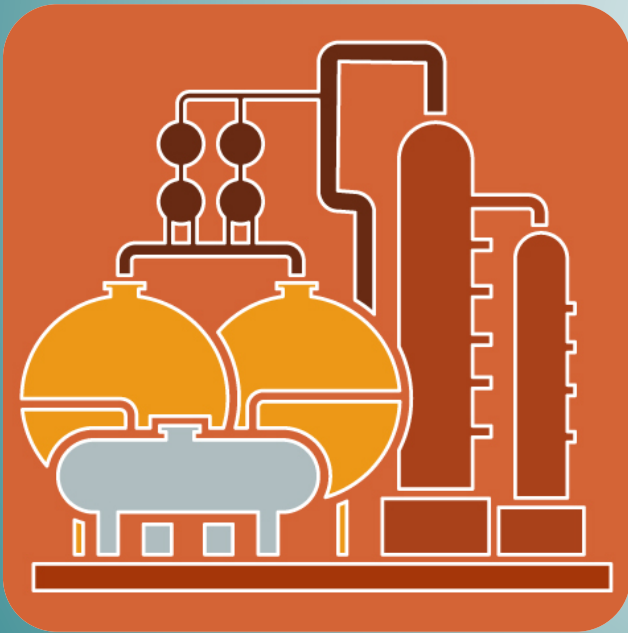


Chemical Process Design / Diseño de Procesos Químicos

Topic 2. Methodology of conceptual design



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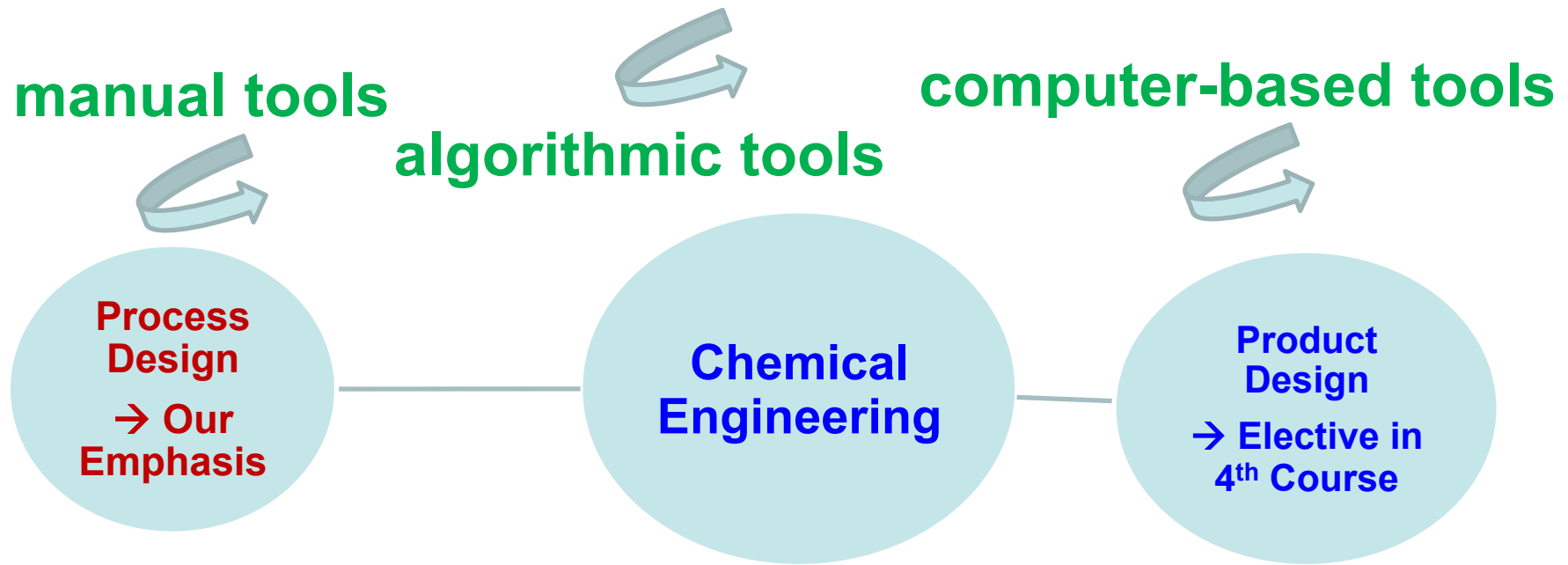
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1.- Design Characteristics

Based on mathematics, basic science and engineering science and flavored by the humanities, social science and economics, **engineering design** is the devising of an *artifact, system, new process or modifications to existing plants* to best meet **a stated objective**, using:



2.- Major Steps in Process Design: Methodology

Engineering design involves the development of **specifications and criteria**, and the **synthesis, analysis, construction, testing, and evaluation** of **alternative solutions** to best meet the desired criteria in light of **safety, reliability, economic, aesthetic, ethical, and social considerations**.

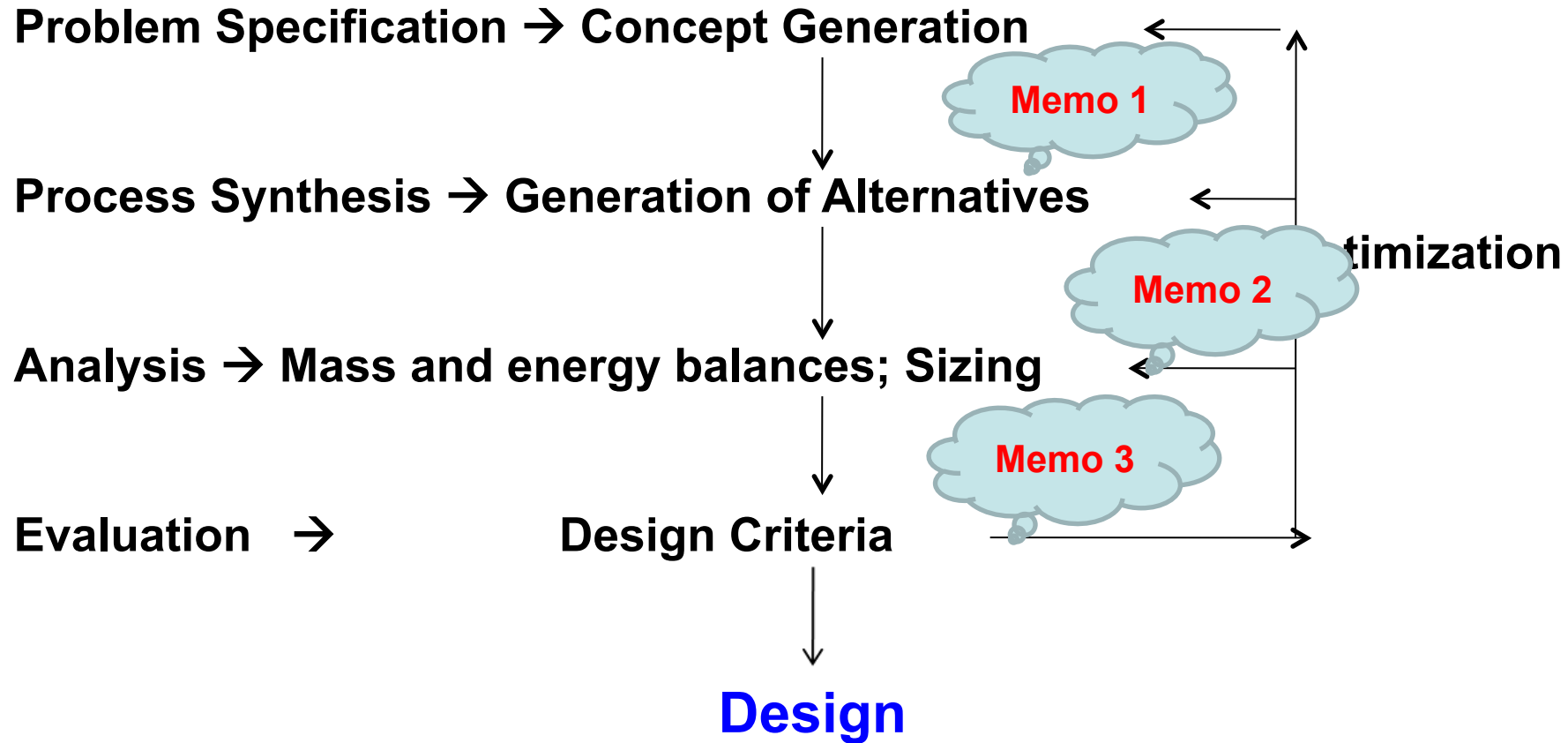
Specifications and criteria: Identification of needs, specifications (*e.g. quantities in the market, product impurities, maximum conversion, C/H ratio in reactor, azeotrope*), and process technology (*e.g. hydrolysis vs. gasification*).

Synthesis: Put together parts. Systematic alternative representation.

Analysis: Predict Behavior. Solving Mass & Energy balances + Design variables → Simulation.

Evaluation: Optimum \$ (+ other criteria) → Decision.

2.- Major Steps in Process Design: Methodology



Note: Iterative process. For improvement → Optimization

2.- Major Steps in Process Design: Methodology

Problem Specification:

Key: Identification of needs, specifications and process technology.

Challenge: ??????????????

Tools: ??????????????????

Problem Specification:

Key: Identification of needs, specifications and process technology.

Challenge: Often incomplete information (Open-ended).

Tools: Meetings, literature (web), link business (marketing).

2.- Major Steps in Process Design: Methodology

Synthesis Process Strategy:

Define: Flowsheet structure.

Challenge: ????????????????

Tools: ????????????????????

????????????????????

Synthesis Process Strategy:

Define: Flowsheet structure.

Challenge: Very large number of alternatives.

Tools: Literature, patents.

Heuristics (rules of thumb).

Hierarchical decomposition (levels).

Superstructure optimization (Mathematical programming).

2.- Major Steps in Process Design: Methodology

Analysis → Mass and energy balances; Sizing:

Key: Predict performance → need models (Simple – Complex).

Challenge: ??????????????????????

Tools: ????????????????????

????????????????????

Analysis → Mass and energy balances; Sizing:

Key: Predict performance → need models (Simple – Complex).

Challenge: Complexity of models.

Tools: - Rules of Thumb: Quickly understood, easily used, practical method yielding approximate results.

- Short-cut methods (EXCEL, Matlab, GAMS, FORTRAN).
- Process simulating → Useful to check ranges, phases, etc.:
 - Sequential modular (ASPEN).
 - Equation oriented (gPROMS).

2.- Major Steps in Process Design: Methodology

Evaluation: Design Criteria:

Define: Evaluate “goodness” design.

Challenge: ????????????????????

Tools: ??????????????????????

???????????????????????

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Evaluation: Design Criteria:

Define: Evaluate “goodness” design.

Challenge: Multiple criteria.

Tools: Economic evaluation (NPV).

Reliability analysis (IGCC).

Environmental Impact (CO₂).

Flexibility (Refinery).

Exergy analysis (energy efficiency).

HAZOP (HAZard and Operability– Analysis (Safety)).

Controllability (Biomass not uniform).

LCA (Ecoindicator-99).

What is the Meaning of each criterion?

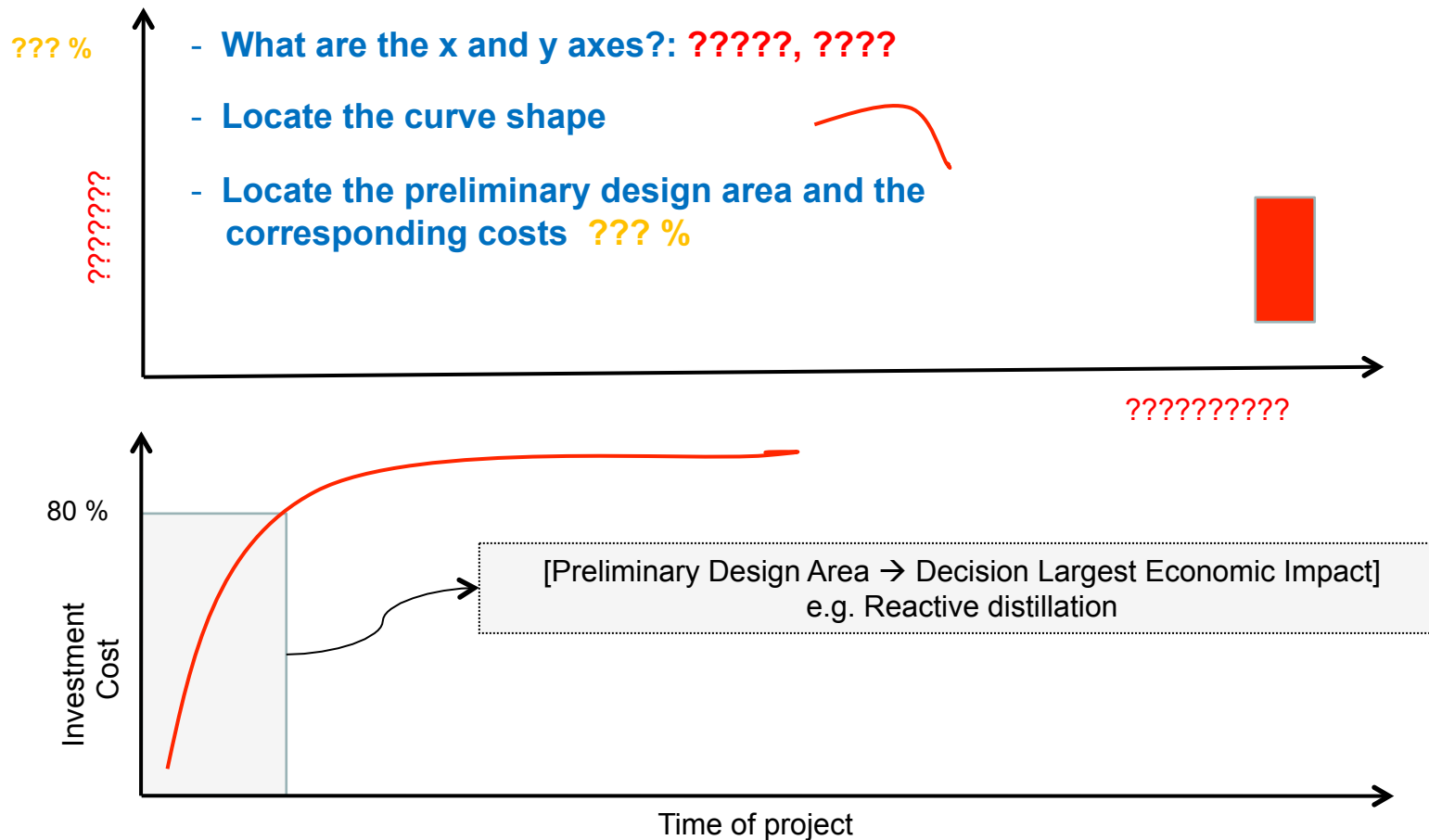
What is the Key Step

Since the number of alternatives is large, the key decision step is Process Synthesis.

3.- Emphasis and Importance of the Preliminary Process Design

Why is the preliminary design important?:

Decisions in the preliminary design have the greatest economic impact → With just 10-15% of the money, 80% of the final capital (main equipment) and the manufacturing costs (Raw materials and reaction step) are fixed.



3.- Emphasis and Importance of the Preliminary Process Design

PROJECT PHASE (Natural Gas Cogeneration) Engineering, Procurement, and Construction" (EPC) /Turnkey PROJECT: Contractor is made responsible for all the activities from design, procurement, construction, to commissioning and handover of the project to the End-User or Owner.	INVESTMENT	TIME (Years / Months)
SUPPLY PHASE (CONCEPTUAL ENGINEERING)		1 y
PROJECT PHASE		2.5 y x 12 = 30 m
- BASIC Engineering	40% Main equipment (Gas and vapor turbines, condenser)	12 - 18%
- DETAILED Engineering	Definition of the remaining equipment	40 - 45%
- CONTRACTING Engineering	15% Purchase of the remaining equipment	35 - 40%
- CONSTRUCTION	25% Assembly and construction	10 - 15%
- TRAINING Engineering	5% Engineering 15 % Management, contingencies, start-up, various...	3 - 5%
USEFUL LIFE PHASE		15 y x 12 = 180 m
DISMANTLING PHASE		1 y

4.- Case Study

- Presentation of the case study: production of ethanol from ethylene:
 - How to generate flowsheets.
 - Generation of the rule to generate flowsheet (limit of costs).
- Consideration of process alternatives.

5.- Further Reading and References

- Biegler, L.; Grossmann, I. & Westerberg, A. (1997): «*Systematic methods of chemical process design*». Prentice Hall.
- Douglas, J.M. (1988): «*Conceptual design of chemical processes*». McGraw-Hill.
- Seider, W.; Seader, J.; Lewin, D. & Widagdo, S. (2010): «*Product and process design principles. Synthesis, analysis and evaluation*». 3rd Ed. John Wiley & Sons.
- Thakore, S.B. & Bhatt, B.I. (2007): «*Introduction to process engineering and design*». 1st Ed. Tata McGraw Hill Education.

RELEVANT TO LEARNING

- Major steps in Process Design Methodology.
- Name of each step, objectives, tools.
- Why is Preliminary Design important → graphical answer!!