

GE
Global Research

Biofuels & Fuel Flexible Gasification

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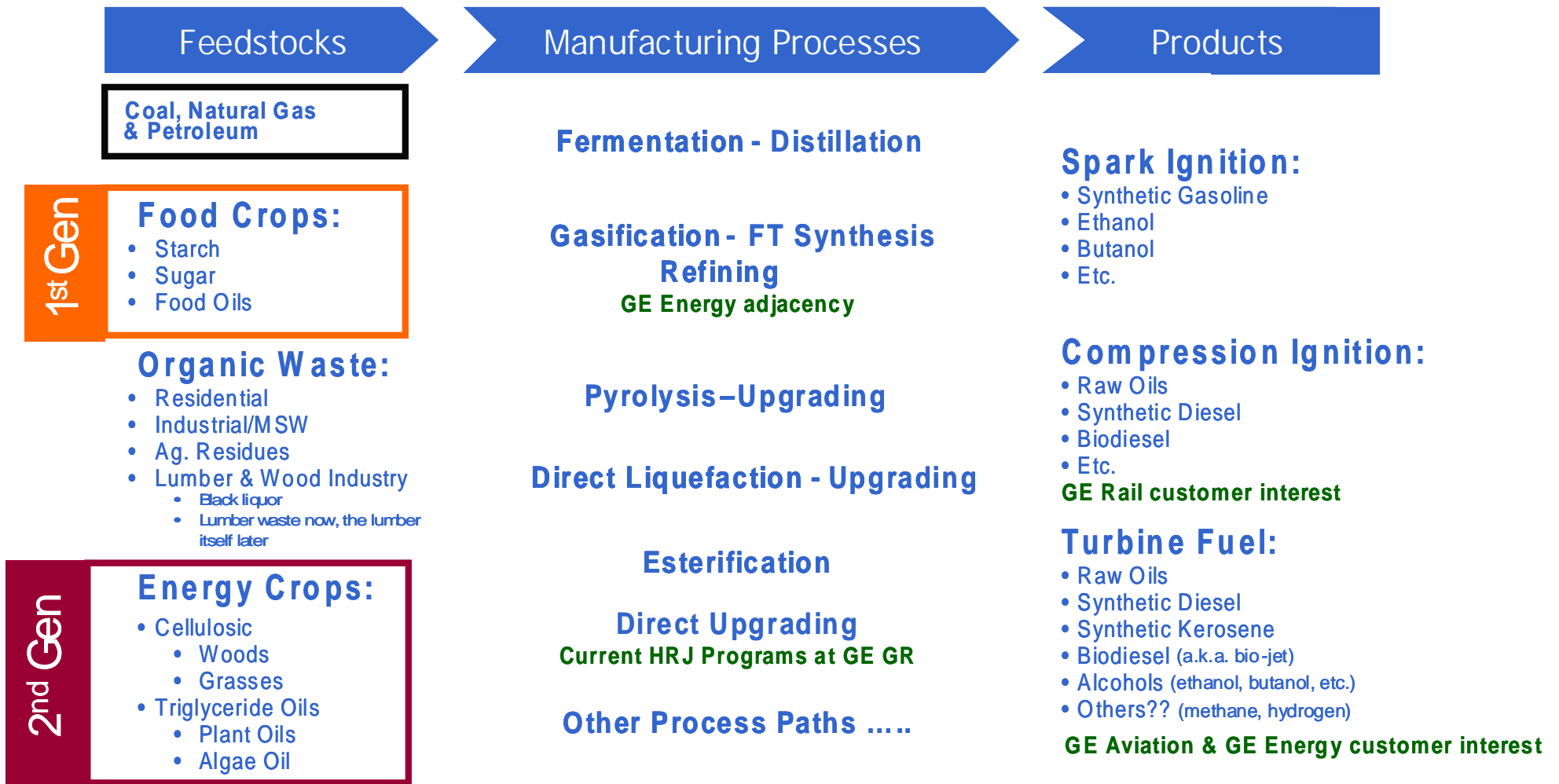


Sustainable Energy

Advanced Technology for *ecomagination*[™]



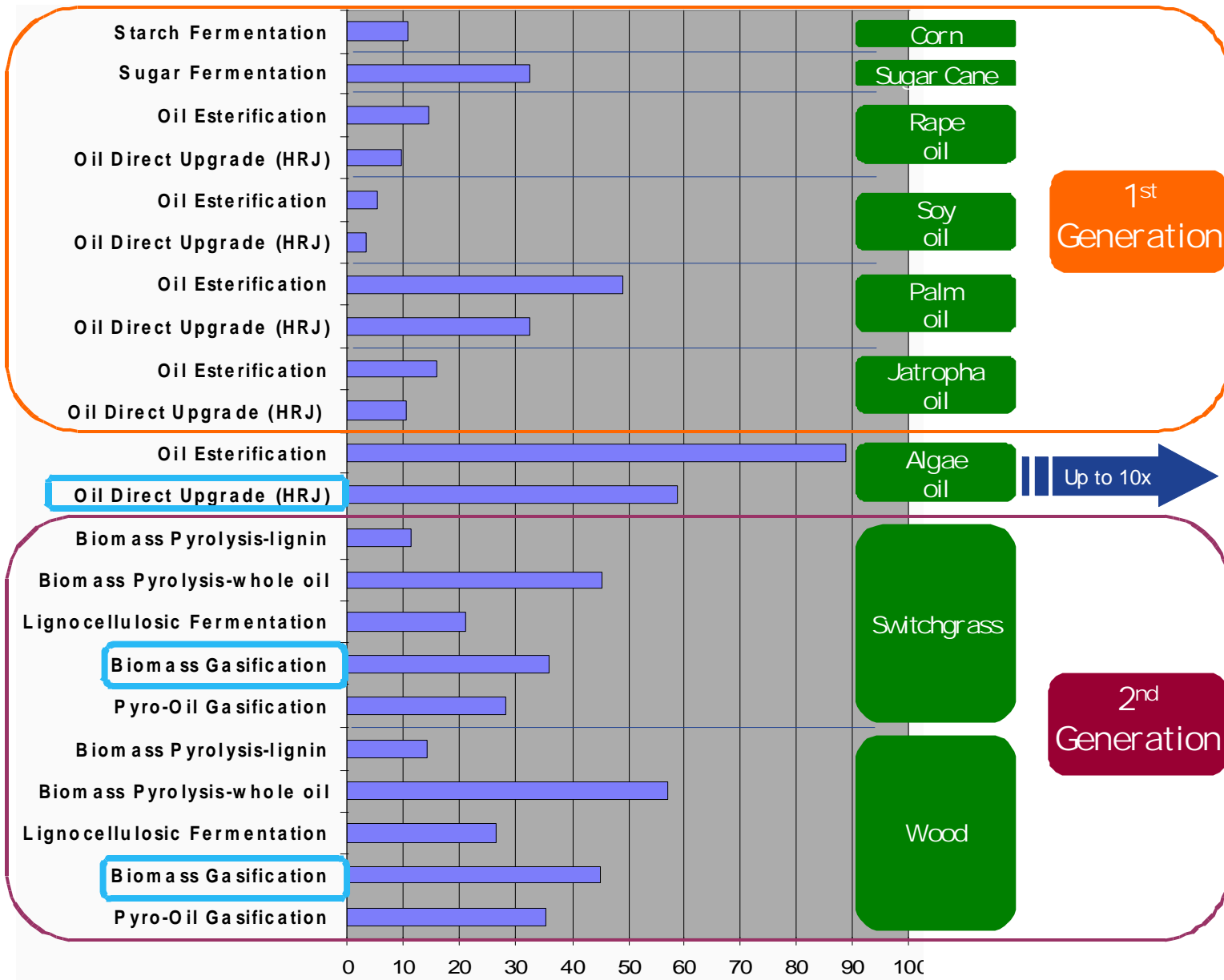
Alternative Fuels Landscape



Reduce petroleum dependency
& move to more GHG friendly fuels

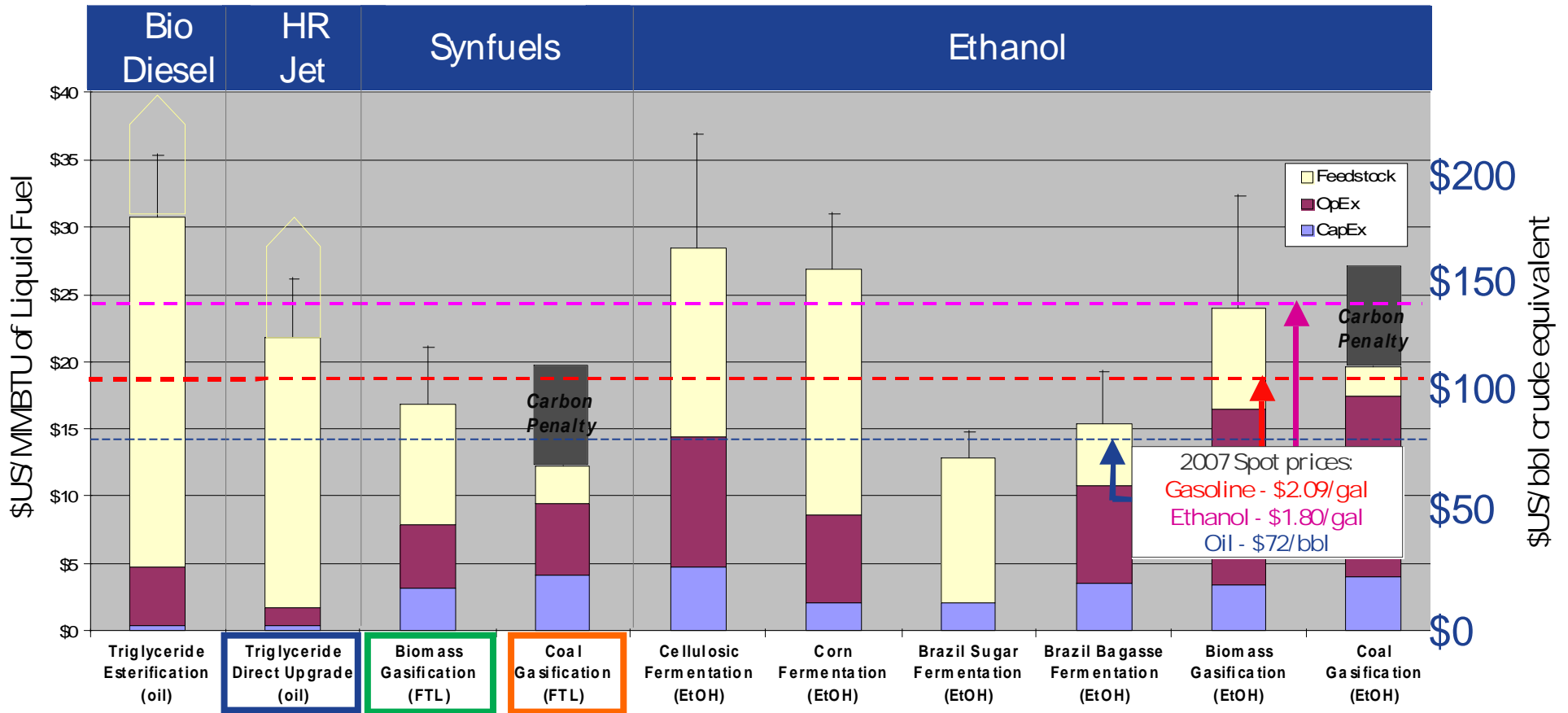
Alternative Fuels Landscape

MBTU/acre



MBtu liquid fuel/ acre-year

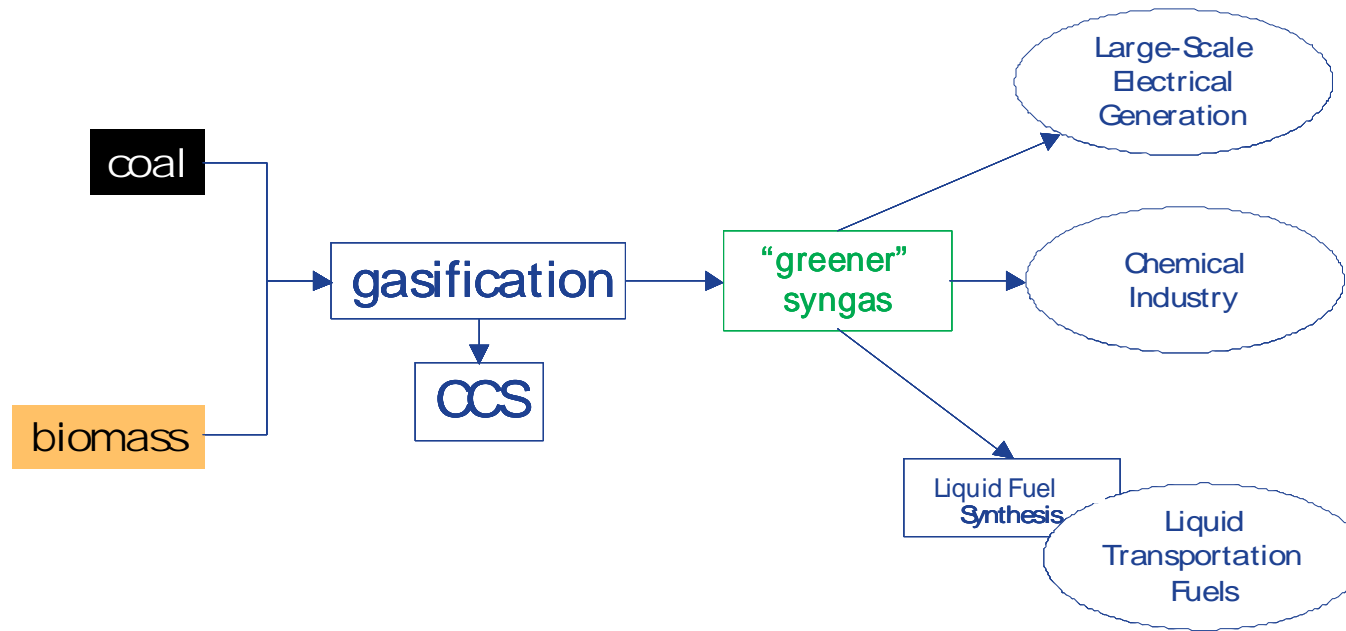
Production costs in US



- Coal-FTL is a good economic choice
But CO2 penalties a risk (\$30/ton ~ \$7 MMBTU)
- Biomass-Thermochemical is cost-competitive and low carbon
Capable of making broad range of fuels from broad range of feedstocks
- HRJ is promising, costs dominated by fluctuating triglycerides feedstock cost

Technology for Greener Syngas

Feeding GE's commercial gasifier products with coal+biomass blends



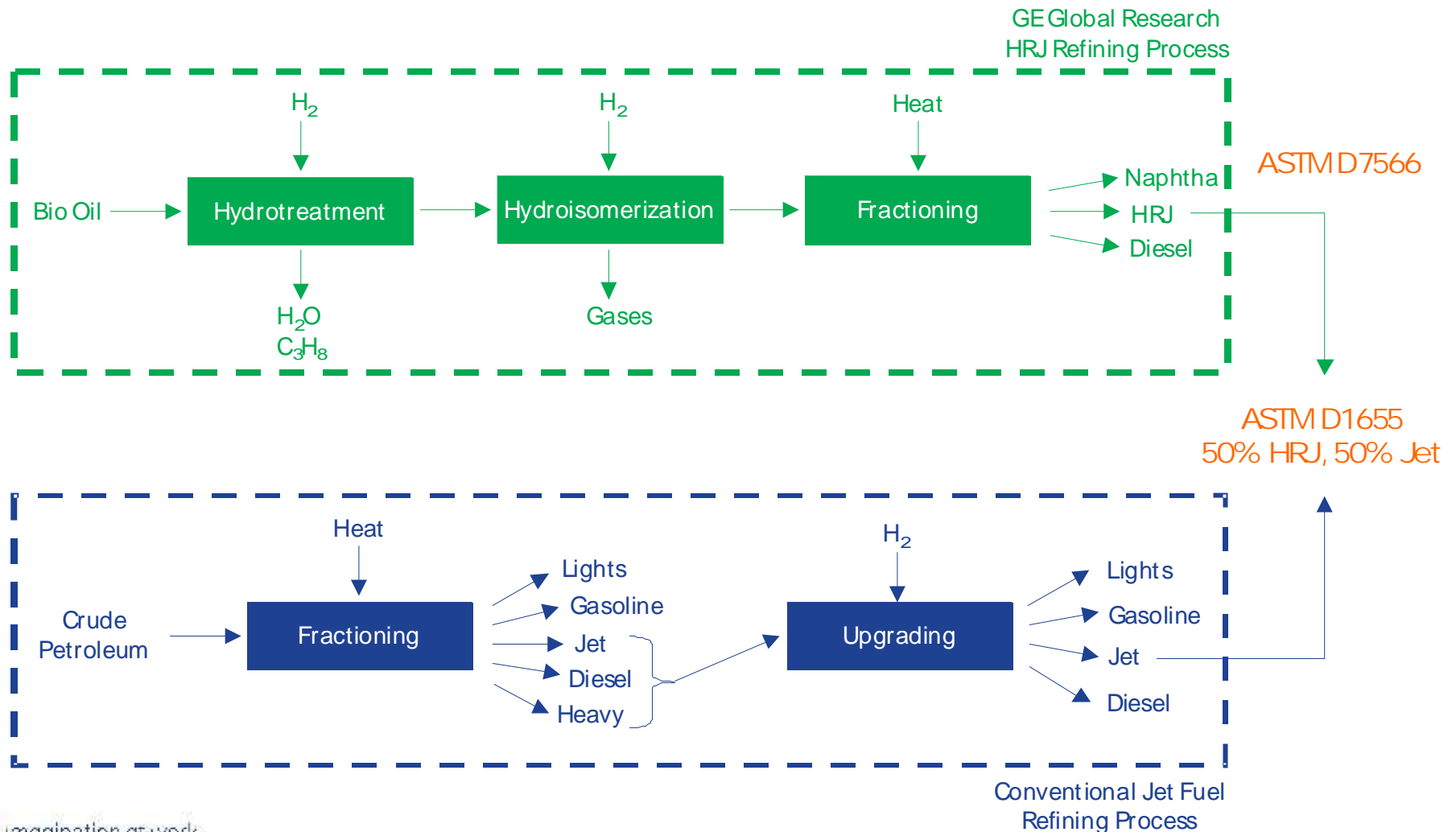
- Evaluate technical challenges of biomass in current equipment
 - Internal work with GRC and GE Energy
 - DOE/CBTL contracts for dry feeding & syngas characterization
- Evaluate needs for different scale gasification system / other elements
- Develop collaborations with front-end & back-end suppliers

Technology for BioOil to Jet (BOTJ)

DARPA program to convert plant oils to JP-8



Objective: *Develop energy efficient process for converting plant based oils to JP-8*



Comparison of Gasification / Fisher Tropsch with Bio Jet

CBTL



Wide range of biomass feedstocks (& coal)

Capital Cost High (100% biomass through gasifier)

Competitive operating cost

Proven Technology

FT wax requires upgrading for use as Jet/ diesel/ gasoline.

Likely Stand Alone Plant

Bio Oil Process

Process limited to oil producing crops/ algae

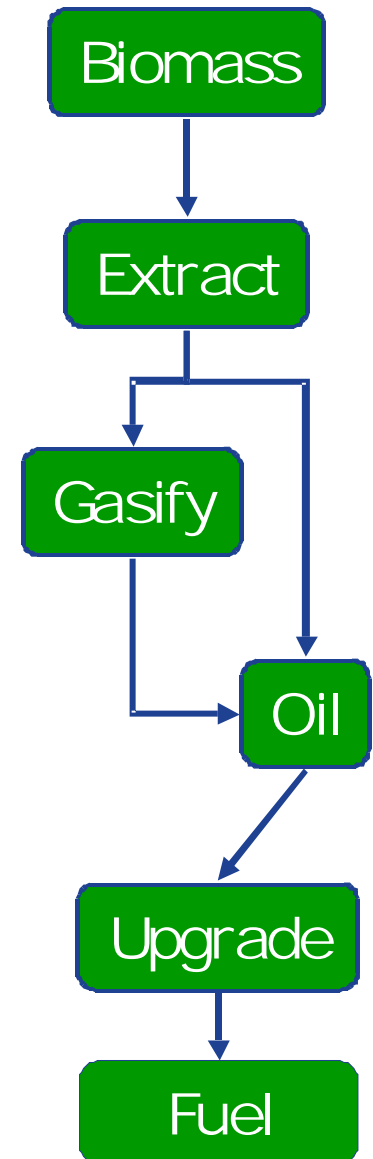
Capital Cost Low (85% biomass bypasses gasifier)

High operating cost (feedstock = bio-oil)

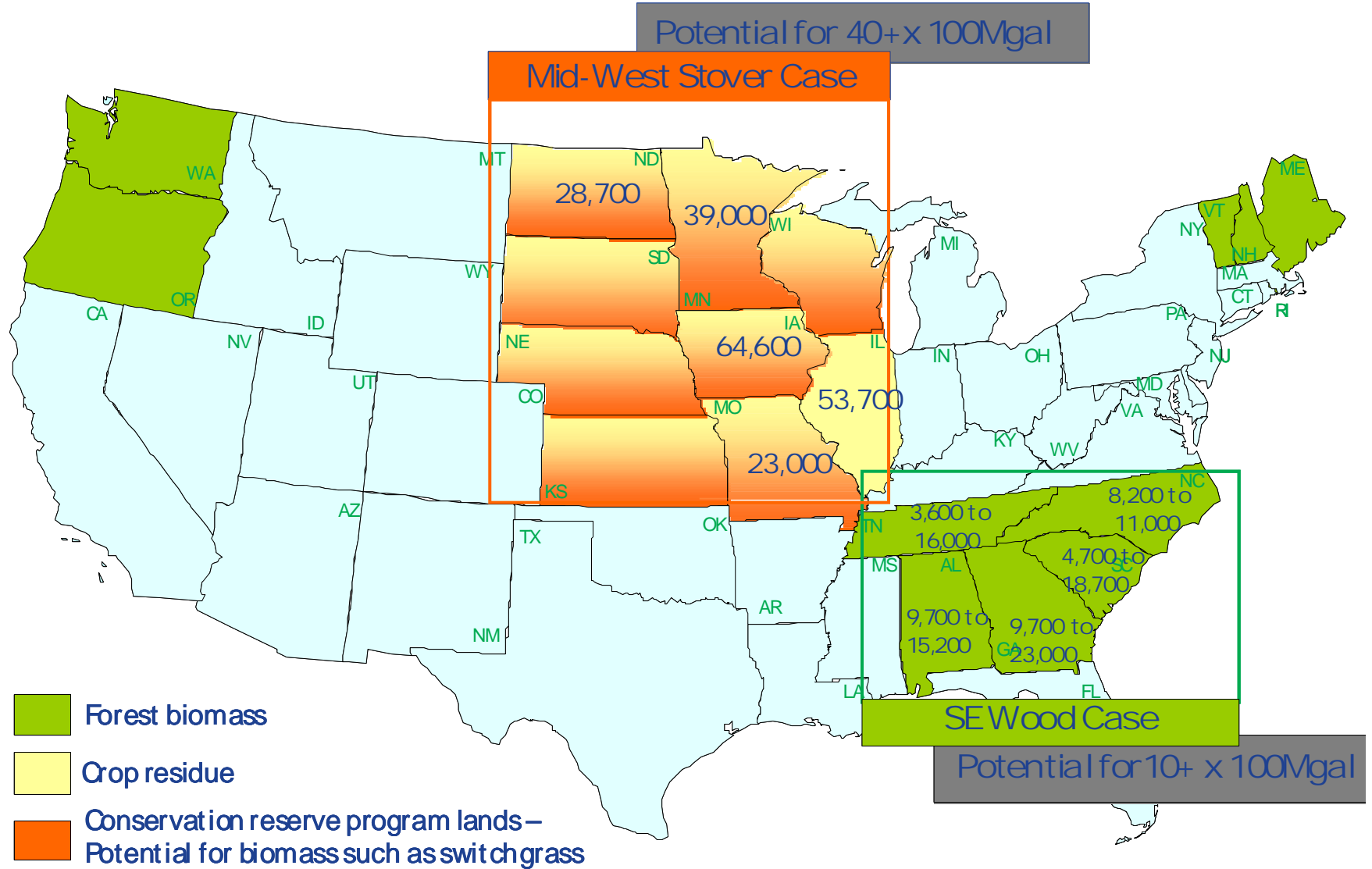
Technology proven in parts, but not as integrated system

Hydrotreating/ isom. process similar in size/ cost to FT upgrading

Stand alone plant or "green" addition to existing refinery



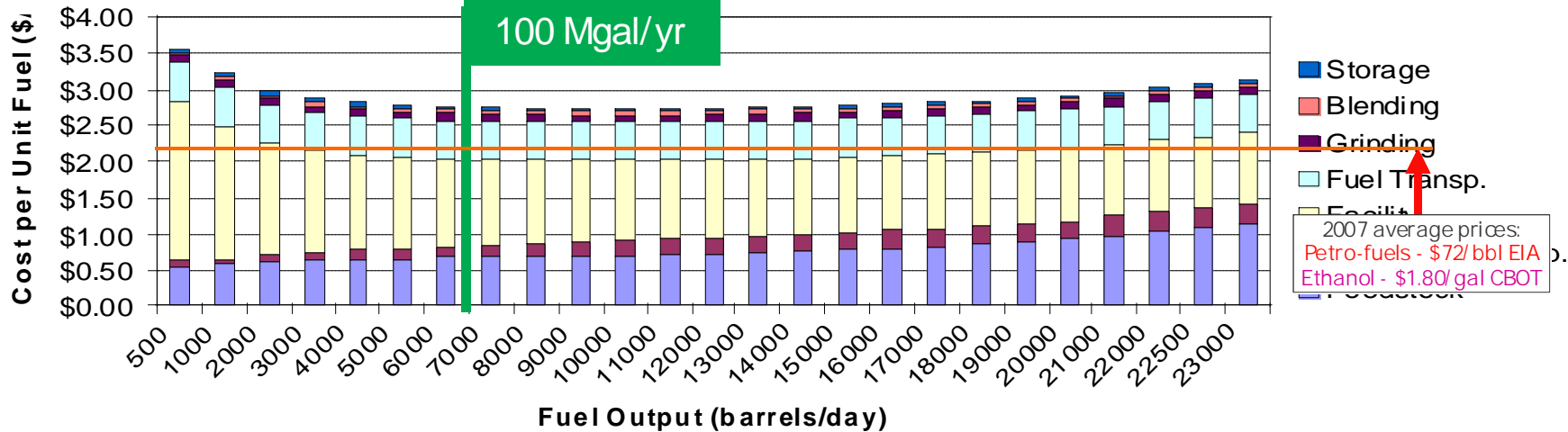
Near-Term Cellulosic Availability in USA



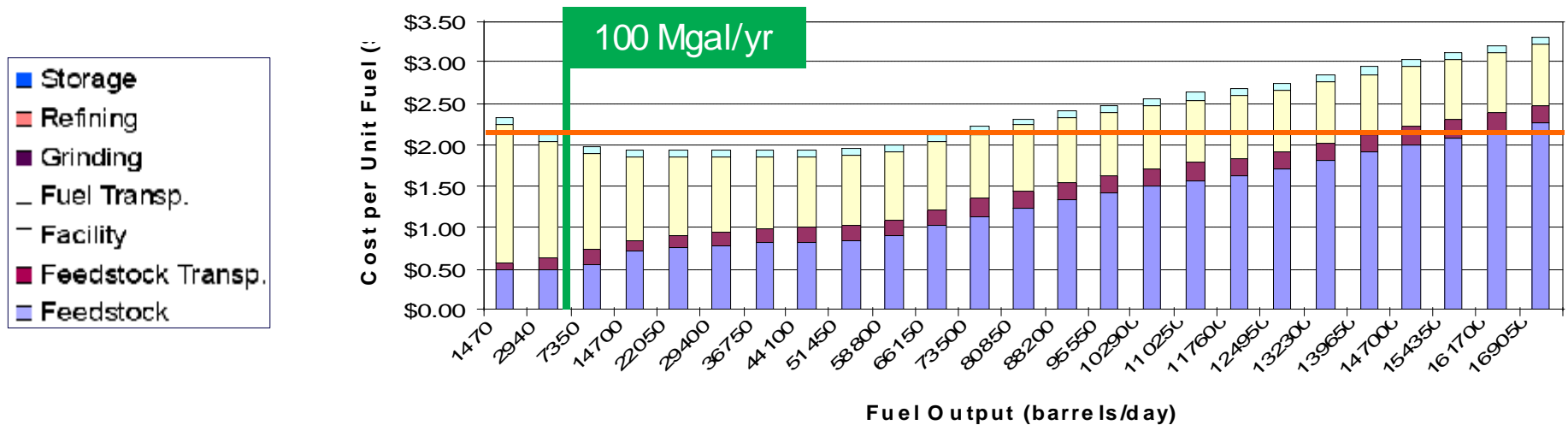
* Biomass availability in tons/day sustainable yield

Woody Biomass in USA

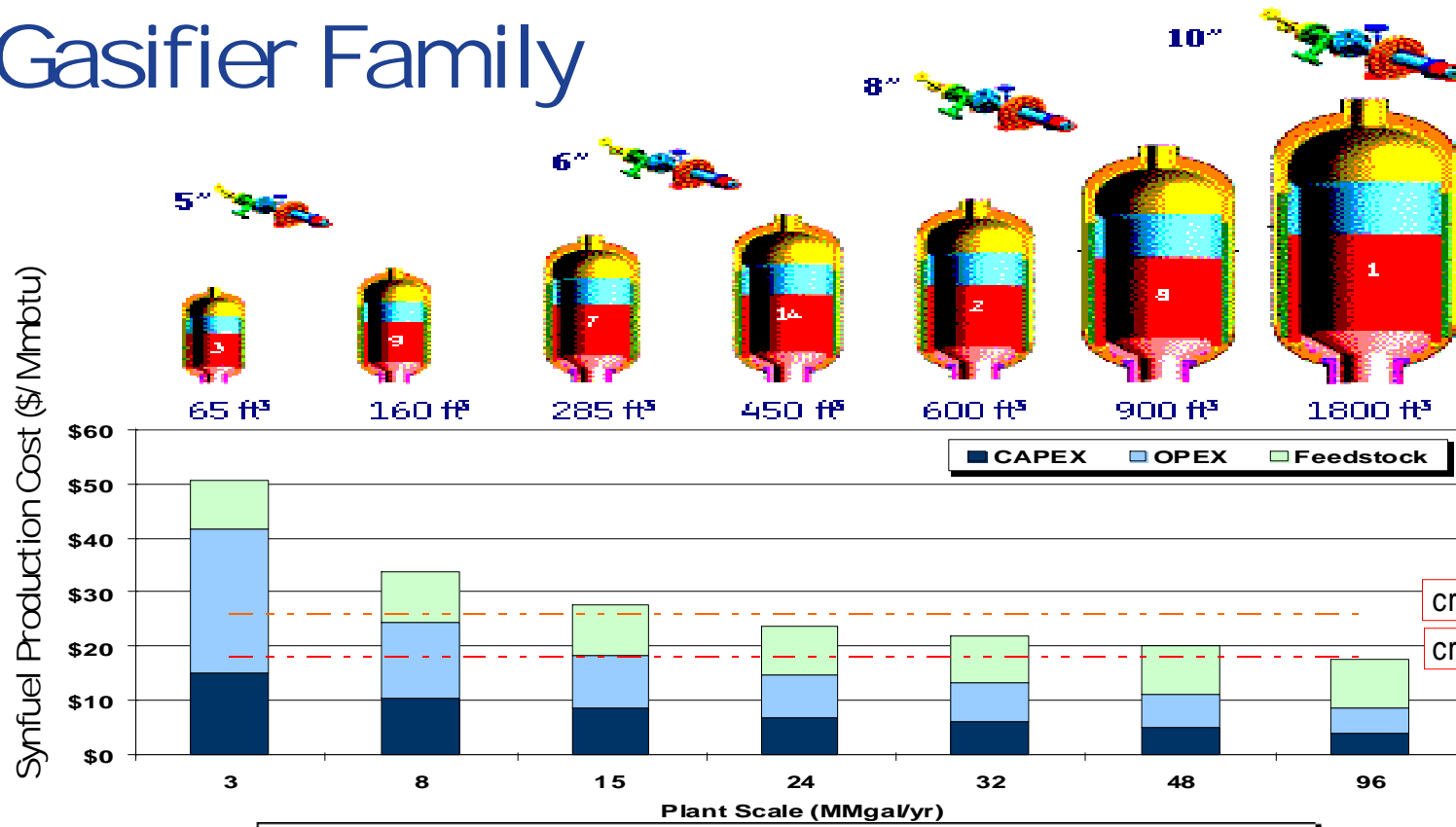
Cost Breakdown per Unit of Fuel by Scale (Auburn, ME)



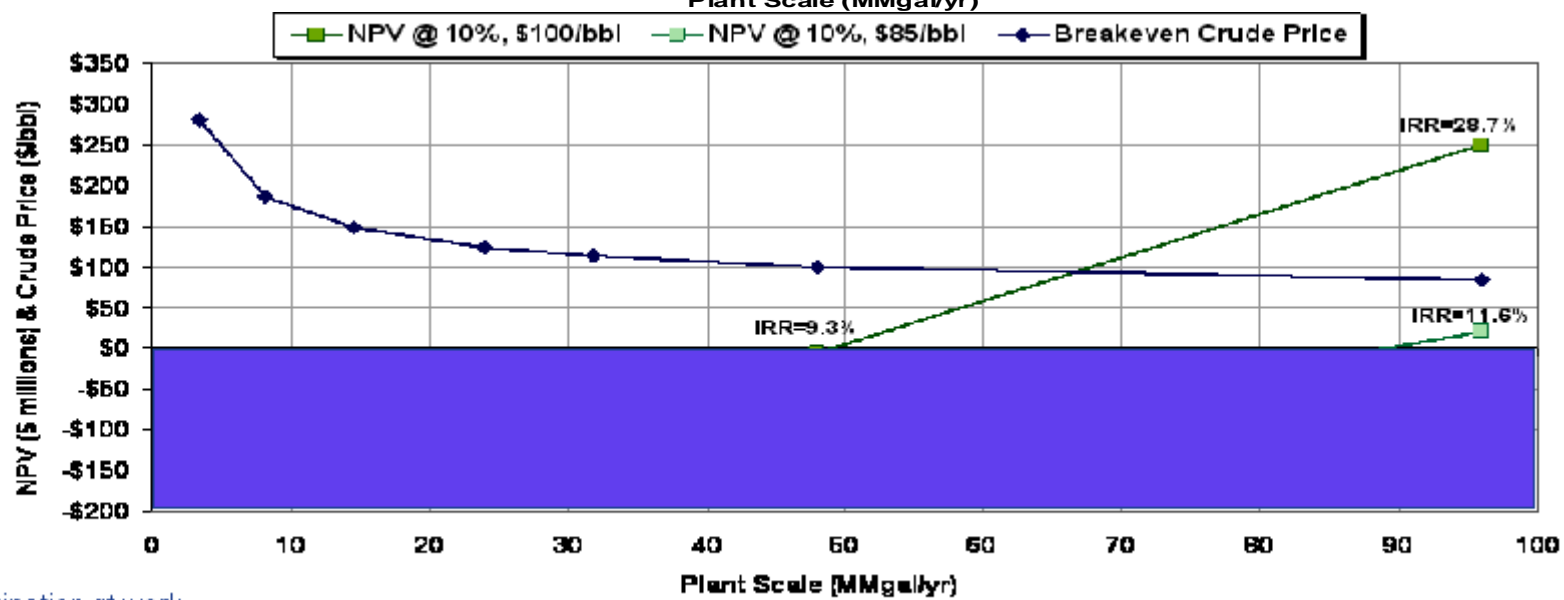
Cost Breakdown per Unit by Scale (Olympia, WA)



GE Gasifier Family



crude oil @ \$100/bbl
crude oil @ \$70/bbl



Key questions & findings

Which production path is most cost competitive?

- Sugar cane ethanol has cost advantage
- Thermochemical processes offer potential for cost-effective, low-carbon fuels
- Many emerging alternatives from biology – feedstocks & bio-conversion
- “Greener” syngas provides options, e.g., synfuels, chemicals, electricity

What is market demand for biofuels and when?

- 1st gen. cannot meet US biofuel volume targets for LDV
- Thermochemical approaches are likely to be ready sooner ..but require significant market pull to support large investment requirements
- Aviation requires “drop-in” replacement: FT-fuels & HRJ moving through ASTM

What about biomass availability?

- Logistics for biomass as a commodity not in place.. start with fuel blending
- Different cellulosic & plant oil feedstocks in different regions likely, perhaps seasonal
- Thermochemical approaches may be more feedstock flexible



imagination at work