

# Basics in Process Design

## Introduction

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# Contact

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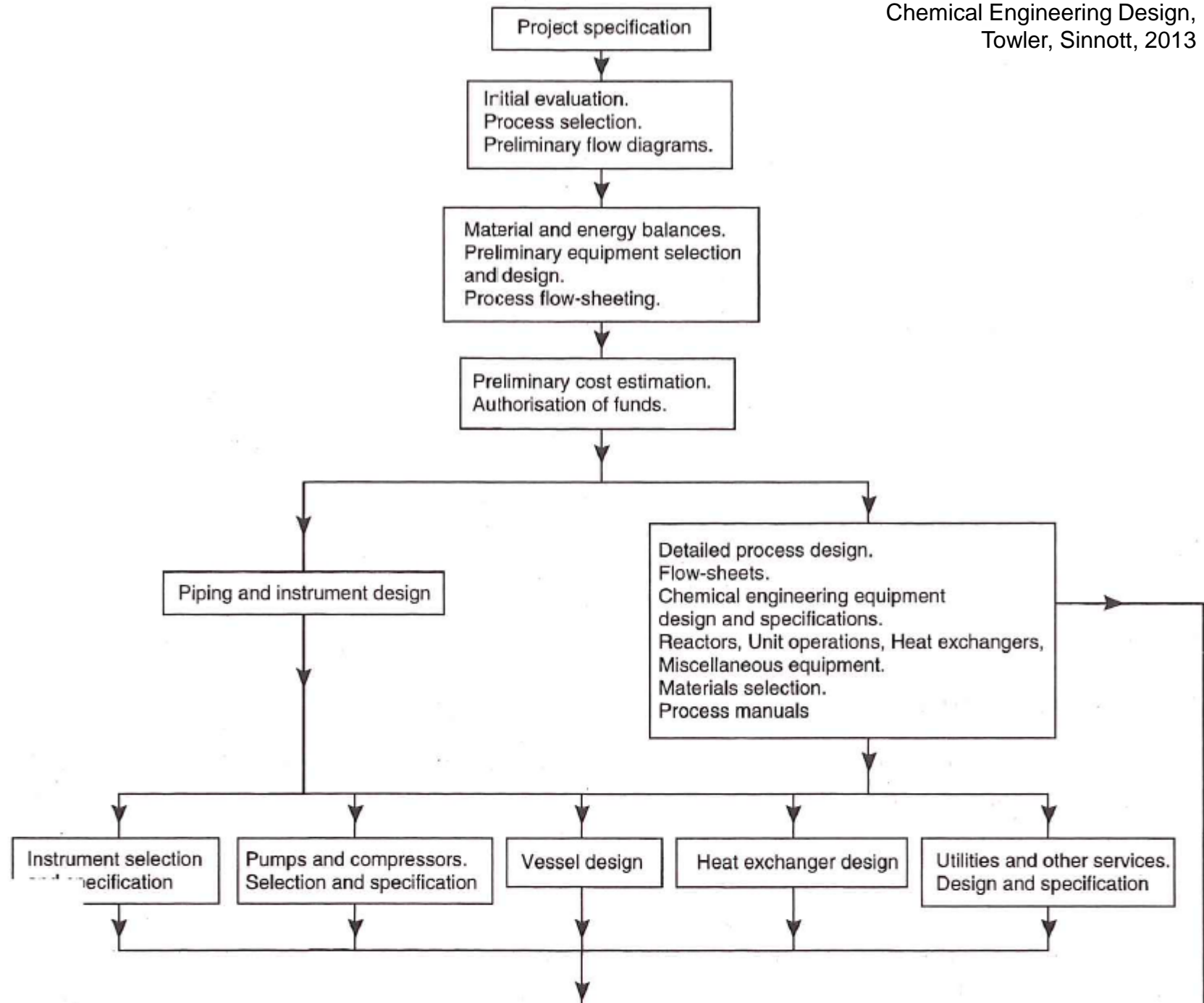
# What is process design?

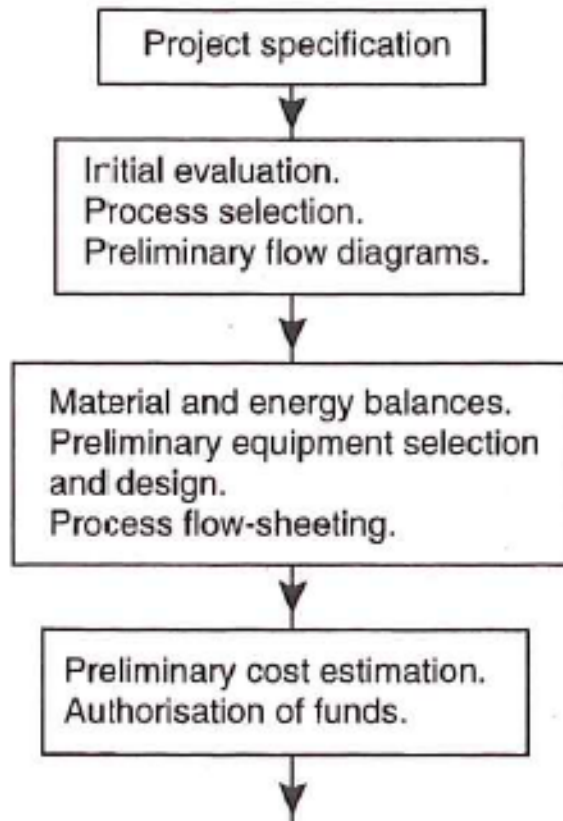
- What do you think process design is?



# What is process design?

- “Starting from a vaguely defined **problem statement** such as a customer need or a set of experimental results, chemical engineers can develop an **understanding** of the important underlying physical science relevant to the problem and use their understanding to **create a plan** of action and a set of detailed specifications, which, if implemented, will lead to a predicted financial outcome.”
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- Block flow diagrams
- Calculate flows from mass and energy balances
- Rough sizing of equipment for
  - storage
  - preprocessing
  - reaction
  - separation,
  - heat exchange
  - transport
- Instrumentation
- Cost estimates

# Work

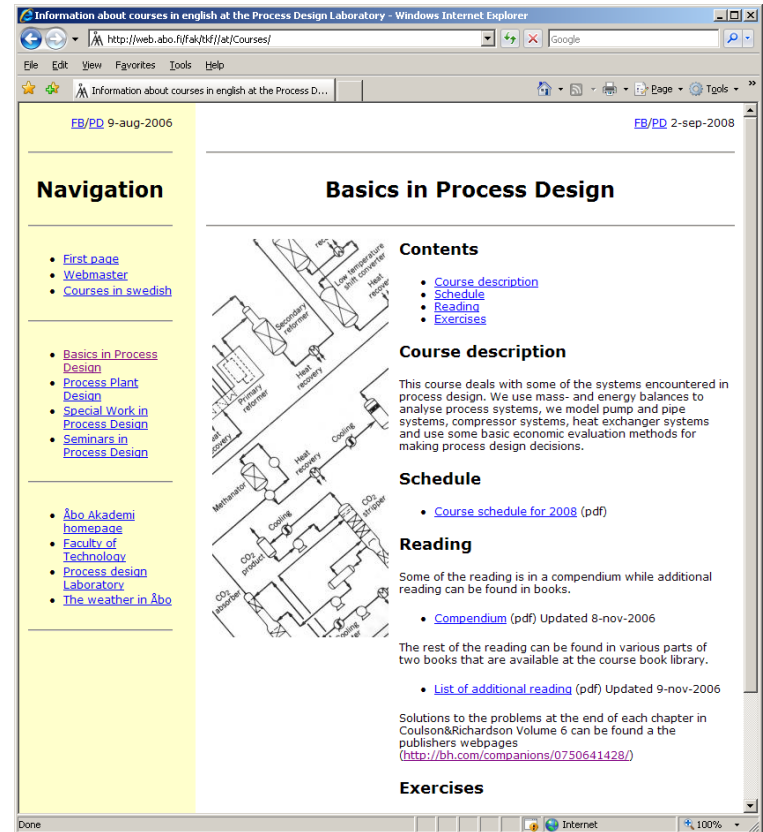
- 9 weeks of lectures
- One lecture per week
- Weekly reading assignment
- Weekly exercise assignments with **compulsory** reports (and corrections)
- Exam (open book)



# Course material

- Course info
  - Schedule
  - Compendium
  - Exercise assignments
  - Additional reading

[ebrary](#)



Information about courses in english at the Process Design Laboratory - Windows Internet Explorer

http://web.abo.fi/tkf/at/Courses/

File Edit View Favorites Tools Help

Information about courses in english at the Process D...

FB/PD 9-aug-2006 FB/PD 2-sep-2008

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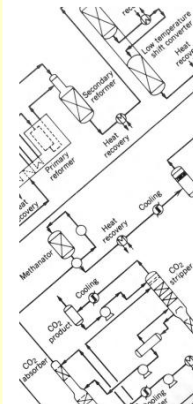
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### Basics in Process Design



#### Contents

- [Course description](#)
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#### Course description

This course deals with some of the systems encountered in process design. We use mass- and energy balances to analyse process systems, we model pump and pipe systems, compressor systems, heat exchanger systems and use some basic economic evaluation methods for making process design decisions.

#### Schedule

- [Course schedule for 2008 \(pdf\)](#)

#### Reading

Some of the reading is in a compendium while additional reading can be found in books.

- [Compendium \(pdf\)](#) Updated 8-nov-2006

The rest of the reading can be found in various parts of two books that are available at the course book library.

- [List of additional reading \(pdf\)](#) Updated 9-nov-2006

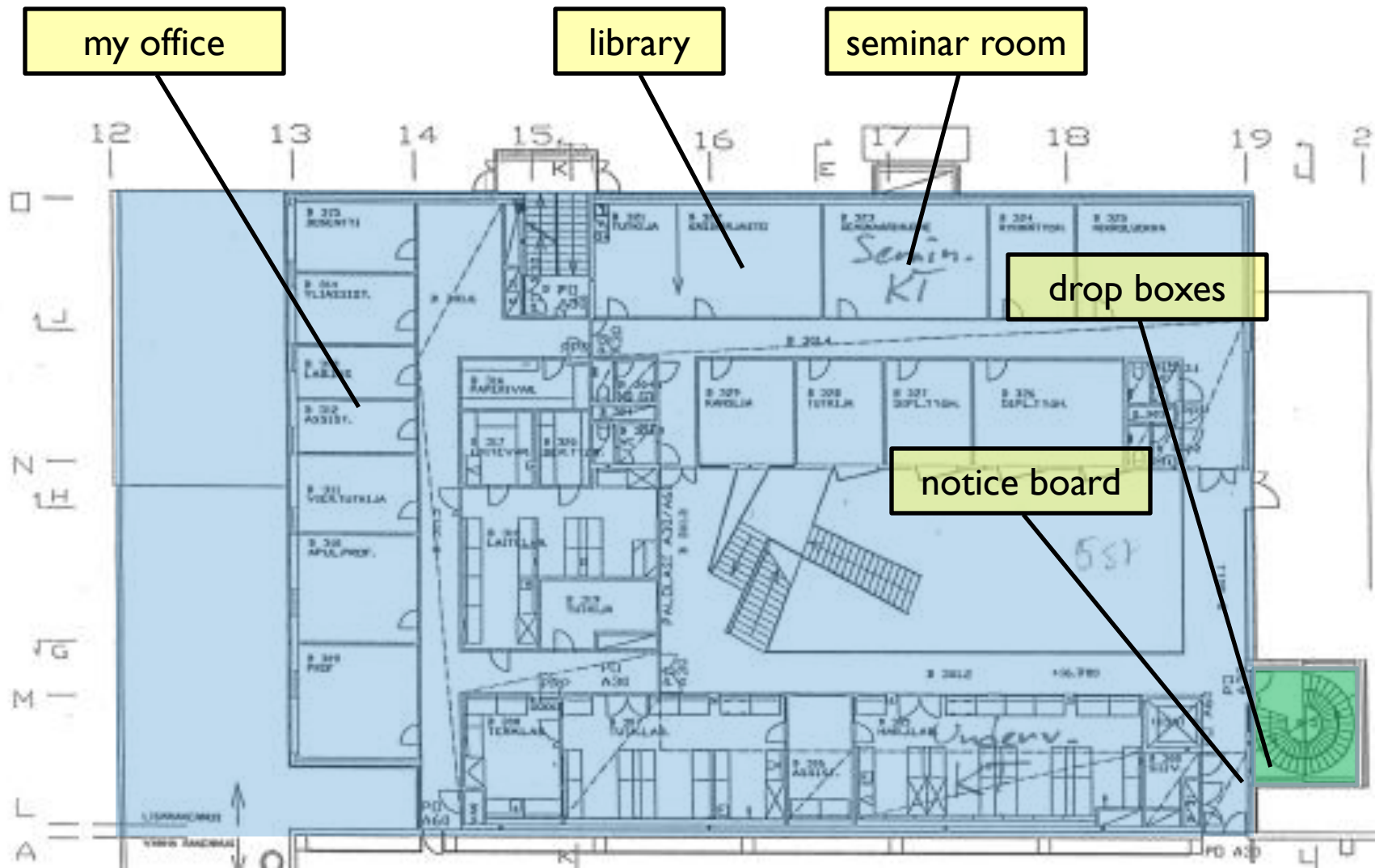
Solutions to the problems at the end of each chapter in Coulson&Richardson Volume 6 can be found at the publishers webpages (<http://bh.com/companions/0750641428/>)

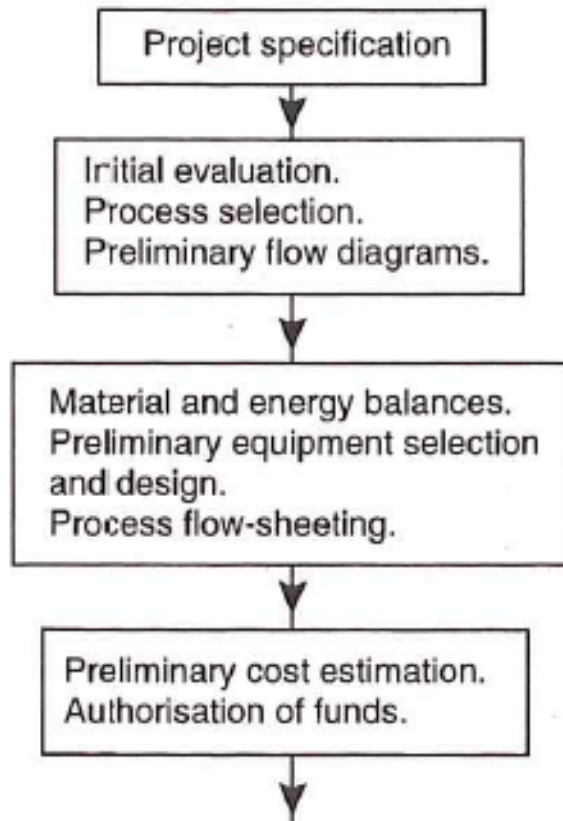
#### Exercises

<http://web.abo.fi/tkf/at/Courses>



# Axelia II 3rd floor – Process Design and Systems Engineering



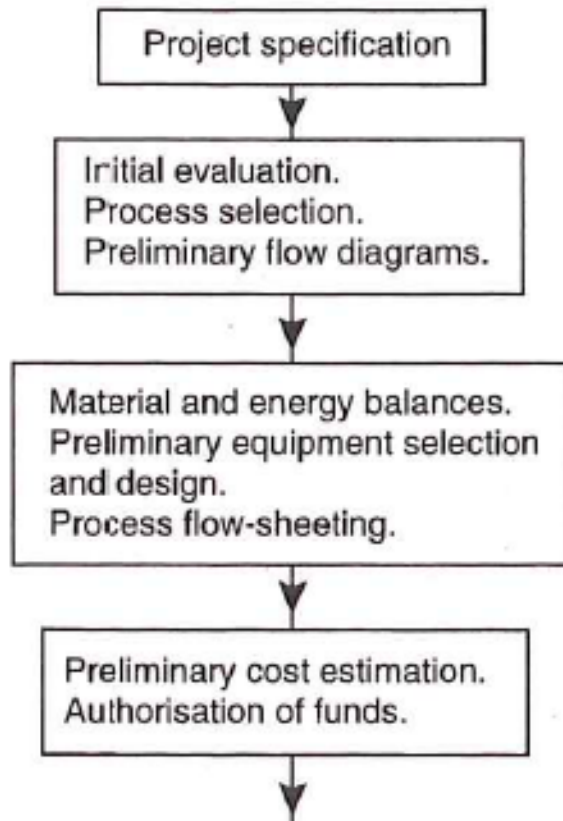


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# Specification

- Production of 150000 ton/year ammonia ( $\text{NH}_3$ )
- 8000 h/year operation
- Is this specification reasonable?
  - [www.indexmundi.com](http://www.indexmundi.com)
  - [www.kbr.com](http://www.kbr.com)

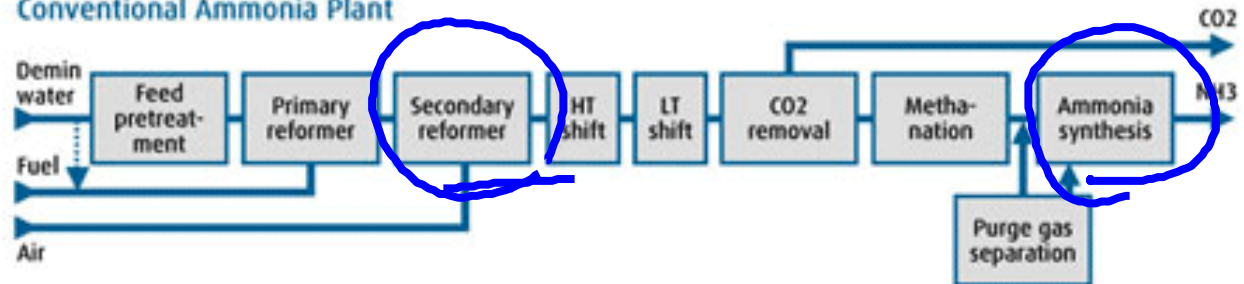




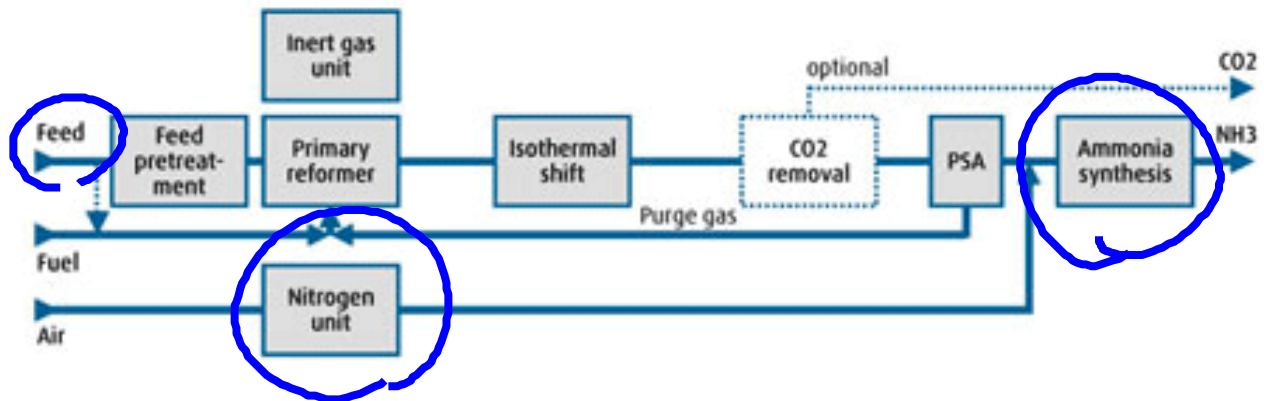
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## Process comparison of a conventional ammonia plant and Linde Ammonia Concept (LAC)

Conventional Ammonia Plant



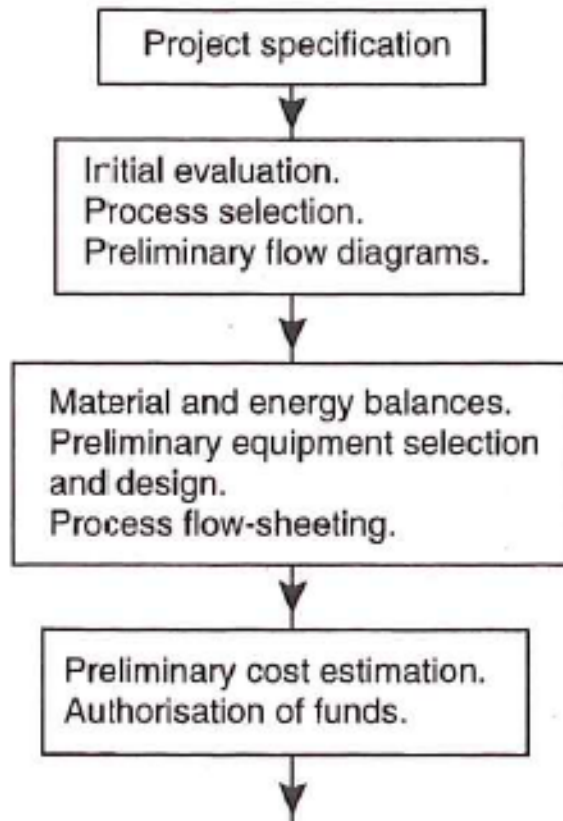
Linde Ammonia Concept (LAC)



Source: Linde Engineering (<http://www.linde-engineering.com/>)

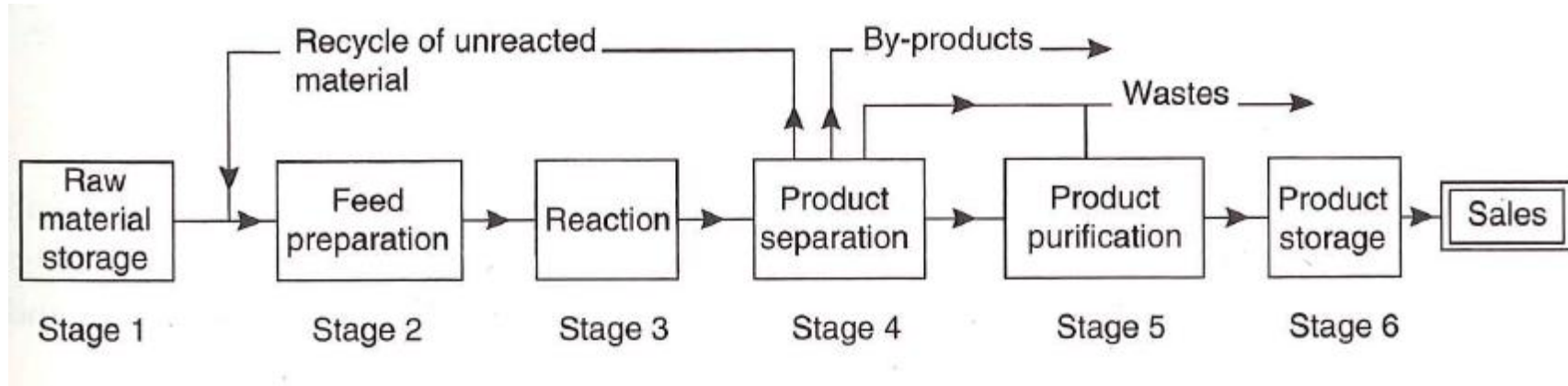
# Process selection

- Haber-Bosch
    - Hydrogen from steam reforming of natural gas/petroleum gas/naphtha
    - Nitrogen from air distillation
    - Ammonia synthesis in catalytic high pressure/temperature reactor
    - Separation by condensation of ammonia from gases
    - Recycle of unreacted gases
-



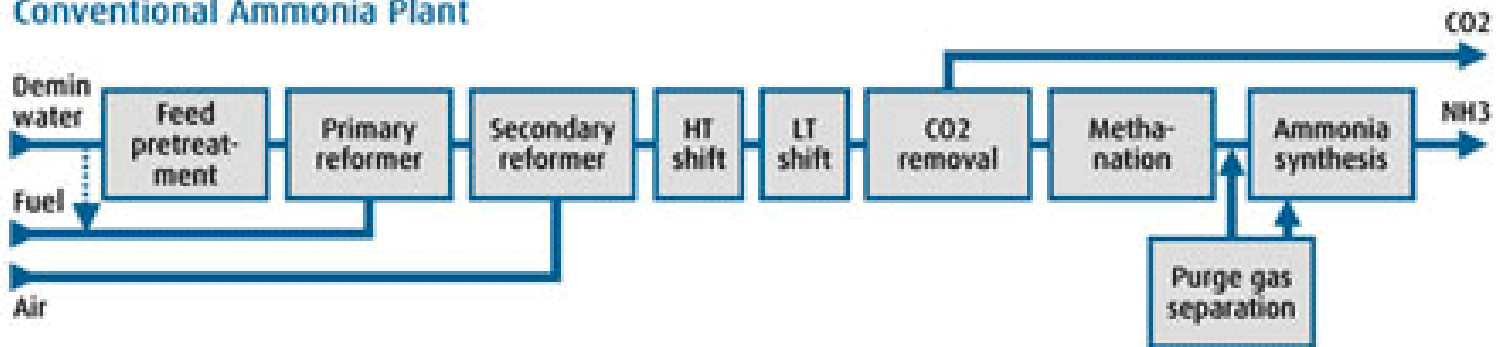
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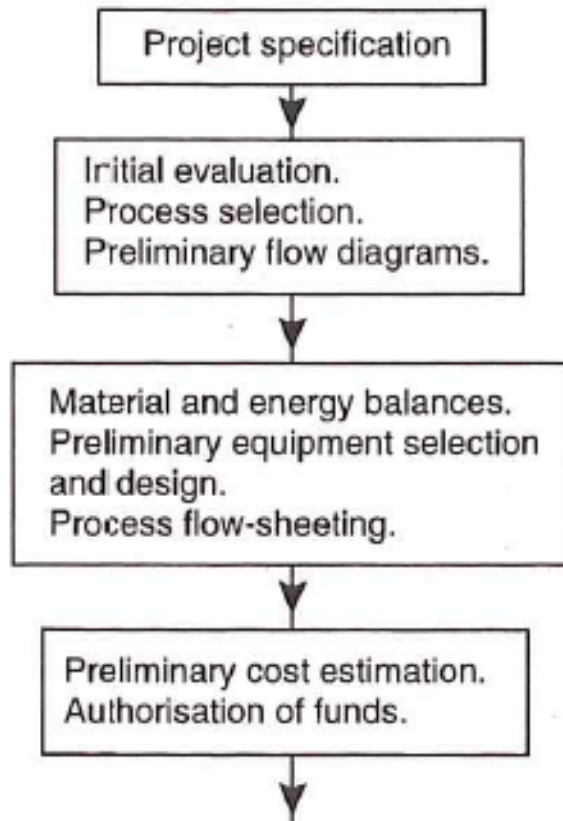
# Block flow diagram





## Conventional Ammonia Plant





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# Reactors

- Kinetics is used for calculating average residence time  $\tau$  in reactor (CSTR, plug flow, catalyst filled...)
- Volume flow through reactor,  $\dot{V}$ , from mass balances
- Reactor volume

$$V = \dot{V} \cdot \tau$$

- Length/diameter depending on reactor type
-

# Separation

- Screening, filtering, centrifuging
- Distillation
- Decanting
- Sizing according to type of separation based on mass/volume flow, concentration, particle size...



# Storage

- Volume flows from mass balances
- Delivery by truck, train, pipeline, ship demands intermediate storage
- Buffer storage for short periods of time
- Silos for solids, tanks for liquids and gases...
- Storage volume

$$V = \dot{V} \cdot \tau$$

- Dimensions depend on storage type
-

# Preprocessing

- Screening, grinding
- Melting, gasifying, freezing
- Mixing



# Transport

- Belt conveyors, screws, pneumatic conveyors etc for solids
  - Pipes and pumps for liquids and slurries
  - Ducts and fans for low pressure gases
  - Pipes and compressors for high pressure gases
  - Sized according to type of transport and mass flow
-

# Heat exchange

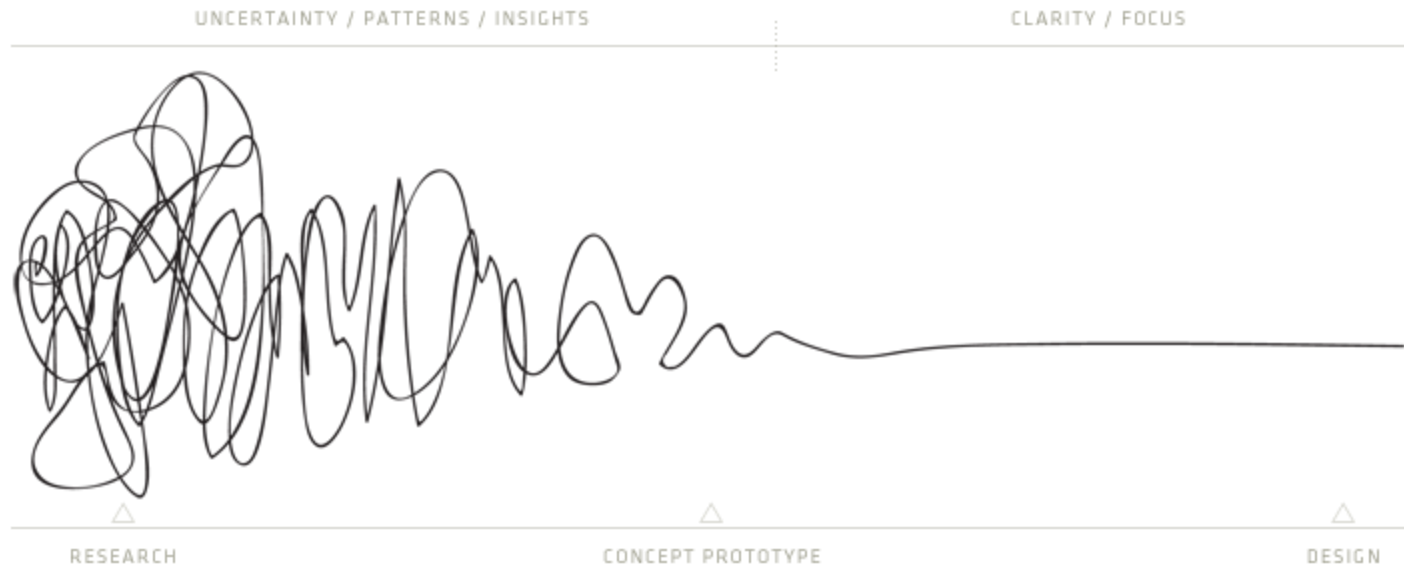
- Plate heat exchangers, shell and tube heat exchangers, regenerative heat exchangers





# Instrumentation

- Temperature
  - Pressure
  - Flow
  - Level
  - Concentration
  - ...
  - For control, indication, quality, permit, safety, production
-



<http://v2.centralstory.com/about/squiggle/>