

# Scale-Up of Chemical Engineering Process

## Chapter 2: R & D and Commercialization

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# Issues in Malaysian R & D

- **95% of 6000 patent application in Malaysia (2001) were based on technology researched elsewhere.**
- **Spend 0.5% of GDP on R&D**
- **Out of RM 380 millions spent, Malaysian only managed to get 16 patents (2001)**

**(Source : Dr. Nikolai Dobberstein, McKinsey & Co, Malaysia, 2004)**



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# Issues in Malaysian R & D

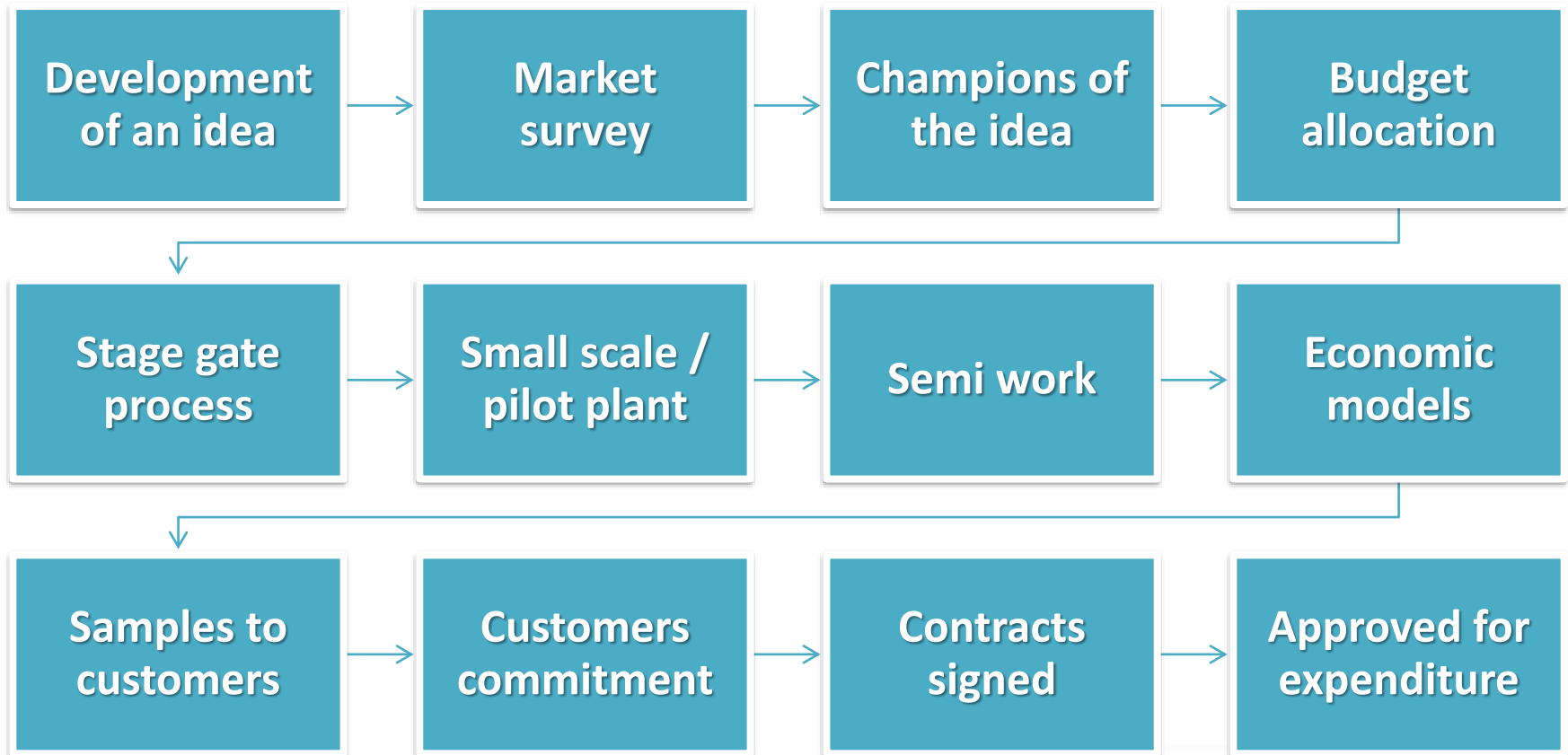
- **Under 6th & 7th Malaysian Plan, from 5232 public and universities research projects,**
  - **14.1% have the potential to be commercialized;**
  - **5.1% successful in commercialization.**
- **Good research projects but weak in transform it to commercial values.**

**(Source : Dr Ariffin Aton, President & CEO Sirim, 3 Feb 04)**



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# Commercialization Stages



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# Scale Up Considerations

There are a lot of issues need to be considered from product or process development scale up such as:

- Economical
- Raw materials
- Production vulnerability
- Logistics
- Social
- Mechanical and technical restrictions
- Start-up, management, maintenance
- Safety



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# Major Issues in Scale-up

- Unexpected problems in a commercial manufacturing operation
  - examples : impurities not encountered during pilot scale; flow stability; materials; flow pattern; determination of explosive limits; waste disposal; storage of unstable materials; logistics of raw materials; utilities requirement
- Mode of operation :
  - examples: batch operation might become an issues if the process in exothermic. Thus, selection of operation mode for scale up is crucial.



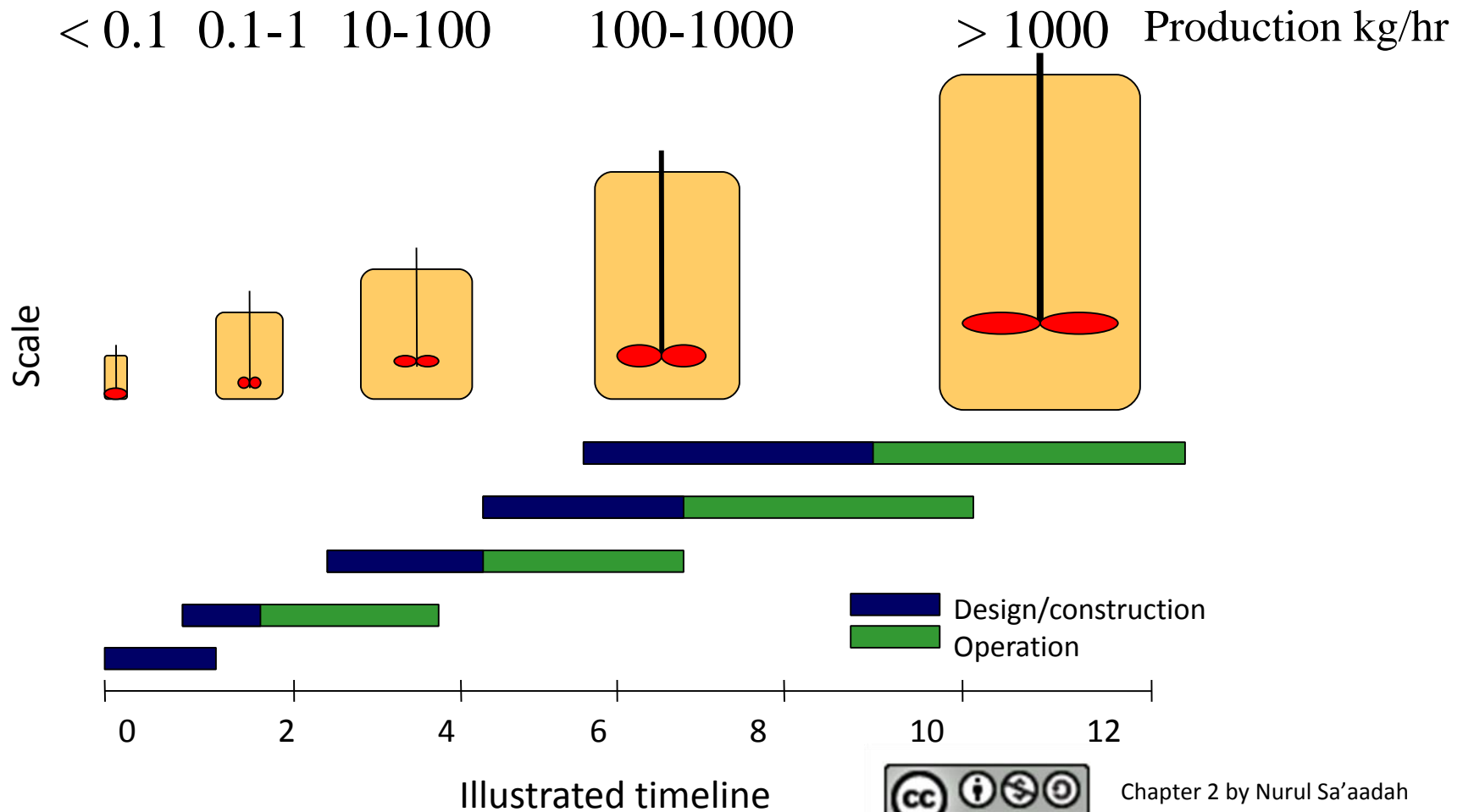
# Approaches to Scale-up

- Full scale test (existing plant)
- Modular scale up (limited scale up)
- Known scale up correlations (available from previous studies)
- Fundamental approach (proper modeling)
- Empirical approach (sequential)



# Timeline Vs Scale

(Source: Moulijn et al. 2014)





# Factors Affecting Scale-up

- Overall process understanding
- Physico-chemical phenomena
- Similitude – geometric vs dynamic
- Business plan (customer requirement; timeline including when to sell; pricing)
- Local and international regulations (osha; epa)
- Product quality
- Availability of raw materials



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# Is there a Royal road to scale-up?

- Once King Ptolemy of Egypt asked Euclid whether he could make his geometry simpler, so that Ptolemy himself could learn it with less effort. Euclid's answer was : “There is no Royal road to geometry”
- The answer to the 'big' question is NO!



# Success Factors of Scale-up

- Multidisciplinary
- Strong R & D back-up
- Sufficient budget
- Details
- Customers relationship
- Thorough market survey
- Solid organization
- Raw materials availability
- Infrastructure
- Competent manpower



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# Author Information

**Credit to the author:**

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