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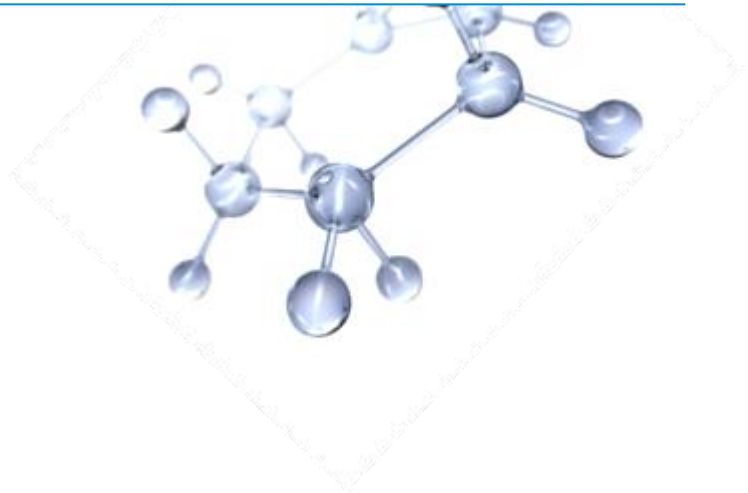


NSF PI Workshop

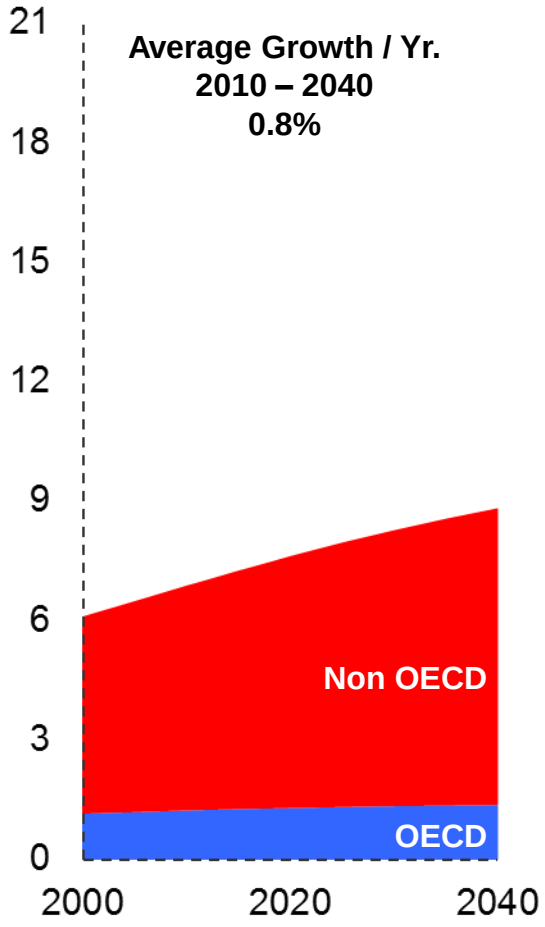
Jeffrey M. Grenda
David O. Marler

ExxonMobil Research and Engineering Company
September 30, 2014

Energy Outlook

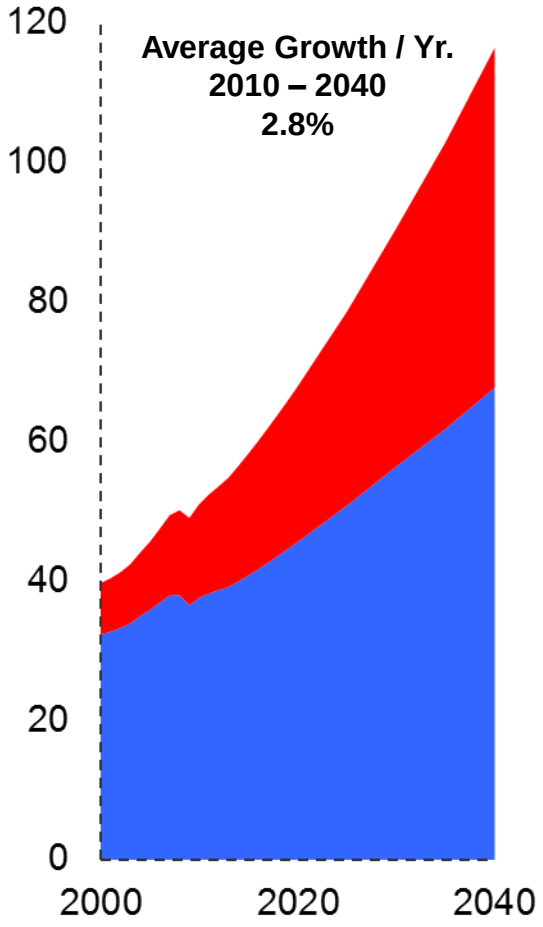
Population

Billion



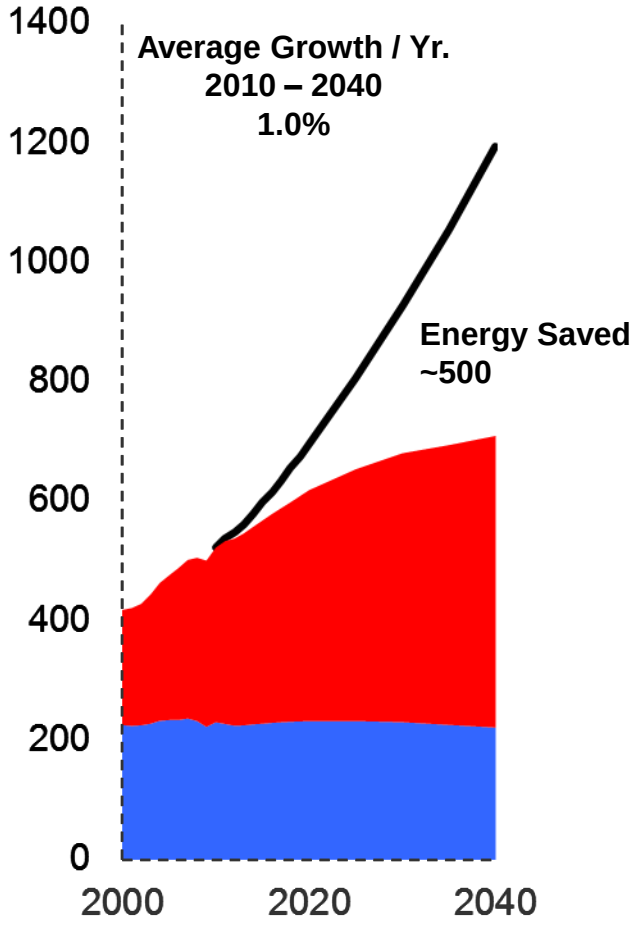
GDP

Trillion 2005$



Energy Demand

Quadrillion BTUs



Source: ExxonMobil 2014 Outlook for Energy

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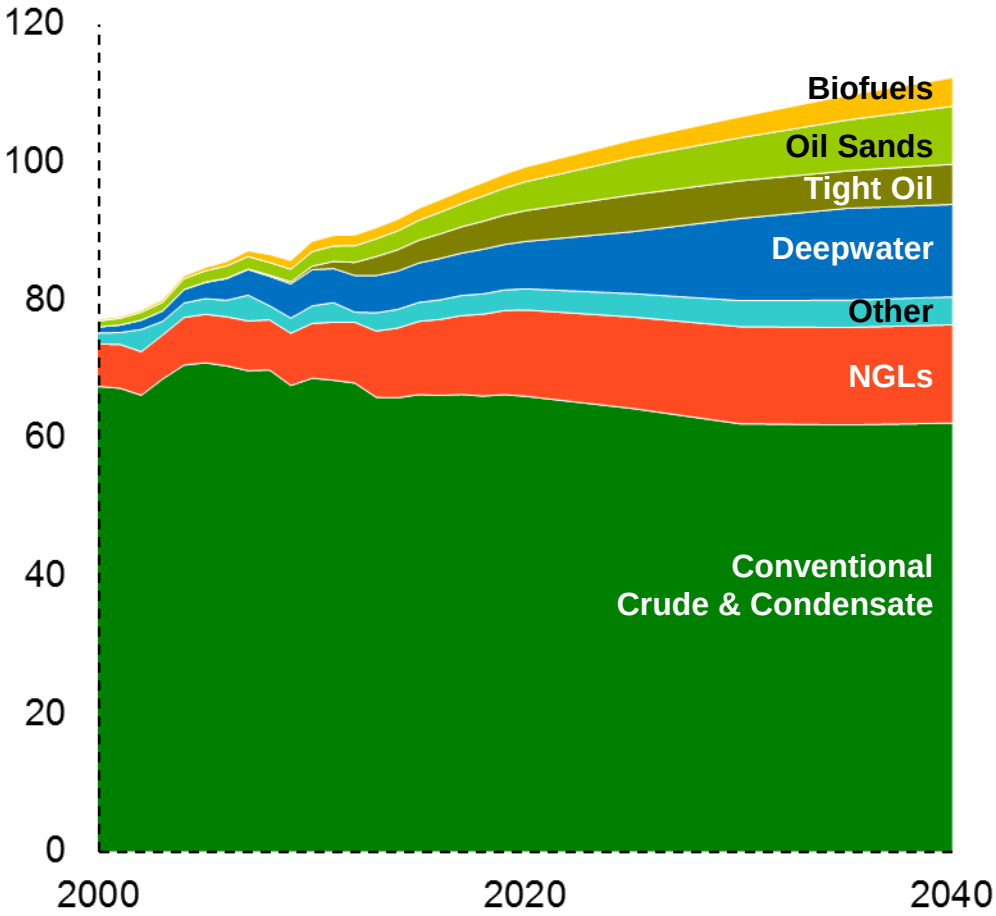
Liquids Supply

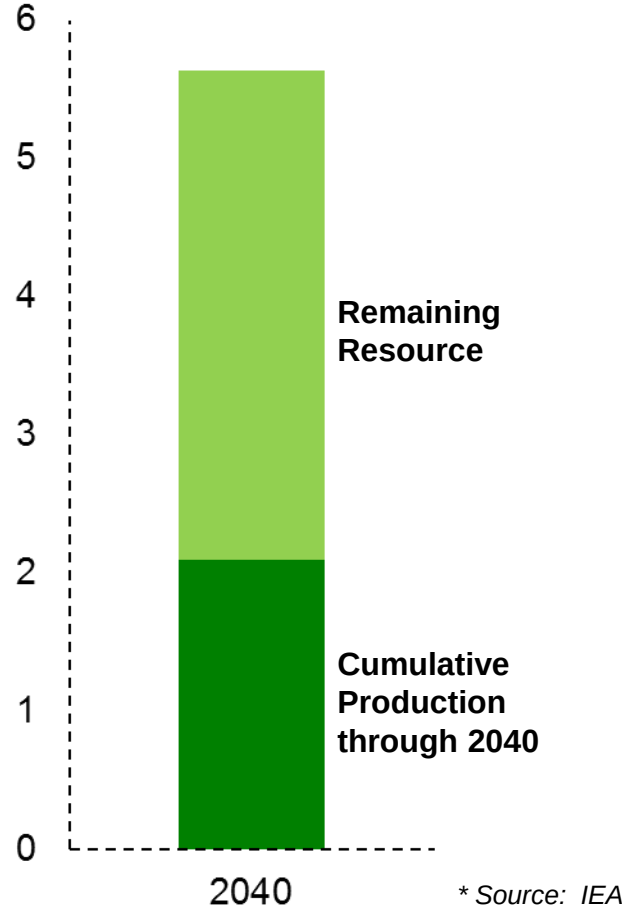
Liquid Supply by Type

MBDOE



Crude and Condensate Resource*

Trillion barrels of oil



* Source: IEA

Source: ExxonMobil 2014 Outlook for Energy

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Multiple Business Sector Opportunities

High Performance

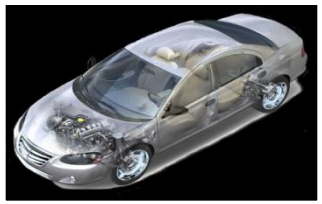
Operational Excellence

Drilling

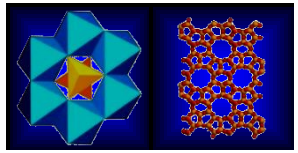
Concepts
Processes
Materials

Consumer Products

Clean Fuels

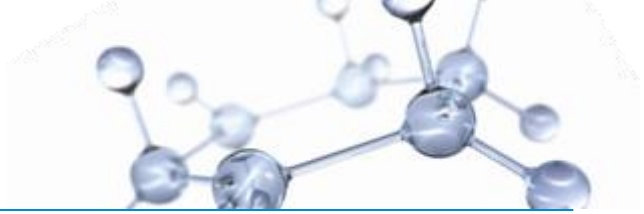


Advanced Fuels
and Vehicles



Advanced Materials

Bifurcation - Trends



Resources

Lighter
NGL, North American Crudes

⟷

Heavier
Bitumen, Challenged Crudes

Products

Lighter
Ethylene, Propylene, BTX

⟷

Heavier
Lubricants, Diesel, Specialties

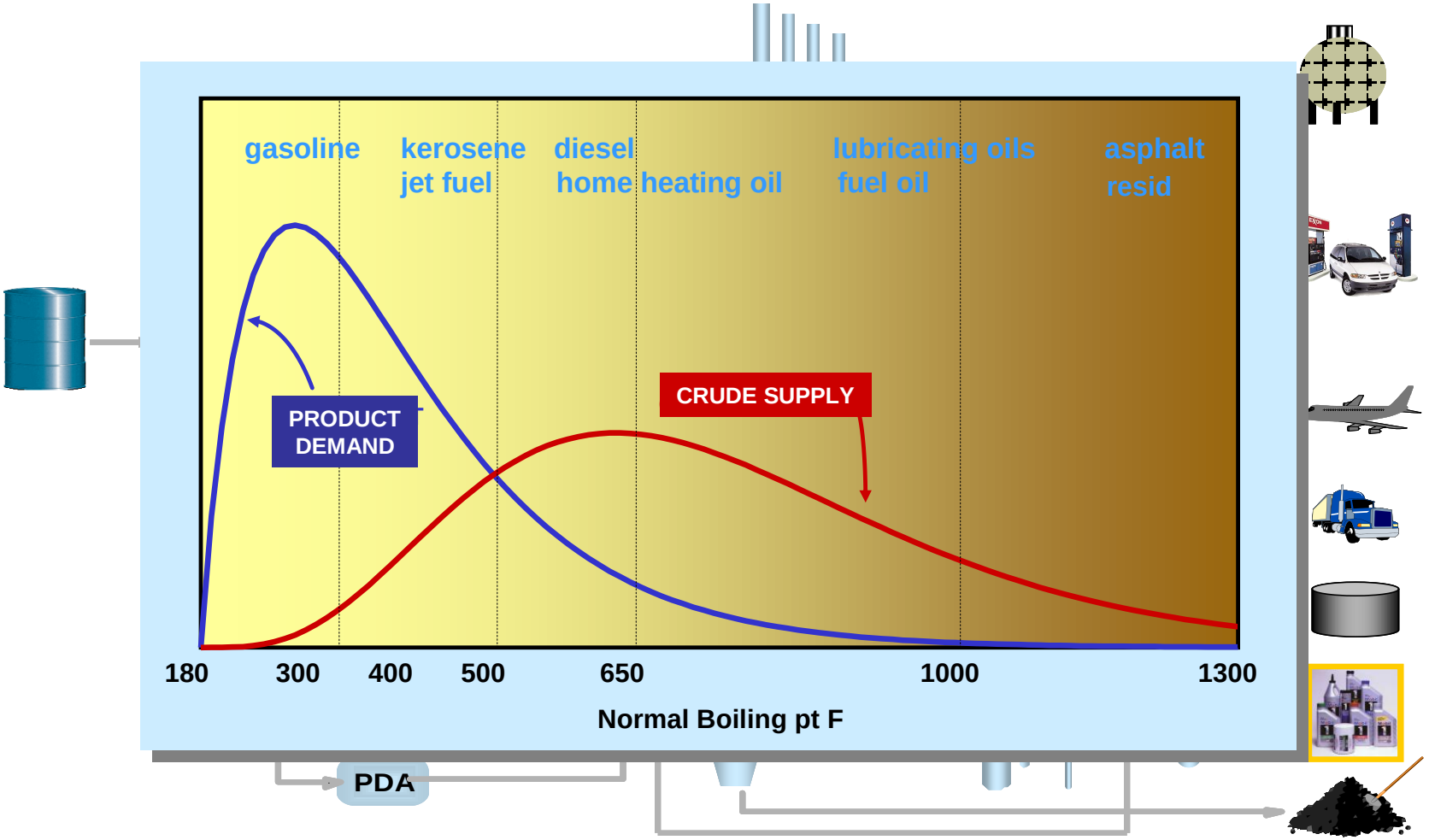
Manufacturing

Simple and Distributed
Biorefineries, MTX,
and regions
with infrastructure challenges

⟷

Complex and Integrated
OECD countries or countries with
large, highly networked
infrastructures

The Resource: Crude and Product Composition ~2000



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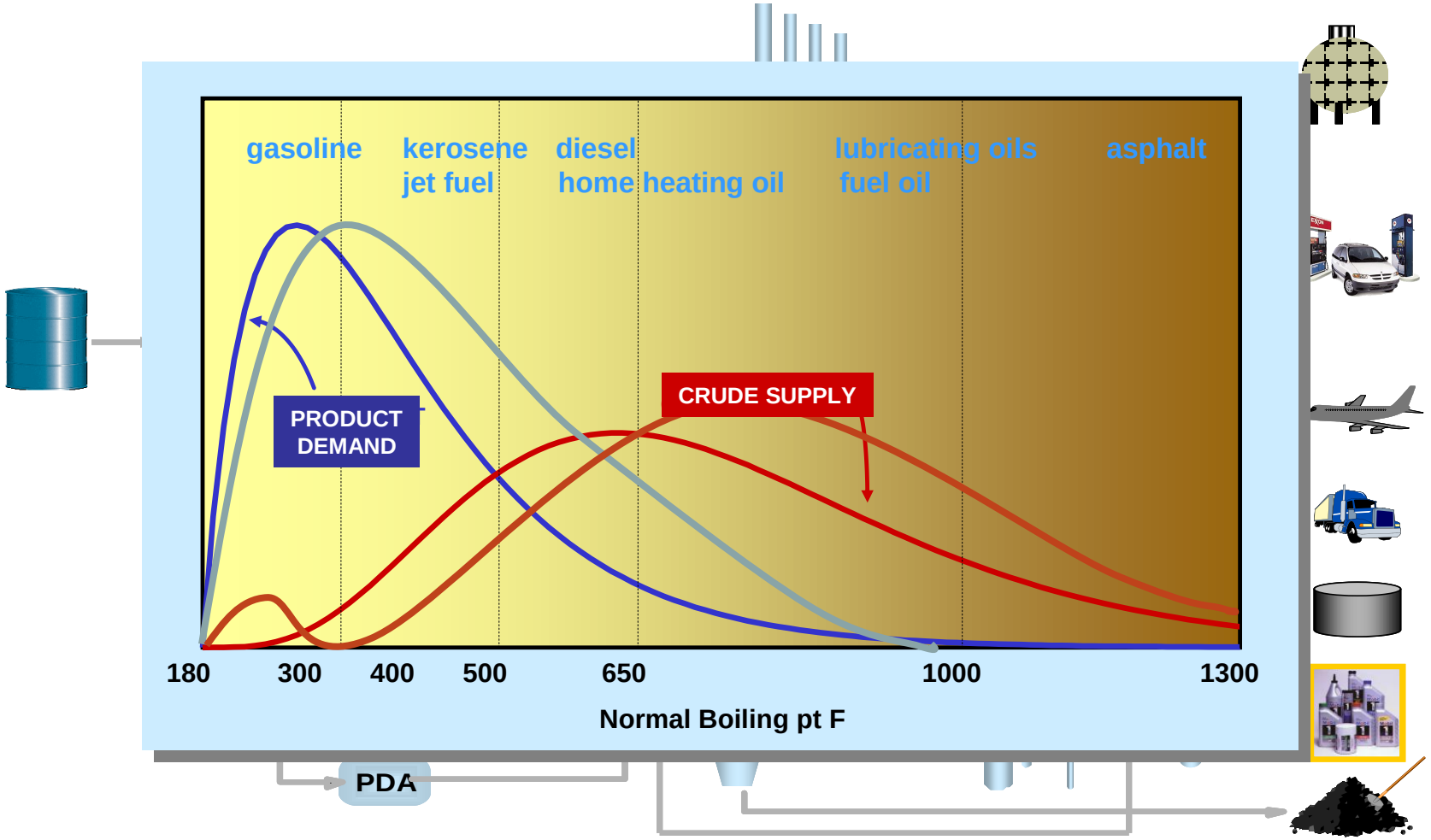
The Resource: Crude and Product Composition – 2000 to 2020



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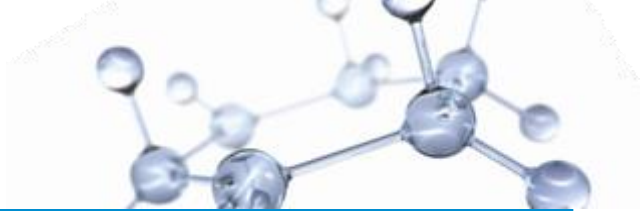
Bifurcation - Challenges



Conversion

M. W. Increase ⟷ M.W. Reduction

Oligomerization, Aromatization, Alkylation, Methanol-to-Everything

Cracking, Dealkylation, Hydrocracking

Separation

Lighter ⟷ Heavier

Natural Gas Cleanup, Lt. Olefin Separation

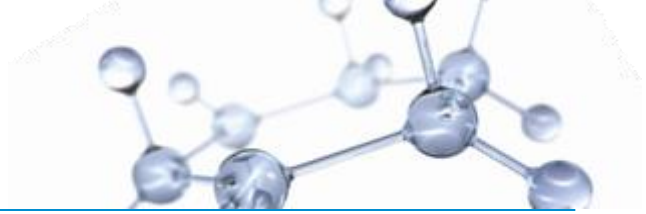
Vacuum Distillation, Wax Removal

Modeling

Simple and Intuitive ⟷ Complex and Rigorous

Learning models, explanatory

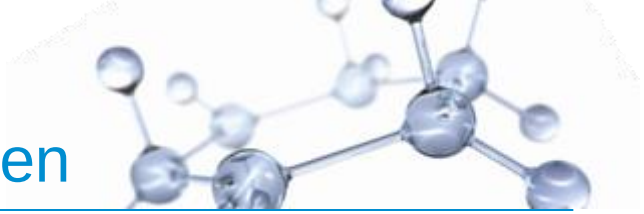
Simulation models, predictive

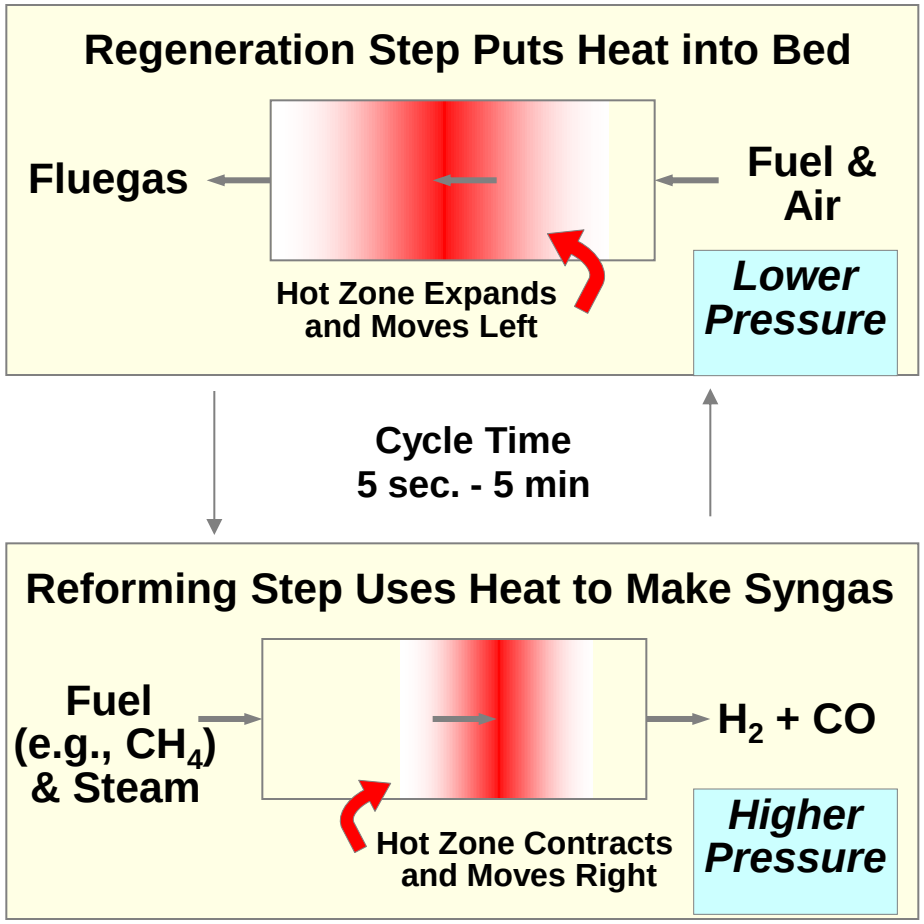


ExxonMobil Process Intensification Example:

Pressure Swing Reforming

Pressure Swing Reforming:
New Way to Make Syngas and Hydrogen





Key Features

- *Cyclic Process:*
  - Combust & Reform in bed
  - Reverse Flow
  - In-situ heat exchange
- *Pressure swing transfers heat from low to high pressure*

Avoids Economic Debits

- *No Air Separation*
- *No High-Temp. Furnaces*
- *No Excess Steam*
- *Efficient Energy Use*

Chemical Engineering for the Future

- Chemical engineering is central to solving many of the energy challenges
- Success depends on applying the traditional curriculum …
  - Thermodynamics
  - Fluid mechanics
  - Heat/mass transfer and kinetics
- … to address tomorrow's challenges
  - Interdisciplinary interfaces with materials science, biology, geology
  - Modeling, informatics, visualization
  - Multi-scale principles for process design
  - Process integration and intensification

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