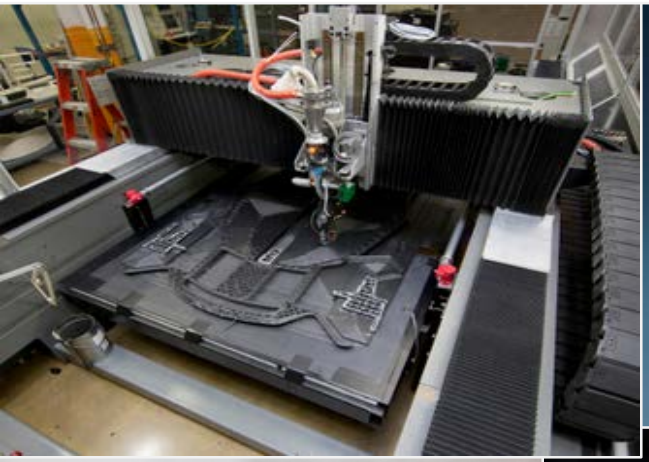
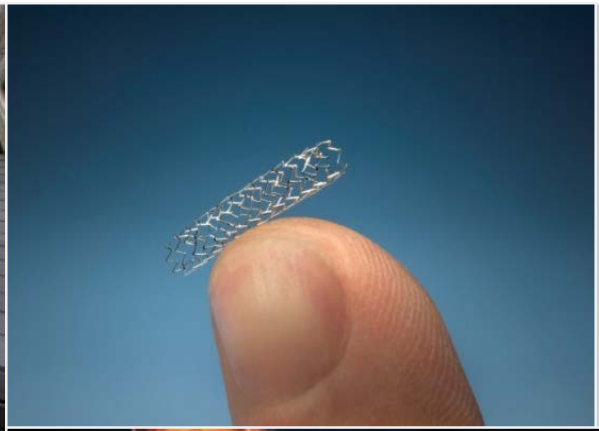
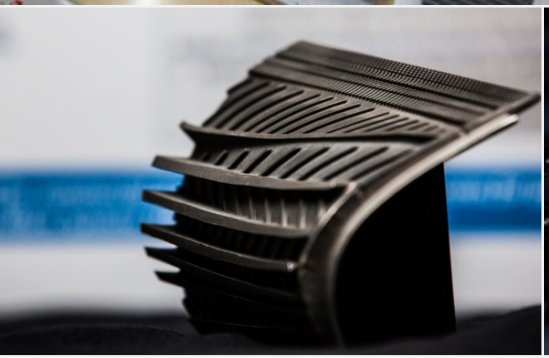
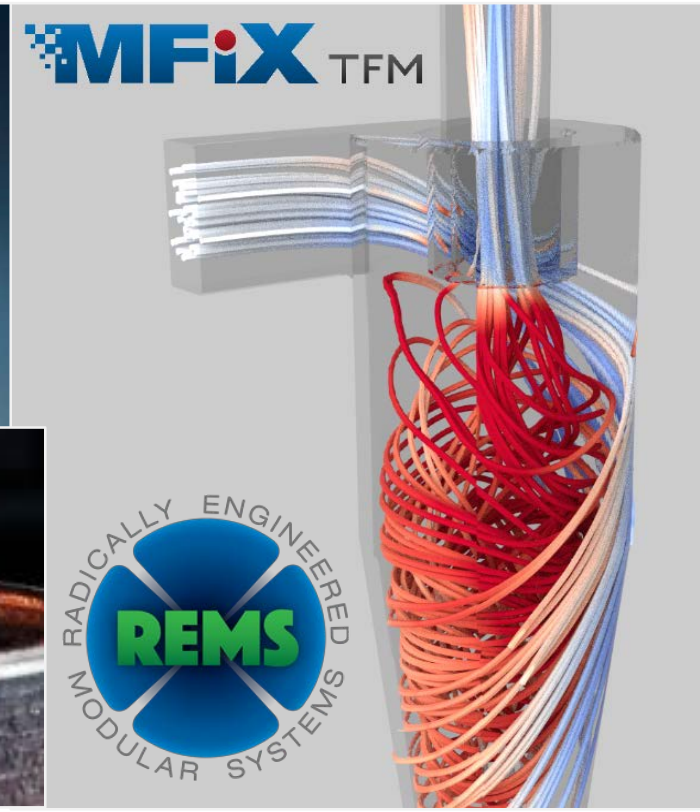
Radically Engineered Modular Systems (REMS)







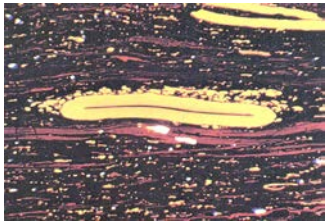


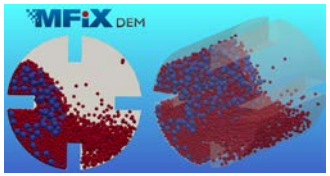
Clearwater Clean Coal Conference

June 9, 2016

Jenny Tennant
Portfolio Manager

Questions….





Why do reactors have to be made up of cylinders and spheres?

Why do we react coal as if it's a homogenous fuel, when it's not?

Why must we remove excess carbon from coal when it's mixed up with other gases, and then pump it underground?

What if multiphase models could become powerful enough to help us manipulate coal to unprecedented levels?

Is bigger always better?

Radically Engineered Modular Systems (REMS) is a new coal conversion initiative with heavy reliance on advanced manufacturing, sophisticated modeling and simulation, and reaction and process intensification

REMS Foundation

- Take advantage of advanced manufacturing & increasingly powerful process models to create unique, low-cost reactors, able to manipulate coal with unprecedented accuracy (radical engineering)
- Reduce capital costs via advanced manufacturing
- Focus on plant-wide cost reduction opportunities
- Increase availability & flexibility via modularity
- Small plants to reduce the cost of functional prototypes, and the cost of using biomass
- Increased availability for larger plants (multiple trains)
- GHG emission reduction without geological storage
- Model reactors & systems to reduce development time & cost

Four Cornerstones of Coal Conversion Programs' Strategy

1. **R&D Focused on Specific Location** – knowns include: available feed (coal, biomass, etc.); site infrastructure, altitude, weather, workforce sophistication, regulations; and most marketable products
   - Early site and application selection will allow multiple R&D efforts to be focused from early development stages and more coordination of different R&D teams
2. **Radically Engineered Modular Systems (REMS)**
   - Reactor Engineering Design
   - Balance of Plant
   - Continuously improving tool set should allow each following modular system to be more quickly developed and at lower cost
3. **Target Technologies with Sharp GHG Emission Reductions without Geological CO_2 Storage**
   - Future integration with advanced CCS technologies will further reduce GHG emissions to AES goals
4. **Target Smallest-Scale & Lowest Economic Risk Applications First**
   - Stepping stone to larger modular plants aimed at larger markets as techniques improve – learning by doing.

REMS Approach

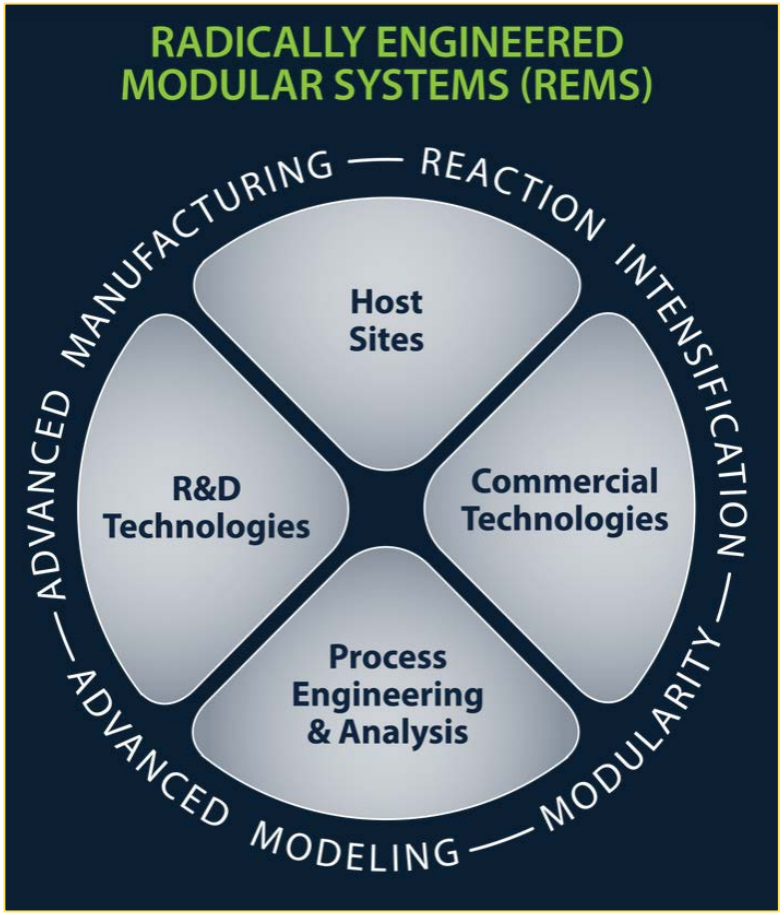
- Determine target locations for prototype REMS plants
- Simultaneously, and in an iterative fashion, model REMS reactors, perform cold flow tests, & perform system analyses on the REMS plant concepts
- Determine what manufacturing & balance-of-plant R&D can reduce capital costs, and seek partners for this work
- When technologies are mature, contract with an EPC to build the REMS plant.
- Negotiate for a specific test site, with a goal of the REMS plant being useful to local populations, leading to continued operation after project completion

Overarching Goal: To develop a REMS toolbox including reactor & plant optimization software, reactor characterization, advanced manufacturing, solid/liquid carbon capture & re-use, systems analysis optimization. The toolbox will lower the risk and cost of designing an optimized modular system for any application and location.

REMS and GHG Emission Reduction

- **REMS plants will be able to take advantage of CCS when it is available for small-scale distributed applications**
- **In the meantime, REMS plants will significantly reduce GHG emissions even without CCS:**
  - Small plants can economically co-feed coal with biomass & municipal solid waste (reducing land fill needs)
  - REMS will be at lower temperature operations, resulting in high carbon char – rather than capture CO_2, the excess carbon will be captured earlier in the process in solid form
  - REMS will explore nearly permanent and profitable solid carbon storage, for example carbon fiber & carbon foam

For more information….



https://edx.netl.doe.gov/FossilREMS/

REMS Panel

Panel Members:

- *Dr. James Fisher, FE, U.S. Department of Energy*
- *Dr. Ronald Breault, FE, U.S. Department of Energy*
- *Dr. Raghubir Gupta, RTI International*
- *James Bennett, FE, U.S. Department of Energy*
- *Thomas Brouns, Energy & Environment Directorate, Pacific Northwest National Laboratory*

Format:

- *Each panel member will make a brief presentation*
- *Q/A and discussions* at the end of all presentations*

**Audience participation is appreciated!*

James Fisher and Ron Breault Bios

James Fisher: James Fisher received his PhD in Chemical Engineering in 2009 from the University of Akron and subsequently joined NETL's in house research. In 2013, James finished his MBA from WVU and moved to the systems analysis team at NETL where he resides today. His areas of interest include carbon capture sorbents, fuel cell electro-catalysis, systems analysis, and catalysis for process intensification.

Ron Breault: Dr. Breault has over thirty five years of industrial and government research experience in the energy conversion technologies. He is currently the supervisor for the Thermal Science Team within the Energy Conversion Engineering Directorate of the Research & Innovation Center at a the US DOE's National Energy Technology Laboratory where he leads a team focused on reactor development for advanced energy production and emissions reduction processes.

Raghubir Gupta and James Bennett Bios

Raghubir Gupta: Dr. Raghubir Gupta is currently Vice President of RTI's Energy Technology Division. Dr. Gupta obtained his B. Tech. degree in Chemical Engineering from the Indian Institute of Technology, New Delhi, India, and earned his Ph.D. degree (also in Chemical Engineering) from the Illinois Institute of Technology, Chicago. Dr. Gupta's technical expertise ranges from coal/biomass gasification, biomass conversion, synthesis gas (syngas) cleanup and utilization, methane storage and conversion, carbon capture and utilization, and industrial water reuse, and holds more than 20 U.S. and foreign patents.

James Bennett: James Bennett is a Ceramic Engineer, graduating with a BS from Clemson University and a MS from Georgia Institute of Technology. He has worked on liner materials, slag models, and temperature sensors for dry ash and slagging gasification systems for over 20 years.

Thomas Brouns Bio

Thomas Brouns: Tom Brouns manages the clean fossil energy business for the Pacific Northwest National Laboratory. He is a chemical engineer with more than 28 years of experience in R&D management, spanning both process and subsurface technology, and both energy and environmental missions areas.