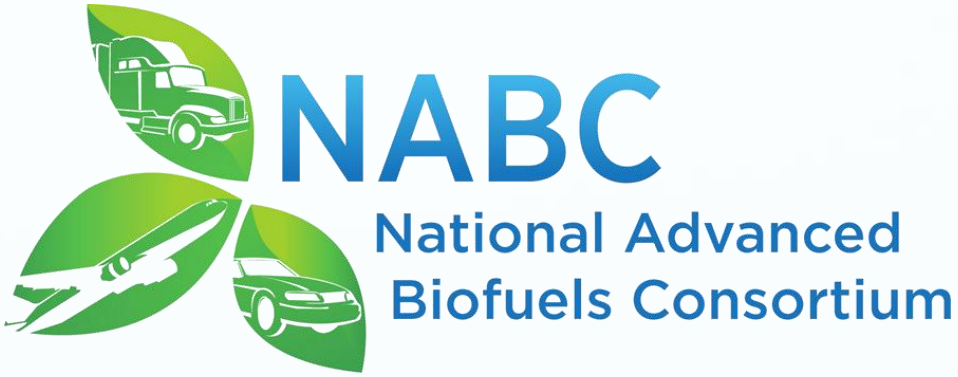

Integrating NABC bio-oil intermediates into the petroleum refinery

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Biomass 2013

Session 2-D: Working Together: Conventional Refineries and Bio-Oil R&D Technologies

NABC
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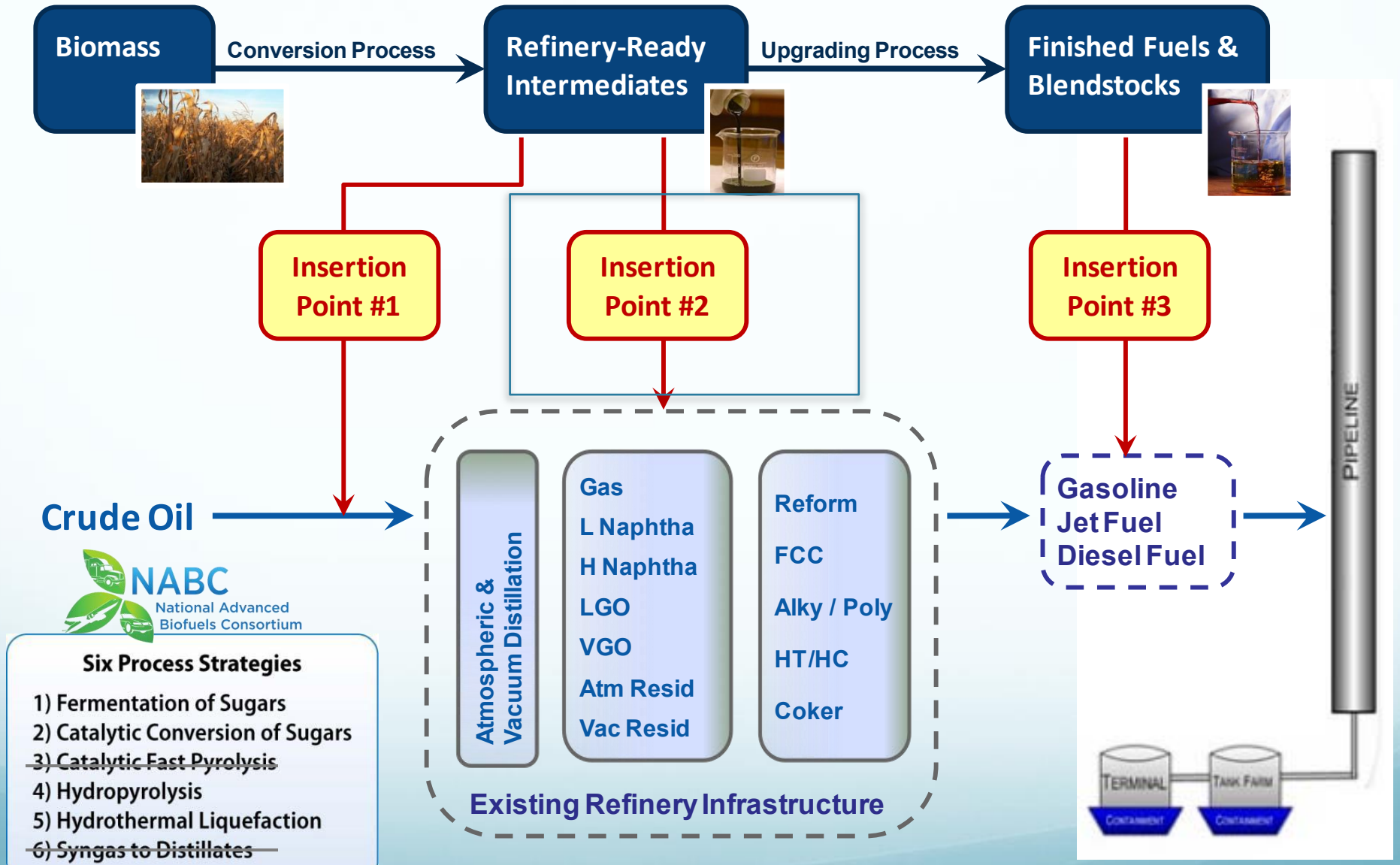
Biofuels Consortium

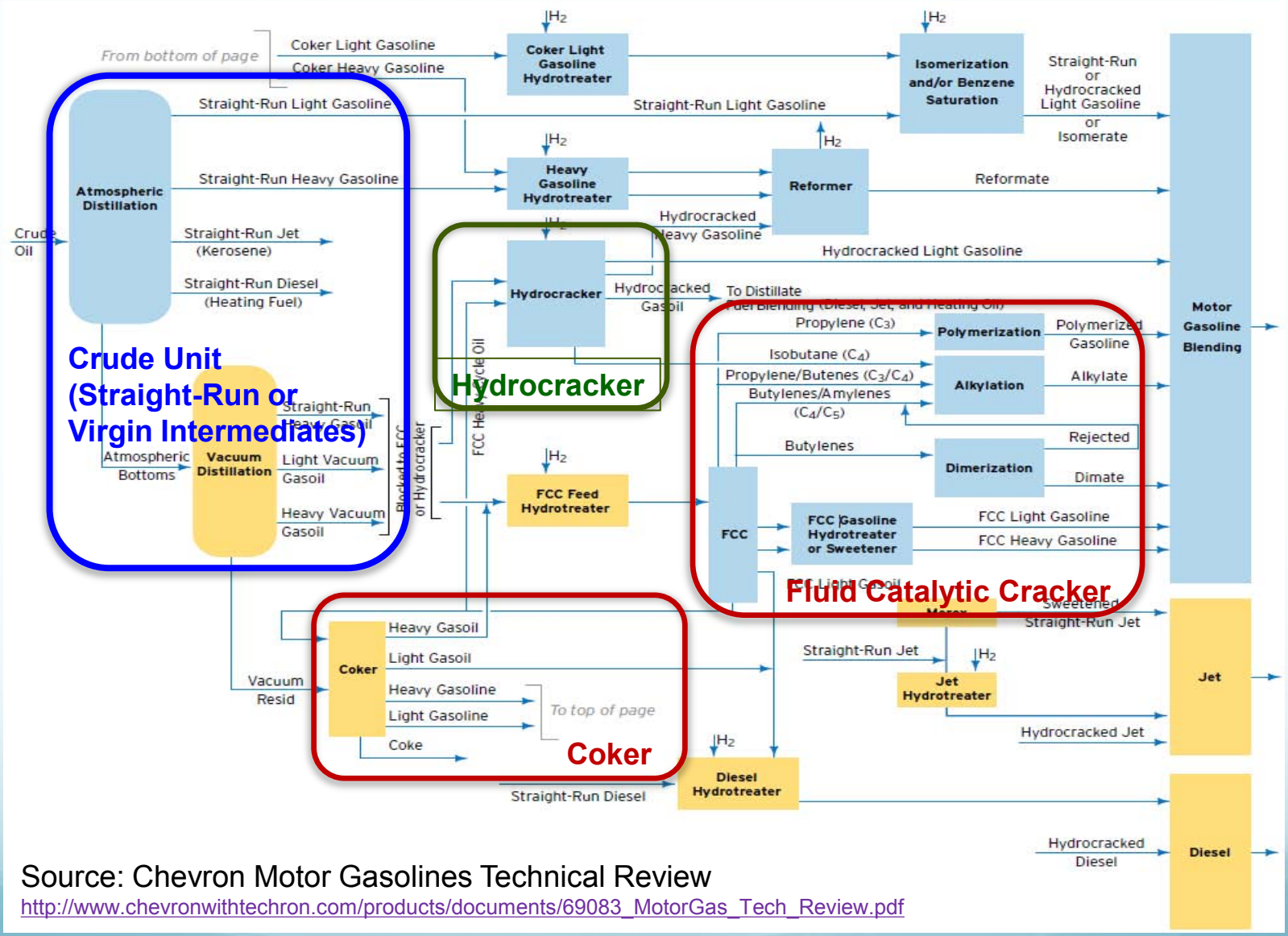
Agenda

- Petroleum refinery overview
- Bulk property comparison between NABC bio-oil intermediates and petroleum refinery materials (intermediates, blendstocks and finished fuels).
- Progress in developing a gasoline and diesel blending model to incorporate bio-products.

NABC Infrastructure Compatibility Strategy



Petroleum Refinery Overview



Source: Chevron Motor Gasolines Technical Review
http://www.chevronwithtechron.com/products/documents/69083_MotorGas_Tech_Review.pdf

Bulk Property Comparison

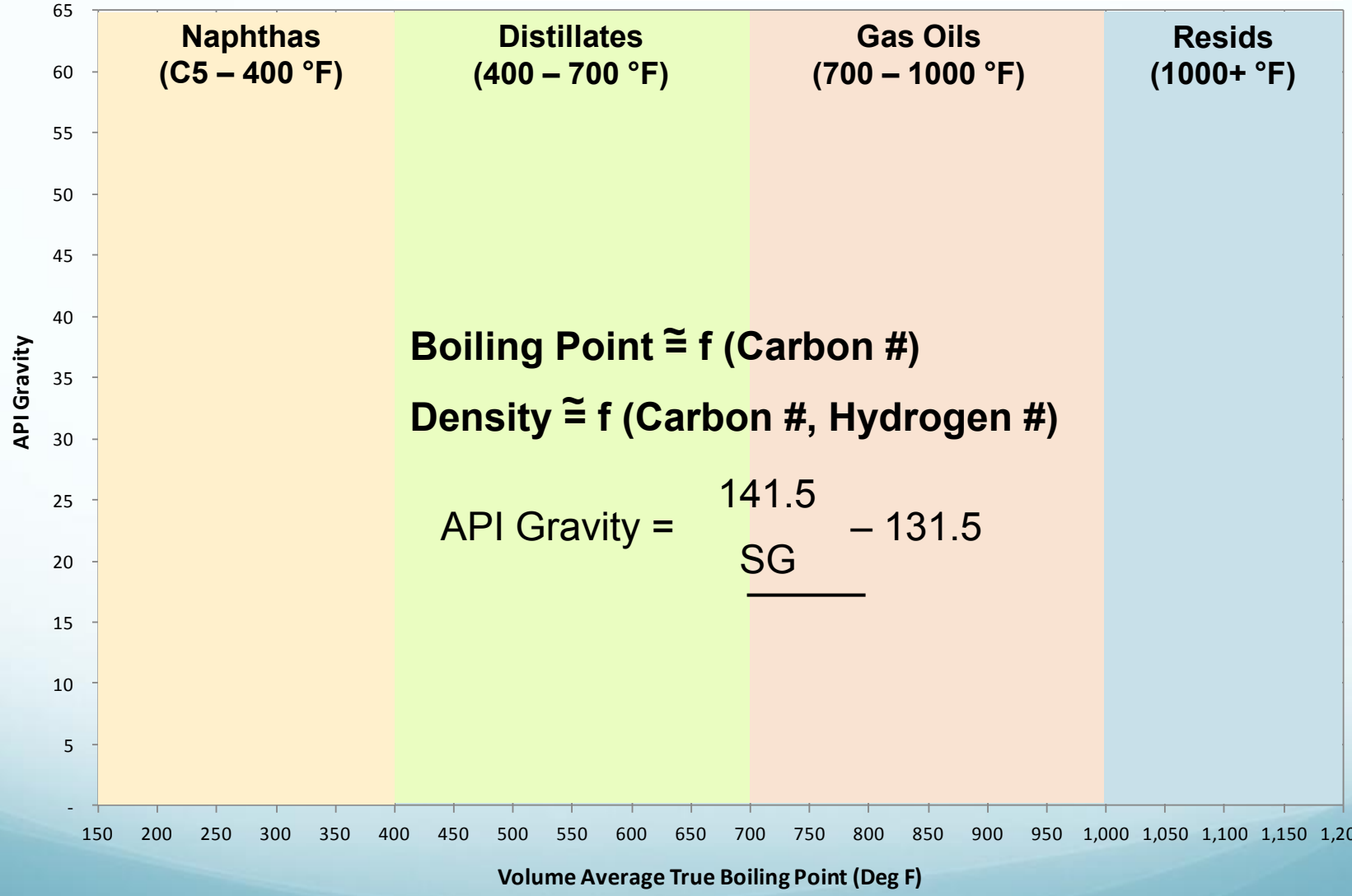
Purpose: Utilize analysis results to characterize biomass-derived intermediates relative to typical petroleum refinery intermediates, blend stocks, and finished fuel blends.

Benefits:

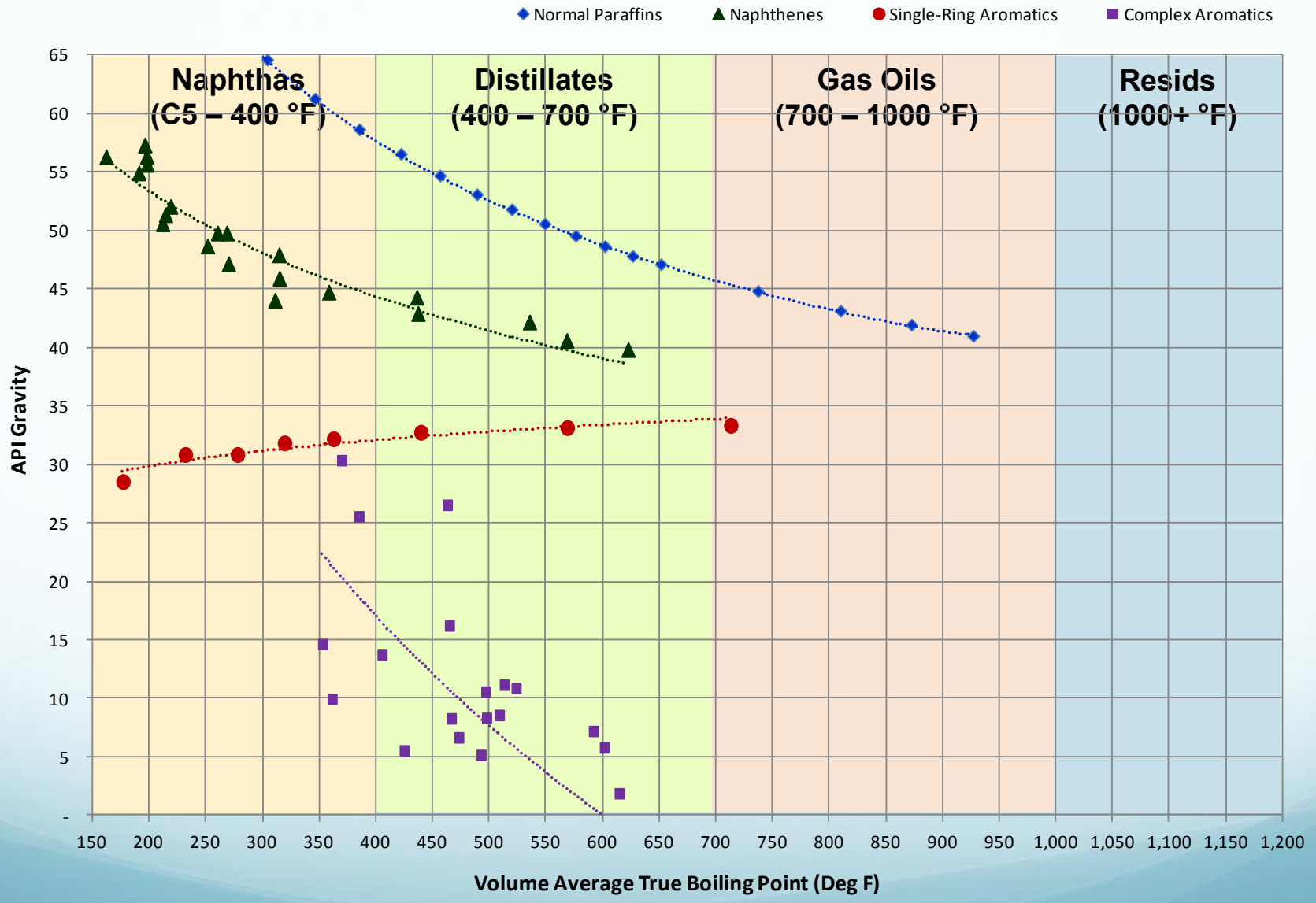
- Compare bulk properties of NABC products to those of refinery streams
- Determine theoretical hydrogen consumption (production) values
- Identify refinery integration strategies

Note: This analysis is based solely on bulk properties (boiling curves, gravities, overall elemental compositions) presented with the Stage 1 results.

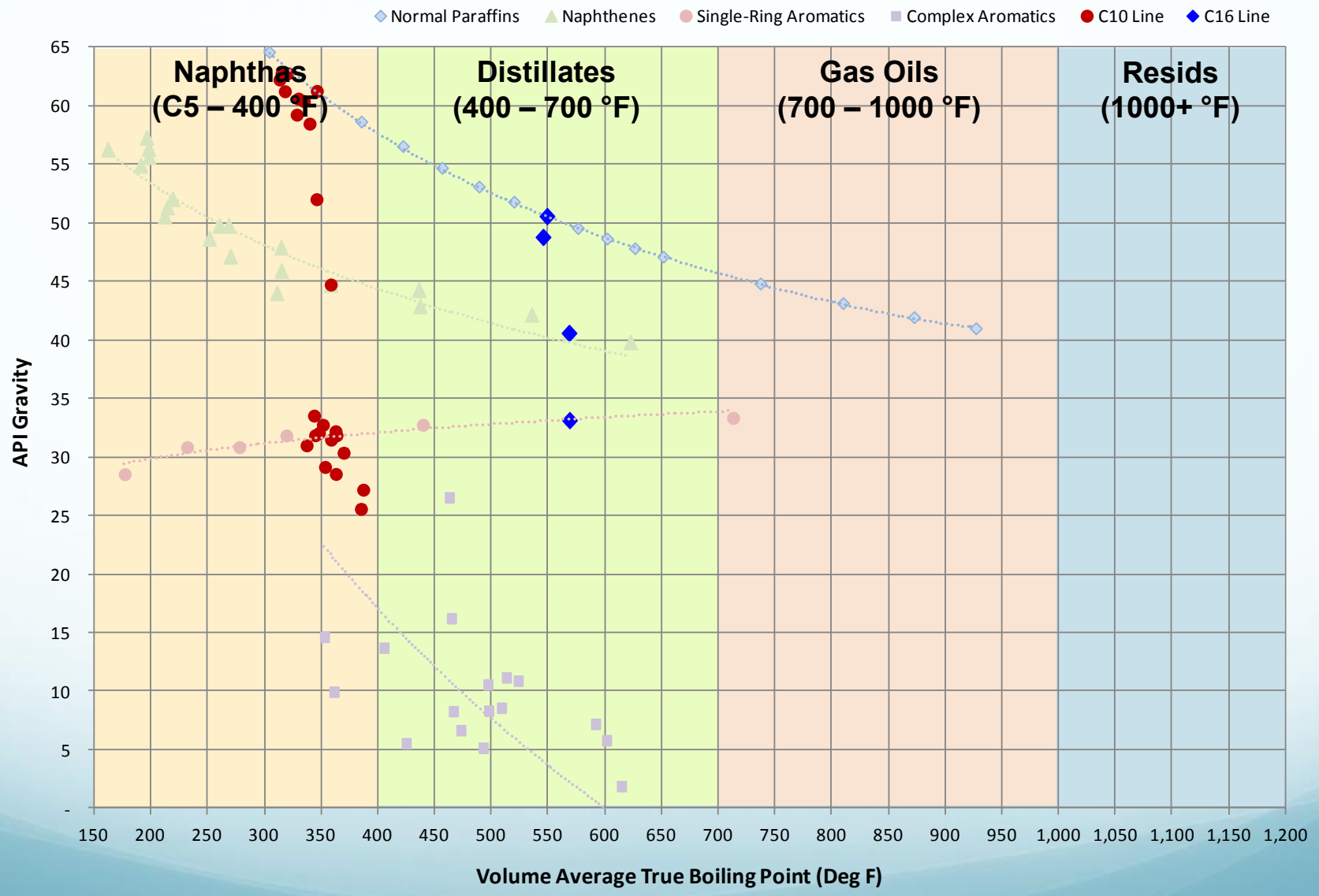
Intermediate / Product Comparison



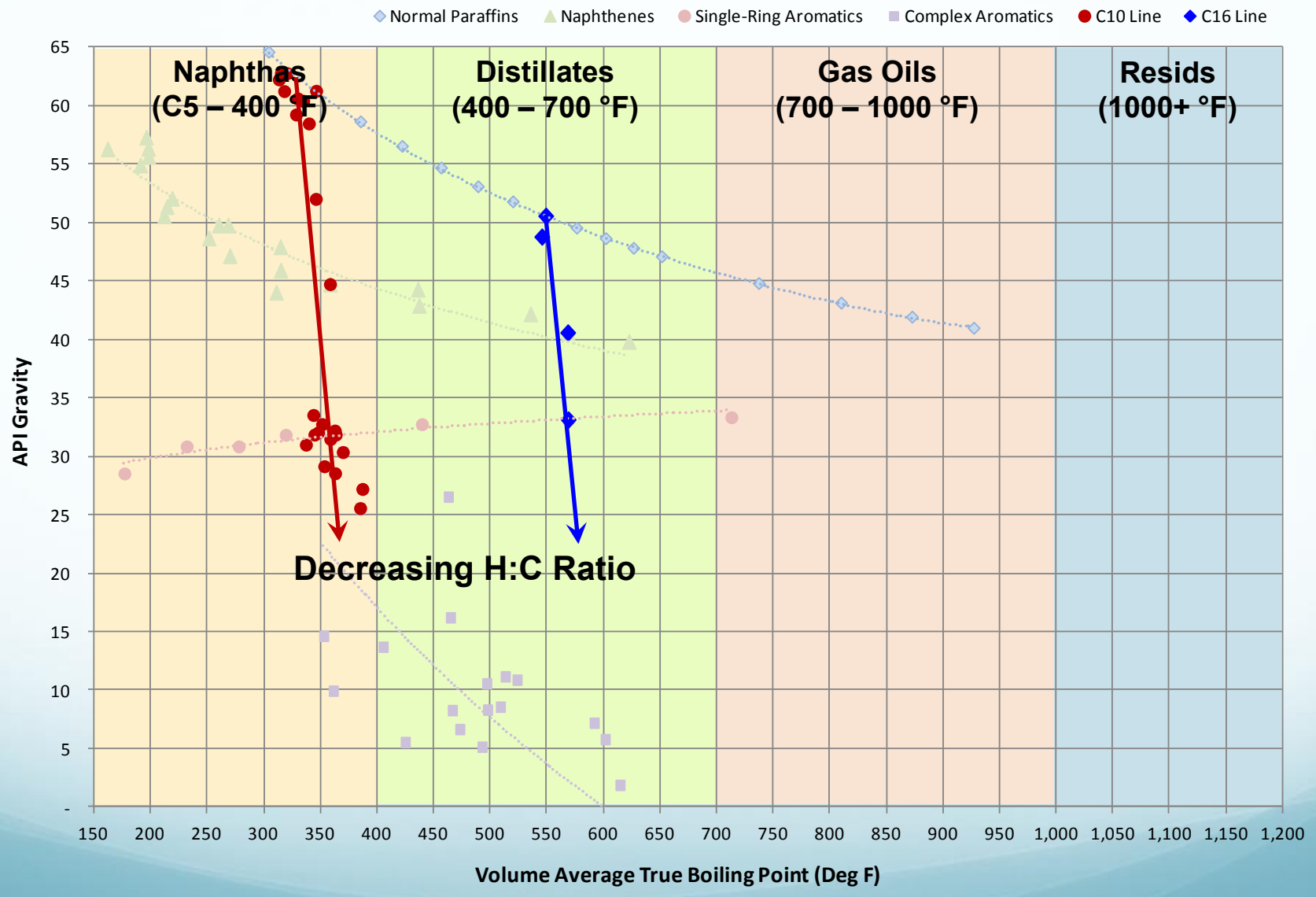
Intermediate / Product Comparison



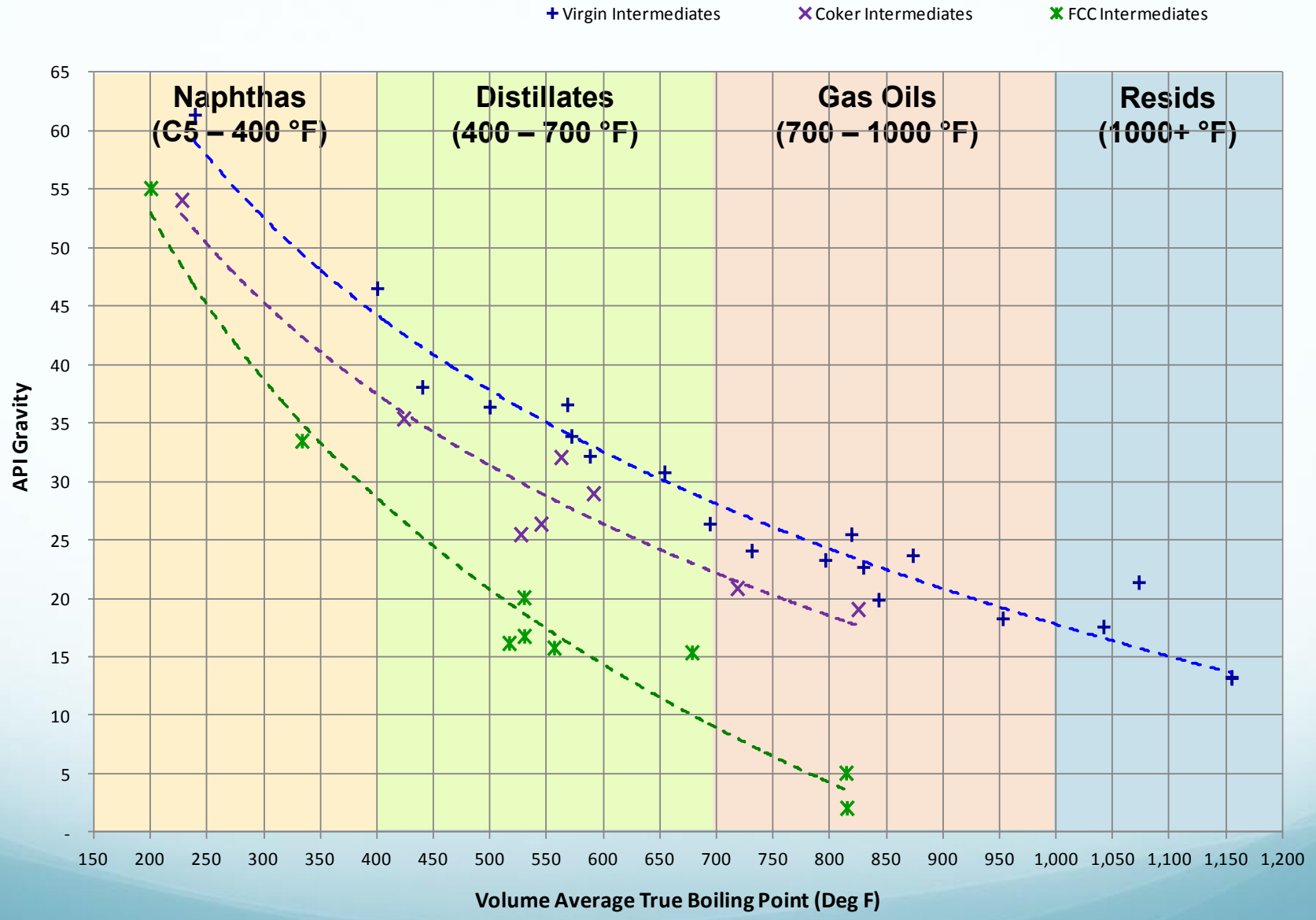
Intermediate / Product Comparison



Intermediate / Product Comparison



Intermediate / Product Comparison



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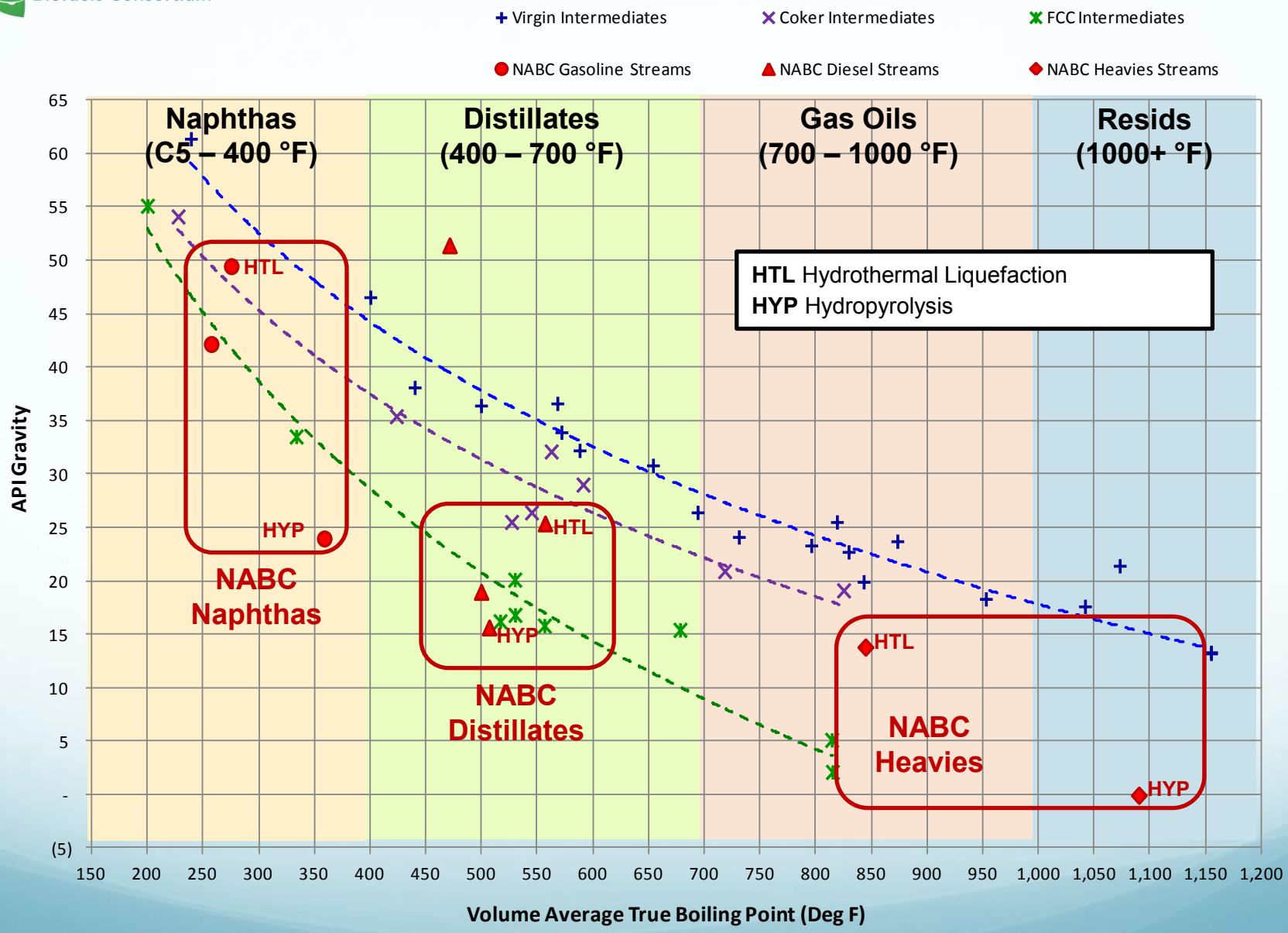
Impact of Oxygen Content

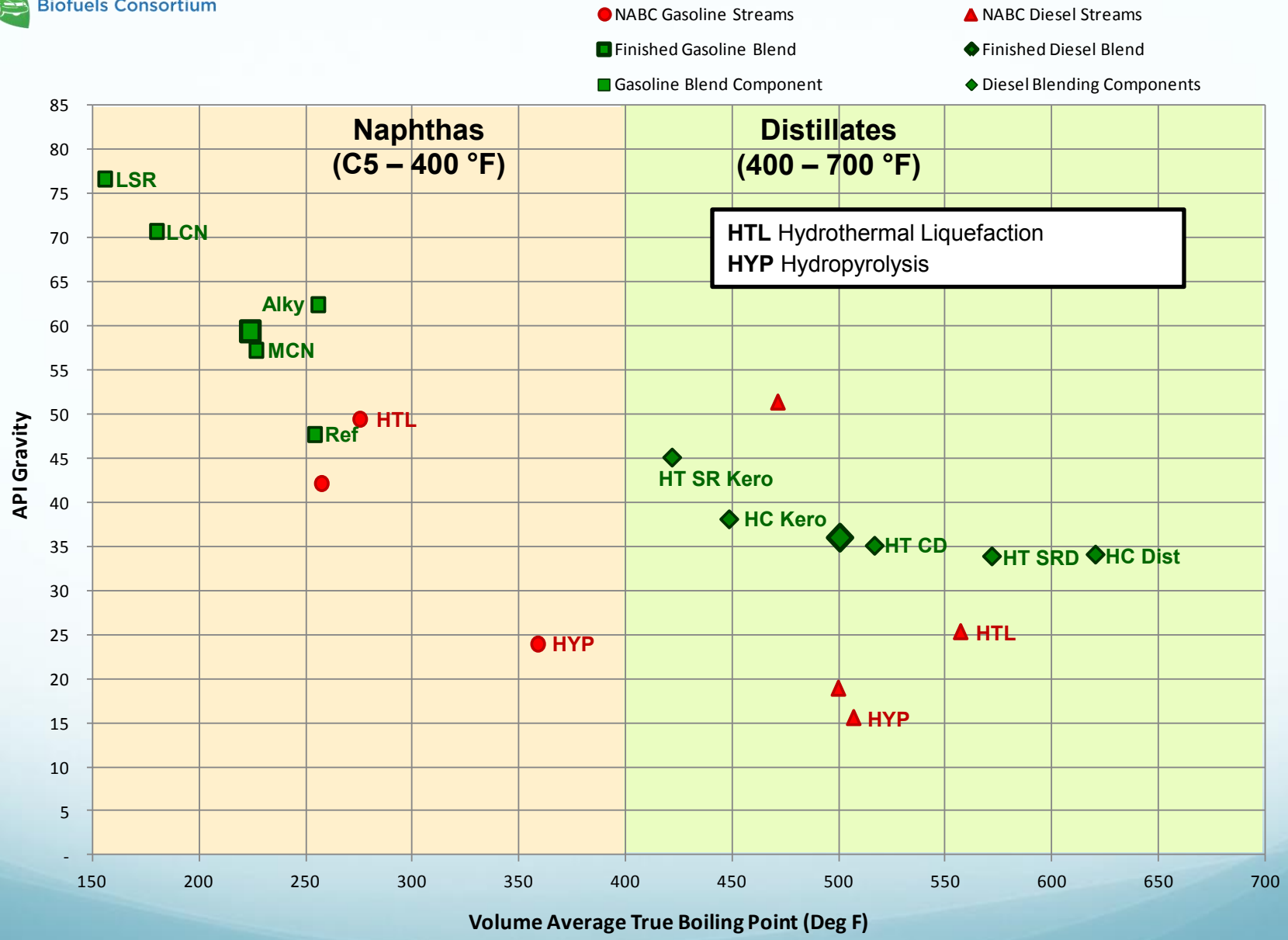
	Formula	Oxygen (Wt%)	Boiling Point (°F)	Specific Gravity	API Gravity
N-Decane	$C_{10}H_{22}$	0.0	**346**	**0.734**	61.2
Decanol	$C_{10}H_{22}O$	10.1	448	0.833	38.3
Decanediol	$C_{10}H_{22}O_2$	18.4	567	1.080	-0.5
73% N-Decane + 27% Decanol (Hysys)	$C_{10}H_{22}O_{0.28}$	3.0	**363**	**0.752**	54.2

Impact of oxygen content on bio-product properties ignored as Stage 1 NABC materials contained ~3wt% or less

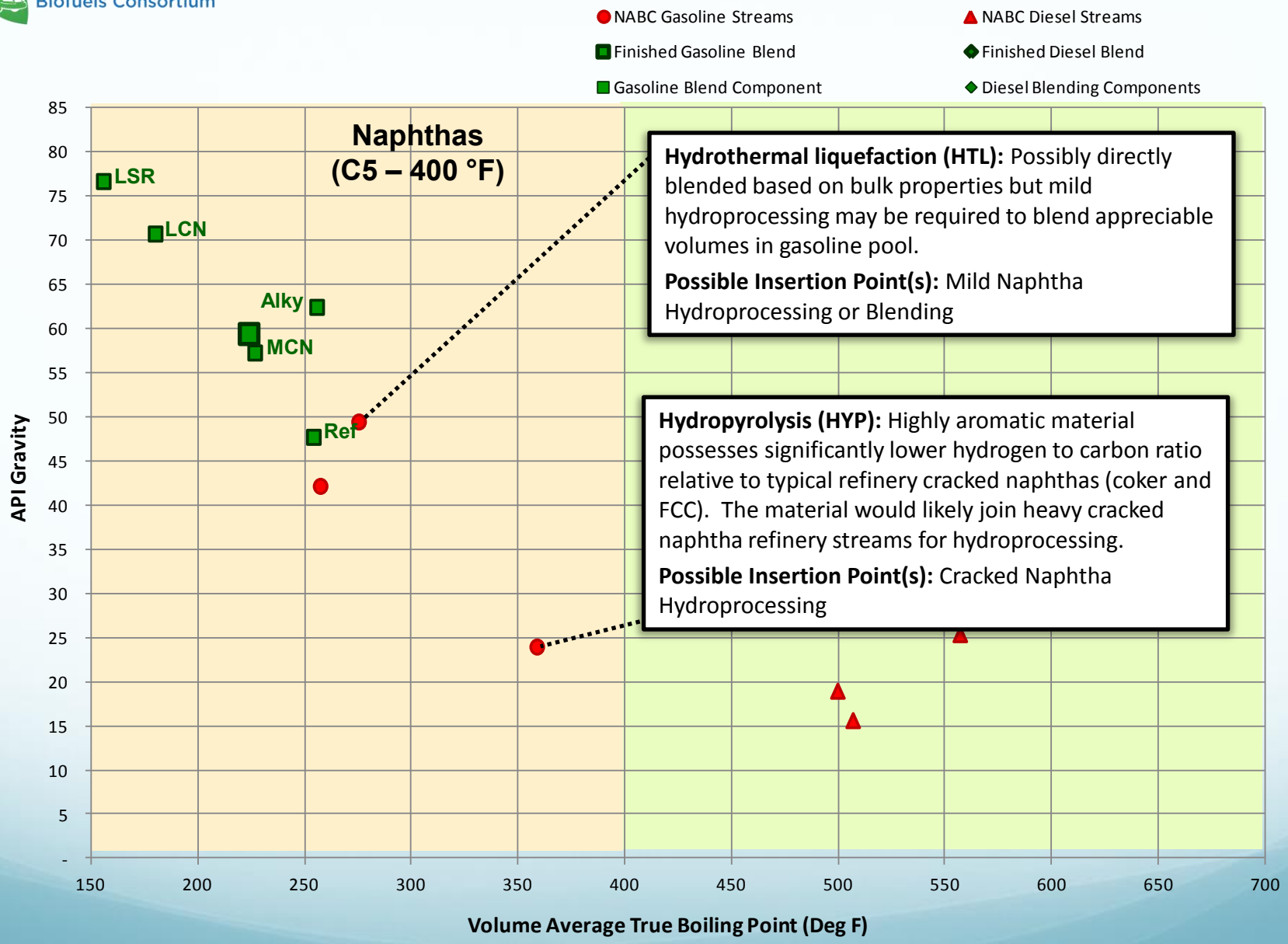
Intermediate / Product Comparison



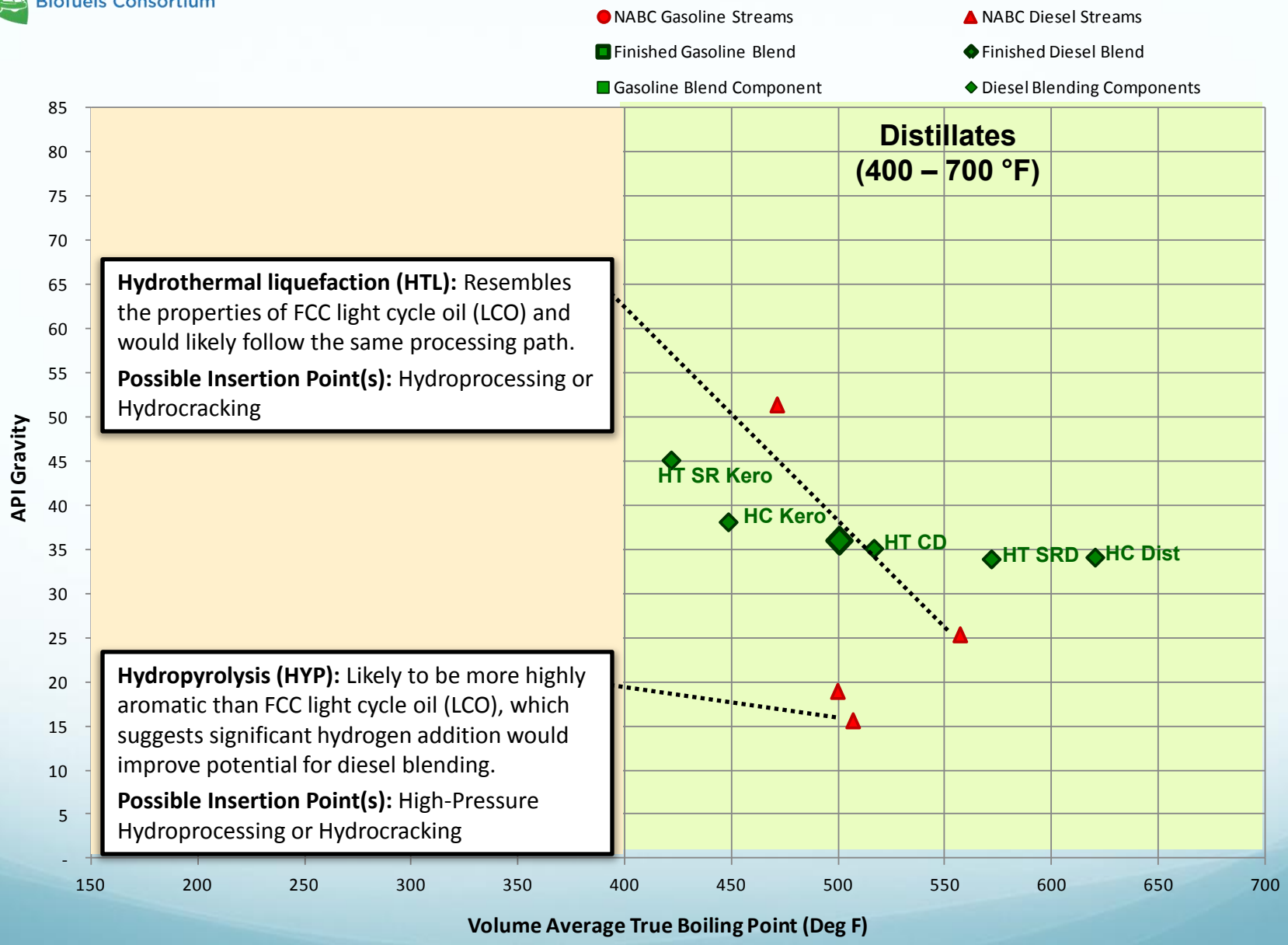
Naphthas & Distillates (Hysys Results)



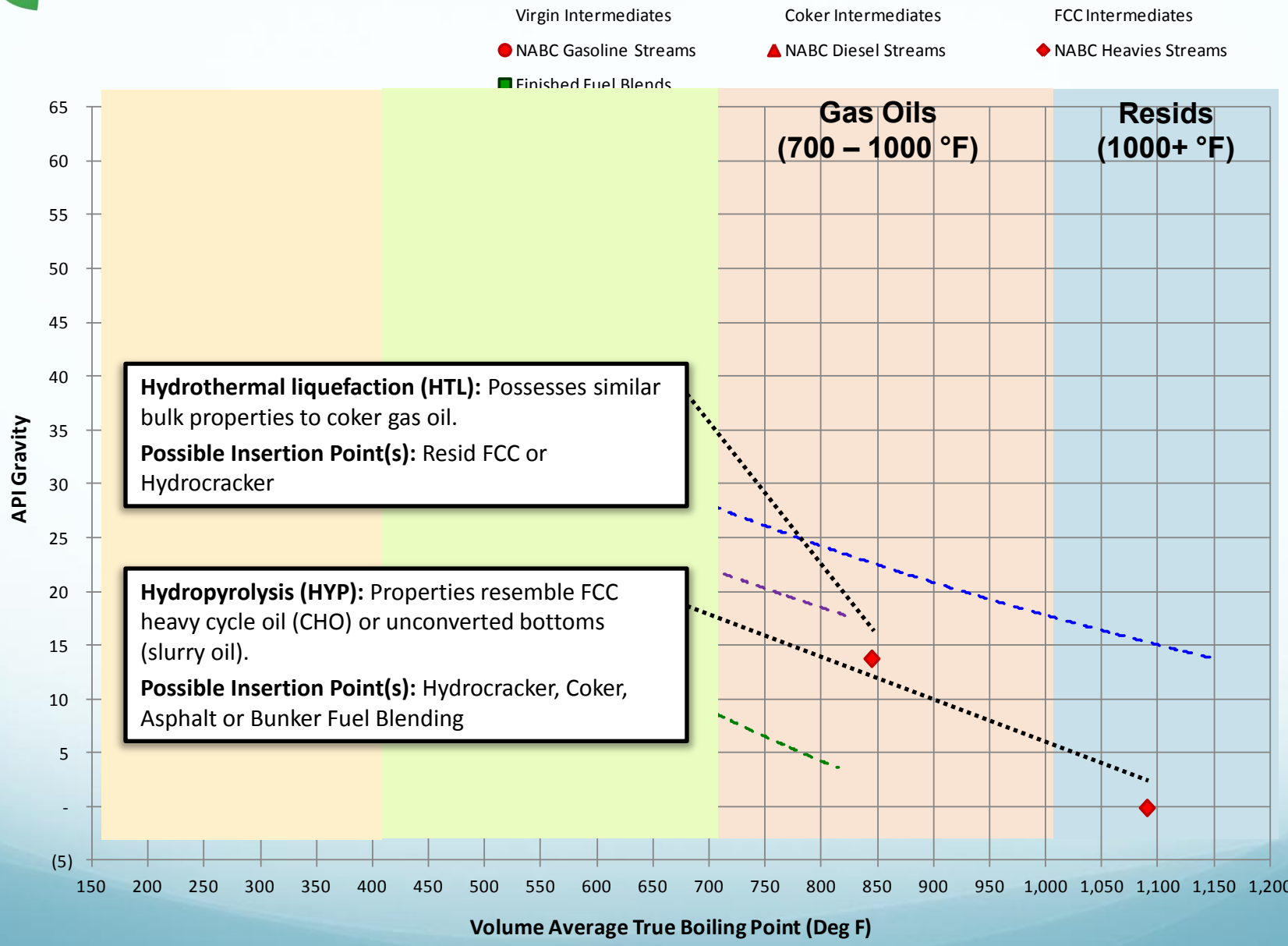
Refinery Integration – Naphthas



Refinery Integration – Distillates



Refinery Integration – Heavies



NABC Blending Model

Purpose: Integrate NABC Stage 2 analysis results and refinery blendstock data into Aspen PIMS product blending model to evaluate the NABC product value to U.S. refineries with varying complexities.

Benefits:

- Value ($ / Bbl or Gal) of NABC materials to refiners
- Allowable blending volumes (blend wall)
- Blending constraints

NABC Blending Model

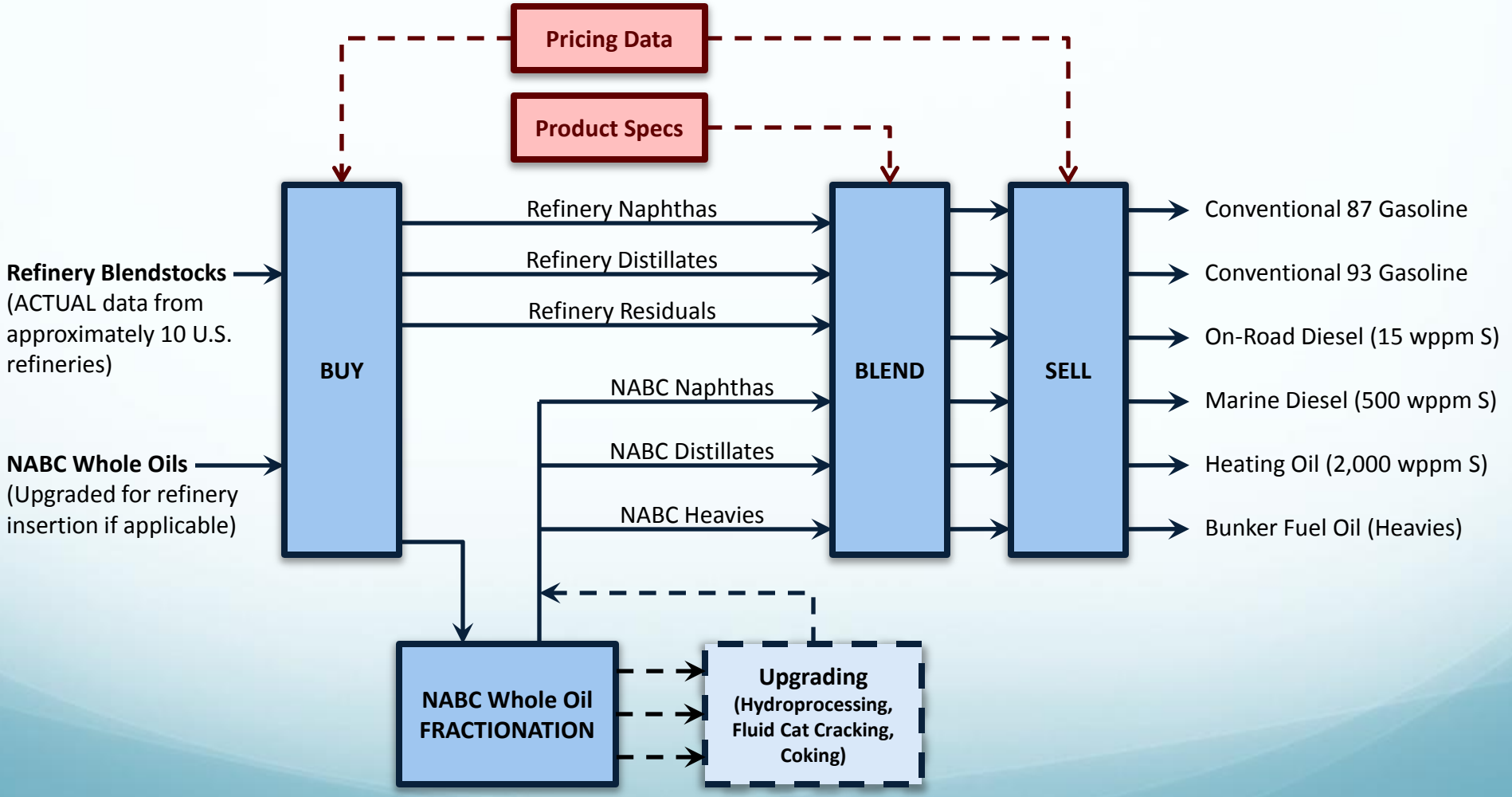
Blending Model Basics

- Linear programming (LP) model in Aspen PIMS
- Blendstocks and costs from refinery and NABC
- PIMS solver maximizes profit
- RIN credits for bio-products
- Blend specifications

Gasoline	Diesel
Specific gravity / API gravity	Specific gravity / API gravity
Reid vapor pressure (RVP)	Distillation curves (D86 or D2887)
Road octane number (RON)	Aromatics (Vol %)
Motor octane number (MON)	Oxygen (Wt %)
Distillation curves (D86 or D2887)	Sulfur (Wt ppm)
Benzene (Vol %)	Flash point (Deg F)
Olefins (Vol %)	Viscosity @ 122 Deg F (Cst)
Aromatics (Vol %)	Pour point (Deg F)
Existing Gum (mg / 100 ml)	Cloud point (Deg F)
Oxygen (Wt %)	Carbon residue (Wt %)
Mercaptan sulfur (Wt ppm)	Cetane index
Sulfur (Wt ppm)	Total acid number (TAN)

NABC Blending Model

PIMS (Process Industry Modeling System) by aspentech



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Thank you for your time and attention!

QUESTIONS?