# Introduction Cost Engineering in the process industry NESMA November 2010



## Cost Engineering Consultancy B.V.

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# Cost Engineering

- Member of DACE
- Member of AACEI
- Member of ICEC
- Member of the int. group for location factors
- Teacher cost engineering





# Introduction Cost Engineering

Cost Engineering,
Applying of methods and techniques for:

- Estimating
- Planning
- Cost control
- Contracting
- Quantity survey
- Value Engineering

# Introduction Cost Engineering

## Work Area

- Feasibility studies
- Estimating
- Technical and economic evaluations
- Optimisations
- Capitalisations
- Fiscal aspects
- Evaluation profit
- Value -analysis
- Risk -analysis
- Start-up costs, operational costs
- Maintenance costs
- Cash-flow planning



## What happenes with to much pressure

Budgets are always under pressure

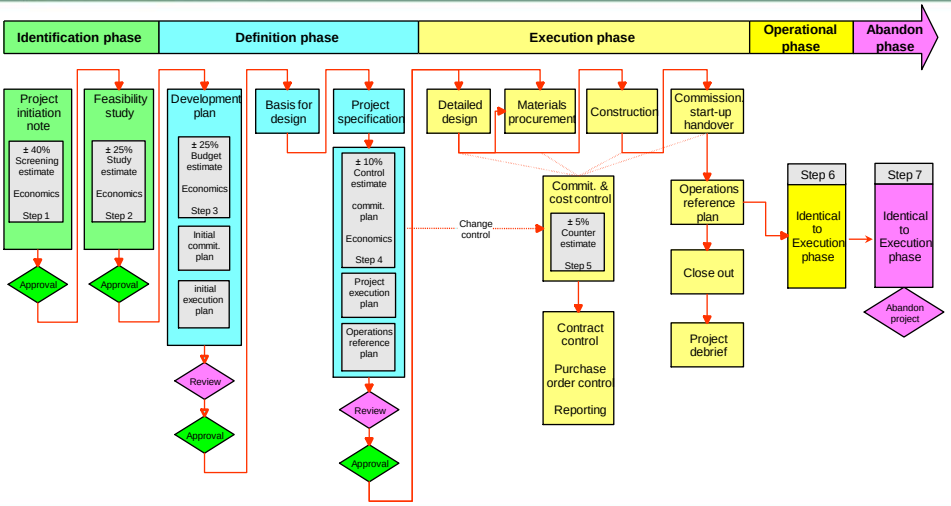
# The practical interpretation

**Total Cost Management (TCM) - AACEI**

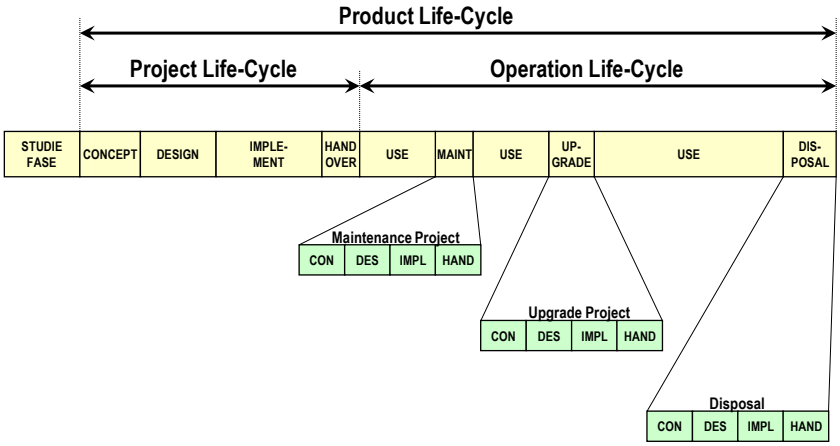
- The need
- Target, objective, management
- Identify requirements
- Evaluate/select
- Investigation, development
- Concept design
- Execution
- Operation
- Modifications
- Shut down
- Abandonment







## Life Cycles






## Estimating classification

**AACE Cost Estimate Classification System - Process Industries**

| | *Primary Characteristic* | *Secondary Characteristic* | | | |
|---|---|---|---|---|---|
| **ESTIMATE CLASS** | **LEVEL OF PROJECT DEFINITION** | **END USAGE** | **METHODOLOGY** | **EXPECTED ACCURACY RANGE** | **PREPARATION EFFORT** |
| **5** | 0% to 2% | concept screening | capacity factored, parametric models, judgment, or analogy | L: -20% to -50%<br>H: +30% to + 100% | 1 |
| **4** | 1% to 15% | study or feasibility | equipment factored or parametric models | L: -15% to -30%<br>H: +20% to + 50% | 2 to 4 |
| **3** | 10% to 40% | budget, authorization or control | semi-detailed unit cost with assembly level line items | L: -10% to -20%<br>H: +10% to + 30% | 3 to 10 |
| **2** | 30% to 70% | control or bid / tender | detailed unit cost with forced detailed take-off | L: -5% to -15%<br>H: +5% to + 20% | 4 to 20 |
| **1** | 50% to 100% | check estimate or bid / tender | detailed unit cost with detailed take-off | L: -3% to -10%<br>H: +3% to + 15% | 5 to 100 |

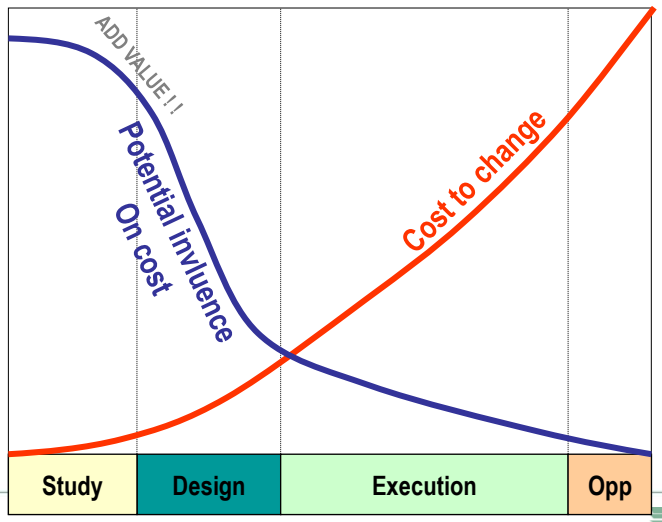
## The practical interpretation

INCREASING PROJECT DEFINITION

| AACE Classification Standard | ANSI Standard Z94.0 | AACE Pre-1972 | Association of Cost Engineers (UK) ACostE | Norwegian Project Management Association (NFP) | American Society of Professional Estimators (ASPE) |
|---|---|---|---|---|---|
| Class 5 | Order of Magnitude Estimate -30/+50 | Order of Magnitude Estimate | Order of Magnitude Estimate Class IV -30/+30 | Concession Estimate | Level 1 |
| | | | | Exploration Estimate | |
| | | | | Feasibility Estimate | |
| Class 4 | Budget Estimate -15/+30 | Study Estimate | Study Estimate Class III -20/+20 | Authorization Estimate | Level 2 |
| Class 3 | | Preliminary Estimate | Budget Estimate Class II -10/+10 | Master Control Estimate | Level 3 |
| Class 2 | Definitive Estimate -5/+15 | Definitive Estimate | Definitive Estimate Class I -5/+5 | Current Control Estimate | Level 4 |
| Class 1 | | Detailed Estimate | | | Level 5 |
| | | | | | Level 6 |



## Front end Loading



## What is estimating?





# What's an estimate?

A collection of categorized data, which is based on 'something' and gives an indication of the expected costs of 'something'.

**What is 'something'?**

- Something of the past
- Something like that
- Something of 'A' and half of something of 'B'
- Something new

**Conclusion =** Define and document 'something' otherwise it becomes 'nothing'.

# What's an estimate?

**What does an estimate look like?**

> For every company this is different (also the name!)

However there are some rough parts:

**Direct costs**

> These are the costs of those things which remain such as equipment, foundations, insulation, cable systems etc.

**Indirect costs**

> These are the costs of those things which are temporary needed for construction.





# Estimating basis

An estimate has no value if one does not know the basis for the data, the 'estimating basis'.

**Estimating Basis:**

> Used estimating method.
> Description of the battery limits.
> Equipment list, flow charts and plot plans.
> Price level and currency with exchange rates.
> Location.
> What is NOT included!

# What is estimating?

Estimating is to determine
***in advance*** expected costs of:

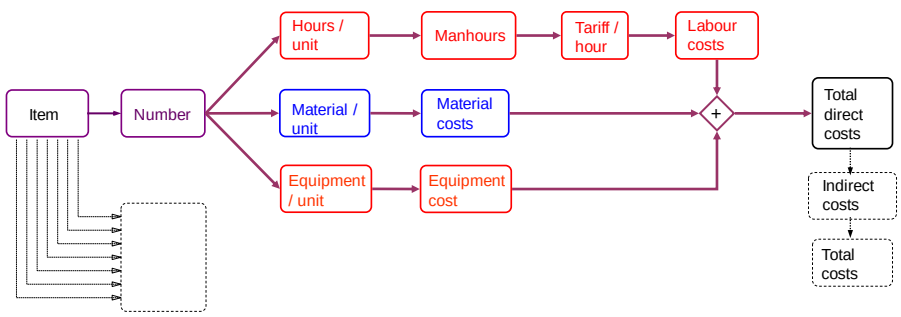
- Labour
- Material
- Construction equipment & Tools

which is needed to complete
your project.





# Construction of an estimate



# Estimating

- Estimating is a mix of:
  - Technical terminology
  - Tricks
  - Common sense
  - Experience

Particularly for estimating the experience component is very important!





# Parametric:

Parametric estimating entails the analysis of cost, programmatic and technical data to identify cost drivers and develop cost models. The approach essentially correlates cost and manpower information with parameters describing the item to be costed. This process results in sets of formulae known as “Cost Estimation Relationships”(CERS), which are applied to produce cost outputs for different elements of an estimate.

## Parametric: Example Pumps

- Total Price pump = Price (pump) + Price (motor)
- Key parameters
  - Power, Head, Flow rate



## Parametric: Dataset Pumps

| Pump | Flow rate (m3/h) | Diff. Head (m) | Disch. Press. (Bar) | Design temp. | Casing mtrl. | Impeller mtrl. | Est. Power (kW) | Quoted Price 1 (€) | Quoted Price 2 (€) | Average Quoted Prices (€) |
|---|---|---|---|---|---|---|---|---|---|---|
| P-1 | 20 | 46 | 5,1 | 180 | SS304L | SS304L | 4,5 | 14.895 | 8.085 | 11.490 |
| P-2 | 20 | 54 | 4,9 | 250 | SS304L | SS304L | 5 | 16.461 | 9.664 | 13.063 |
| P-3 | 30 | 63 | 6,6 | 120 | SS304L | SS304L | 8,2 | 20.078 | 8.316 | 14.197 |
| P-4 | 29 | 61 | 5,6 | 120 | SS304L | SS304L | 10 | 40.188 | 17.510 | 28.849 |
| P-5 | 37 | 275 | 24,9 | 200 | SS304L | SS304L | 50 | 129.182 | 60.476 | 94.829 |
| P-6 | 39 | 66 | 6,8 | 135 | SS304L | SS304L | 10,3 | 28.376 | 22.400 | 25.388 |
| P-7 | 13 | 18 | 2,7 | 120 | SS304L | SS304L | 1 | 11.638 | 10.377 | 11.008 |
| P-8 | 3 | 51 | 5,1 | 100 | SS304L | SS304L | 0,7 | 17.956 | 16.416 | 17.186 |
| P-9 | 100 | 56 | 9,5 | 100 | SS304L | SS304L | 25,2 | 31.546 | 31.456 | 31.501 |
| P-10 | 37 | 140 | 14,1 | 160 | SS304L | SS304L | 23 | 60.028 | 71.904 | 65.966 |
| P-11 | 140 | 54 | 15 | 190 | SS316L | SS316L | 40 | 81.320 | 50.966 | 66.143 |
| P-12 | 31 | 271 | 23,3 | 120 | SS304L | SS304L | 40 | 70.656 | 30.462 | 50.559 |
| P-13 | 34 | 36 | 2,9 | 200 | SS304L | SS304L | 5 | 21.634 | 11.460 | 16.547 |
| P-14 | 33 | 68 | 5,2 | 200 | SS304L | SS304L | 8,83 | 30.350 | 11.200 | 20.775 |
| P-15 | 23,3 | 54 | 5,4 | -10/+250 | SS304L | SS304L | 5,35 | 13.489 | 8.686 | 11.088 |

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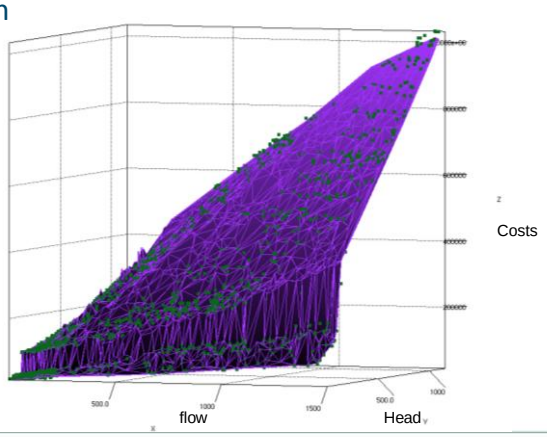
## Parametric: Dataset vs Regression function

Green: Datapoints dataset

Purple: Regression Function






## What is estimating

# Ratio or Factor estimating

Sometimes called Top-Down estimate is based on limited Project scope – uses rules of thumb or parametric models or Historical data bases to provide relevant cost data – to develop cost per square foot for a building or cost for a similar piece of equipment.

# Factor estimating methods

1) 0,6 exponent (cost/capacity exponent)
2) Lang-method
3) Hand-method
4) 'cost per capacity' method
5) The 'Zevnik-Buchanan' method
6) De 'Stallworthy' method
7) Miller-method
8) Guthrie-method
9) Specific factor method





# 3) Hand

> To make a fair estimate in an early stage
> Equipment separated in groups
> Basis : equipment prices free on board
> Possible quotations for a proper equipment price base
> Cost factors are divided in supply and assembly

## Hand method

| | Columns | Heat Exchangers | Vessels, Tanks | Pumps | Compressors | Furnaces | Instrumentation | Others |
|---|---|---|---|---|---|---|---|---|
| Process equipment FOB (Free on Board) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Supply of materials:** | | | | | | | | |
| Foundations and paving | 10 | 5 | 5 | 5 | 5 | 10 | 5 | 5 |
| Platforms and Supporting | 15 | 25 | 20 | - | - | - | 20 | 10 |
| Buildings | - | - | - | 10 | 15 | - | 15 | 10 |
| Piping | 60 | 50 | 65 | 30 | 15 | 10 | 50 | 15 |
| Insulation and fireproofing | 25 | 14 | 12 | 7 | 7 | 7 | 7 | 7 |
| Electrical | 5 | 3 | 5 | 75 | 15 | 5 | 40 | 10 |
| Painting, cleaning | | | | | | | | |
| Testing and miscellaneous | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Subtotal supply of materials | 118 | 100 | 110 | 130 | 60 | 35 | 140 | 60 |
| *Supply of equipment and materials* | *218* | *200* | *210* | *230* | *160* | *135* | *240* | *160* |
| **Transport and installation:** | | | | | | | | |
| Transport and installation of equipment | 10 | 3 | 10 | 10 | 10 | - | 10 | 10 |
| Installation of materials | 72 | 62 | 80 | 60 | 20 | 15 | 50 | 20 |
| Subtotal Transport and installation | 82 | 65 | 90 | 70 | 30 | 15 | 60 | 30 |
| Total direct cost | 300 | 265 | 300 | 300 | 190 | 150 | 300 | 190 |
| Indirect cost 1/3 of the direct cost | 100 | 85 | 100 | 100 | 60 | 50 | 100 | 60 |
| *Total cost* | *400* | *350* | *400* | *400* | *250* | *200* | *400* | *250* |
| **Hand factor: Total cost / Process equipment** | **4** | **3,5** | **4** | **4** | **2,5** | **2** | **4** | **2,5** |





## Detailed estimating

Sometimes called bottom-up. With this method, detailed estimates are made at relatively low levels in the work breakdown structure (WBS), typically at work-package or task level. This approach is closely related to scheduling, planning and resource allocation and is both time-consuming and costly. It requires a good knowledge of the activity and there also needs to be a reasonable level of definition for the exercise to be meaningful.

## Detail Estimating

What is detail estimating?

1. Defining activities
2. Defining quantities

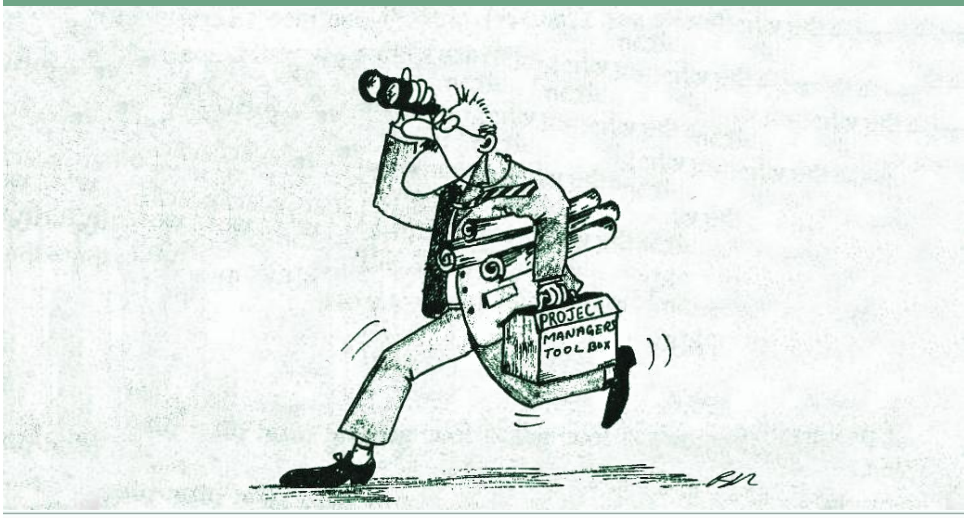
A Unit-Rate contains:

> Labour Norm * Labour rate
> Construction equipment & tools
> Material
> Preamble



## Unit-Rates, Weld composition

## Project Controls

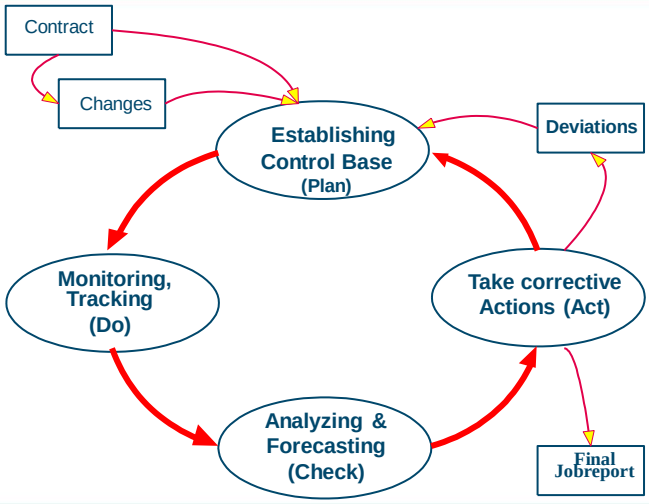





## PC – Definitions

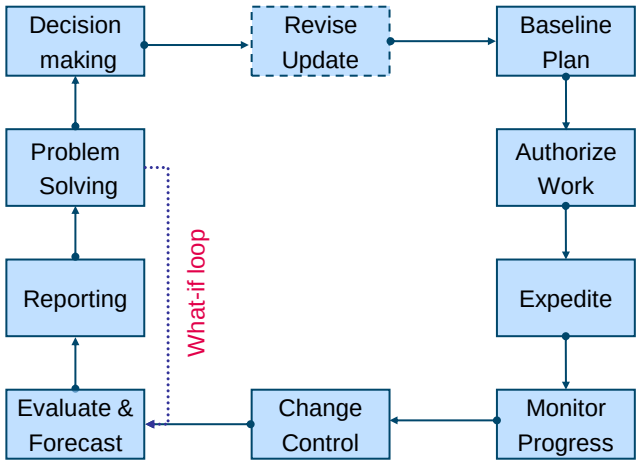
- Project Controls requires the timely evaluation of potential cost and schedule hazards and the presentation of recommended solutions to project management.
- Project Controls assists the project team in controlling the project, in such a way that it will be completed in time and within budget, with maximum profit.

## Project Control Cycle based on Deming Circle






## Project Control Cycle



# Cost Report

**PROJECT:** Petchem
**CLIENT:** CEC
**LOCATION:** Europe

**Contractnr.:**
**Statusdate:**

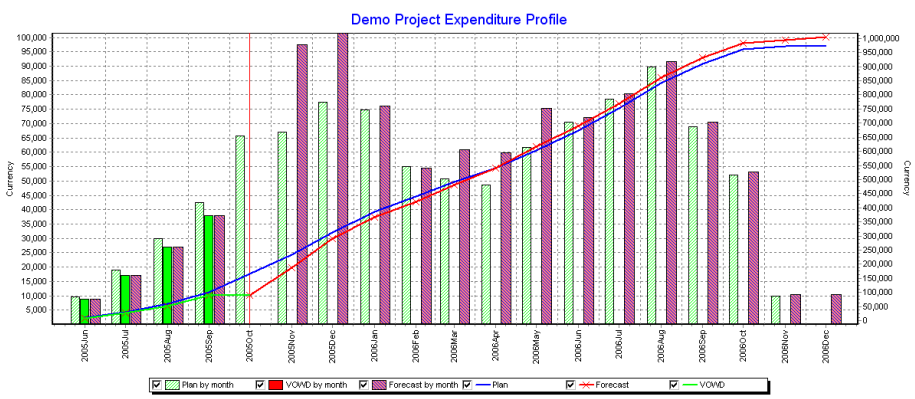
## COST REPORT - SUMMARY SHEET

(K EURO)

| Cost Code | DESCRIPTION | BUDGET ORIGINAL BUDGET A | BUDGET SHIFTS B | BUDGET APPROVED CHANGES B | BUDGET CURRENT BUDGET A+B | FORECAST ORIGINAL VALUE | FORECAST CURRENT COMMITMENT C | FORECAST ESTIMATE TO COMPLETE D | FORECAST CURRENT FORECAST C+D | ANALYSIS CURRENT EXPENDITURE F | ANALYSIS Expend. Budget F/(A+B) | ANALYSIS OVERRUN/ (UNDERRUN) (C+D)-(A+B) | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Subtotal Mechanical Equipment : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subtotal Piping Materials : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subtotal Electrical Equipment : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subtotal Instrumentation : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subtotal Steel : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subtotal Contingency Equipment : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | **TOTAL EQUIPMENT AND MATERIALS :** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0,0%** | **0** | |
| | Subcontract Civil : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subcontract Structural : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subcontract Piping & Mech Inst. & Testing : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subcontract Painting & Insulation : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subcontract Electr & Instrumentation inst. : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subtotal Contingency Subcontracts : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | **Subtotal Subcontracts:** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0,0%** | **0** | |
| | Subtotal Engineering : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | Subtotal Contingency Subcontracts : | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | **Subtotal Engineering :** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0,0%** | **0** | |
| | **TOTAL DIRECT COSTS :** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0,0%** | **0** | |
| | Subtotal project Contingency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | |
| | **GRANDTOTAL COST PROJECT :** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0,0%** | **0** | |



# Chapter – 16 Earned Value (p.224)



## Value Engineering





## The letter scale

What is the price of this letter scale?

**New price € 50,-**

What is the function of this letter scale?
Design a new one for half the price!

# Solution

Estimated value:
+/- € 0,20





# Questions