Exciting ITFC-Hybrid Systems

- Multipurpose system to
  1) turn fuels to electricity,
  2) Reverse mode: convert CO2 to fuel on off-hours
  3) chemical conversion to upgrade chemicals to higher value.
  APUs for both power, and NOx reduction.

- Consolidation of subsystems, such as power electronics to manage both cell and pack voltage. Perhaps there is opportunity to be flexible. Use the same package to manage fuel cells, battery storage and energy sources, such as solar PV.
- Produce some sort of chemical looping to cycle metal-metal oxide at intermediate temperatures for energy storage.
- New developments in hydrides both produce hydrogen, and are very exothermic. Many are out of the range of ITFCs, so coupling the materials with the cell would be useful. Such as intermediate proton conductor with a metal air battery.
- Problem in metal air battery, there is a large change in entropy.
- One advantage of ITFCs is that you can have nanophase catalysts.
- At 1.3V vs. SHE, NOx and water converts to nitric acid. Perhaps useful industrially.
- Intermediate temperatures, you can run systems more effectively, cheaply, with less corrosion.
- Could fuel cells offer flexibility that batteries and generators can't do? Could a fuel cell + PV or hydrogen provide advantage? Make fuel from the water, CO2 and H2 produced or near fuel cells be used to also make fuel?

Value and Drawbacks of Hybrid ITFCs

VALUE

- With lower temperatures stability increases, especially microstructure.
  - Microstructure innovations that cannot survive SOFCs become useful
- Chemical looping with ITFCs to make fuels/store energy invaluable, increase their flexibility. Area is unresearched. Difficult to quantify metrics.
- Major advantage in heat-up and cool-down energy losses. Combine with thermal or energy storage in a battery?
- ITFCs enable Increased simplicity of the fuel cell due to reforming in the cell.
  - Seals and steel interconnects get much cheaper. Chromium poisoning problem could disappear.
- Lower temps bring opportunity of new materials, such as
  - Bismuth chemistry to replace Zirconium?
  - Lanthanum – Gallium systems become more useful
  - Replacements for Nickel YSZ materials with fewer problems?
- Major opportunity in fuel cells BOP, especially water transport and heat rejection.
- Look at CHP systems in a totally new way. (i.e. power and cooling?)

DRAWBACKS / POSSIBLE DRAGONS

- Despite lower temperatures, the reactions need to be understood before making blanket statements about low temp advantages

Why ARPA-E Should do ITFC Hybrids

- No one is looking at ITFCs right now
- This is high risk, high benefit research
- Natural gas is “the” American fuel, and there is no program at all which focuses on efficient use of natural gas.
  - Residential CHP is being looked at elsewhere, we could fall behind like we did in batteries.
- Based on EERE data, a big drop in BOP costs, would change paradigms dramatically.
- Energy resiliency is energy security. This is the only low emission, resilient distributed generation capability possible
  - Answer for energy stability in face of man made or natural disasters

Communities that need to come together

- CHP people with refrigeration?
- Low and high temperature FC communities together?