SCALE-UP STRATEGIES FOR COMMERCIALIZATION

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INTRODUCTION

- Overview of the Challenge
- Common Pitfalls
- Proper steps to Commercialization
- Strategies
- Benefits
- Costs
- Practical Applications
THE CHALLENGE

- Engineering information
- Market development
- Mitigate risk
- Capital, Funding
- Product timing
COMMON PITFALLS

- Scope development
- Improperly sized equipment
- Relying on modeling
- Costly modifications, Repairs
- Lack of safety considerations
- Quality vs. time
- Feedstock supply, Market demand
- Damaged relationships
WAYS TO REDUCE RISK – PHASED APPROACH

- Strategic phases
  - Lab/Bench
  - Pilot
  - Demo
  - Commercial

- Factor of 10
LAB PHASE
Objectives: Quickly and inexpensively test feasibility and approach for a wide variety of products and processes.

BENCH PHASE
Objectives: Investigate possible issues and collect data for future scale-up to pilot level. Integrate process steps and possibly collect information for development of IP.

EXAMPLES
• Drying – Fluidized Bed, Rotary Drum
• CSTR – Reacting, Mixing
PILOT PHASE

Objective: Assess the process for feasibility and to more effectively and efficiently plan for scale up.

Benefits:
- Identify process parameters
- Identify process pitfalls
- Flexibility to make changes
- Training for plant personnel
- Sample product for potential markets
- Demonstrate technology and products – customers, investors
Objective: Built to closely resemble the full-scale plant and to further de-risk commercial operations.

Benefits
- Co-located with commercial facility
- Large quantities of final product
- Feedstock supply, logistics
- Satisfy performance expectations
- Operator training, procedures, etc.
- Mitigate risk - commercial investment
FACTORS AFFECTING COST

- Process conditions
- Complexity, automation
- Scale/throughput
- Location
- Capital
- Operating
- Research & development
- Market development

<table>
<thead>
<tr>
<th>Scale</th>
<th>Rate</th>
<th>Cost*</th>
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</thead>
<tbody>
<tr>
<td>Lab/bench</td>
<td>Beaker</td>
<td>Up to $50,000</td>
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<tr>
<td>Pilot</td>
<td>up to 1000 lbs/hr</td>
<td>Up to $500,000</td>
</tr>
<tr>
<td>Demo</td>
<td>up to 5000 lbs/hr</td>
<td>Up to $5,000,000</td>
</tr>
<tr>
<td>Commercial</td>
<td>10+ tons/hr</td>
<td>$5,000,000++</td>
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</tbody>
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Order of magnitude estimates only. Actual values will likely vary.
KEY CONSIDERATIONS, BENEFITS

- Time is important → Success is Required
- Safety first!
- IP Protection
- Permitting, Regulations
- Size matters
- Technical and Financial Risk
- Phased funding
THE MACARTHUR PLAN

SUMMARY

- The Approach to Scale-Up is Important
- Stay focused
- Seek experienced partners
THANK YOU

For more information please visit our website
www.appliedchemical.com

If you have any questions, please contact me:
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