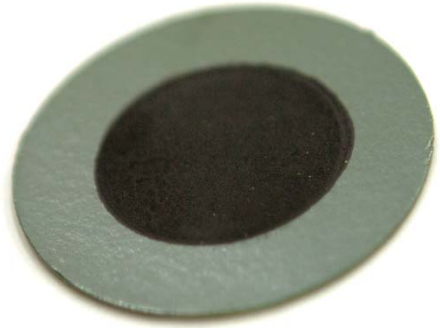
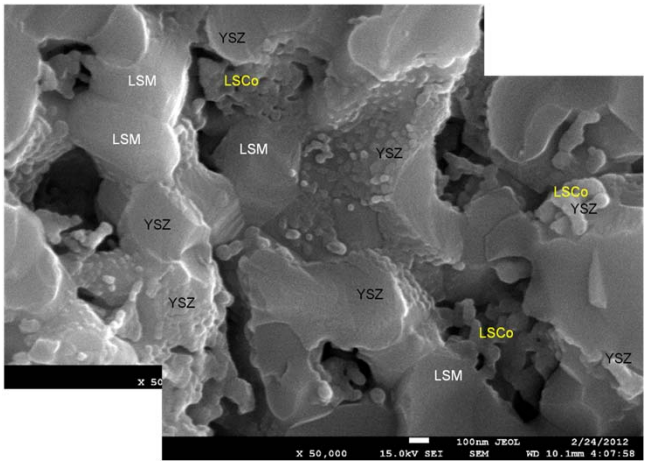
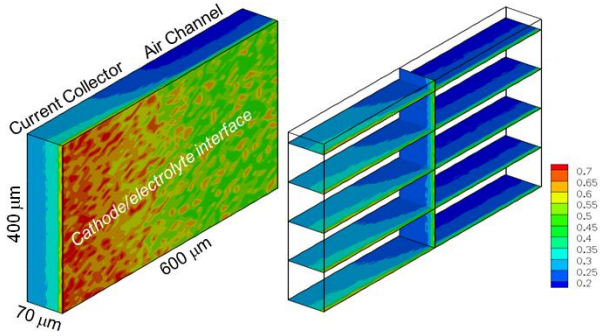
NETL-RUA
Regional University Alliance

U.S. DEPARTMENT OF ENERGY







Fuel Cell Team
2013 NETL RUA Spring Meeting

Kirk Gerdes
Technical Coordinator – Fuel Cells

NETL Carnegie Mellon PENNSTATE University of Pittsburgh VirginiaTech WestVirginiaUniversity URS

Overview

- **Introduction to Solid Oxide Fuel Cells**
- **NETL RUA Fuel Cell Team**
  - Participants
  - Global technology thrusts and team integration
  - Technology demonstration video
- **FY13 program integration**
- **Technology transfer initiatives**

Overview

- **Introduction to Solid Oxide Fuel Cells**

- **NETL RUA Fuel Cell Team**
  - Participants
  - Global technology thrusts and team integration
  - Technology demonstration video

- **FY13 program integration**

- **Technology transfer initiatives**

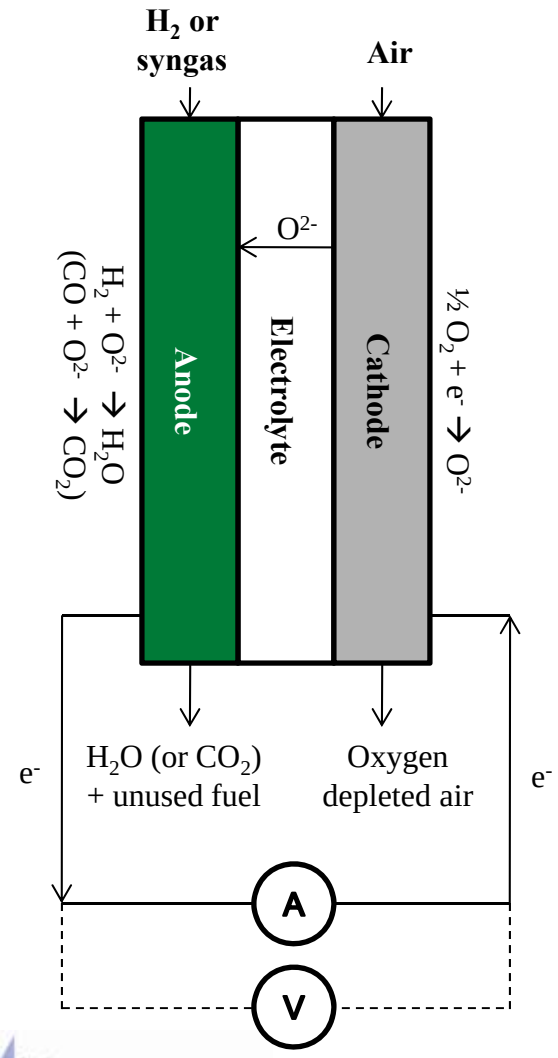
Solid Oxide Fuel Cells

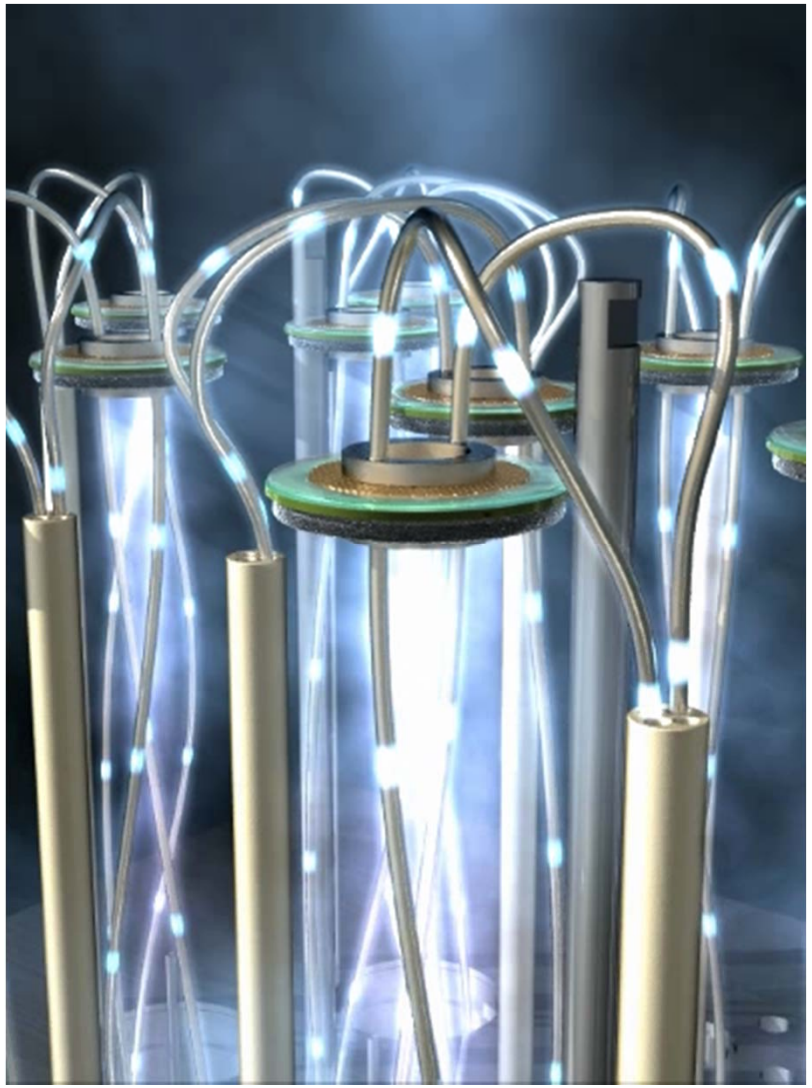
- **Direct chemical → electrical energy conversion device**
  - Fuel flexible – natural gas, hydrogen, synthesis gas, etc.
  - High efficiency at scales from 10 kW → 100 MW
  - High-quality waste heat suitable for power system integration

- **Technical barriers: Cost, Durability, and Lifetime**
  - Diminished cost → Cell cost scales ≈ 1:1 with cell efficiency
  - Enhanced lifetime / durability → Improved degradation resistance

- **NETL RUA team research: Fundamental evaluation, enhancing technology, and innovating advanced concepts**
  - Electrode engineering (electrocatalysts and microstructure)
  - Predictive models of SOFC (lifetime service and operation)
    - Evaluation and modeling of fundamental cell degradation
    - Multi-physics modeling and long-term degradation

Solid Oxide Fuel Cells





Overview

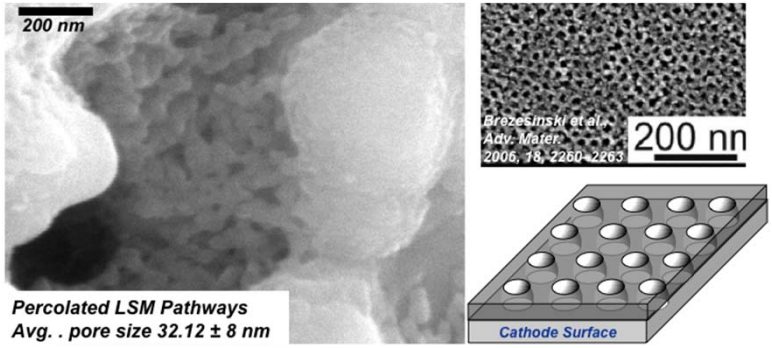
- Introduction to Solid Oxide Fuel Cells
- **NETL RUA Fuel Cell Team**
  - Participants
  - Global technology thrusts and team integration
  - Technology demonstration video
- FY13 program integration
- Technology transfer initiatives

NETL RUA - Solid Oxide Fuel Cells

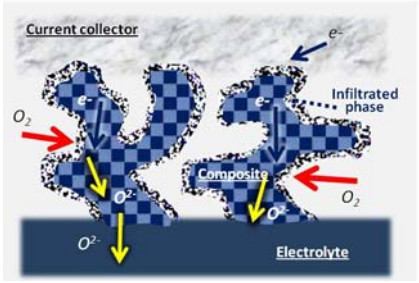
Support Industrial Development

Operation of NETL Solid Oxide Fuel Cell Multi-Cell Array on direct, coal-derived synthesis gas at the National Carbon Capture Center at Wilsonville, AL in August/Sept 2009.

Collected 4,000 + cell-hours of data to support development of gas cleanup systems sufficient for gasifier / fuel cell integration.

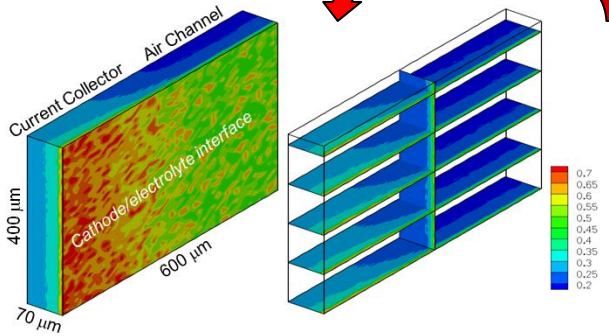


Innovate Technology



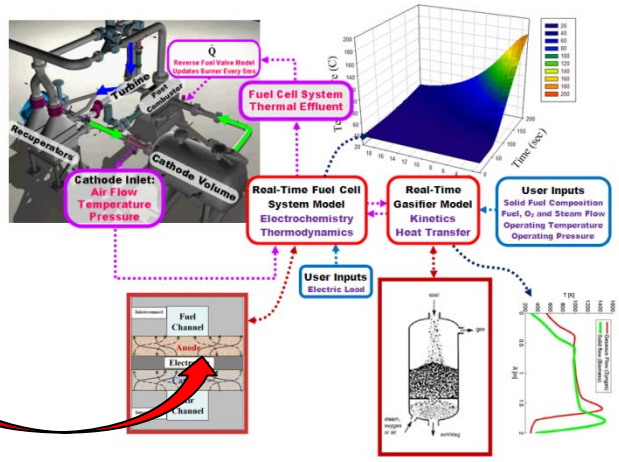
Cathode infiltration technology is being developed to enhance the SOFC operating performance. Initial results have demonstrated > 40% performance improvement and acceptable material stability.

Evaluate Advanced Concepts



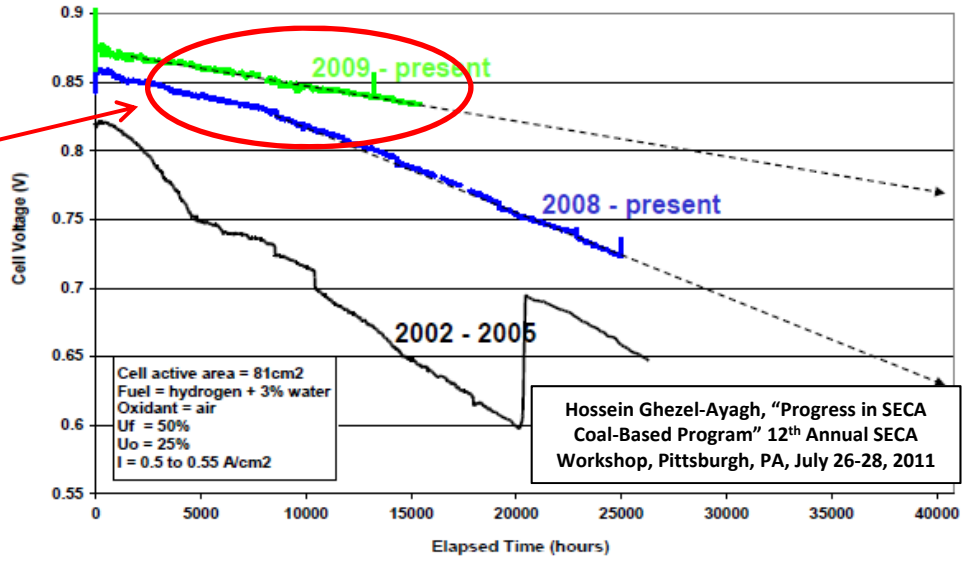
Fundamental computations (3D multi-physics model, at left) inform modeling of advanced degradation, performance, and microstructural evolution at the cell and stack level.

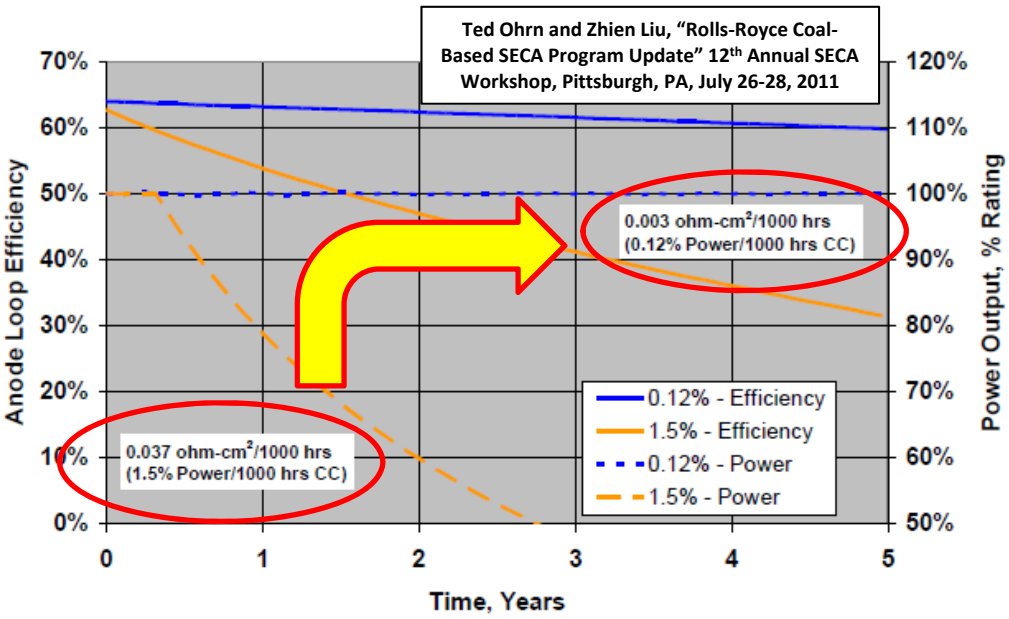
Integrated gasifier / fuel cell / turbine systems (IGFT, at right) support advanced fuel cell demonstrations efforts (2013+). NETL operates a system hardware evaluation and controls development platform.



FC Team Vision: Modeling

- **Long-term degradation**
  - Initial goal: DESCRIPTIVE
  - Identify sources of degradation
  - Recommend degradation mitigation methods
  - *Intrinsic modes* (**Core**)
    - Materials, rxn, and x-port
    - Microstructural evolution
  - *Extrinsic modes* (**Industry**)
    - Material purity
    - Stack design, mat'ls constr
    - Operating conditions
  - Assist industry teams in meeting stack degradation targets necessary for commercialization

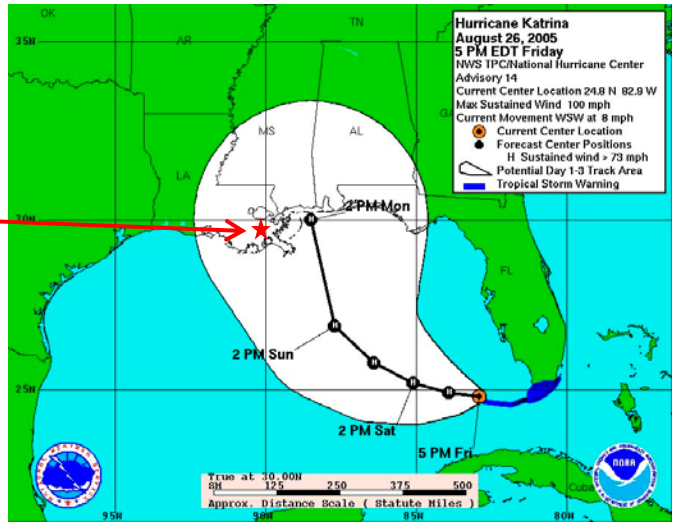




FC Team Vision: Modeling

- **Long-term degradation**
  - Stretch goal: PREDICTIVE
  - Forecasting of performance
    - Analog: Hurricane tracking
  - Supports stack operator at strategic operating decisions points

Eventual landfall near New Orleans, LA

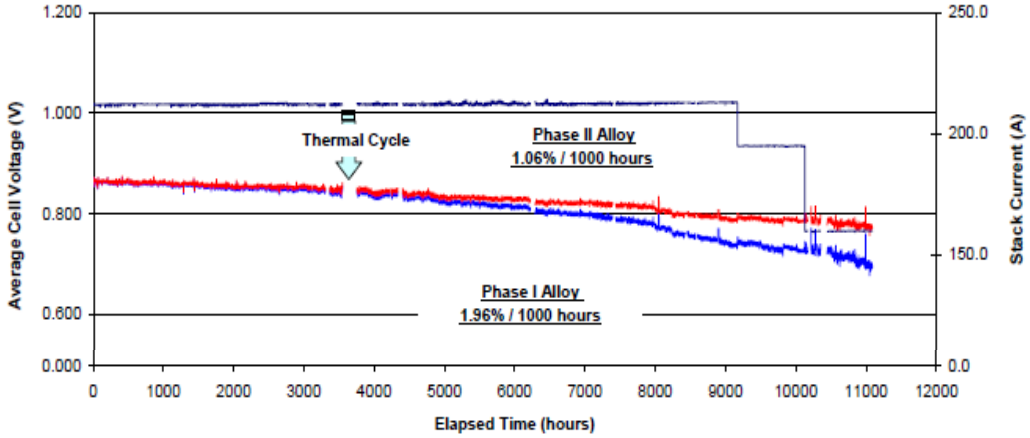


http://www.katrina.noaa.gov/forecast

- **Answer critical operating questions:**

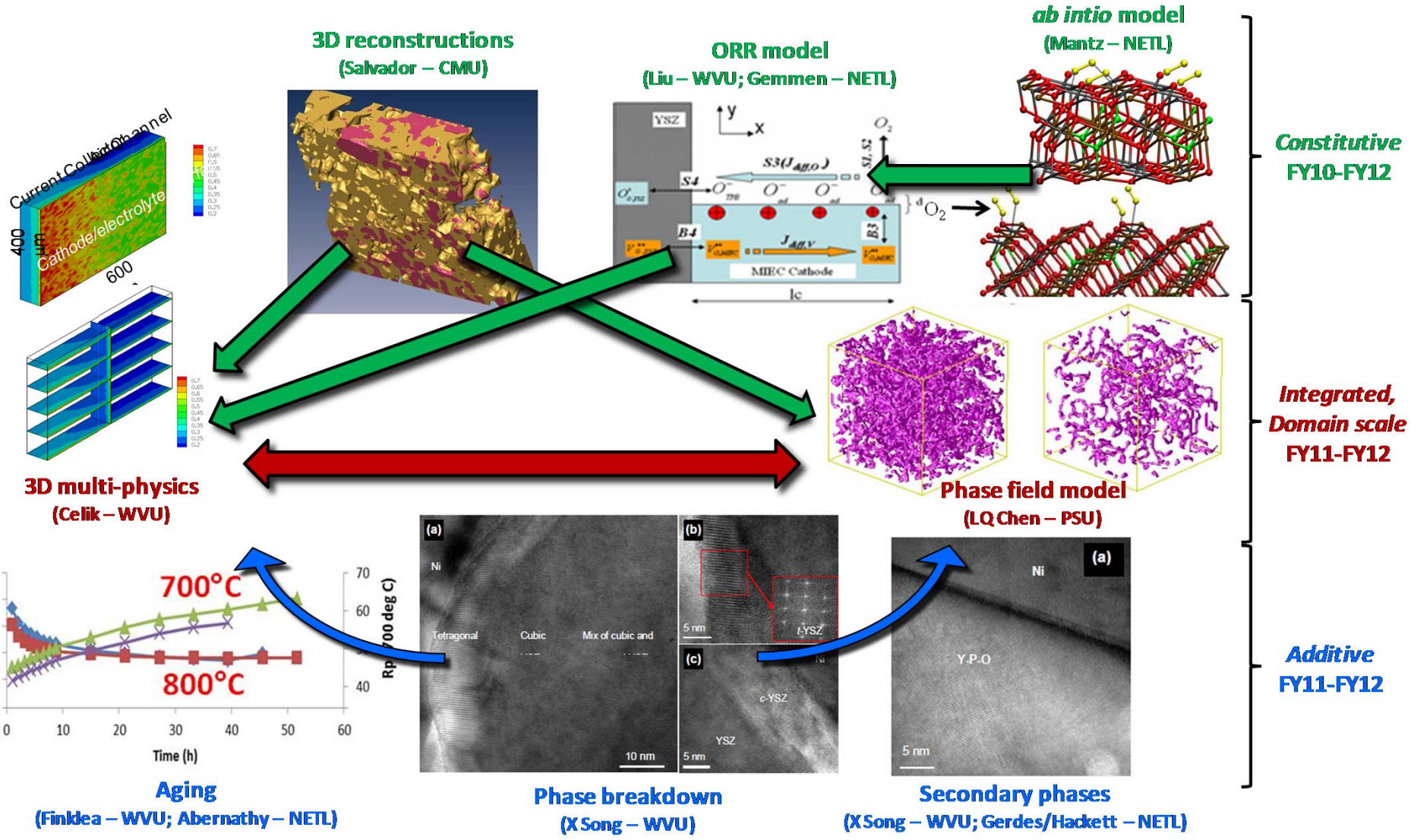
What will stack performance be in 2 to 4 khrs (3 to 6 months)?

When shall corrective action be taken to repair/replace a stack?



Hossein Ghezel-Ayagh, "Progress in SECA Coal-Based Program" 12th Annual SECA Workshop, Pittsburgh, PA, July 26-28, 2011

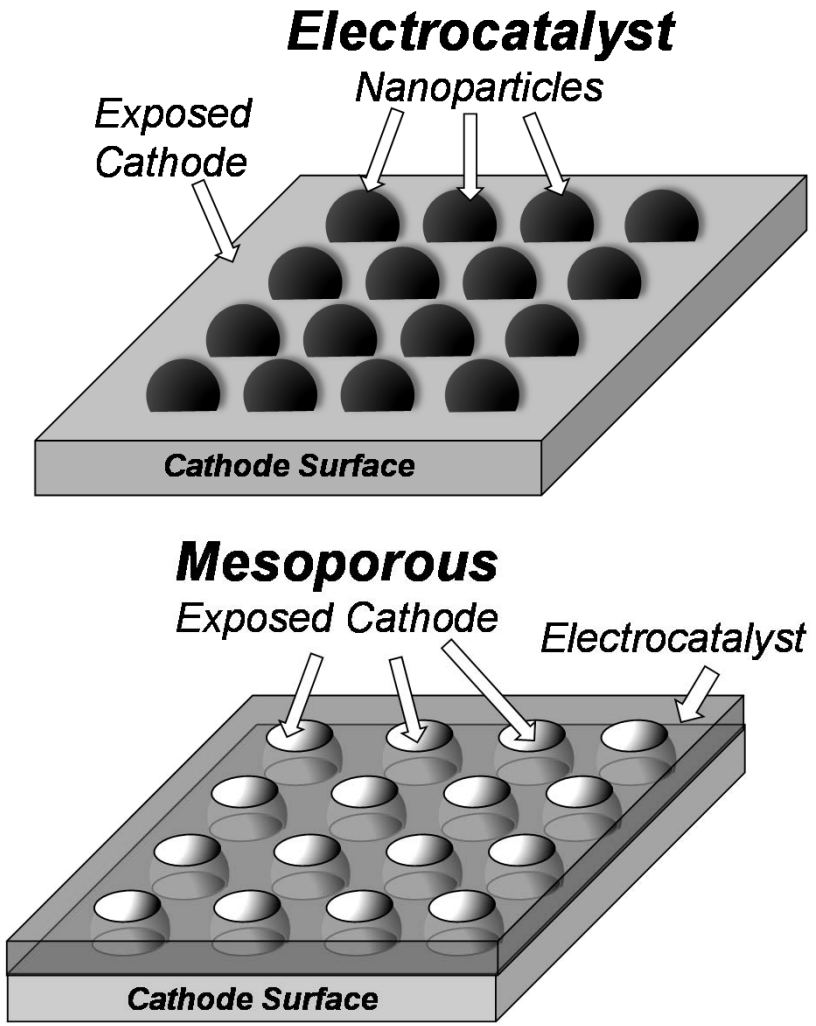
FC Team Integration: Modeling



NETL-RUA

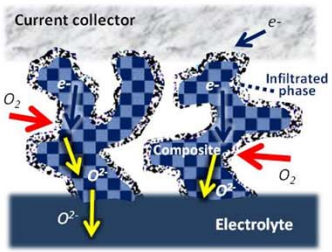
FC Team Vision: Electrode Engineering

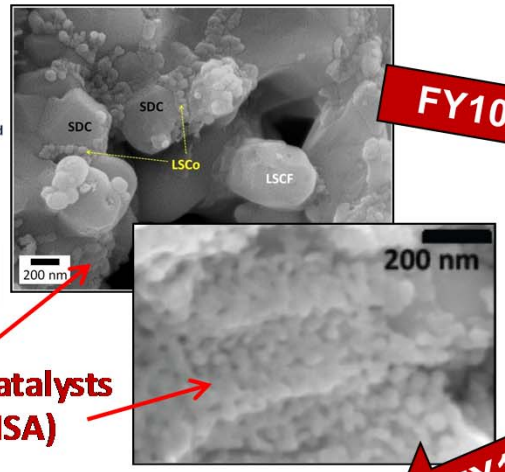
- **Innovate advanced cathode structures and materials**
- **Critical development criteria**
  - Actual performance increase
  - Low cost
  - Compatible materials
  - No impact to cell durability
- **Cathode infiltration**
  - Addition of high surface area and electrocatalytically active materials cell structures



FC Team Integration: Electrode Engineering

Infiltration concept



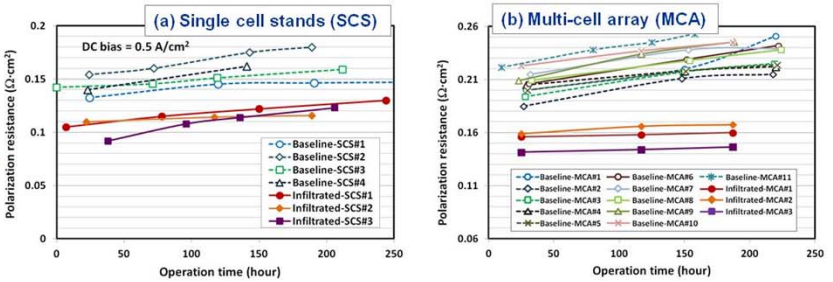


Cathode infiltrates

- **Nano-scale electrocatalysts**
- **High-surface area (EISA)**

FY10

➢ Polarization resistance vs. time of baseline cells and infiltrated cells



(a) Average Rp after 24 h operation (SCS)
Baseline cells: 0.14 ± 0.009 Ωcm²
Infiltrated cells: 0.10 ± 0.012 Ωcm²

(b) Average Rp after 24 h opeation (MCA)
Baseline cell = 0.21 ± 0.014 Ωcm²
Infiltrated cell = 0.15 ± 0.010 Ωcm²

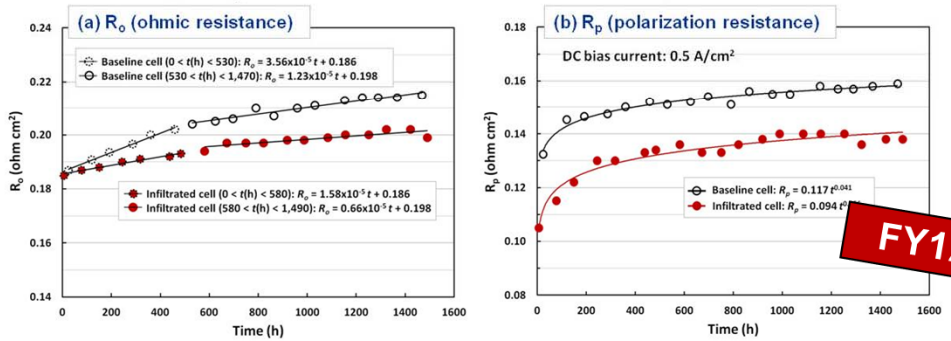
Short-term performance validation

Demonstrated <u>statistically significant</u> performance improvement for infiltrated cathodes in <u>200 hour tests</u>
> 30% peak power density increase (average) observed

FY11

Long-term stability verification

➢ Variation of R_o and R_p of selected baseline cell and infiltrated cell for 1,500 h

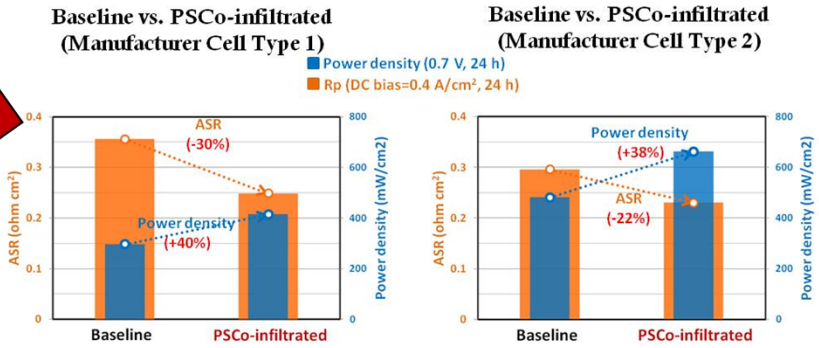


Verified stability of electrochemical performance in <u>1500 hour test</u>, cell *degradation not accelerated* above baseline

FY12

Industry Engagement

Unaltered industry cells + unmodified infiltrate: <u>200 hour tests</u> > 38% power density increase @ 0.7 V (average)



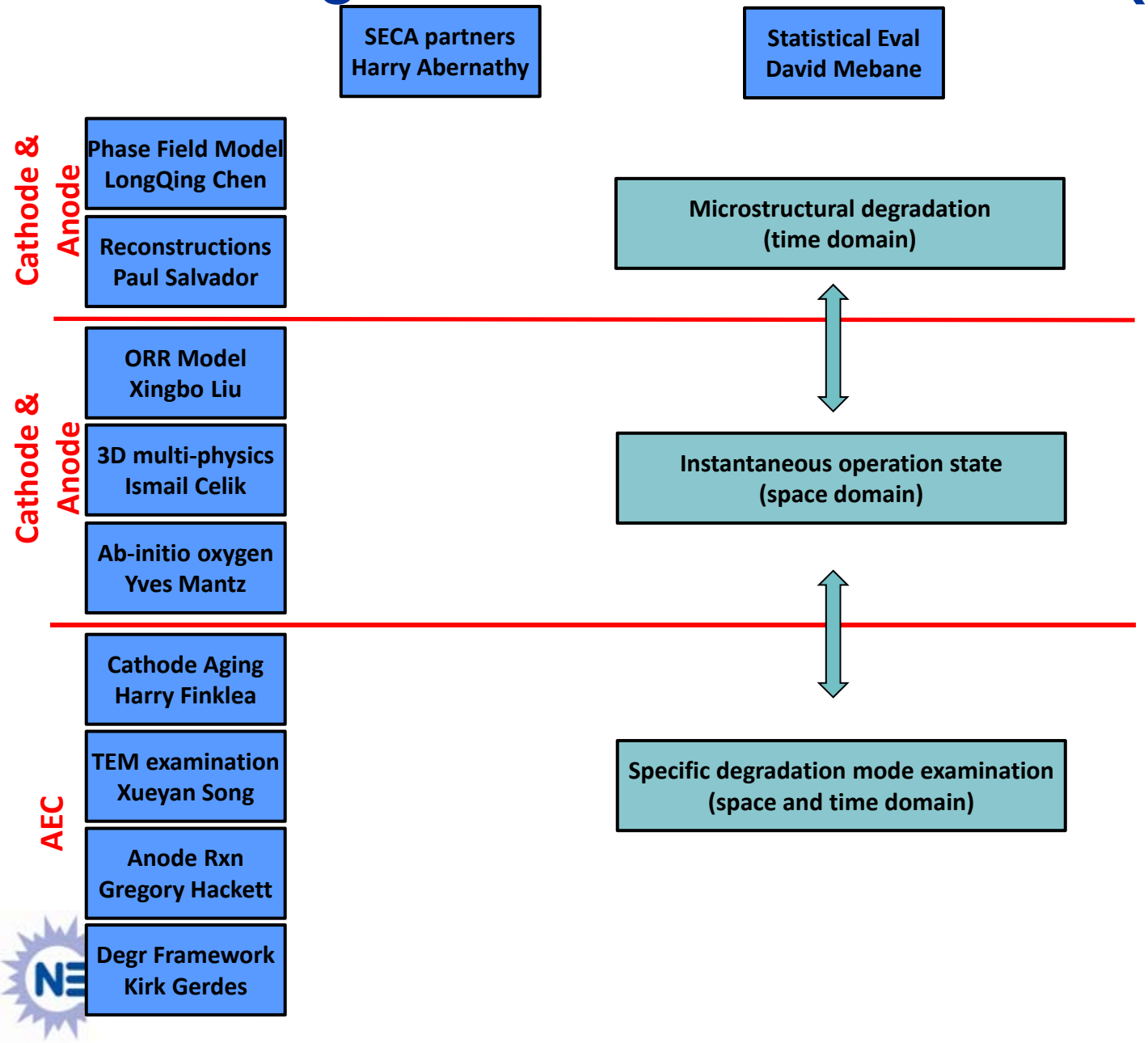
NETL-RUA

FC Team: Research Portfolio

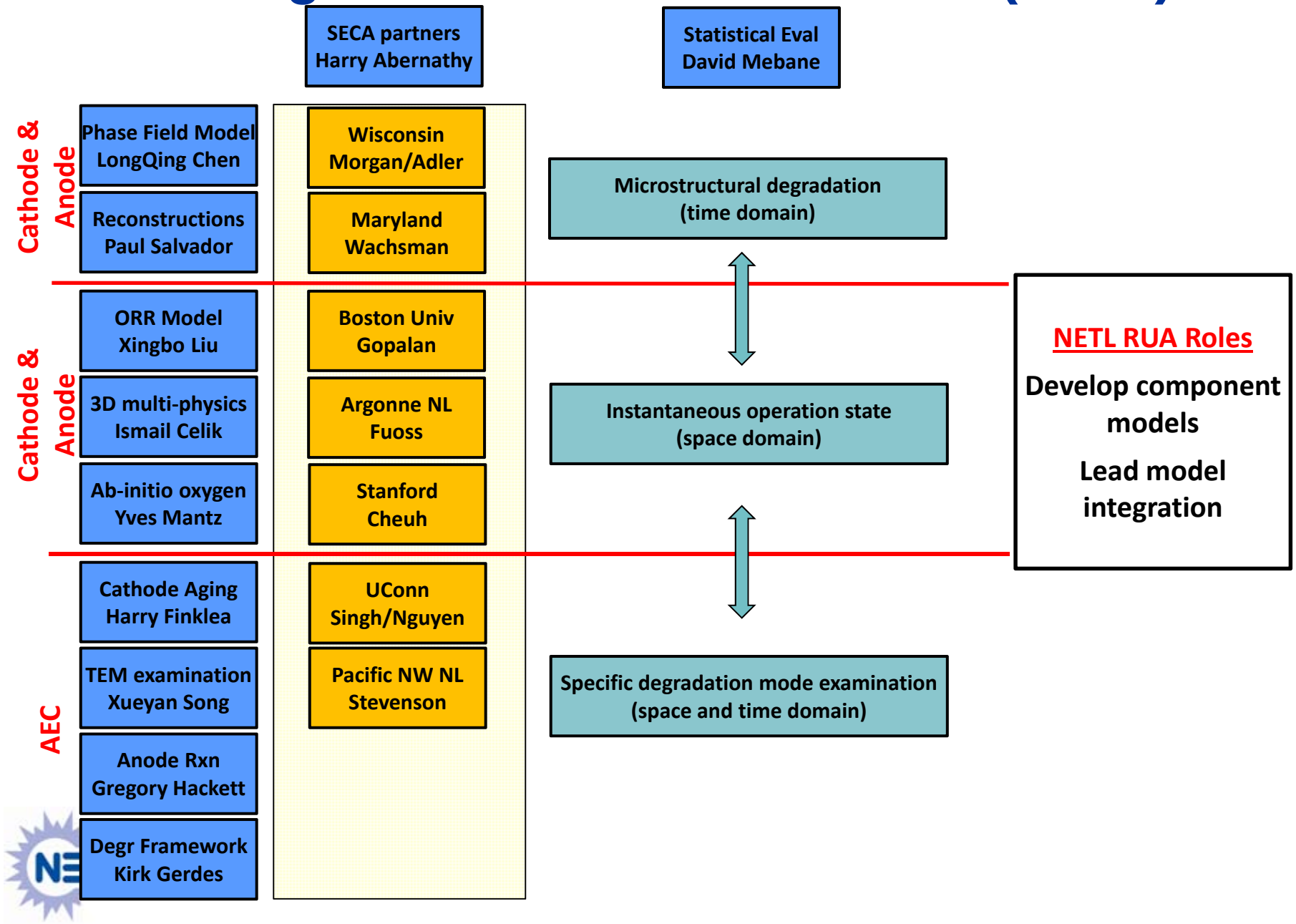
Overview

- Introduction to Solid Oxide Fuel Cells
- NETL RUA Fuel Cell Team
  - Participants
  - Global technology thrusts and team integration
  - Technology demonstration video
- **FY13 program integration**
- Technology transfer initiatives

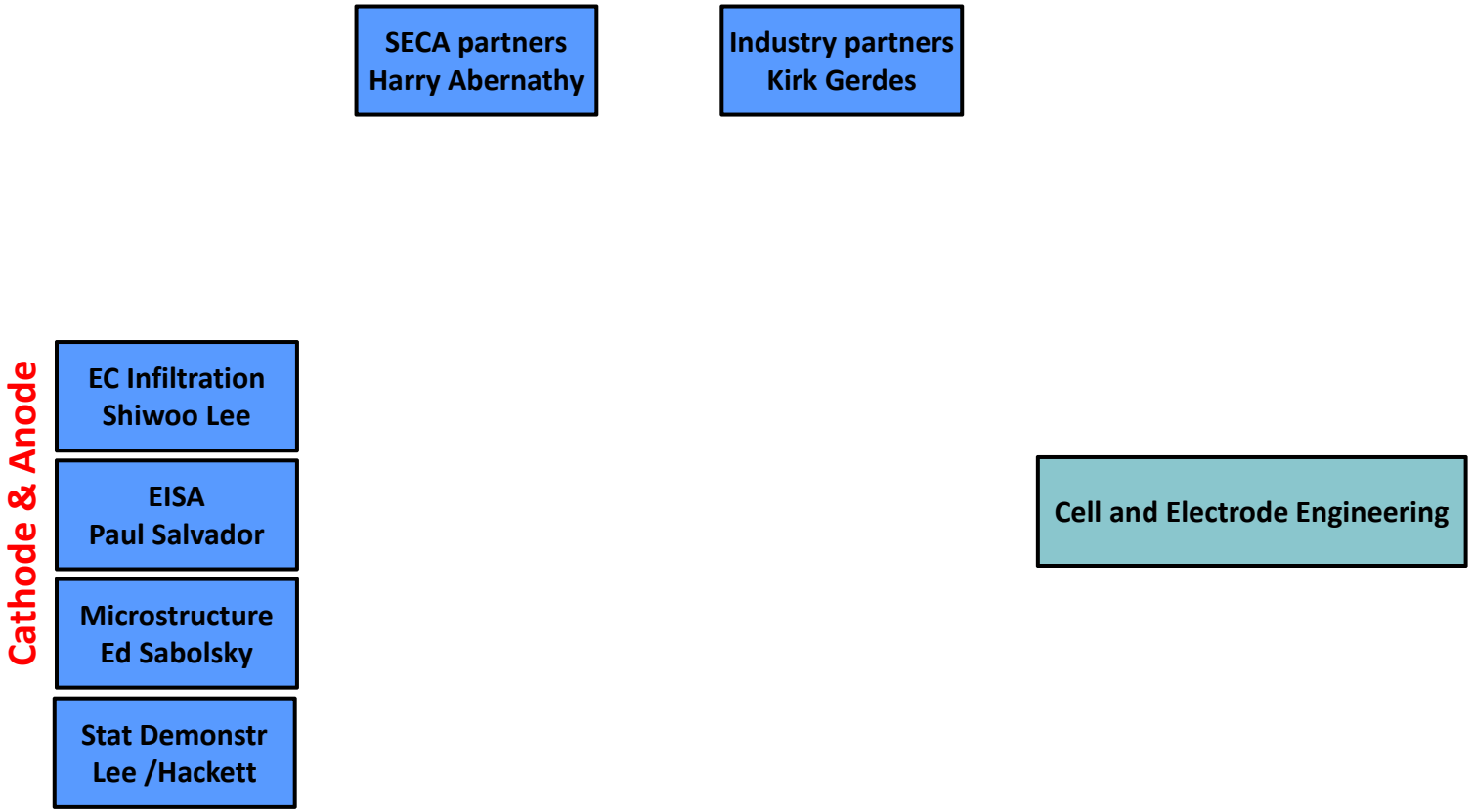
Modeling: Association Schematic (FY13)



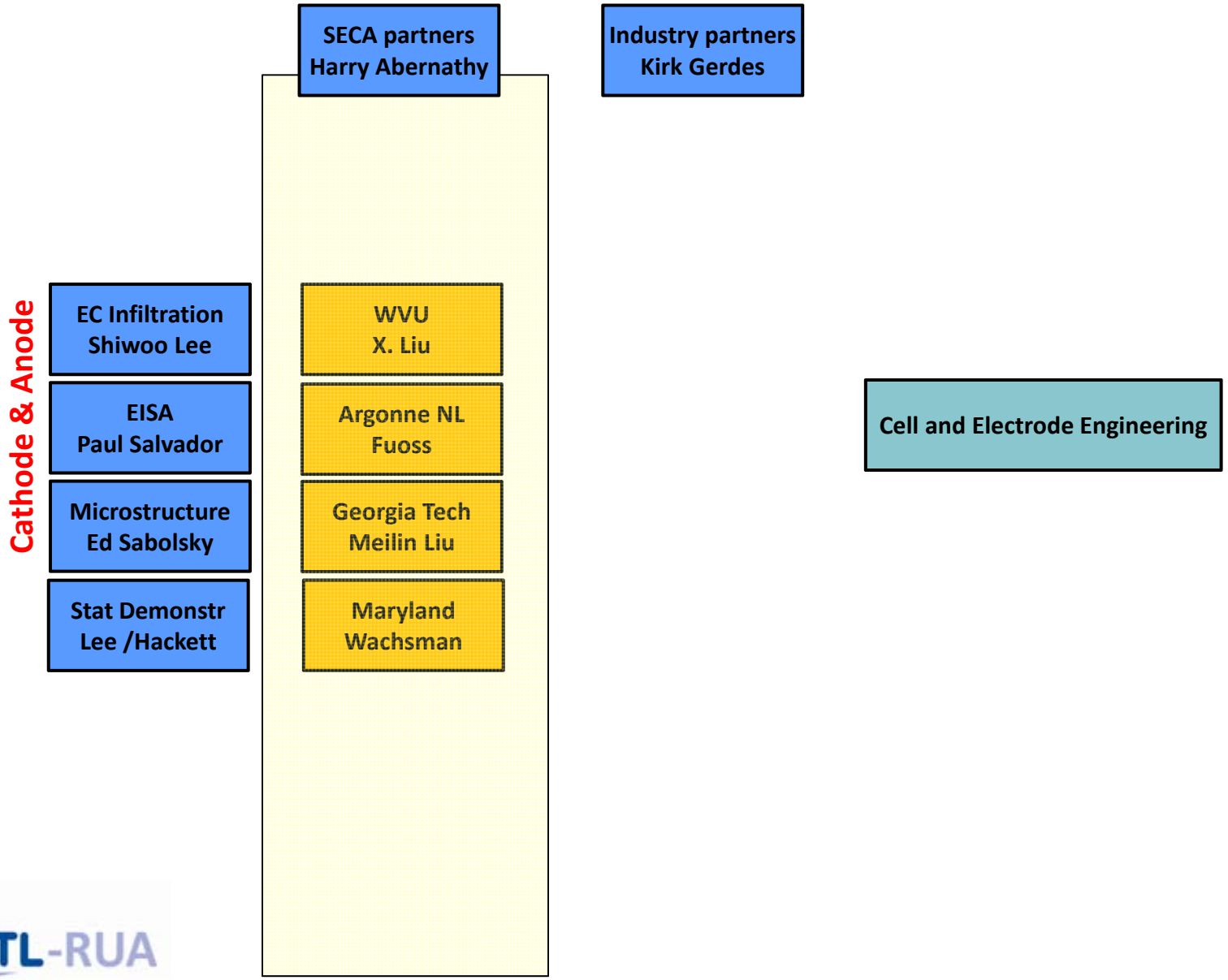
Modeling: Association Schematic (FY13)



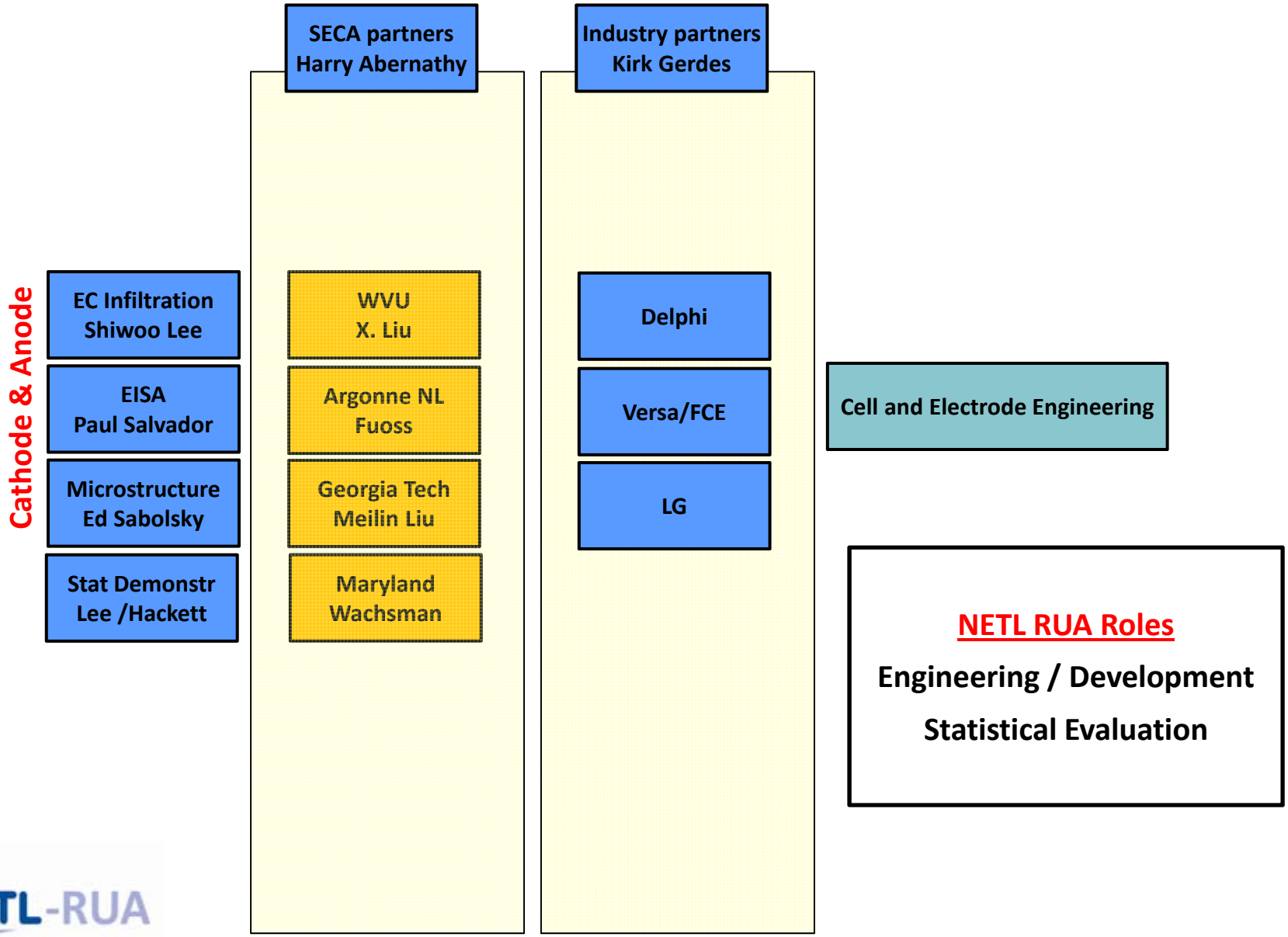
Materials: Association Schematic (FY13)



Materials: Association Schematic (FY13)



Materials: Association Schematic (FY13)



Overview

- **Introduction to Solid Oxide Fuel Cells**
- **NETL RUA Fuel Cell Team**
  - Participants
  - Global technology thrusts and team integration
  - Technology demonstration video
- **FY13 program integration**
- **Technology transfer initiatives**

FC Team: Integration and Tech Transfer

- **NETL RUA FC Team**
  - 13 principal investigators at 4 institutions covering 20 projects
  - Mature, collaborative integration of research activity

- **Program – SECA**
  - Integration of NETL RUA with 7 universities and 2 additional National Labs on 6 topical areas

- **Industry**
  - Supporting 3 direct SECA industrial partners
  - Engaging multiple SECA SBIR partners
  - Pursuing SECA-external development opportunities

Contact information

Kirk Gerdes

Technical Coordinator – Fuel Cells

U.S. Dept of Energy

National Energy Technology Laboratory

Office: (304)285-4342

EM: Kirk.Gerdes@NETL.DOE.GOV

Breakout session: Wharf B at 3:15 pm