Modeling Refining and Logistics Operations for the Global Hydrocarbon Supply Project

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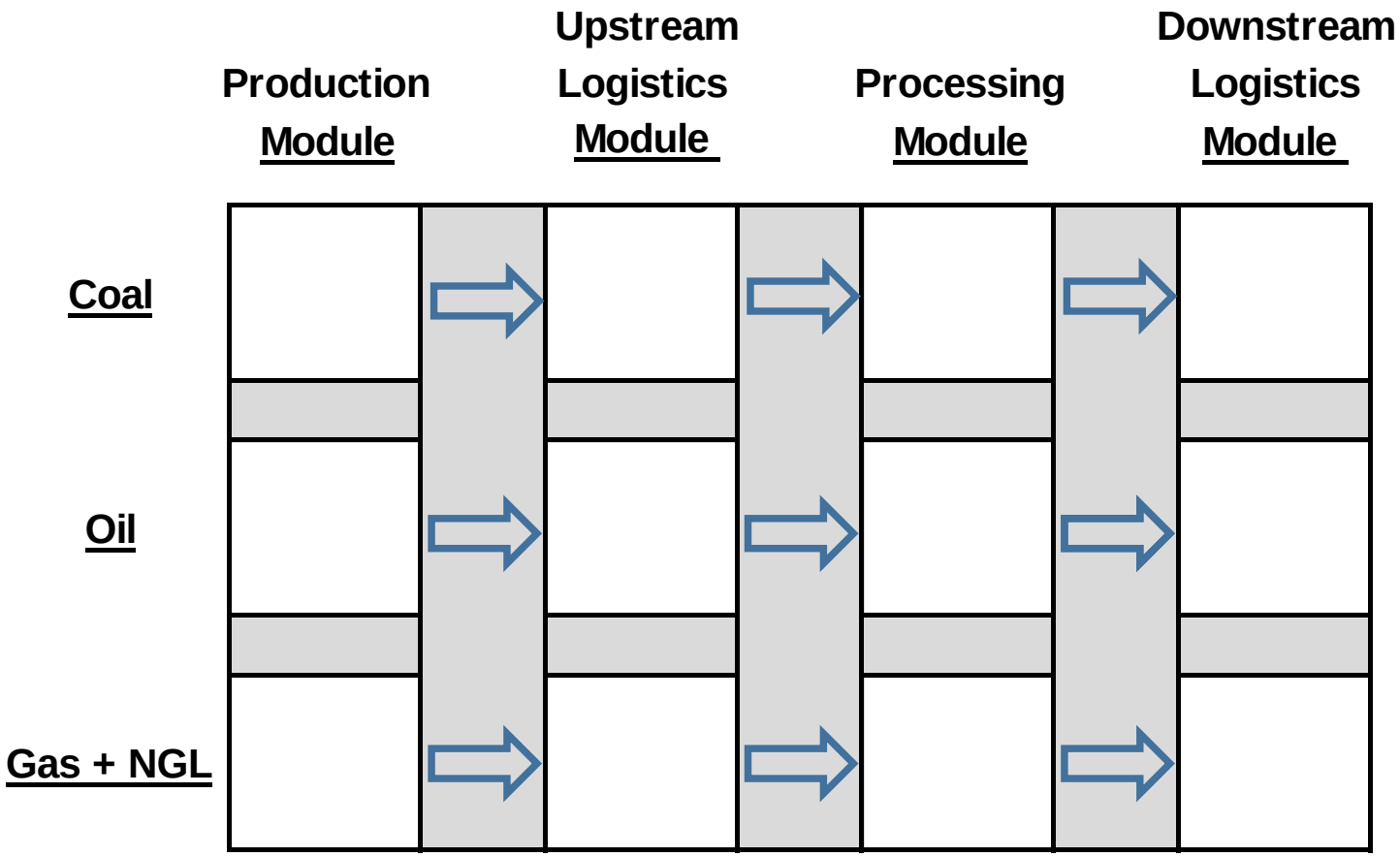
GHSP Supply Modules: Current View



Another way of viewing the Logistics Module

- Logistics operations for coal, oil, and natural gas have relatively little physical interactions with one another.

- In the long term, logistics operations do not constrain supply of energy commodities.

- The Logistics Module should serve mainly as an accounting framework
  - Establishing volume and energy balances for each energy commodity transported
  - Placing a per-unit cost (e.g., $/Bbl) on each source/destination/mode combination
  - Honoring exogenous capacity constraints imposed in near-term time period

- Focus on upstream logistics only.

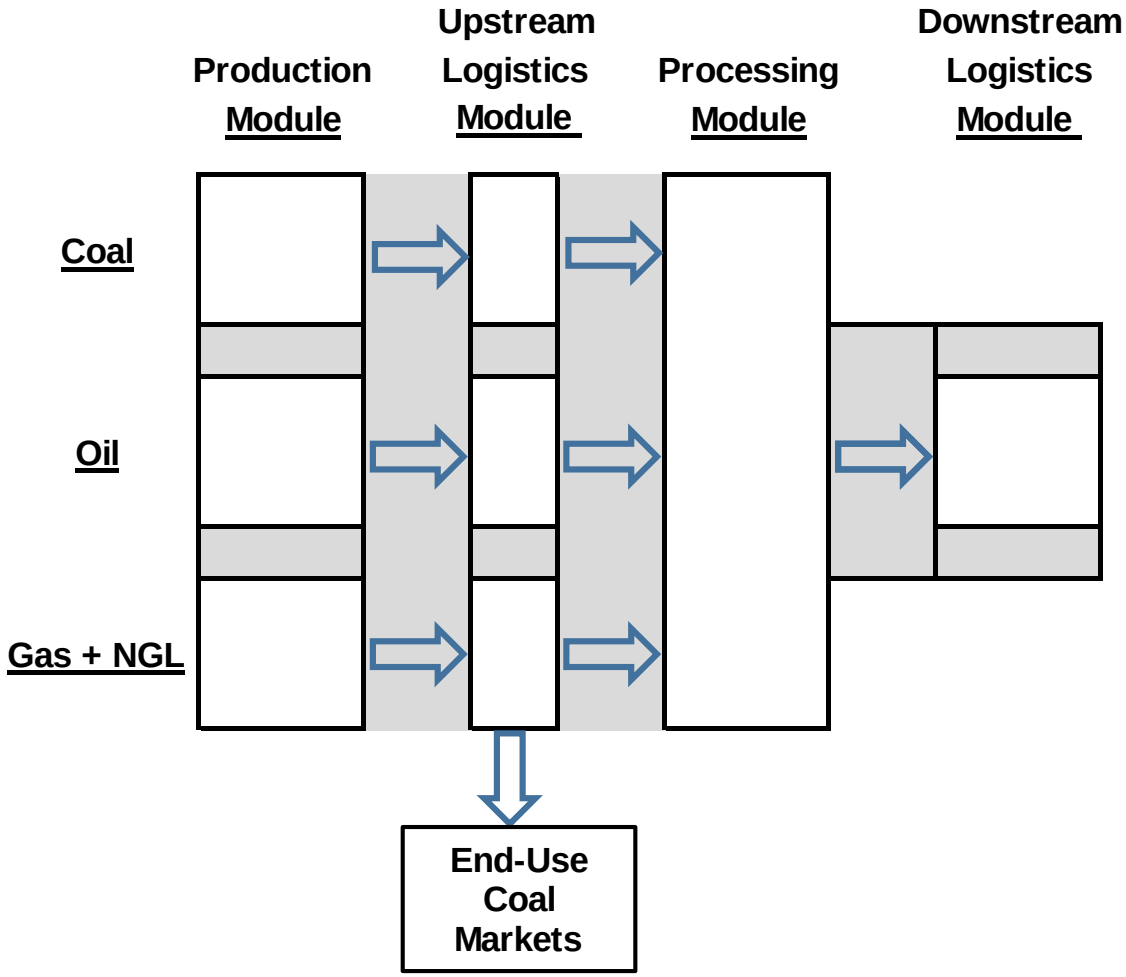
Another way of viewing the Processing Module

- Processing operations in the real world incorporate numerous interactions between primary energy commodities.
- Outputs of natural gas and coal processing serve as inputs to petroleum processing (refining).
  - Lease, field, and plant condensate, NGLs
  - CTL and GTL liquids
  - Merchant hydrogen, MTBE
- Some outputs of natural gas processing and petroleum refining are similar and compete in end-use markets (e.g., NGL, condensates).
- Model formulation techniques and underlying data structures for refining processes apply to other process flow operations as well.

Another way of viewing the Processing Module (cont'd)

- The Process Module could handle the processing of coal (e.g., CTL), natural gas, and crude oil in a single integrated module, rather than in separate sub-modules.
- The Process Module also could handle downstream logistics.
- An integrated, all-commodity approach offers numerous benefits.
  - More direct representation of real world interactions
  - Similarities in modeling techniques and data structures
  - More efficient and stable computation.

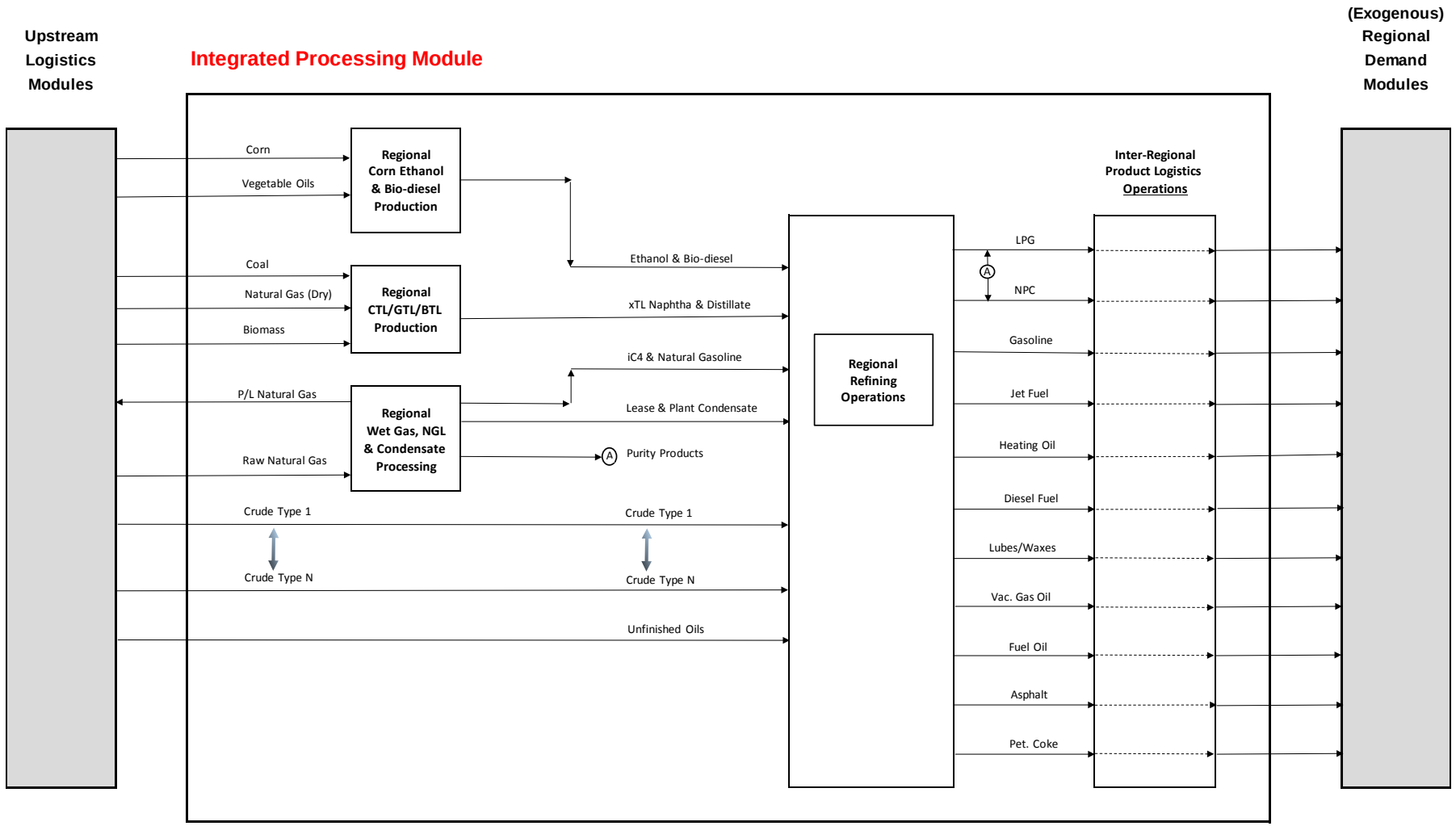
GHSP Supply Modules: An Alternative View



- Processing Module
  -- Integrated over coal, oil, & gas
  -- Includes downstream logistics

- Logistics Module
  -- Simplified
  -- Accounting oriented
  -- Upstream logistics only

Overview of an Integrated Processing Module



The Integrated Processing Module and the LFMM

- The diagram on the previous could serve to depict LFMM as it now exists in NEMS.
- LFMM already embodies
  - Multi-regional structure
  - Representation of refining, bio-fuels, CTL/GTL/BTL
  - Represetnation of downstream, inter-regional logistics
  - A robust scheme for classifying crude oils
- LFMM is scalable and data-driven.

Crude oil classes represented in LFMM

Crude Oil Type	Property Range	
	API Gravity (o)	Sulfur (wt.%)
Condensate	> 50	
Ultra Light	45-50	0-0.5
Light Sweet	35-45	0-0.5
Light Sour	35-45	> 0.5
Medium Sweet	26-35	0-0.5
Medium Sour	26-35	> 0.5
Heavy Sweet	10-26	0-0.5
Heavy Sour	10-26	> 0.5
Synthetic Crude Oil	30-35	0-0.5
Dilbit	> 20	< 3.5

Representation of crude oil classes in GHSP

- Compatibility of LFMM and NEMS crude oil classes is important.
- The GHSP Processing Module must pass product prices to the demand modules
- Given a crude oil price, computed product prices reflect the interplay of:
  - Product slate
  - Refinery configuration
  - *Crude oil slate and its properties*
- Recognition of crude oil classes is essential to
  - Allocation of crude oils to refining regions
  - Calculation of refinery gate product prices
  - Estimation of refinery investment requirements.

Dave's modeling aphorisms – maybe trite but still true

- A model should be as simple as possible, but not simpler.
- The goal of analysis is insight, not precision.
- Analysis is done by analysts, not by models.
- The bigger the model, the easier it is to forget these things.