Scale-Up of Chemical Engineering Process

Chapter 1: Introduction of Scale-Up Processes

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Definition of Scale-up

"The successful startup and operation of a commercial size unit whose design and operating procedures are in part based upon experimentation and demonstration at a smaller scale of operation"

(Source: Bisio & Kabel, 1985)

Definition of Scale-up

"Indeed, to a very significant extent, scale up *is* Chemical Engineering"

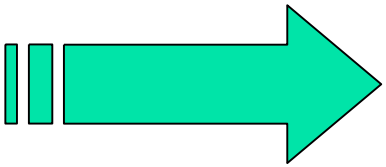
-Prof. G. Astarita

Why Scale-Up

Scale up is basically needed for:

- Market growth
- Introduction of new processes
- Reduction in making expensive errors in design and operation
- Concentrate on addressing areas of doubts and uncertainty
- Economic feasibility

Scale-up



How to scale up from small scale to large scale?

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Scale-Up theory and Calculation

There are three categories of scale up:

1. WELL-DEFINED, EASY AND QUANTIFIABLE
   (e.g. distillation, heat exchanger, absorption etc.)

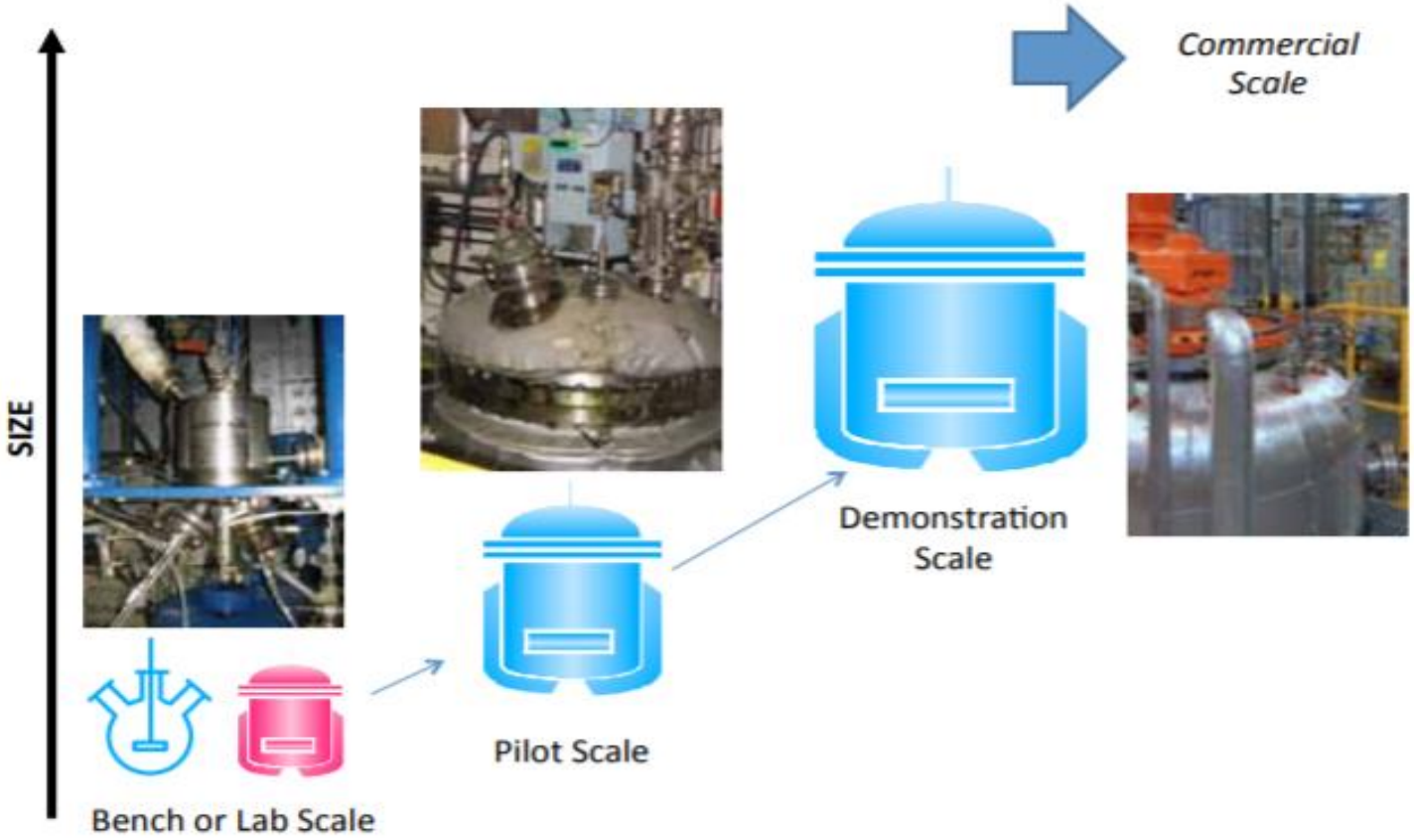
2. DIFFICULT BUT QUANTIFIABLE (e.g. reactors)

3. VERY DIFFICULT AND RARELY CAN BE QUANTIFIABLE (e.g. particulate processes)

Scaling up Step by Step

- Product and process development for scaling up is typically move in small steps.
- For instance, the development is initially from lab scale to bench scale then move to pilot scale and finally to commercialization scale.
- By performing scale up step by step, the risk with large investments could be lessen.
- The following figure illustrates the conventional scale up procedure for bio fuel.

Conventional Scale-up Procedure



(Source: Biofuels International Magazine, November 2012)

Conventional Scale-up Procedure

1. Bench or laboratory scale

   - This is an early-stage tools to assess and scaling new product or technology

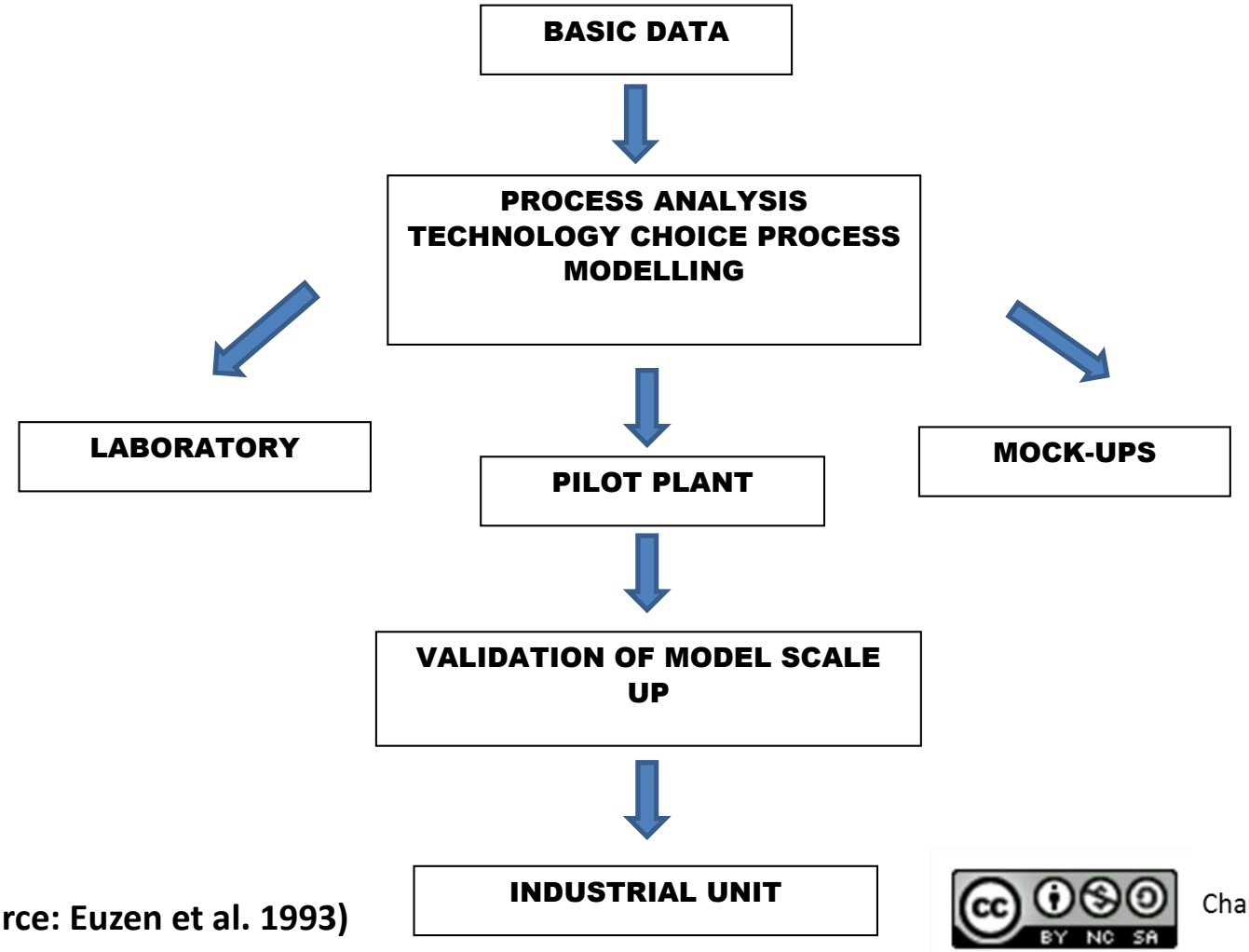
2. Pilot Scale

   - Pilot scale is a first view into continuous processing of a product

3. Demonstration scale

   - In this step, the process flowsheet is closely resemble commercial scale operations.

ESSENTIAL STEPS



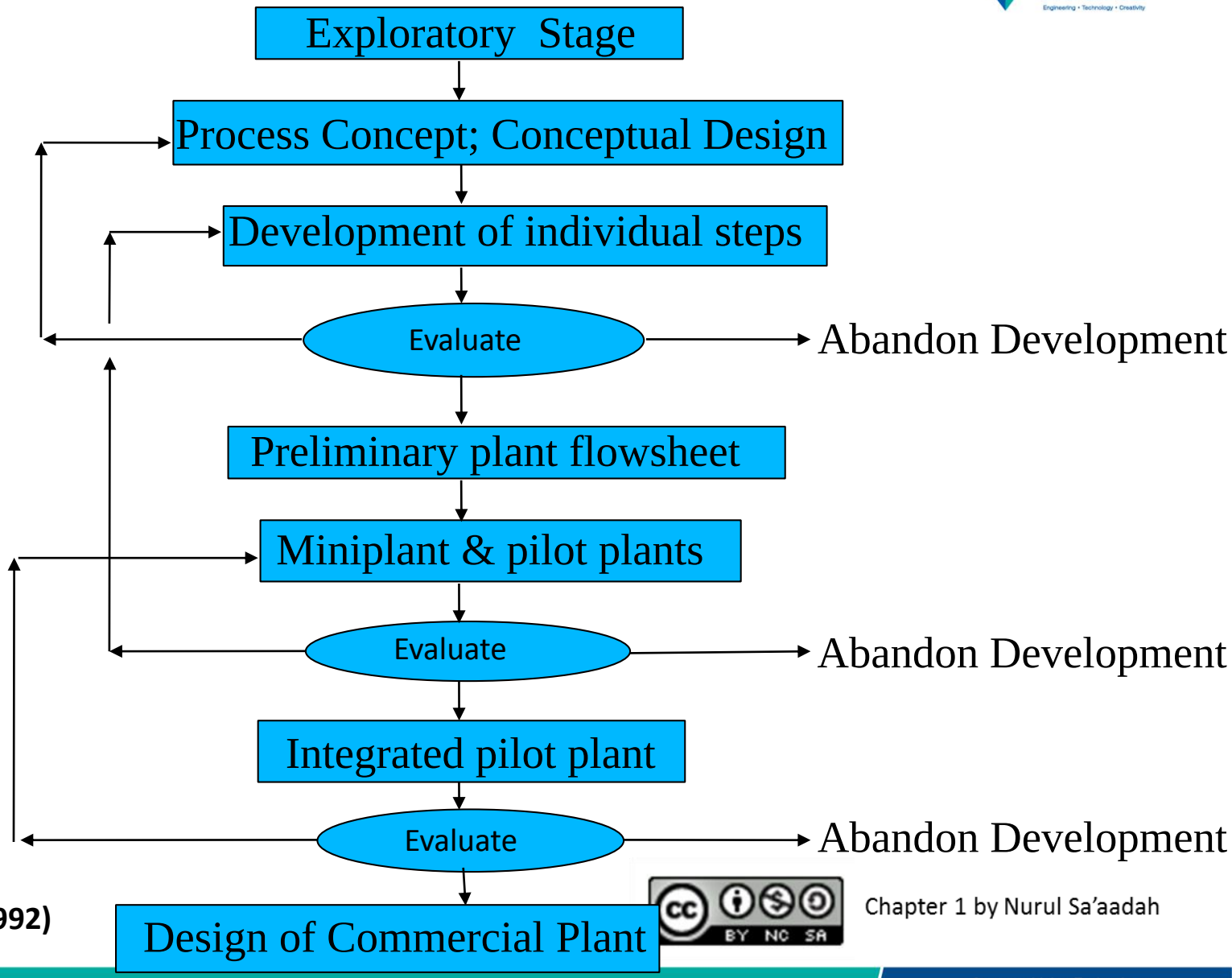
(Source: Euzen et al. 1993)

Production Capacity

Table below shows the general production capacity of each scaling up step in the process industries.

Scaling factor	Typical production capacity
Bench/ Laboratory	0.001 – 0.1 kg/h
Pilot Plant	10 – 100 kg/h
Demonstration Plant	100 – 1000 kg/h
Commercial Plant	> 1000 kg/h

STEPS IN DEVELOPMENT OF A PROCESS



(Source: Vogel, H. 1992)