"Radical Chemical Concepts for CO_2 Removal from Exhaust Gas"

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Olav Juliussen, Malcolm McLarney,
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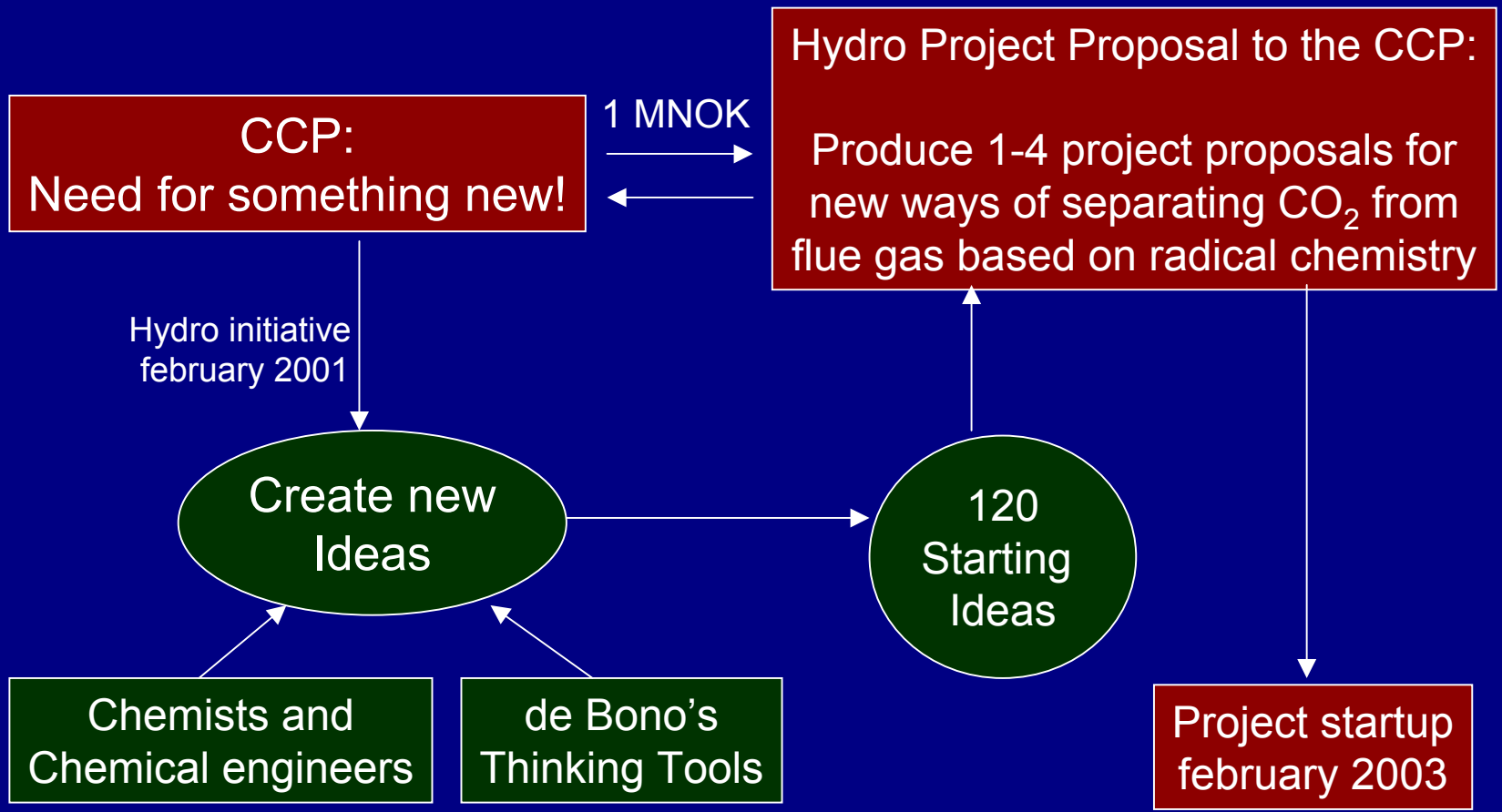
BACKGROUND AND TARGET



RADICAL CHEMISTRY – PROJECT TEAM

- Chemistry and Chemical Engineering
  - Dag Eimer (Norsk Hydro Oil & Energy)
  - Richard Heyn (SINTEF Applied Chemistry)
  - Olav Juliussen (SINTEF Applied Chemistry)
  - Merethe Sjøvoll (Norsk Hydro Oil & Energy)
  - Ole Swang (SINTEF Applied Chemistry)
- Thinking Tools
  - Malcolm McLarney (ThinkStrat Consulting)
- Cost estimates
  - Nils Eldrup (Siv.ing. Eldrup)

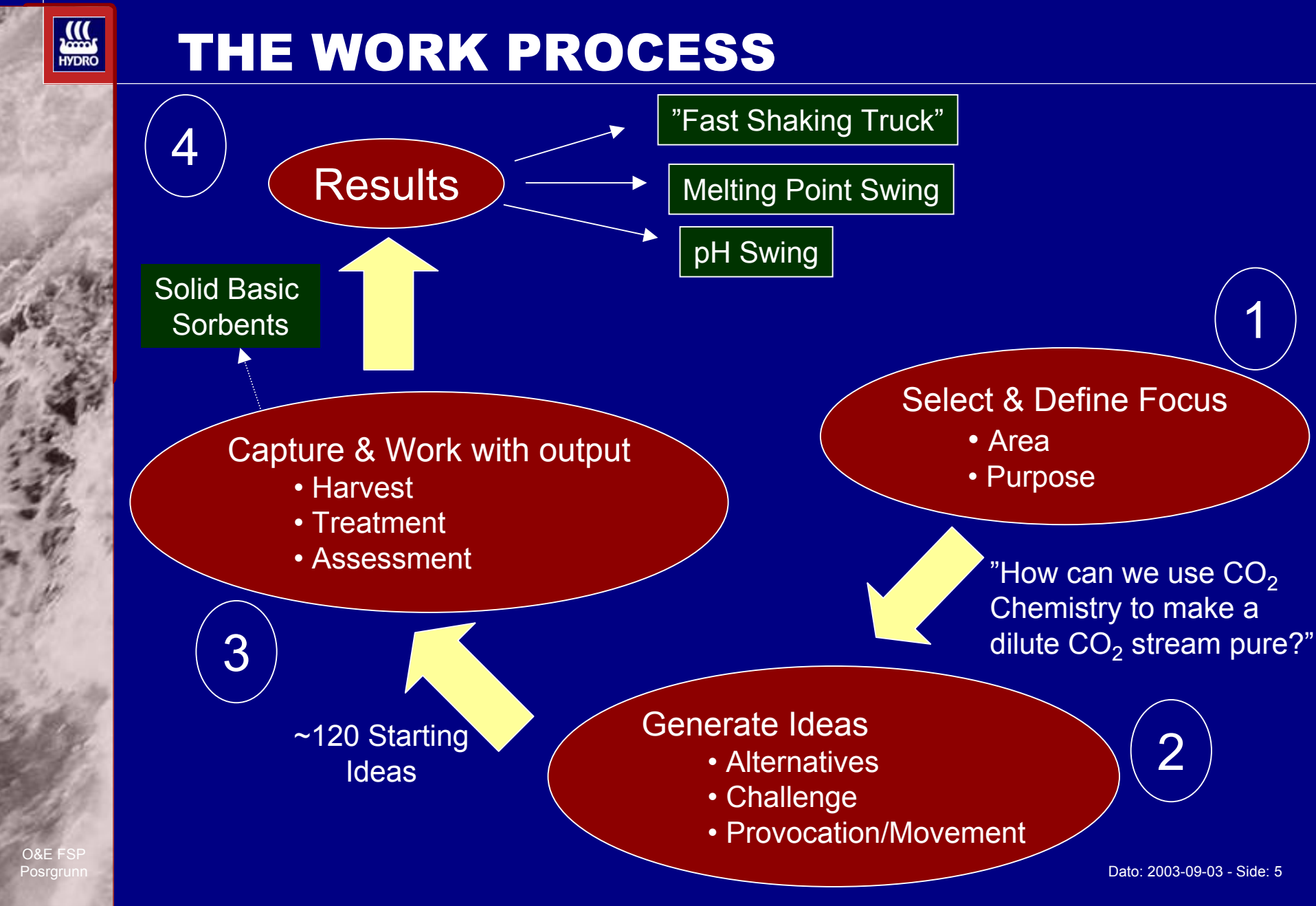
WHY FORMAL THINKING TOOLS?

- Challenging problem requires new solutions, need for creative effort
  - 120 ideas created by 16 participants in one day
- Need to shape initial (very immature) ideas into something practical and usable within a strict time and cost frame
- Some of the ideas developed further by 6-7 participants to a stage where economic potential could be assessed
- Difficult to achieve without using some type of formal thinking process

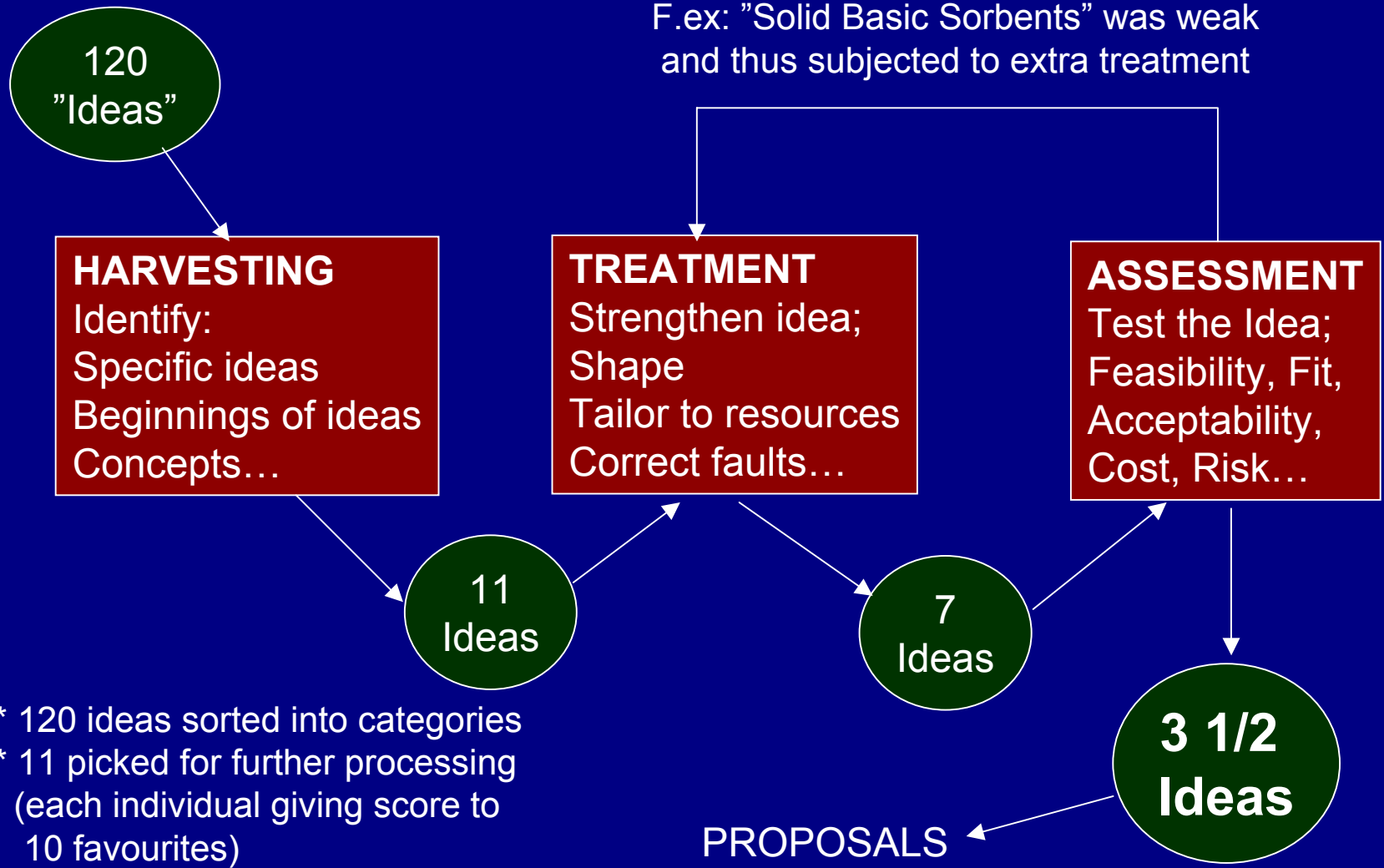
Common mistakes in ”Deliberate Creativity”:

- **Focus too vague**
- **Ideas do not fit the focus**
- **No capturing of the output**

THE WORK PROCESS



THE HARD WORK: CAPTURE THE OUTPUT

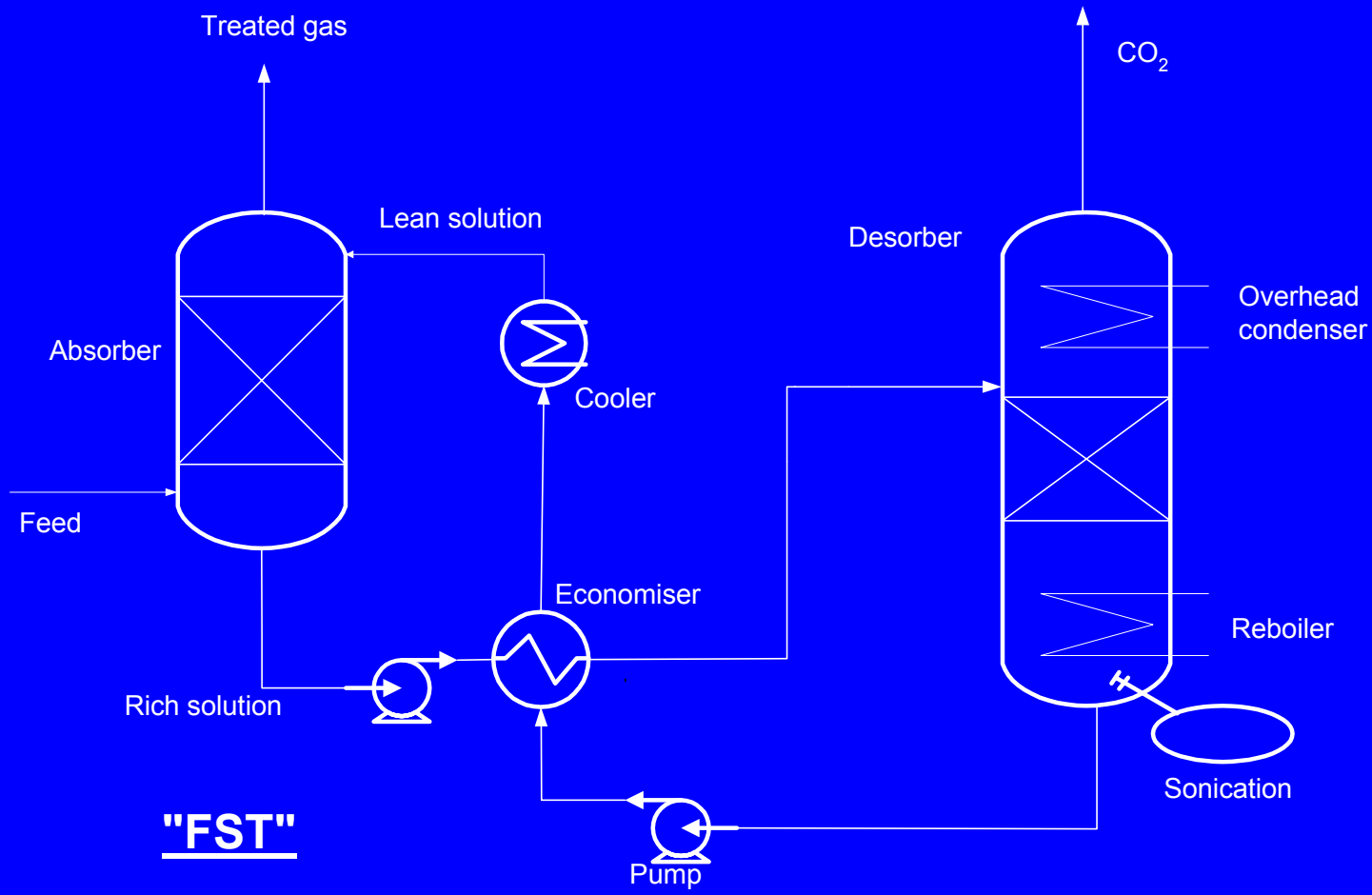


* 120 ideas sorted into categories
* 11 picked for further processing
  (each individual giving score to
  10 favourites)

PROMISING RESEARCH AREAS

- Transition metal (TM) complexes
- Biomimetic chemicals
- Sonochemistry
- Salt Hydrates
- pH controlling chemicals

FAST SHAKING TRUCK (FST)



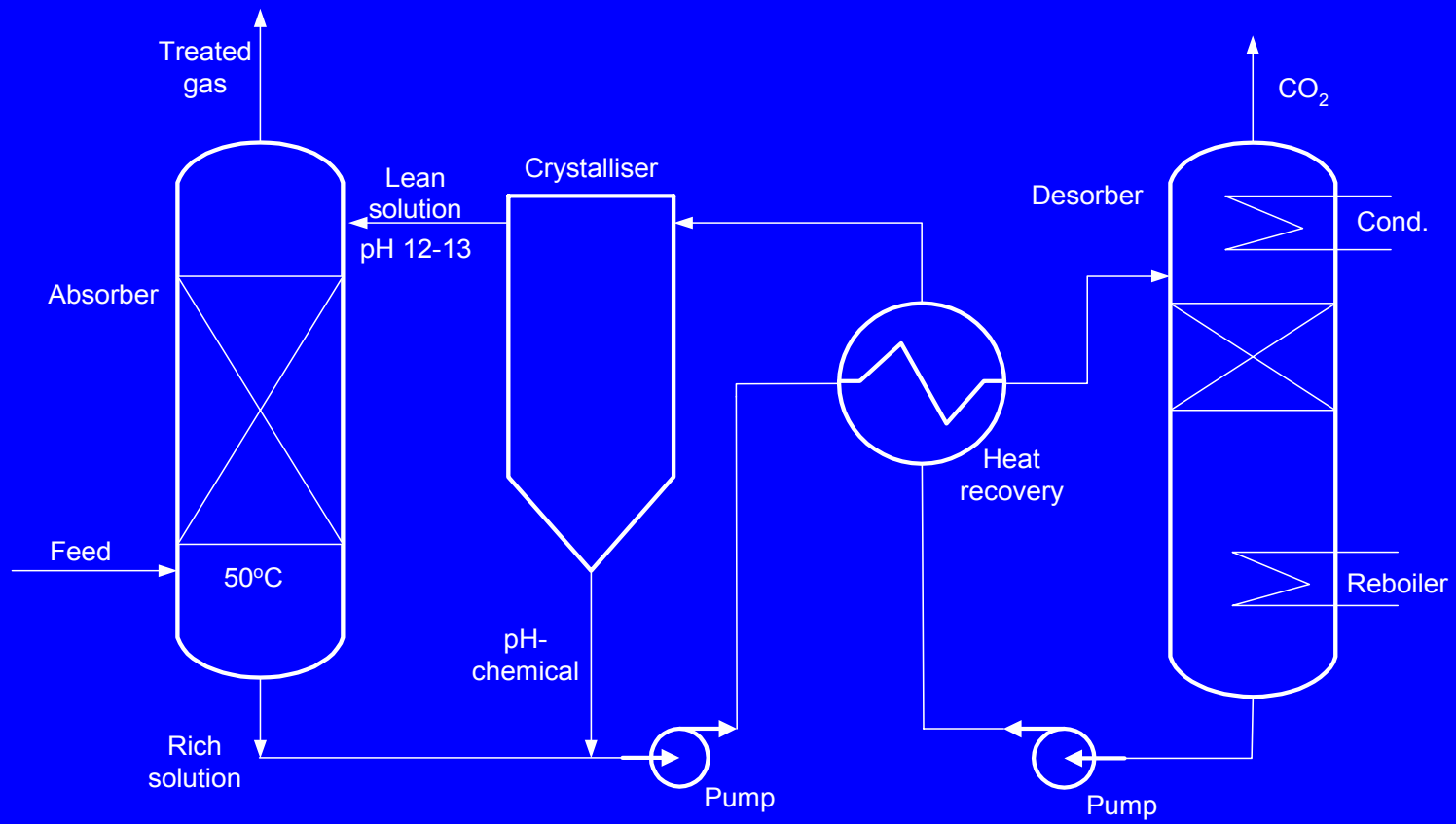
FST - DESCRIPTION

- Familiar process, new absorbent
  - Transition metal complexes in aqueous solution
  - Biomimetic accelerator (if needed)
  - Desorption enhanced by sonication
- Main assumptions in cost estimate
  - ”Delta-loading” 0.7 mol CO_2/mol carryer
  - TM complex concentration: 5M
  - Desorption temperature reduced to 60 ^oC
- Research targets
  - Find the TM complex with defined capacity
  - Confirm sonic regeneration at 60 ^oC
  - Find biomimetic accelerator

MPS - DESCRIPTION

- New process equipment, new sorbent
  - CO_2 recovered using salt hydrate cycled by swinging the temperature around its melting point
- Main assumptions in cost estimate
  - CO_2 uptake 5% by weight
  - Low grade heat can be used to cycle the sorbent
- Research targets
  - Find absorbent with required capacity at absorber conditions
  - Find absorbent with melting point as assumed
  - Verify design assumptions for apparatus

pH SWING (PHS)



pH-swing process

PHS - DESCRIPTION

- Similar to standard absorption-desorption, but desorption is achieved by changing the pH through the use of a pH controlling agent; less heat needed
- Main assumptions in cost estimate
  - CAPEX 10% higher than base case. (Extra unit)
  - Steam consumption is only 10% of base case
  - Stable chemicals
- Research Targets
  - Find pH agent with required properties
  - Match with absorbent
  - Confirm heating needs

SOLID BASIC SORBENTS (SBS)

- High focus on adsorbents within CO_2 recovery from flue gas
- Adsorbents with high capacity (up to 40% by weight) possible
- No cost efficient process solution exists
- Should focus on inventing the process before further research on the chemical
- Run a similar project to this one, but with chemical engineers?

CONCLUSION

- The project has reached its target and has delivered 3 ½ project proposals on new ways of recovering CO_2 from flue gas
- 3 of the proposals show potential for cost reductions
- The proposals are (necessarily) radical and thus have a high risk of failing
- The cost of testing the implicit assumptions is moderate