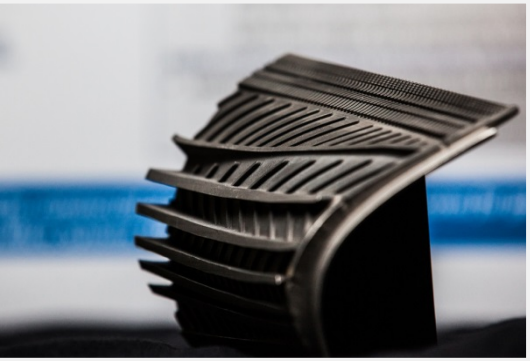
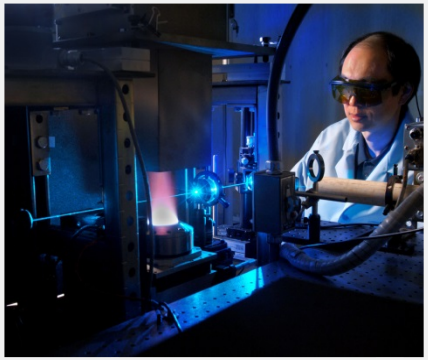
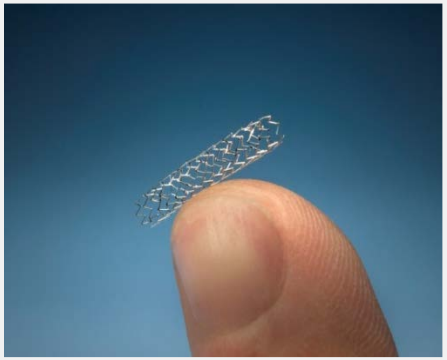
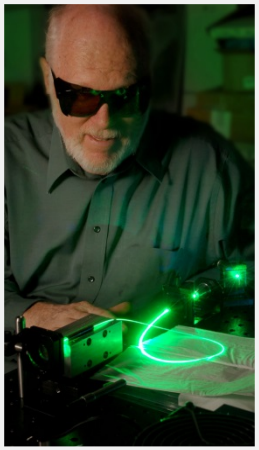
Driving Innovation ♦ Delivering Results



Radically Engineered Modular Systems (REMS)

Research Team: James Fisher, James Bennett, Ronald Breault, William Rogers, Dushyant Shekhawat

Management Team: Jenny Tennant, Geo Richards, Madhava Syamlal

REMS Will Reduce Time, Cost, and Risk

Carbon-based Fuel Reactor Challenges:

- New approaches for carbon-based fuels to power/chemicals technologies are expensive to develop & deploy
- Capital costs for plants are very high
- Varying feedstocks, distributed power generation, optimal product mix

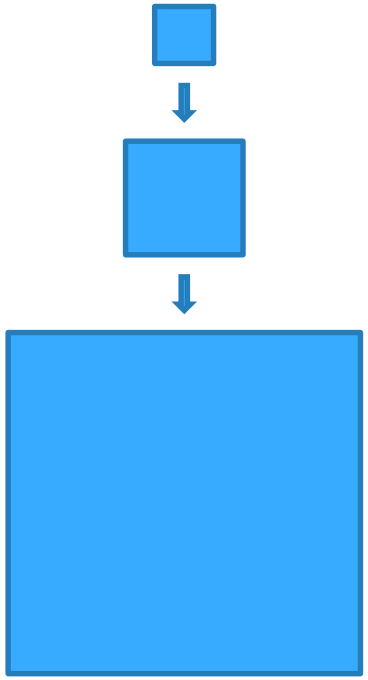
How do we address the challenges?

- Reduce time/risk scale up
- Reduce build/capital costs
- Fuel flexible designs, distributed systems
- Enhanced reactor/process performance
  - *Reaction manipulation at the particle level*

Multiphase CFD Reactor Optimization, Advanced Manufacturing, Process Simulations, Cost Analysis & Reaction Intensification will address these challenges

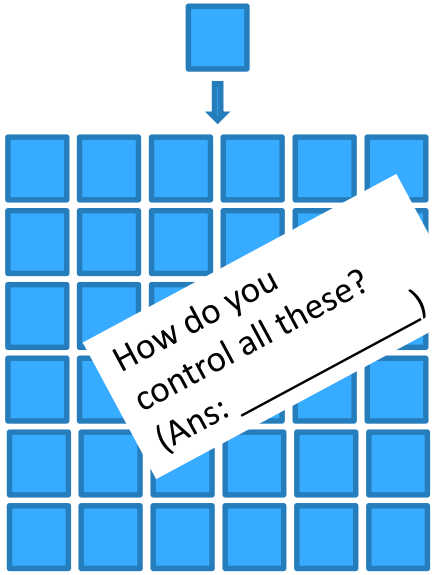
How Will REMS Differ from Traditional Approaches

Traditional



- Unreliable scale up
- Expensive, long development
- Incremental improvements

REMS



Beat economies-of-scale by using

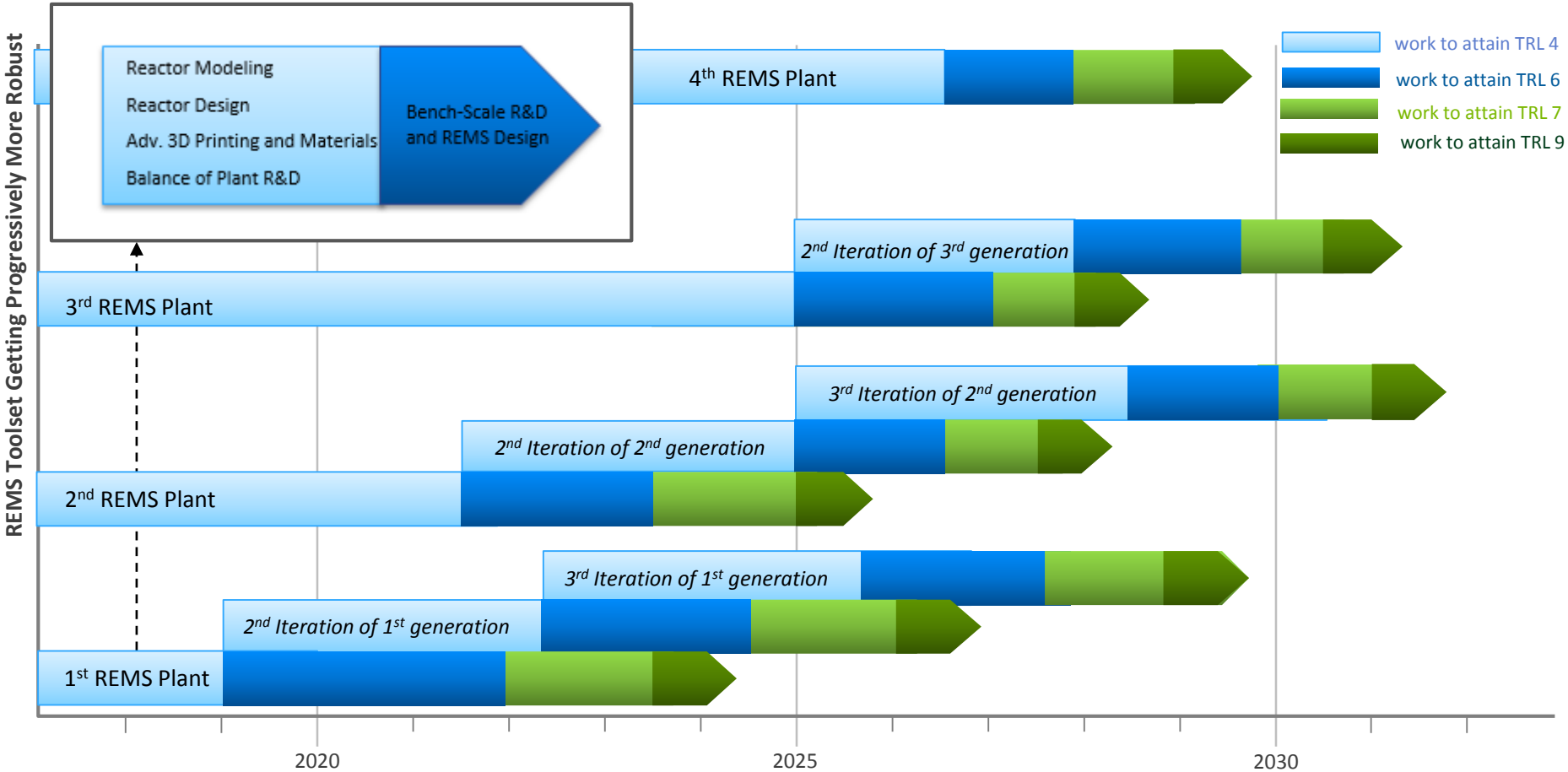
- CFD to rapidly create novel reactor configurations
- Microwave, plasma etc. to intensify reactions
- Advanced manufacturing to replicate reactors at low cost

Example of Emerging Industrial Approach

Velocys: Small, Modular & Efficient GTL Reactors

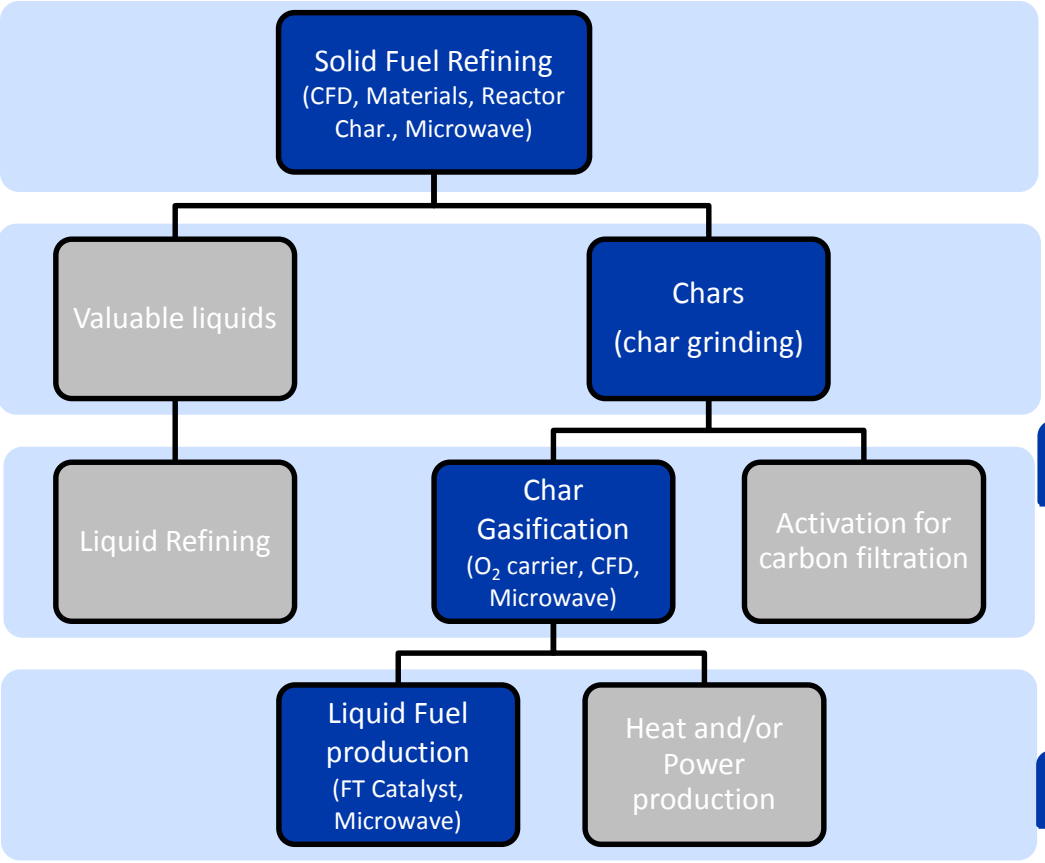
Reactor Image from www.velocys.com

Technology Development Schedule
Two Potential Starting Points



- Each generation could be started by identified locations and/or funding availability
- Every iteration would take lessons learned coupled with latest technological advanced to reduce capital cost, increase availability, and improve the economics
- KEY: The R&D to enable these later plants must be started today, otherwise only incremental improvements likely. This will also expand the market REMS plants are applicable to.

R&IC REMS Vision



Solid Fuel Refining

- 3 main parts
  - Pre-feed heat exchanger
  - Coal refiner
  - Liquid/Char separator
- Development of CFD toolset to design and optimize the reactor for given feed and products
- New Materials and coatings for reactor lining

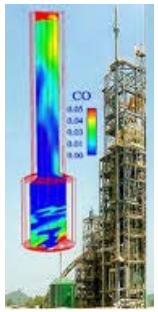
Char Gasification

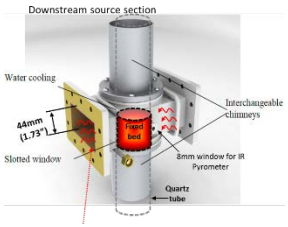
- Char grinding to reduce particle size
- Chemical Looping oxygen carriers that can convert char directly to syngas.
- Conventional syngas production

FT Catalyst and Microwave Reactions

- Catalytic development to move beyond the Anderson-Shultz-Flurry product distribution

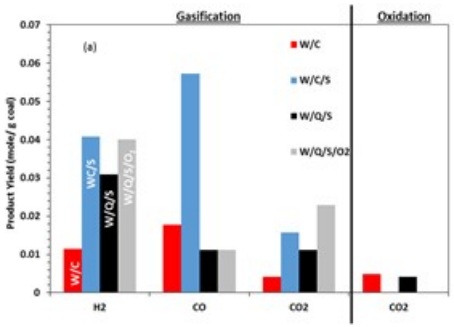
Radically Engineered Modular Systems (REMS): Research Areas





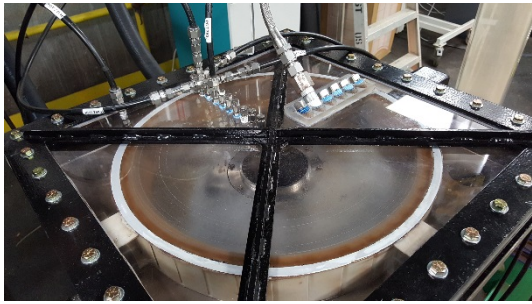
- **Simulation-based Reactor Optimization (Bill Rogers)**
  - Development of physics-based submodels
  - CFD Optimization and Toolsets
  - Validate models using cold flow and reacting flow data generated at NETL
- **Reactor Characterization and CFD Model Validation (Ron Breault)**
  - 3D printing for rapid testing of prototypes
  - Development of characterization tools
  - New and novel reactor concept design and testing
- **Advanced Manufacturing and Reactor Materials Development (James Bennett)**
  - Materials for unusual reactor geometries & conditions
  - Rapid, low cost, fabrication techniques
- **Reaction Intensification (Dushyant Shekhawat)**
  - Microwave/Plasma driven reactors
  - Catalyst Design
- **Small Scale Reacting Flow Experimentation (TBD)**
  - Purchase an OTS biomass gasification unit
  - Modify for coal use and instrumented to capture data for CFD validation.
  - Fully integrate heat exchanger, reactor, and separator to demonstrate the complete R&IC vision for the fuel refining reactor
- **Process Simulation and cost analysis (James Fisher)**
  - Use process simulation tools and cost analysis techniques
  - Aid in site specific design and costing
  - Evaluate balance of plan needs and performance

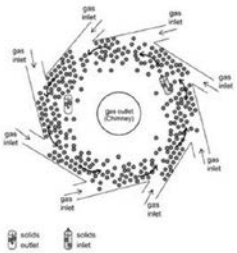
REMS Research at NETL



Nitrogen free syngas
Without oxygen generation

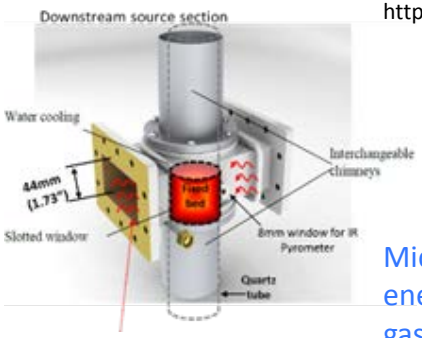
http://www.allpowerlabs.com/products/gasifier-k





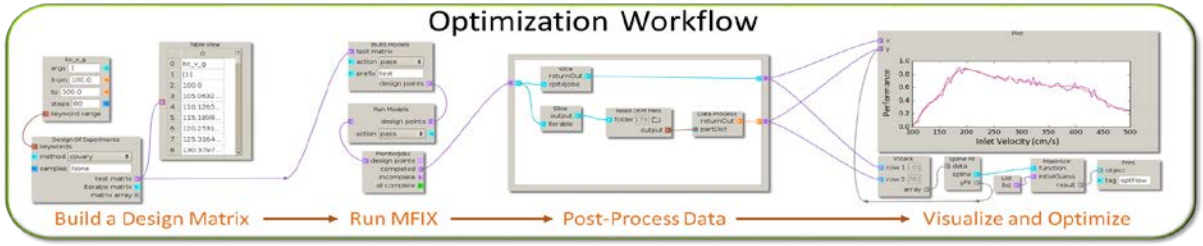
(planned) lab-scale
research gasifier
5-20kWth

Advanced manufacturing
for thermal protection
and embedded sensors

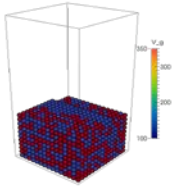


Microwave reactor –
energy inputs to control
gasification

Rotating bed – "high-g" fluid bed
- Improved solid separation
- Process intensification



Optimizing
Particle
Separation



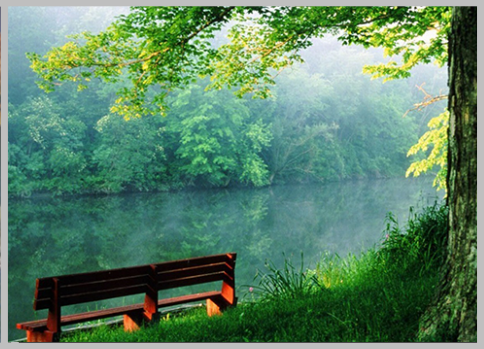
Collaborations

- **External potential collaborations**

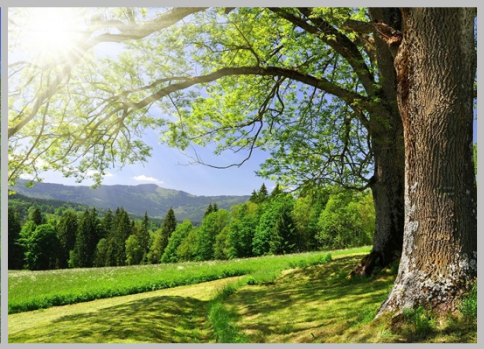
Existing tech. to be leverage today	– Boeing has a 50kw SOFC that can capture solar energy for energy or fuels production at a later time – Velocys has developed a microchannel FT reactor for almost any syngas
	– RTI: Has made a NG to methanol and ready to start R&D on a skid for coal + biomass to FT liquids in 3 years
Tech. in the near future	– Morgantown has an effort to turn MSW into useful products – HQuest is a Pittsburgh company looking at microwave process intensification

- **Big Idea and other modular teams**
- **Current NNMI by AMO via EERE**
- ***NETL is National Lab that can leverage R&D to make a paradigm shift in modular coal based systems***

It’s All About a Clean, Affordable Energy Future



For More Information, Contact NETL

the ENERGY lab

Delivering Yesterday and Preparing for Tomorrow