

## 6. Cost-in-use

*Airtightness, thermal insulation, thermal bridges, condensation, ventilation, **cost-in-use** and windows*

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**ZEPHIR training session | Train-the-Trainers pilot programme (Day 3)**

Dolni Rakovets (Bulgaria), 28 September to 2 October 2026

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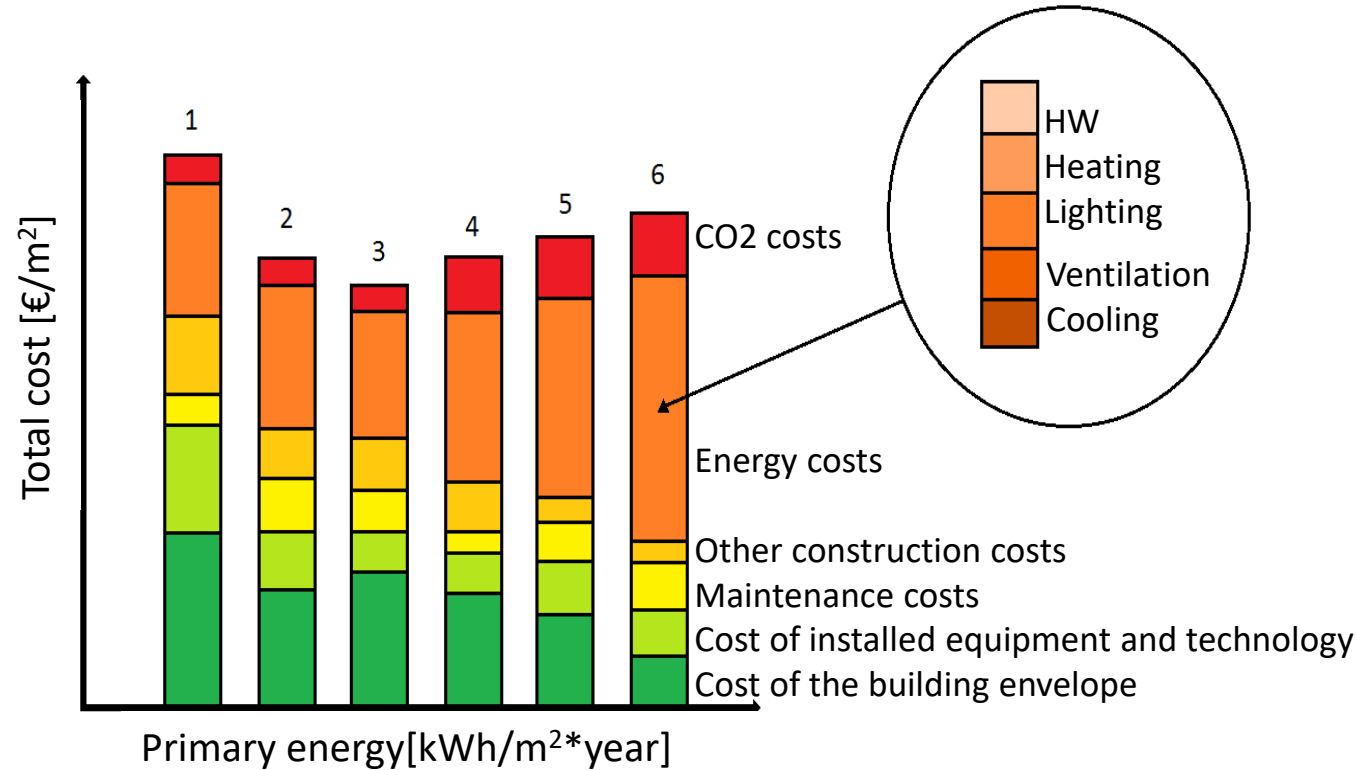
*"Let's build ecologically together"*

## SECTION 1

# Financial analysis fundamentals

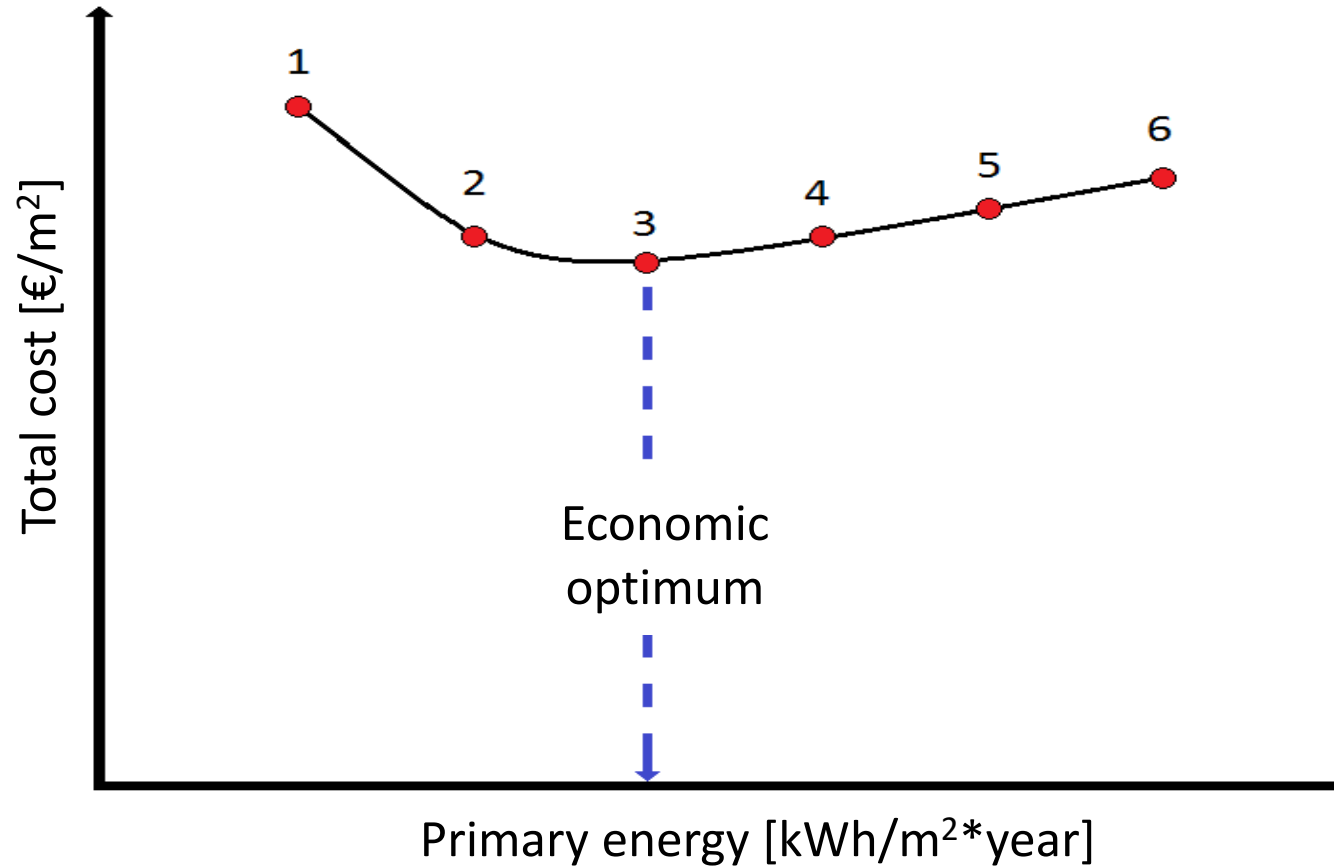
*Terminology, cost effectiveness, LCA*

# Cost effectiveness



- Balance between acquisition costs and operating costs
- High investments do not automatically bring the best possible

# Cost effectiveness



- The best option is 3
- But which of variants 2 and 4 is better?

# Cost effectiveness - economic calculations



- Simple Payback Period (SPP)
- Dynamic Payback Period (DPP)
- Net Present Value (NPV)
- Internal Rate of Return (IRR)
  - Discount  $r$  (%)
  - Annual energy price growth  $p_{En}$  (%)
  - Evaluation period  $T_N$

$$T_{SPP} = \frac{IN}{CF_{inflow}(t=0)}$$

$$T_{DPP} = -\frac{\ln \left[ 1 - \frac{r IN}{CF_{inflow}(t=0)} \right]}{\ln(1+r)}$$

Typically, yearly energy savings

$$NPV = \sum_{t=1}^{T_N} CF_t \cdot (1+r)^{-t} - IN$$

$$\sum_{t=1}^{T_N} CF_t \cdot (1+IRR)^{-t} - IN = 0$$

*PP, NPV and IRR are the economic indicators required by EN 15459 (economic evaluation procedure for energy systems in buildings) for EU cost-optimal calculations under the EPBD.*

# Cost effectiveness - economic calculations



## Economic Calculations - IRR

- Internal Rate of Return (IRR) =>

$$\sum_{t=1}^{T_N} CF_t \cdot (1 + IRR)^{-t} - IN = 0$$

- $CF_t$  ... cash flow for a certain period of time
  - $t$  ... time value.
  - $IN$  ... investment costs
  - $T_N$  ... evaluation period
- The interest rate at which the present value of the cash income from the project equals capital expenditure
  - It is a discount rate at which  $NPV = 0$

# Cost effectiveness - economic calculations



## Calculation - Example

- Investment costs (EUR) • 28 000 EUR
- energy consumption before realization (kWh) • 50 000 kWh
- energy consumption after implementation(kWh) • 32 000 kWh
- Type of fuel before • Electricity
- Fuel type after • Heat pump
- fuel price before (EUR / kWh) • 0.30
- fuel price after (EUR / kWh) • 0.12
- Evaluation period  $T_N$  (a) • 15
- Rising energy prices (%) • 3
- Discount (%) • 4
- $CF_t = [C_{inflow} * (1 + p_{En}) - C_{outflow}]_{t-1} / (1 + r) \rightarrow CF_{t-1} * (1 + p_{En}) / (1 + r)$   
if the sole investment only occurs at the beginning

# Cost effectiveness - economic calculations



## Calculation - Example

| CF        |        |        |        |        |        |     |        |
|-----------|--------|--------|--------|--------|--------|-----|--------|
| 0         | 1      | 2      | 3      | 4      | 5      | ... | 15     |
| -28 000   | 11 495 | 11 840 | 12 195 | 12 561 | 12 938 | ... | 17 387 |
|           |        |        |        |        |        |     |        |
| $T_{SPP}$ |        |        |        |        |        |     |        |
| 2.51      |        |        |        |        |        |     |        |
|           |        |        |        |        |        |     |        |
| $T_{DPP}$ |        |        |        |        |        |     |        |
| 2.55      |        |        |        |        |        |     |        |
|           |        |        |        |        |        |     |        |
| NPV       |        |        |        |        |        |     |        |
| 127 083   |        |        |        |        |        |     |        |
|           |        |        |        |        |        |     |        |
| IRR       |        |        |        |        |        |     |        |
| 44%       |        |        |        |        |        |     |        |

# Cost effectiveness - economic calculations



## Another example

| Parameter                           | Unit  | Variant I | Variant II | Variant III | Variant IV |
|-------------------------------------|-------|-----------|------------|-------------|------------|
| Investment costs of the project     | EUR   | 1 684 120 | 308 480    | 1 344 040   | 726 800    |
| Total project benefits              | EUR/Y | 177 672   | 50 960     | 74 680      | 65 560     |
| Evaluation period                   | Years | 30        | 30         | 30          | 30         |
| Annual energy price growth $p_{En}$ | %     | 3         | 3          | 3           | 3          |
| Discount $r$                        | %     | 5         | 5          | 5           | 5          |
| Simple payback time                 | Years | 9.5       | 6.1        | 18          | 11.1       |
| Real payback time                   | Years | 10.6      | 6.5        | 22.4        | 12.6       |
| Net present value                   | EUR   | 2 327 161 | 842 038    | 342 002     | 753 340    |
| IRR                                 | %     | 13.2      | 19.8       | 6.8         | 11.4       |

# Cost effectiveness - economic calculations



- Investment costs
- Cost of energy savings
- Capital costs
- Cost of savings measures



**COST**

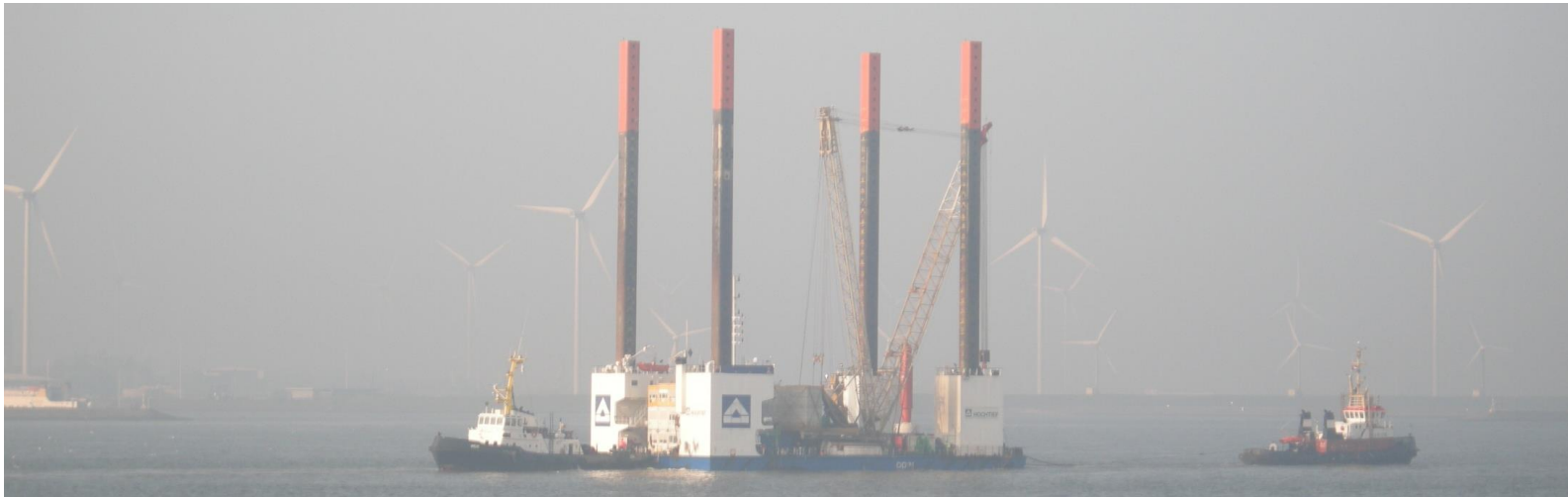
**BENEFIT**



- Energy savings
- Cost savings
- Revenues

## Sustainable Development

**Sustainable development is a way of development that meets the needs of the present, without undermining the possibilities of future generations to meet their own needs.**

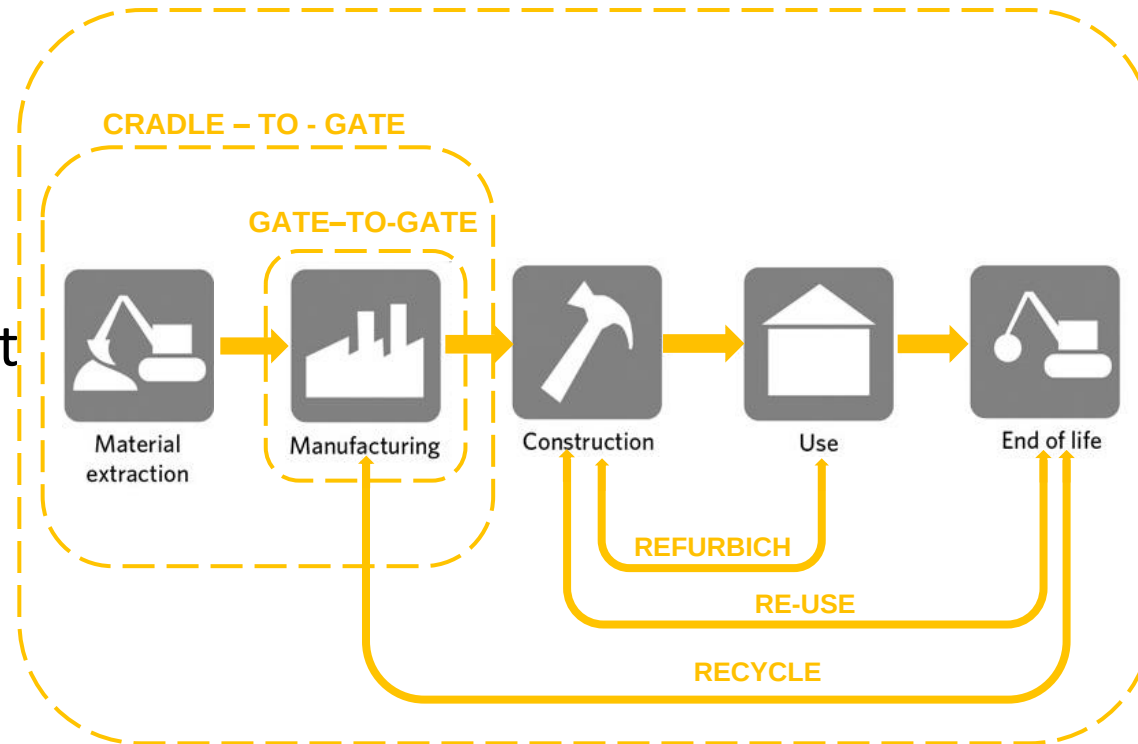


# Life cycle assessment - Economic and Analytical



## LCA - Life Cycle Assessment

- is a multi-step procedure for calculating the lifetime environmental impact of a product or service
- The complete process of LCA includes **CRADLE - TO - GRAVE**
  - goals
  - scope definition
  - inventory analysis
  - impact assessment
  - interpretation



Source Adapted from K. Simonen, Life Cycle Assessment

# Life Cycle Assessment - ingREeS



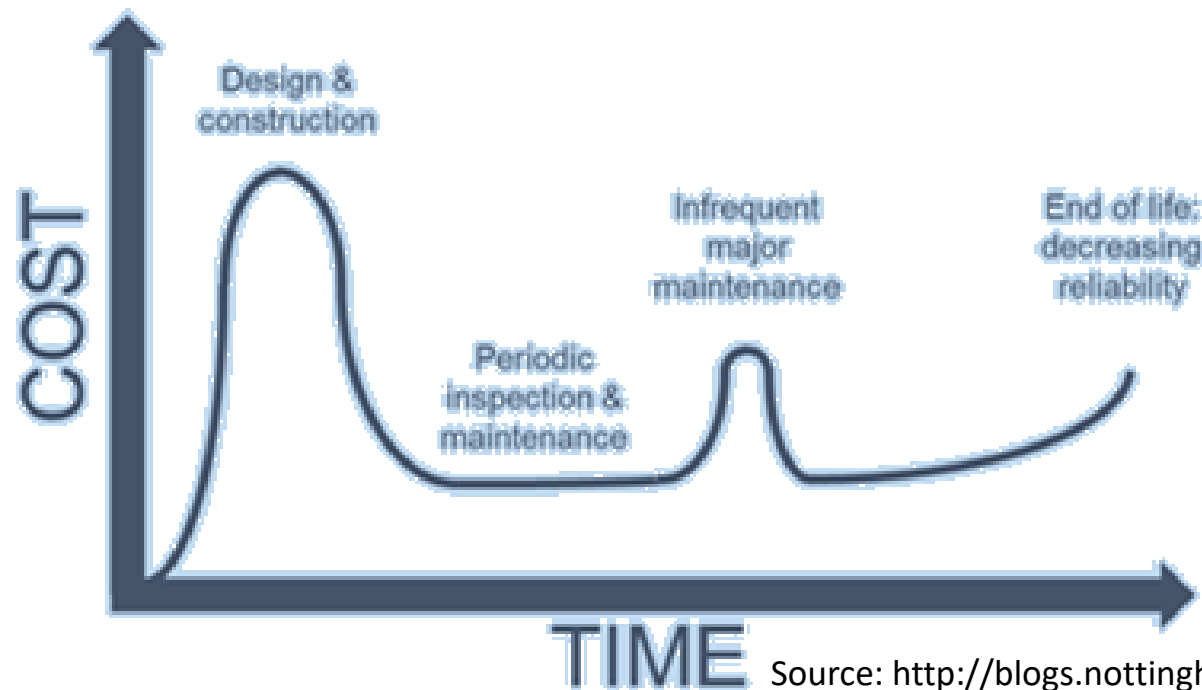
- **Increased motivation to invest in competencies** through increased market demand in intelligent energy solutions in the sector of buildings;
- **Facilitated investments in competencies** through building up legal and financial framework for continuing education and training.
- Improved competencies of middle and senior level construction professionals through **5 education programmes**:
- Development of **training materials** for each training module, including e-learning
- Preparation of **training of trainers**
- Preparation of **database of trainees and trainers**

# Life cycle assessment - Economic and Analytical



## LCC: Life Cycle Cost

- Is another life cycle approach (i.e, cradle to grave)
- It looks at the direct monetary costs involved with a product or service
- Not environmental impact.



Source: <http://blogs.nottingham.ac.uk>

# Life cycle assessment - Economic and Analytical



## LCC: Life Cycle Cost

Operating costs, maintenance and reconstruction costs often account for more than 80% of the total lifecycle cost

Lower energy  
consumption



Cheaper operation of the building and less  
negative impacts on the environment

Lower energy consumption and lower operating costs are  
closely related to higher investment costs

# Life Cycle Cost - Cost optimum for a case study



## Legend of the variants considered

- Heat transfer coefficient (1-4):
  - 1 - required value
  - 2 - recommended value
  - 3 - passive houses (moderate values)
  - 4 - passive houses (strict values)

## Reference buildings

- Family house
- Apartment building
- Administrative building
- School

| SYSTEM           | VAR A (1-4)                            | VAR B (1-4)          | VAR C (1-4)            | VAR D (1-4)         | VAR E (1-4)       | VAR F (1-4)                |
|------------------|----------------------------------------|----------------------|------------------------|---------------------|-------------------|----------------------------|
| Heating          | Natural Gas Boiler<br>Condensing       | Electric<br>heaters  | Heat pump              | Boiler on<br>coal   | Biomass<br>boiler | Central. of<br>heat supply |
| Preparation HW   | Central<br>preparation                 | Local<br>preparation | Central<br>preparation | Central preparation |                   | Central<br>preparation     |
| Ventilation      | Natural ventilation                    |                      |                        |                     |                   |                            |
| Lighting         | High-quality energy efficient lighting |                      |                        |                     |                   |                            |
| Solar collectors | No                                     |                      |                        |                     |                   |                            |

Source: SEVEN

# Life Cycle Cost - Cost optimum for a case study



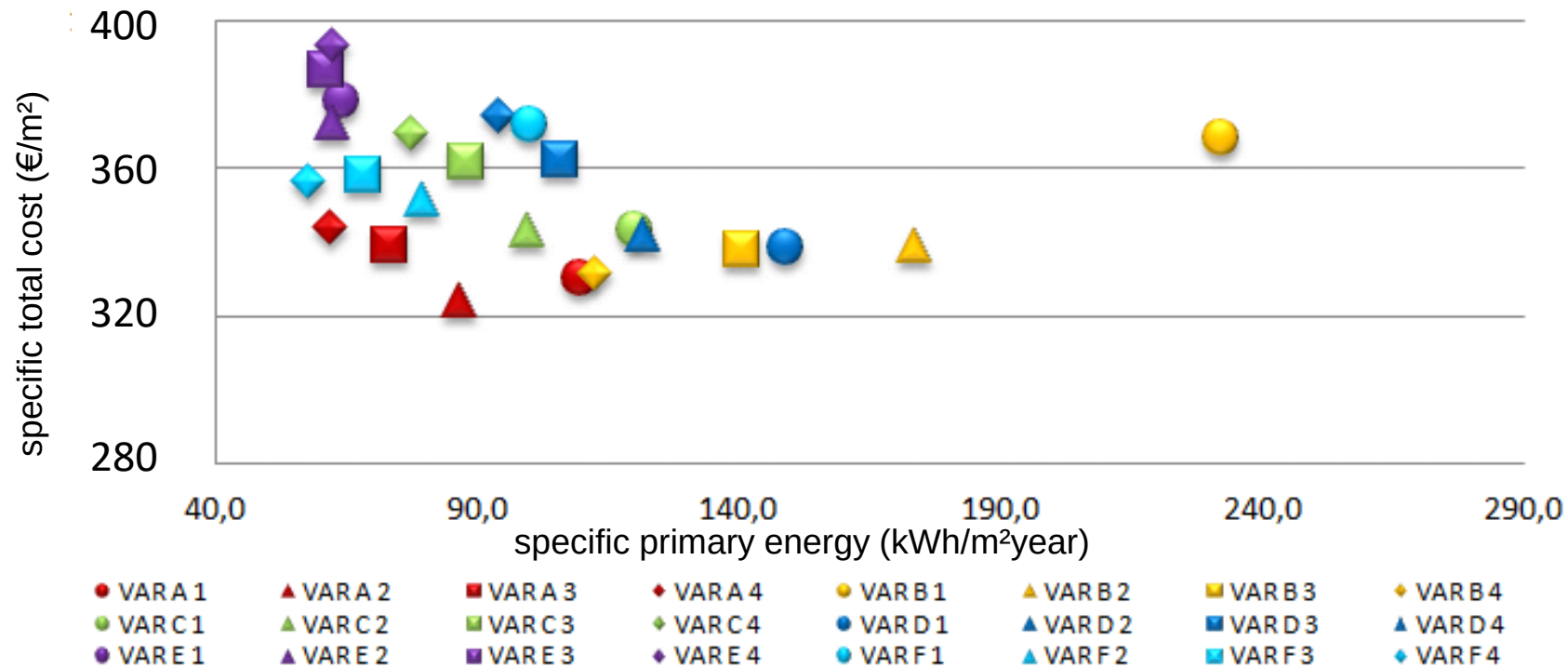
## Residential - retrofit

● - required

▲ - recommended

■ - Passivhaus buildings (moderate values)

◆ - Passivhaus buildings (strict values)



Source: SEVEN

# Thank you.

Every detail shown here is a detail you will teach a craftsman.

State the problem, give the principle, show the wrong and the right example,  
let them practise by hand, test it, document it.

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