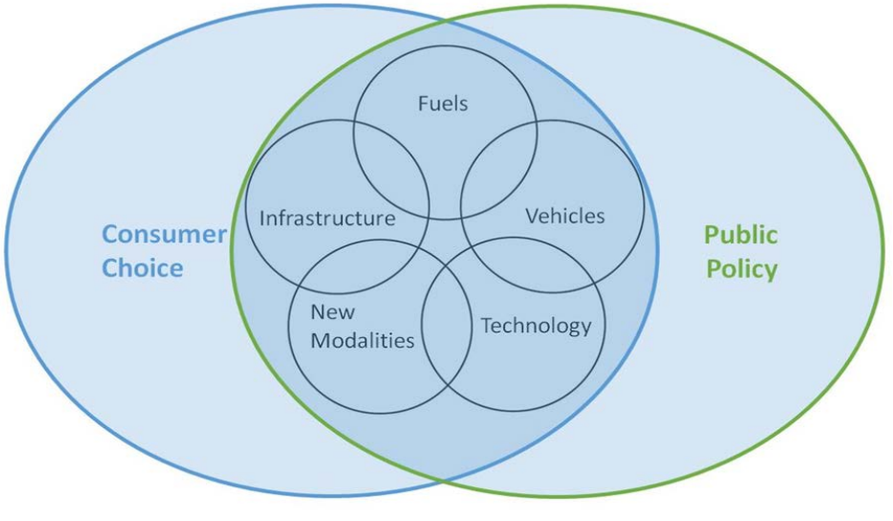
# Joint Program's Input to the MIT Mobility of the Future Study

Webinar for the MIT Joint Program Sponsors

Sergey Paltsev

May 11, 2017



# Mobility of the Future

- Question: How the interactions between advanced drivetrain options, alternative fuels, refueling infrastructure, consumer choice, vehicle automation, public transit options, mobility-as-a-service business models and government policy will shape the future for mobility?
- The goals are to explore how consumers and markets will respond to potentially disruptive technologies, business models, and government policies.
- The scope of the study is ground transportation with an emphasis on the movement of people.
- Intended timing of the project: 3-years (officially started in August 2016).

Webpage:

http://energy.mit.edu/research/mobility-future-study/

# MIT Team

**RANDALL FIELD**
Executive Director, Conversion Research Program
MIT Energy Initiative

## GLOBAL ECONOMIC AND POLICY MODELING

**SERGEY PALTSEV**
Senior Research Scientist
MIT Energy Initiative; MIT Joint Program on the Science and Policy of Global Change

## RECHARGING AND REFUELING INFRASTRUCTURE

**JOHN HEYWOOD**
Professor
Mechanical Engineering; MIT Joint Program on the Science and Policy of Global Change

## MOBILITY POLICY AND ANALYTICS

**CHRISTOPHER KNITTEL**
Professor
Center for Energy and Environmental Policy Research; MIT Joint Program on the Science
Policy of Global Change; Sloan School of Management

## VEHICLES AND FUELS

**WILLIAM GREEN**
Professor
Chemical Engineering

## URBAN MOBILITY

**MOSHE BEN-AKIVA**
Professor
Civil and Environmental Engineering

## SYSTEM DYNAMICS

**CHINTAN VAISHNAV**
Senior Lecturer
Sloan School of Management

## VEHICLE AUTOMATION

**BRYAN REIMER**
Research Scientist
MIT AgeLab

## MOBILITY CULTURE AND CHINA POLICY

**JINHUA ZHAO**
Assistant Professor
Urban Studies & Planning

# Joint Program Team

## Sergey Paltsev

**Deputy Director, Joint Program**
**Senior Research Scientist, Joint Program**
**Senior Research Scientist, MITEI and CEEPR**

paltsev@mit.edu
Website

**Phone:** 617-253-0514

**Office:** E19-429F

### Focus Areas

Energy, Climate Policy, Regional Analysis

## Abbas Ghandi

**Research Staff, Joint Program**

aghandi@mit.edu

**Phone:** 617-715-5254

**Office:** E19-429b

### Focus Areas

Energy

## Paul Kishimoto

**Research Assistant, Joint Program and China Energy and Climate Project**
**Doctoral Degree candidate, Institute for Data, Systems, and Society**

pnk@mit.edu
Website

### Focus Areas

Energy, Regional Analysis

## Y.-H. Henry Chen

**Research Scientist, Joint Program**

chenyh@mit.edu

**Phone:** 617-715-5432

**Office:** E19-429N

### Focus Areas

Energy, Climate Policy

# Goals of the Global Economic and Policy Modeling Task

- To explore interactions between different transportation technologies (ICE, PHEV, BEV), fuel prices, transportation policies, energy policies, and climate policies in an economy-wide setting at a global level (disaggregated by 18 regions).
- To assess implications for GHG emissions, air pollutants, fuel consumption, fleet composition, economic growth, and macroeconomic cost of avoided $CO_2$ emissions.

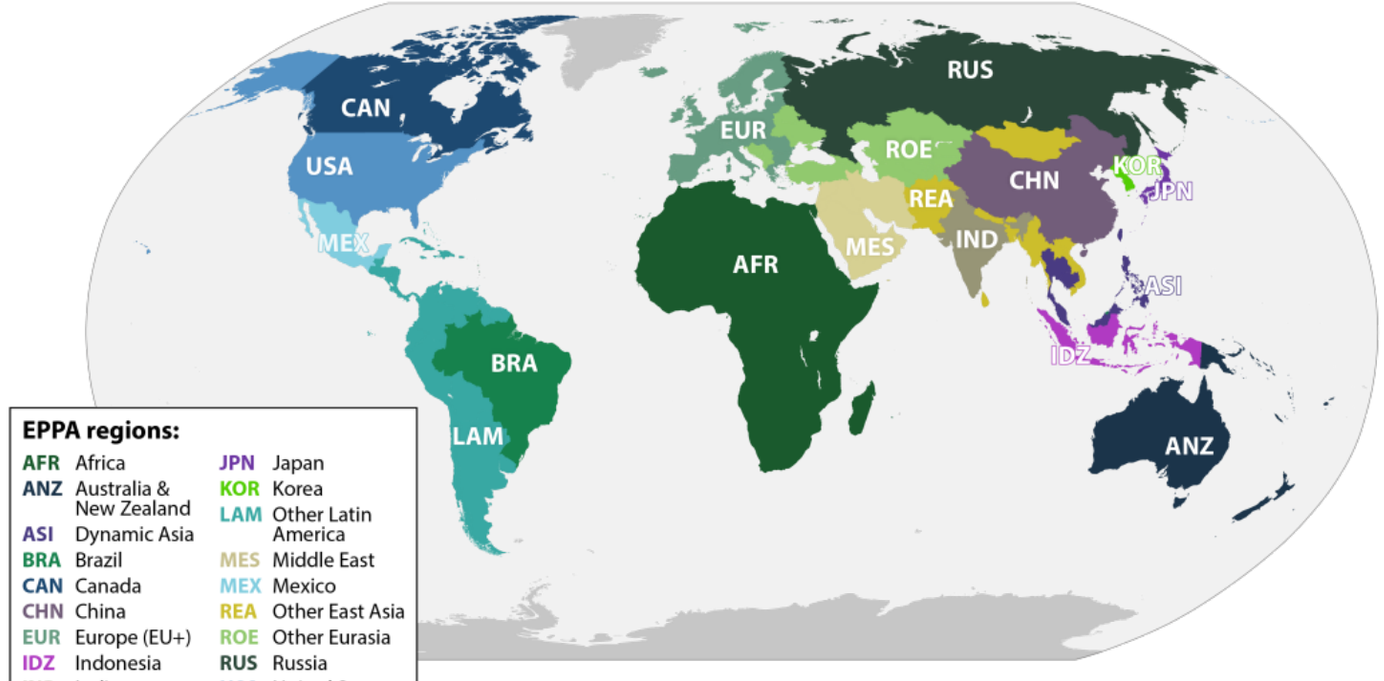
# Target Questions

- What are the impacts of energy, transportation, and climate policies on energy demand, on the economy, on the environment including global climate change?
- How will the vehicle fleet and fuel mix evolve in response to various policy scenarios?
- What are the macroeconomic costs of different policy options?

# Model: EPPA

Major goals:
Energy, economy, GHG and air pollutants projections.

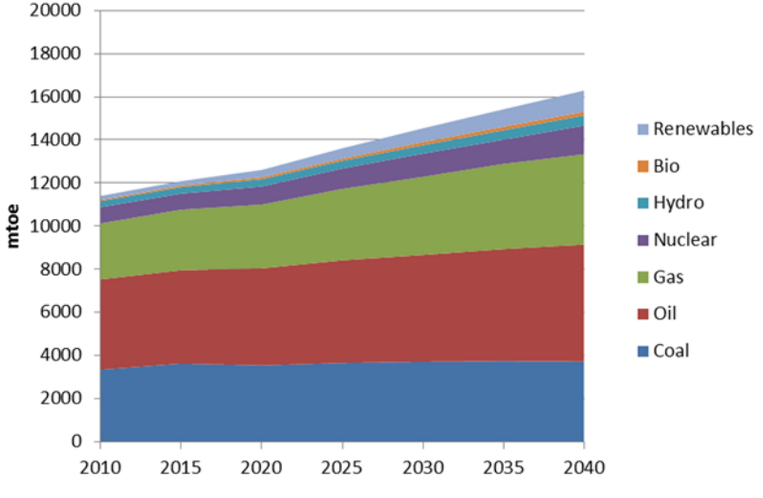
Representation:
All sectors of economy;
Global coverage.



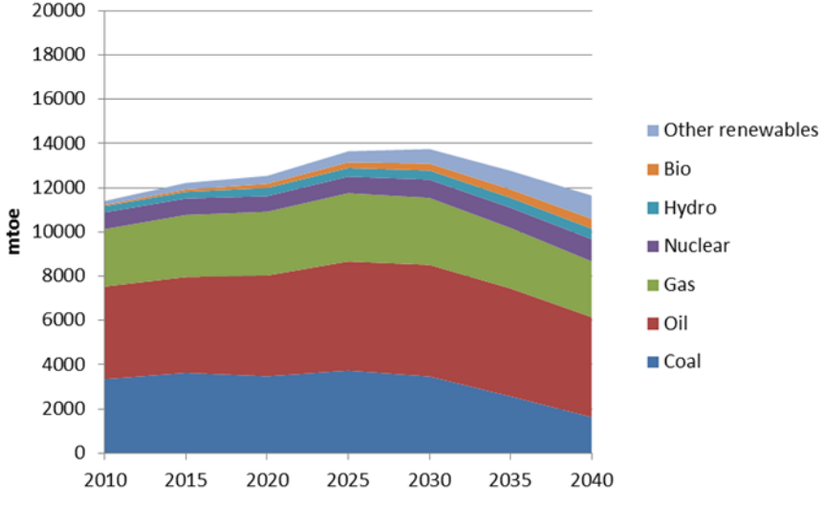

Features: Theory-based; Prices are endogenous; International Trade; Inter-industry linkages; Distortions (taxes, subsidies, etc); GDP and Welfare effects.
Cost: Aggregated representation of technologies.

# Expected EPPA Reporting Outputs for the Study

- Fleet mix, fuel mix, electricity mix, GHG emissions, air pollutants, economic growth, and macroeconomic cost of avoided $CO_2$ emissions.



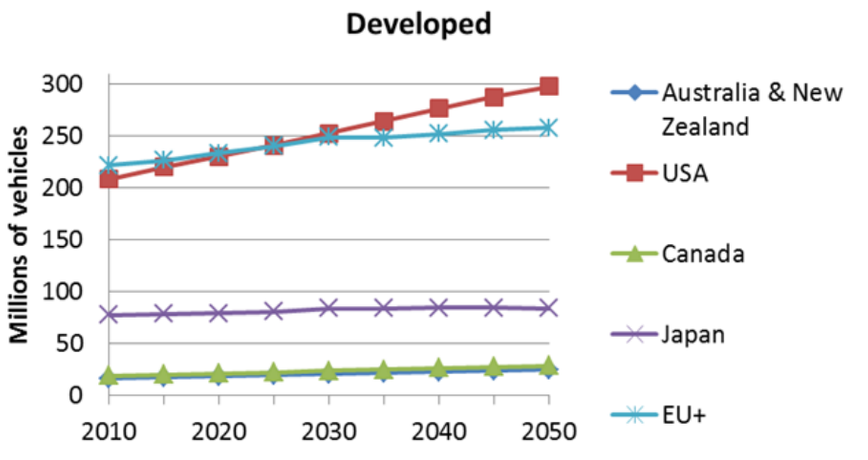

Baseline

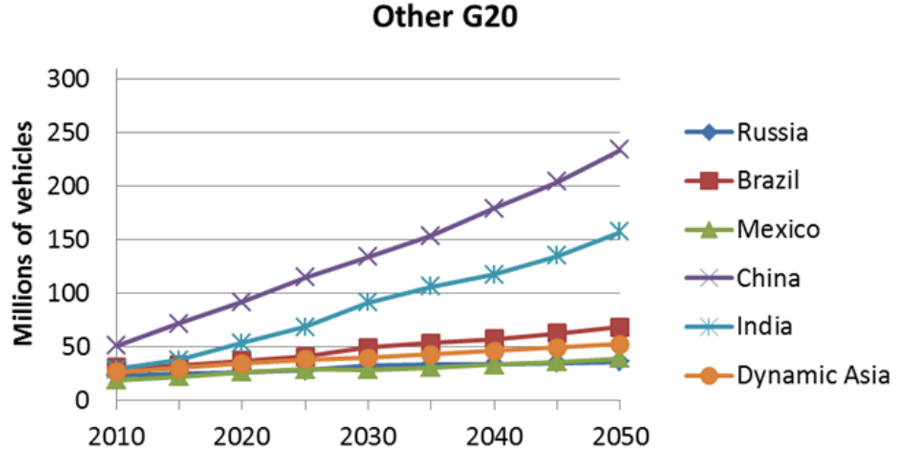


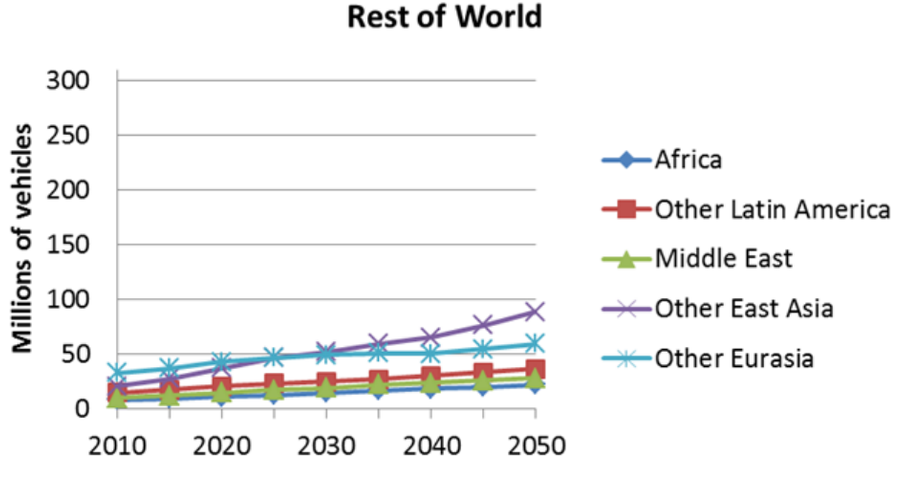

2C Policy

# Expected EPPA Regional Details on Private Transport

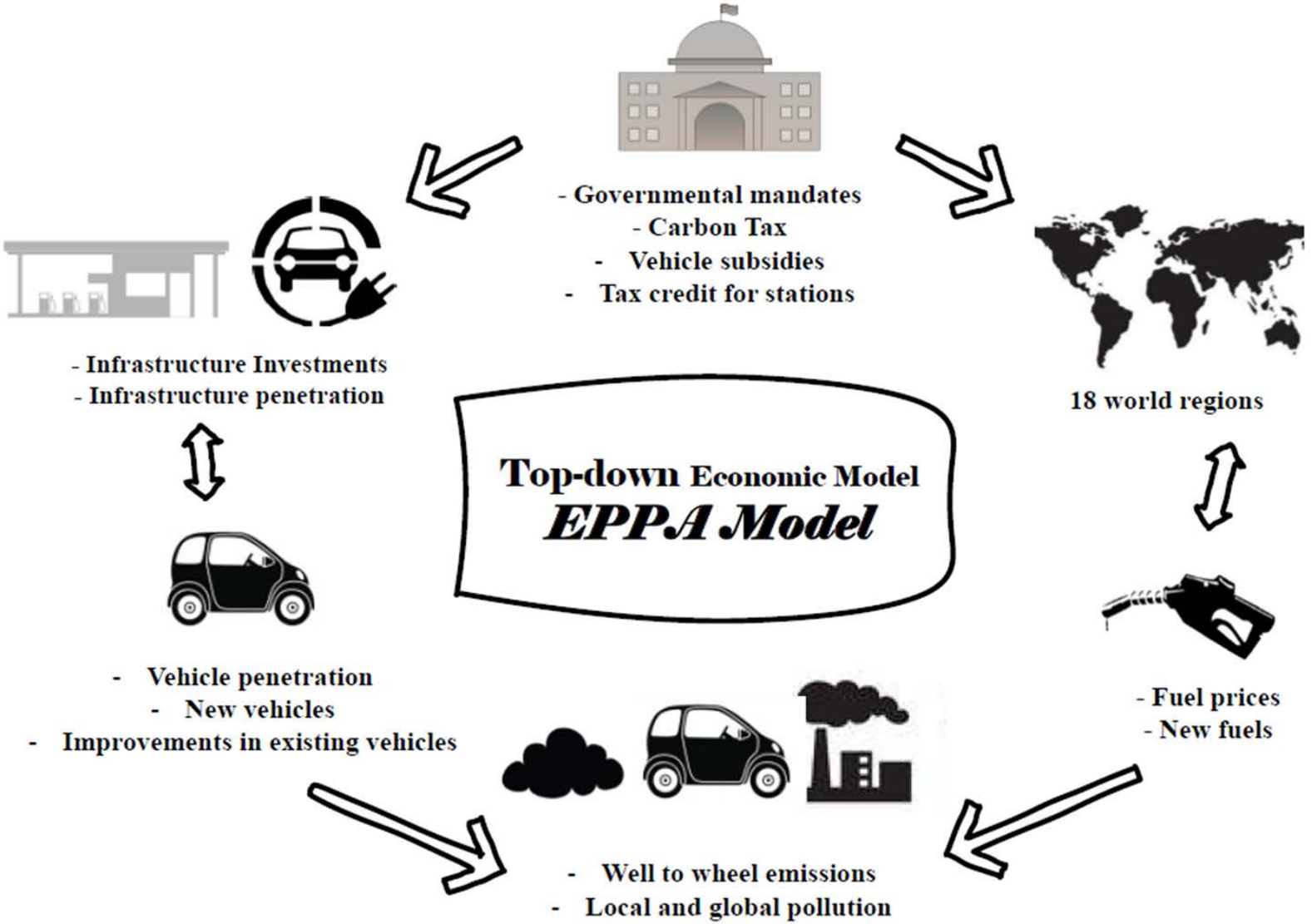
- Vehicle Stock (private cars and light trucks)
  - ICE, PHEV, BEV, (FCHV);
  - New and Old.



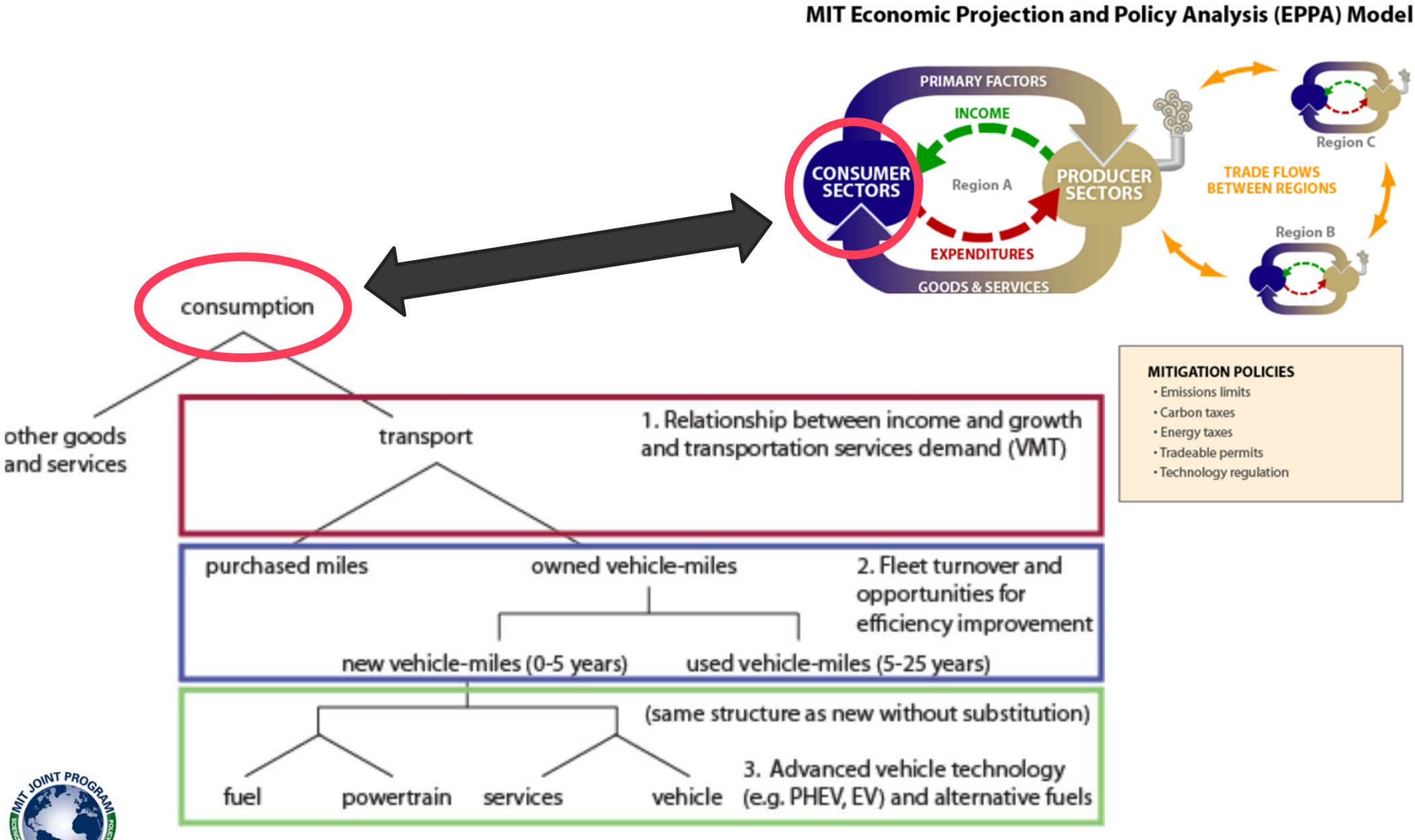



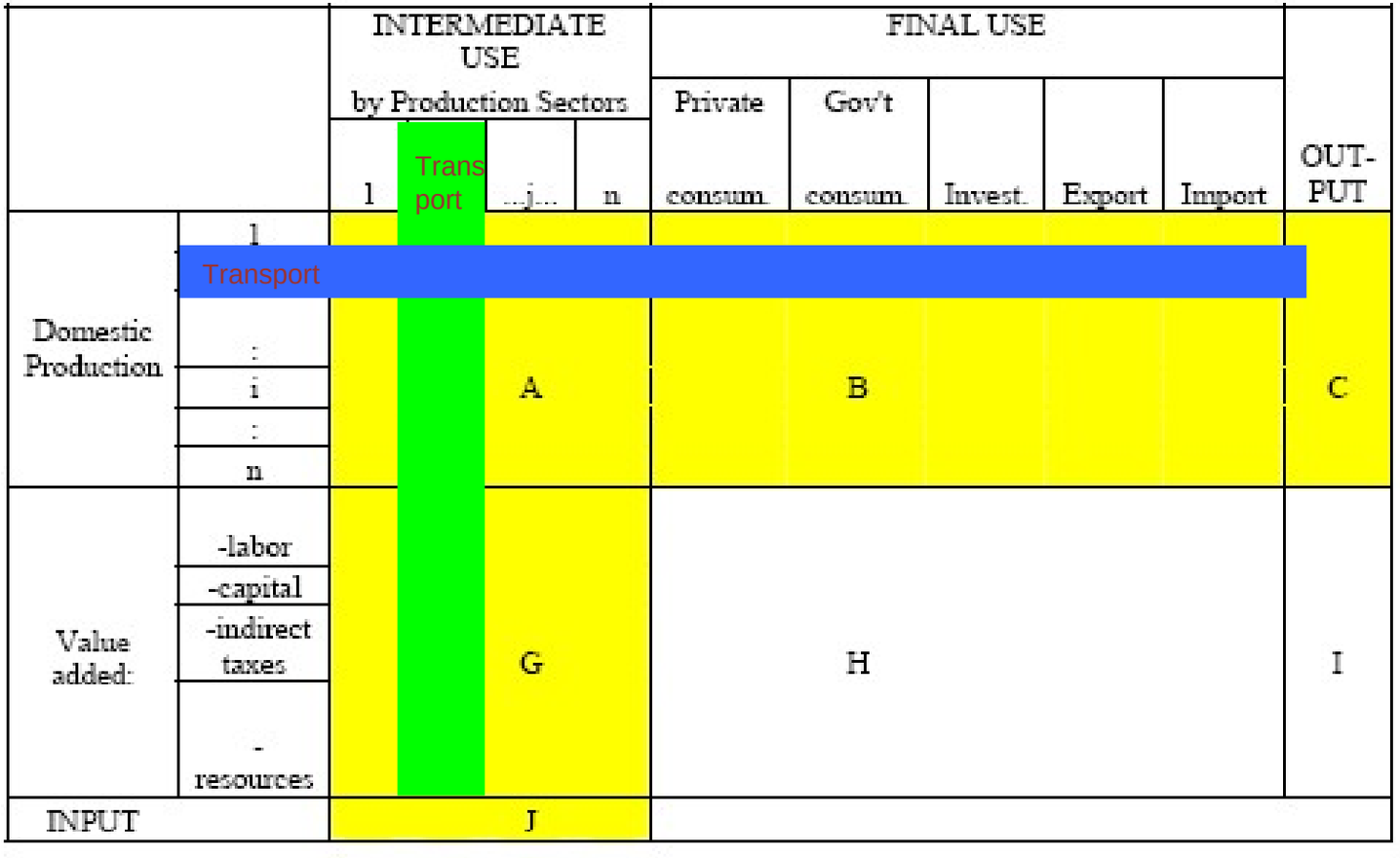
# Key Transport-related elements in the EPPA model



# Disaggregated Household Transportation



# Baseyear Data for the Model: Input-Output Table




**Input-Output Table provides information about production structure (inputs to production – green line) and output use (blue line).**

**Full accounting (examples): Expansion of biofuels leads to expansion of agriculture production that uses fertilizer and energy inputs; Expansion of solar panel or wind mills production requires energy and capital.**

# Sectors in the Model

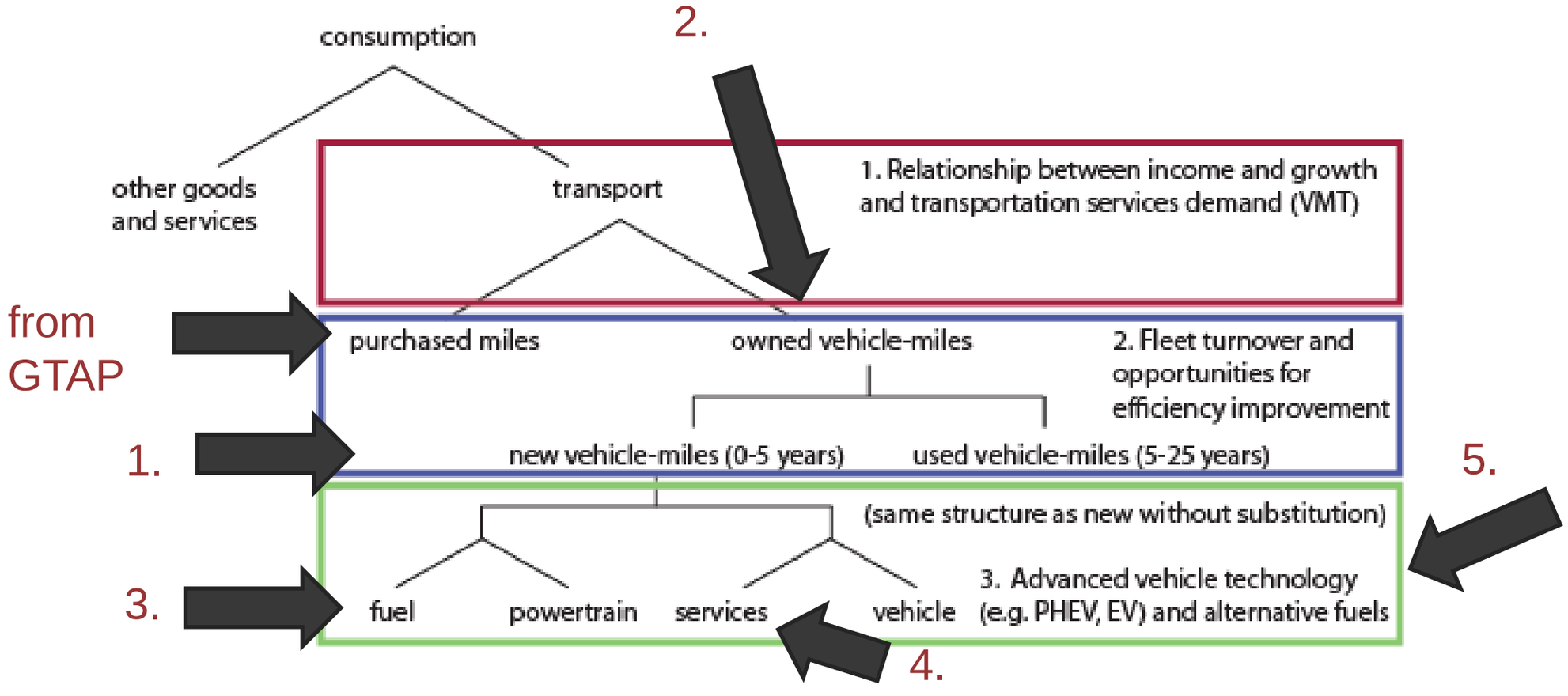
**Non-Energy**
- **Crops**
- **Livestock**
- **Forestry**
- **Food**
- **Energy Intensive Industries**
- **Manufacturing**
- **Services**
- **Industrial Transport**
- **Household Transport**

***Vehicle Types:***
New ICE, Used ICE, New EV, Used EV (New PHEV, Used PHEV)

**Energy**
- **Crude oil**
- **Refined oil**
- **Liquid fuel from biomass**
- **Oil Shale**
- **Coal**
- **Natural gas (conv, shale, tight, CBM)**
- **Electricity**
- **Synthetic gas (from coal)**

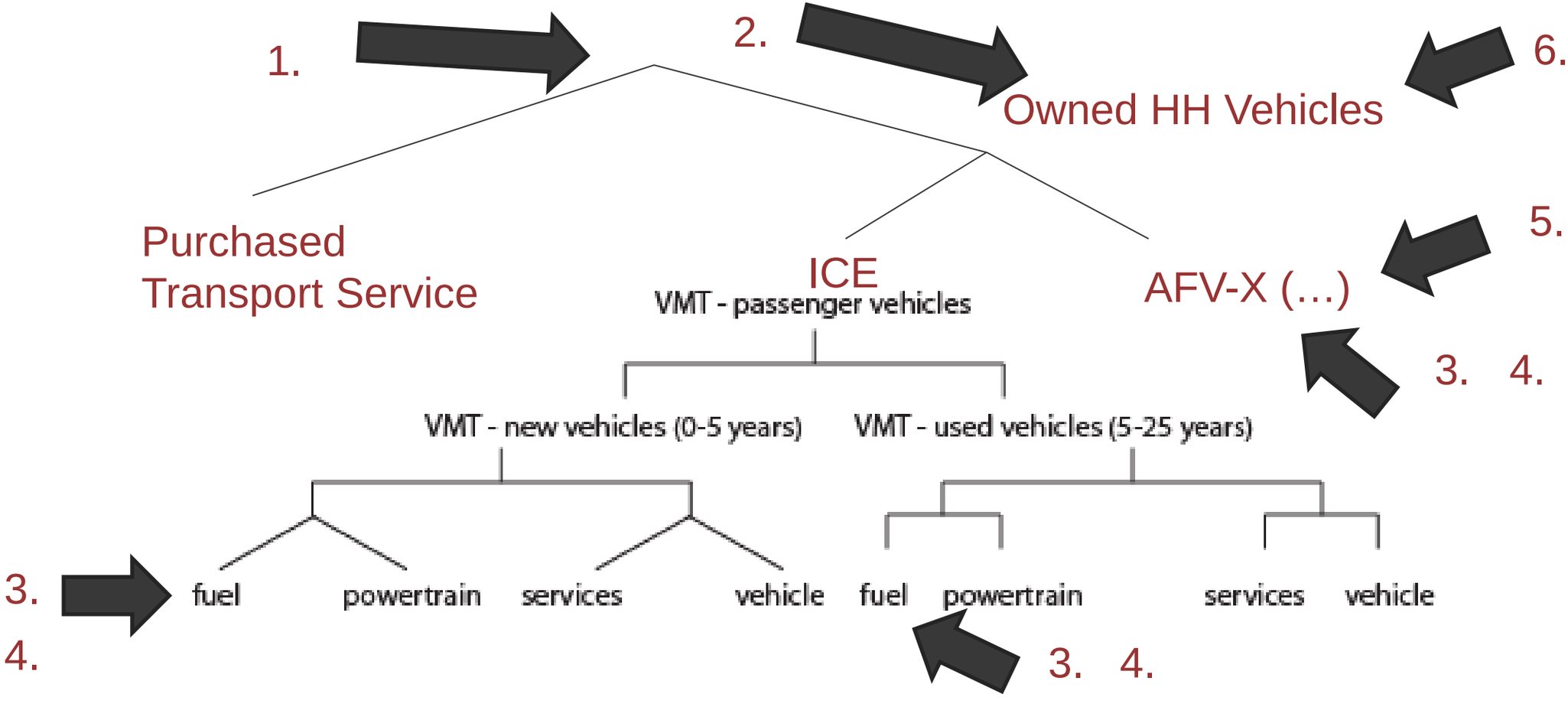
***Technologies Included***
Fossil (oil, gas, coal)
Advanced gas, Advanced coal
Coal with carbon capture
Gas with carbon capture
Nuclear
Hydro
Wind, Solar, Wind with backup
Biomass

# Baseyear (2007) data collection and calibration for historic data (2010-2015)




1. Number of cars and VMT driven by new and used vehicles;
2. Share (of total consumption) for expenditures on own vehicles (for future periods – income elasticity of demand);
3. Fuel and vehicle expenditures;
4. Service expenditure (residual);
5. Relative cost of alternative vehicles.

# Projections




1. Owned vs Purchased Transport Services;
2. Miles travelled;
3. Fuel (and the resulting MPG);
4. Pollutants (coefficient on fuel use);
5. Alternative fuels;
6. Change in car ownership (coefficient on demand function).

# Status of own-supplied HH model settings development

Current features:

- ICE, EV
- ICE, EV fleet turnover (new, used)
- Fuel efficiency

Features under development:

- Income elasticity
- PHEV+BEV, (CNG in China)
- PHEV+BEV fleet turnover (new, used)
- Service with lower car ownership

# Status of Historic Data Update (2005-2015)

- Number of private cars and light-duty trucks
- Global
  - Organization of Motor Vehicle Manufacturers (OICA): Passenger Cars, Commercial Vehicles
  - IEA (MoMo)
- USA
  - DoT, EIA
- China
  - Statistical Yearbook

# Challenges for Historic Data Update

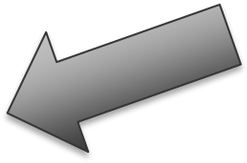
- Private household-owned light-duty vehicle is not a well-established category in primary sources of data
- Share of private household vehicles is changing in some countries/regions
- Need data sources with global coverage

# Transport Primary Data Sources

| Data Source | Transport Parameter | Data Input |
|---|---|---|
| IEA | Light-Duty Vehicle Stock | Vehicle Registrations (Country Level) |
| EIA | Light-Duty Vehicle Stock | Polk (IHS Markit) |
| OICA (Organisation Internationale des Constructeurs d'Automobiles) | Registered Vehicles on Road (Passenger separate from commercial) | Ward's (US)<br>Fourin (Other countries) |
| Transport Energy Data Book | Vehicles per Thousand People | Ward's (Other Countries/Regions2004 and 2014) |
| | | US (US DOT) |
| US DOT | Light-Duty Vehicle | Highway Statistics (States Vehicle Registrations) |
| US EPA | Passenger Cars | IHS Automotive Vehicle Registrations |
| Ward's world motor vehicle data | Total Vehicles in Operation by Country<br>Passenger and Commercial Cars | |
| Polk (IHS Markit) | Passenger Cars | Vehicle Registrations<br>Coverage: 45 countries |

# US DOT: Highway Total (Registered Vehicles)

- Before 2007
  - Passenger Cars (2006: 135 mln)
  - Other 2-axle 4-tire vehicles (2006: 99 mln)
  - (2006 Total: 234.5 mln)
- From 2007
  - Light duty vehicle, short Wheel base (2007: 196 mln)
  - Light duty vehicle, long Wheel base (2007: 39 mln)
  - (2007 Total: 235.5 mln)
- Common before and after 2007:
  - Motorcycle
  - Truck, single-unit 2-axle 6-tire or more
  - Truck, combination
  - Bus

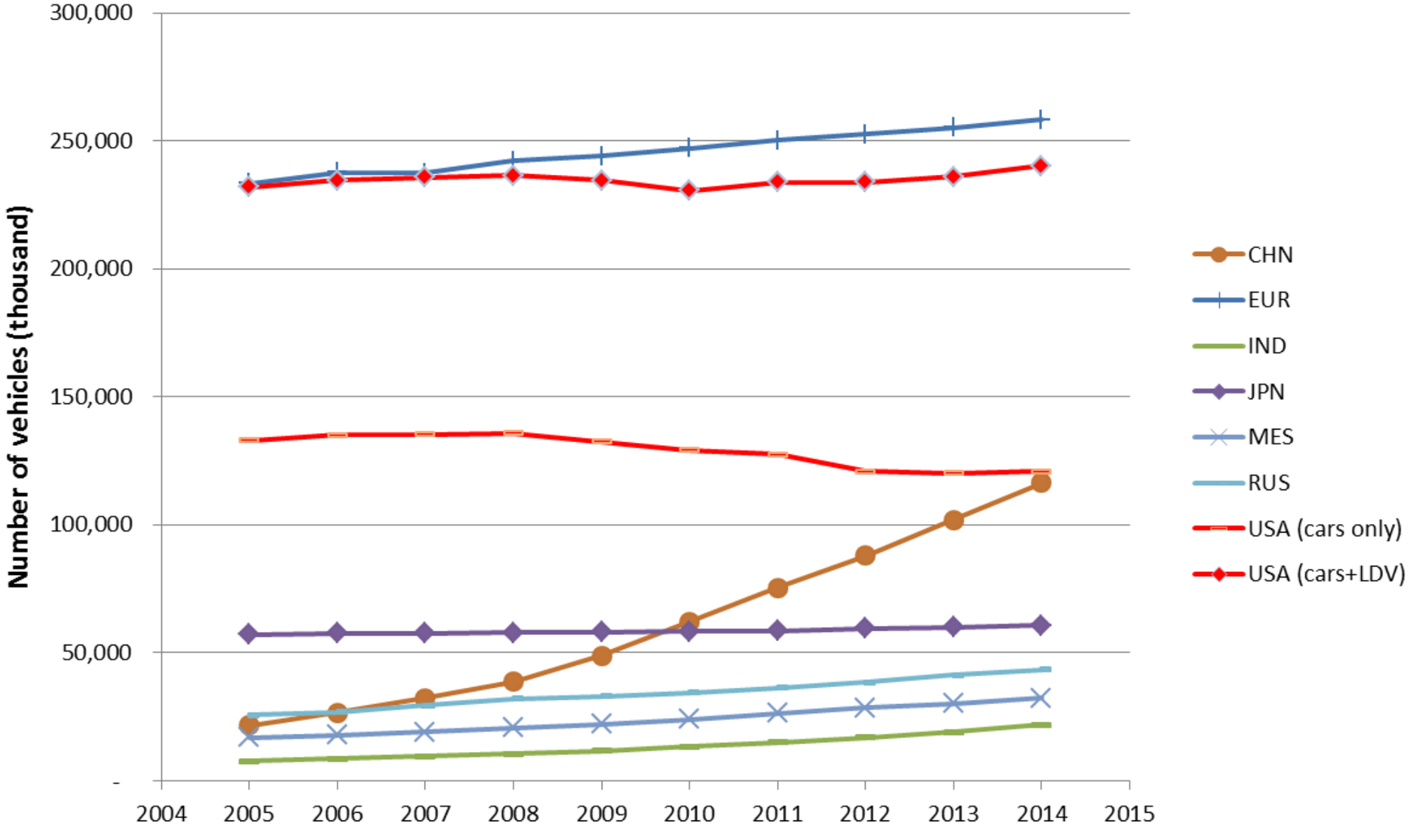


OICA continues to use this category for US and other countries

# US DOT/ DOE (EIA) Light-Duty Vehicle Specifications

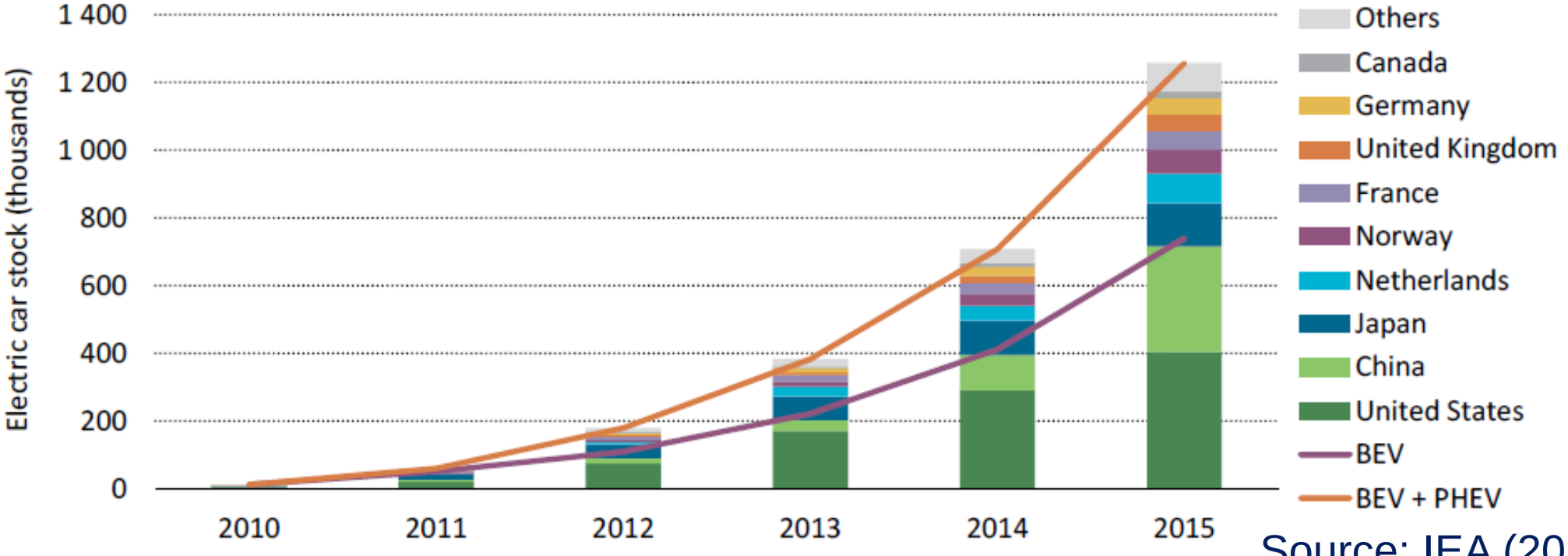
- DOT: Light duty vehicle, short wheel base
  - includes passenger cars, light trucks, vans and sport utility vehicles with a wheelbase (WB) equal to or less than 121 inches
- DOT: Light duty vehicle, long wheel base
  - replaces Other 2-axle, 4-tire vehicle and includes large passenger cars, vans, pickup trucks, and sport/utility vehicles with wheelbases (WB) larger than 121 inche
- EIA: Light-Duty Vehicle
  - Vehicles weighing less than 8,500 lbs (include automobiles, motorcycles, and light trucks)
  - Includes personal and fleet vehicles

# Historic Data for Major Regions




Source: OICA (2017),
DOT (2017) – for USA (cars+LDV)

# Historic Data for EV (BEV+PHEV)




Source: IEA (2016)

2015

USA: car stock – 120 mln, electric car stock – 0.4 mln
car sales – 7.5 mln, electric car sales – 0.07 mln
(IEA – 0.7% market share)

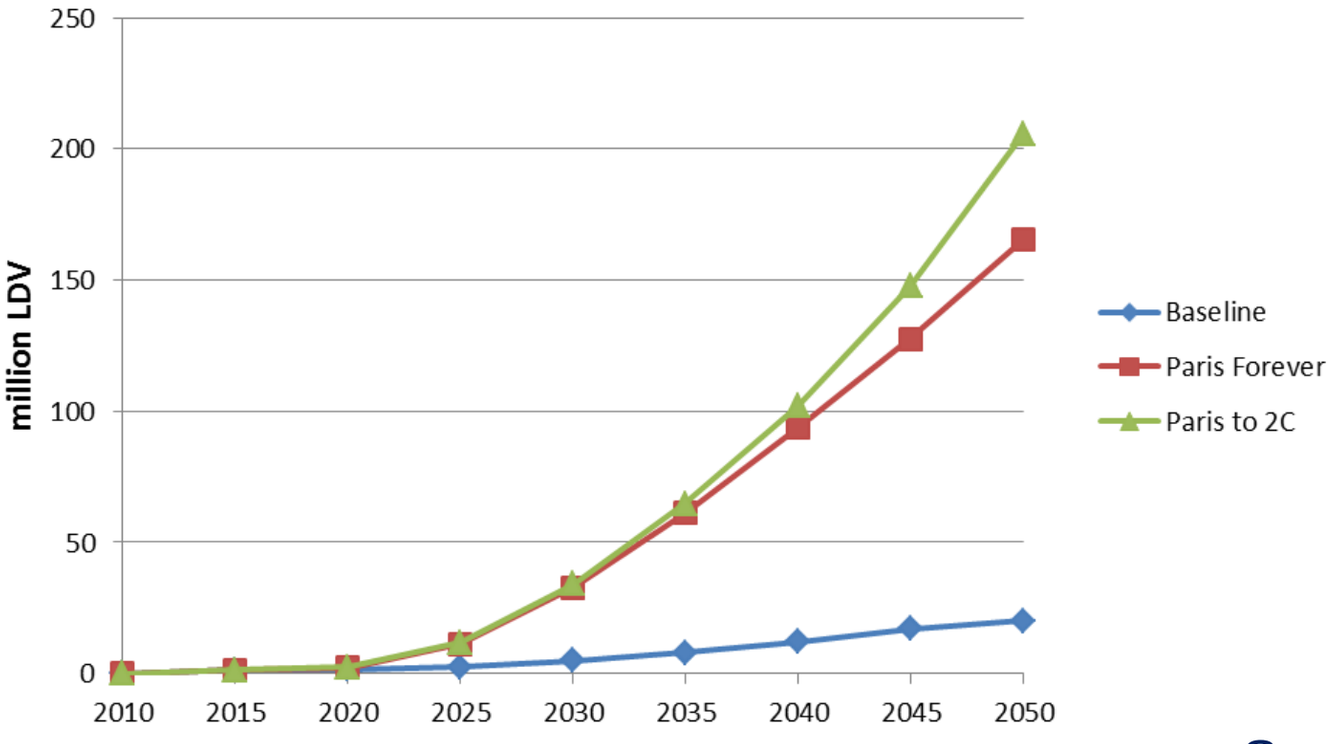
China: car stock – 120 mln, electric car stock – 0.3 mln
car sales – 21 mln, electric car sales - 0.15 mln
(IEA – 1% market share)

Source: OICA (2017), IEA (2016)

# Scenario Setting (in progress)

- Baseline Scenario: Continue current policies with permanent extension after the last targeted date (e.g., CAFE extends beyond 2025 based on 2025 requirements); no Paris commitments; prices are determined by supply and demand.
- Policy Scenarios: Paris Forever, Paris to 2C.
  - Paris Agreement is modeled based on an assessment by Jacoby et al (2017) available at: https://globalchange.mit.edu/publication/16547
  - Extensions after 2030 are based on carbon price policy
- Exploration: low-high oil prices, battery costs, fuel/$CO_2$ standards for cars, support for electric cars, support for renewables.

# Preliminary Results for EV (BEV+PHEV)




Source: EPPA

2050

USA: LDV stock – 300 mln; EV stock: baseline – 1 mln, Paris Forever – 8.2 mln, Paris to 2C – 8.5 mln (EUR is about the same as USA)

China: LDV stock – 250 mln; EV stock: baseline – 1 mln, Paris Forever – 40 mln, Paris to 2C – 50 mln

Note: PHEV and BEV are not represented explicitly yet. The work is in progress.

# Current Major Findings - 1 (in progress)

- Climate policy goals affect all sectors of the economy:

  - most of the action is in electricity sector: energy use response, move to lower-carbon power generation;

  - other sectors are also affected, including private transportation: more efficient ICE, fewer miles travelled.

- These goals also result in a major acceleration on deployment of EV.
- 2050 global LDV stock: around 1,500-1,700 mln.
- 2050 global EV stock in the Baseline Scenario – 20 mln, Paris Forever – 160 mln, Paris to 2C – 200 mln.
- 2050 EV share of total LDV stock in the Paris scenarios – 9-12%.

# Current Major Findings - 2 (in progress)

- More aggressive emission reduction targets come at a higher economic cost:

  - global welfare cost of the Paris Forever scenario is about 1% in 2030 and about 1.5-2% in 2050;

  - additional global welfare cost of the Paris to 2C scenario is 1-1.5% in 2050.

- Crude oil prices (i.e., producer prices) are reduced in Paris scenarios:

  - 2020 price is about $55/barrel;

  - 2050: Baseline - $75/barrel, Paris Forever – $60/barrel, Paris to 2C – $50/barrel.

# Next steps

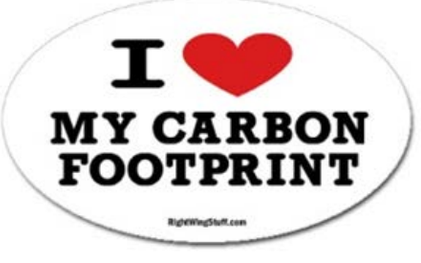
- Finish collection of historic data for LDVs and emissions by region.
- Calibrate income elasticity (affects fleet growth).
- Update data on battery cost and EV premium.
- Represent BEV and PHEV explicitly.
- Incorporate scenarios.
- Check preliminary results with the MIT team and MoF sponsors.

# Interaction with other MoF teams

- Collaborate with Professor Heywood and Professor Green on updating ICE and alternative vehicles representation.
- Collaborate with Professor Green on updating fuel costs and efficiencies.
- Collaborate with Professor Knittel on the current transportation policies.
- Prices and costs to System Dynamics model.
- Methanol vehicles in China.
- Detailed look at EV and air pollution impacts in China.

# Thank you

Questions or comments?
Please contact Sergey Paltsev at paltsev@mit.edu.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