Collecting energy efficiency data for transport

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IEA Energy Data Centre

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IEA
1. Why are transport efficiency indicators important?

2. What data do we need for transport efficiency indicators?

3. Collecting the data: principles and country examples
Why are transport efficiency indicators important?
World energy consumption in transport grows fast

World total final consumption by sector, 2015

Source: IEA World Energy Balances, 2017
Energy consumption in transport sector

World transport consumption by source, 2015

- Oil
- Gas
- Biofuels
- Electricity
- Other

World transport by sub-sector, 2015

- Road
- World aviation bunkers
- World marine bunkers
- Domestic aviation
- Pipeline transport
- Rail
- Domestic navigation
- Non-specified (transport)

Source: IEA World Energy Balances, 2017
Basic transport energy consumption data are available

In order to compile annual energy balances, most statistical offices collect:

- **Total** annual energy consumption in transport
- Split by **fuel**
- Split by **sub-sector/mode** (road, rail, navigation, aviation)

Data currently available provide a high level view on transport
What else do we need to know?

• What is the split between passenger transport and freight transport?

• How much energy is spent in my country to transport one passenger on a distance of one kilometer?

• How does it compare to other countries in my region?

• What consumes less energy per km to travel in my country – a bus, a car or a train?

• Etc.
With additional data we can see where energy is used.

Figure 12. Energy consumption in transport in IEA, 2013

- **Road**: 91%
- **Passenger cars**: 60%
- **Freight road**: 28%
- **Buses**: 2%
- **Motorcycles**: 0.6%
- **Domestic air**: 5%
- **Domestic water**: 2%
- **Rail**: 2%

Source: IEA Energy Efficiency Indicators, 2016
Energy by end use: examples

• France

Largest end-uses by sector, 2013

- Residential: 29%
- Services: 16%
- Manufacturing: 22%
- Transport: 28%
- Ferrous metals: 4%
- Other industries: 5%
- Agriculture: 3%
- Residential space heating: 20%

• United States

Largest end-uses by sector, 2014

- Residential: 20%
- Transport: 40%
- Passenger cars*: 20%
- Mining: 5%
- Residential space heating: 9%
- Other industries*: 7%
- Manufacturing: 18%
- Chemicals: 4%
- Services: 16%

Source: IEA Energy Efficiency Indicators, 2016
Transport activity by mode/vehicle type: examples

Source: IEA Energy Efficiency Indicators, 2016
*Transport excludes international marine and aviation bunkers, pipelines, and when possible fuel tourism; pkm refers to; passenger cars includes cars, sport utility vehicles and personal trucks;
Energy intensities in passenger transport: examples

Source: IEA Energy Efficiency Indicators, 2016

*Transport excludes international marine and aviation bunkers, pipelines, and when possible fuel tourism; pkm refers to; passenger cars includes cars, sport utility vehicles and personal trucks;.
What data do we need for transport efficiency indicators?
**Energy consumption data:**
- Transport segment
  - passenger
  - freight
- Transport modes
  - road,
  - rail,
  - air,
  - water,
  - etc.

**Activity data:**
- Vehicle stocks
- Passenger-kilometers
- Tonne-kilometers
### Selected modes/vehicle types by segment and sub-sector

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>Passenger</th>
<th>Freight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road</strong></td>
<td>Powered 2- to 4- wheelers</td>
<td>Freight light-duty vehicles</td>
</tr>
<tr>
<td></td>
<td>Passenger light-duty vehicles (PLDVs)</td>
<td>Heavy-duty vehicles (HDV)</td>
</tr>
<tr>
<td></td>
<td>Buses</td>
<td>Other</td>
</tr>
<tr>
<td><strong>Rail</strong></td>
<td>Passenger trains</td>
<td>Freight trains</td>
</tr>
<tr>
<td><strong>Air</strong></td>
<td>Passenger airplanes</td>
<td>Freight airplanes</td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td>Passenger ships</td>
<td>Freight ships</td>
</tr>
</tbody>
</table>

## Data requirements - activity

### Passenger transport

<table>
<thead>
<tr>
<th></th>
<th>Road</th>
<th>Rail</th>
<th>Waterways</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal cars</td>
<td>Passenger</td>
<td>Passenger</td>
<td>Passenger</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trains</td>
<td>Ships</td>
<td>Airplanes</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Buses</td>
<td></td>
</tr>
<tr>
<td>Motorcycles</td>
<td></td>
</tr>
</tbody>
</table>

- Passenger-kilometres (gasoline, diesel, LPG, ...)
- Vehicle kilometres (gasoline, diesel, LPG, ...)
- Number of vehicles in use (gasoline, diesel, LPG, ...)

### Freight transport

<table>
<thead>
<tr>
<th></th>
<th>Road</th>
<th>Rail</th>
<th>Waterways</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trucks</td>
<td></td>
<td></td>
<td>Freight</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Ships</td>
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- Tonne-kilometres
- Tonnes
- Number of vehicles in use

### Equations

\[
\text{pkm} = \text{vkm} \times \text{occupancy} = \text{stocks} \times \text{average mileage} \times \text{average occupancy}
\]

### Vehicle stocks

- Mostly available in many countries (e.g. Ministries, Statistical offices)
- Can be estimated using vehicle data base
- Vehicle classification is not the same by countries

### Average mileage & occupancy (load)

- Rarely available
- Can be found in household surveys, travel diaries, odometer readings in vehicle database, public transport utilities
- Often estimated
Activity data for efficiency calculation in transport

- **Passenger-km or tonne-km**
- **Vehicle stock**
- **Distance travelled**
- **Occupancy**
- **Load factor**

Collecting the data: principles and country examples
Where to get data?

- Administrative sources
- Surveys
- Measuring/metering
- Modelling

* Collecting additional data on vehicle sales can be extremely useful to validate/complement stock information

IEA Country practice database: [https://www.iea.org/eeindicatorsmanual/](https://www.iea.org/eeindicatorsmanual/)
### Examples of methods for energy data

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy data</td>
<td></td>
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<tr>
<td>Total transport consumption</td>
<td>National energy balance</td>
<td>Administrative sources</td>
</tr>
<tr>
<td></td>
<td>National energy statistics</td>
<td>Modelling</td>
</tr>
<tr>
<td>Consumption by sub-sector</td>
<td>National energy balance</td>
<td>Administrative sources</td>
</tr>
<tr>
<td></td>
<td>National energy statistics</td>
<td>Mobility surveys</td>
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<tr>
<td></td>
<td></td>
<td>Modelling</td>
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<tr>
<td>Consumption by segment</td>
<td></td>
<td>Mobility surveys</td>
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<tr>
<td></td>
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<td>Modelling</td>
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<tr>
<td>Consumption by vehicle type</td>
<td></td>
<td>Mobility surveys</td>
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<td>Modelling</td>
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</tbody>
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### Examples of methods for activity data

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<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Activity data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP, population</td>
<td>National statistics offices</td>
<td>Administrative sources</td>
</tr>
<tr>
<td>Vehicle-km (vkm)</td>
<td>Vehicle registers/Roadworthiness testing services/Inspecting organisations</td>
<td>Measurements: odometer readings</td>
</tr>
<tr>
<td></td>
<td>Municipalities/Transport authorities</td>
<td>Measurements: road traffic count</td>
</tr>
<tr>
<td></td>
<td>National and international databases</td>
<td>Administrative sources</td>
</tr>
<tr>
<td></td>
<td>Transport ministries</td>
<td>Mobility surveys</td>
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<tr>
<td></td>
<td>Transport ministries</td>
<td>Mobility surveys</td>
</tr>
<tr>
<td>Tonne-km (tkm)</td>
<td>National and international databases</td>
<td>Administrative sources</td>
</tr>
<tr>
<td></td>
<td>Transport ministries</td>
<td>Mobility surveys, freight surveys</td>
</tr>
</tbody>
</table>
### Administrative sources

- **Annual fuel use from national energy balances** (collected via questionnaires sent to ministries and national statistical offices)
- **Activity statistics from transport operators and government agencies** (e.g. railway operators)
- **Vehicle registration data, with detailed characteristics from respective government bodies and the private sector** (e.g. associations of vehicle manufacturers)
- **Vehicle import/export data, with detailed characteristics** (e.g. from trade offices/border control services/private sector vehicle trade associations)
- **Vehicle characteristics (by size/fuel) from government organisations** (e.g. US EPA or EU EEA) and comparative studies issued by NGOs
- **Studies on: mode share, travel, trips, fuel content, fuel consumption, travel patterns..**

Great way to get comprehensive, often official data, however:
- **Collection methodology (and data quality) sometimes unclear**
- **Comparisons between providers may be difficult**
Examples of administrative sources: Japan

Sources:
- Government statistics office
- Manufacturers
- International organizations

Manual for Passenger vehicles average fuel economy performance calculation
Surveys

• National travel survey
• Survey of fleets, trucking companies
• Observational (e.g. roadside) surveys
• Household surveys, focus groups

Pros:
• Data collection via direct observation or questionnaires on travel activities, energy use, etc.
• Can provide very rich information, useful for understanding variation, correlations, and other aspects of the sample
• The people

Cons:
• Can be labour intensive, require large sample sizes, etc.
• Estimates, not hard data
### Examples of surveys: Australia

<table>
<thead>
<tr>
<th>Format</th>
<th>Elements Collected</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper form sent by mail</td>
<td>Vehicle fuel efficiency Type and volume of annual fuel consumed Distance travelled Vehicle size (weight/capacity/volume) Vehicle age group</td>
<td>2 years</td>
</tr>
</tbody>
</table>

Mandatory survey to: Registered road vehicle owners (government and private)

Measuring and metering

- Direct observation
- Can use existing metering systems or create new ones
  - Odometers
  - Roadside car counters
  - Vehicle fuel economy testing
  - GPS data and vehicle location monitoring
  - Vehicle fuel economy computers (in use performance)
  - Portable Emissions Monitoring (PEMS)
  - Speed detection systems
  - Atmospheric concentration monitoring

Typically reliable but often expensive
- Based on scientific and replicable tests
- Sample size and data processing requirements affect costs
Measuring / metering example: Canada (1)

Canadian Vehicle Use Study (CVUS) by Transport Canada Vehicles equipped with GPS and a screen so that driver inputs some information regarding the trip.

Data collected not only for energy purposes: “The electronic data logger also uses the GPS technology and records the spatial coordinates that could be used in analysis of traffic congestion, road safety and infrastructure planning”

Elements collected:

- Trip patterns over time
- Fuel consumption over time
- Carrier utilisation pattern and impact on fuel economy
- Impact of fuel switching on vehicle fuel economy
**Measuring / metering example: Canada (2)**

**Canadian Vehicle Use Study**

- The logger device records accurate vehicle activity at one-second intervals (e.g. distance, time, speed, fuel, etc.) directly from the vehicle’s engine.
- The logger touch screen captures the remaining trip questions.
  - Light: Driver Age/Sex, # Passengers, Trip Purpose, Fuel Information
  - Heavy: Trip Purpose, Facility Type (Origin), Configuration, Trailer Style, Cargo (Weight/Volume), Cargo Type (Best Description)
Canadian Vehicle Use Study

- The logger is also easy to install by connecting the logger to the vehicle’s connector socket via a 16-pin (SAE J1979 Standard) or 9-pin connector cord (SAE J1939 Standard) usually located under the dashboard or behind the driver’s seat.

- Should the connector socket not use a 16 or 9 pin connector cord, the logger can be connected to the cigarette lighter via a 12 volt connector cord adapter.
Sound modelling of transport energy demand requires extensive data gathering efforts

**Mileage (Activity)**
- Total mileage in vehicle kilometers (vkm)

**Vehicle stock (Structure)**
- Of cars, buses, light commercial vehicles and heavy duty vehicles
- With split for diesel and gasoline powertrains

**Average specific consumption (Intensity)**
- Specific energy use (l/100km)

**Transport fuel consumption**

- Combine official statistics with data from state companies (commercial vehicles) and insurance companies (passenger vehicles)

- Combine official stock statistics and data from electronic registry
  - Data adjustment based on scrappage assumptions

- Obtain data on fuel economy from European Environment Agency (EEA)

Modelling example: Ukraine - State Road Transport Research Institute (Kiev)
Collecting data for transport efficiency indicators

• Transport efficiency requires detailed monitoring

• Energy efficiency indicators are a good framework to monitor the sector

• Data needs to be collected for energy and activity, across modes and vehicle types

• Countries are using a variety of methodologies to collect data: administrative sources, surveys, metering and modelling

The IEA is committed to facilitate national work and exchange across countries, with a view to strengthening the long-term institutional capacities