

Innovations in energy system modeling



For

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By

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This talk is about –
Innovations in energy system modeling
– not about –
Modeling innovations in energy systems
(but they're related)

Modeling innovations in energy systems (1 of 2)

- Breakthrough innovations cannot be predicted...
 - By definition, (the timing of) their emergence is a surprise
 - EIA has never successfully predicted a breakthrough innovation
 - But, we have modeled many innovations that never “broke through”: hydrogen fuel cells, oil shale, methane hydrates, lacustrine shale, LNG trains
- ...And are very difficult to model
 - Models with foresight cannot be surprised
 - Models without foresight aren't surprised enough (impulse-response)
 - IRL, the markets' expectations are altered by the breakthrough innovation

Modeling innovations in energy systems (2 of 2)

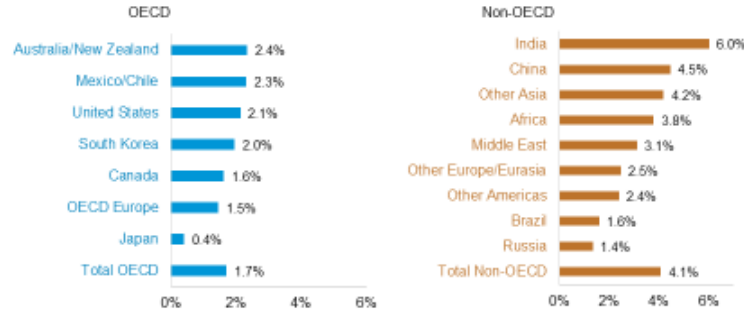
- The best we can do is model incremental, continuous change...
 - Technological change improves cost and/or performance characteristics (e.g., Moore's Law)
 - Learning-by-doing (and forgetting-by-not-doing)
 - Economies of scale
- ...And watch out for leading indicators of new, breakthrough innovations
 - Shale resources
 - Autonomous vehicles
 - Mobility-as-a-service/ride sharing
 - Technology leapfrogging
 - Microgrids

What's the right model
to capture the effects of an innovation
that has not yet happened?

Growth and innovation both centered in Asia

Many non-OECD countries are projected to lead global economic growth

IEO2018 Reference case
average annual percent change in real GDP by region, 2015–40



Source: EIA, International Energy Outlook 2018

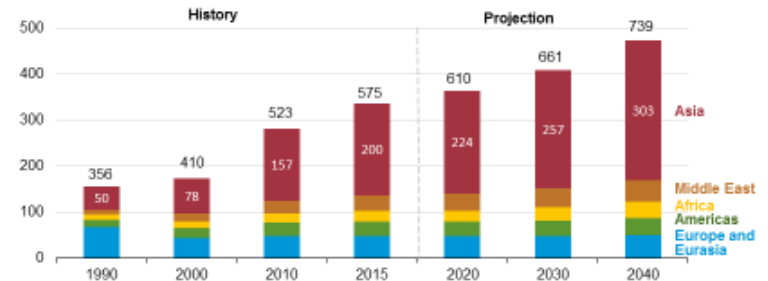


Dr. Linda Caposno, CSIS
IEO2018, July 2018

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Asia is projected to have the largest increase in energy use of non-OECD regions

IEO2018 Reference case
non-OECD energy consumption by region
quadrillion Btu



Source: EIA, International Energy Outlook 2018



Dr. Linda Caposno, CSIS
IEO2018, July 2018

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Source: EIA, International Energy Outlook 2018



David Daniels, APERC Annual Conference
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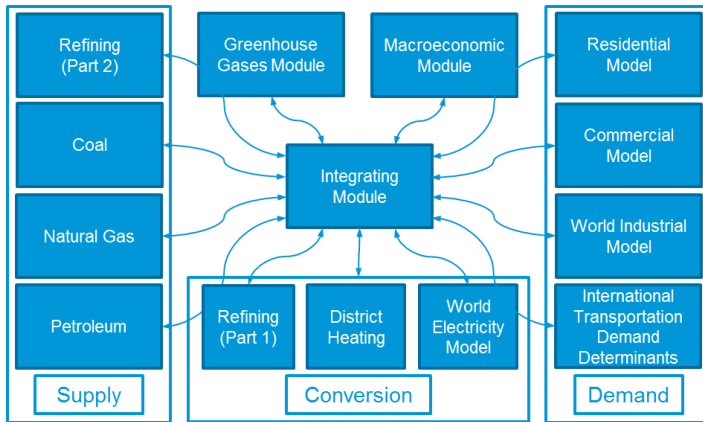
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EIA cannot model the U.S. without accounting for Asia

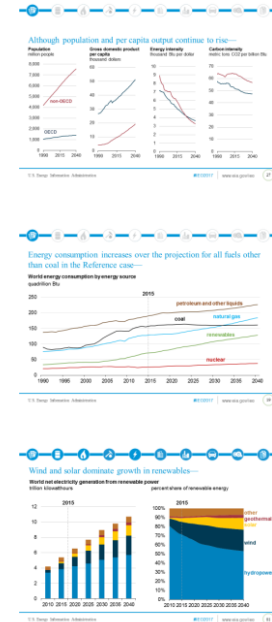
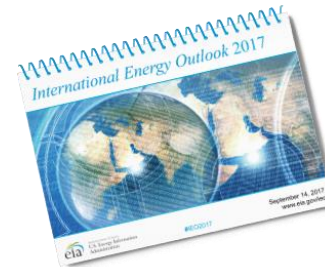
- Global demand growth affects energy trade
 - GDP growth
 - Energy-intensive manufacturing sector growth
 - Consumer behavior, efficiency
- Technological innovation impacts costs
 - EV deployment
 - Battery development
 - Solar PV

That is why EIA is focusing on its international outlook

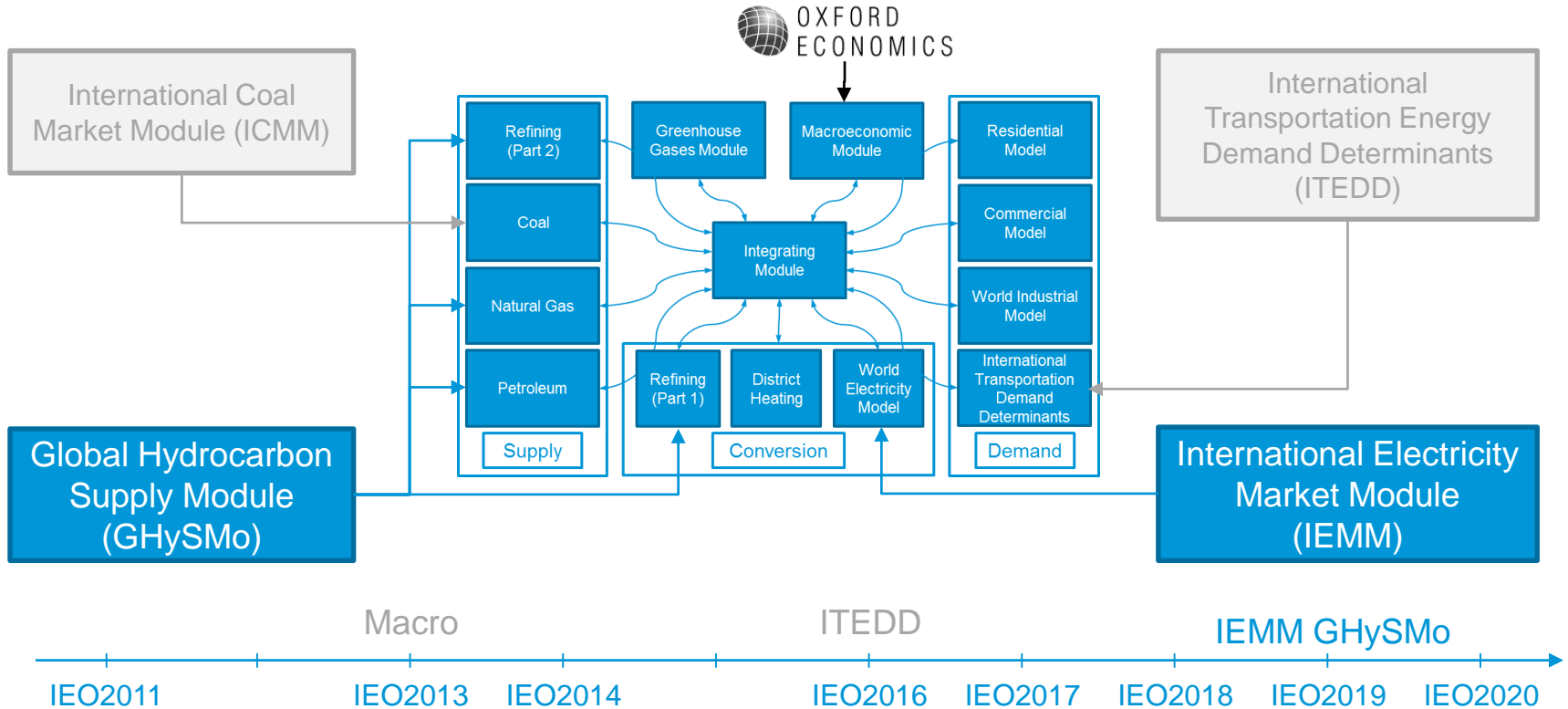
World Energy Projection System (WEPS)



International Energy Outlook (IEO)



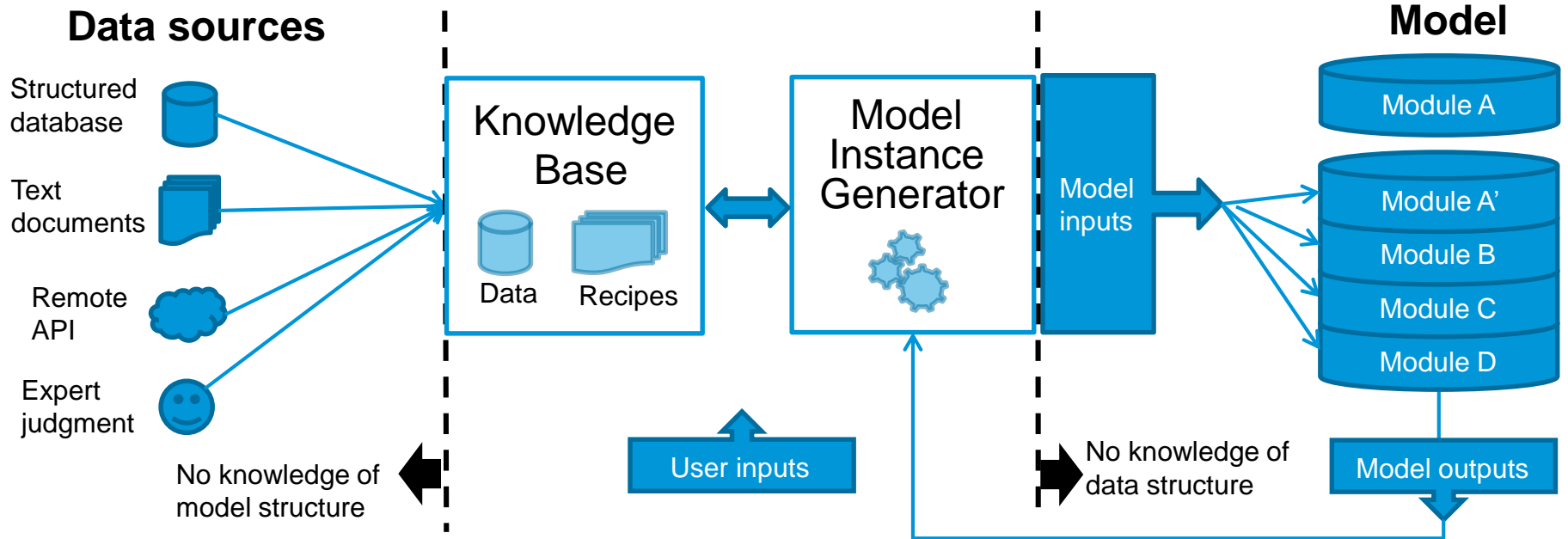
For IEO2019, several WEPS modules are being redesigned



EIA is adopting a Knowledge-Based Modeling (KBM) approach for its new models

- Start from system knowledge, not data
 - Where are the logical system boundaries?
 - On what timescales are decisions made?
 - Over what geographic scales is the system relatively homogeneous?
- Build model at appropriate scale to problem at hand
 - Choose model architecture to fit problem
- Fit data to model

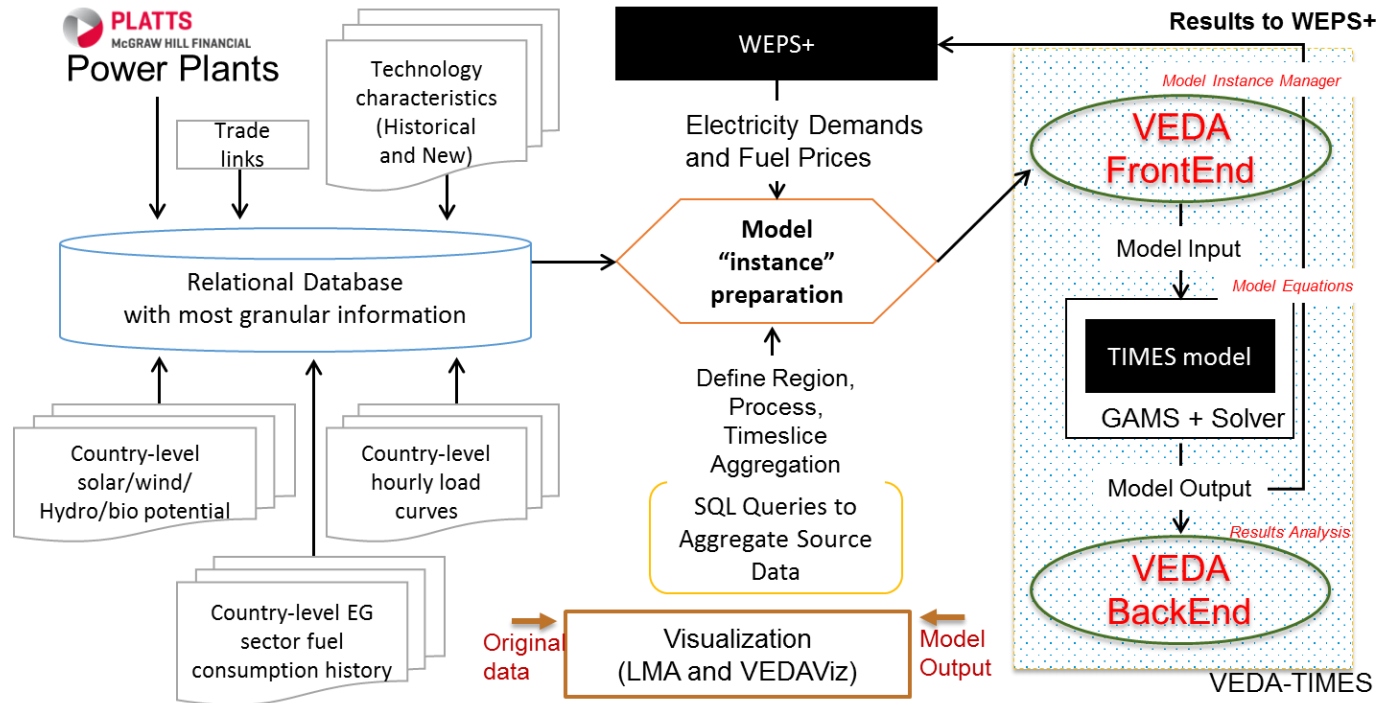
KBM separates data from model



Note: Example information flows

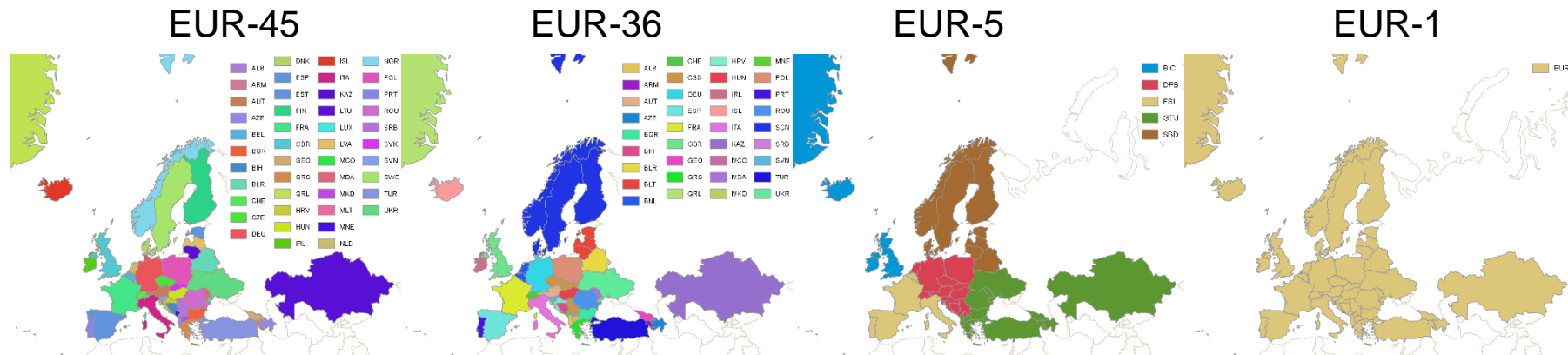
IEMM is a KBM implementation of the TIMES model

KBM implementation for IEMM



It allows analysis at easily-reconfigurable levels of geographic aggregation

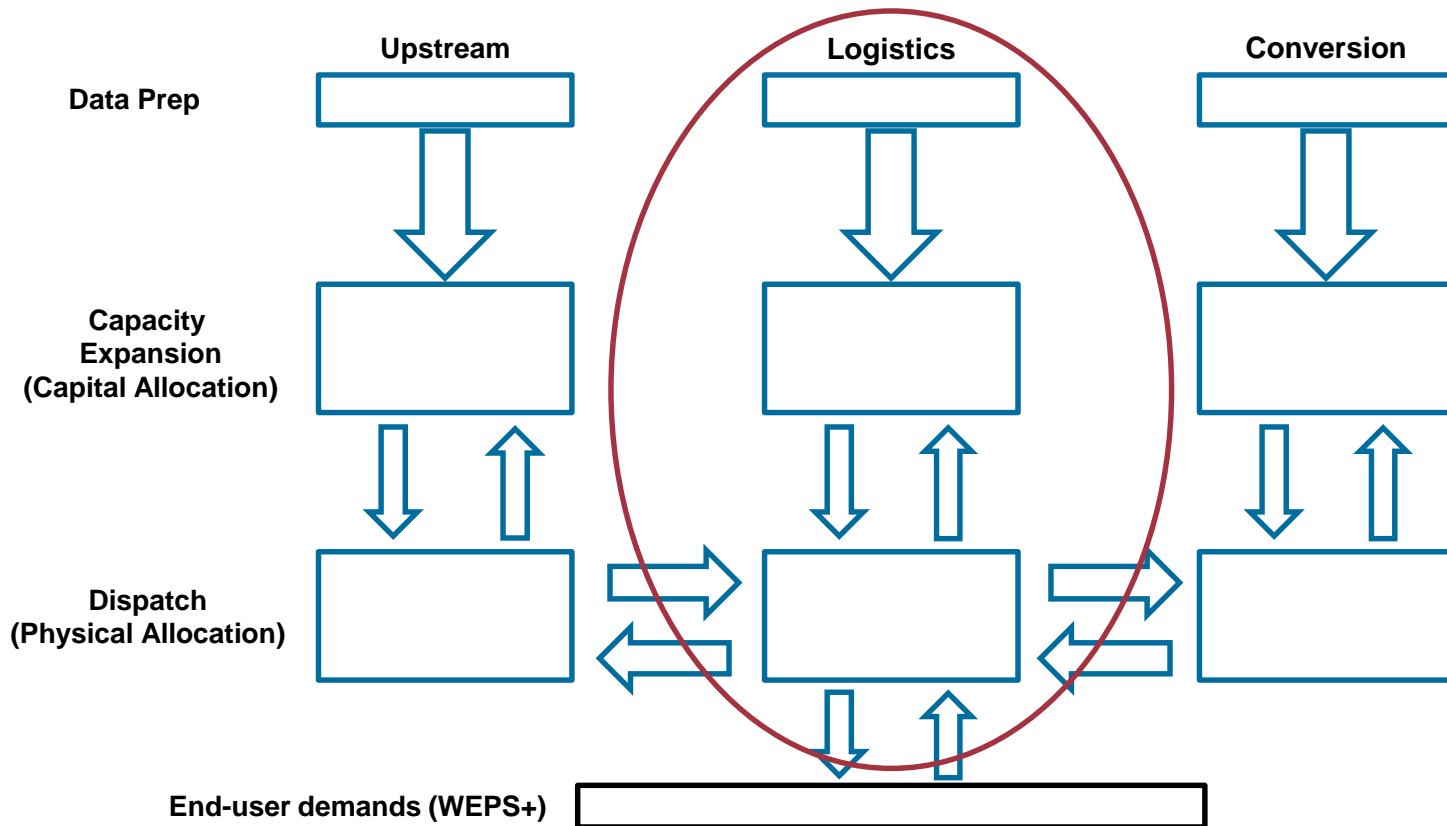
Example: Different aggregations of “Europe” yields different projections of intermittent renewables



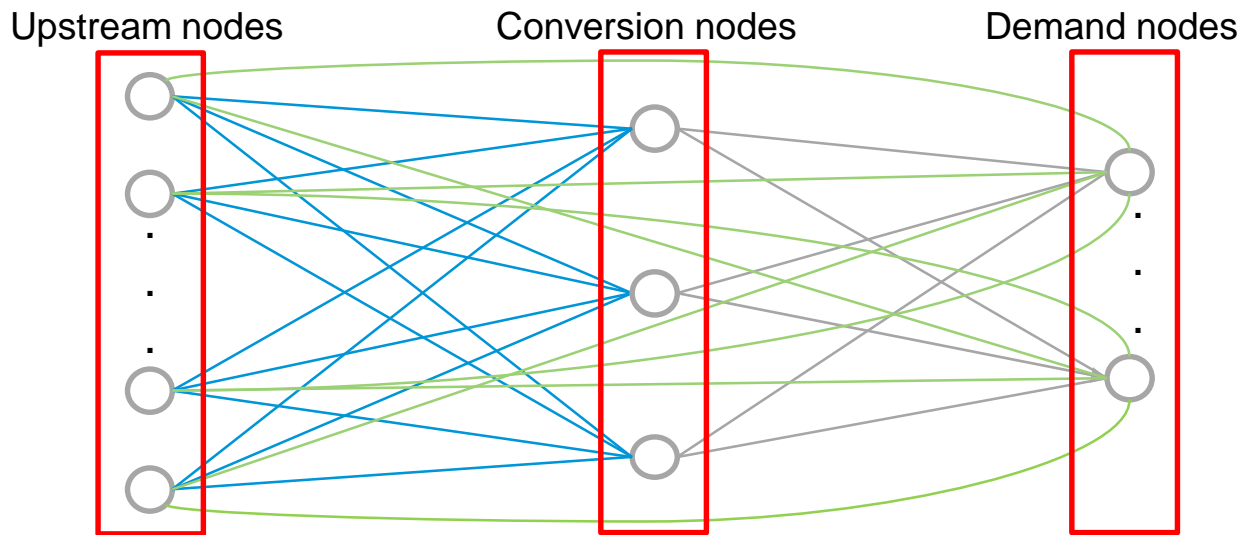
Hypothesis: Lack of internal structure (i.e., transmission constraints) will allow unrealistic high levels of intermittent renewable capacity at coarser regionalities

Source: Analysis presented at IEW 2018 in Gothenburg, Sweden

GHySMo models oil and gas from upstream to downstream



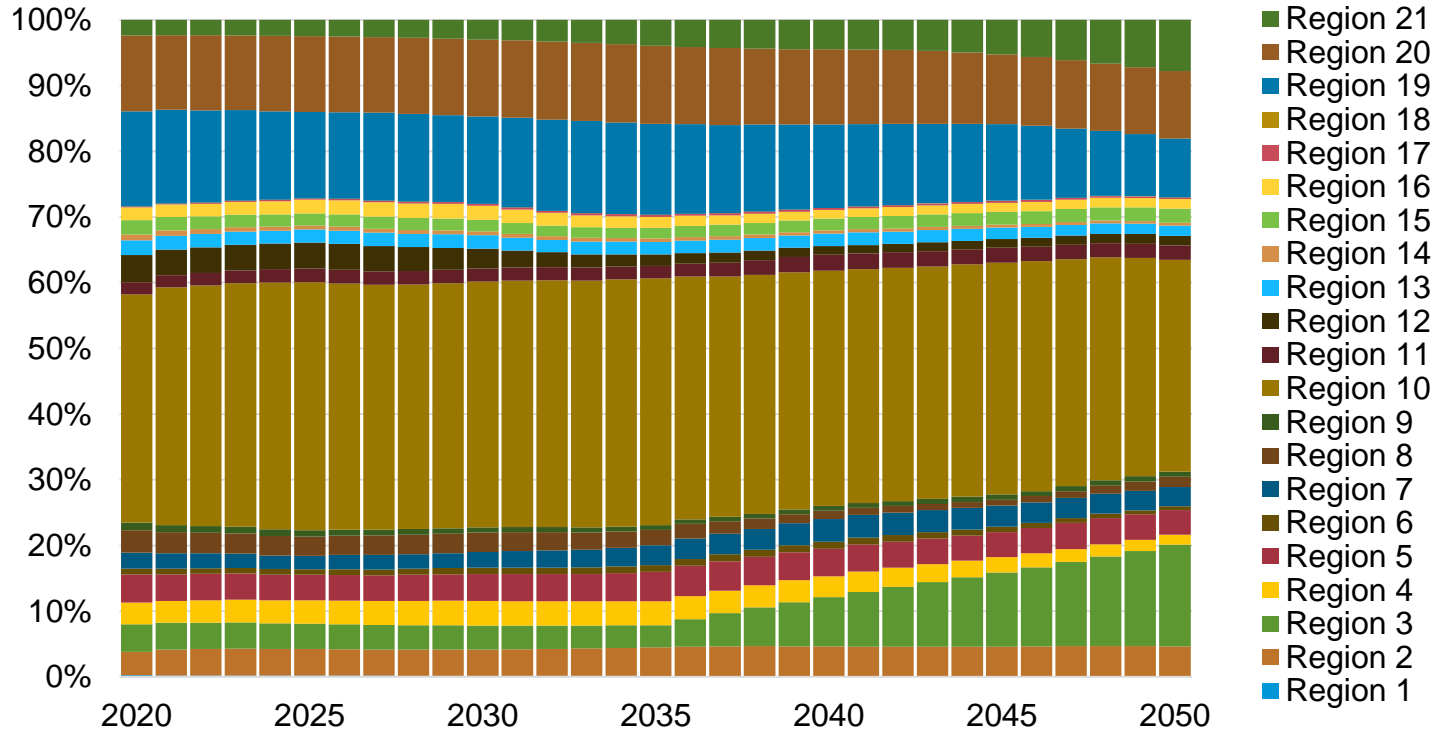
GHySMo uses a generalized network structure for flexibility



In the current prototype:

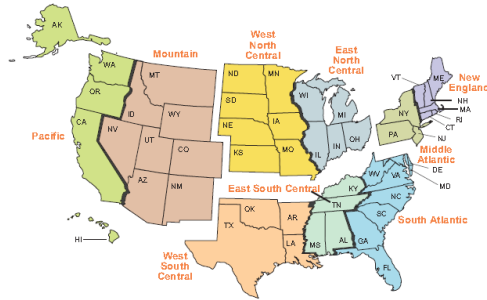
- 24 Upstream regions, 3 Conversion regions, and 16 Demand regions. Model years 2015-2050.
- Each arc has 2 modes of transportation: pipeline, ship
- Each arc has 4 commodity classes per mode of transportation: clean, dirty, LPG, NatGas
- 14 commodities: 4 crudes, Natural Gas, LPG, 8 refinery products

Preliminary results – regional shares of annual total crude oil production for 21 regions



Source: EIA GHySMo upstream model test results

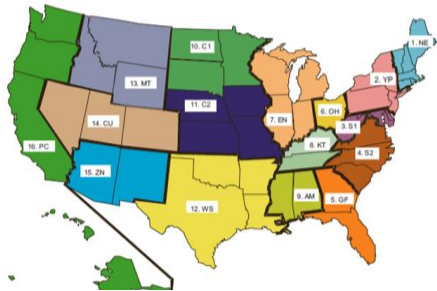
Why go to all this trouble? Because regionality matters...



Demand modules use 9 Census Divisions



Natural gas module uses 16 regions



Coal market module uses 16 regions



Electricity module uses 22 regions based on ISOs

...And our ability to model global regions needs to keep up

