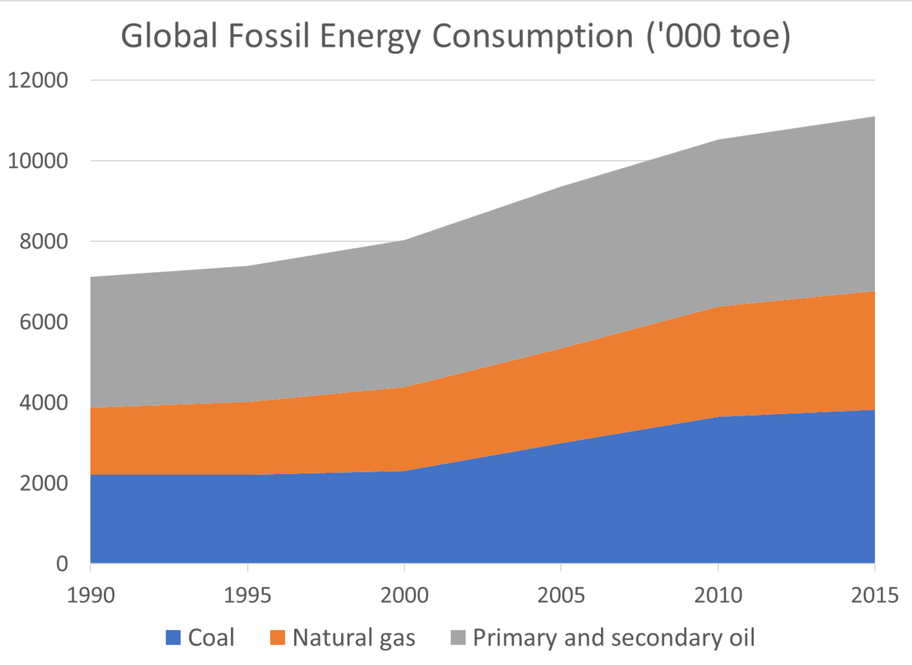
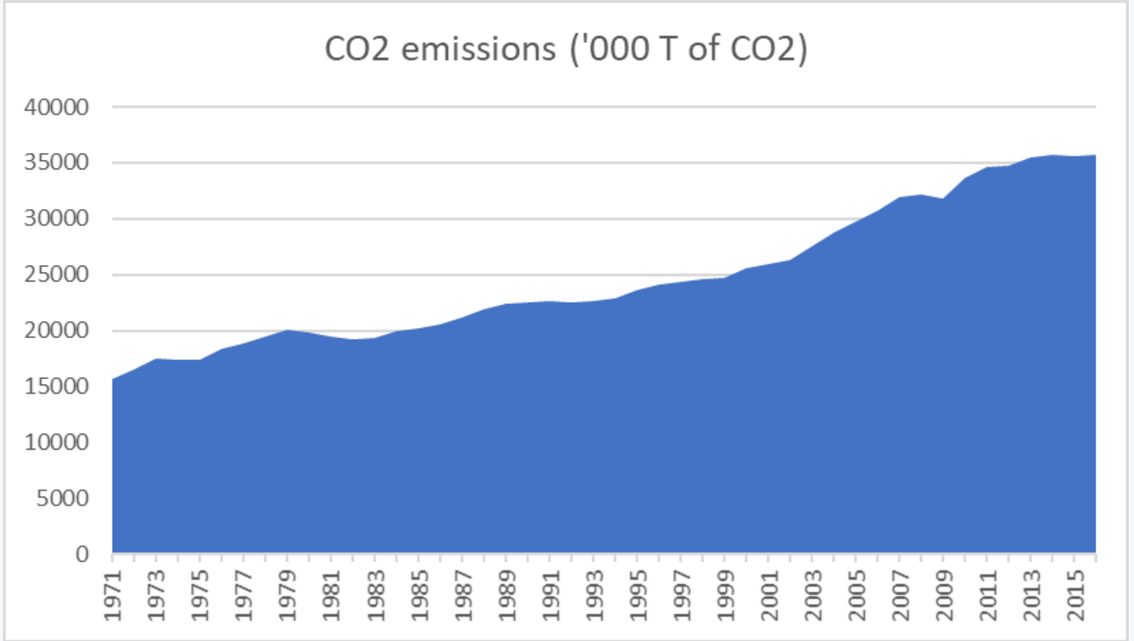
PTI GLOBAL SOLUTIONS

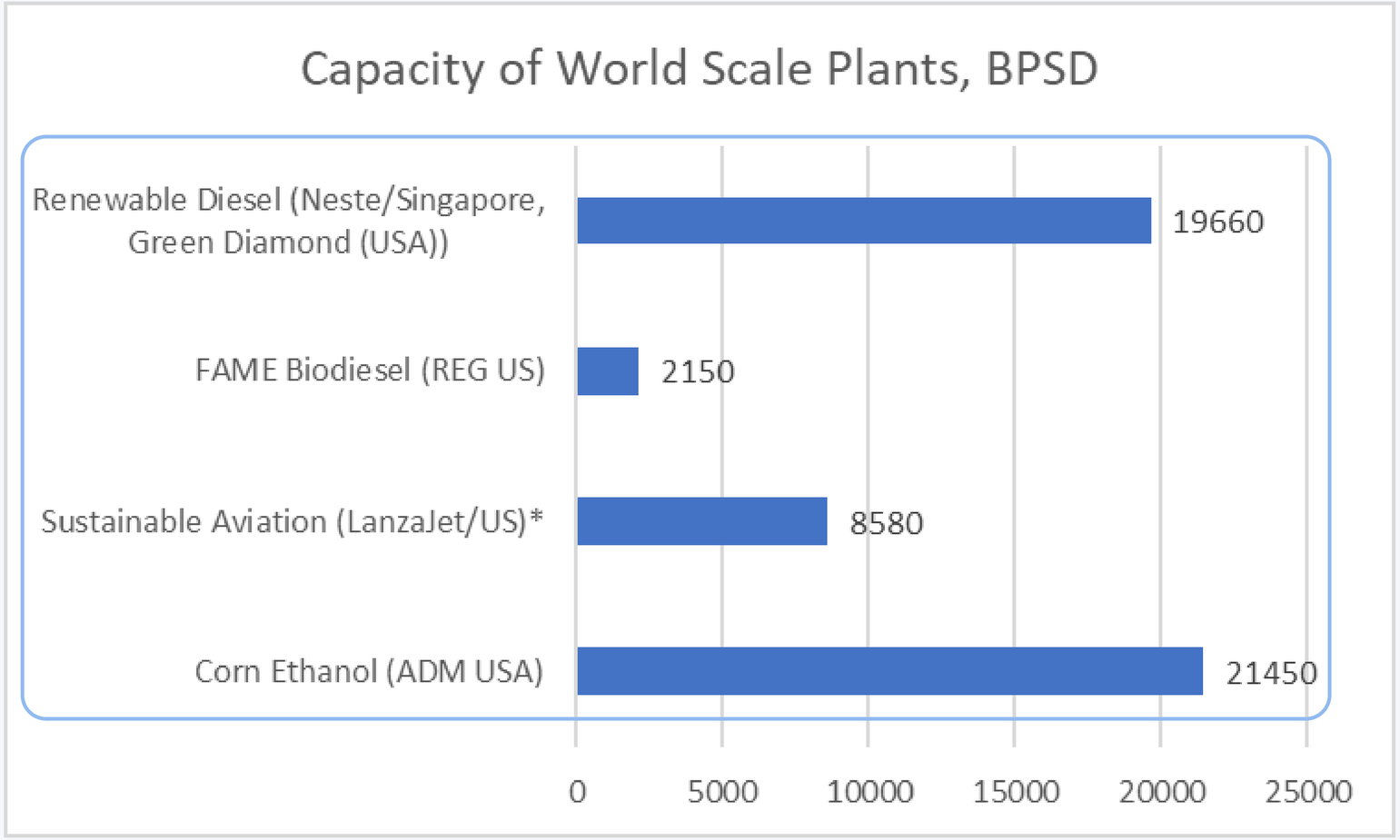
Drawing on the Past to Innovate a Sustainable Future

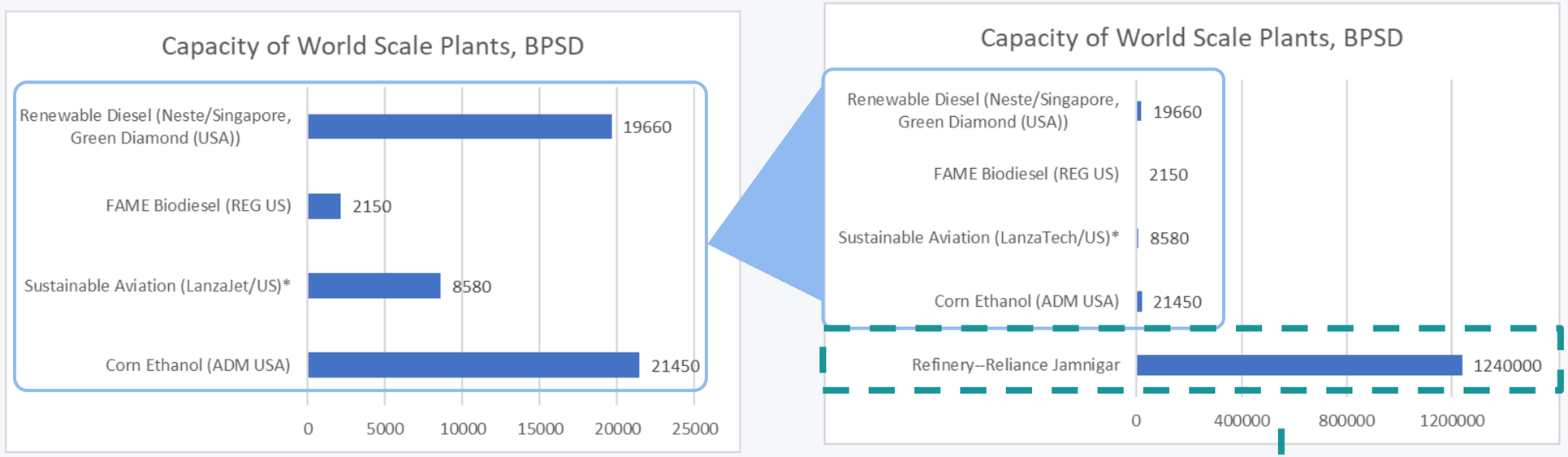
Mike Schultz, Ph.D. | World Future Fuel Summit, 17 Feb 2022



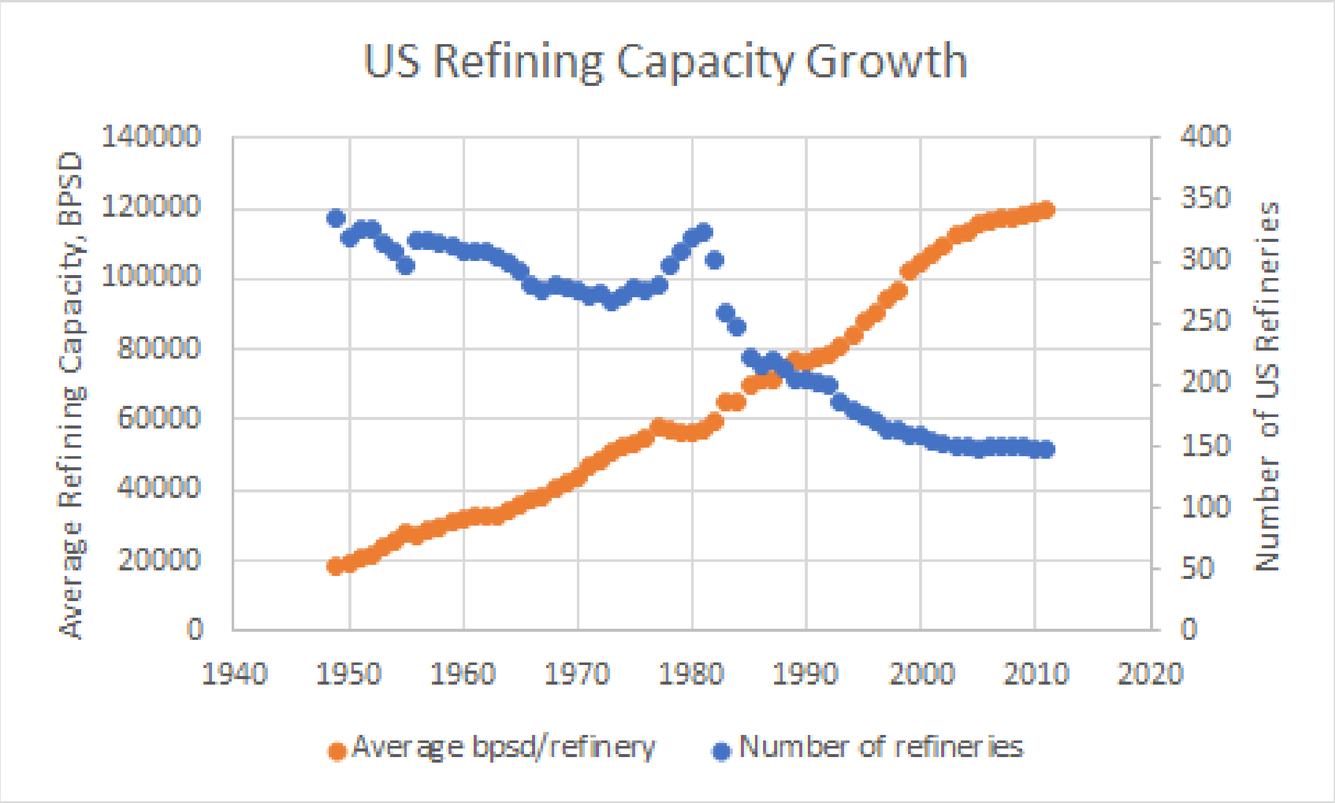


The Scale of the Problem is Massive





Scale mismatch in state of the art refineries vs next generation, low carbon fuels



- Capacity improvement
- Cost reduction
- Increasing complexity

We Need to Move More Quickly to Address Our Sustainability Challenges

	Selection of Flowsheet Alternative Qualitative--useful for fixing the flowsheet	Design Guideline Quantitative—useful for optimizing the design
Reactors	Batch vs Continuous CSTR vs Plug Flow Fixed Bed vs. CCR vs. FCC	HDT LHSV =5 (naptha) or 0.5 (resid) Selectivity vs conversion curves
Heat Exchangers	Shell & Tube vs Plate & Frame vs Spiral Air or water cooled	Approach temperature guidelines Fouling factors
Fractionators	Sequencing (lightest first vs heaviest first) Packed vs trayed column	R=1.2-1.5 Rm Tray efficiencies Tray height and pressure drop

Pumps, pipes, compressors, instrumentation, agitators, spargers, vessels, boilers, ….

Rules of Thumb for Chemical Engineers, Stephen Hall 2012
420 pages of experienced based design rules

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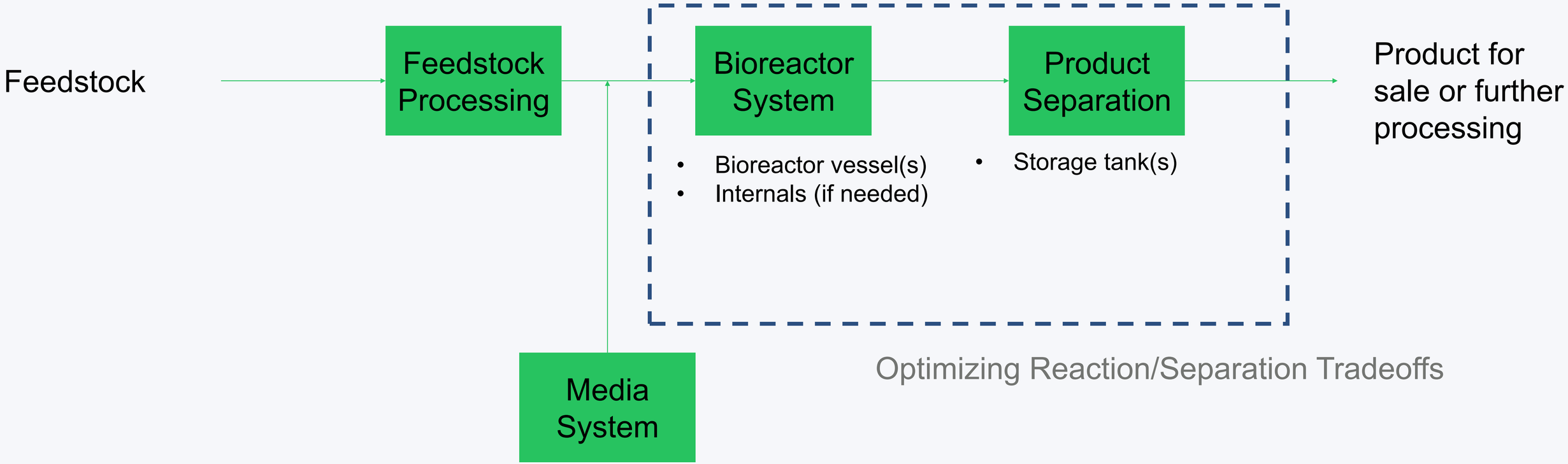
Using Operational Knowledge to Drive Process Design

- Heuristics and design rules dominate process design of refining and petrochemical processes:
  - Coking Rates
  - Space velocity rules to set reactor volume
  - Tray efficiencies for distillation and absorber columns
  - Heat exchanger fouling factors and approach temperatures
- Used in process design to support/replace rigorous experimentation and scale-up

Encapsulating operational knowledge to enable rapid scale-up
We can do the same with sustainable technology!

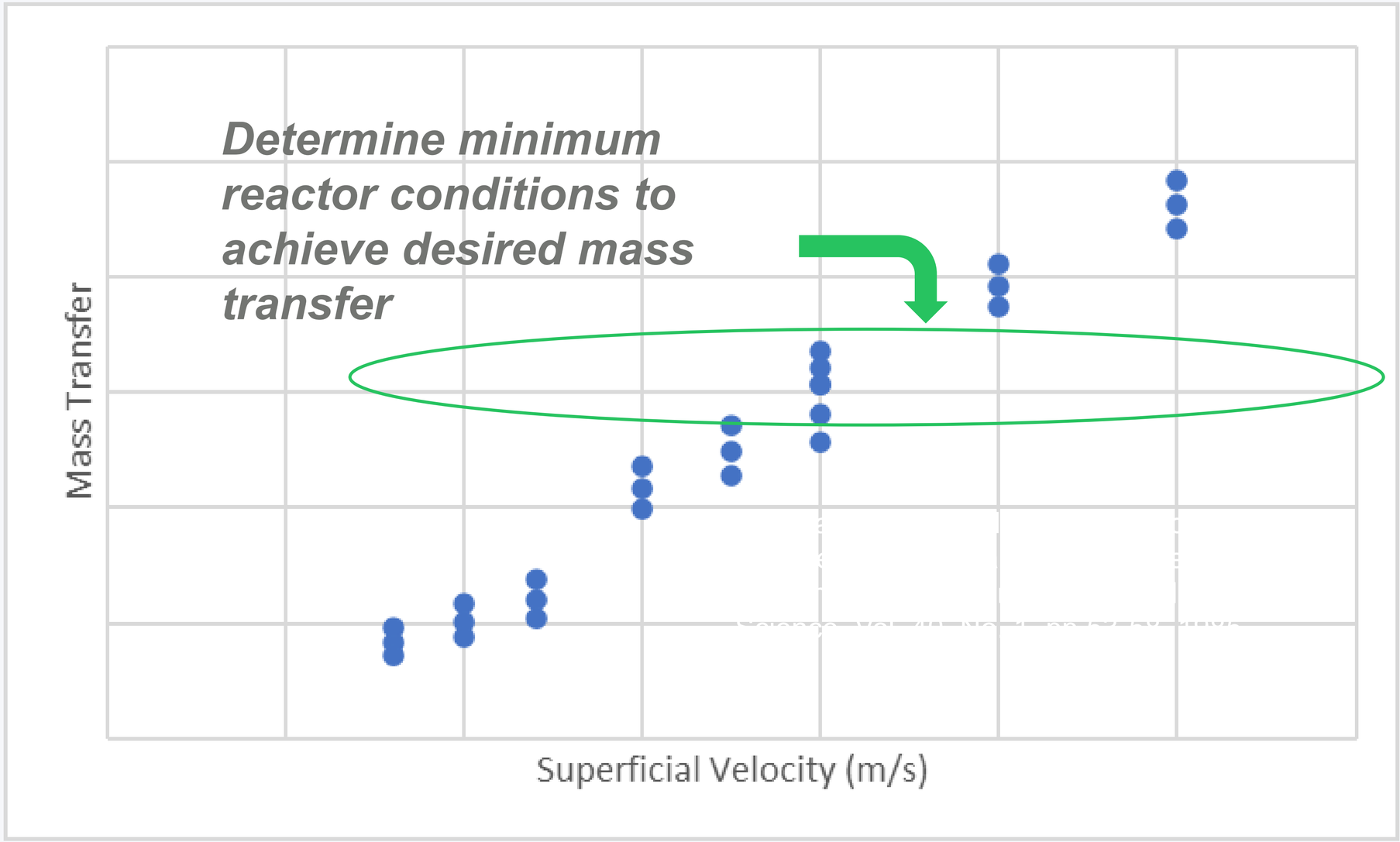
Drawn from Experience with Refining Technology Development

- Determine system requirements
- Size bioreactor
- Size supporting equipment (pumps, heat exchangers)
- Integrate separation system
- Develop cost model
- Evaluate tradeoffs and set targets for further data generation



Optimizing Reaction/Separation Tradeoffs

- Draw on mass balance to determine the desired productivity
- Evaluate reaction kinetics: Is the system kinetic or mass transfer limited?



Standard equipment in novel bioprocesses

….we can draw on what is known, and adapt to a unique technology

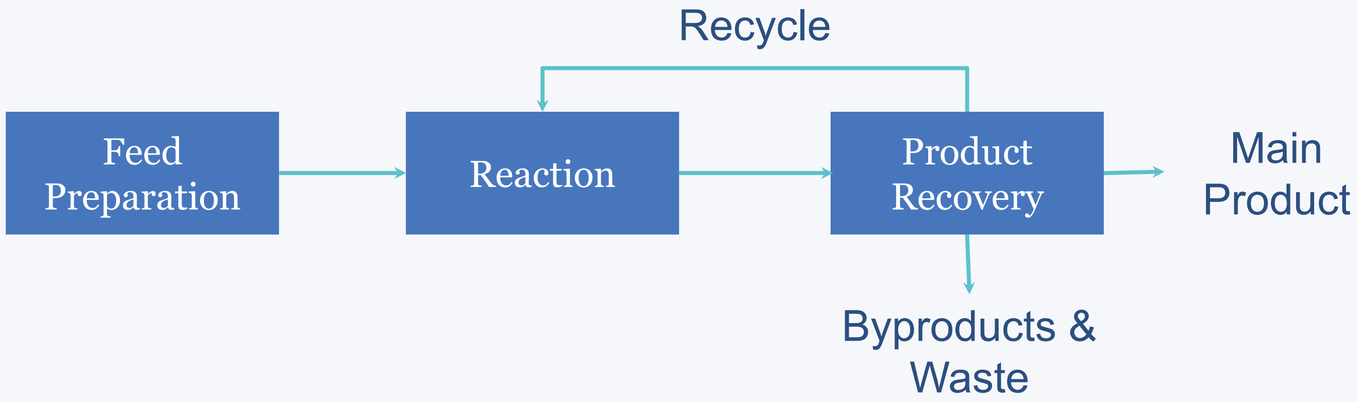
Agitator Selection

Fluid properties and mixing requirements guide selection of the agitator type

Heat Exchanger Selection & Design

Approach temperature, fouling factors guide selection of exchanger type, and set the basis for the design

> Heuristics provide guidance to the ‘easy’ problems…focus more resources on the difficult problems



Feed Preparation

- Remove Impurities
- Increase Concentration
- Separate Fractions

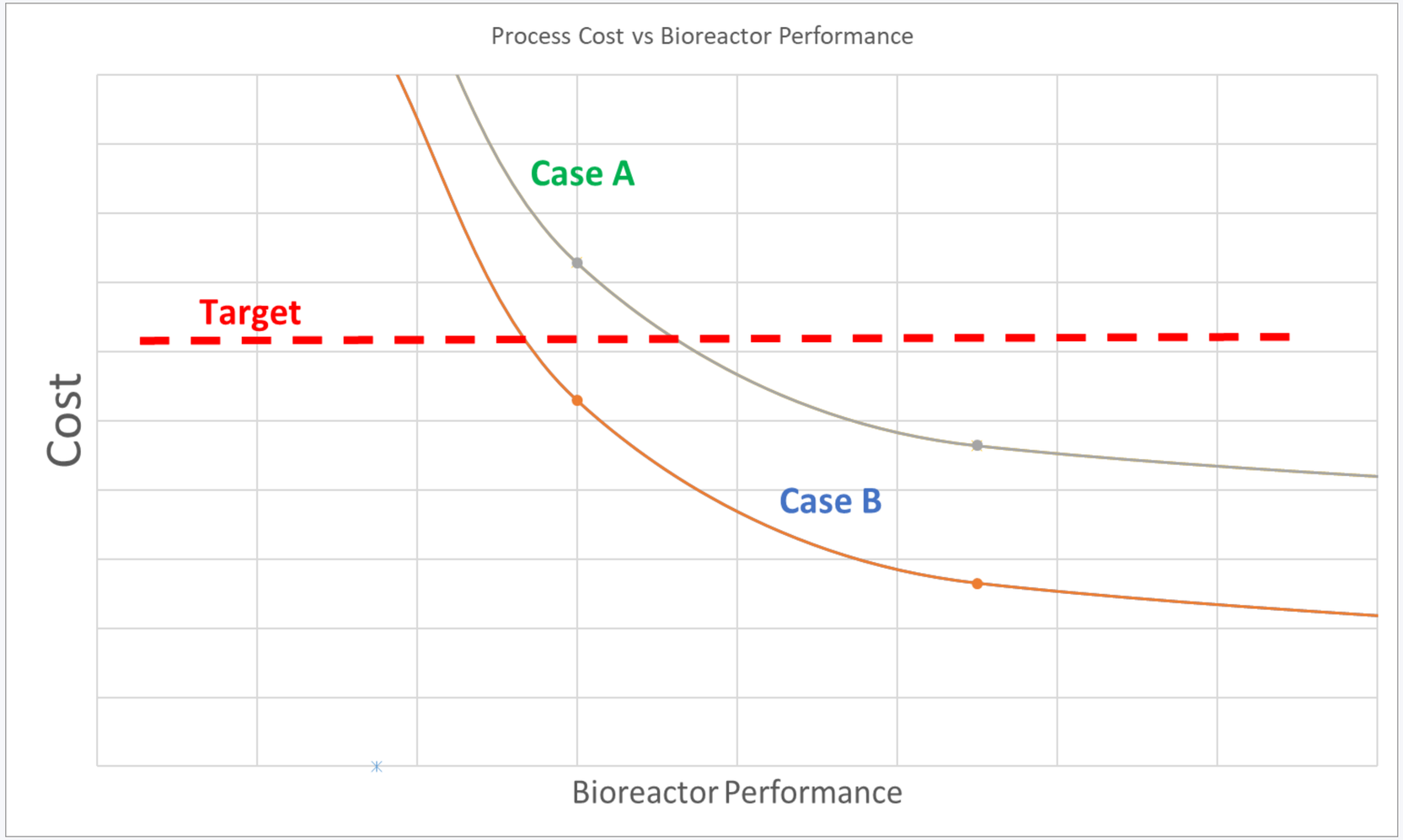
Reaction

- Microbe Recovery
- In-Situ Metabolite Recovery

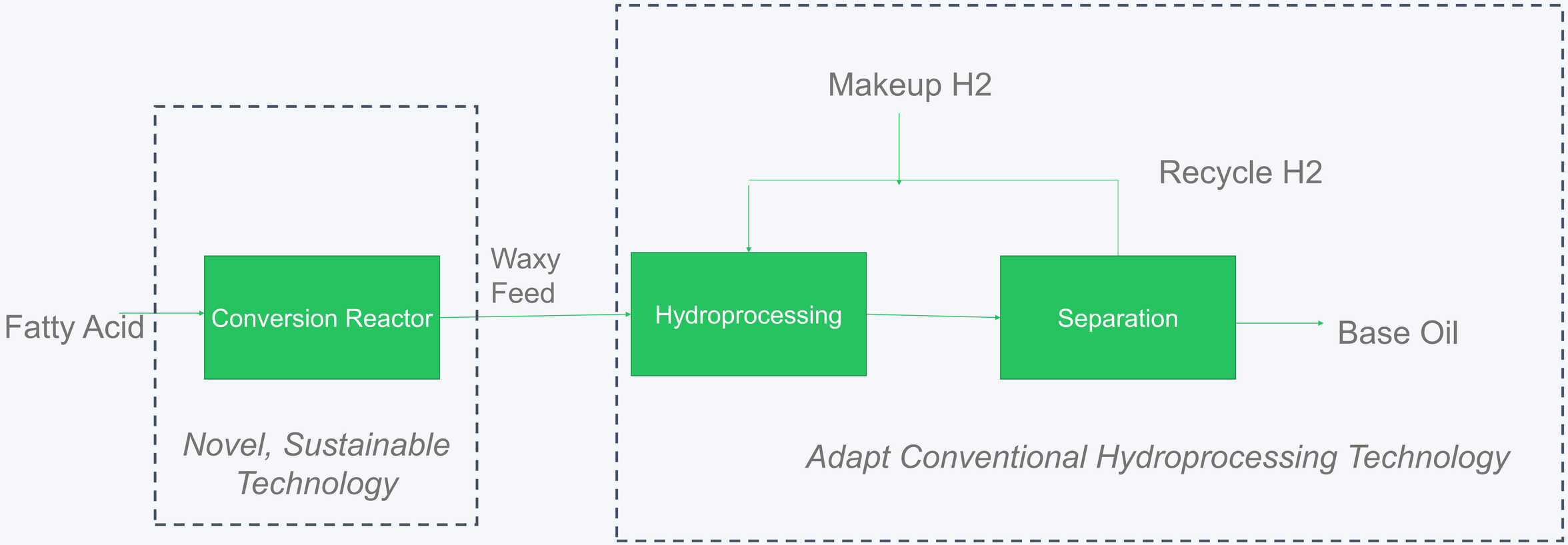
Product Recovery

- Product Purity
- Byproduct/Waste Recovery
- Reactant Recycle

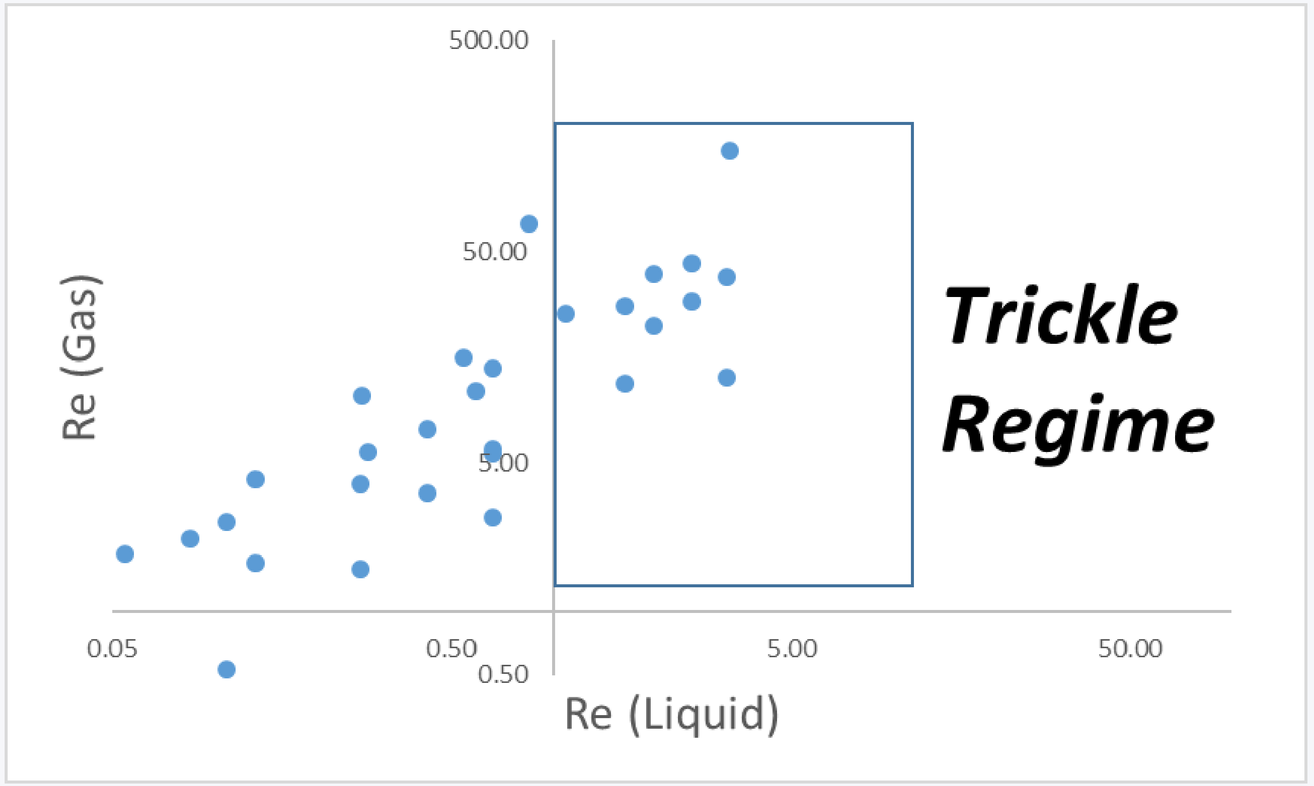
Evaluate Reaction/Separation Tradeoffs



Optimize design conditions and set targets for future data generation



Standard Re correlations and reactor design rules of thumb



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Let’s draw on this past to innovate to a sustainable future

‘Take the mystery out’

- Design Guidelines
- Operational Experience
- Correlations and Models

We are passionate about new technology in this space and will work with you to create the most value from your great ideas

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