Chemical Engineering in the next Decade: PSE perspective

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Trends over past 20 years

Expansion of ChE discipline

- Bio- and biomedical engineering
  - Themes: biomaterials & tissue engineering, drug delivery, metabolic engineering, systems biology
  - Department renaming: Chemical & Biomolecular; Chemical and Biological, Chemical & Biochemical
- Nanotechnology
  - Themes: Nanoparticle synthesis, namomaterials, membranes,nanoscale sensors & diagnostics
  - Emphasis on material science & Edisonian synthesis approaches

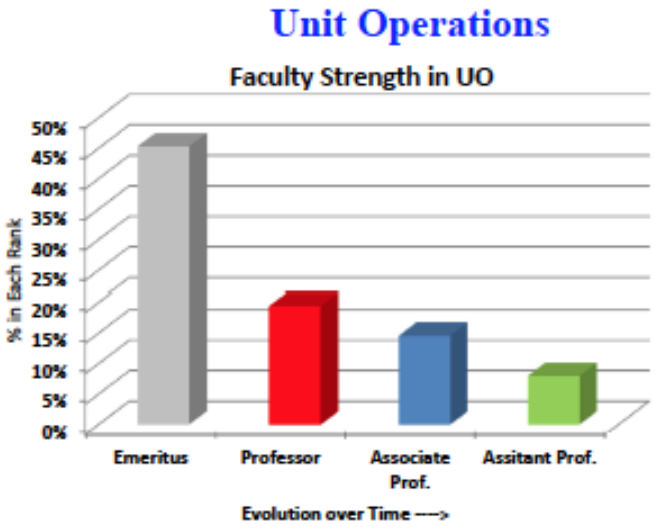
Consequences

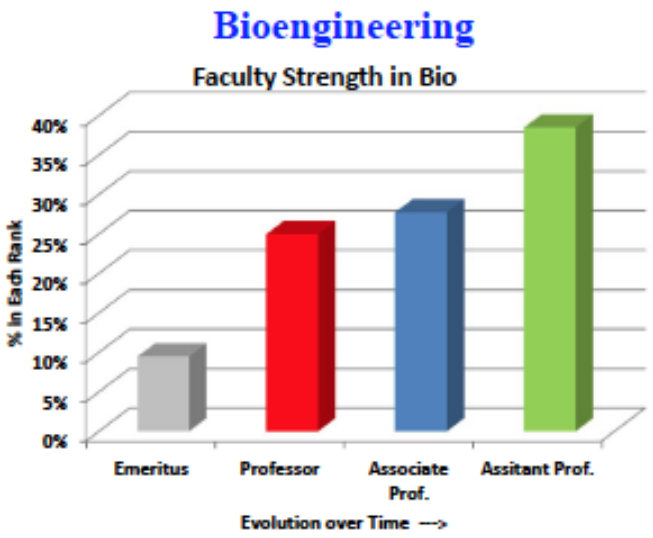
Academic Shift from Engineering to Science

Impact Factor
~2.8

Impact Factor
~30

Shift in ChE Department Faculty Expertise





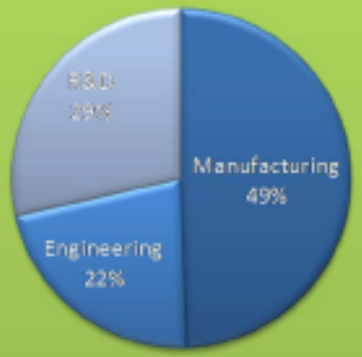
John Chen
AICHE 2013

Industrial Survey on Importance of Skills

13AIChE
Annual Meeting, San Francisco, CA

John Chen (2013)

Skill	Average Relative Importance 1-5
UO: unit operations, transport phenomena, thermodynamics, separation processes *	4.6
RE: reaction engineering, catalysis, kinetics.	4.0
AM: analysis, modeling, simulation, process control *	4.0
MAT: materials, surface science, polymers *	3.2
BIO: biotechnology, medical and life sciences	2.1
NANO: nanotechnology and its applications	1.8



93 respondents (ChemE recruiters and leaders)

* *main perceived gaps between importance and proficiency by new hires*

Chemical & Process Industry Concerns

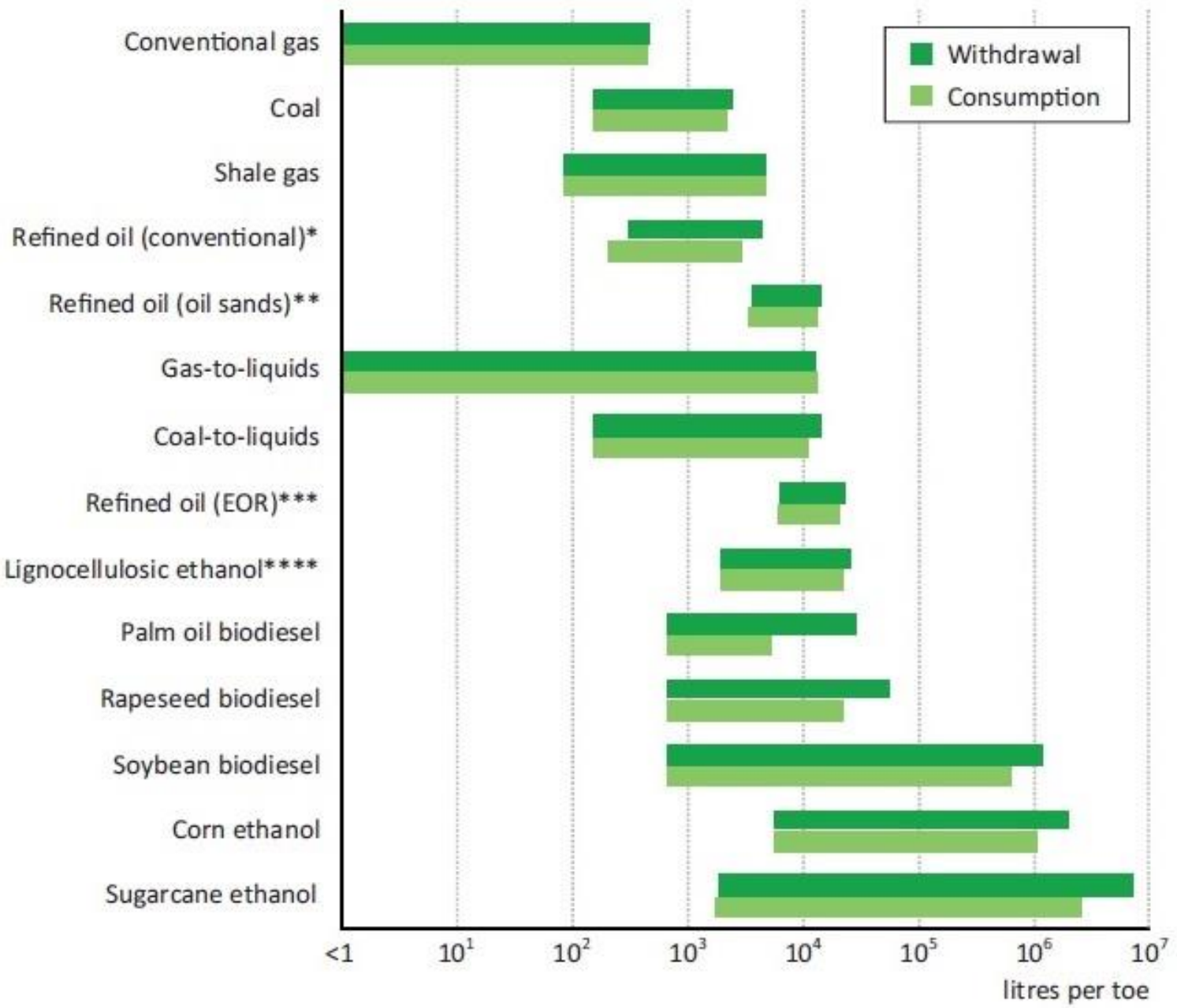
- Fewer Faculty with Process Engineering expertise & experience
- Declining availability of engineers trained in CPI relevant technologies
  - Reaction engineering
  - Unit operations
  - Process design & engineering
  - Process control
  - Data analytics
  - Polymer processing

Chemical Engineering Academia-Industry Alignment, AICHE-NSF, Nov 2015

Current Societal Concerns

- Energy & Sustainability
  - CO_2 accumulation in atmosphere & oceans
  - Renewable biomaterials for fuels & chemicals
  - Exploitation of solar, wind and hydro power sources
  - Replacement of coal & oil with gas, esp. shale gas
- Energy-Food-Water nexus
  - Water management & reuse in communities
  - Balancing of water uses between homes, farms & industry
  - Balancing of water use with preserving natural ecosystems
  - Integration of energy & water subsystems

Water Use for Primary Energy Production (IEA, 2012)



Process Systems Engineering Contributions

Energy Related Systems Analysis

- Biorefinery synthesis & design
- Integration of renewable electric sources & innovative energy storage systems into conventional power grids
- Systems for CO_2 capture, conversion, sequestration
- Rational development & operation of shale gas supply chains
- Process & reaction path synthesis to exploit new availability of cheap C_2 - C_4 feedstocks

Process Systems Engineering Contributions

Robust tools & methods for improving efficiency in Manufacturing

- Process Integration/ innovative operations
- Smart Manufacturing – real time measurements, models & decision tools
- Conversion from batch to continuous processing, esp. pharmaceutical industry
- Resource integration in manufacturing complexes
- Integration of manufacturing & supply chain subsystems
- Enterprise-wide optimization

Prediction

- Renewed emphasis on process design, operations and engineering in academia & more process innovation in industry
  - Understanding at molecular & fundamental levels
  - Greater emphasis on mechanistic predictive models
- Innovations in software tools to support these & related functions
  - Limited new developments to support manufacturing functions
  - Entrepreneurship opportunities (aps?)