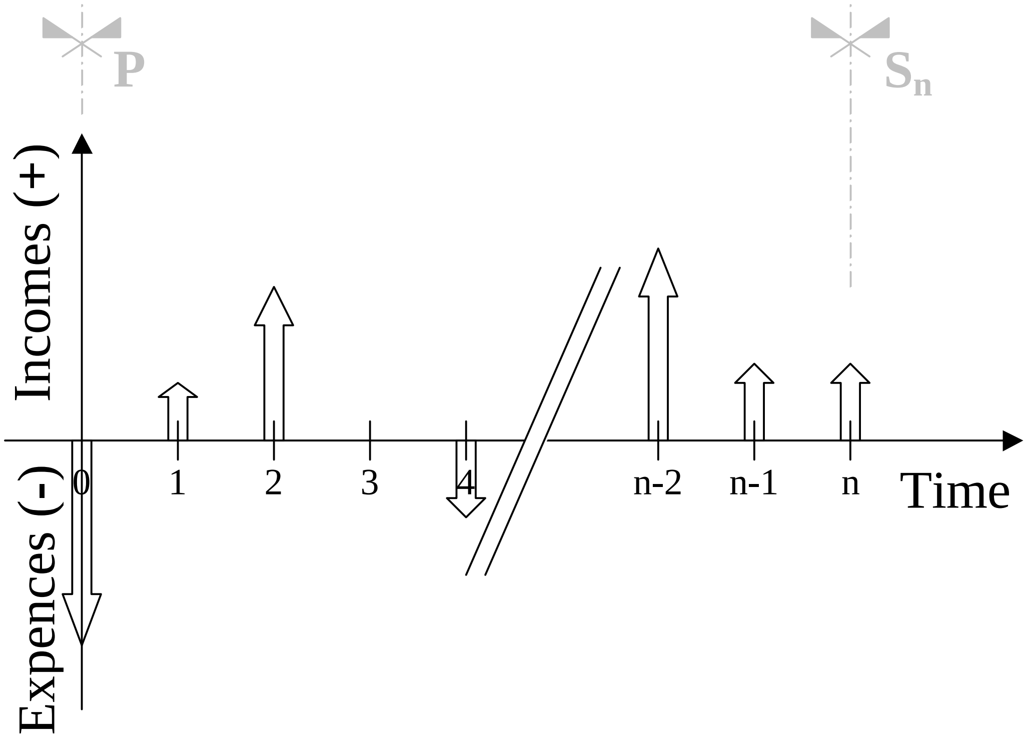
(Infaltion works on the interest itself too !)

$$i_r = \frac{1 + i}{1 + f} - 1$$

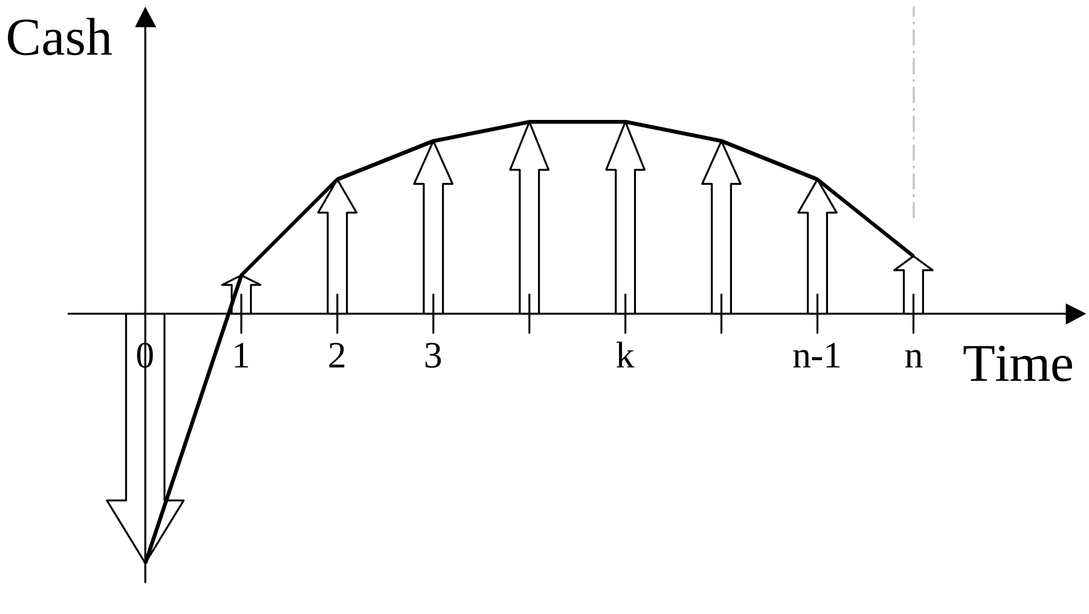
Cash-Flow

Cash-Flow Analysis

The Cash-Flow Diagram



A „typical” cash-flow of an investment

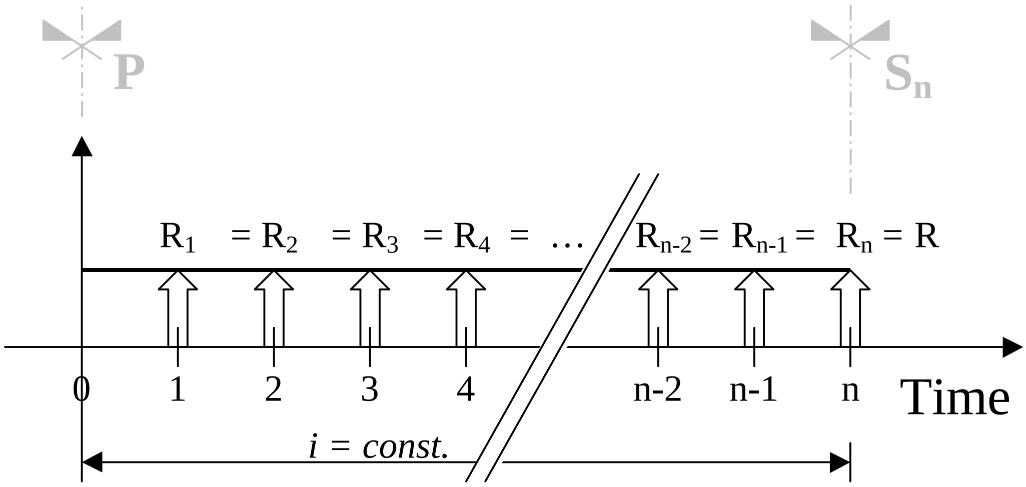


Cash-Flow

Cash-Flow Analysis

Annuity *(uniform series payment)*

e.g. : pention, rent, pay-back of a loan …



a ., $\mathbf{S = R \times [\,(1+\mathit{i})^{n-1} + (1+\mathit{i})^{n-2} + (1+\mathit{i})^{n-3} + \ldots + (1+\mathit{i})^{2} + (1+\mathit{i}) + 1\,]}$

Multiplying equation α by (1+*i*) we get equation β …

b ., $\mathbf{S \times (1+\mathit{i}) = R \times [\,(1+\mathit{i})^{n} + (1+\mathit{i})^{n-1} + (1+\mathit{i})^{n-2} + \ldots + (1+\mathit{i})^{3} + (1+\mathit{i})^{2} + (1+\mathit{i})\,]}$

… Equation β less equation α we get equation ϒ ...

¡ ., $\mathbf{S \times \mathit{i} = R \times [\,(1+\mathit{i})^{n} - 1\,]}$

... Rearranging equation ϒ we get …

$$\boxed{\mathbf{S = R \times \frac{(1+\mathit{i})^{n} - 1}{\mathit{i}}}}$$

Eternal Assets, „Capitalized Cost”

$$\lim_{n>\infty} R = \lim_{n>\infty} P\cdot\left(i + \frac{i}{(1+i)^{n} - 1}\right) = P\cdot i$$

Taking resale value (V) into account

$$R = (\,P - V\,)\cdot\left[\frac{i\cdot(1+i)^{n}}{(1+i)^{n} - 1}\right] + V\cdot i$$

„Sinking Fund”

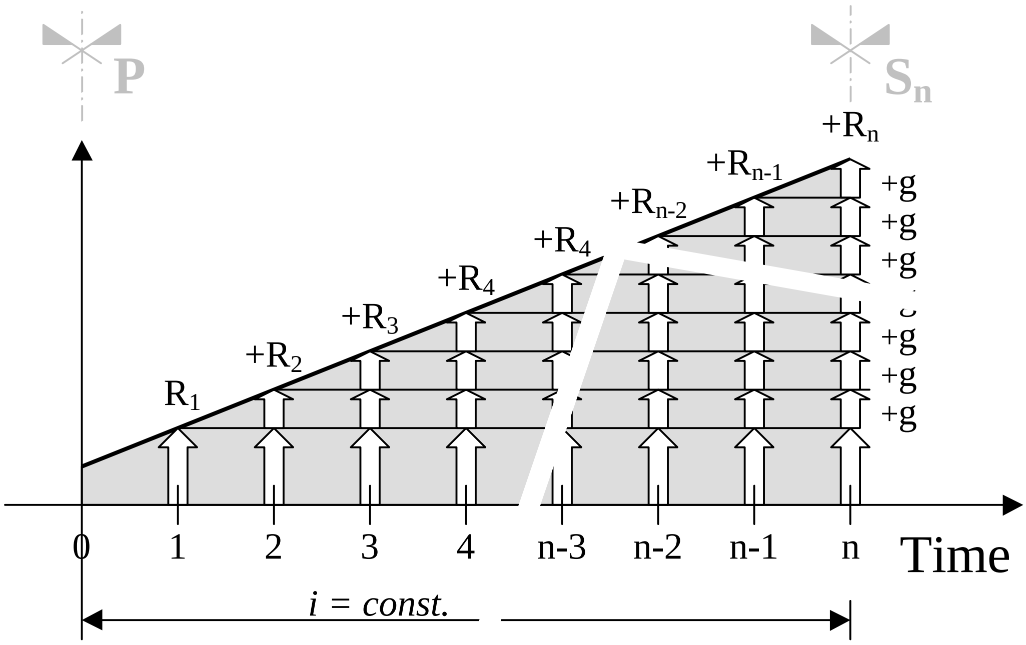
$$n = \frac{\log\left(\frac{R}{R - P\cdot i}\right)}{\log(1+i)}$$

Cash Flow

Cash-Flow Analysis

Gradient Series Payment:

e.g. : operation, maintenance (… approach)



$$S = g \cdot \left(\frac{(1+i)^{n-1} - 1}{i} + \frac{(1+i)^{n-2} - 1}{i} + \frac{(1+i)^{n-3} - 1}{i} + \ldots + \frac{(1+i)^{2} - 1}{i} + \frac{(1+i) - 1}{i} \right)$$

$$S = \frac{g}{i} \cdot \left((1+i)^{n-1} + (1+i)^{n-2} + (1+i)^{n-3} + \ldots + (1+i)^{2} + (1+i) - (n-1) \right)$$

$$S = \frac{g}{i} \cdot \left((1+i)^{n-1} + (1+i)^{n-2} + (1+i)^{n-3} + \ldots + (1+i)^{2} + (1+i) + 1 \right) - \frac{n \cdot g}{i}$$

$$\boxed{\mathbf{S} = \frac{\mathbf{g}}{\boldsymbol{i}} \times \left[\frac{(\mathbf{1}+\boldsymbol{i})^{\mathbf{n}} - \mathbf{1}}{\boldsymbol{i}} \right] - \frac{n \cdot \mathrm{g}}{\boldsymbol{i}}}$$

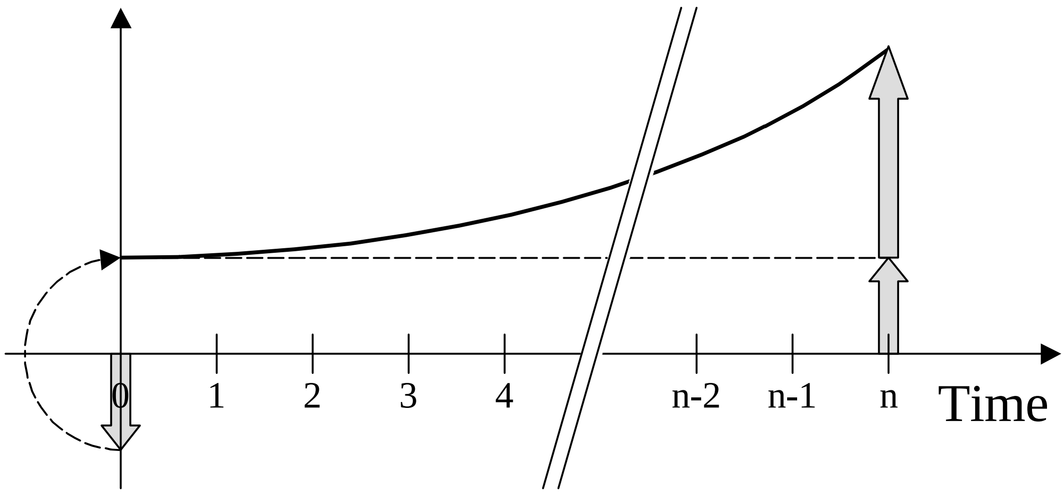
$$\boxed{P = \frac{g}{i} \cdot \left[\frac{(1+i)^{n} - 1}{i \cdot (1+i)^{n}} \right] - \frac{n \cdot g}{i \cdot (1+i)^{n}}}$$

$$\boxed{R = \frac{g}{i} - \frac{n \cdot g}{i} \cdot \left[\frac{i}{(1+i)^{n} - 1} \right]}$$

Basic Loan Pay-Back Constructions

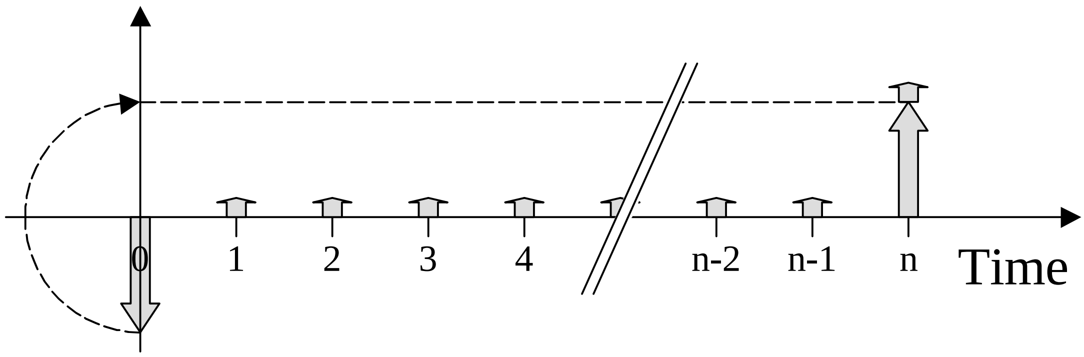
Lump-Sum Pay-Back:

The capital lended and all the periodic interests (compounded) are paid back at the end of lending period as one sum.



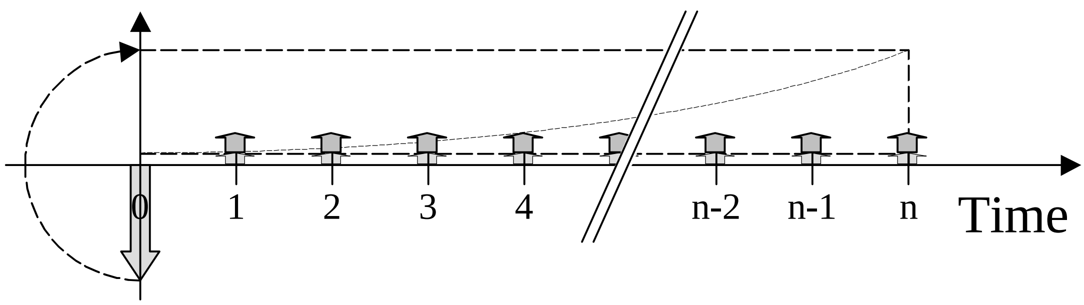
Periodic Interest Payment:

The periodic interests on lended capital are paid as a uniform series payment, the capital itself is paid back at the end of lending period.



Uniform Series Payment:

Both the capital lended and all the periodic interests are paid „back" as a uniform series payment.



Economic Comparisions

Present Value Comparisions
(Point of view of a trade's investor)

Uniform Series Payment Comparisions
(Point of view of a trade's operator)

Rate of Return Comparisions
(Point of view of a financial investor)

Pay-Back Time Analysis
(Point of view of a trade's developer)

Cost/Benefit Analysis
(Point of view of a governor)

Break-Even Analysis
(Point of view of a designer / estimator)

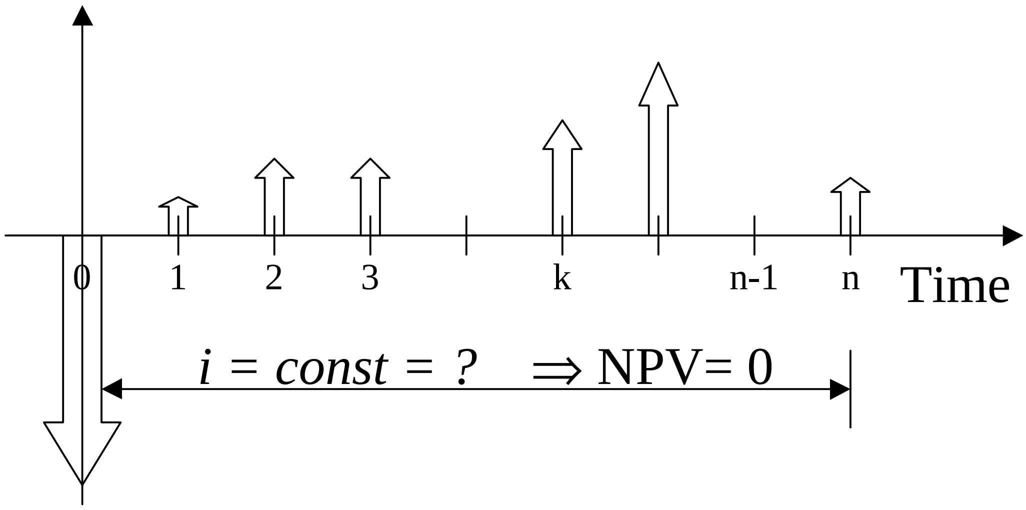
Sensitivity Analysis
(Point of view of an expert / consultant)

Rates of Return

Internal Rate of Return (IRR)

A constant fictive rate of return applying which for discounting the Net Present Value of the Cah-Flow (investment) results in Zero.

(Solution via iterations: The Yield Method)



Overall Rate of Return (ORR)

Also known as Financial Management Rate of Return (FMRR)

An indicatrix, rate of return calculated with consideration of re-investment possibilities.

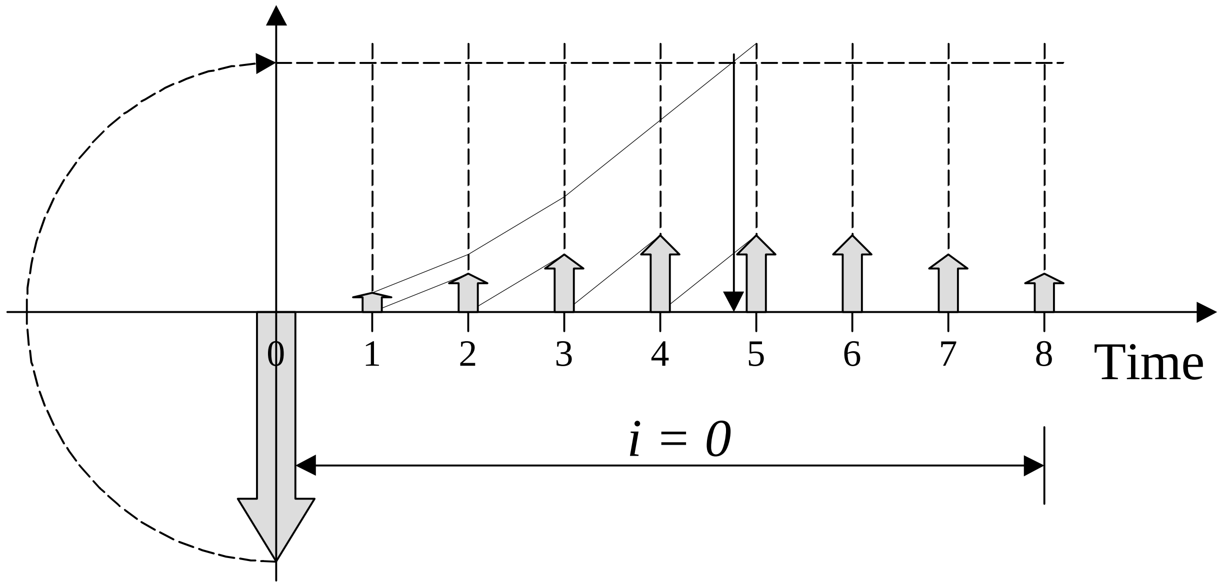
$$i_{external} \quad \Rightarrow \quad i_S = \sqrt[n]{\frac{S^{\oplus}}{P^{\ominus}}} -1$$

Pay-Back Time

(Nominal) Pay-Back Time:

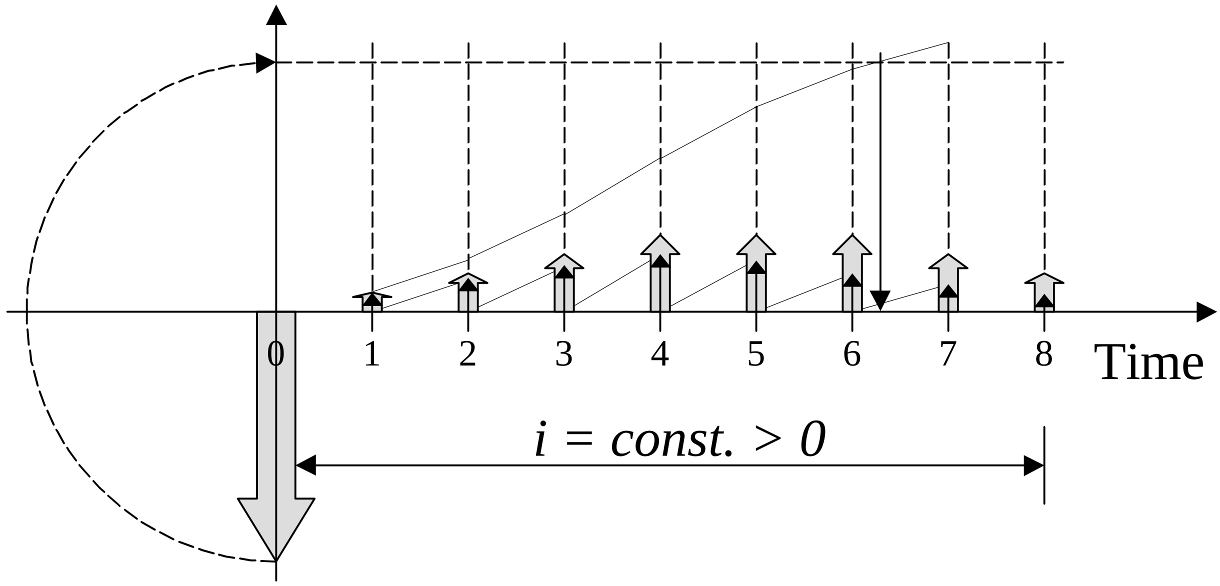
Extent of time by the end of which net incomes recover the initial expences (investment).

(… not considering „time-value” of money)



Discounted Pay-Back Time:

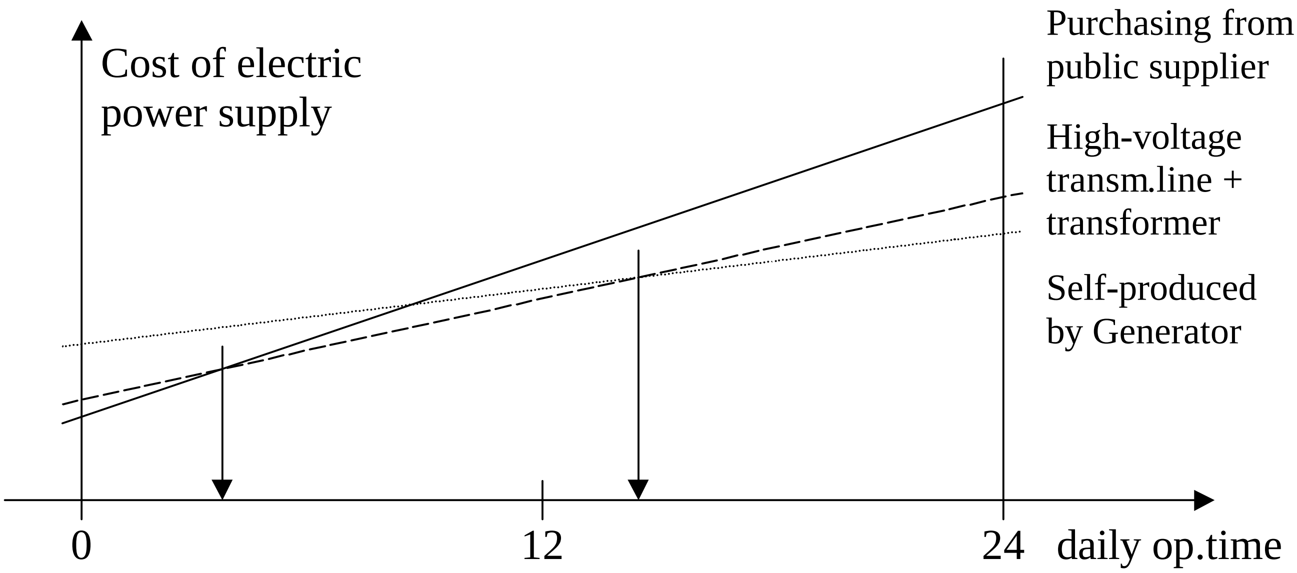
(… considering „time-value” of money)



Graphics at Comparisions

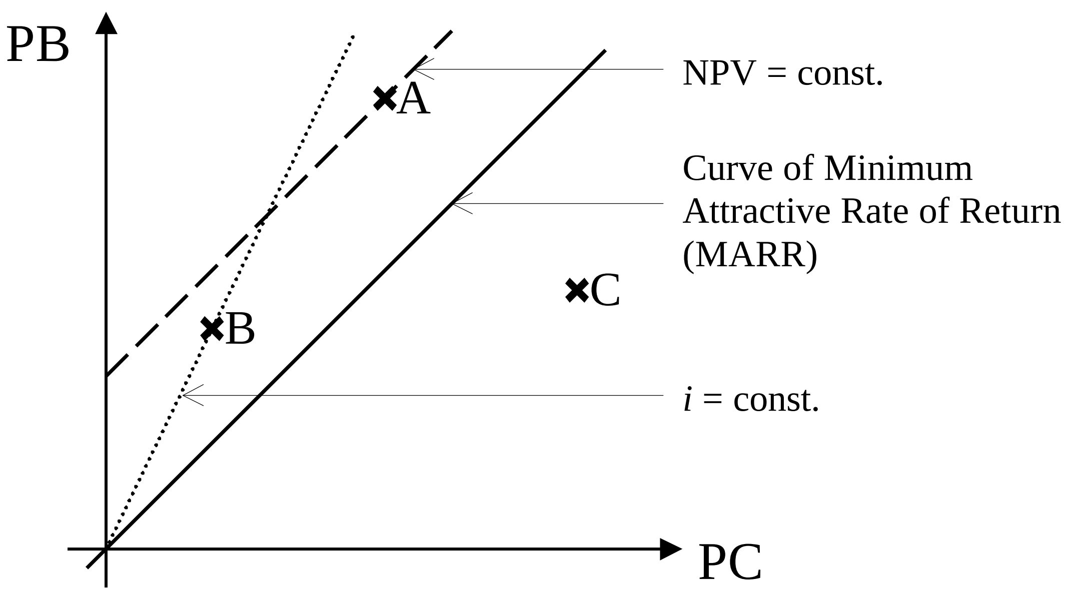
Break-Even Analysis:

Comparisions in function of a common (functional or technical) parameter



Discounted Cost-Benefit Diagram

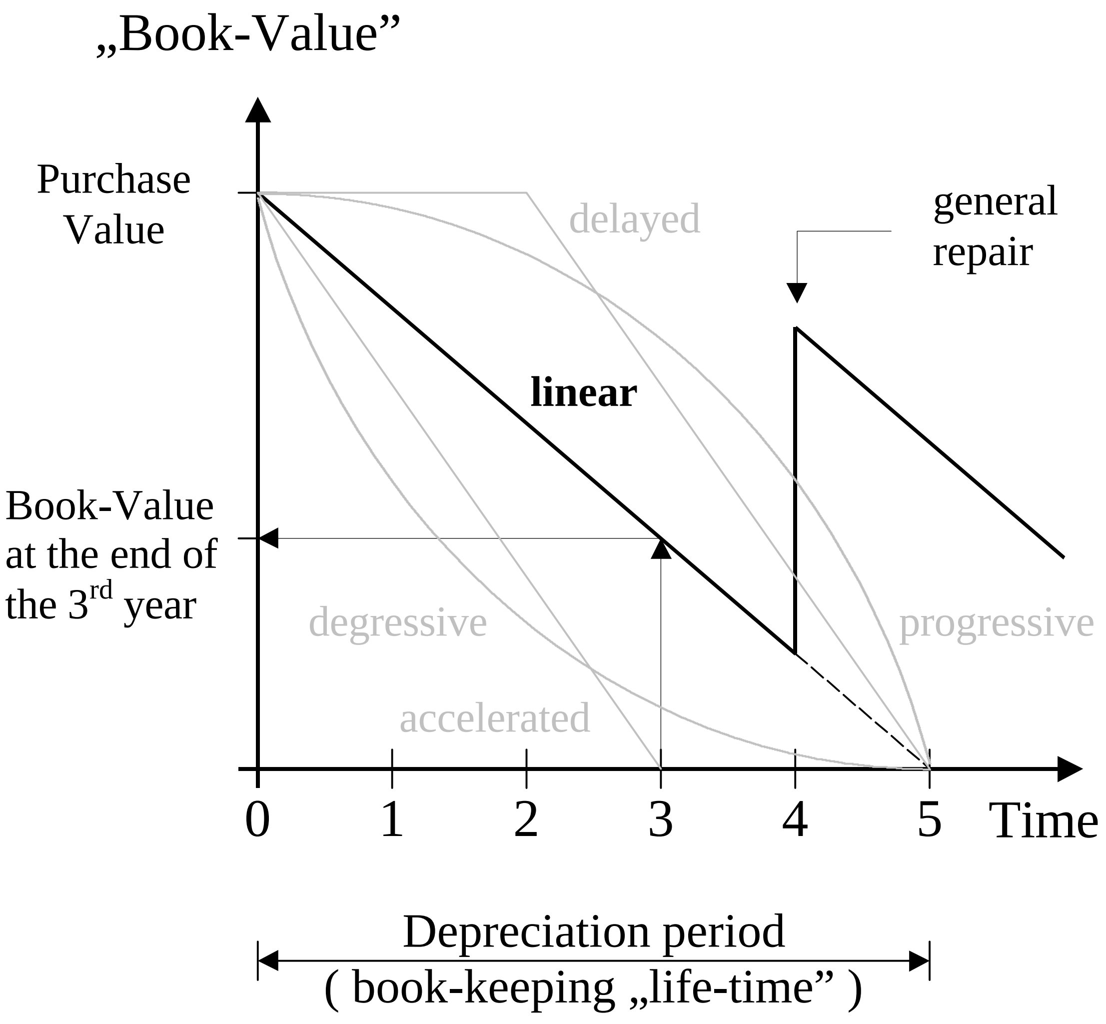
(Typically used at Real-Estate Development)



Consideration of Taxation
(e.g.: rules of depreciation)

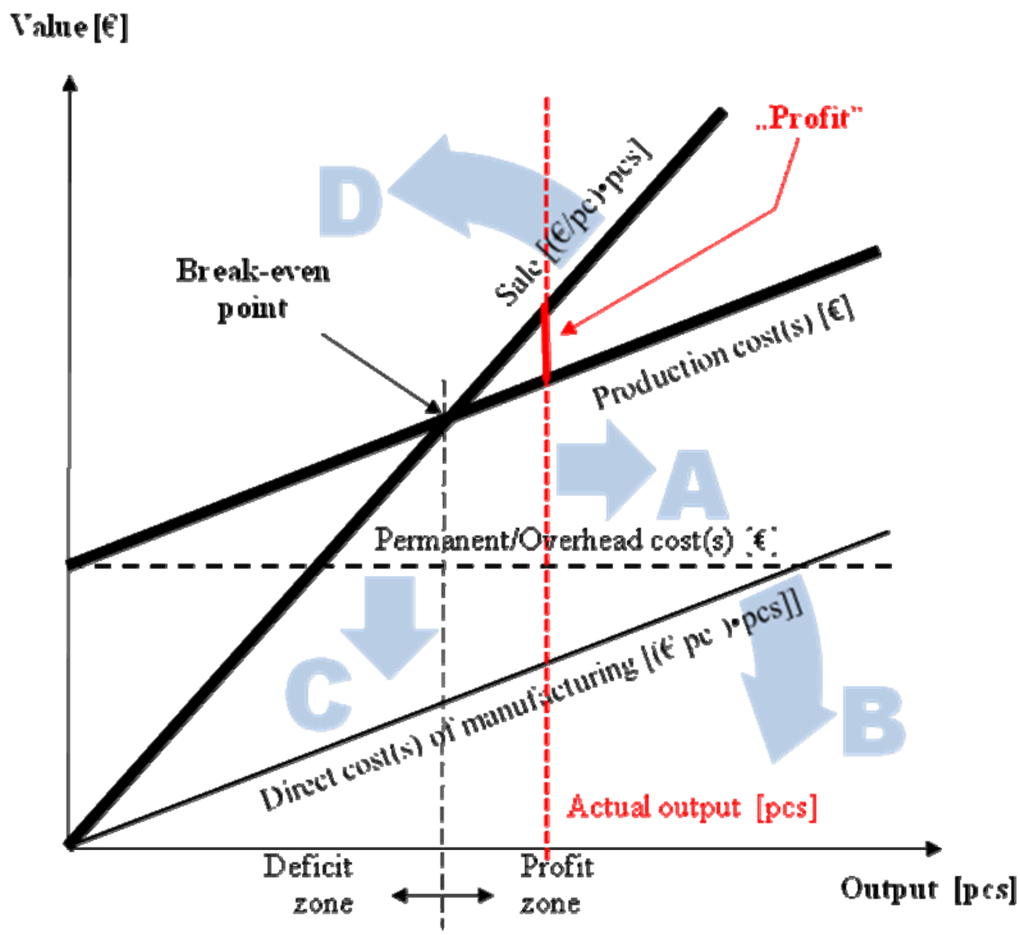
Depreciation

A legally regulated way of accounting costs of investments in fixed assets necessary for operating a venture as expences before taxation.
(A mean of Economic Government)



Quasi-graphic methods

„Break-even point" calculation



Four ways of increasing „profit" (or decreasing loss)

A: Increasing output
increasing market shares, entering new markets, marketing, …

B: Decreasing direct cost(s) of manufacturing
decreasing procurement costs (labour, material), applying cost-effective technologies, product/design optimalization, …

C: Decreasing company's permanent/overhead cost(s)
outsourcing, stop uneconomic activities, reorganization, …

D: Increasing sale prices
rise prices (but: market competition, cartelization mallowed !!!)

Range of Examinations in Engineering Economics

Though it is a popular idea that everything can be measured in cash it is highly recommended for decision makers to understand the limits of modelling capabilities of any engineering economic examination …

Reducible Factors:

Each and all factors can be subject of engineering economic analysis financial consequences of which can be predicted with high accuracy and is unconditionally morally accepted.
(e.g.: technical, financial constructions)

Irreducible Factors:

Any or all factors must not be subject of engineering economic analysis financial consequences of which can not be predicted with sufficient accuracy or quantifying of which is not morally accepted.
(e.g.: religious, moral, sensual, cultural, aesthetic, political, etc. considerations)