IN-MARKAL: Modeling Indiana's Energy System (Work-in-Progress)

Presented by: Liwei Lu and Emrah Ozkaya

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Outline

- Goals
- Current Progress
- Future Work and Conclusion

Research Summary

Goals

- Develop a detailed, well-documented MARKAL model
  - Representing the overall energy systems of Indiana
- Federal policies on emissions
  - Potential impact on Indiana's economy and power system?

- Voluntary Clean Energy Portfolio Standard Program (SB251)
  - Impact on the energy supply and demand for the state?
- Electric Vehicles and PHEVs
  - Impact on the electricity grid?

Current Progress

- Sectors considered

Residential | Commercial | Industrial | Transportation

- Modeling period
  - 2007 to 2037
  - 3 year increments
- Technology database
  - EPAUS9r_2010_v1.0
- End-use demands and projections at the state level
  - Completed the four sectors

Residential Sector

- 5 Fuel Types
  - Electricity, Natural Gas, Distillate Fuel Oil (DFO), Liquefied Petroleum Gas (LPG) and Other
  - Other includes Kerosene, Coal and Renewables (around 5%)

- 9 End-Uses
  - RSH Residential Space Heating
  - RSC Residential Space Cooling
  - RWH Residential Water Heating
  - RRef Residential Refrigeration
  - RFr Residential Freezer
  - RLig Residential Lighting
  - Other-ELC Residential Other-Electricity
  - Other-GAZ Residential Other-Natural Gas
  - Other-LPG Residential Other-LPG

Residential Sector

Base Year Useful Energy Services Provided by Electricity, NG and DFO

SUFG's MAISY REDMS Forecast Report 2007 for the state of Indiana

Data for 12 demand categories and 3 primary fuel types (electricity, natural gas and distillate fuel oil)

SEDS-2007 residential energy consumption data for the state of Indiana

Energy use shares for each demand category of the three primary fuel types

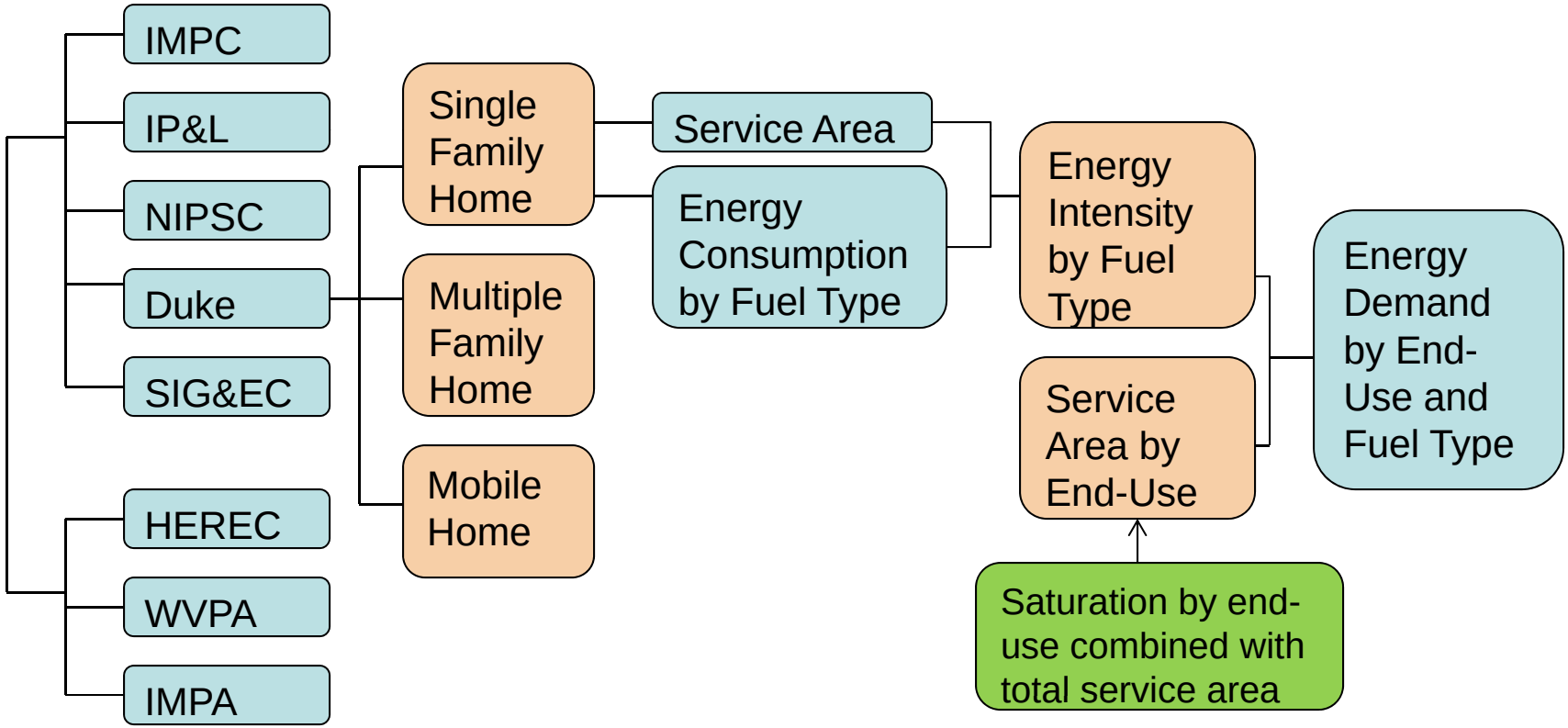
2007 end-use equipment efficiency from AEO 2010 adapted based on Indiana's equipment stock

Base year primary energy consumption by end-uses

Base year end-use energy services provided by electricity, natural gas and distillate fuel Oil

Residential Sector

MAISY REDMS End-Use Energy Consumption Estimation



Residential Sector

Base Year Demand for Liquefied Petroleum Gas

- Available Data

2007 LPG Consumption

	US	ENC	IN
Space Heating	216.0200		
Water Heating	92.2110		
Cooking	31.1910		
Miscellaneous LPG	142.0390		
Total	481.4610	108.7500	15.5000

- Matrix Balancing

Step 1: Creating an A Matrix

A Matrix

	US-ENC	ENC-IN	IN	US End-Use Total
Space Heating	216.0200	216.0200	216.0200	216.0200
Water Heating	92.2110	92.2110	92.2110	92.2110
Cooking	31.1910	31.1910	31.1910	31.1910
Miscellaneous LPG	142.0390	142.0390	142.0390	142.0390
Total	372.7110	93.2500	15.5000	481.4610

Residential Sector

Step 2: Applying Energy Intensity Multiplier to A Matrix

A Matrix after Applying Energy Intensity

	US-ENC	ENC-IN	IN	US End-Use Total
Space Heating	159.2496	49.9189	6.8515	216.0200
Water Heating	77.6747	12.5338	2.0025	92.2110
Cooking	26.2740	4.2396	0.6774	31.1910
Miscellaneous LPG	119.6477	19.3067	3.0847	142.0390
Total	279.4610	77.7500	15.5000	481.4610

Energy Intensity Data

- Space Heating: HDD*Housing Unit /Residential Sector LPG Price
- Water Heating/Cooking/MisLPG: Housing Unit
- Energy Intensity Multiplier: (US-ENC)/US, (ENC-IN)/US and IN/US

Step3: Applying Matrix Balancing (Scaling Algorithm)

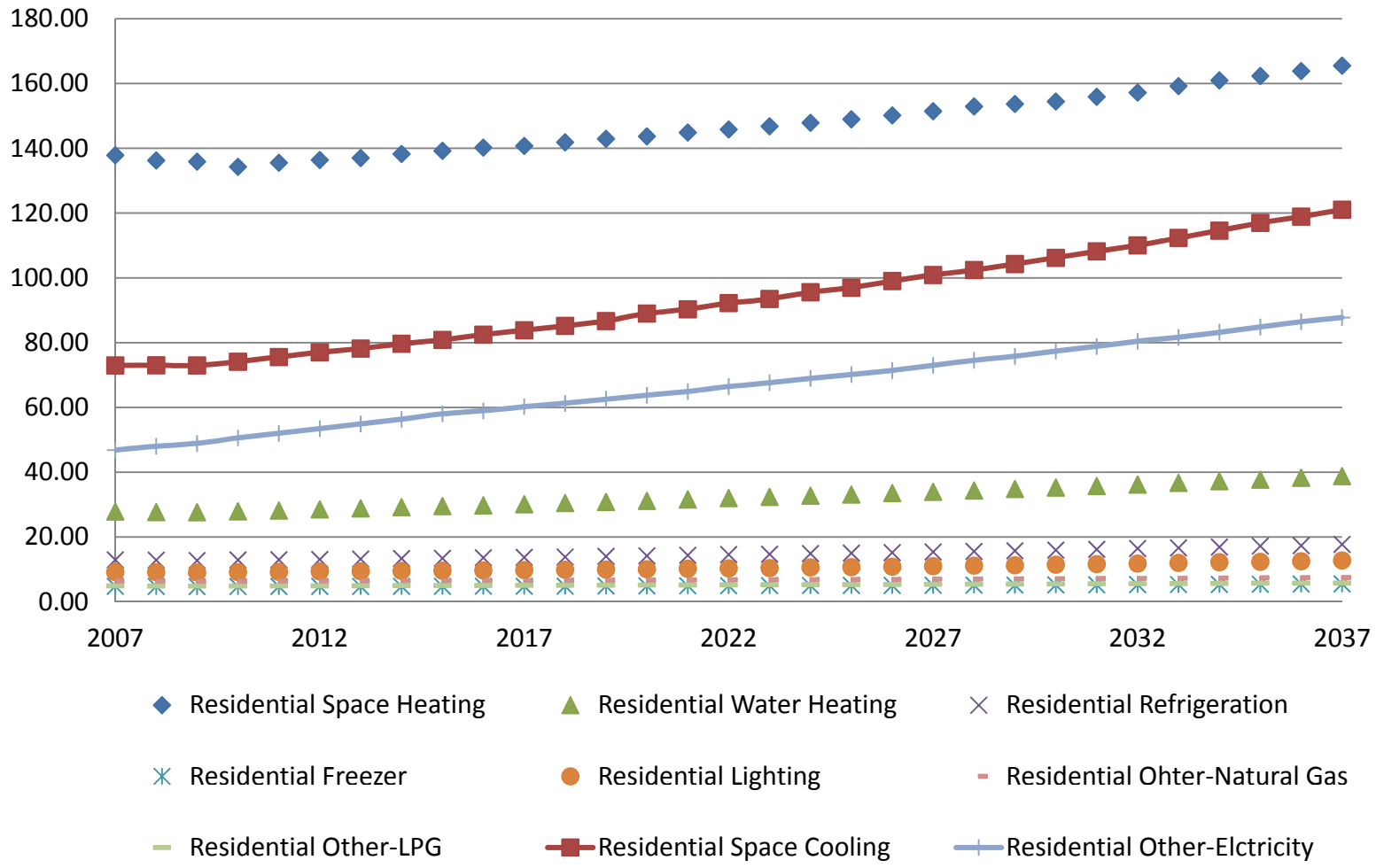
Source: HDD from National Climatic Data Center under US Department of Commerce
Housing Unit from Annual Estimates of Housing Units for the United States
LPG price for residential sector from EIA AEO and SEDS

Residential Sector

Base Year Residential Usable Energy Services

Demand	Descriptor	Unit	Electricity	NG	DFO	LPG	Other	Total
RSH	Residential Space Heating	PJ	15.98	95.68	2.25	6.88	17.09	**137.88**
RSC	Residential Space Cooling	PJ	72.98					**72.98**
RWH	Residential Water Heating	PJ	8.72	17.57	0.11	1.48		**27.88**
RRef	Residential Refrigiration	PJ	12.96					**12.96**
RFr	Residential Freezer	PJ	4.80					**4.80**
RLig	Residential Lighiting	billion lumen yr	9.17					**9.17**
Other-ELC	Residential Other-Elctriicty	PJ	46.84					**46.84**
Other-GAZ	Residential Ohter-Natural Gas	PJ		6.33				**6.33**
Other-LPG	Residential Other-LPG	PJ				4.91		**4.91**

Residential Sector Useful Energy Services Projection



Note: Energy services except lighting are in PJ. Demand for lighting service is in billion lumen years.

Commercial Sector

Base Year Useful Energy Services Provided by Electricity, NG and DFO

SUFG's MAISY CEDMS Forecast Report 2007 for the state of Indiana

Data for 12 demand categories and 3 primary fuel types (electricity, natural gas and distillate fuel oil)

SEDS-2007 commercial energy consumption data for the state of Indiana

Energy use shares for each demand category of the three primary fuel types

2007 end-use equipment efficiency from AEO 2010

Base year primary energy consumption by end-uses

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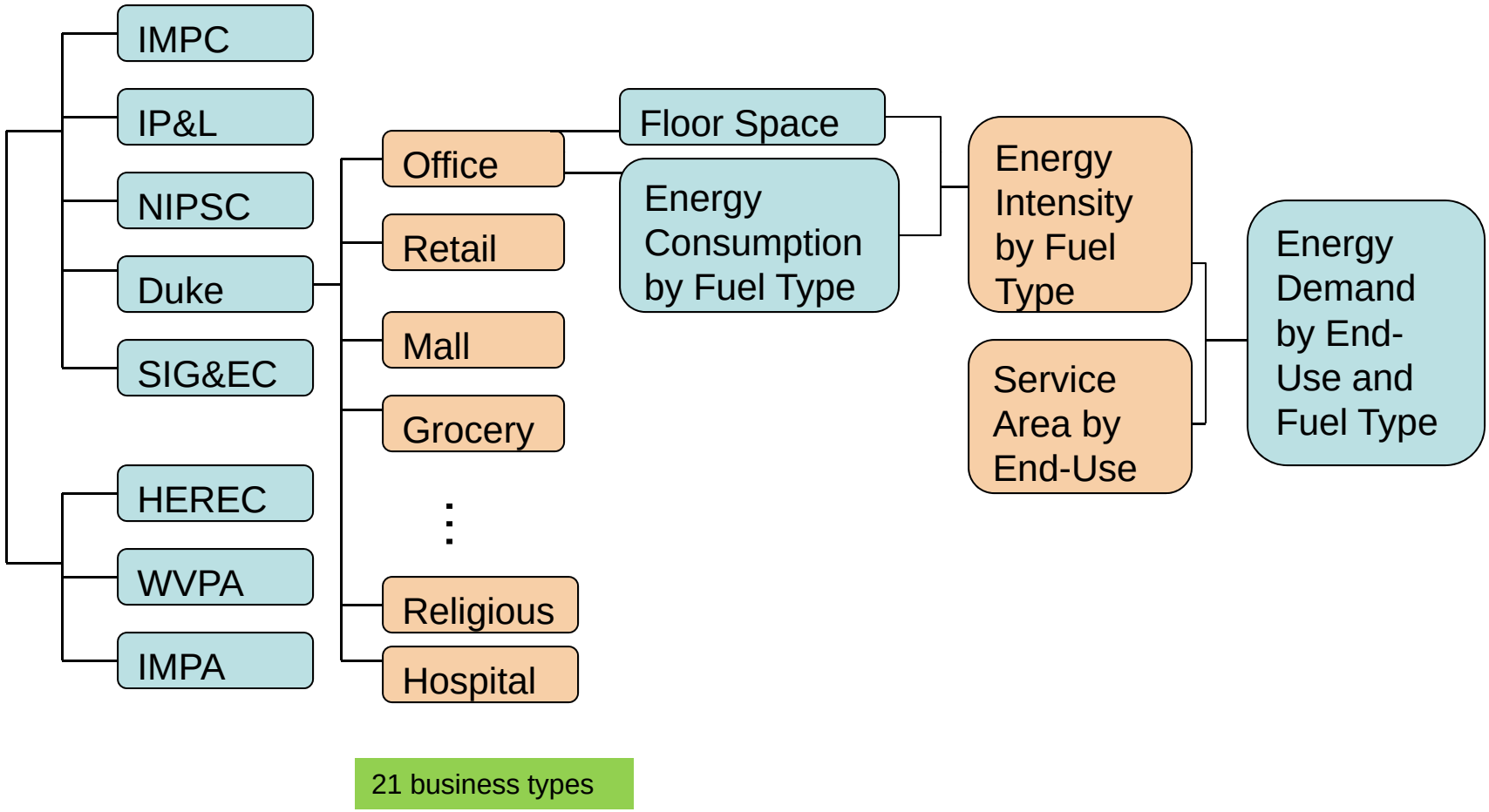
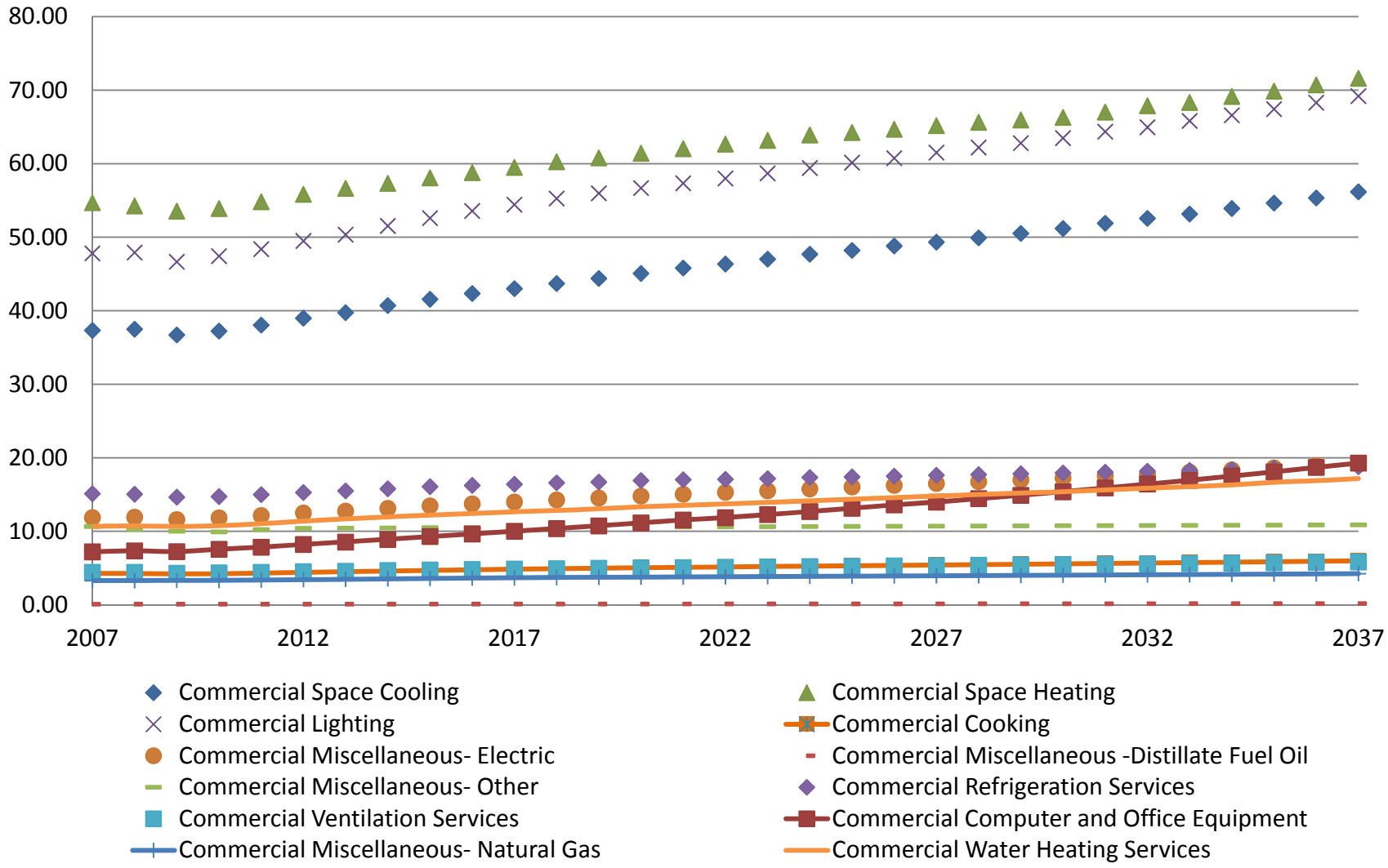
Commercial Sector

MAISY CEDMS End-Use Energy Consumption Estimation



Commercial Sector Useful Energy Services Projection



Industrial Sector

Demand and Projection

Matrix Balancing with

SEDS-2007 (BTUs)

→

GSP growth rates from

IU-CEMR's

Long-Range Projections

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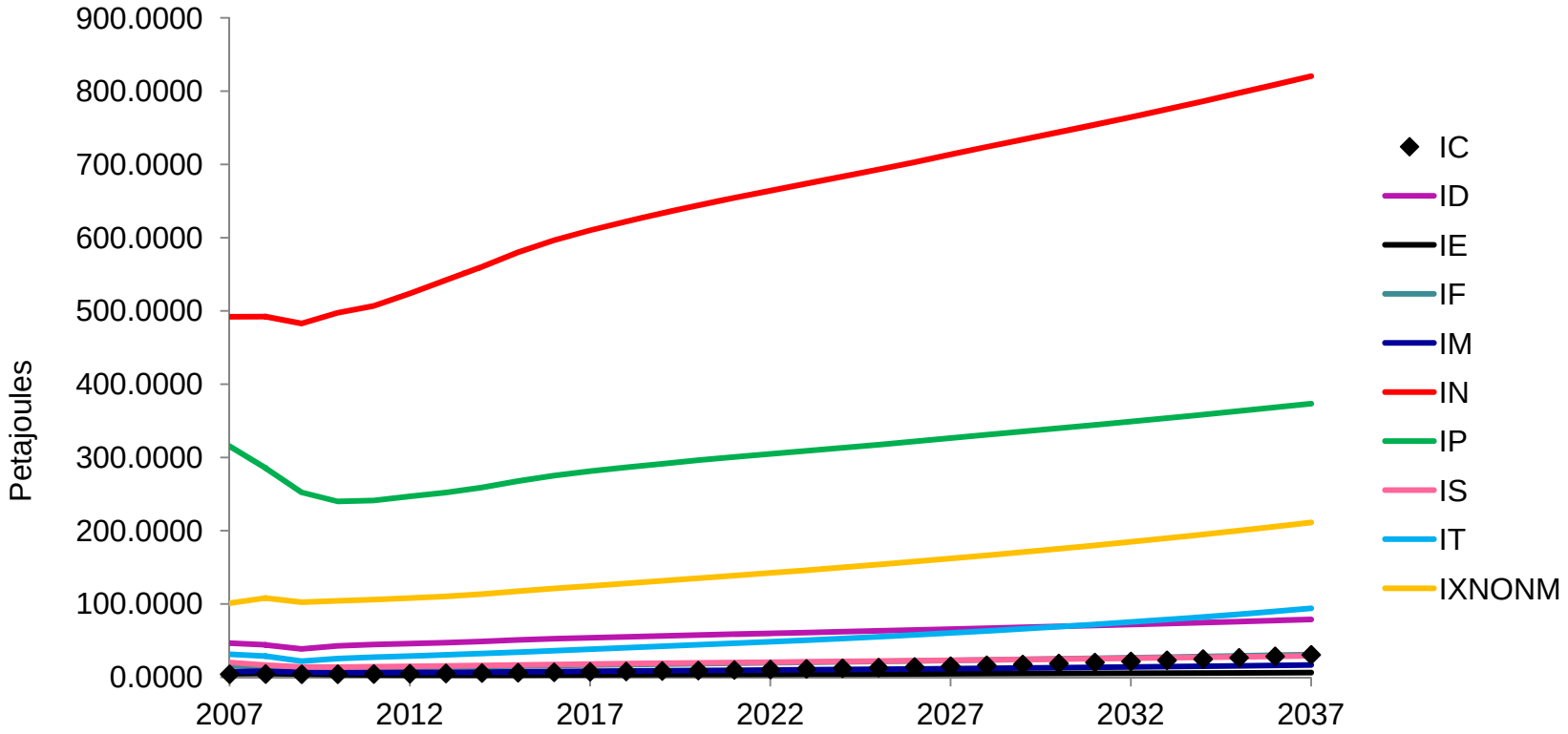
Base year energy consumption data for 10 demand categories

Projections into 2037

Industrial Sector Useful Energy Services Projection



IC: Computers Manufacturing
ID: Other Durables Manufacturing
IE: Electrical Equipment Manufacturing
IF: Fabricated Metal Products Manufacturing
IM: Machinery Manufacturing
IN: Other Non-Durables Manufacturing
IP: Primary Metals Manufacturing
IS: Plastic Products Manufacturing
IT: Transportation Equipment Manufacturing
IXNONM: Non-Manufacturing

Transportation Sector

Demand and Projection

Matrix Balancing with
SEDS-2007 (BTUs)

→

Apply
Energy intensities to
Convert to meaningful units

↓

AEO 2010 coupled with pop. proj.
GSP from IU CEMR L-R proj. report
AEO 2010

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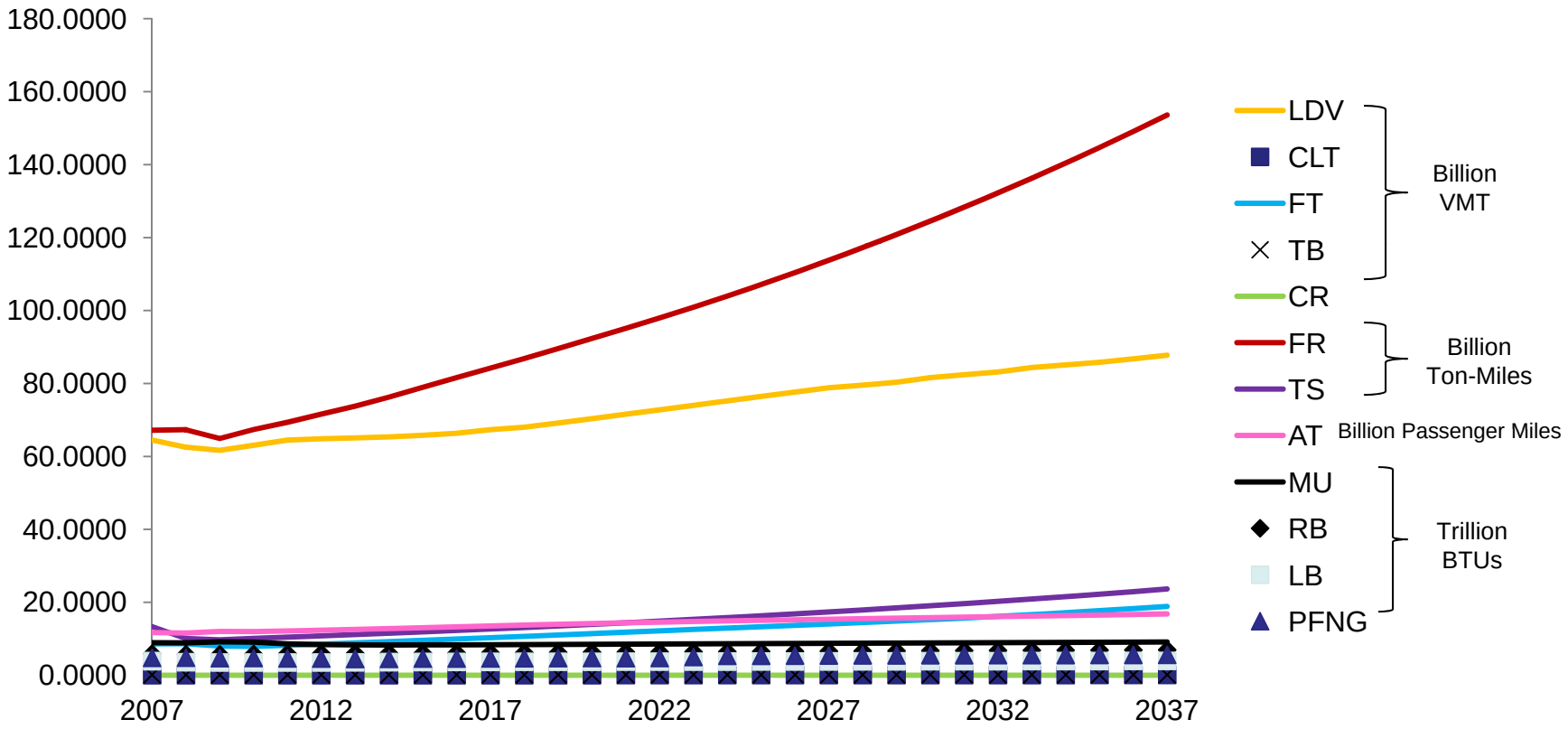
Base year energy consumption data for 12 demand categories

Projections into 2037

Transportation Sector Useful Energy Services Projection



LDV: Light-Duty Vehicles
CLT: Commercial Light Trucks
FT: Freight Trucks
TB: Total Bus

CR: Commuter Rail
FR: Freight Rail
TS: Total Shipping
AT: Air Transportation

MU: Military Use
RB: Recreational Boats
LB: Lubricants
PFNG: Pipeline Fuel Natural Gas

Future Work and Conclusion

- MARKAL demand technologies
  - Residential sector completed
  - Commercial, Industrial and Transportation to follow
- Technology database
  - EPAUS9r_2010_v1.0
- Supply and power generation
  - Coal critical to state
- Policy analysis
  - Clean Energy Standard proposed by Obama Administration and related proposals
  - ARRA 2009 and PEV subsidies

Thank you !