GCAM Fossil Fuel Efficiencies & Transportation Module Updates

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GCAM Modeling Conference
Nov. 29, 2011
Energy Flow

Primary energy (p)  Secondary energy (s)  Final energy (f)  Useful energy (u)  Energy service (z)

Natural gas  Processed natural gas  Pipeline natural gas  Building (lighting, cooling, heating, cooking, refrigeration)  Building (heated space, lighted area, cooking, heated water)

Crude  Liquids from crude  Distributed refined liquids from crude/gas  Industrial (process heating and cooling, machine drive, facility lighting, eletro-chemical processes, steam, and HVAC)  Industrial (process heat, steam, machine drive, and chemical feedstock)

Extracted energy  Delivered energy  Consumed energy  Useful energy  Energy service
Developed vs. Developing Countries

Developing Countries

Developed Countries

Efficiency

NG Efficiencies

Ref. Liquids Efficiencies

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050

65% 60% 55% 50% 45% 40% 35% 30% 25% 20%
Desired changes to transport module

- **Model Structure**
  - Include *2- & 3-wheelers* in India and China
  - *Break buses* into minibuses and large buses
  - *Break aviation* into domestic vs. international trips

- **Input Parameters**
  - *Load factor*: region specific, f(GDP, motorization rate)
  - *Non-fuel costs*: (capture infrastructure/capital, O&M costs)
  - *Value of time*: (VOT) multiplier
  - *Speed*: mode; region- and time-specific
  - *Income and price elasticity*: region- and time-specific

- Both Model Structure and Input Parameters
  - *Energy intensity*: by mode; region- and time-specific
Load Factor – Vehicle Occupancy Ratio: region specific and time variant
Share of vehicles and Energy Intensity of 2- & 3-wheelers and passenger LDVs
Buses – minibuses and large buses

- Minibuses: 8-10 pass. vs. Large buses: 30-40 pass.
- Share of minibuses = f (MOR, GDP) \(\Rightarrow\) increases

Schäfer, presentation at UC Davis, 2011
Truck Load Factor vs. Energy Intensity (partial data)
Load Factor – Road Freight

- Energy intensity of trucks is strongly dependent on payload
- Most of the changes in energy intensity are due to changes in payload not technology improvement

\[
y = 7.5582x^{-0.683} \\
R^2 = 0.99812
\]
Non-Fuel Costs

- GCAM default assumptions: same non-fuel costs (i.e. taxes/subsidies, capital costs/depreciation, and non-fuel operating costs) of vehicle ownership and operation in the U.S. and for all other countries/regions
  - Differences in fuel taxes (figure below)
  - Differences in public transit fare
Value of Time (VOT)

- VOT comprises a large share of total travel cost.

- GCAM assumes a VOT multiplier of 1 (a traveller values his travel time at the same rate as his wage) across all regions and modes. However, literature suggests otherwise.
Conclusions – results of UCD updates

(1) Regional trends in total energy consumption / total transportation demand (T-km, P-Km) will not change substantially (absolute service values will change).

(2) Effectiveness of carbon taxes will change:
   - Non-fuel costs will rise due to incorporation of taxes → reducing the impact of any given level of carbon tax.
   - Reduce VOT multiplier values from current level = 1. This will increase the potential impact of taxes.

(3) Stock-average EI (BTU/pass-km) may rise for some modes/technologies (vs. current assumption that EI decreases at an exogenously defined rate).
   - Share of cars will rise and 2-/3-wheelers will decrease.
   - Share of Minibuses will increase.
Acknowledgements

- Kenneth Gillingham
- Raul Quiceno
- Andreas Schäfer
Forecasting – three approaches:

Three scenarios: **base case**, **advanced**, and **“very” advanced**

1. Derive parameters from authoritative models
   - e.g. IEA’s Momo model
   - limited to existing forecasts, proprietary data

2. Search for general global relationships (‘holistic’ regressions)
   - e.g. Andreas Schäfer’s mode-specific relationships EI(LF)
   - Existing relationships may be masked by data that is not consistent over time/among countries (data limitations)
   - General, global relationships may not exist

3. Derive country- / region-specific relationships (‘targeted’)
   - Premised upon accurate data, continuation of past trends
   - Time intensive, less transparent, depends on many assumptions
LDV (cars) Energy Intensity vs. fuel costs

[Graph showing relationship between fuel consumption and retail price increase, with data points from various studies.]
Energy Intensity of LDVs in Europe

Stock-average intensity MJ/VK

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- IEA MoMo
- GCAM-UCDavis
- EU 2010