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Multiphase Simulation of Entrained Flow Gasification – Modeling Needs

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ConocoPhillips – an Energy Company

Tomorrow Begins Today

Oil
Coal
Oil sands
Natural gas
Petroleum coke
Coal bed methane
Transportation fuels
Gas-to-liquids
Gasification
Electricity
Shale oil
LNG

3rd integrated energy company in the U.S
4th largest refiner in the world
6th largest worldwide reserves holder of National Oil Companies

Outline

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- Gas-solids flow in the value chain
- E-Gas™ process overview
- Engineering needs
- Modeling requirements
- Summary

ConocoPhillips Value Chain

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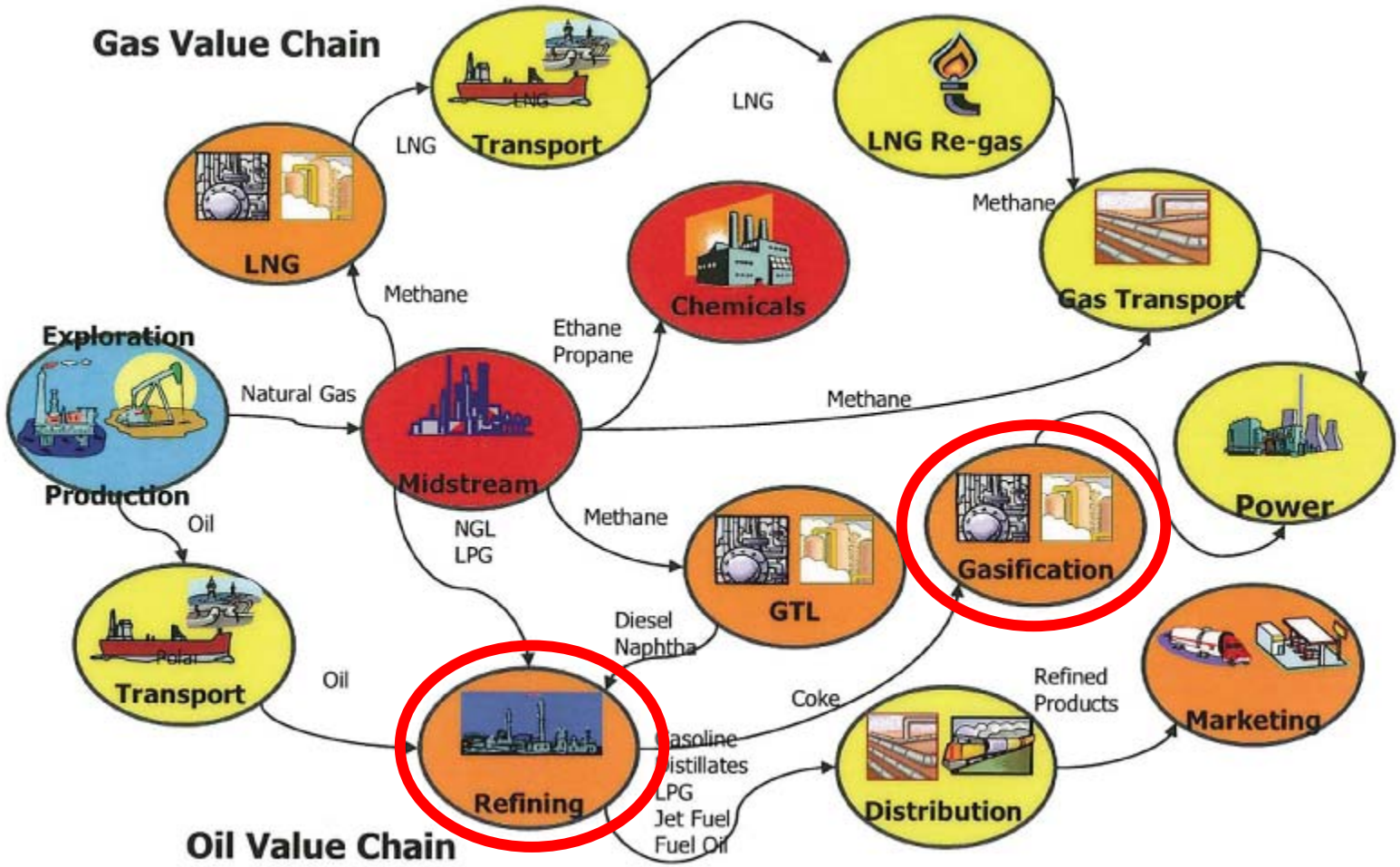

E-Gas™ Technology for Gasification

A Look Inside the Process

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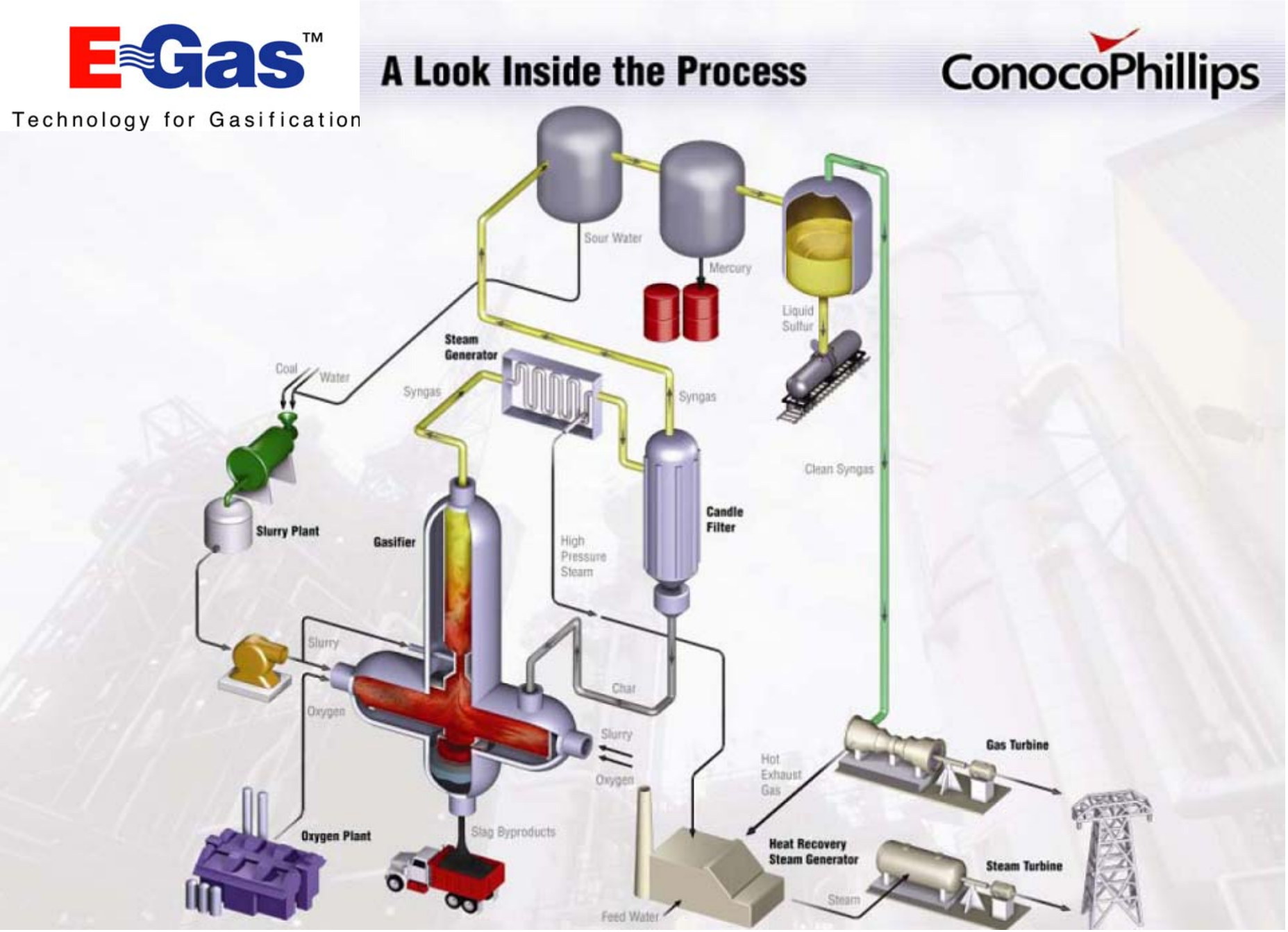

E-Gas™ Gasifier

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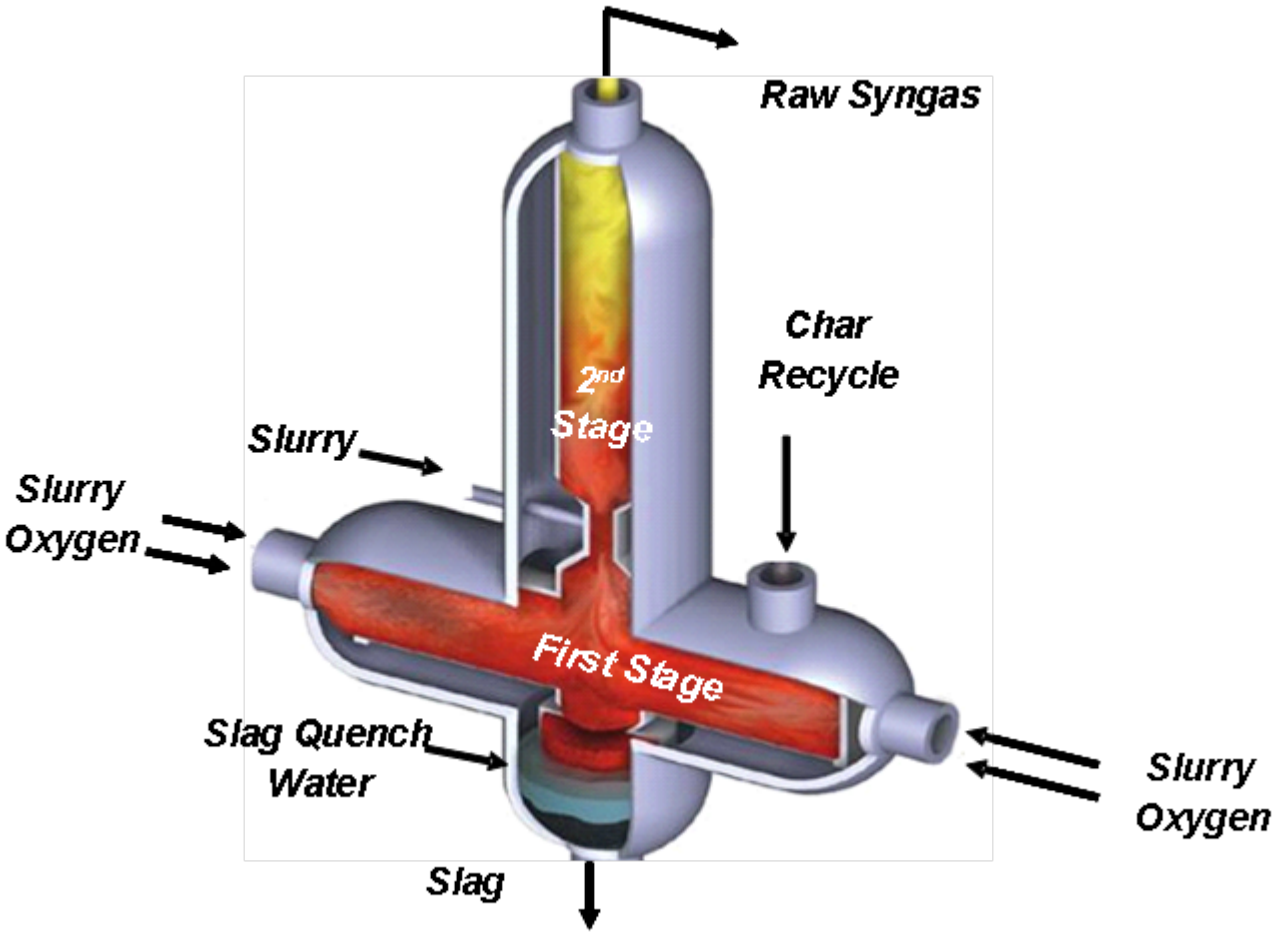

Engineering Information Desired

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- Inputs
  - Feed – Type, Water content, Solids loading, temperature, Injection…
  - Oxidant – O_2 concentration, Temperature
- Outputs
  - Gas flow field – Temperature, velocity, composition
  - Wall conditions – Temperature, heat flux, slag flow
  - Carbon conversion, cold gas efficiency
  - Quantity of carryover – unburned carbon in fly-ash
  - Influence of process, operating conditions and geometric configurations

Coal/Petcoke Gasification

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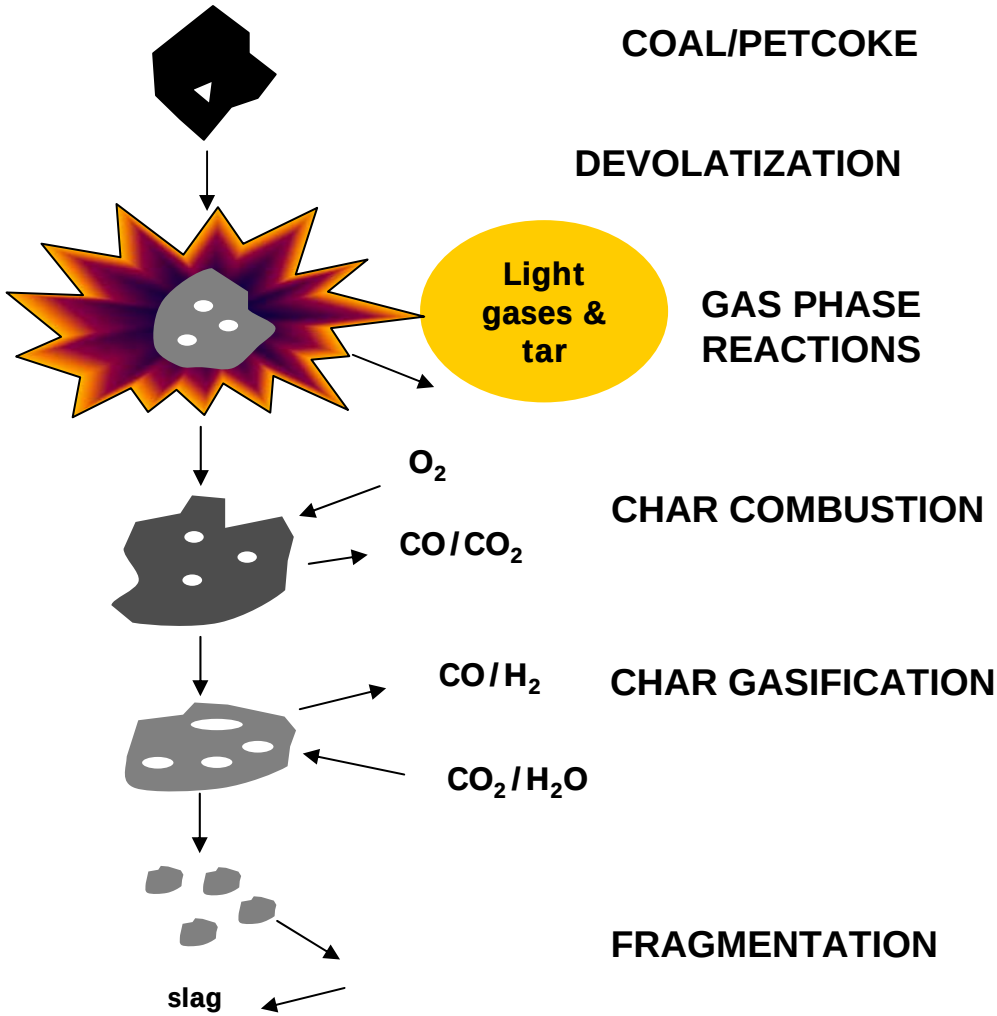

Multiphase Flow Simulation Needs

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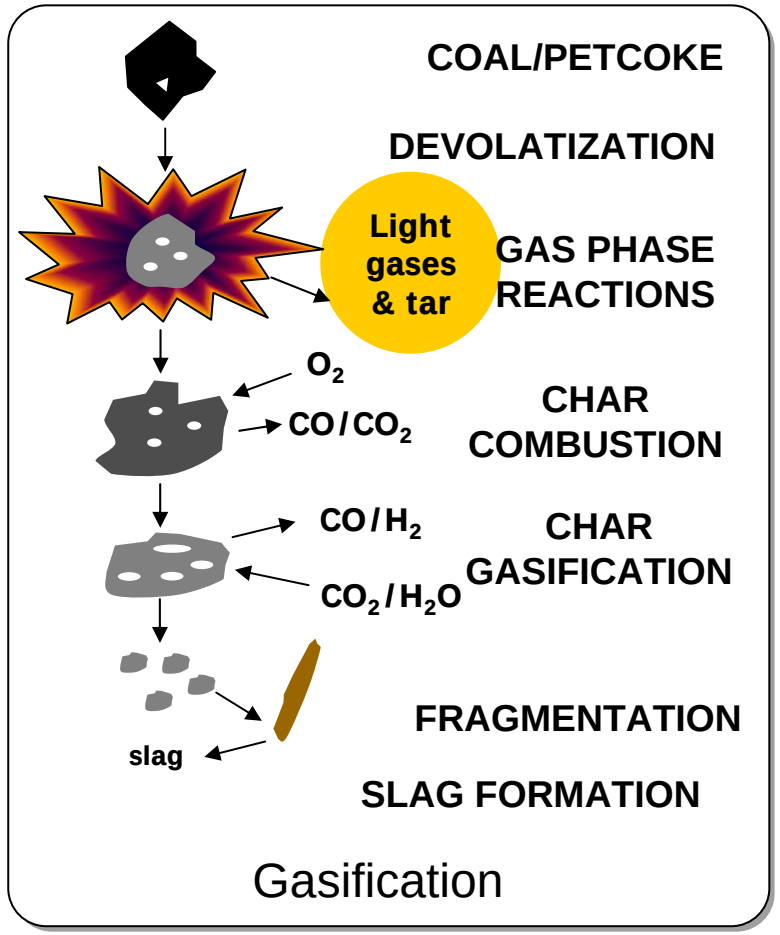
- High-fidelity models – detailed geometry and mesh
- Steady-state and transient
- Heat transfer – convective, radiation
- Particle-size distributions, solid collision behavior
- Devolatization kinetics – for range of fuel types
- Detailed kinetic modeling – gas-phase, gas-solid, gas-solid-catalyzed
- Range of flow conditions from high-speed multiphase injection, turbulent combustion, high-viscosity slag flow
- Particle-wall interaction
- Soot production models
- Pollutant models
- Accurate EOS and material properties



Gasification

Solids Transport

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- Relatively high velocity liquid/solid injection
- Particle size distribution of slurry – wetted solids + water
- Fragmentation
- Influence of injector on spray pattern
- Ash deposition and slag transport
- Turbulent dispersion

Devolatization

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- Reaction, chemical or network models
- Predictable for any fuel and range of process conditions (T, P)
- Influence on particle transport
  - Solid or porous

Reactions

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- Gas-phase
  - Equilibrium
  - Partial equilibrium
  - Full or reduced mechanisms
- Gas-solid
  - Pore-scale modeling
  - Mineral matter
  - Ash formation and inhibition

Turbulence

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- Scales
- Transients
- Interaction with solid phase
- Accurate “engineering” models

Speed

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- Faster algorithms
- Better parallelization
- Efficient model methods

Value to ConocoPhillips

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- A predictive CFD modeling tool could be used to guide engineers to derive much higher improvements in the efficiency and overall cost-savings

- CFD can be used to identify optimal design and reject poorly performing configurations

- Continuously improve the existing technology and design for the future

Acknowledgements

- Guy Lewis, Sergei Filatyev, Albert Tsang
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Feedback?