ENERGY EFFICIENCY IN BUILDINGS (Municipality Program)

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Energy Efficiency Definition

- Reduction in energy consumption
- Without reduction in comfort

Examples :

Is decreasing of indoor temperature (below a recommended level) an energy efficiency measure?

Reasons for Energy Efficiency

- Fastest way
- Most effective way (according to investment)
- Good for environment
- Development of sustainable energy

Energy Efficiency at Country Level

- Energy strategy and energy law (energy efficiency law as a part of energy law or as a separate law)
- Energy efficiency agency
- Energy prices
- Taxes

Energy Efficiency Methods in Municipalities

- District heating company
- Public lighting
- Public transportation
- Waterworks company
- Public buildings
- Others

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Advantages

- Economy : savings in municipality budget
- Ecology : global and local (connected with economy) pollution reduction
- Good example for citizens
- Good result for local government

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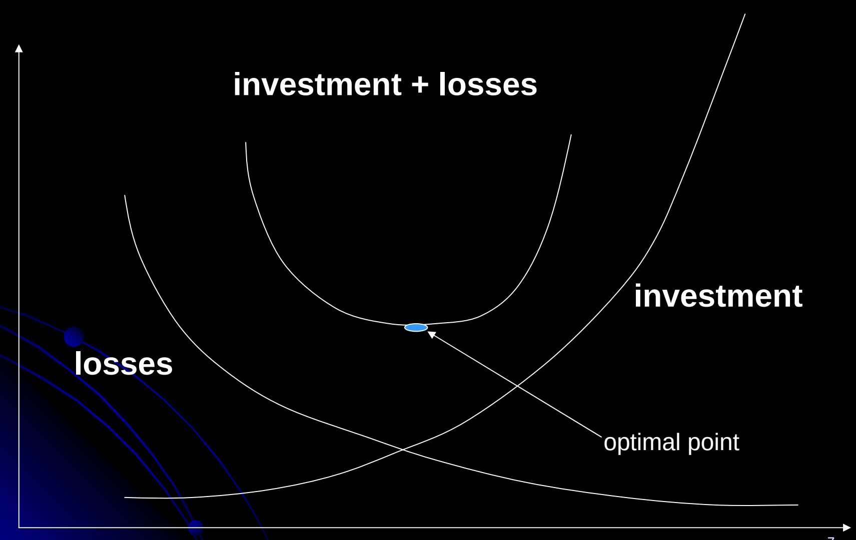
Optimal investment



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Energy management

- Establishment of energy efficiency group or agency inside municipality (small group with two or three individuals)
- Education on country or regional level (in order to apply same methodology)
- Preparation of energy strategy
- Activities according to strategy

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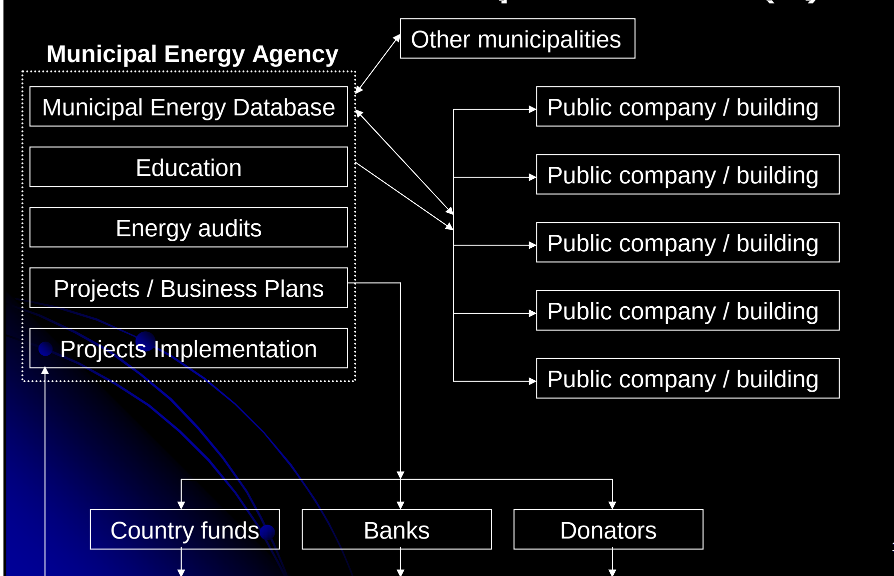
How to solve problems (1)

- Municipality energy database
- Education in public companies (great results can be obtained without any investment)
- Periodical energy audits
- Business plan preparation
- Energy efficiency project implementation (with equity investment, with commercial loan, or with donation)

How to solve problems (2)



Energy Consumption in Buildings

- Heating, cooling and ventilation
- Indoor lighting
- Domestic hot water
- Cooking
- Other

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BEEP – Introduction

- Detailed building modeling
- EE measure group (package) preparation
- Pollution as part of objective function
- Reports preparation (EE Project, Business Plan, Thermal Calculation, Multi Project)
- Multi-language option
- Multi-currency option

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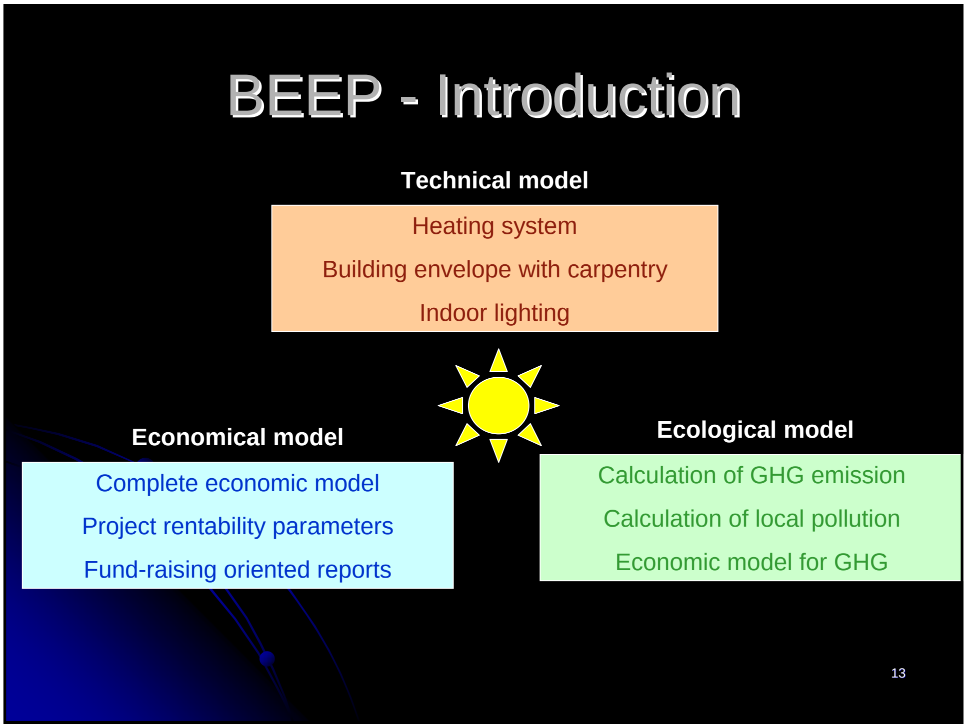
BEEP - Introduction
Technical model
Heating system
Building envelope with carpentry
Indoor lighting
Economical model
Complete economic model
Project rentability parameters
Fund-raising oriented reports
Ecological model
Calculation of GHG emission
Calculation of local pollution
Economic model for GHG
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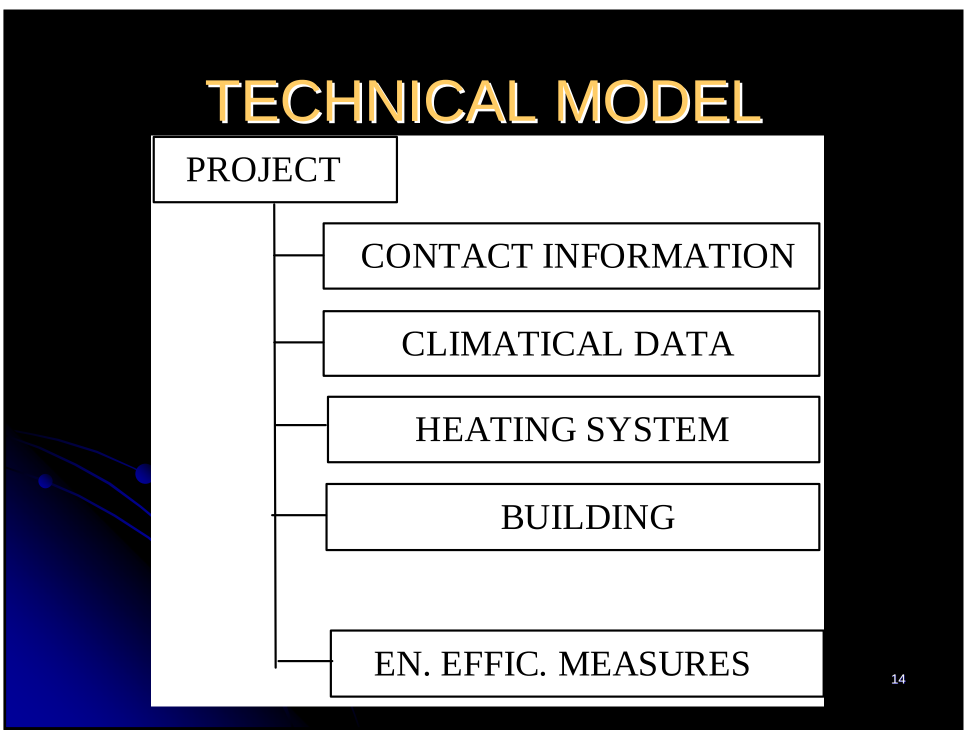
TECHNICAL MODEL
PROJECT
CONTACT INFORMATION
CLIMATICAL DATA
HEATING SYSTEM
BUILDING
EN. EFFIC. MEASURES
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Climate Data

- Heating season duration (days)
- Projecting and average air temperature during heating season
- Projecting and average ground temperature during heating season
- Data for water steam diffusion calculation (for moisture and drying season)

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Heating system (1)

- Model enables to define one common heating system that supplies several buildings,

Example 1: A school is comprised of 3 buildings (the school itself, the sports hall and a dining room with kitchen). A common coal fueled boiler heats the entire block of buildings. The regulation of the heating system is manual. Transport of heating energy from the boiler to the buildings passes through external heat pipes buried into the ground. In this case, we have all the elements shown on diagram 2.1. The energy source is coal, the converter is a kettle on solid fuel, and the regulation is manual. There are heat and heating (external and internal) pipes.

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Heating system (2)

- Boiler / Stove / District heating
  - Type, Efficiency, Installed power
- Energy source
  - unit of measure, energy capability, price, GHG and local pollution emission
- Regulation
  - Type, Efficiency

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Building

- Data about building usage (working days per week, working hours per day, holidays, etc.)
- Level of consumption during non-working days (heating system protection)
- Building position
- Description of outdoor and indoor pipeline network
- Building envelope description

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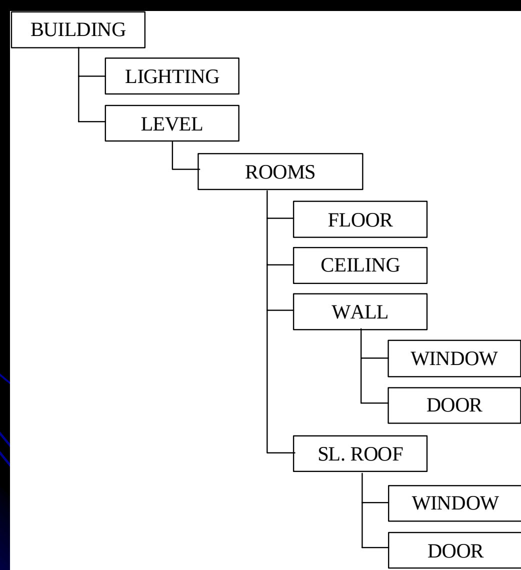
Building - Model



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Indoor lighting

- Goal : keep same lighting quality with less annual costs (sum of electricity costs and costs for light-source replacement)
- Replacement of lamps and light-source (most expensive)
- Replacement of light sources only (sockets have to be same)

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Indoor lighting – Model (1)

- The year is divided into two periods, and the user defines the duration of each period in days:
  - Period 1 is the period of intensive use of internal lighting (winter period)
  - Period 2 is the period of less intensive use of internal lighting (summer period)

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Indoor lighting – Model (2)

- In order to consider the difference in price for electrical energy during the day, each period includes two intervals. The user defines the energy price for each interval (high and low tariff)
- Users whose bill for include the component “peak power”, will point out that - for each period - a price has been set for a kilowatt. For each group of bulbs, the input should include group related coincidence factors according to the peak power of the whole building

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Indoor lighting – Model (3)

- Inner lighting bulbs of a building are classified into **bulb groups.**
- One group is comprised of bulbs with identical characteristics
  - power, flux, life length and with identical use in both intervals and both periods

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Building's envelope

- Each level/floor of a building is comprised of one or more rooms
  - The desired/projected temperature during the heating season in case a room is heated
  - The number of heating devices (radiators) in case a room is heated
- Every room is separated from other rooms and from the surrounding ambient by its segments: the floors, ceilings, walls and pitched roofs

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Building's envelope

- Segments of floor, ceiling, walls, and roofs consists information about:
  - Area or relevant dimensions
  - Layers (building materials and thickness)
  - Space that surround segment (space above, bellow or beside; "unknown" space, outdoor space (air or ground))

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Carpentry

- Dimensions (width and height)
- Type of window or door (frame material, number of frames, panes)
- Perimeter of carpentry jointing (defined by the number of width (Nwid) and the number of height (Nhei))
- Quality of carpentry joints (good, average, bad)
- Insulation quality of shutter boxes above doors/windows (if exists)

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Energy efficiency measures

- Energy source replacement
- Converter replacement / repair
- Regulatory system improvement
- Thermal insulation of external heat pipes
- Insulation of horizontal element (floor, ceiling)
- Insulation of vertical element (wall)
- Insulation of pitched roof
- Carpentry replacement (windows, doors)
- Insulation of carpentry joints
- Insulation of shutter boxes
- Indor lighting replacement

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ECONOMIC MODEL (1)

- Technical and economic Project life length and measures life lengths
- It is essential to define the life length of a project, particularly in cases where the project is made up of measures which have different life lengths.
- In such case, it is necessary to calculate the repetition of each of the measures (the so-called cycle of measures) during the life length of a project.

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ECONOMICAL MODEL (2)

- Actualization of money in time
- The actualization can be done in two ways
  - from present to future
  - from future to present
- Real and nominal interest rates, inflation

$$r = \frac{n_r - b}{1 + b}$$

Example 2: What is the current value V_n = 150 of the monetary units that we shall have in the fifth year n = 5, with an actual interest rate r = 5% ?

$$V_o = \frac{150}{\left(1 + \frac{5}{100}\right)^5} = \frac{150}{1{,}05^5} = \frac{150}{1{,}276} = 117{,}5$$

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ECONOMICAL MODEL (3)

- The interest rate for an arbitrary period of time

$$r_2 = (1 + r_1)^{T_2/T_1} - 1$$

Example 4: What is the interest rate for the whole life length (T_2=5 years) of some energy efficiency measures in a project, knowing that it amounts to r_1 = 12% on a yearly basis (T_1=1 year) ?

$$r_2 = \left(1 + \frac{12}{100}\right)^{(5/1)} - 1 = 1{,}12^5 - 1 = 0{,}76234 = 76{,}234\%$$

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ECONOMIC MODEL (4)

- Investments : global investment (I_o) can be divided into the investment needed only once - at the beginning of the project (I_{oF}) - , and cyclic investments that are essential to keep the project alive (I_{oC}).
- There are two kinds of investment costs:
  - Initial investment costs
  - Actualized investment costs

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ECONOMICAL MODEL (5)

- Annual costs and savings : For a year *t*, the annual costs (C_t) can be defined as the sum of the costs for the acquisition of the energetic source (C_{tei}) and the costs for maintenance and spare parts (M_t)
- The difference between the initial annual costs and the new annual costs represent the annual savings (*Bt*)

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ECONOMICAL MODEL (6)

- Cumulative (actualized) savings (CB)

$$CB = \sum_{t=1}^{n} \frac{B_t}{(1+r)^t}$$

General / Special

$$CB = B\frac{(1+r)^n - 1}{r(1+r)^n}$$

Example 7: The implementation of an energy efficiency project will result in yearly savings of B = 100 monetary units. Calculate the cumulative savings that will be achieved during the life length of the project n = 10 years. The actual yearly interest rate amounts to r = 5%.

$$CB = 100\frac{(1+0{,}05)^{10} - 1}{0{,}05(1+0{,}05)^{10}} = 722{,}17$$

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ECONOMICAL MODEL (7)

- Net Present Value (NPV) and Net Present Value Coefficient (NPVC)

$$NPV = CB - I_{ac}$$

$$NPVQ = \frac{NPV}{I_{ac}} = \frac{CB - I_{ac}}{I_{ac}} = \frac{CB}{I_{ac}} - 1$$

Example 8: Investments needed for the implementation of some energy efficiency project amount to I_{ac} = 700 monetary units. We expect yearly savings of B = 200 monetary units during the life length of the project n = 5 years). Calculate the net present value and the net present value coefficient, knowing that the yearly interest rate amounts to r = 4%.

$$NPV = CB - I_0 = 890{,}36 - 700 = 190{,}36$$

$$CB = 200\frac{(1+0{,}04)^5 - 1}{0{,}04(1+0{,}04)^5} = 890{,}36$$

$$NPVQ = \frac{NPV}{I_0} = \frac{190{,}36}{700} = 0{,}27$$

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ECONOMICAL MODEL (8)

- Pay back period (PBP) and Pay off period (POP)

$$PBP = \frac{I_{ac}}{B}$$

$$CB(POP) - I_{ac} = B\frac{(1+r)^{POP} - 1}{r(1+r)^{POP}} - I_{ac} = 0$$

$$POP = -\frac{\ln\left(1 - r \cdot \frac{I_{ac}}{B}\right)}{\ln(1+r)} = -\frac{\ln(1 - r \cdot PBP)}{\ln(1+r)}$$

- Internal Rate of Return (IRR)

$$NPV(IRR) = B\frac{(1+IRR)^n - 1}{IRR \cdot (1+IRR)^n} - I_{ac} = 0$$

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ECOLOGICAL MODEL (1)

- Greenhouse Gases
  - carbon dioxide (1)
  - Methane (21)
  - nitrogen sub oxide (310)
  - chlorofluorohydrocarbons
  - halogens
  - sulfur- hexafluoride

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ECOLOGICAL MODEL (2)

- Other harmful emissions
  - carbon monoxide
  - sulfur dioxide
  - nitrogen oxides
  - soot

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