R & D for Hydrogen Technology Implementation

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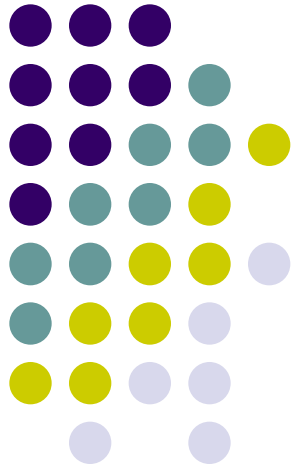


Carnegie Mellon's role for a Pittsburgh hydrogen fueling station

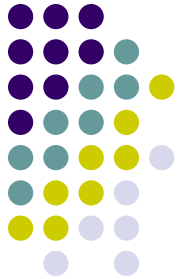
- Carnegie Mellon has a long history of advancing the deployment of alternative energy. From actions such as initiating what was, at its time, the largest purchase of wind power in U.S. history, the University has integrated its research and education mission with a focus on contributing to the development of energy technology.
- Carnegie Mellon is pleased to accept a lead role in exploring the development of a Pittsburgh hydrogen fueling station, building upon the successful opening of the Charleston facility and the progress being made in Morgantown. Capitalizing on the successful roadmap established by these efforts, the University is committed to convening the industry, educational, state and local and NETL and other federal partners needed to identify the location, utilization and research issues associated with creating the Pittsburgh leg of the emerging hydrogen highway.
- In addition to advancing Carnegie Mellon's energy research and educational efforts and contributing to progress in energy diversification, the University also recognizes that the hydrogen highway highlights the vital role that the presence of NETL has for advancing this region as the nation's incubator for energy solutions.

Timothy McNulty
Associate Vice President for Government Relations
Carnegie Mellon University

Carnegie Mellon University

- Leader in energy research
- Expertise in basic sciences, engineering, public policy and economics
- NETL partner
  - Institute for Advanced Energy Solutions
- Portfolio
  - Hydrogen and others
- Funded by NETL, other DOE, NSF, others

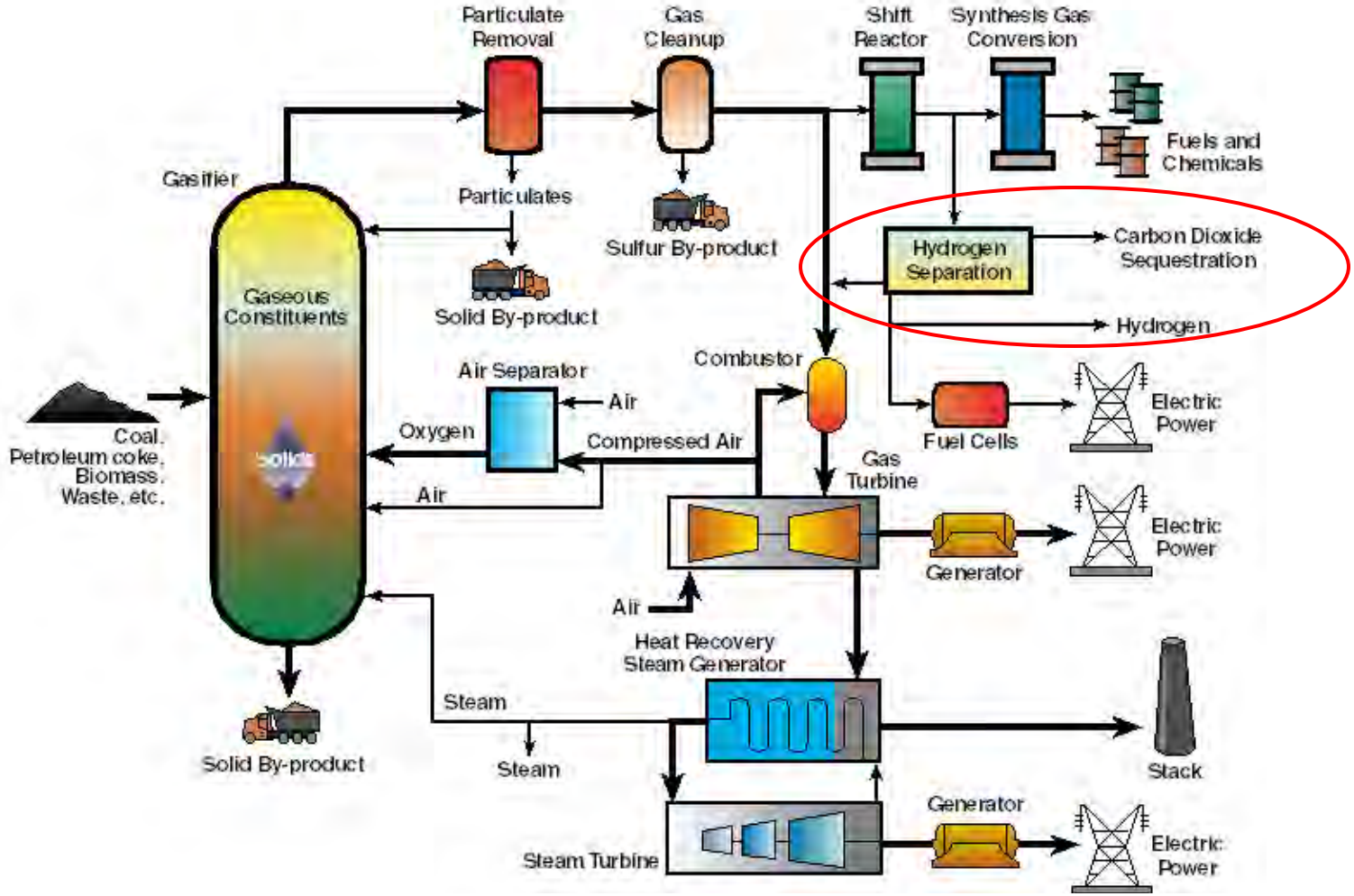
Issues in Hydrogen technology development



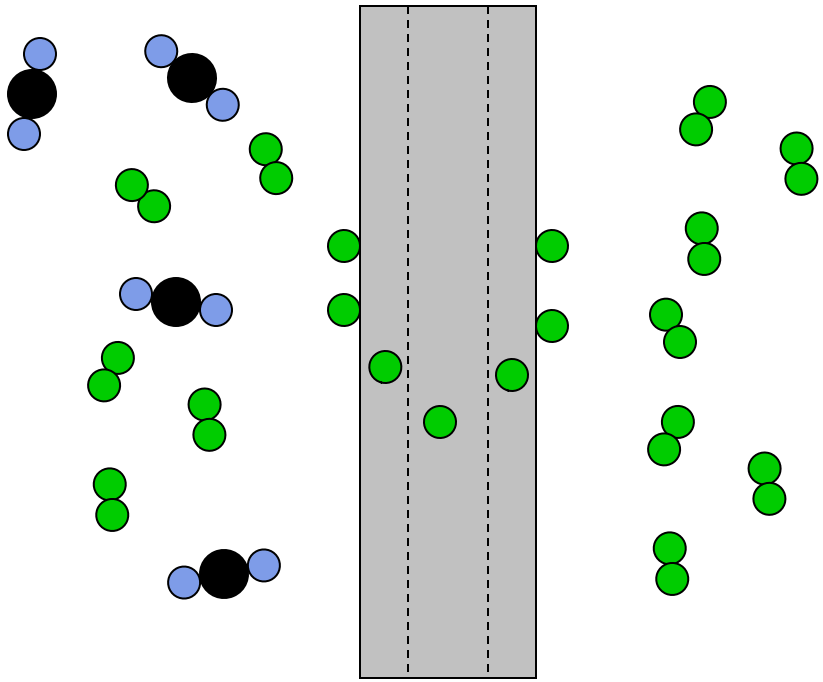
- Generation
  - Electrolysis
  - Hydrocarbon reforming
  - Gasification
  - CO2
- Storage/transport
  - Hydrides
  - CNTs
  - Pressure vessels
  - Pipelines
- Deployment
  - Fuel cells
  - Filling stations
  - Cars/devices

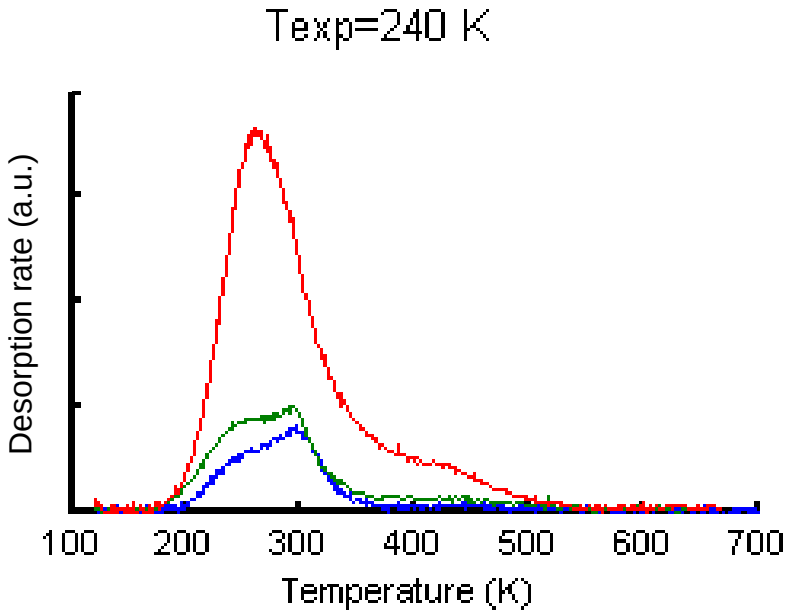
- Fundamental science
  - What are the atoms doing?
- Component level
  - How do we make and evaluate a device—a catalyst or an electrode?
- Systems level
  - Support components
  - Scalability
  - Economic viability
- Verification (tech specs) and Validation (user needs)

Hydrogen separation in a gasification flowsheet



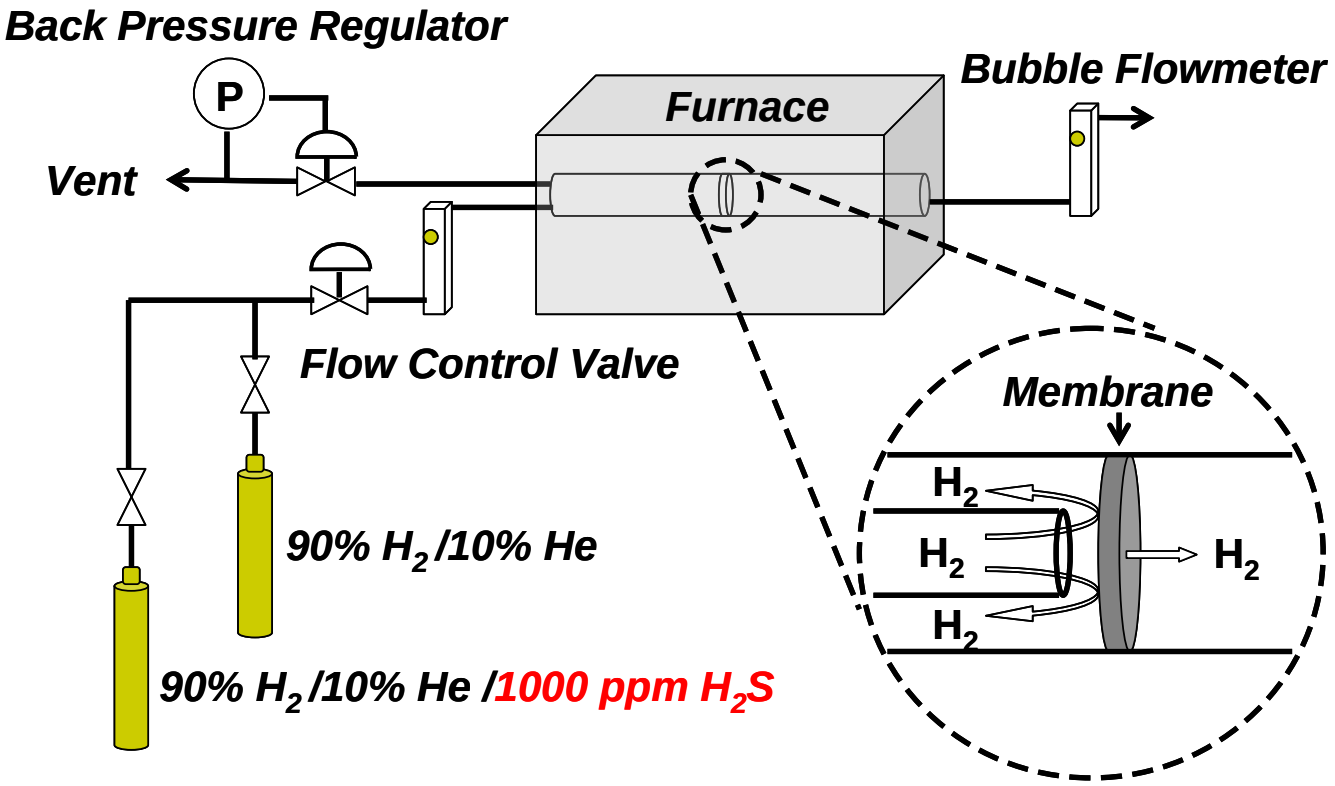
Atomic view of hydrogen separation with Pd membranes



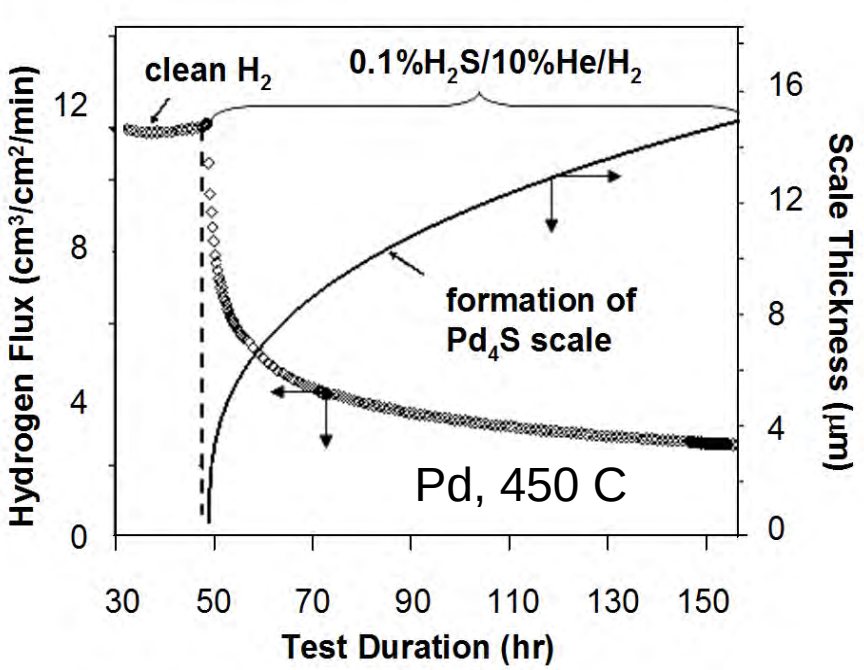


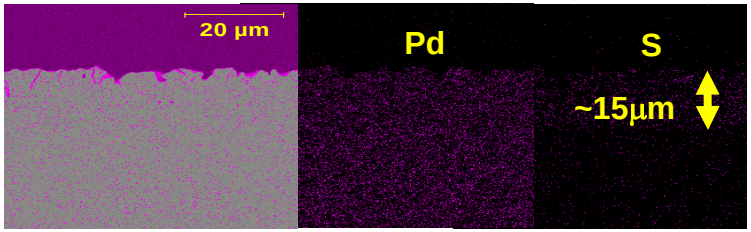
- Expose Pd(100) to H_2, then heat to desorb
- Acquire fundamental info about transport steps

Hydrogen separation membrane: “device characterization”



Hydrogen separation membrane: “device characterization”



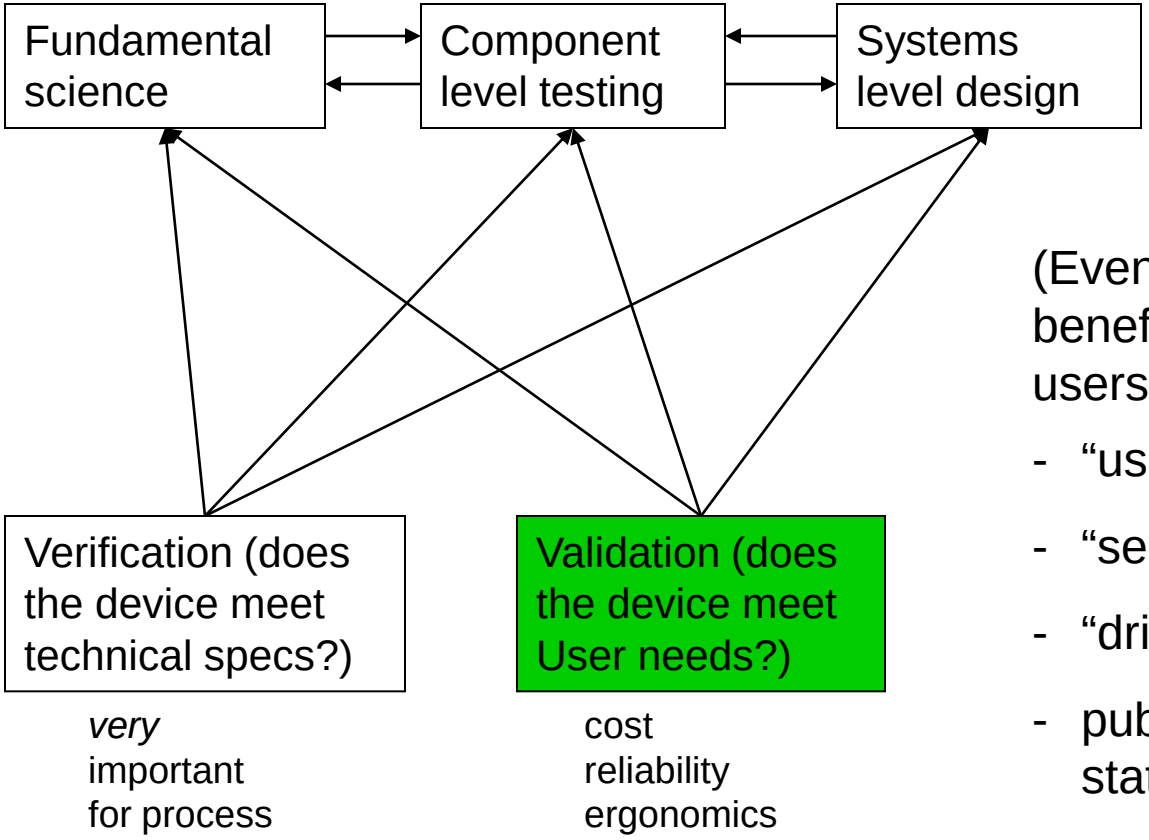


Pd_4S

EDS/XRD

- Exposure to H2S causes performance to deteriorate as scale layer forms
- Strategy:
  - Understand mechanisms
  - Functionalize surface to control/eliminate

Verification and Validation



(Even early) prototypes benefit from being in users hands

- “use it like it’s yours”
- “seamless”
- “drivers like the quiet”
- public response to filling station
- “open architecture” for continuous experiment and improvement