

# Basics in Process Design

## Introduction

# Contact

- Frej Bjondahl
- University teacher
- Room B 312
- [Frej.Bjondahl@abo.fi](mailto:Frej.Bjondahl@abo.fi)

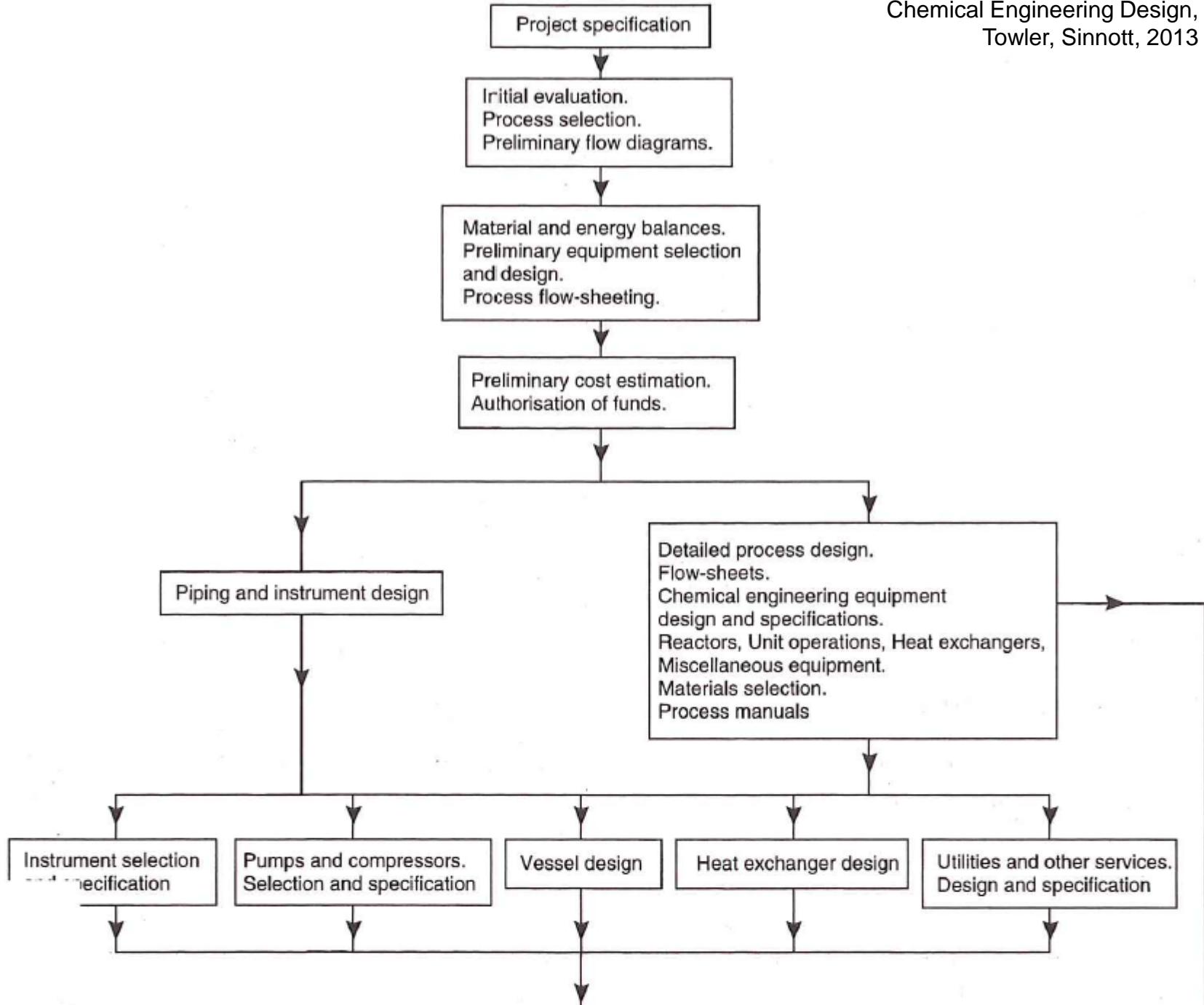


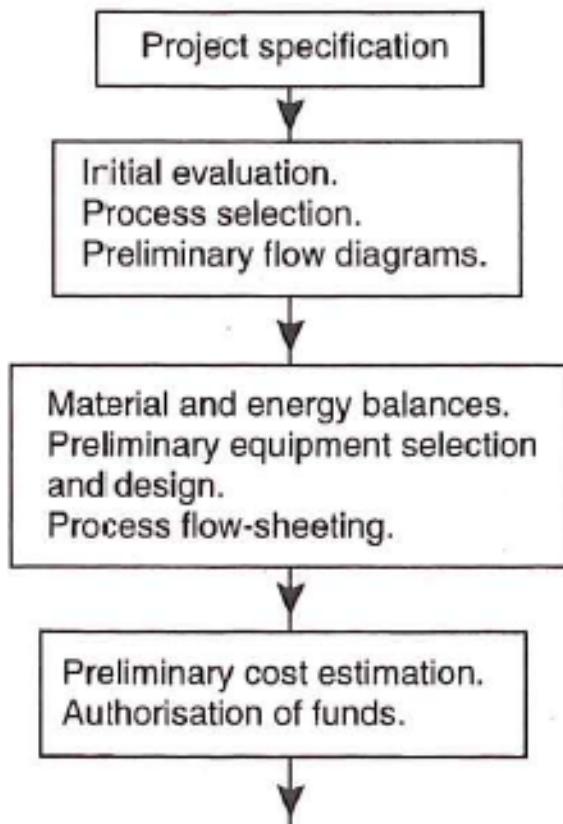
# What is process design?

- 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**.”





- 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)



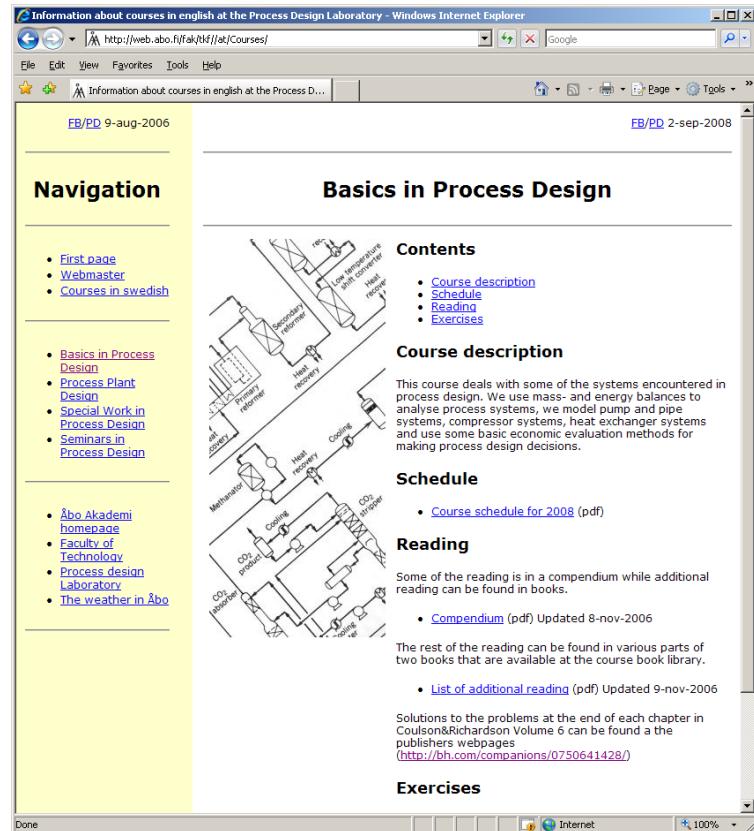
# Course material

## ■ Course info

- Schedule
- Compendium
- Exercise assignments
- Additional reading

[ebrary](#)

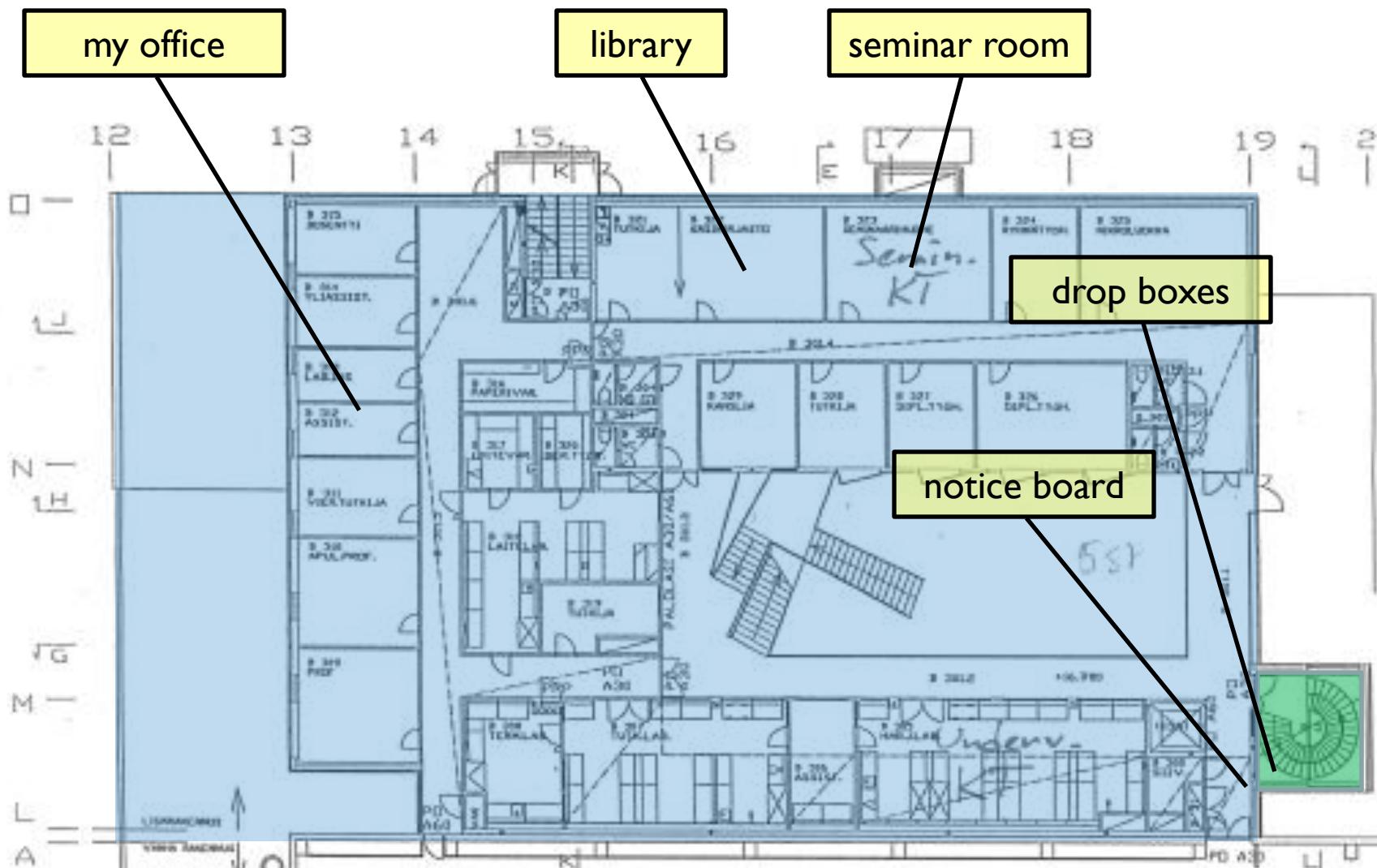
<http://web.abo.fi/tkf/at/Courses>

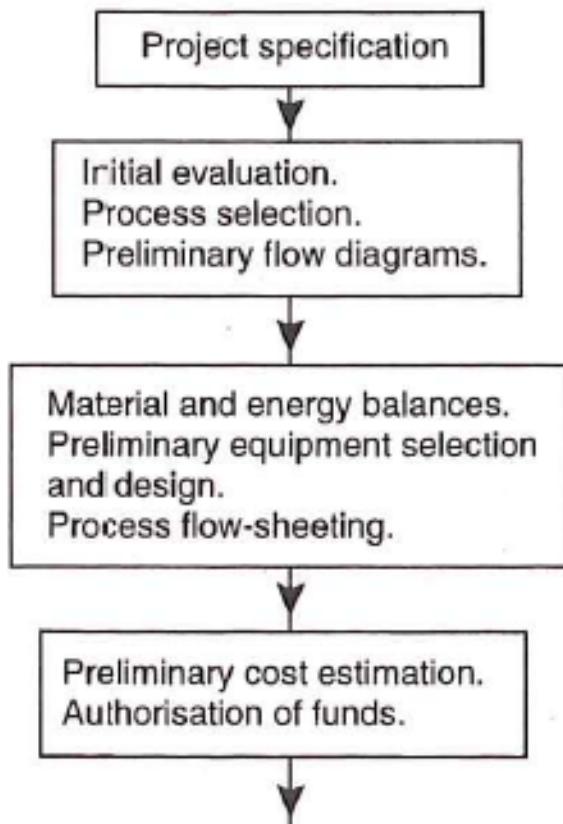


The screenshot shows a web browser window with the following content:

- Header:** Information about courses in english at the Process Design Laboratory - Windows Internet Explorer, URL: http://web.abo.fi/tkf/at/Courses/
- Left Sidebar (Navigation):** FB/PD 9-aug-2006, FB/PD 2-sep-2008. Includes links: First page, Webmaster, Courses in swedish, Basics in Process Design, Process Plant Design, Special Work in Process Design, Seminars in Process Design, Åbo Akademi homepage, Faculty of Technology, Process design Laboratory, The weather in Åbo.
- Content Area:**
  - Basics in Process Design:** Course description, Schedule, Reading, Exercises. 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. Description: The rest of the reading can be found in various parts of two books that are available at the course book library.
  - Exercises:** 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/>)

Axelia II 3rd floor – Process Design and Systems Engineering

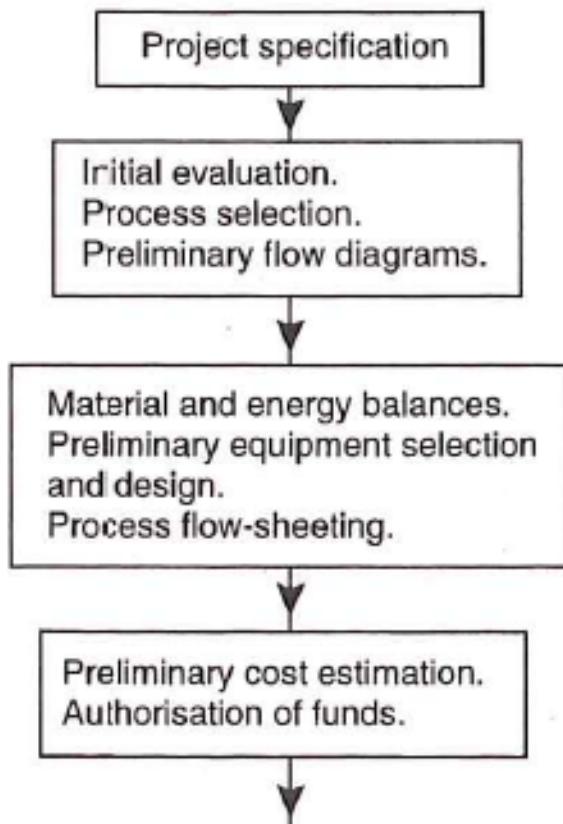




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# Specification

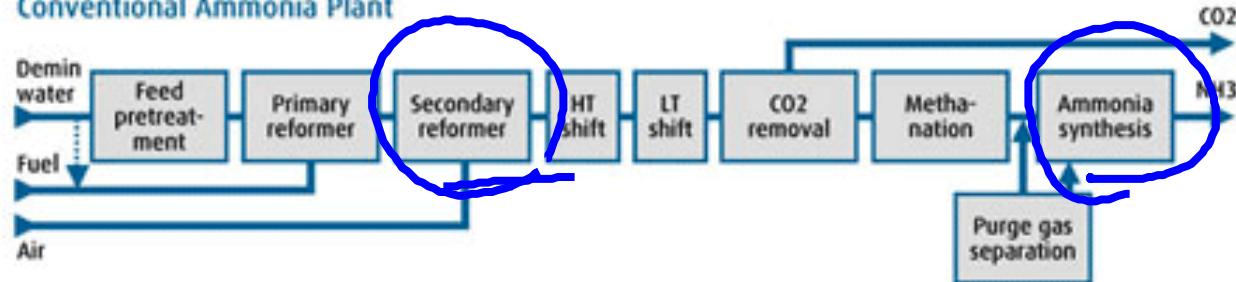
- Production of 150000 ton/year ammonia ( $\text{NH}_3$ )
- 8000 h/year operation
- Is this specification reasonable?
  - [www.indexmundi.com](http://www.indexmundi.com)
  - [www.kbr.com](http://www.kbr.com)



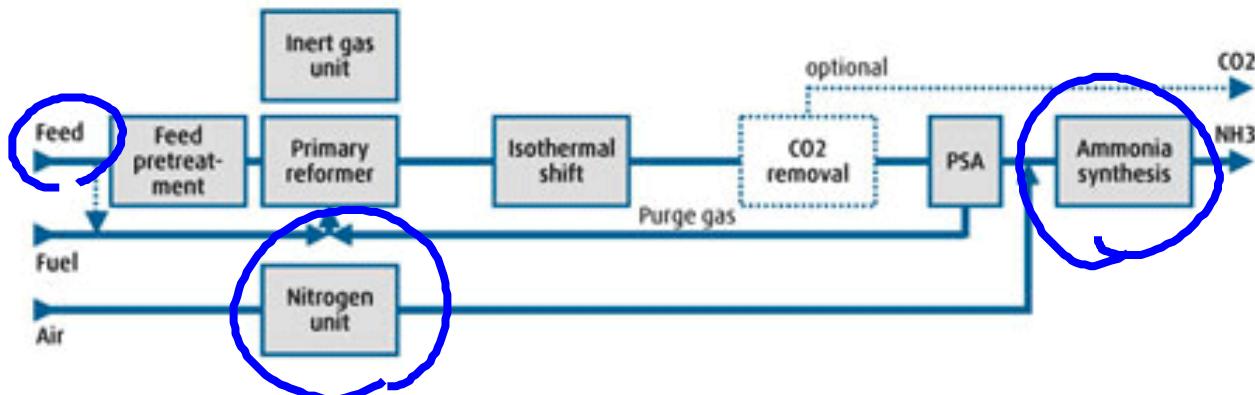
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## Process comparison of a conventional ammonia plant and Linde Ammonia Concept (LAC)

Conventional Ammonia Plant



Linde Ammonia Concept (LAC)

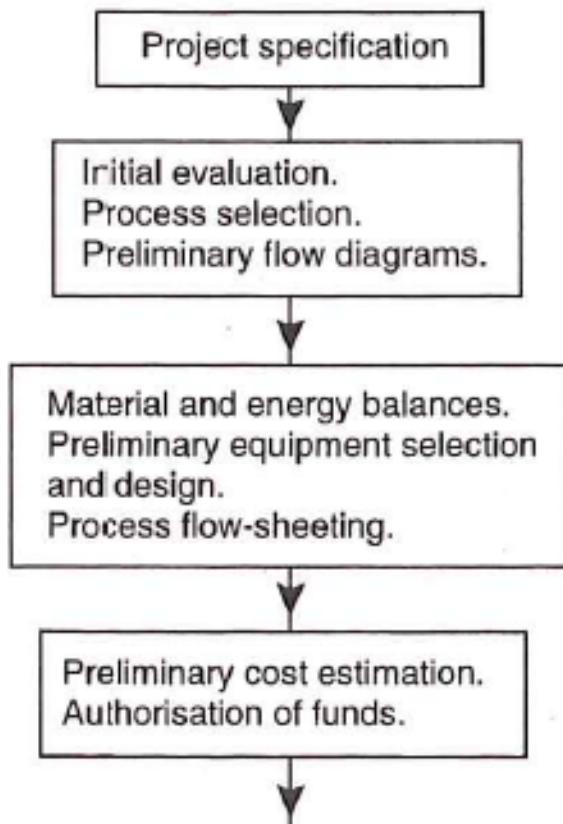


Source: Linde Engineering (<http://www.linde-engineering.com/>)

# Process selection

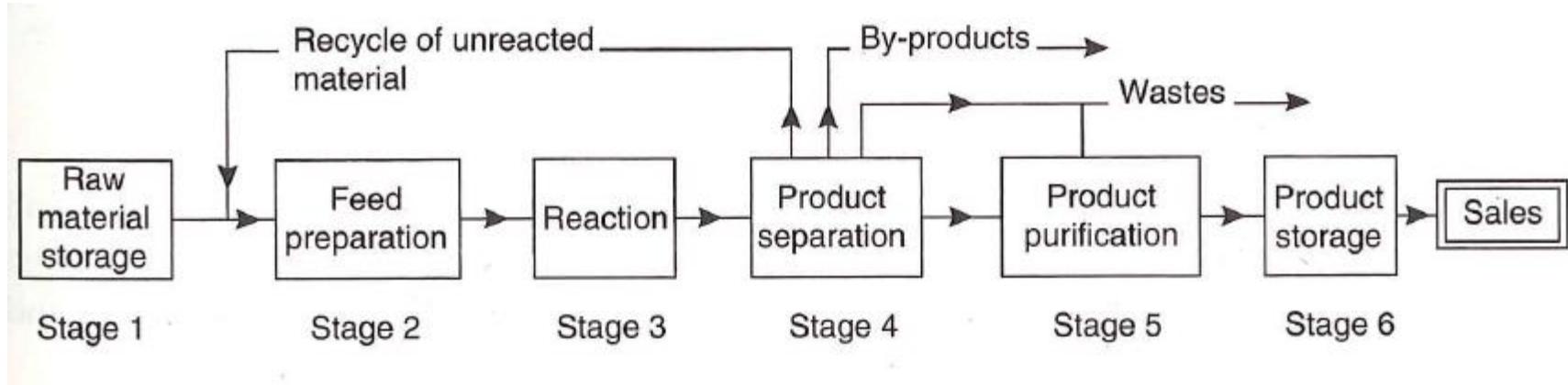
- Haber-Bosch
  - Hydrogen from steam reforming of natural gas/petroleum gas/naptha
  - Nitrogen from air distillation
  - Ammonia synthesis in catalytic high pressure/temperature reactor
  - Separation by condensation of ammonia from gases
  - Recycle of unreacted gases

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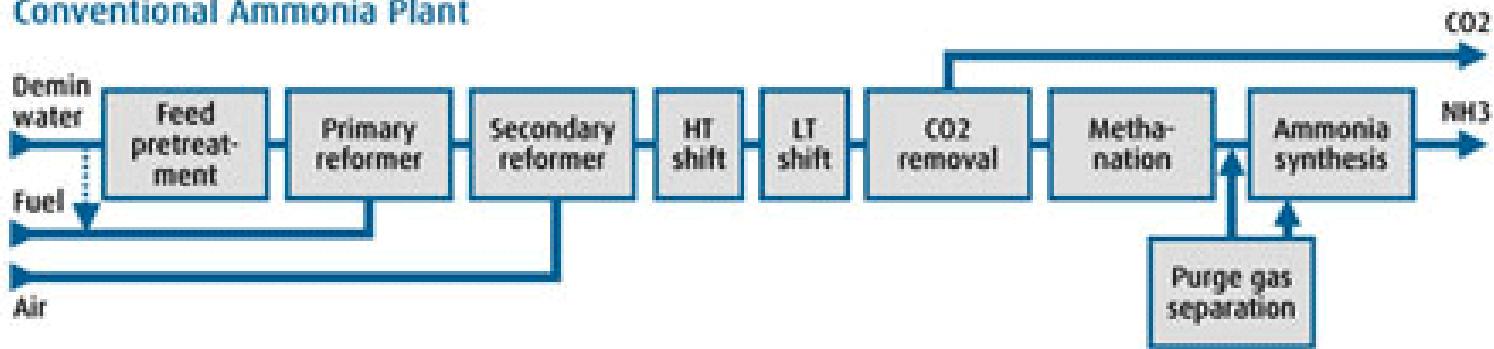


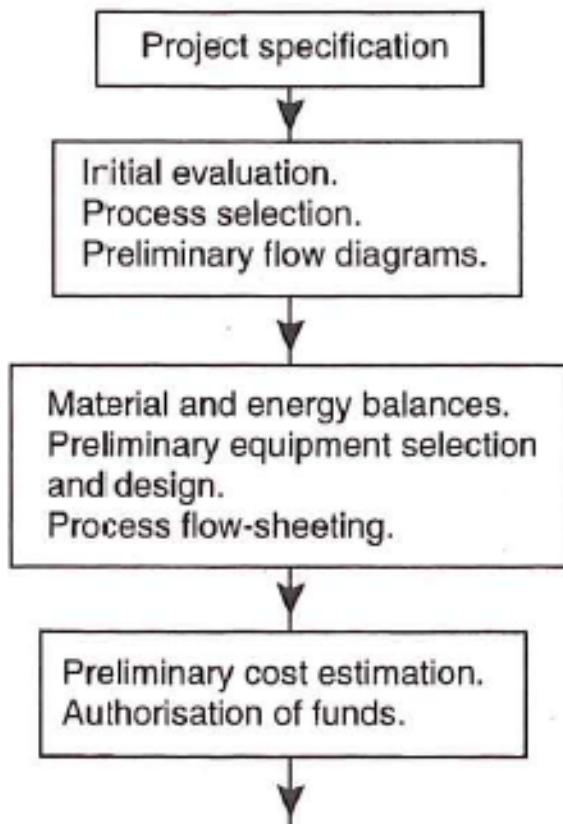
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# Block flow diagram



## 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

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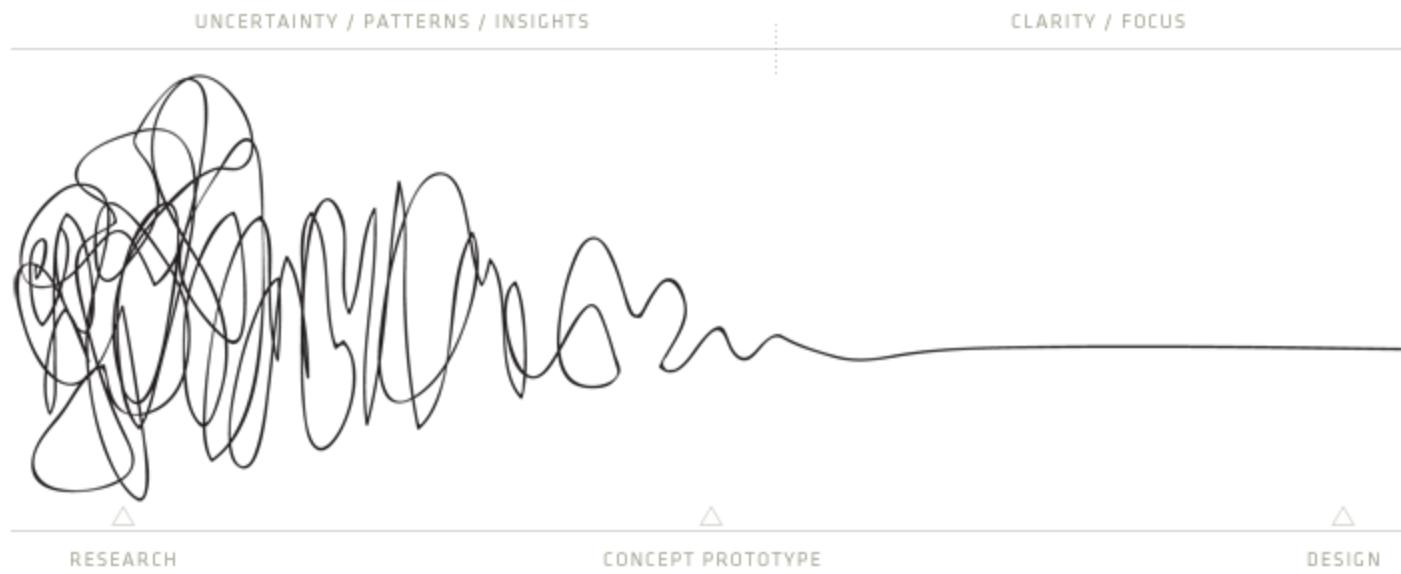
# Heat exchange

- 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/>