Methodologies for Cost Estimation of Chemical Plants as a Function of Engineering Progress

BASF
The Chemical Company

Dr. Kunzmann, W. Pehlke
GT/MR – Project Controlling, Cost Engineering & Engineering Governance

BASF – The Chemical Company

The world's leading chemical company

Our portfolio ranges from chemicals, plastics, performance products, agricultural products and fine chemicals to oil and natural gas

Customers in virtually all industries

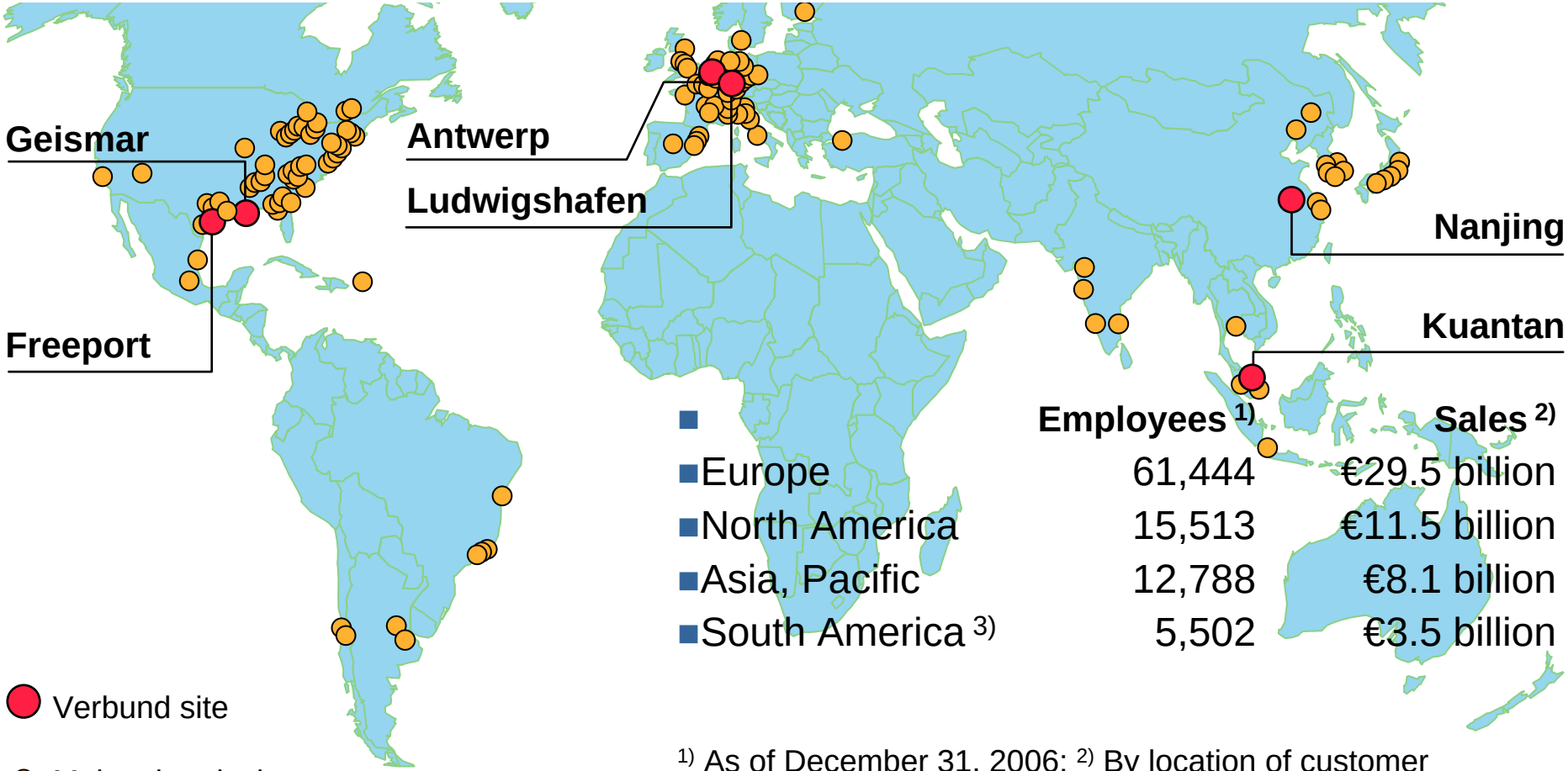
Sales 2006: €52,610 million

Income from operations (EBIT) 2006: €6,750 million

Employees (at year-end 2006): 95,247

14 operating divisions manage
68 global and regional business units

Global Presence



	Employees [1]	Sales [2]
Europe	61,444	€29.5 billion
North America	15,513	€11.5 billion
Asia, Pacific	12,788	€8.1 billion
South America [3]	5,502	€3.5 billion

[1] As of December 31, 2006; [2] By location of customer
[3] South America, Africa, Middle East

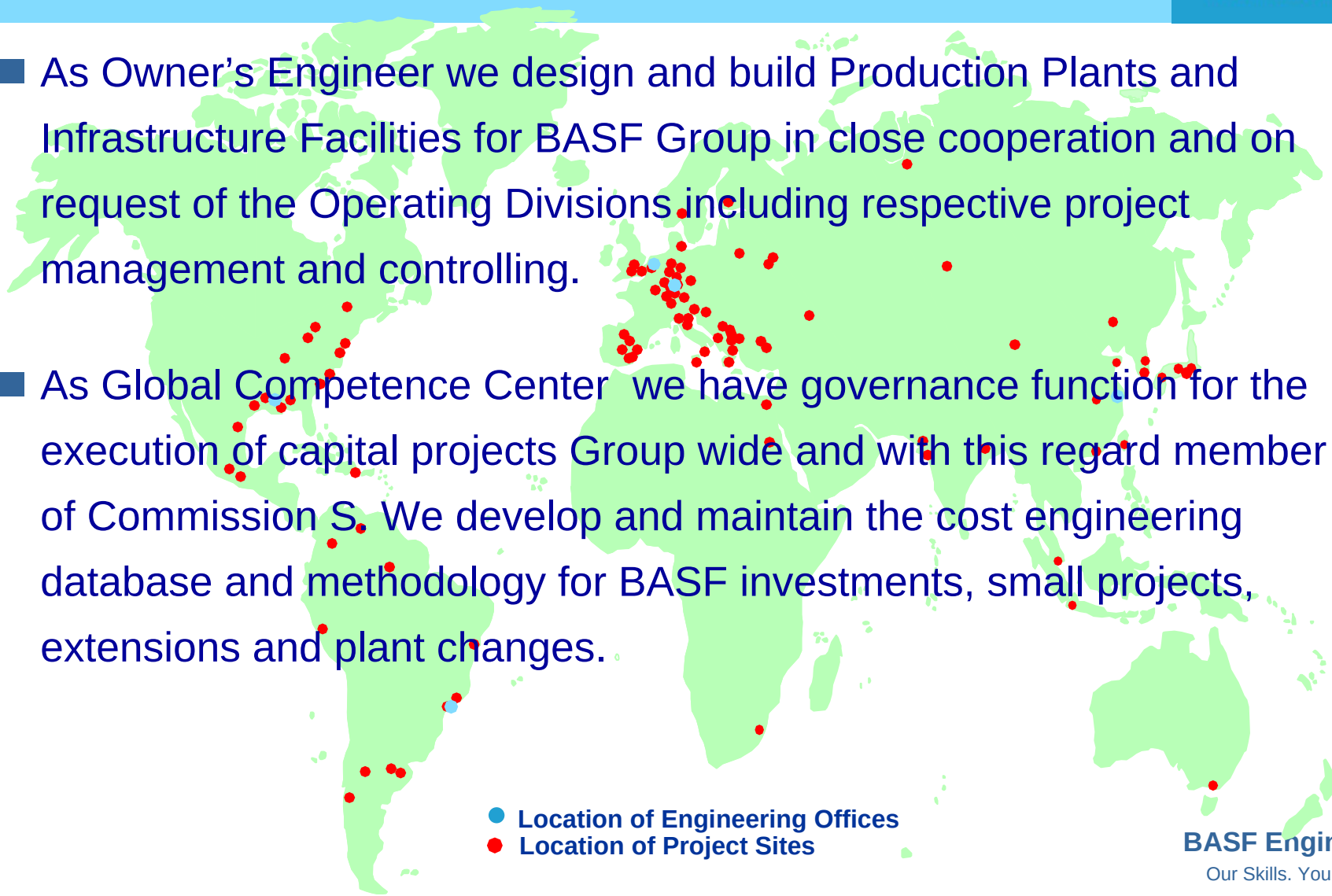
The Ludwigshafen site: The world's largest integrated chemical complex

- BASF Group's largest Verbund site with a total site area of
- 10 sq. km. ⇨ approx. 2,500 acre
- Location of the company's global headquarters
- Manufactures high-value products in a dense network of plants
- Location of BASF Group's technology platforms and competence centers

Tasks and Responsibilities of Corporate Engineering Business Mission

- As Owner's Engineer we design and build Production Plants and Infrastructure Facilities for BASF Group in close cooperation and on request of the Operating Divisions including respective project management and controlling.

- As Global Competence Center we have governance function for the execution of capital projects Group wide and with this regard member of Commission S. We develop and maintain the cost engineering database and methodology for BASF investments, small projects, extensions and plant changes.



Project Controlling, Cost Engineering & Engineering Governance

Competence Center Cost Engineering

- Cost estimates in all project phases (300 per year)
- Site studies & technology benchmarks
- Cost workshops

Competence Center Project Controlling

- Continuous analysis & report of project progress and project cost status
- Scope & claims management

Engineering Governance

- Comments on cost estimates for Commission S
- Development and maintenance of methods & tools for Cost Engineering, Project Controlling, Scheduling
- Review Technical Packages
- Project Management Procedures

Cost Engineering Methods
From Innovation to Successful Project

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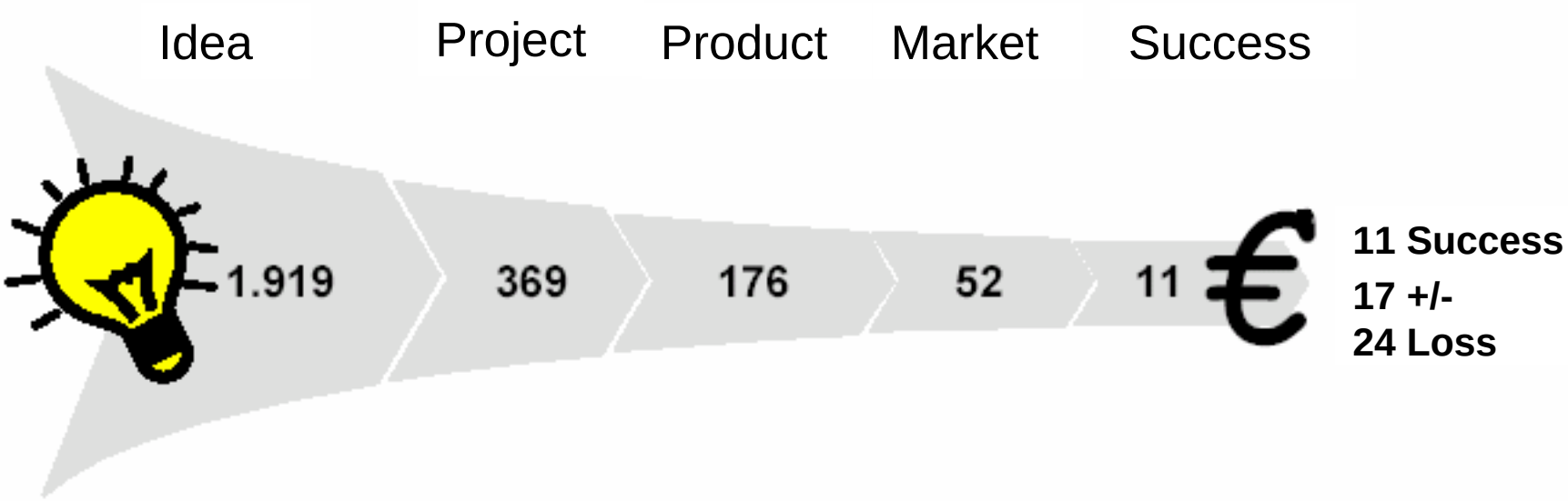
Less than 1 % of ideas finally successful implemented



11 Success
17 +/-
24 Loss

Source: University of St. Gallen, Prof. Gassmann

Cost Engineering Methods
Phase Gate Method
a Control Instrument for Innovation Chains

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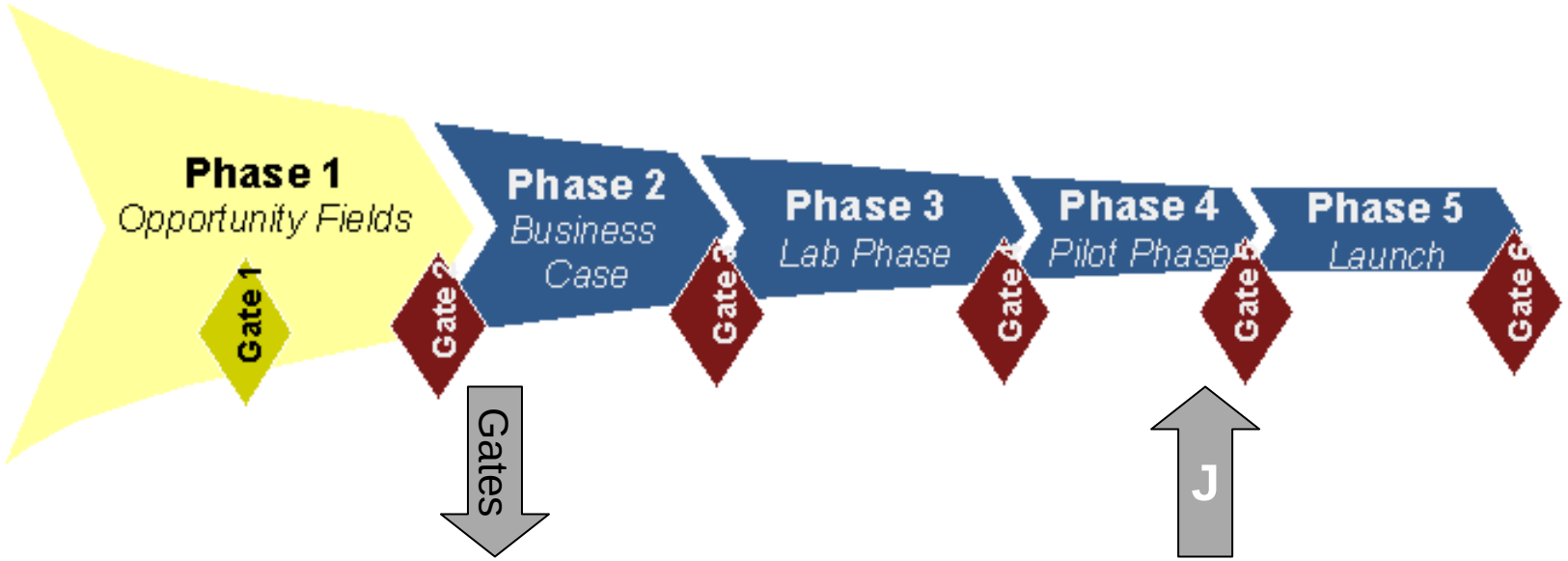
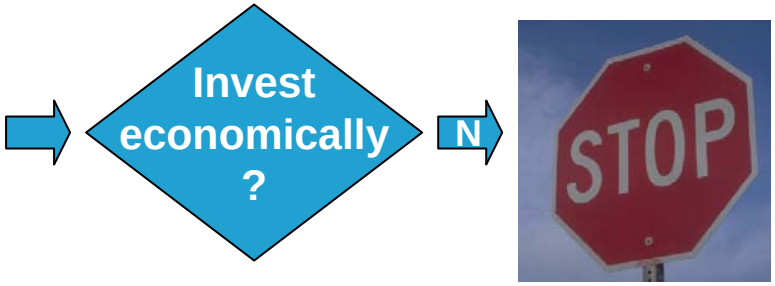
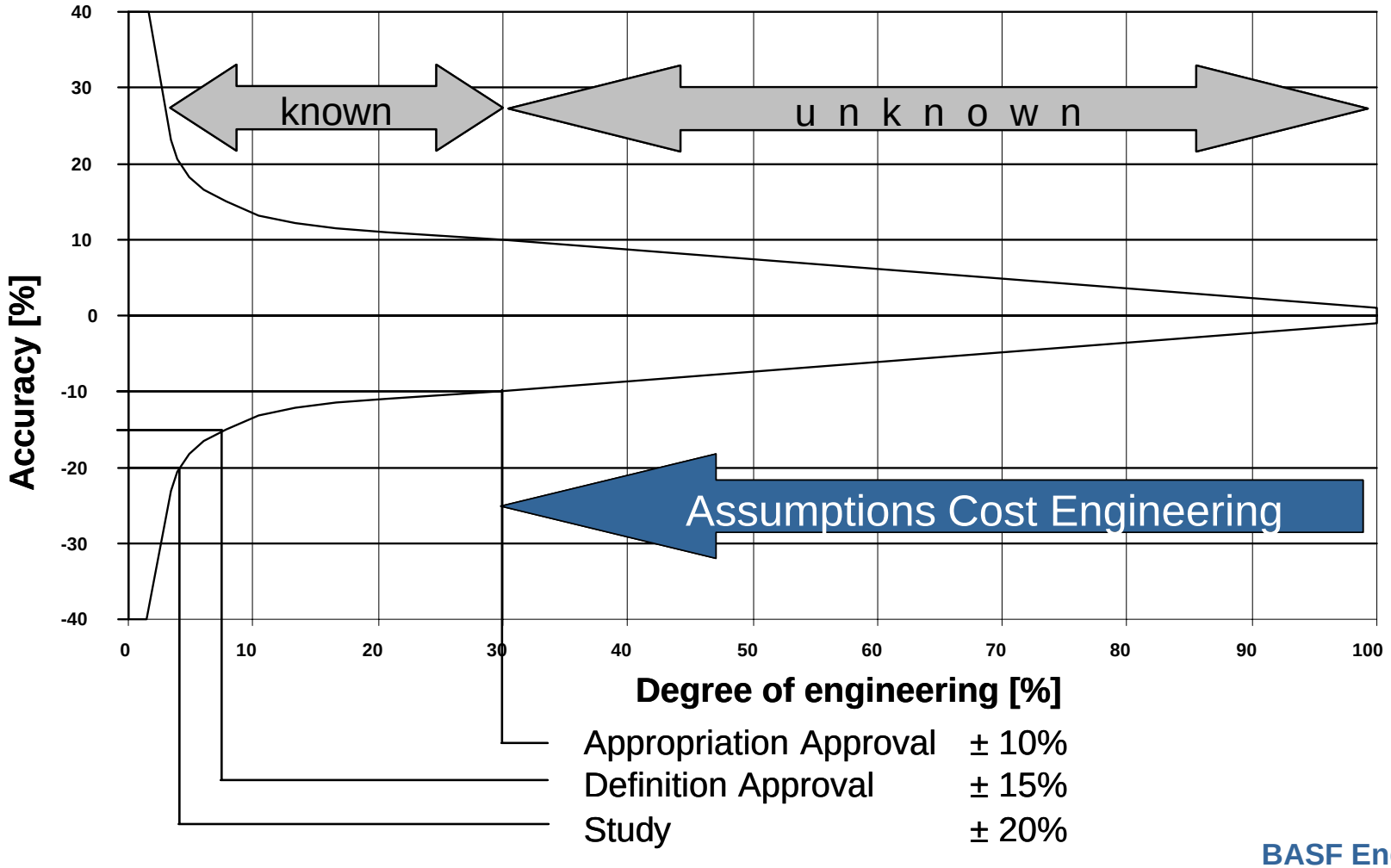


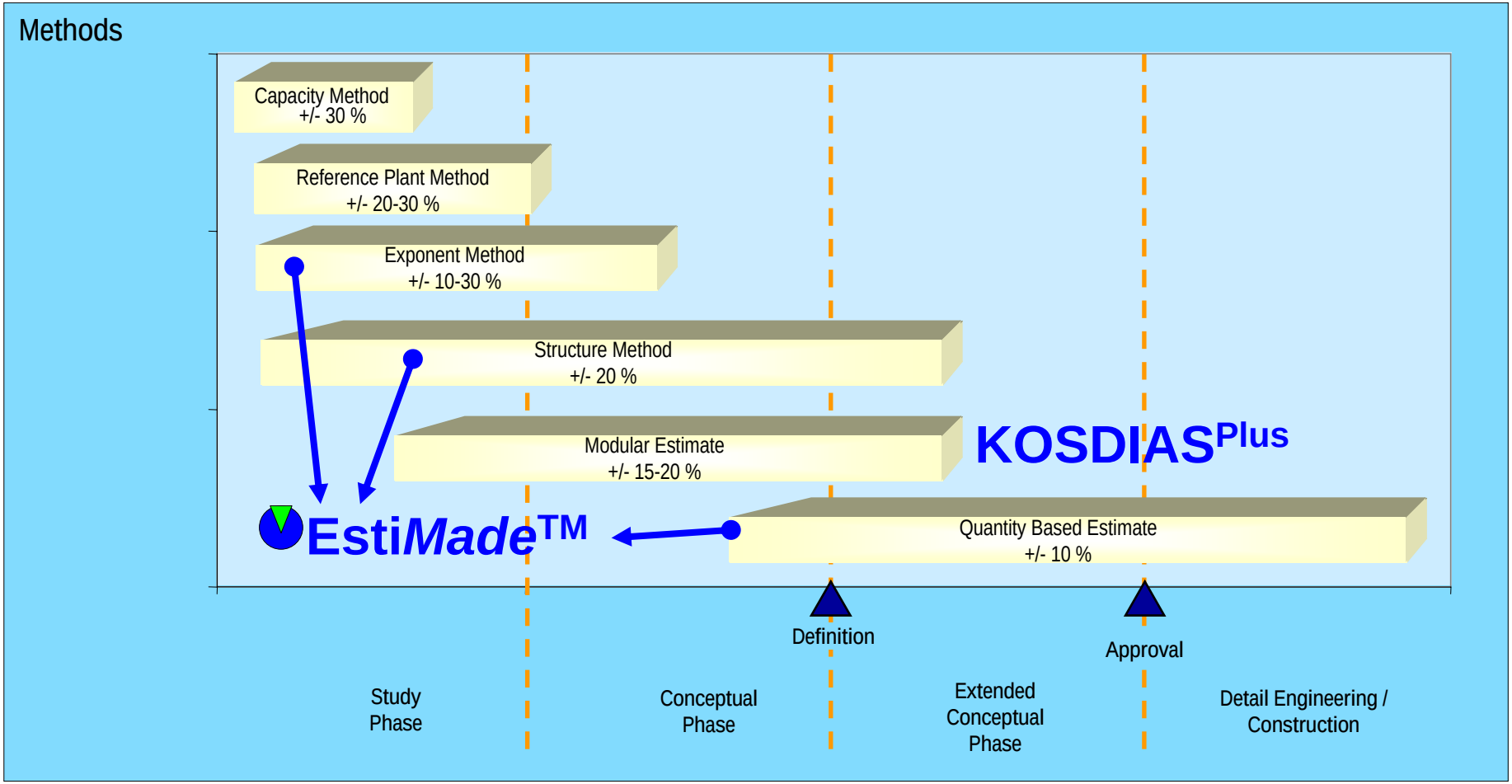
Project Cost Estimate as one Criteria for Selection at Innovation Chain Control



Cost Engineering Methods
Accuracy and Engineering Progress



Cost Engineering Methods
Accuracy of Estimates



Cost Engineering Methods
Capacity Method

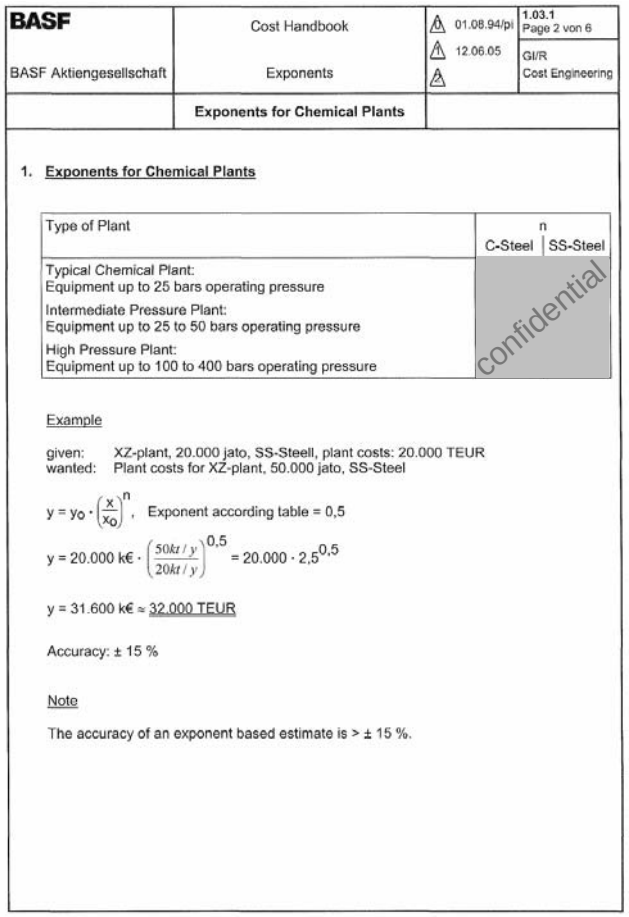
$$y = c_s \bullet x$$

y = Investment costs to be estimated
c_s = Specific Investment
X = Plant Capacity

Applied for: First rough estimate for „Business Case“ by „non Engineers“

Accuracy: ± 30 %

Cost Engineering Methods
Exponent Method



BASF	Cost Handbook	01.08.94/pl 12.06.05	1.03.1 Page 2 von 6
BASF Aktiengesellschaft	Exponents		GI/R Cost Engineering
	Exponents for Chemical Plants		

1. **Exponents for Chemical Plants**

Type of Plant	n C-Steel | SS-Steel
Typical Chemical Plant: Equipment up to 25 bars operating pressure Intermediate Pressure Plant: Equipment up to 25 to 50 bars operating pressure High Pressure Plant: Equipment up to 100 to 400 bars operating pressure	confidential

Example

given: XZ-plant, 20.000 jato, SS-Steell, plant costs: 20.000 TEUR
wanted: Plant costs for XZ-plant, 50.000 jato, SS-Steel

$y = y_o \cdot \left(\frac{x}{x_o}\right)^n$, Exponent according table = 0,5

$y = 20.000\ k€ \cdot \left(\frac{50kt/y}{20kt/y}\right)^{0,5} = 20.000 \cdot 2,5^{0,5}$

$y = 31.600\ k€ \approx$ 32.000 TEUR

Accuracy: ± 15 %

Note

The accuracy of an exponent based estimate is > ± 15 %.

General formula:

$$y = y_o \cdot \left(\frac{x}{x_o}\right)^n$$

y = plant costs to be estimated, equipment cost
y_0 = known costs
x = new capacity, volume, size
x_0 = known capacity , ...
n = Exponent

Applied for:	Calculation of plant costs from existing size and costs to new size
Accuracy:	± 10 – 30 %

Cost Engineering Methods
Exponent Method

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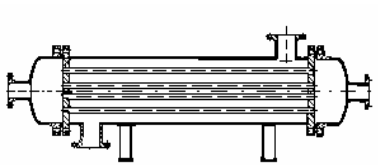
General formula:

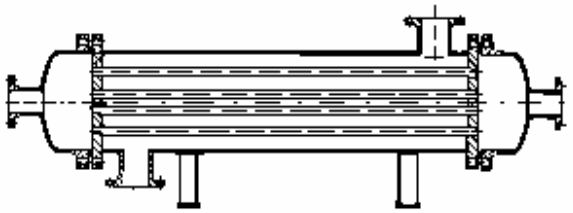
$$y = y_o \cdot \left(\frac{x}{x_o}\right)^n$$

y = costs to be estimated

y_0 = known costs
x = new heat exch. area
x_0 = known heat exch. area
n = Exponent



Mat. of Construction:	1.4541
Heat Exch. Area:	43 m²
Tubeside pressure:	40 bar
Shellside pressure:	10 bar
Price (ex works):	**25 TEUR**



Mat. of Construction:	1.4541
Heat Exch. Area:	93 m²
Tubeside pressure:	40 bar
Shellside pressure:	10 bar
Price (ex works):	**40 TEUR**

Applied for:	Conversion of known specific costs (eg. equipment costs) scale up / down
Accuracy:	± 10 – 30 %

Cost Engineering Methods
Structure Method

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Controlling & Reporting - GI/R

1.01.1.1.
Status: 12/2004
Rev. 2
Page 1 of 1

Cost Structure of chemical plants at BASF AG

- only for GI-internal use -

		ø Equipm.-Costs:	5 tEuro	30 tEuro	100 tEuro	30 tEuro
Gr.	Description		% relating to			
			Σ D-G			Σ A-M	Σ A-U
A	Sewers, roads, railroads					
	Pipe racks/bridges					
	Ground, concrete and masonry work					
	Steel structure					
	Architectural (doors, windows)					
	Engineering and Construction Supervision					
	Aux. Constr. (Fdns, misc supports)					
	CIVIL AND STRUCTURAL					
B	Insulation					
	Painting					
	HVAC/Fire protection					
	INSULATION/PAINTING/HVAC/ETC					
C	**MOVEABLE INVENTORY**					
D-G	**PLANT EQUIPMENT**					
	CS Piping					
	Alloy Piping					
	CS Valves and specialities					
	Alloy Valves and specialities					
H	**PIPING**					
I	**PIPING outside Plants**					
K	**ELECTRICAL primary system**					
L	Electrical secondary system					
	Instruments					
	DCS (incl. Programming)					
	Installation materials					
	ELECTRICAL and INSTRUMENTATION					
M	Installation Labor for D-G					
	Installation Labor for H					
	Installation Labor for I					
	Installation Labor for K					
	Installation Labor for L					
	Scaffolding					
	Temporary Construction Facilities					
	Start-up preparation					
	Construction management and supervision					
	INSTALLATION LABOR					
Σ A-M	**DIRECT COSTS**					
N	Project Engineering					
	Design Engineering					
	Design by others					
	Permit Fees					
	ENGINEERING					
O	**Others**					
	Construction Interest Costs					
U	**Contingency**					
ΣΣ A-U	**TOTAL COSTS**					

Basis:
70 E & I

ø Equipm.-Costs:	5 tEuro	Total plant costs	3 Mio Euro
ø Equipm.-Costs:	30 tEuro	Total plant costs	9 Mio Euro
ø Equipm.-Costs:	100 tEuro	Total plant costs	20 Mio Euro

- Breakdown total investment in cost groups
- For simular process plants the relation of cost groups is considered be constant
- Detailed analysis of executed projects

Applied for: Study estimate and „Check & Balance“

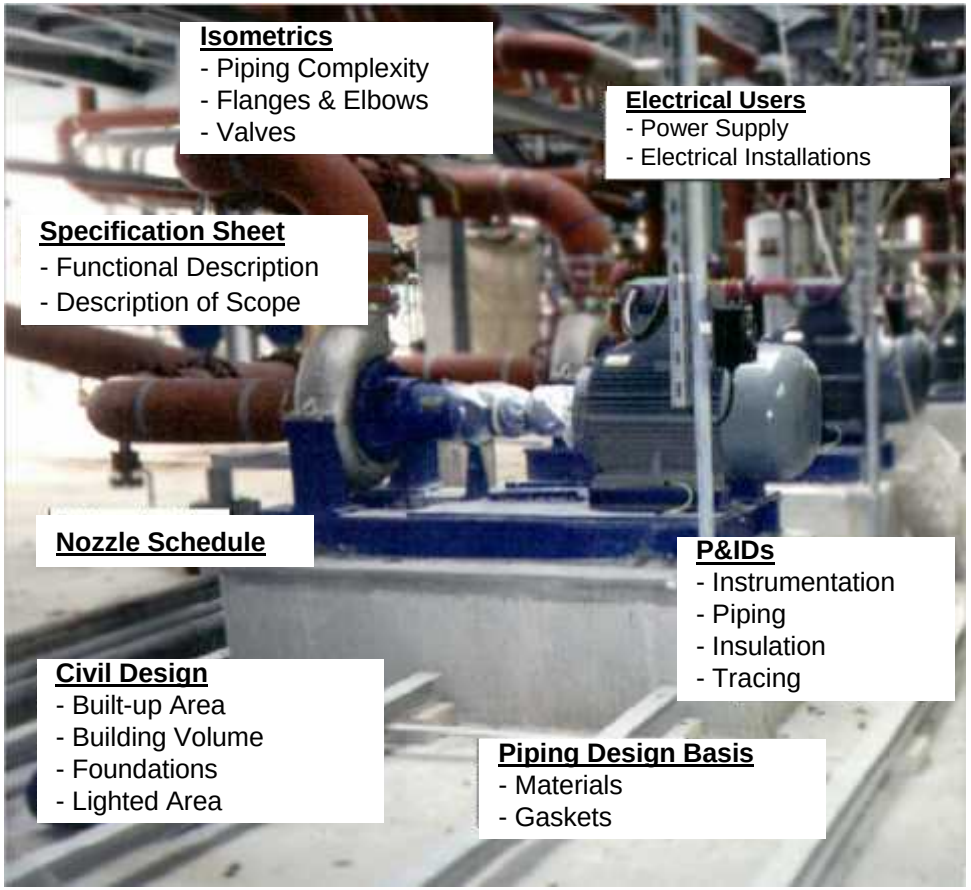
Accuracy: ± 20 %

Cost Engineering Methods

A	CIVIL AND STRUCTURAL (LABOR & MATERIAL)
B	INSULATION / PAINTING / HVAC / ETC (LAB. & MAT.)
C	MOVABLE INVENTORY (MATERIAL ONLY)
D-G	PLANT EQUIPMENT (MATERIAL ONLY)
H	PIPING IN PLANTS – ISBL (MATERIAL ONLY)
K	ELECTRICAL PRIMARY SYSTEM (MATERIAL)
L	ELECTRICAL AND INSTRUMENTATION (MATERIAL)
M	INSTALLATION LABOR
N	ENGINEERING
O	EXPENSES
U	CONTINGENCY
∑∑	A–U TOTAL COSTS

Cost Engineering Methods
Modular Estimate

- Scope definition for equipment moduls:



- Survey of typical solutions
- Typical scope for each cost group
- Modul costs include typical costs from all cost groups

Applied for:	Research & Development
Accuracy:	± 20 %

Cost Engineering Methods
Quantity Based Estimate

$$c = m \bullet c_s$$

Example:

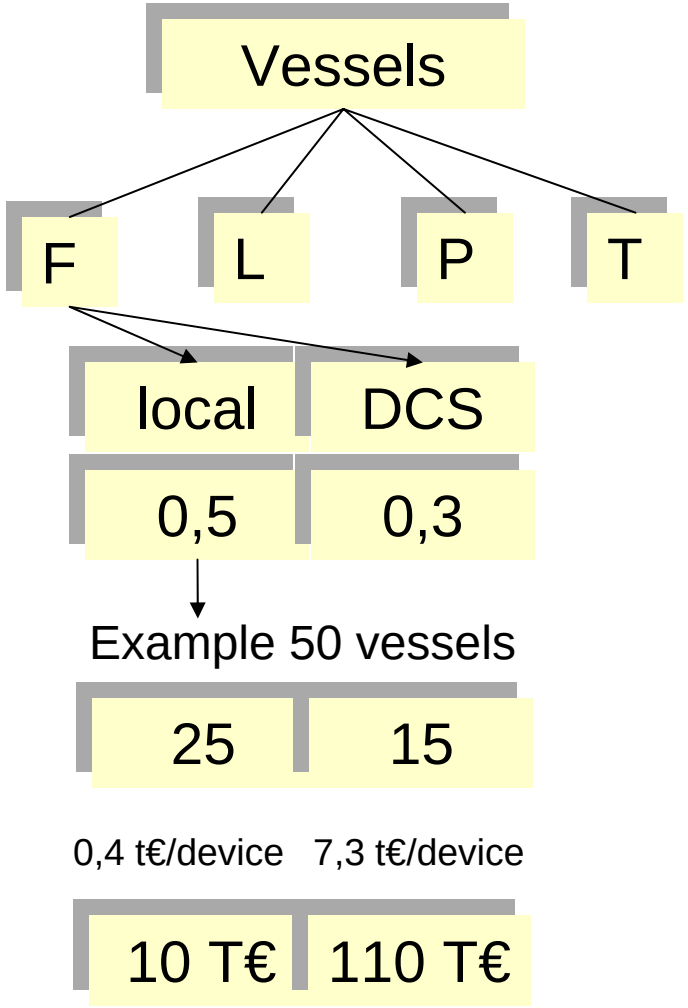
C_{steel} = 250 t • 1800 €/t

C_{steel} = 450 T€

c = Costs to be estimated
m = Quantity
c_s = Specific cost

Applied for: For project definition and appropriation approval
Accuracy: ± 10 %

Cost Engineering Methods
Example for Quantity Based Method, Instrumentation



. . . Equipment List

. . . Instrument type

. . . Typical number of Instruments

Evaluation of existing plants
+ technology specifics
+ plant specifics

. . . Average specific costs

. . . Estimate result

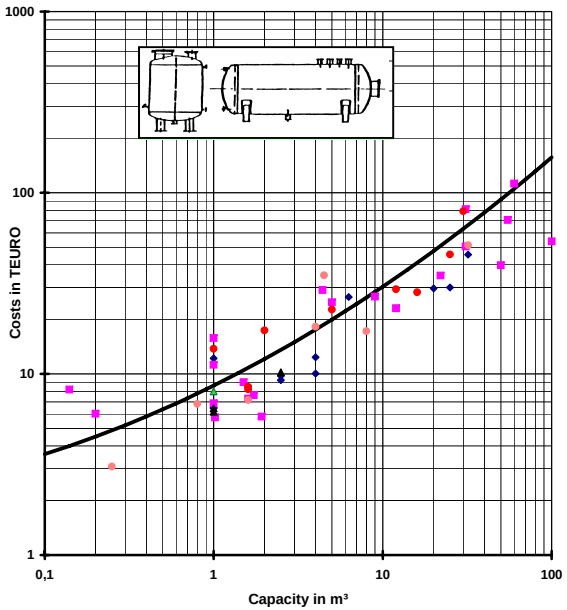
Cost Engineering Methods
Cost Curve

BASF The Chemical Company	Cost Estimating Data Group E	30.11.98 10.03.00 05.08.05	1.E.B.2.2 Page 1 of 1 GI/R Controlling & Reporting
Contact: Pieroth-Lenz	**Apparatus**	**Status: 09 / 2005**	

Vessel SS 304 L

valid for: 25 gal to 26.500 gal; 0 psi to 300 psi

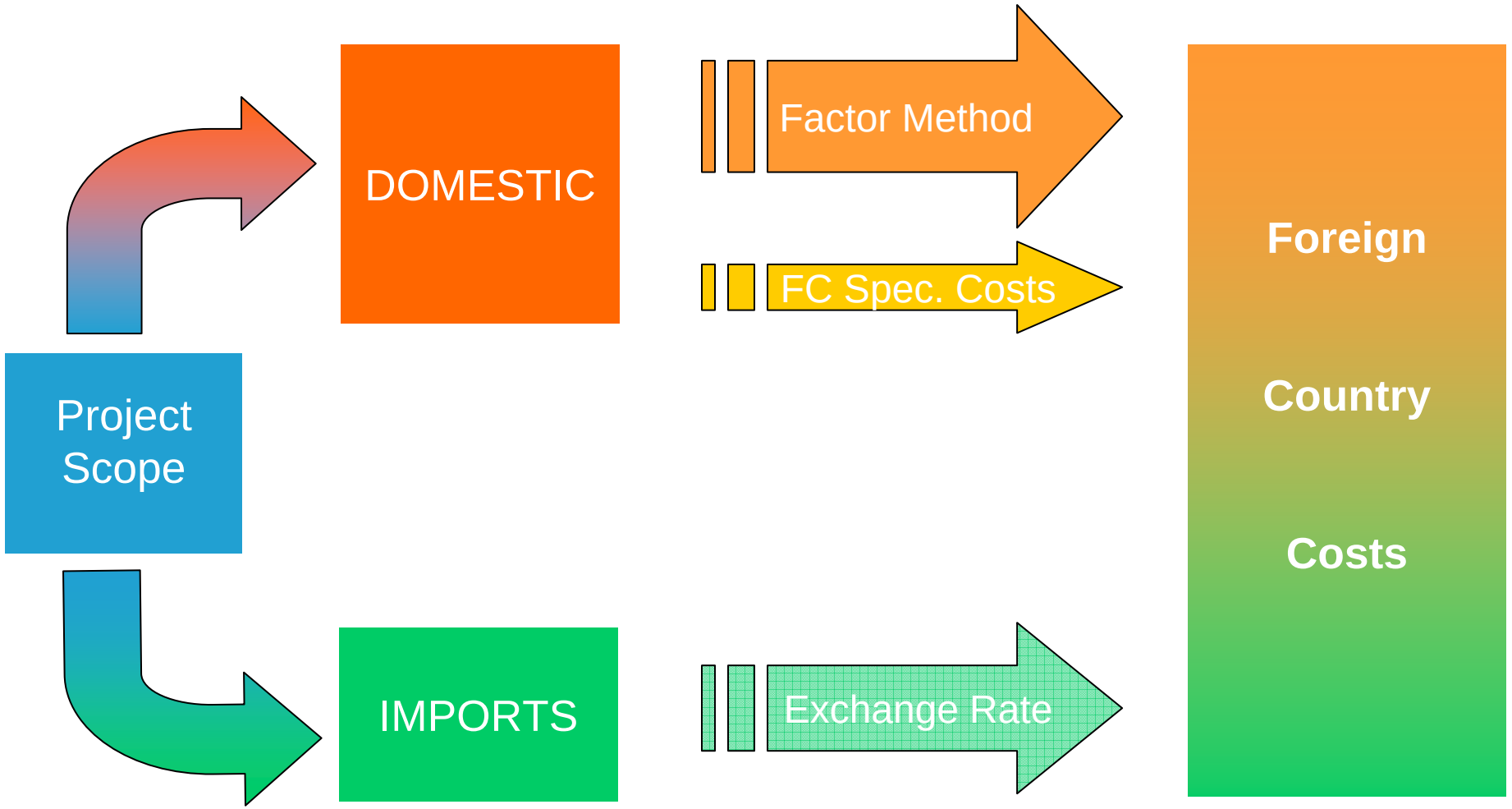
Standard design:
vertical or horizontal orientation, 6 nozzles, 1 manhole, not heated.



Comments:
Purchase order value plus design allowance, changes and transportation to site, **ASME Code**.
Gulf Coast Basis

- Cost curves a basis for cost estimates
- Data from executed projects
- Procurement situation reflected
- Review of projects and update of data sets performed on a regular basis
- Used in software for cost engineering

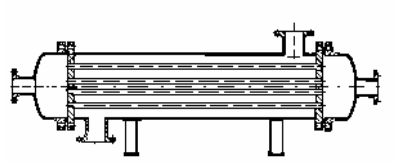
Cost Engineering Methods
Foreign Country Estimate



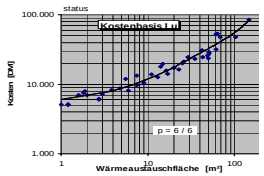
Cost Engineering Methods
Foreign Country Estimate

MADE IN GERMANY

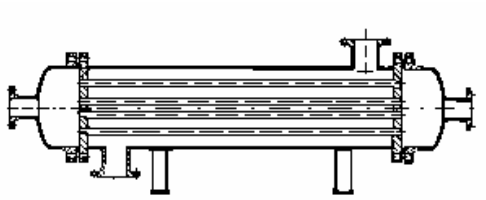
DIN



Mat. of Construction:	1.4541
Heat Exch. Area:	93 m²
Tubeside pressure:	40 bar
Shellside pressure:	10 bar



MADE IN USA



ASME

Mat. of Construction: 304 L	(= 1.4541)
Heat. Exch. Area: 1000 sq. ft	(= 93 m²)
Tubeside pressure: 580 psi	(= 40 bar)
Shellside pressure: 145 psi	(= 10 bar)

Estimated costs LU: 31.500 EUR

Actual purchasing cost: 37.000 USD

Factor **0,9**

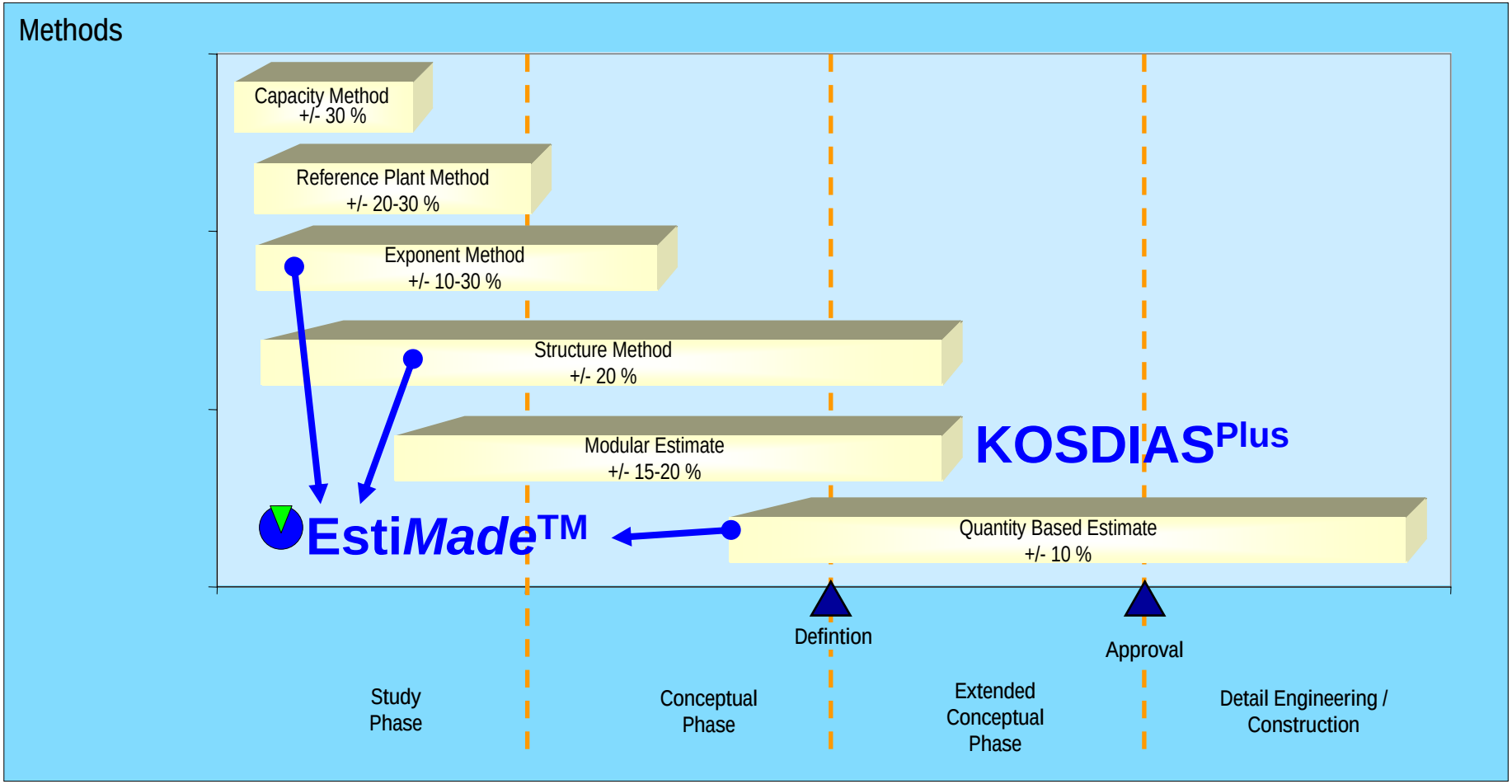
„EUR-USA“ 28.500 EUR

Exchange rate **0,77 EUR/USD**

LU Conditions

Foreign Conditions

Cost Engineering Methods
Survey



Cost Engineering Methods
Data Basis and Evaluation

- More than 1400 project evaluations including detailed cost structure
- More than 1000 data sets for installed modules
- Cost curves for all types of equipment, 800 data sets updated on a regular basis
- Cost Engineering basis for more than 45 foreign countries
- Procurement situation to be updated twice a year including specific forecasts


THE END