



Refinery Integration of Renewable Feedstocks

CORINNE DRENNAN

Energy and Environment Directorate
corinne.drennan@pnnl.gov

ARB/CalSTA/Caltrans Governor's Office Five Pillars Symposium
Rethinking Transportation in California

Bioprocessing and today's infrastructure

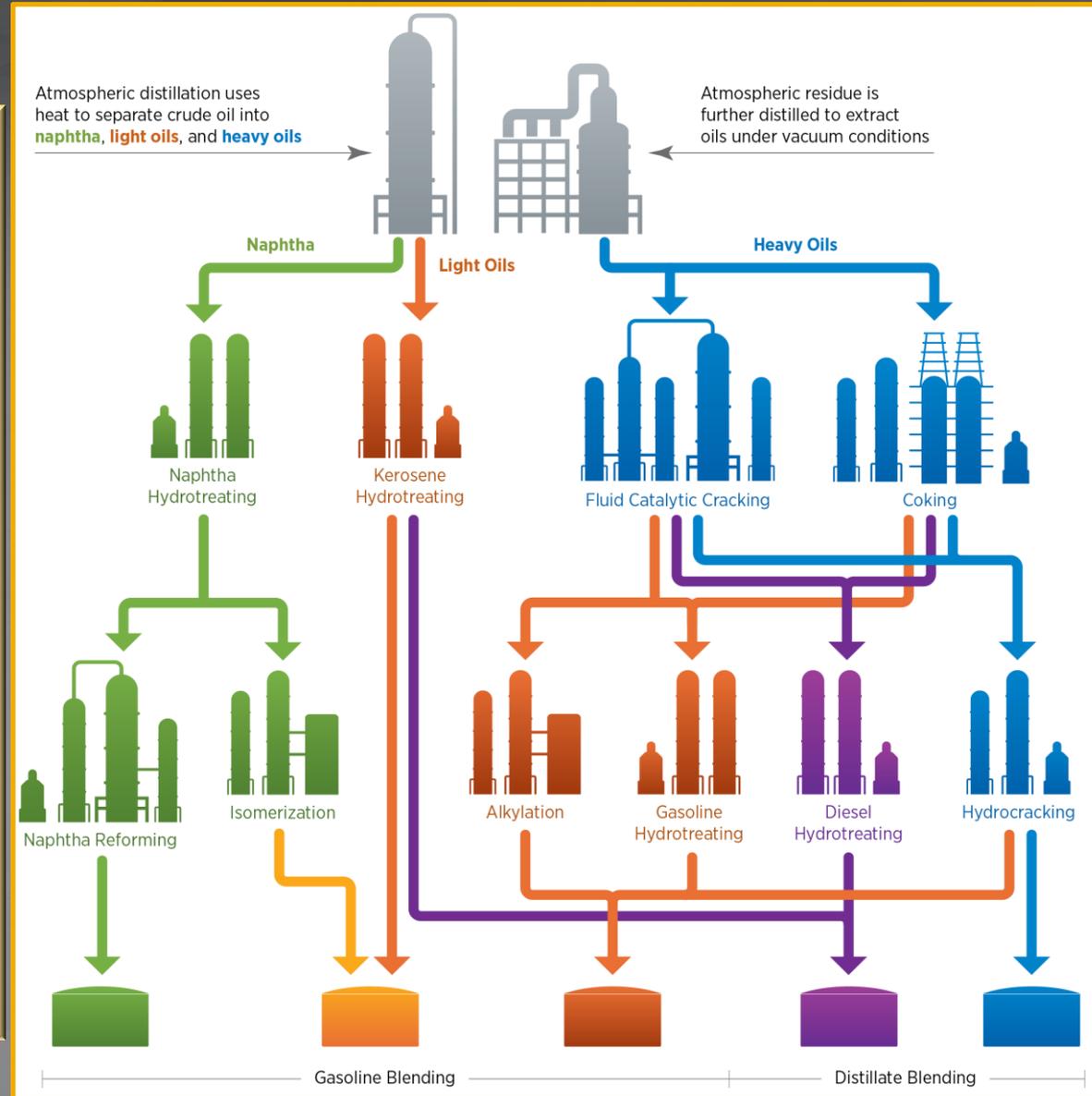
Figure Courtesy of NABC

Refining

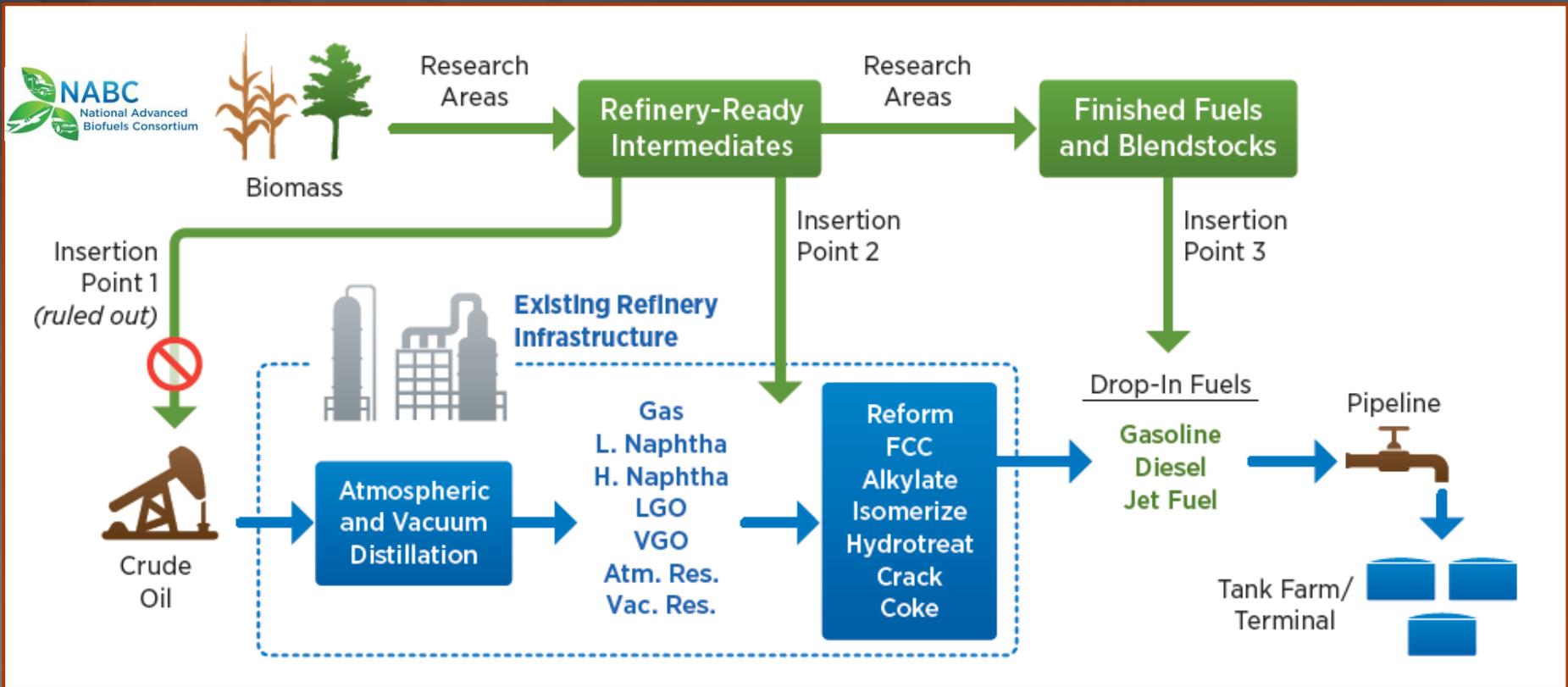
- ❖ Complex but efficient
- ❖ ~100 years experience
- ❖ ~150 refineries
- ❖ ~20 MM BPD

Scientific/technical Challenge

- ❖ Catalysts developed for the petrochemical and refining industries are generally not stable to bioprocessing
- ❖ Engineering (materials of construction, etc)



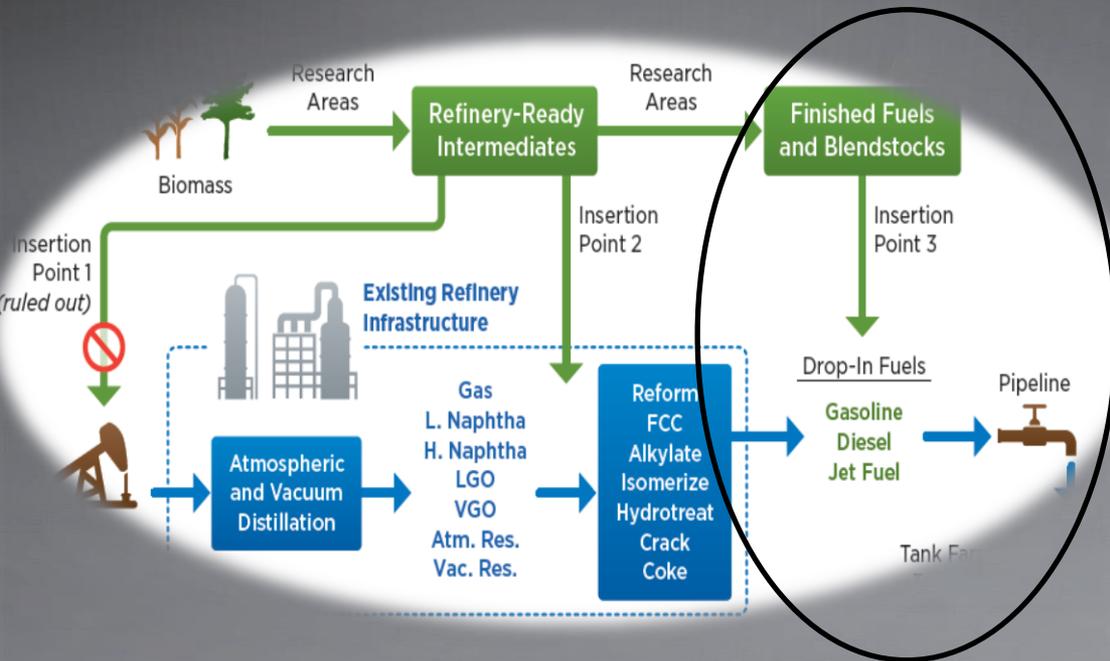
Refinery insertion points



- ❖ Renewables may be added to petroleum refineries at different locations.
- ❖ The easiest is as a blendstock (insertion point 3),
- ❖ Greater capital savings may occur if the renewables use refinery unit operations for processing (Insertion 2)

Insertion point 3

Biomass products blended into near finished fuel

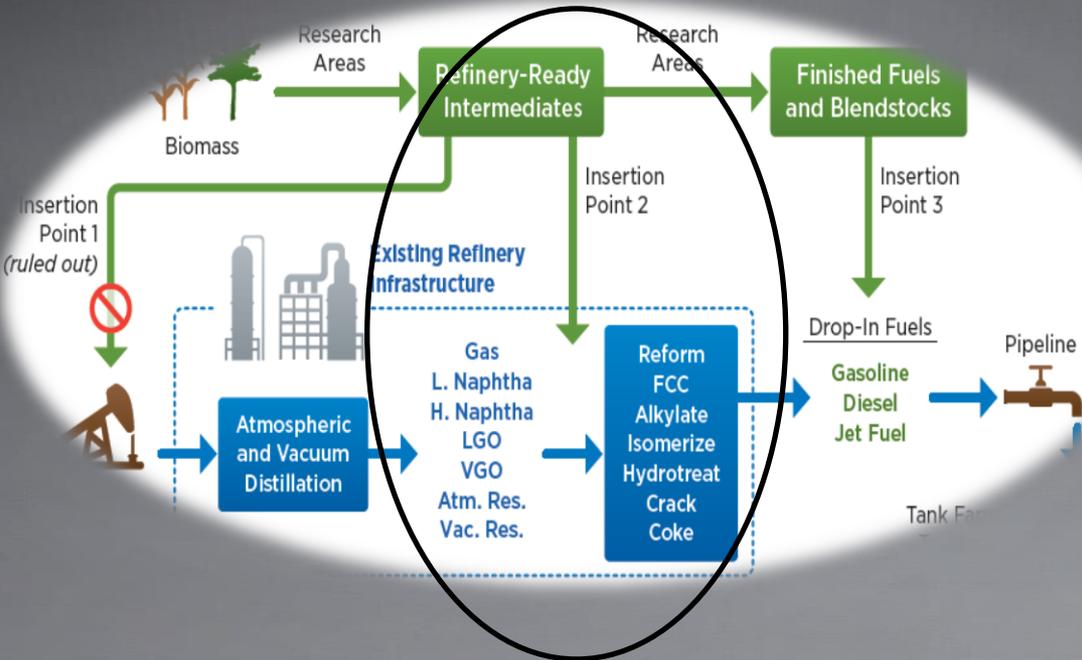


- ▶ Biomass is converted to a near-finished fuel or blendstock
- ▶ Blended component must meet all applicable standards (ASTM) for finished fuel
- ▶ Allows tailoring processes to unique properties of biomass
- ▶ Allows blending to be controlled by refiner
 - Strict rules on blending outside of the refinery may require re-testing of controlled properties

- *Allow use of infrastructure for moving fuels around*
- *The right renewable can provide value to a refinery (bringing low value refinery streams to spec)*

Insertion point 2

Biomass Intermediate is fed into facilities within the refinery



- ▶ Conversion processes
 - Hydrocrackers
 - Fluid catalytic crackers (FCC)
 - Cokers

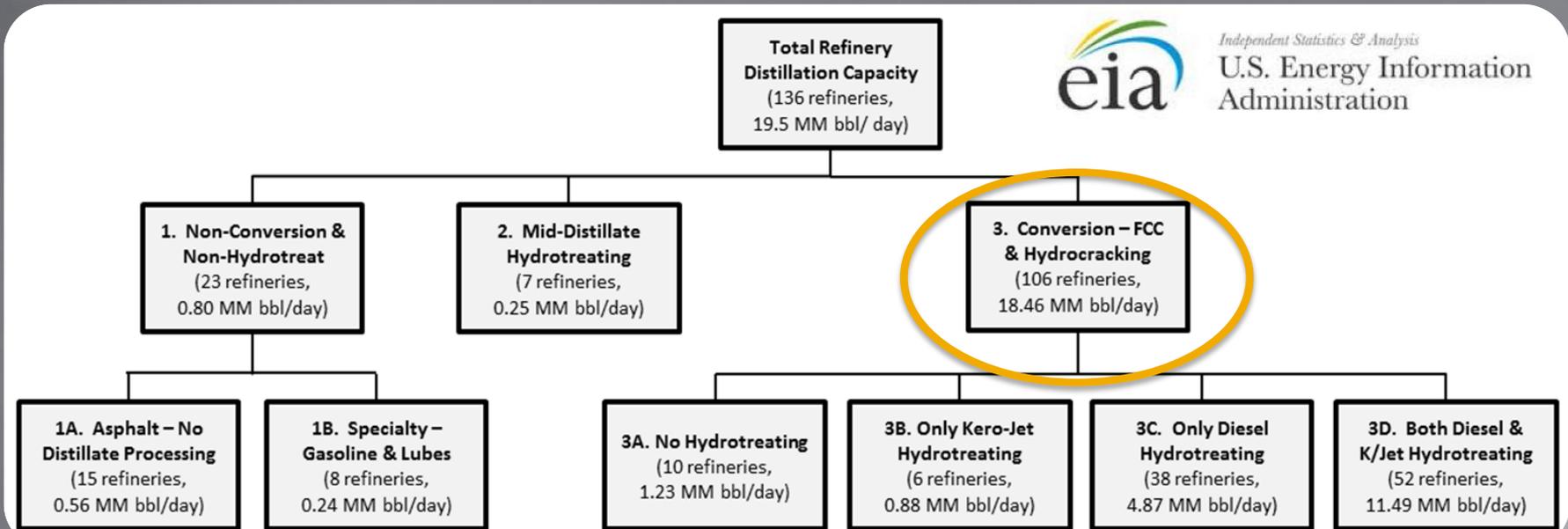
- ▶ Finishing processes

- Hydrotreating
 - Naphtha HT
 - Distillate HT
 - etc
- Specialty units
 - Isomerizing
 - Reforming
 - Alkylating

- *Must not harm catalyst or reactor (carbon steel)*
- *Product yield cannot be reduced*
- *Product quality cannot be compromised*

High-level impact assessment

- ▶ What refining capacities and capabilities currently exist in the US?
 - Per EIA, 149 refineries total, 136 sufficiently detailed
 - ~20 million barrels/day total capacity (136 refineries)
 - Categorized into three main types:
 - Non-conversion & non-hydrotreating
 - Middle-distillate hydrotreating capability
 - Full conversion – fluidized catalytic cracking and hydrocracking



Survey of projected 2022 biomass availability near petroleum refineries



Pacific Northwest
NATIONAL LABORATORY

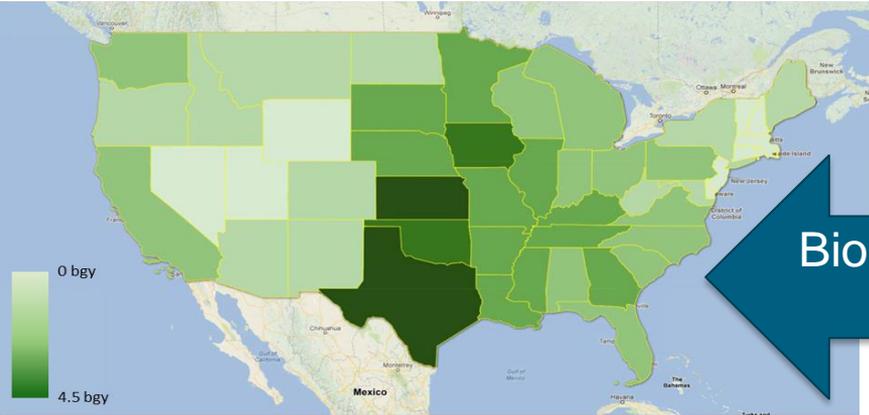
Proudly Operated by **Battelle** Since 1965

Q: Proximity of biomass suitable for 20% co-processing?

Refinery locations



Bio-oil production in 2022*

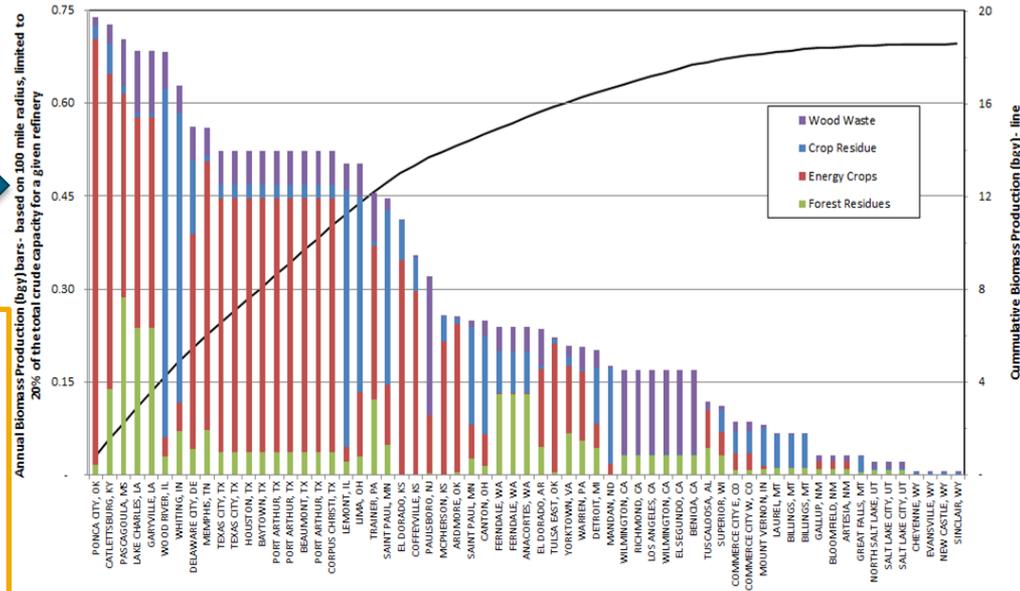


Refinery sites with highest likelihood of biofuel production**

* 20% additional yield loss
\$60/ton farm gate
85 gal/dry ton conversion

**US refinery sites with highest est. fuel volumes
100 mile radius around each refinery
FCC and HCK refineries only (Cat 3)
Equiv. biofuel intermediate into any refinery limited to 20% of total crude capacity

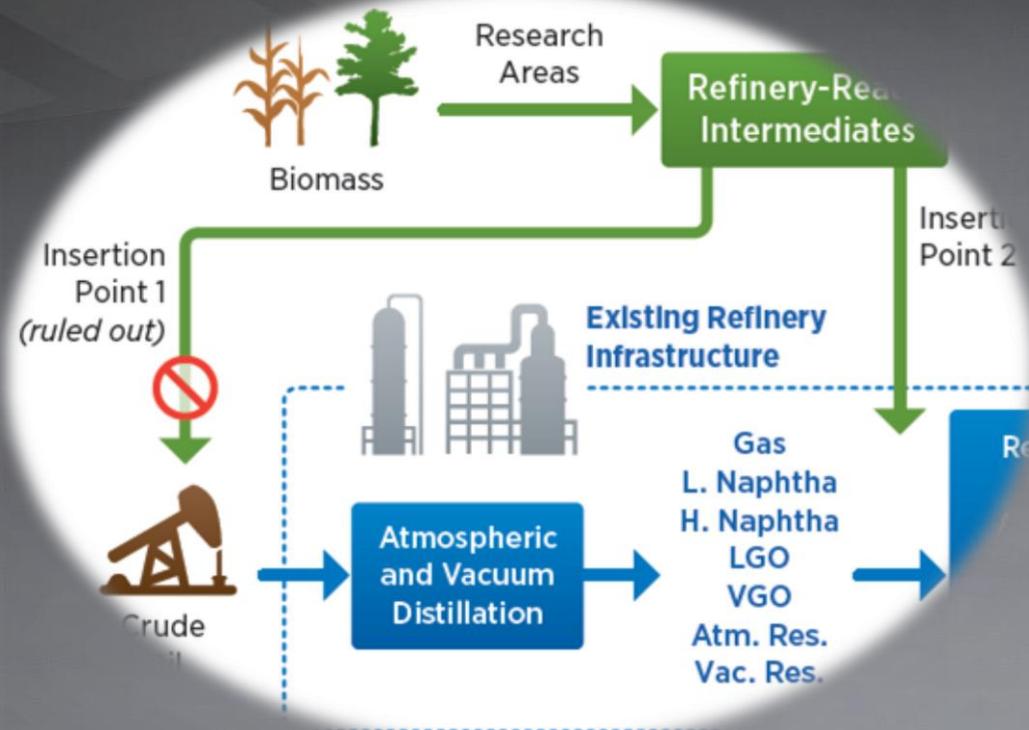
A: Initial look suggests refineries & biomass may fit



Renewables must offer...

- ❖ Safety
- ❖ Reliability
- ❖ Predictability
- ❖ Profitability

Insertion point 1



- ▶ Crude units separate molecules
 - do not chemically alter the material that they process
- ▶ Contaminants would be spread throughout the refinery
 - Rather than be concentrated into facilities that are best able to handle these materials
- ▶ Many refineries produce jet fuel directly from the crude unit

Insertion point 1 (blending renewable materials into crude) is not viable unless the material is essentially purely composed of carbon and hydrogen, with minimal levels of olefins