Evaluating CO$_2$ emissions in inland transport and climate change mitigation

ForFITS: a monitoring and assessment tool "For Future Inland Transport Systems"

The ForFITS input file and its setup for the pilot case of Ethiopia

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Even if ForFITS has the capacity to adapt to different levels of data availability, the model does require a substantial amount of data, for:

- the characterization of the transport system in the base year (historical inputs)
- the definition of the context in which the transport system should evolve (projections)

Information on the initial and final times, the characterization of the areas, and the selection of the modelling approach for the powertrain choice (exogenous or endogenous), are also firm needs

**Minimum data requirements** (other inputs are defined by default data and can be modified)

### Historical inputs
- GDP, population
- Vehicle stock: number of vehicles by powertrain, average travel and loads, average fuel consumption
- New vehicle registrations: same detail used for stocks needed for the base year, 5 and 10 years earlier (data in between are taken into account with linear interpolations)

### Projections
- GDP and population
- Fuel prices (cost and taxation)
- Vehicle shares between two and three wheelers
- Pkm shares for different public transport modes (e.g. due to the construction of urban rail)
- Modal shares of light road freight vehicles
- Evolution of the network extension for pipelines
- With endogenous powertrain selection (optional), discount rate and powertrain shares

**Need for coherence for inputs on each AREA, SERVICE, MODE, VEHICLE CLASS and POWERTRAIN**
A wide set of default data are included in the ForFITS Excel file

These default data are used to characterizing several parameters of the ForFITS model

They concern the following input categories:

M Data absolutely required
   Corresponding to the minimum data requirements

A Inputs expected to be introduced by the user
   The default value in ForFITS is for guidance only
   This category includes policy inputs that allow exploring different scenarios

B Input containing technical information (e.g. technological potential and costs by powertrain)
   These data may be maintained unchanged
   The defaults are set on the basis of research activities involving literature reviews and statistical analyses (further information on this is provided in the relevant section of the ForFITS manual)

C Inputs on structural characteristics of the model
   Unless the users acquired significant experience with the model, these inputs shall not be modified: changes to these inputs will result in significant modifications to the model behaviour
ForFITS model: data requirements

(2/3)
Inputs on the time period modelled

Modelling switches and setup parameters

Initial and final projection times

Base year and final year

<table>
<thead>
<tr>
<th>YEAR</th>
<th>BASE</th>
<th>FINAL</th>
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</thead>
<tbody>
<tr>
<td>YEAR</td>
<td>2010</td>
<td>2040</td>
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</table>

Powertrain technology choice switch

Choice switch (endogenous / exogenous)
(either exogenous, requiring powertrain shares directly, or endogenous, requiring inputs on powertrain availability)

POWTRAINS: endogenous (from model)

=> inputs on powertrain shares in the 'Pwtrn shares (over time)'

Discount rate
(required to perform endogenous technology choice)

Discount rate: 25%

Notes on the inputs on the time period modelled

• Base year: always the same (consistency for all inputs needed) – 2010 for Ethiopia
• Inputs over time needed for the whole period
• All variables are calculated over this time period
Number of active vehicles (vehicle stock):
Road: Data from Daniel Redda, (Ph.D.) (Vehicle Stock Statistics, presentation under the GFEI framework on Ethiopia as pilot country)
Rail and Air: Central Statistical Agency of Ethiopia, National Statistics Abstract, Transport and Communication

Data from Daniel Redda and CSA of Ethiopia
Vehicle travel:
Road: [UITP, Report on statistical indicators of public transport performance in Africa].
Rail and Air: Based on assumption on speed (km/h) time of vehicle usage (hours/day and days/week), adapted so that pkm and tkm are consistent with statistics from [CSA of Ethiopia].

Vehicle loads:
Road: [UITP, Report on statistical indicators of public transport performance in Africa].
Rail and Air: Based on assumptions on load factors and information on capacity defining each class, adapted so that pkm and tkm are consistent with statistics from [CSA of Ethiopia]. Continental data available from [ICCT model].

Fuel consumption per km: estimates based on [UITP (Report on statistical indicators of public transport performance in Africa)], [detailed IEA report] for LDVs, IEA publications (e.g. on energy efficiency indicators, such as [IEA, 2004]), [IEA statistics] on energy use in transport combined with vkm data, technical estimates based on published information (e.g. [Kenworthy, 2003]), data on new vehicle registrations and vehicle scrappage assumptions. Continental data available in the [ICCT roadmap model].
New vehicle registrations: based on assumptions on average vehicle age (by mode) and data on stock. Road data checked against information from Demiss Alemu Amibe (Dr.-Ing), presentation on the Final Draft Report on Pilot Global Fuel Economy Initiative Study in Ethiopia. Calibrated to hit an average vehicle life coherent with the data disaggregated by age of the vehicle provided by John Redda and Demiss Alemu Amibe.

Fuel consumption per km: estimates based on detailed IEA report for LDVs. Ratios amongst fuel consumption per km different powertrains based on technical estimates. This sort of information may be available from energy efficiency agencies, energy efficiency databases and analyses of environmental NGOs dealing with transport (e.g. ICT and T&E). Continental data available in the ICCT roadmap model.
Economic and demographic data (base year)

BASE YEAR

Population: data from World Bank, also available from UN
GDP: data from World Bank (current USD and deflator)
No distinction between urban and non-urban shares implemented in the Ethiopian case
Information typically available from national statistical offices

PROJECTIONS
Crew costs (base year)

Default data containing assumptions on the average cost per day of crew costs, considering an indicative number of people in the crew for public transport and air transport vehicles and an indicative gross salary per month. Defaults are calibrated on an estimation of likely European values.
Economic and demographic data (projections)

BASE YEAR

PROJECTIONS
Population: currently based on World Bank data. Population projections also available from UN and other sources
GDP: currently based on projections from specific studies HSBC
Other possible sources: international organizations (e.g. OECD), consulting companies (e.g. pwc)

.. socio-economic data

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Area characterization
Urban, non-urban, or non specified

Passenger transport system index
0  Focus on personal vehicles, low density of population, significant presence of urban sprawl, horizontal urban development
1  Very high density of population, strong focus on public transport, geographical and other constraints leading to the vertical development of the urban area

Environmental culture index: behavioural aspects, initialized to 0.5 in the base year
0  Low "environmental culture";
1  High "environmental culture"
**Freight transport system over time**

**Constant values**

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>Traffic (veh/km)</th>
<th>Fuel consumption (g/km)</th>
<th>Fuel consumption (g/km)</th>
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<tbody>
<tr>
<td>DEFAULT</td>
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<td>MARITIME</td>
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- **Haul length**: defined as average distance for each large-freight sub-mode
- **Vehicle capacity ratios**: defined by default according to the default vehicle classification. Vehicles in classes A (and sometimes F) represent the average of each large-freight sub-mode and are used as reference for the ratio (value = 1)
- **Load factor ratios**: currently assumed = 1 to reflect the same load factor in all classes
- **Hauls per vehicle ratios**: currently assumed = 1 to reflect the same hauls in all classes
Shares defining the structure of the freight transport system in the base year

- tonnes lifted by good type
- transport distance, divided amongst: a) short & medium distance transport in all large-freight transport, b) short distance in short + medium, c) very large distance in large + very large
- transport zone, to take into account the relevance of imports and exports with respect to local consumption

Information for Ethiopia from [CSA of Ethiopia](#) for rail. Allocated entirely to the category “OTHER” for the other large-freight sub-modes.
Evolution of the shares of tonnes lifted by transport zone (reflecting the balance between the evolution of the internal demand and exports)

Scenario-related inputs
Reference data are constant by default

Evolution of shares of tonnes lifted by haul distance for each area and transport zone (reflecting higher/lower importance of different haul distance, e.g. to mimic growth in local sourcing)
Policy input

Shares of tonnes lifted by good type (reflecting changes in the structure of the economy, such as shift from primary materials to manufactured goods)

Shares of tonnes lifted by large-freight sub-mode (reflecting changes in the competitiveness of different large-freight sub-modes over other options)
Fuel costs before taxes: calculated on the basis of technical estimates of costs based on average primary energy prices, assumptions on margins and fuel transport costs. Data checked against information available from IEA statistics on energy prices and taxes and GIZ (international fuel prices and taxes).

Cost per vkm due to taxation that is specific to each vkm by road modes. Zero by default (no road pricing). Need for weighted averages to be properly working.

Fuel taxation: data from GIZ (international fuel prices and taxes).
Fuel characteristics
(base year and projections)

Tank-To-Wheel (TTW)
Base year data based on IPCC emission factors
Projections: scenario-related inputs

Well-To-Tank (WTT)
Need for data referring to fuel blends, not specific fuels
This means that emission factors shall take into account
for expected alternative fuel shares in projections
Current defaults refer to conventional fuels
• Needed to consider cases where the fuel consumption reduction potential is partly used to increase vehicle performance
• It can be based for instance on the expected evolution of vehicle power over time
• By default, this is set to remain constant
Fuel consumption characteristics by powertrain

Fuel consumption evolution by service, mode and powertrain technology:
- Comparative index with reference technology (GASOLINE PI ICE)
- Index to consider evolution of GASOLINE PI ICE technology due to technology-specific improvements over time
- For plug-ins, information on the share of electric driving (reflecting battery capacity)

Default assumptions are based on a large amount of published information and coupled with vehicle costs: see UNECE, 2012 (Tables 7 and 8)
### Fuel consumption projections: air and pipelines

#### User inputs (over time)

Air transport: base year consumption entered as part of the base year information
Projections of fuel consumption per km entered here, through an index
Default scenarios include constant values and evolution along the trend of the past decade
Other technical estimates (e.g. based on literature assessing the fuel consumption of aircrafts) are appropriate

Pipelines: base year consumption entered as part of the base year information
Projections of fuel consumption per km entered here, through an index
Default evolution: constant values of consumption per km
Other technical estimates would be appropriate
Note: for pipelines, each cubic metre transported is considered as a "vehicle". Fuel consumption values should refer to the movement of this unit over 100 km
Modelling switches and setup parameters

Initial and final projection times

<table>
<thead>
<tr>
<th>YEAR</th>
<th>BASE</th>
<th>FINAL</th>
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</thead>
<tbody>
<tr>
<td>YEAR</td>
<td>2010</td>
<td>2040</td>
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</table>

Powertrain technology choice switch

Choice switch (endogenous / exogenous)
(either exogenous, requiring powertrain shares directly, or endogenous, requiring inputs on powertrain availability)

POWERTREINS endogenous (from model)

=> inputs on powertrain shares in the ‘Pwtrn shares (over time)’

Discount rate
(required to perform endogenous technology choice)

Discount rate 25%
Powertrain technology & ICE fuel: shares

Direct input of powertrain shares (EXOGENOUS POWERTRAIN CHOICE)
Region-specific inputs depend on local characteristics and user-driven scenarios
Default available: constant shares (base year shares self-calculated with other user inputs)

Powertrain technology
ICE, ICE-HYDRAULIC HYBRID, ICE-ELECTRIC HYBRID, ICE-ELECTRIC PLUG-IN HYBRID, fuel cell (FC), FC-ELECTRIC HYBRID, FC-ELECTRIC PLUG-IN HYBRID, ELECTRIC

ICE fuel: inputs on shares of ICE powertrains by fuel (GASOLINE, METHANE, LPG, DIESEL, DME, HYDROGEN)
Powertrain technology & ICE fuel: availability

ENDOGENOUS POWERTRAIN CHOICE, same structure of Region-specific inputs depend on local characteristics and user-driven scenarios
Default available: full availability, double than base year

Powertrain technology
ICE, ICE-HYDRAULIC HYBRID, ICE-ELECTRIC HYBRID, ICE-ELECTRIC PLUG-IN HYBRID, fuel cell (FC), FC-ELECTRIC HYBRID, FC-ELECTRIC PLUG-IN HYBRID, ELECTRIC

Availability: default values for the base year based on the curve below (roughly estimated with values for hybrids and diesels)

ICE fuel: inputs on shares of ICE powertrains by fuel (GASOLINE, METHANE, LPG, DIESEL, DME, HYDROGEN)
Most complex input tables
Contains information on costs, linked to information on potentials
All powertrain technologies included
All data are based on technical estimates, suitable for developed countries (default values based on technical assessments available for developed countries): see UNECE, 2012 (Tables 7 and 8), for reference on sources used
Costs may be lower in developing countries, for the same potentials (labour cost difference, possibility to take advantage of technologies already exploited at large scale level)
Air vehicle costs

- To be associated with technological potential for fuel savings in aviation
- Currently not characterized beyond information on the order of magnitude of the cost of an airplane (based on figures released by the main aviation companies for civil aircrafts)
Modal shares

Needed to characterize modes beyond the detail achieved in the demand generation module
Vehicle shares

Needed to characterize vehicle classes beyond the detail achieved in the demand generation module

<table>
<thead>
<tr>
<th>MODE</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
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</table>

Vehicle shares in personal passenger two wheelers [%]

Personal passenger two wheelers
Personal passenger three wheelers
Personal passenger LDVs
Personal passenger vessels
Public passenger NMT
Public passenger two wheelers
Public passenger three wheelers
Public passenger LDVs
Public passenger vessels
Public passenger large road
Public passenger rail
Air passenger
Medium road freight vehicles
Heavy road freight vehicles
Freight two wheelers
Freight three wheelers
Freight LDVs
Freight vessels (maritime/deep sea)
Freight rail
Freight air
Freight pipelines

User inputs (over time)
Pipelines: distance travelled/network extension

Crew cost per day over time

Evolution of the average distance travelled by each volume unit transported by pipeline

Base year data entered earlier (‘User inputs (BASE Y)’ tab).

Pipelines: distance travelled/network extension

Crew cost per day over time

Evolution of the crew cost over time (e.g. due to changes in labour cost and income profiles)

Not a major transport input, maintained constant (in constant prices) by default
Pipelines: distance travelled/network extension

Crew cost per day over time

Data in the sheet Demand generation parameters.
They include information on the families of driving curves used in the model (e.g. for vehicle ownership) and on all elasticities.

**Passenger**
- Drivers as functions of GDP per capita
- Personal passenger vehicles (PPV) per capita, pkm share on PPV in PPV + public transport, pkm share on air mode in total pkm, people per active bike, personal vessels (boats) per capita
- Environmental culture multipliers
- Personal passenger vehicles (PPV) per capita, PP LDVS, pkm share on PPV in PPV + public transport, pkm share on air mode in total pkm, people per active bike
- Vehicle travel cost multipliers
- Personal passenger vehicles (PPV) per capita, personal passenger LDVS, people per active bike, personal vessels (boats) per capita
- Elasticities as functions of GDP per capita
- Annual personal vehicle travel to cost of driving, pkm on public transport vehicles to cost of driving, pkm on air vehicles to cost of driving

**Freight**
- Drivers as functions of GDP per capita: share of light vehicles in total road freight
- Elasticities: tkm to the cost of tkm, load factors to the cost of tkm