Modeling Deep Decarbonization in USREP

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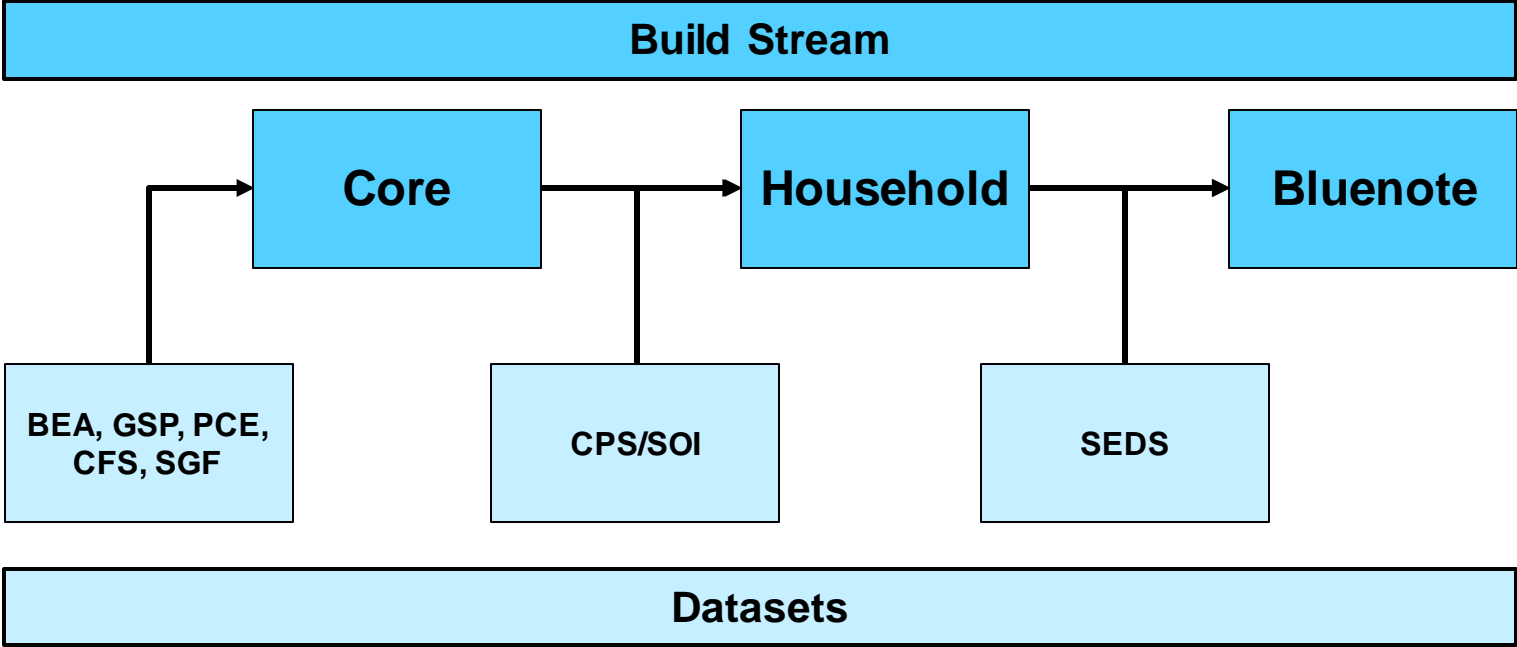
Agenda

1. WiNDC Build Stream Updates
2. Modeling Deep Decarbonization in USREP with WiNDC
3. Results

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1. **WiNDC Build Stream Updates**
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WiNDC Build Stream

Build Stream

Core → Household → Bluenote

BEA, GSP, PCE, CFS, SGF

CPS/SOI

SEDS

Datasets

Abbreviations:

- BEA – Bureau of Economic Analysis Input-Output Data
- GSP – Gross State Product (St. Louis Fed)
- PCE – Personal Consumption Expenditures (BEA)
- CFS – Commodity Flow Survey (Census)
- SGF – State Government Finance
- CPS – Current Population Survey (Census)
- SOI – Statistics of Income (IRS)
- SEDS – State Energy Data System (EIA)

WiNDC Build Stream
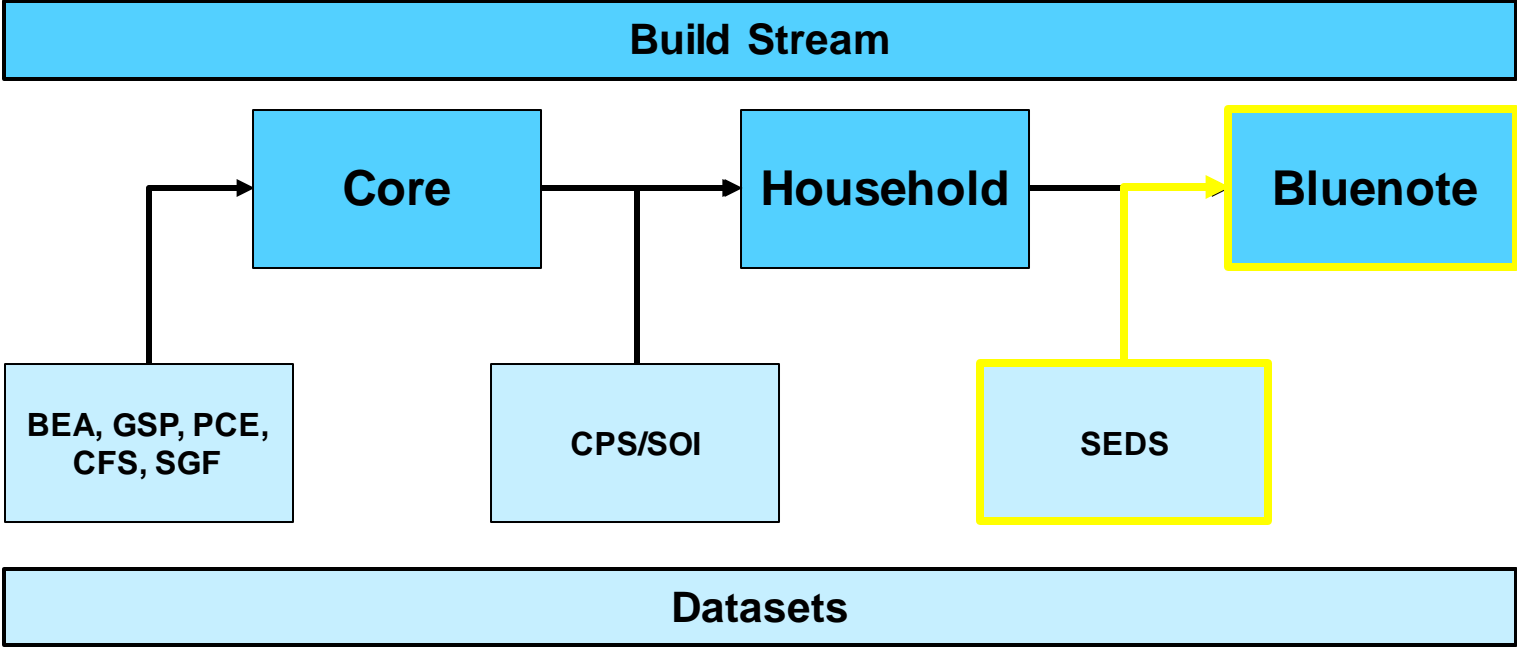
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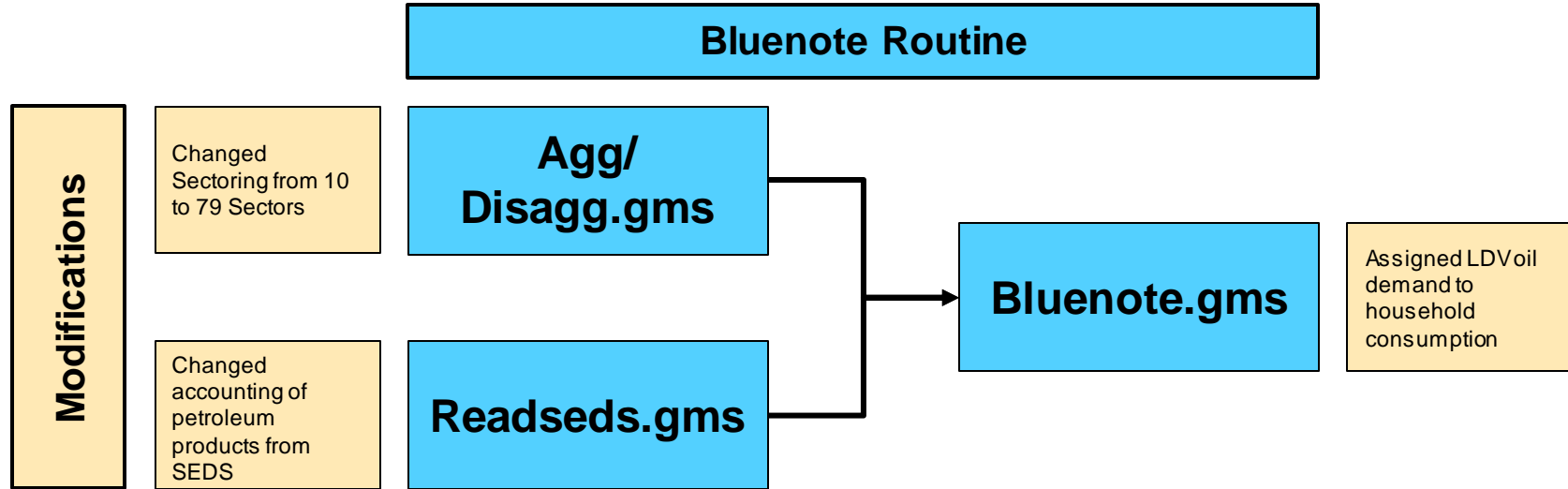- GSP – Gross State Product (St. Louis Fed)
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WiNDC data doesn't readily fit with USREP model

o SEDS database for WiNDC-bluenote shifts oil demand by household to the transportation sector

o With an existing WiNDC dataset, adjusting the related accounts to reallocate motor gasoline consumed in the transportation sector to household leads to a data issue

o Household consumption of transportation is found insufficient to cover the adjustment
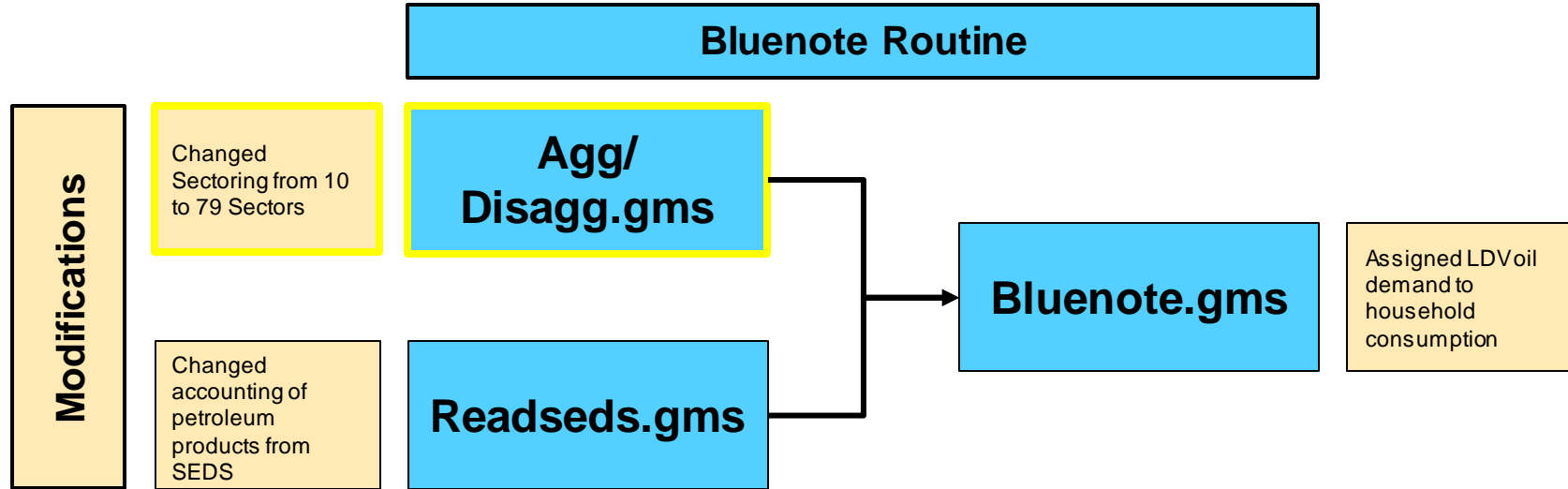
Bluenote Routine Overview

Bluenote Routine

Modifications

Changed Sectoring from 10 to 79 Sectors

Changed accounting of petroleum products from SEDS

Agg/ Disagg.gms

Readseds.gms

Bluenote.gms

Assigned LDV oil demand to household consumption

Additional Modifications:
- LDV oil demand distributed to household income segments per FHA data
- Bounds on energy movement in Bluenote balancing routine tightened

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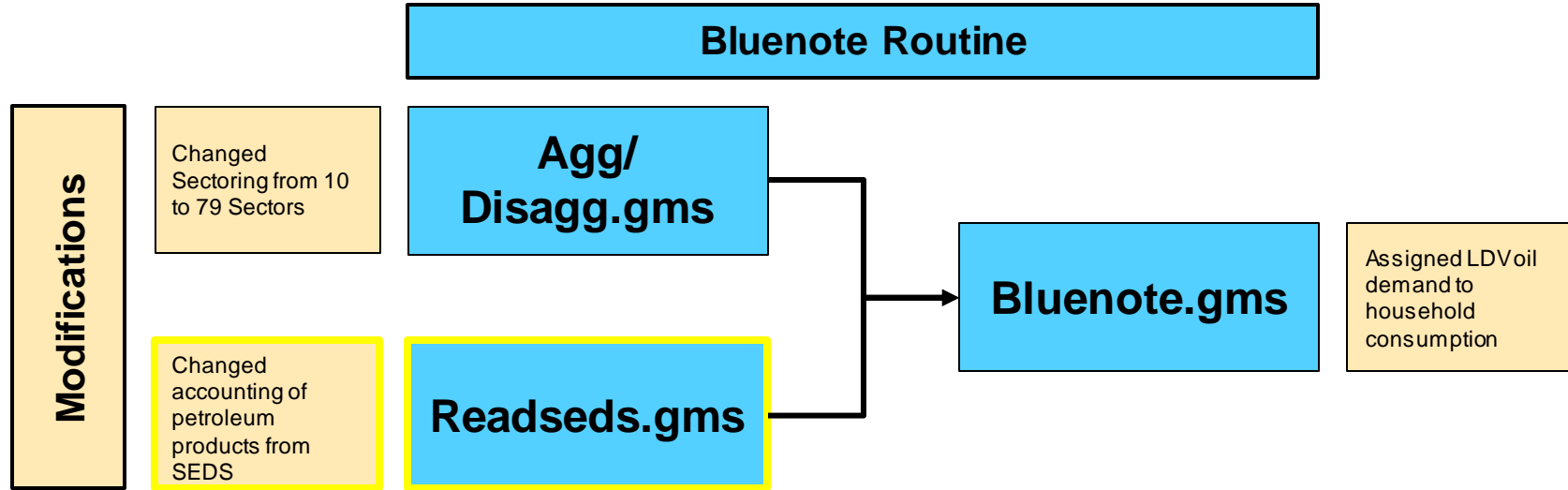- Bounds on energy movement in Bluenote balancing routine tightened

Sectoral Changes

Bluenote Sectors (10)	BEA+ Sectors (79)		
OIL: Petroleum Refineries	OIL		
CNG: Crude Oil, Natural Gas Extraction	CNG		
ELE: Electricity Generation, Transmission, Distribution	ELE		
COL: Coal Mining	COL		
CON: Construction	CON		
OMNF: Other Manufacturing	FPD OTE MMF	PET SMN ALT	FOF CEP
TRN: Transportation Services	AIR TRN WTT	TRK GRD PIP	OTR

Bluenote Sectors (10)	BEA+ Sectors (79)		
OSRV: Other Services	ORE DAT WST BRD RES WRH FIN REC EDU	TSV AMD OSV PUB HOS ADM NRS RNT SOC	ART MAN AMB COM BNK MOV LEG INS HOU
EINT: Energy Intensives	UTI CHE PPD NMP AGR PLA MIN	MOT PMT FMT FBP SEC EEC PRI	TEX MCH WPD ALU CMT GLA IAS
ROE: Rest of Economy	WHT MVT FBT GMT	OTT FDD FND	FEN SLG SLE

Note: See Appendix for full BEA sector names

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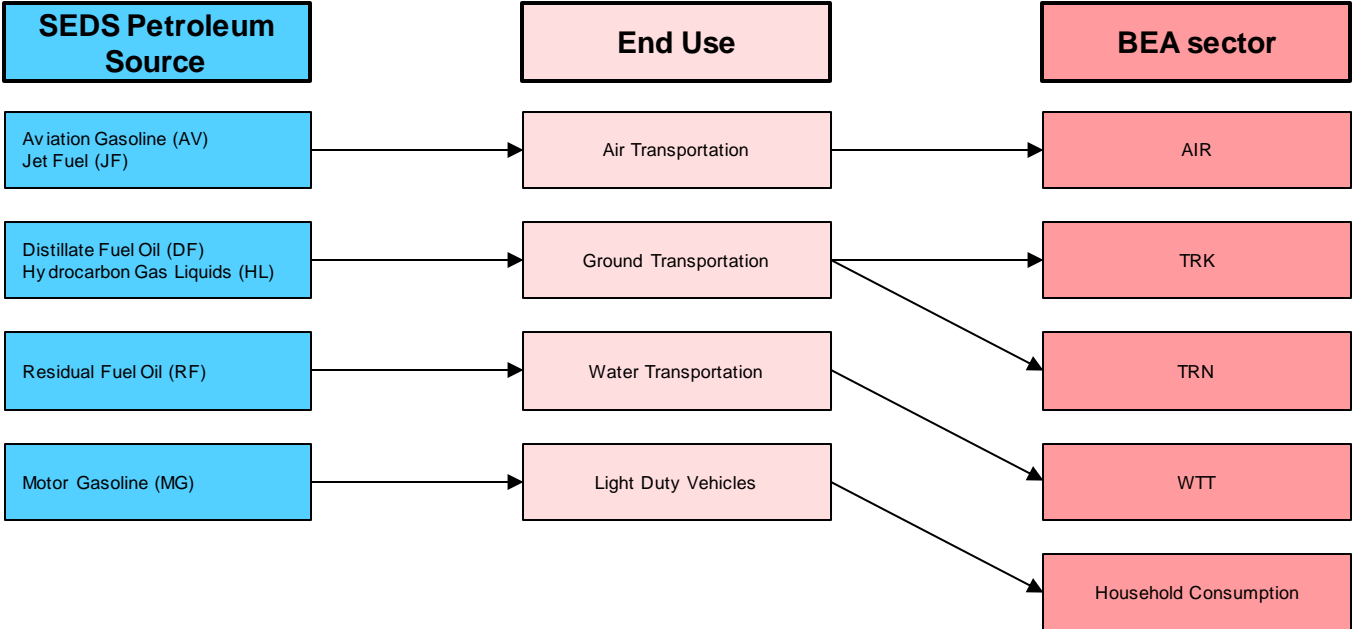**Readseds.gms**

Bluenote.gms

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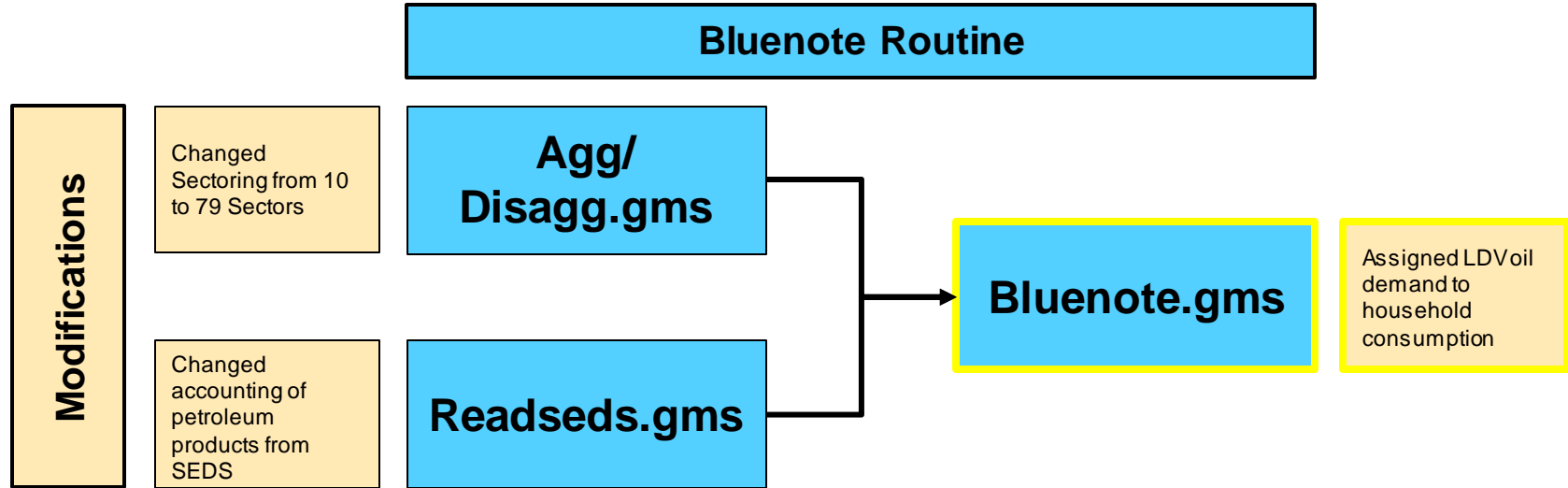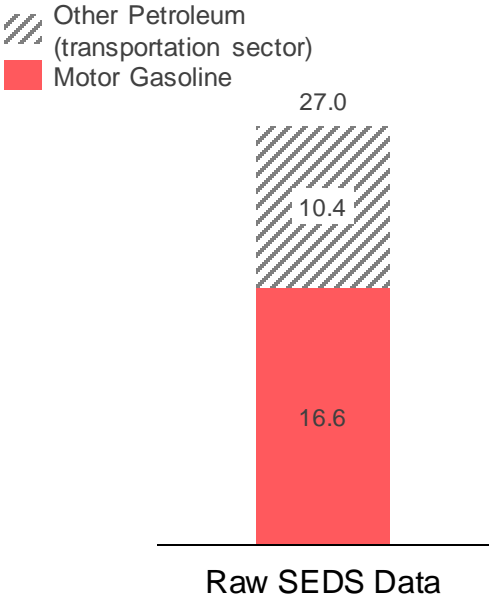
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SEDS petroleum accounting changes

SEDS Petroleum Source	End Use	BEA sector
Aviation Gasoline (AV) Jet Fuel (JF)	Air Transportation	AIR
Distillate Fuel Oil (DF) Hydrocarbon Gas Liquids (HL)	Ground Transportation	TRK
Residual Fuel Oil (RF)	Water Transportation	TRN
Motor Gasoline (MG)	Light Duty Vehicles	WTT
		Household Consumption

Note: See Appendix for full BEA sector names

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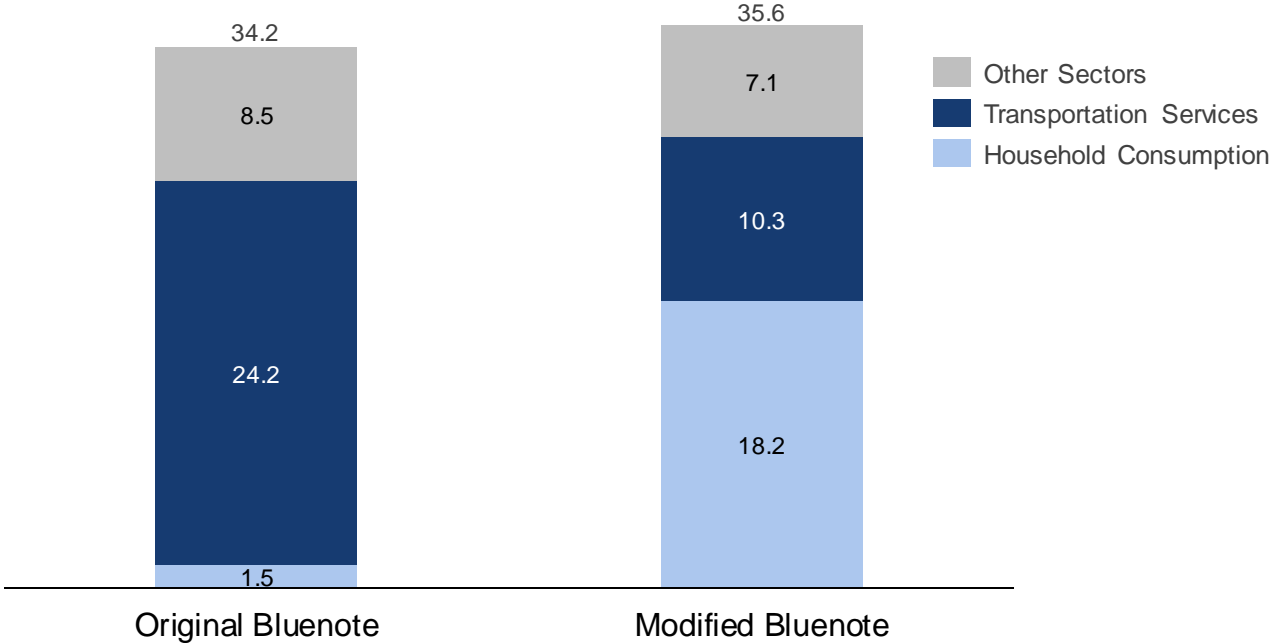Assigned LDV oil demand to household consumption

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# Change in Oil Demand

SEDS transportation oil demand (Quads)

Other Petroleum (transportation sector)
Motor Gasoline

27.0
10.4
16.6

Raw SEDS Data

Oil demand (Quads) by sector: before and after modifications

Other Sectors
Transportation Services
Household Consumption

34.2
8.5
24.2
1.5

Original Bluenote

35.6
7.1
10.3
18.2

Modified Bluenote

Change in Oil Demand

Oil demand (Quads) by sector and census region: before and after modifications
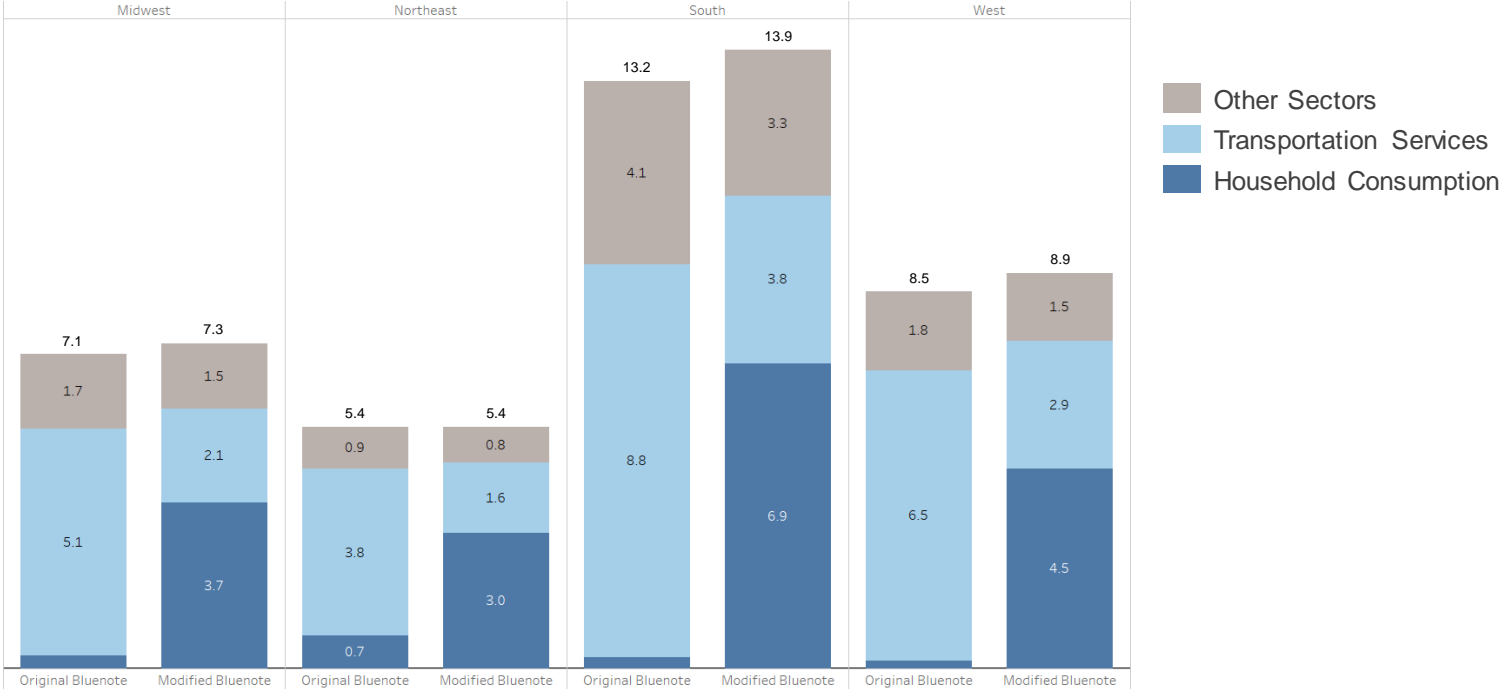
Known remaining issues

o Sectoral oil demand:

- All LDV oil demand is currently given to household consumption, but some should be distributed to BEA sectors. Still searching for source to inform this secondary distribution

o Investment and government demand reconciliation:

- In 2017 WiNDC data, investment and government demand for oil is 0 (going all the way back to the core build stream)

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U.S. Regional Energy Policy Model (USREP)

Recursive Dynamic Energy-Economic Model of the U.S. Economy

Regions

Flexibility in 50 states aggregation
The current version extends to 15 individual states and 14 multi-state regions

Sectors

Flexibility in sector aggregation
The standard version represents 5 energy, 6 non-energy sectors including personal transport

Income Groups

Multiple household earned-income groups
The disaggregated household allows to explore distributional impact
Labor-leisure choice affects the supply curve of labor

Technology

Advanced energy supply technologies
Options are available for electricity generation, fuel production, transport, and emission capture

Vintages

Production are distinguished by generations of technologies
Vintaging capital captures inertia of technology transition in the short run
Coal and nuclear retirement schedule

Trade

Domestic and foreign goods are imperfect substitutes
National market for domestic trade; national fuel market; pooled electricity markets
Foreign trade characterized by elasticity for export demand and import supply

Fuel Depletion

Fossil energy resource depletes based on production of fuel in the previous period
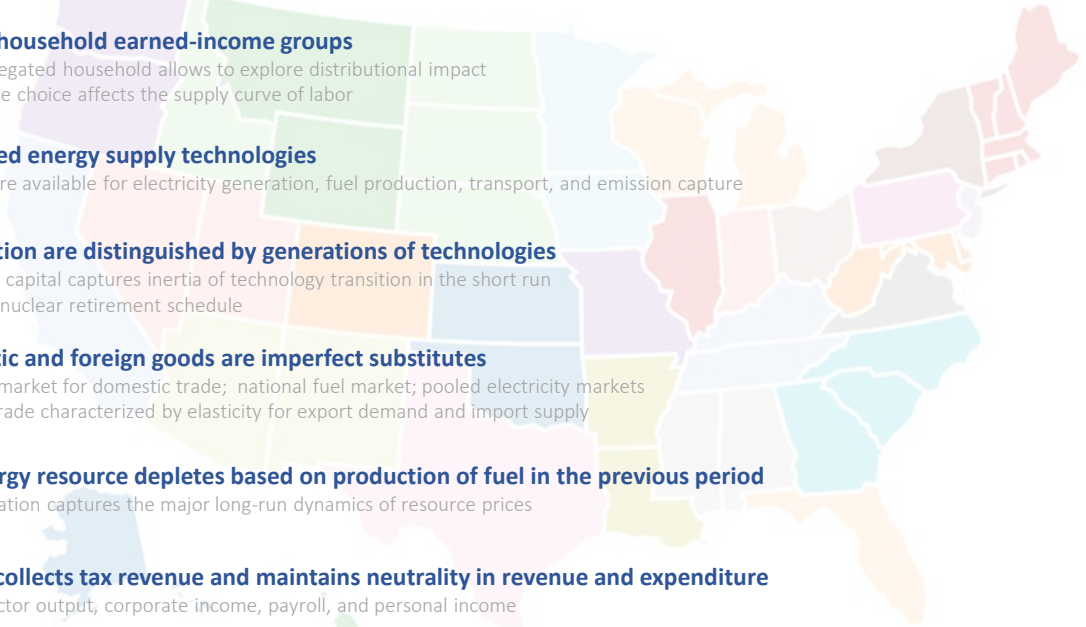This specification captures the major long-run dynamics of resource prices

Government & Tax

Government collects tax revenue and maintains neutrality in revenue and expenditure
Tax applies to sector output, corporate income, payroll, and personal income

GHG Emissions

CO_2 and non-CO_2 GHG emissions (CH_4, N_2O, HFC_S, PFC_S, SF_6)

WiNDC modification for personal transport representation

Steps of Modification

1. Updating oil demand in both economic and energy accounts by reallocating all motor gasoline in the transportation sector to household

2. Using historical transportation statistics to share out household motor gasoline demand by income group; for the non-gasoline portion, share out by the value of household consumption

3. Updating the related accounts due to motor gasoline reallocation (ys0, s0)

4. Holding household oil consumption fixed for the rebalancing routine

A personal transport sector in USREP combines vehicle motor gasoline demand with other associated costs, i.e., vehicle ownership and operation

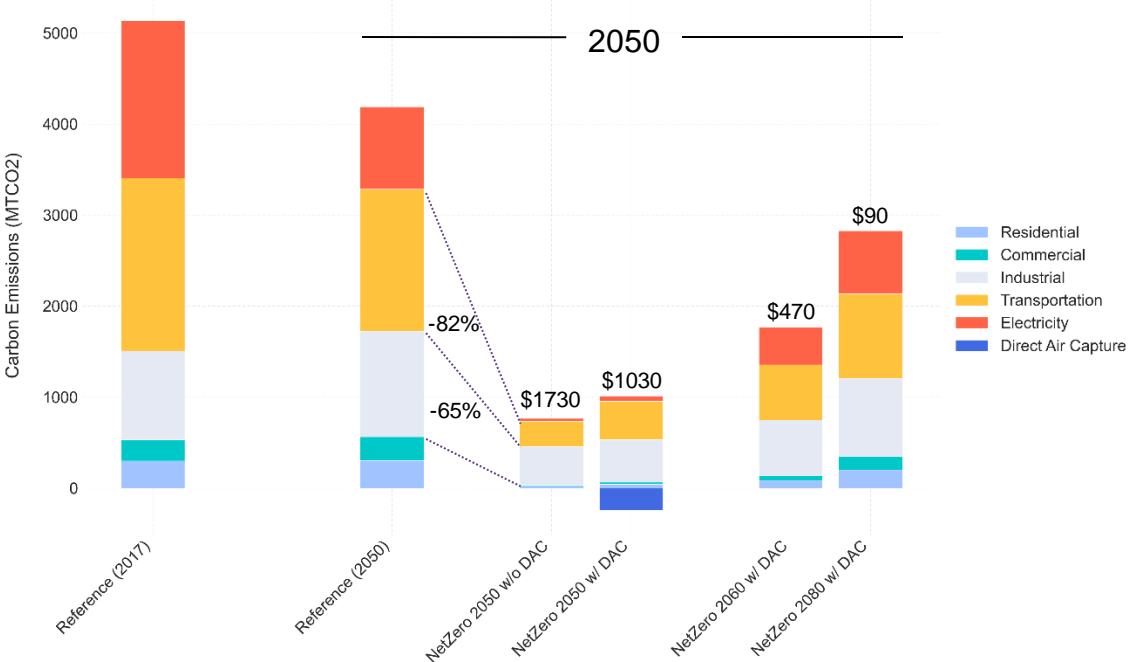With the modified dataset, personal transport can be split from the household consumption

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Modeling net-zero pathways defined by EMF37
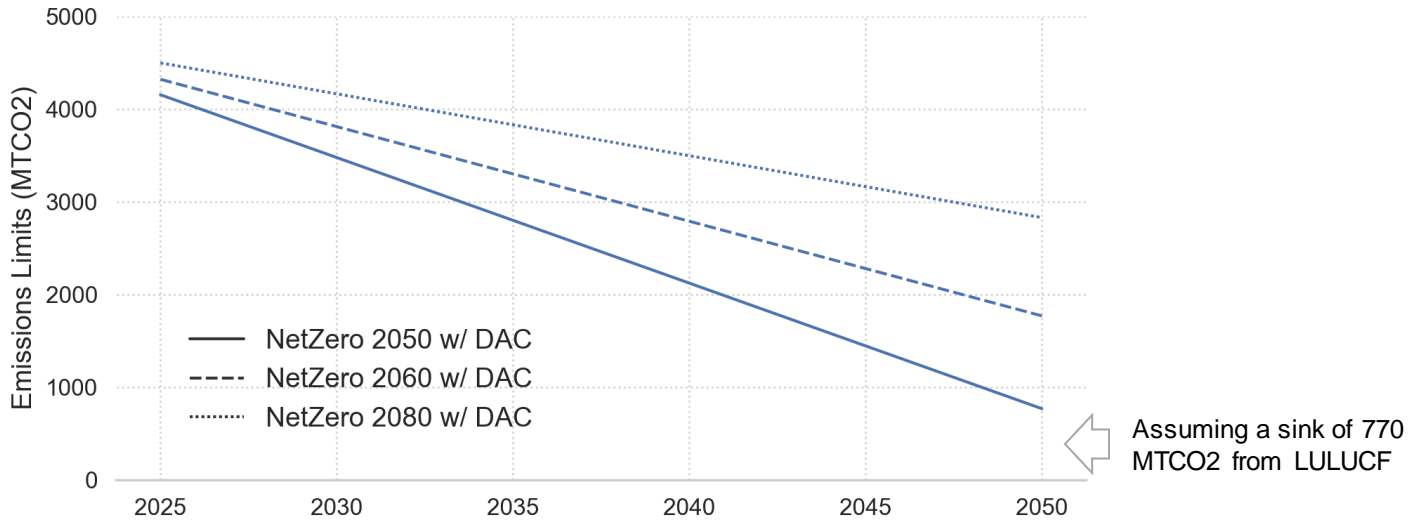
# Achieving net zero by 2050 requires over 90% abatement from the residential, commercial and electric sectors

Key Results

○ To achieve net zero by 2050, cost of abatement increases to $200/tCO$_2$ by 2035. By 2045, at a cost of abatement over $700/tCO$_2$, DAC becomes economically competitive, capturing 100 MtCO$_2$, reducing the cost of abatement by $110/tCO$_2$. DAC increases further to 250 MtCO$_2$ by 2050, reducing the cost of abatement by $700/tCO$_2$.

○ Achieving the net zero target by 2060 leads to a 2% reduction in GDP by 2050. Reaching the target earlier (by 2050) increases the impact to 5%. DAC deployment can mitigate the GDP impact by about one percentage point.

○ Electric vehicle is projected to rise quickly to take over 90% of the new sales market by 2040 in the reference scenario. To reach net zero by 2050, electric vehicle sales rise substantially post 2030.

○ Coupling with NREL's ReEDS model, cost of abatement to achieve net zero by 2050 decreases by $85/tCO$_2$ in 2035, a reduction of 38% from the USREP standalone study.

Future work

- Sensitivity analysis (renewable energy intermittency, DAC)
- Representation of hydrogen
- CCS and fuel switching to industry
- Commercial transportation and industrial sector disaggregation
- ReEDS update for USREP-ReEDS
- Update to GTAP-WiNDC for the non-US representation

WiNDC energy accounts are constructed based on EIA-SEDS database
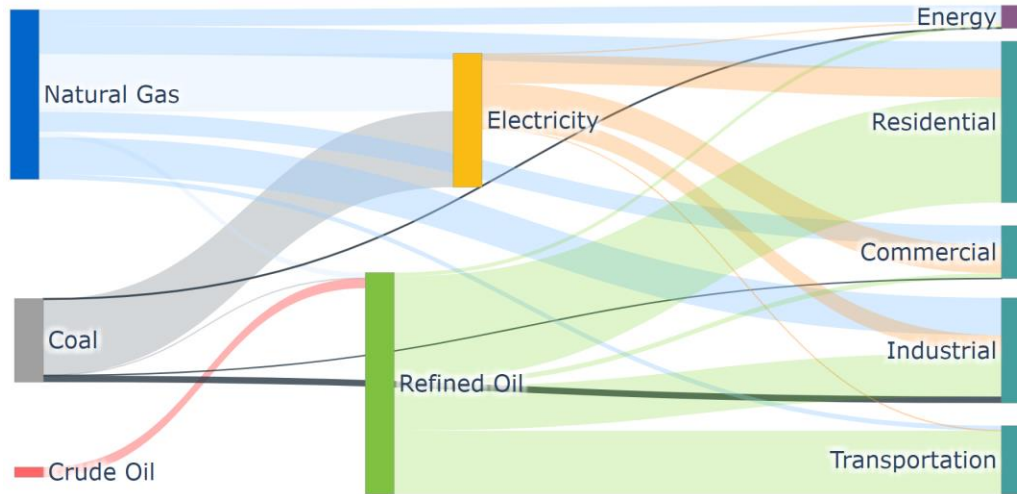
Note: Constructed based on WiNDC 3.0.3 to illustrate the flows from primary energy to energy conversion sectors and final energy consumption sectors in 2017

- Crude oil consumption by refined oil production is not available

- Refined oil production is not available

- Implied prices for refined oil output about 10 times higher

Thank you!

DAC Assumptions

BEA Sector Definitions

ADM: Administrative and support services
AGR: Farms
AIR: Air transportation
ALT: Apparel and leather and allied products
ALU: Aluminium
AMB: Ambulatory health care services
AMD: Accommodation
ART: Performing arts, spectator sports
BNK: Federal Reserve banks, credit intermediation,
BRD: Broadcasting and telecommunications
CEP: Computer and electronic products
CHE: Chemical products
CMT: Cement
CNG: Crude oil and natural gas extraction
COL: Coal mining
COM: Computer systems design and related services
CON: Construction
DAT: Data processing, internet publishing,
EDU: Educational services
EEC: Electrical equipment, appliances, components
ELE: Electricity generation, transmission, distribution
FBP: Food and beverage and tobacco products
FBT: Food and beverage stores
FDD: Federal general government (defense)
FEN: Federal government enterprises
FIN: Funds, trusts, and other financial vehicles
FMT: Fabricated metal products
FND: Federal general government (nondefense)

FOF: Forestry, fishing, and related activities
FPD: Furniture and related products
GLA: Glass
GMT: General merchandise stores
GRD: Transit and ground passenger transportation
HOS: Hospitals
HOU: Housing
IAS: Iron and Steel
INS: Insurance carriers and related activities
LEG: Legal services
MAN: Management of companies and enterprises
MCH: Machinery
MIN: Other mining
MMF: Miscellaneous manufacturing
MOT: Motor vehicles, bodies, trailers manufacturing
MOV: Motion picture and sound recording industries
MVT: Motor vehicle and parts dealers
NMP: Nonmetallic mineral products
NRS: Nursing and residential care facilities
OIL: Petroleum refineries
ORE: Other real estate
OSV: Other services, except government
OTE: Other transportation equipment
OTR: Other transportation and support activities
OTT: Other retail
PET: Other petroleum-based manufacturing
PIP: Pipeline transportation
PLA: Plastics and rubber products

PMT: Primary metals
PPD: Paper products
PRI: Printing and related support activities
PUB: Publishing industries, except internet
REC: Amusements, gambling, recreation industries
RES: Food services and drinking places
RNT: Rental and leasing services
SEC: Securities, commodity contracts, investments
SLE: State and local government enterprises
SLG: State and local general government
SMN: Support activities for mining
SOC: Social assistance
TEX: Textile mills and textile product mills
TRK: Truck transportation
TRN: Rail transportation
TSV: Miscellaneous professional, scientific services
UTI: Other utilities
WHT: Wholesale trade
WPD: Wood products
WRH: Warehousing and storage
WST: Waste management and remediation services
WTT: Water transportation