Modular Gas-to-Liquids Technology

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10th PIN Meeting, Heriot-Watt University, Edinburgh

June 3, 2004

Revolutionary Processing Systems

Conventional Technology

Revolutionary Processing Systems

Velocys® Technology

Presentation Agenda

Velocys Introduction

Technology Overview

Development and Scale-Up

Gas-to-Liquids application

- Steam methane reforming
- Fischer-Tropsch

Velocys Introduction

Formed in 2001 as a spin-out from Battelle Memorial Institute

Over $70 million invested to date

50 employees, including 16 PhD's, many with 10+ yrs industrial experience

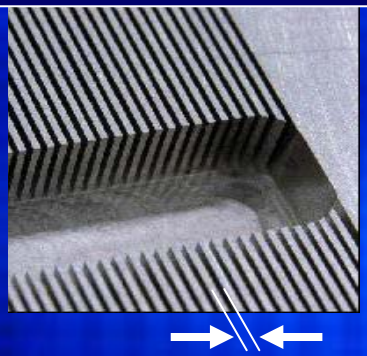
Located in a 27,000 sq. ft. purpose built facility near Columbus, Ohio

Established alliances with engineering and manufacturing firms

Enabling Technology

Velocys
vs
Conventional
Process Technology

Velocys



~ 0.1-0.3 cm

Characteristic dimension

~ 5 -15 cm

Conventional

Velocys Technology Advantage

Very short distances to the wall:

- Enables extremely high rates of heat and mass transfer
- Allows use of new, novel, more active catalysts
- Accelerates chemical processes by factors of 10-1000X
- Results in smaller, more productive reactors
- Facilitates control of reactions under optimum conditions
- Avoids production of undesirable by-products
  - Higher product yields
  - Lower purification requirements

Benefits of Technology

Smaller footprint, reduced capital cost, lower operating cost, and shorter deployment time:

- **Higher performance**
  - High throughput per unit volume of hardware
- **Lightweight and/or compact systems**
  - Modular plant expansion, debottlenecking
- **Large scale economics at smaller scales**
  - Lower initial capital investment
  - Higher yield and efficiency/lower operating costs
- **Greater product yield**
  - Precise control of process conditions

Increased Reactor Throughput

Velocys® Technology systems outperform conventional reactors

- Steam reforming (highly endothermic)
  - Conventional: >1 second
  - Velocys Technology: < 5 milliseconds
- Fischer-Tropsch Synthesis (highly exothermic)
  - Conventional Fixed Bed: >10 seconds
  - Velocys Technology: < 0.2 second contact time

Velocys Scale-up Methodology

Cell

- Internal channel dimensions same as commercial reactor
- Number of channels increase; size of channels does not
- ~ 0.5 - 1 lb/hr

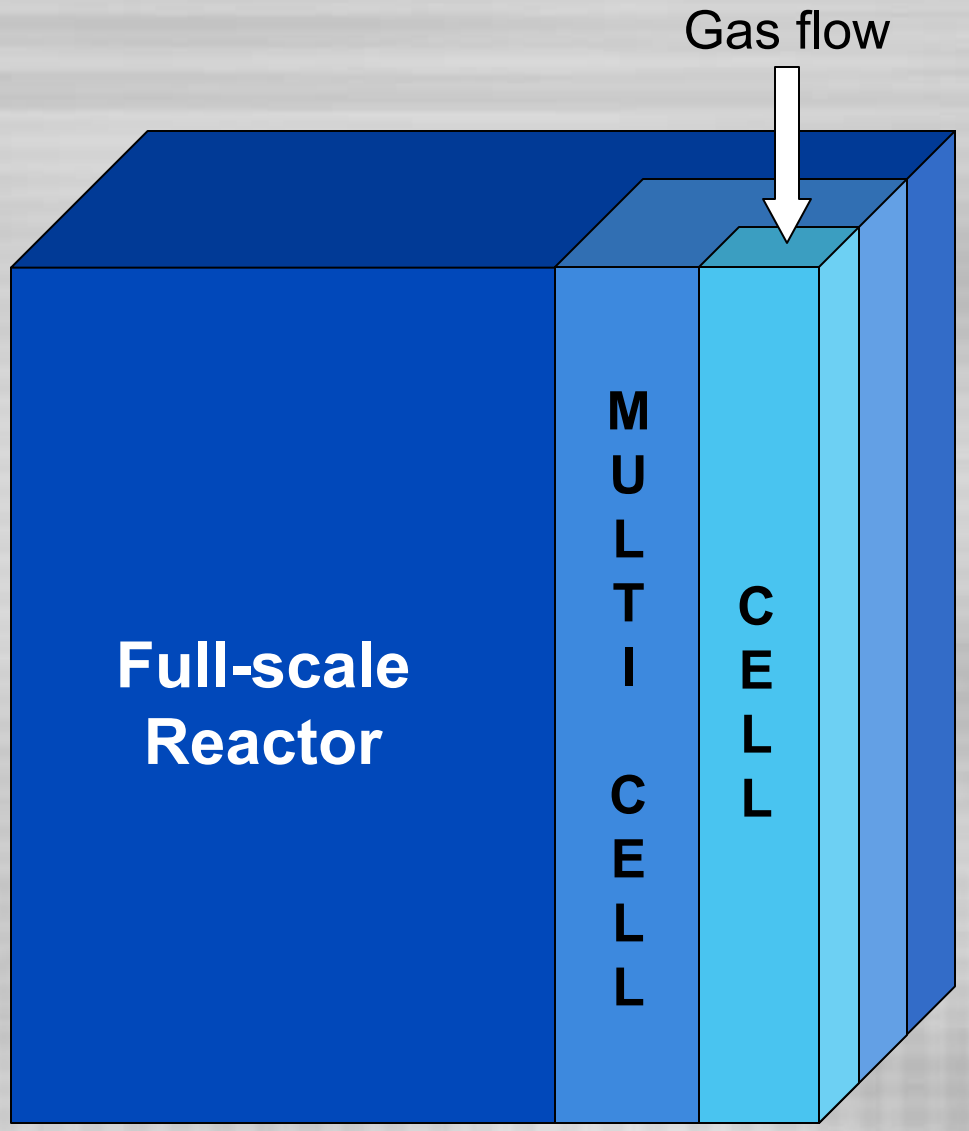
Multi-Cell

- Many channels
- 10 – 100 lb/hr

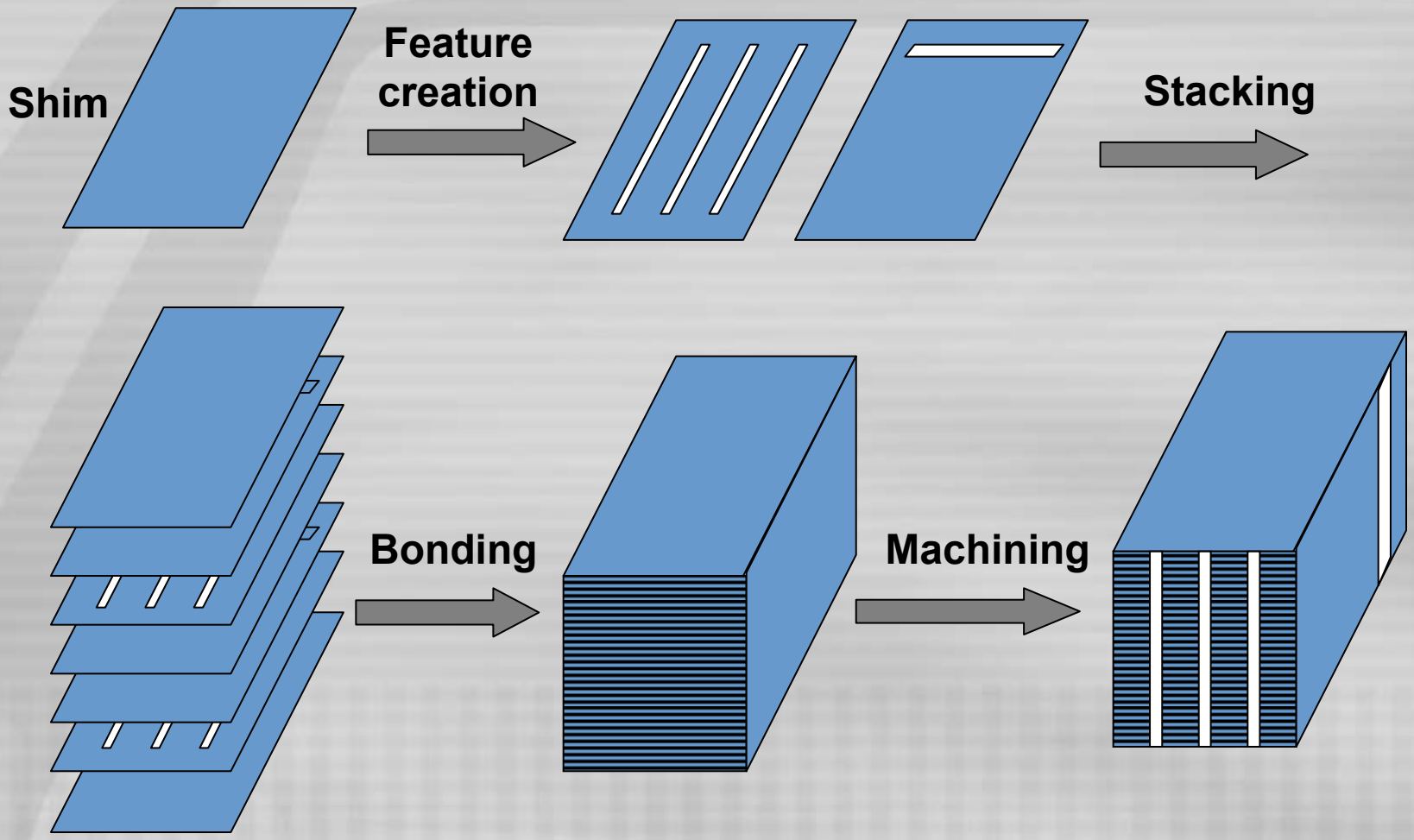
Full-Scale

- >1000 channels
- 1000-3000 lb/hr

Full-scale reactor is the basic building block of a commercial plant



Microchannel Manufacturing



Microchannel Manufacturing

Fabrication development

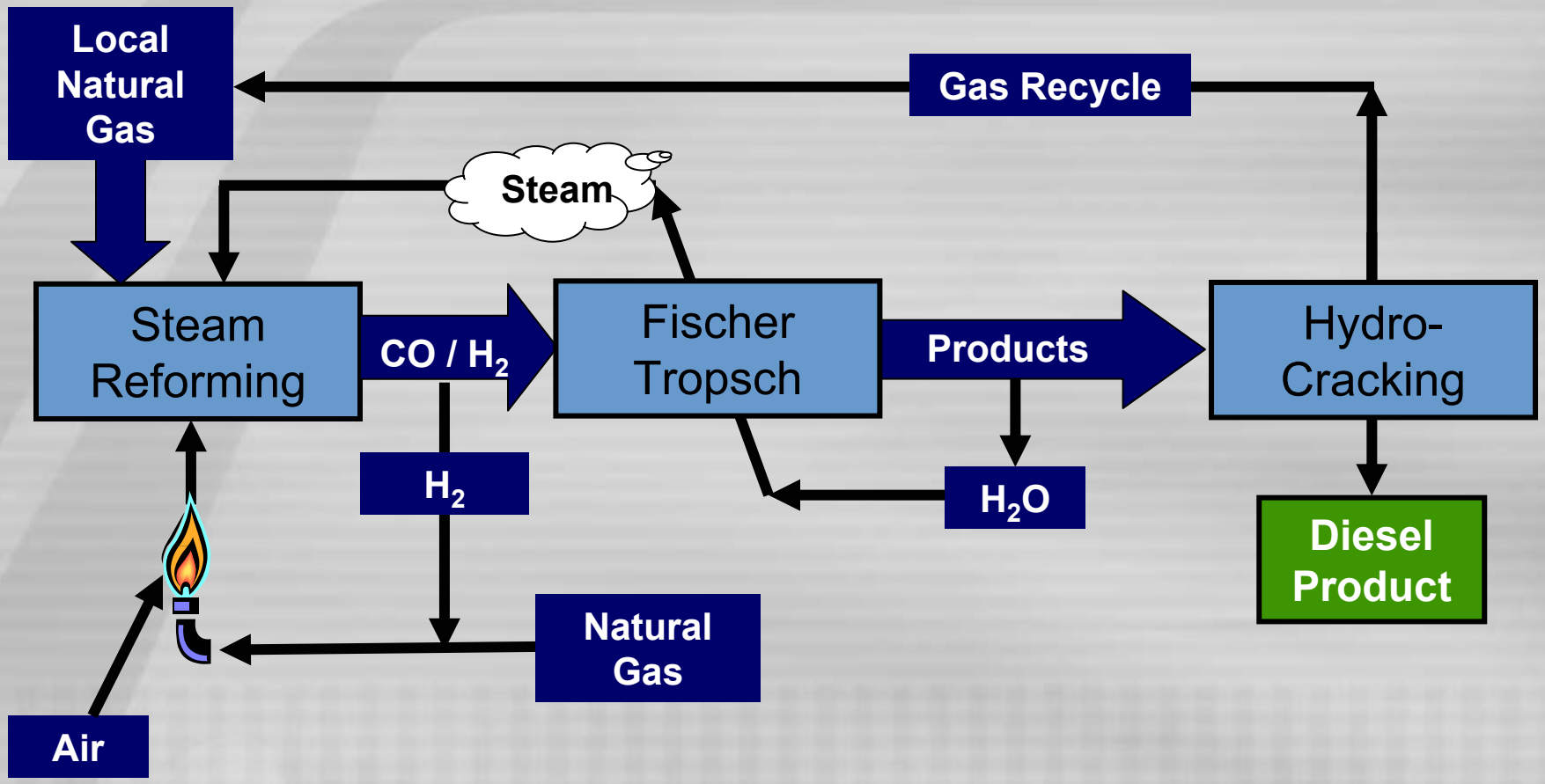
- Large stacks
  - ~ 1000 shims
- Demonstration of mass manufacturing techniques
- Established manufacturing supply chain partners

Finished Device

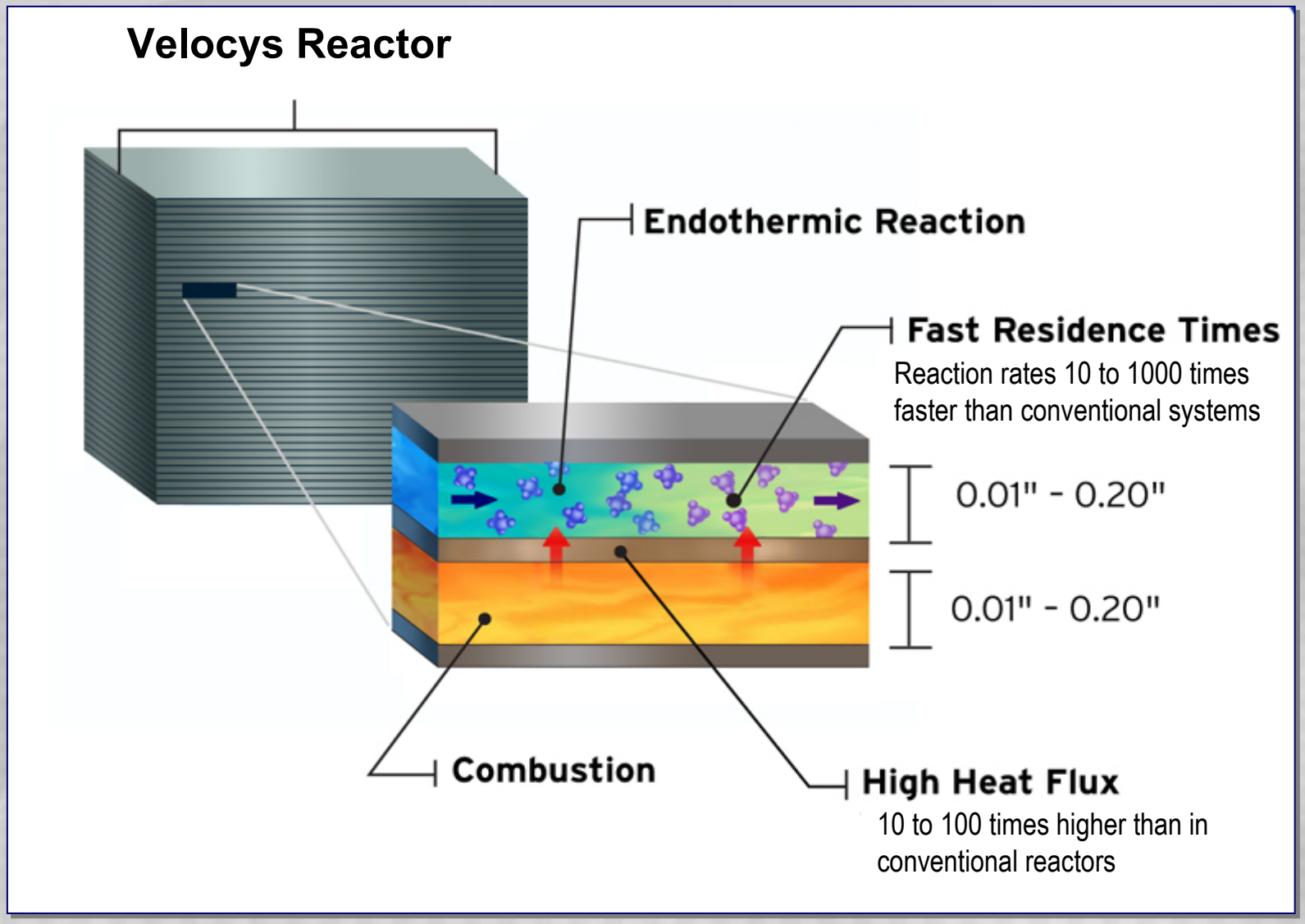
Offshore Gas Upgrading by Gas-to-Liquids Process

Producing syncrude from local natural gas resources

Reviewing the GTL Process



Velocys Steam Reformer



Advantages in Steam Reforming

Transfer heat from combustion reaction directly to reforming reaction

- Avoid high resistance of convective heat transfer
- > 20 W/cm^2 (defined by plane separating SMR and combustion reaction)
- > 50 W/cm^3 (defined by total reactor volume)

Intense reforming reaction

- Conventional reformer: ~1 second contact time
- Velocys reformer: <5 millisecond contact time

Transportable Modules

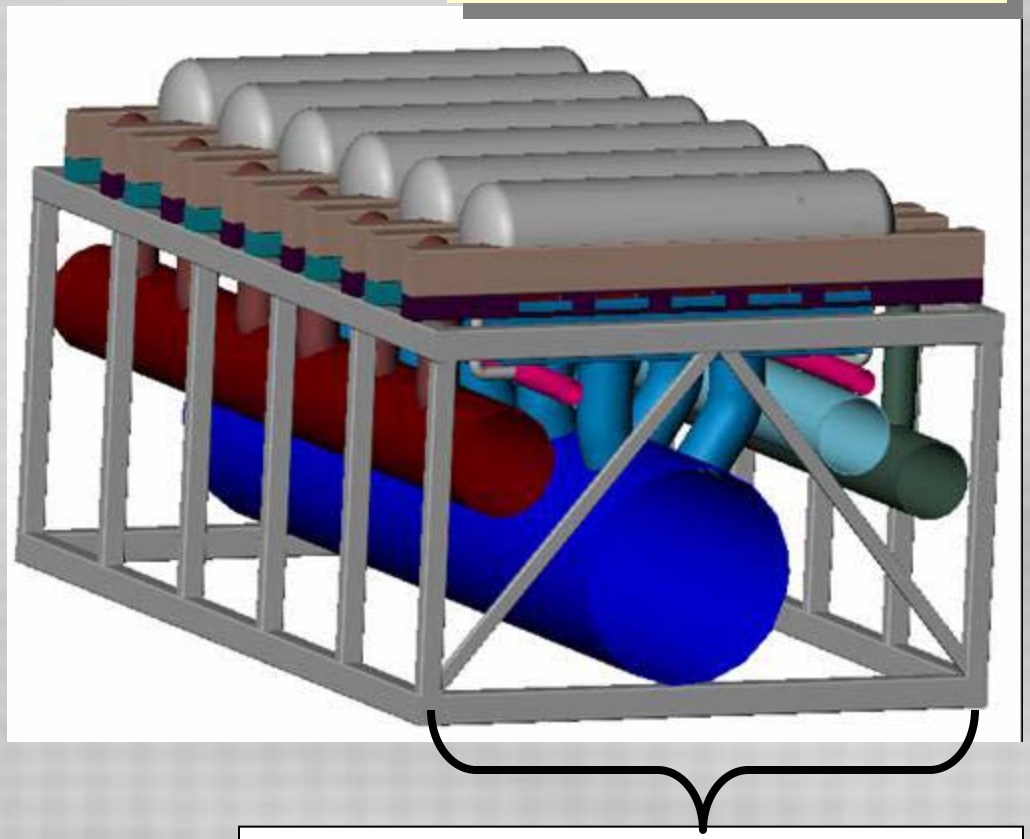
Modules can be scaled to fit on a truck or a barge depending on plant site

Flexible Capacity

- 100 - 1,000+ BPD Multi-module, transportable system

Reformer Modules

- Contain 6 reactor assemblies
- ~13 ft wide x 19 ft long x 13 ft high
- approx 40-50 tons
- 2,000 – 3,000 bpd of GTL fuels



Feed and Product piping manifolds
all connections flanged on ends

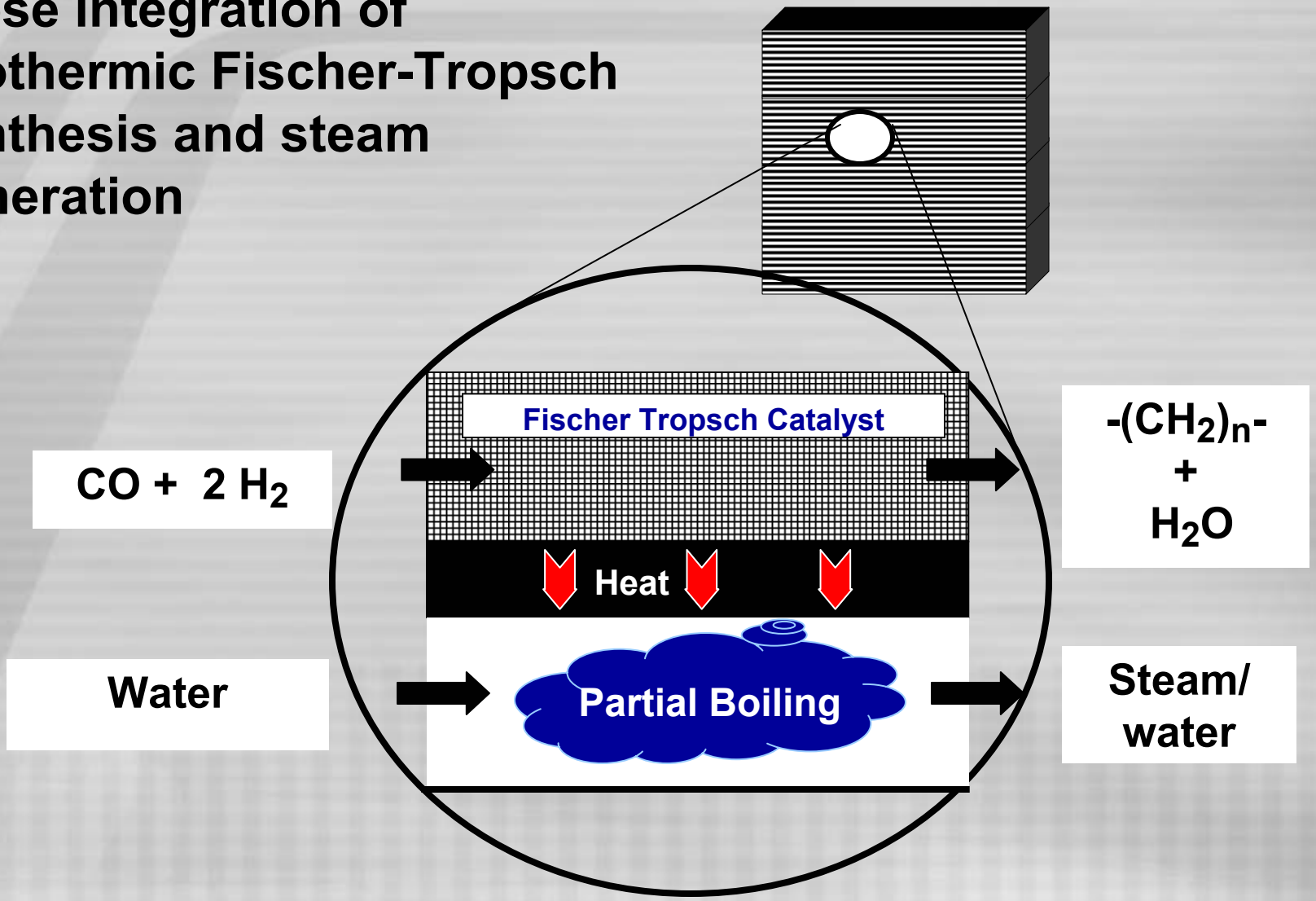
High-Capacity Microchannel Systems

High Capacity

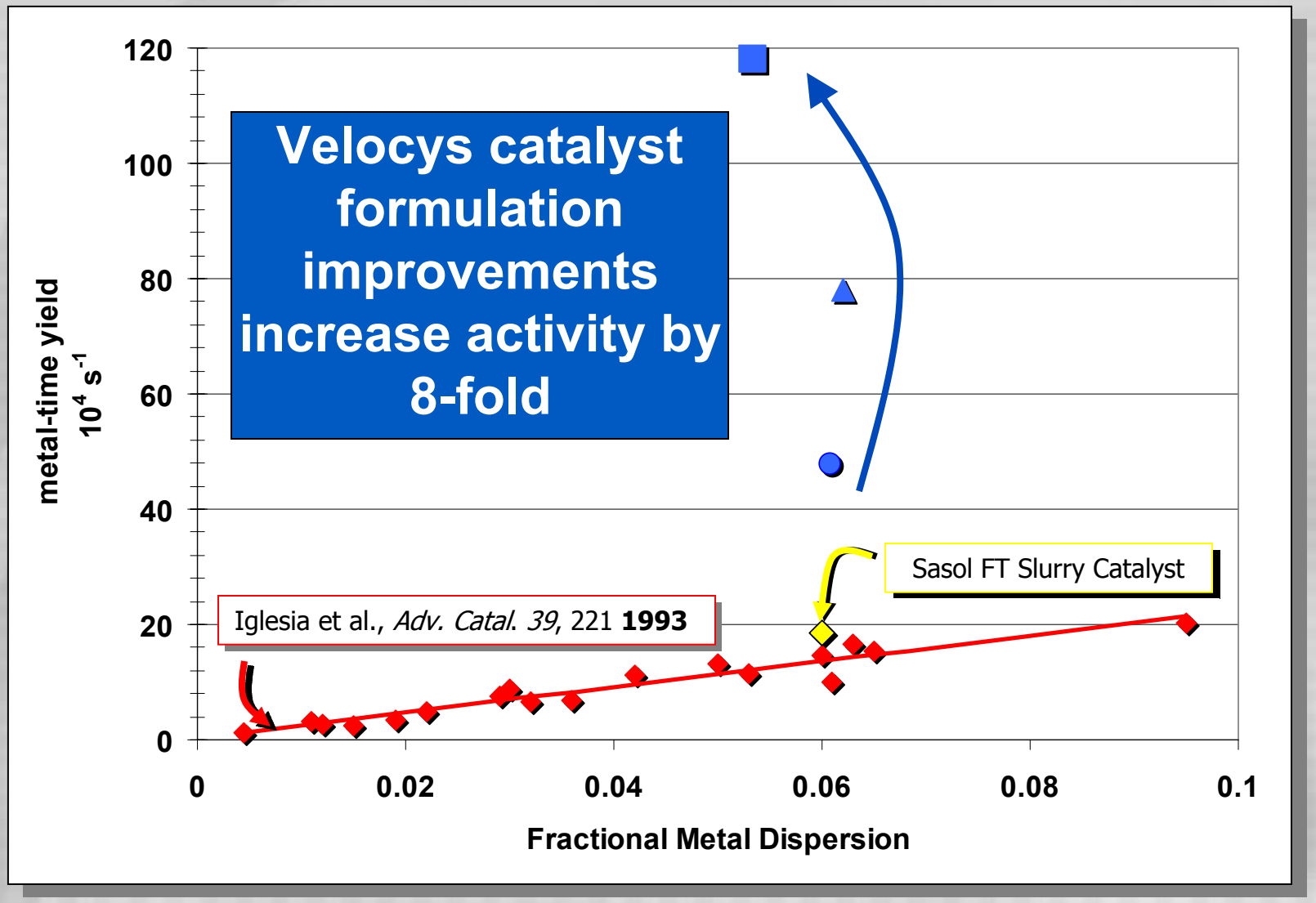
- 10,000+ BPD
- Land-based or ship mounted with conventional marine hulls
- Current design work for commercial floating, production, storage and off-loading facility
- Project completed by external engineering firm

Advantages in Fischer-Tropsch

Close integration of exothermic Fischer-Tropsch synthesis and steam generation



Catalyst Activity Improvements Enabled by Velocys Technology



Advantages in Fischer-Tropsch

Fischer-Tropsch Synthesis (highly exothermic)

- Remove heat via integrated steam generation
- Excellent temperature control enables short contact time
  - Conventional Fixed Bed: ~10 seconds
  - Velocys reactor: < 0.2 second contact time

	Slurry *	Tubular Fixed Bed *	Velocys
Capacity, bpd	**19,000**	**19,000**	**35,000**
Reactor wt, tonnes	**1,800-2,000**	**1,400-1,700**	**300-500**
Reactor productivity, bl/day/te	*10*	*12*	*85*

Velocys FT reactor efficiency is ~ 7 times conventional

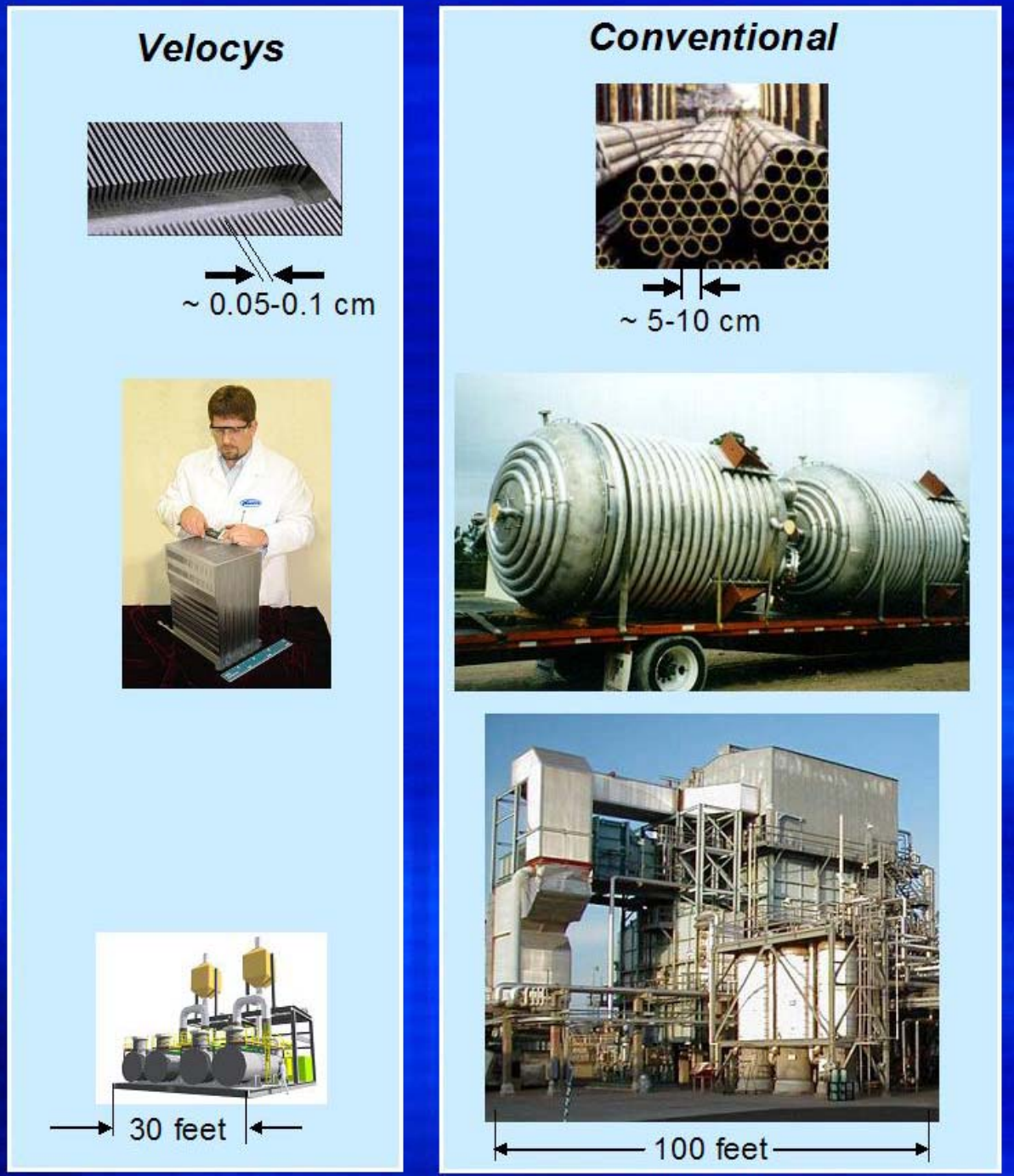
* Source: Hoek, Shell, CatCon2003

Summary

Velocys Technology will change

how, where, and at what cost

fuels and chemicals are produced



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