COPERT - SIBYL workshop

21-22 October 2015

Brussels, Belgium

Policy making and scenario evaluation tool for road transport emissions

Presentation Outline

PART I

- Introduction
  - Development history
- SIBYL model
  - Model structure
  - Methodology
  - Baseline
- Indicative results
- Future work

Presentation Outline

PART II

- Software demonstration
  - Graphic User Interface
  - Scenario building options
    - Stock
    - Activity
- Hands-on Examples
  - Scenario building approach
  - Test cases

Presentation Outline

PART III

- Software demonstration
  - Scenario building options
    - Fuels,
    - Energy
    - Pollutants
- Hands-on Examples
  - Scenario building approach
  - Test cases

GENERAL FEATURES

SIBYL development history

- SIBYL 0.9b (Jan '12)
  - Beta version containing the GUI and the basic model structure
- SIBYL 1.0 (June '12)
  - Bottom-up modelling framework
  - Fuel consumption / emissions based on COPERT 4
  - Calibrated baseline results based on EC4MACS, PRIMES 2010
  - Full stock dataset for 26 EU Countries
  - Built-in, state-of-the-art technologies
  - Intuitive and flexible custom technology introduction
  - Statistics-based annual mileage distribution modelling
  - Interactive chart features
  - Standard import-export options in various formats

SIBYL development history

- SIBYL 2.0 (Aug '13)
  - Introduction of type-approval CO2 related scenarios
  - Generation of input file to COPERT 4
  - Baseline extended to 2050 for all EU-27 MS
  - Activity consistent with latest PRIMES 2012 REF
  - New vehicle classes (G < 0.8l and D < 1.4l)
  - Mileage, speed and share detailed customization:
    - All three features can now be fully customized with respect to vehicle class, year and age
    - Mileage degradation (age dependency)
    - Updated mileage, speed and share baseline values
  - Automatic mileage calibration per vehicle class (user-defined calibration option)
  - Euro standards implementation
  - Efficiency trend following imposed type-approval regulations

SIBYL development history

- SIBYL 3.0 (June '14)
  - Almost 10x faster scenario execution
  - Baseline projection consistent with the most updated estimations in the EU-28 region for the 2010-2050 period, in line with historical data up to 2013.
  - Baseline consistency with the output of the TRACCS project.
  - More intuitive graphical user interaction and pre-defined trends
  - Scenario type options
    - Full scenario execution
    - Stock estimation only – with the option to export data to COPERT
  - Scenario calibration options with respect to the baseline
    - Activity balancing per sector
    - Fleet balancing per sector
    - No balancing
  - Custom fuel consumption factors introduction capability for all vehicle classes in addition to real-world and type-approval factors.

SIBYL development history

- SIBYL 4.0 (July '15)
  - Baseline projection consistent with the most updated estimations in the EU-28 region plus Switzerland, Norway, Turkey, Iceland and FYROM for the 2010 - 2050 period, in line with historical data up to 2014.
  - Additional group entities (other than EU28): EU27, EU15, EU12, Non-EU
  - Updated air pollutant emission factors
  - Well-to-tank CO_2 and Energy emissions are now included; baseline WtT factors are included
  - Custom baseline input option
  - Detailed heavy duty trucks and buses classification, in line with the latest COPERT model
  - GUI enhancements (e.g. Undo/Redo option)

SIBYL model analysis

- Model structure
  - Modular base
  - Basic module functions
- Methodology highlights
  - Stock estimation
  - Energy & CO_2 emissions
  - Advanced technologies
  - Trip modelling
- Integrated baseline
  - Historical data sources
  - Projections
  - Calibration

MODEL STRUCTURE

Vehicle technology coverage

Conventional vehicle technologies (COPERT)

Electricity-based vehicle technologies:

- hybrid electric (various)
- range extender
- battery electric
- plug-in hybrid electric
- Fuel cell electric

Biofuels

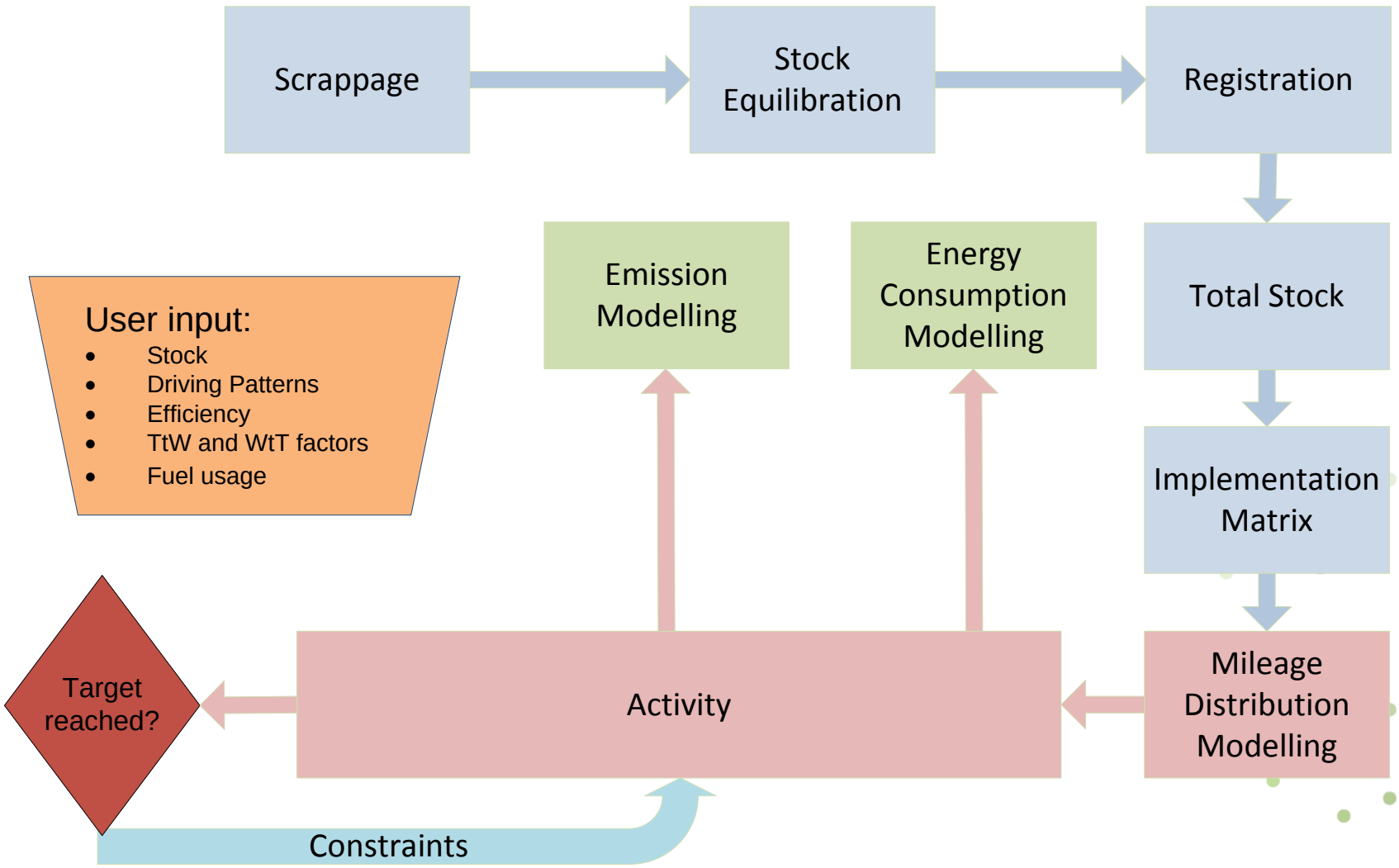
- Fuel blends (EtOH, Biodiesel)
- Flexi-fuel (E10-E85)

Dual-fuel vehicles

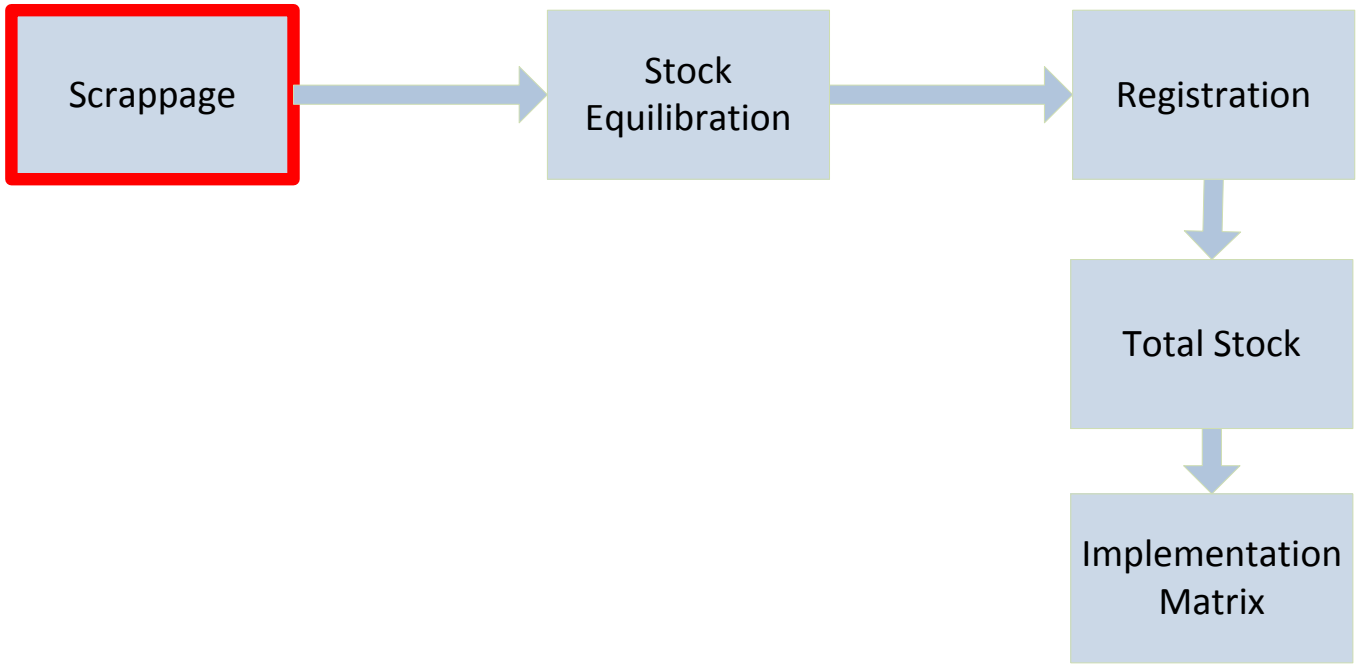
- CNG (various)
- LPG (various)

User-specified vehicle technologies

SIBYL modular structure

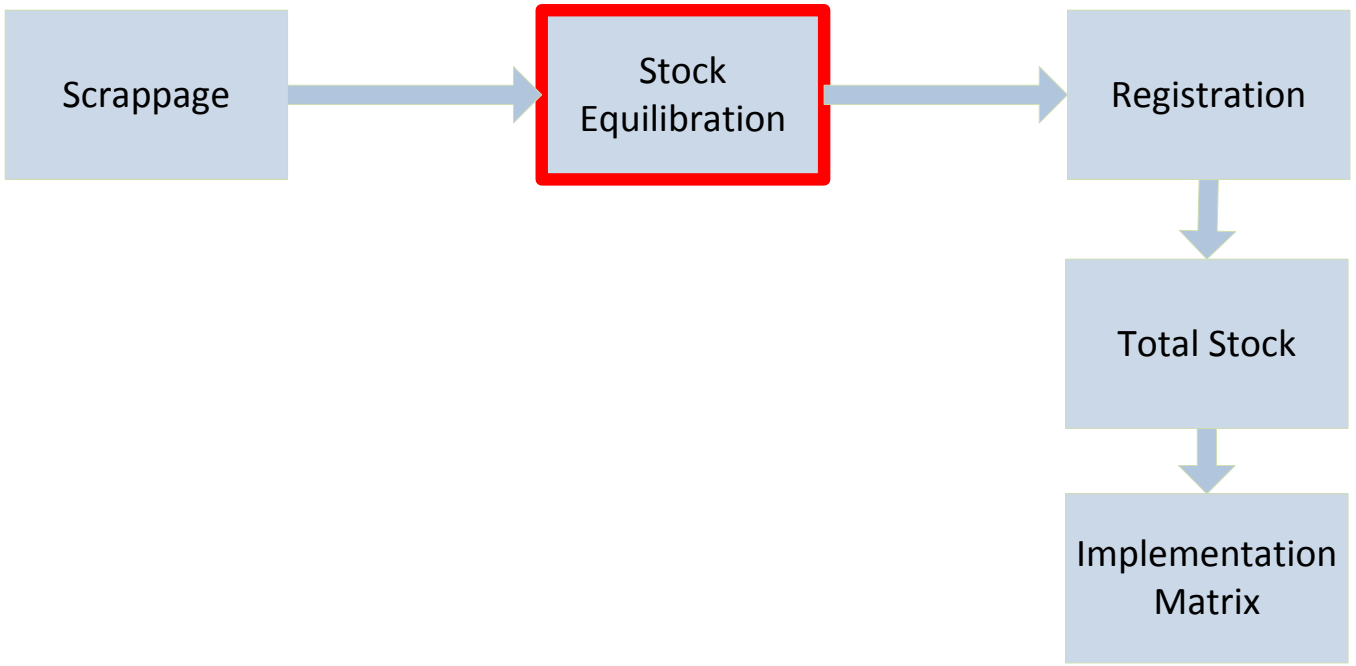


SIBYL modules



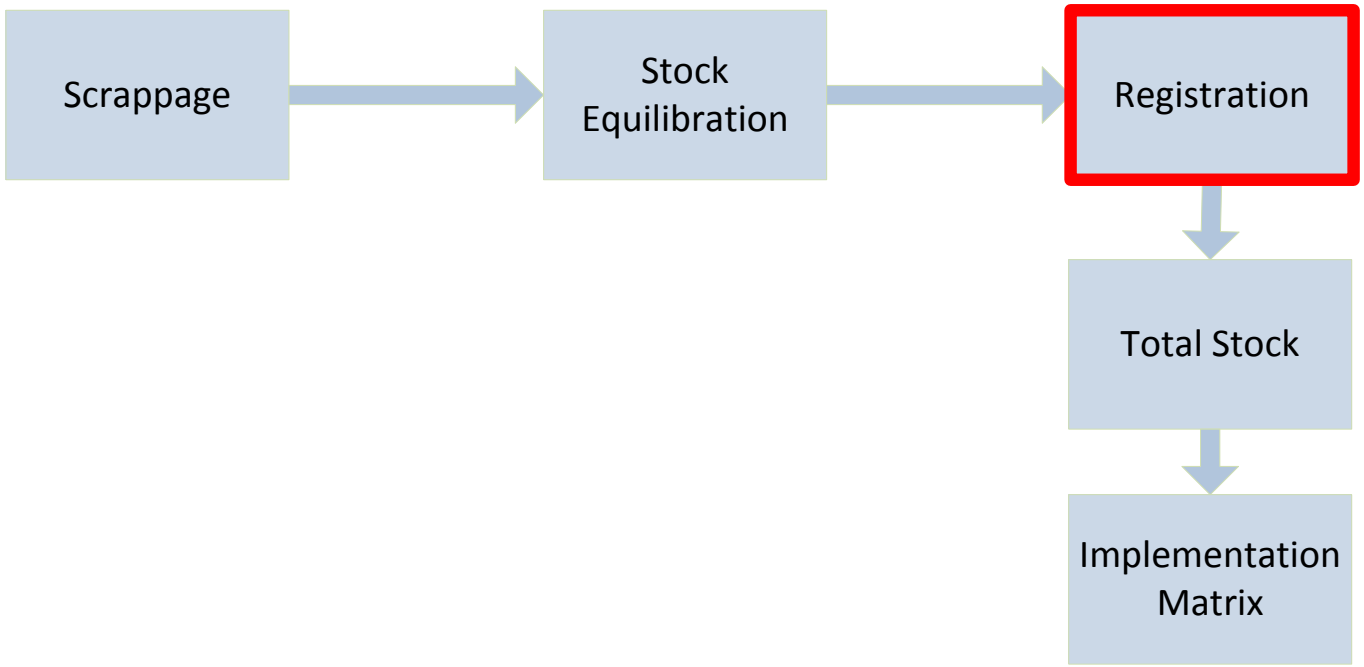
- **Scrappage module**: calculates the total scrapped stock based on the base year stock and the survival rates.

SIBYL modules



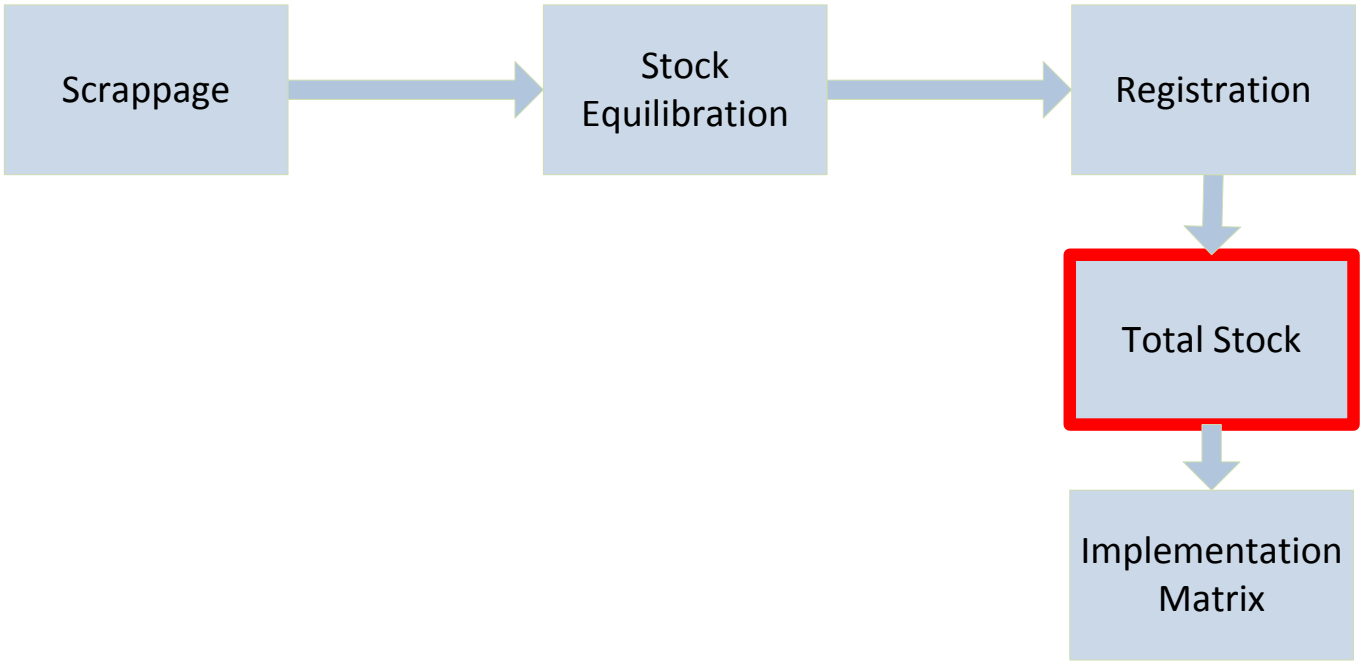
- **Stock Equilibration module**: attempts to balance the stock change.

SIBYL modules



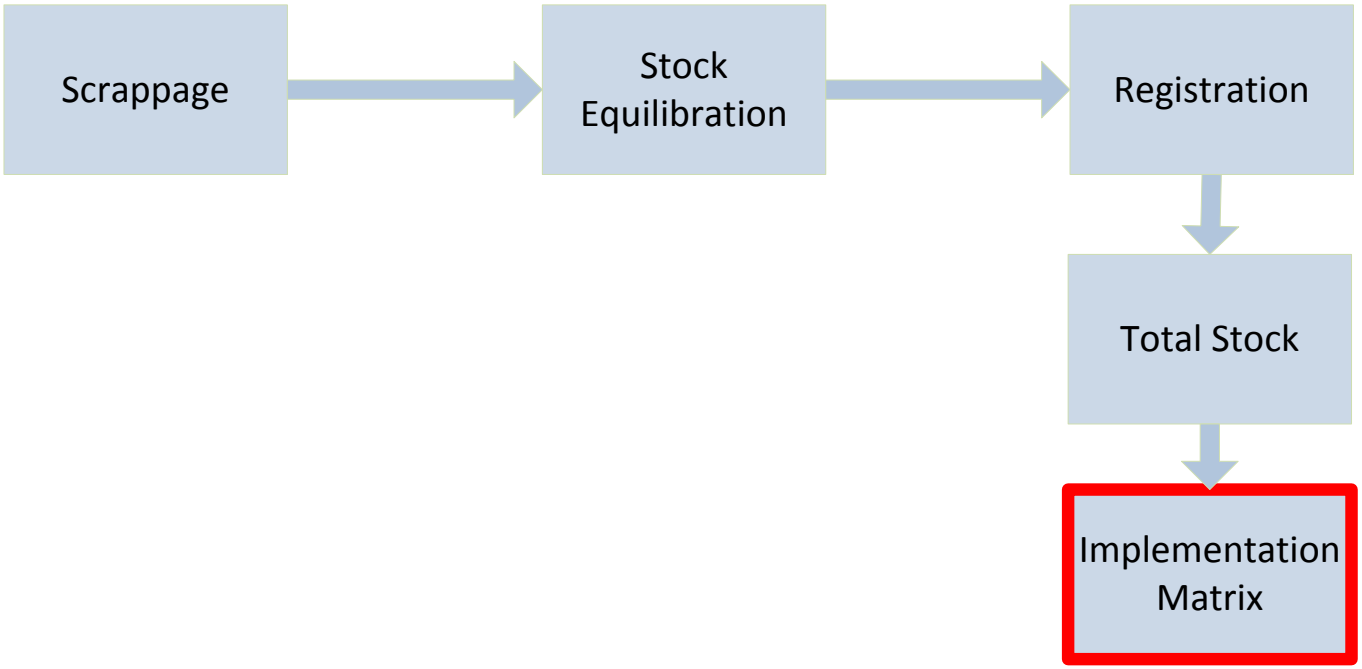
- **Registration module**: distributes the new and second-hand registrations.

SIBYL modules



- **Total Stock module**: combines all the previously calculated data, to yield the detailed stock.

SIBYL modules



- **Implementation matrix module**: produces the Euro standard attribute for the stock.

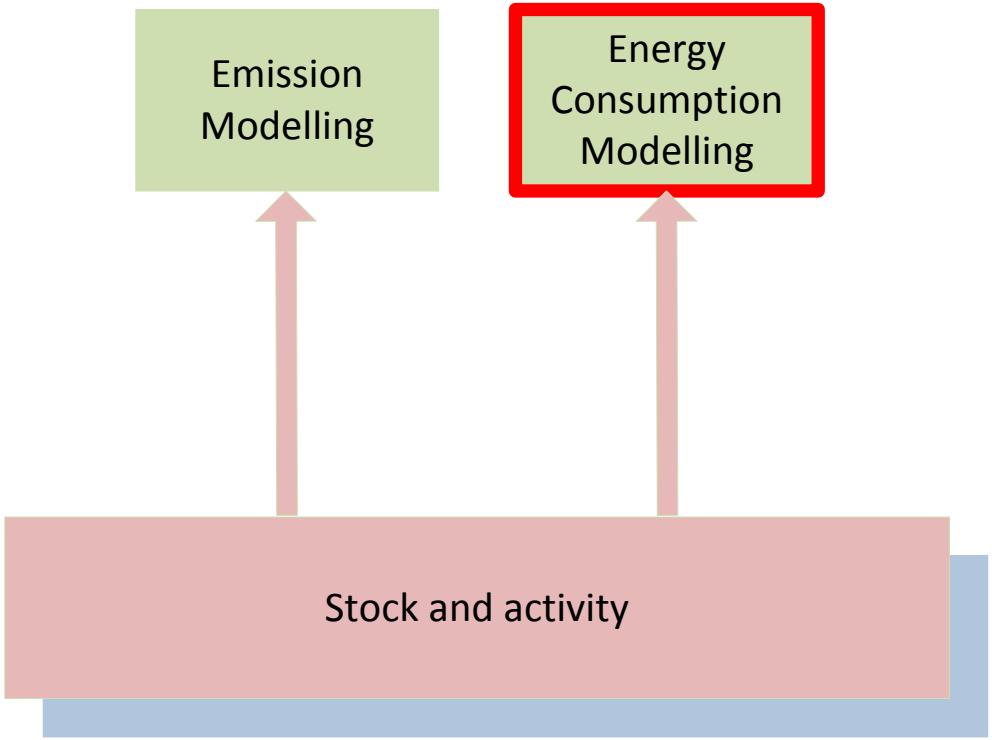
SIBYL modules

- **Mileage Distribution Modelling Module**: processes the mileage-related data and produces the exact mileage per vehicle and age.

SIBYL modules

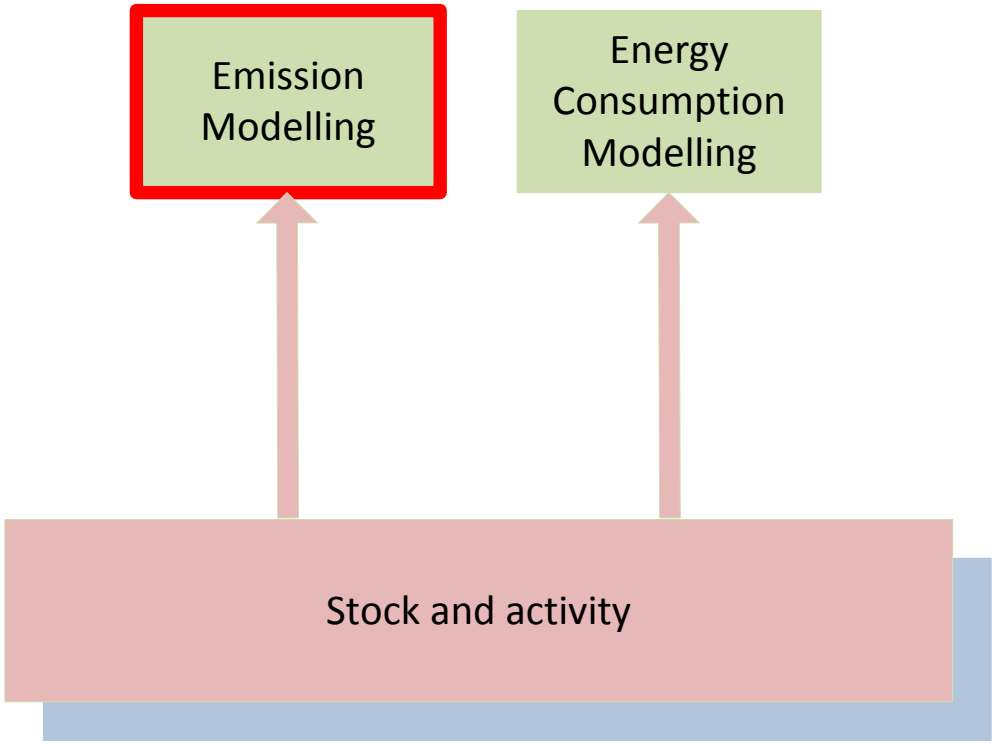
- **Activity Module**: combines stock and mileage data to produce the detailed activity. The activity/stock can be set to match baseline values on a sector basis

SIBYL modules



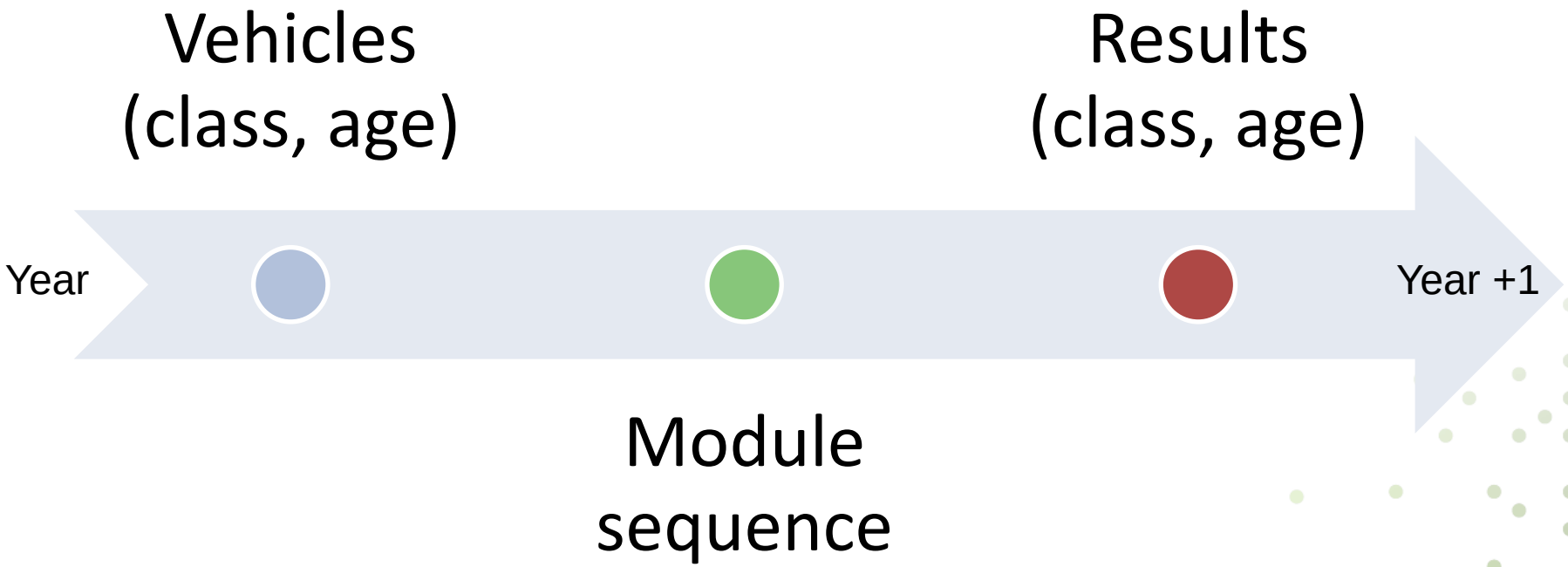
- **Energy Consumption Modelling Module**: combines activity data with consumption functions to produce the detailed energy consumption.

SIBYL modules

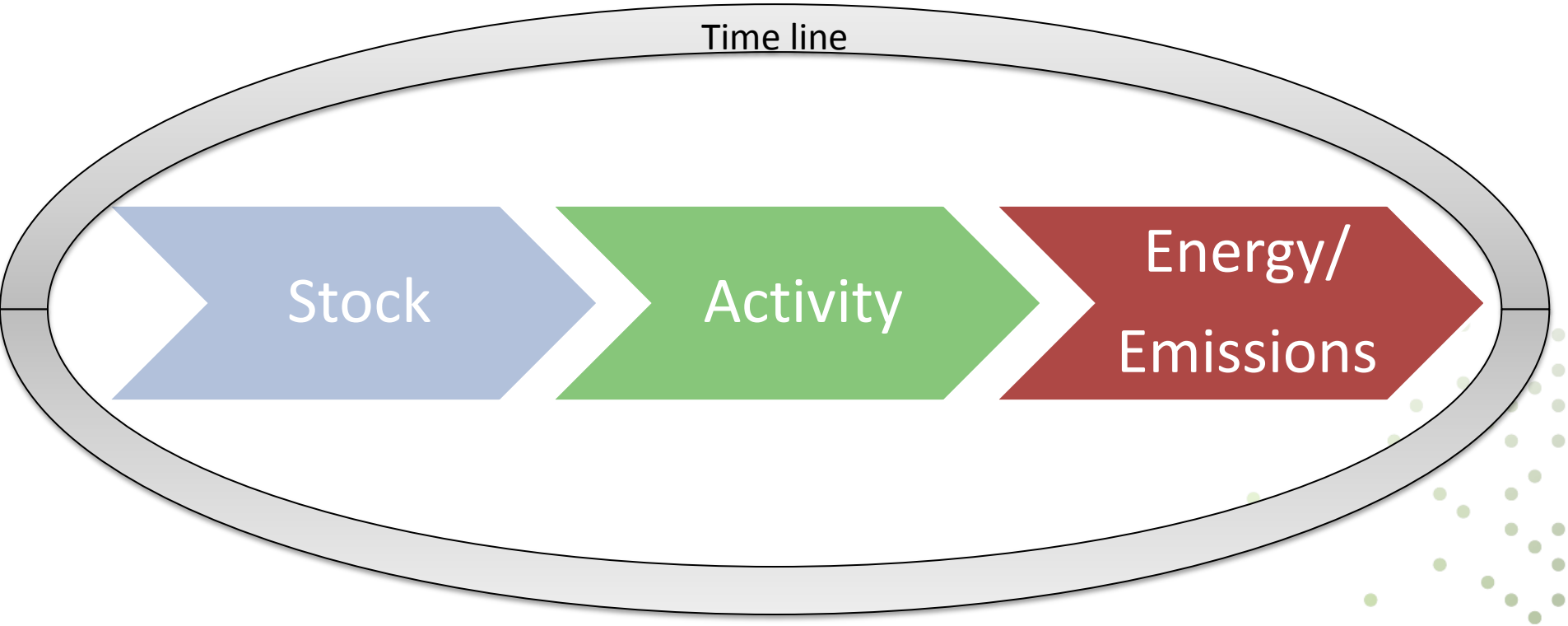


- **Emission Modelling Module**: similar to the previous module but uses the emission factors instead.

SIBYL model sequence



SIBYL model

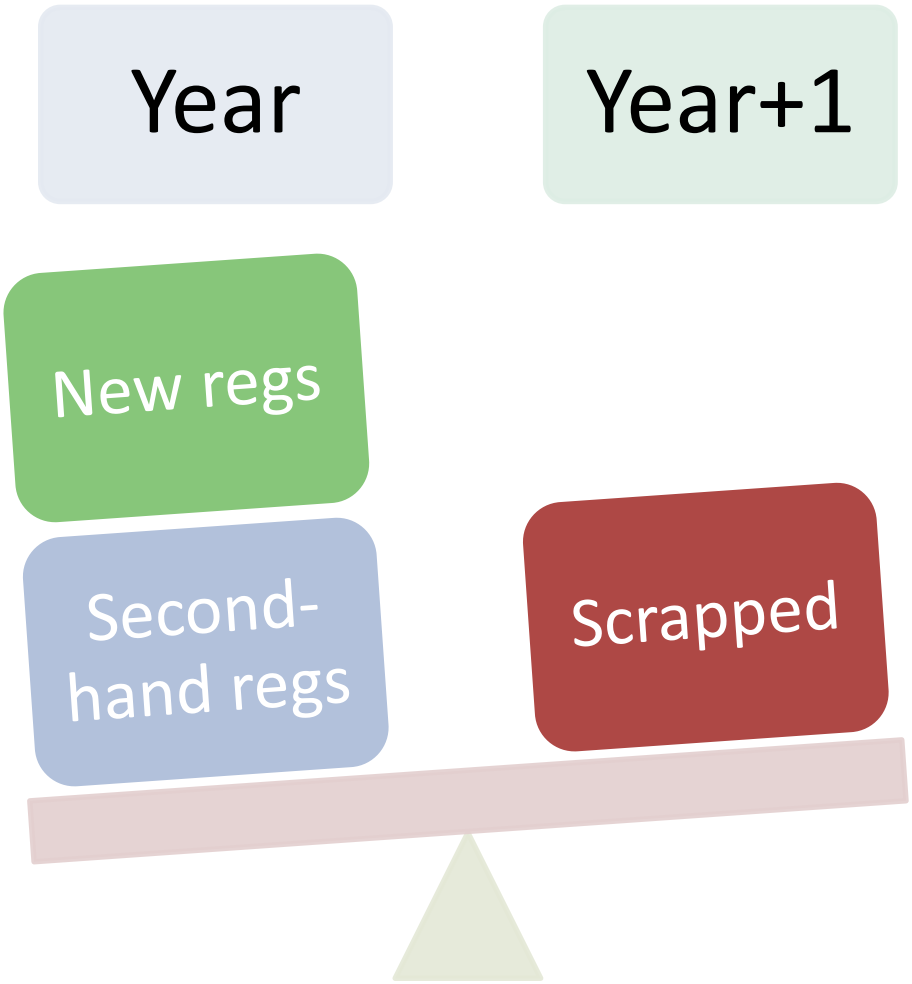


METHODOLOGY HIGHLIGHTS

Methodology highlights

- Stock Estimation
- Energy consumption
- Activity modelling

Stock estimation

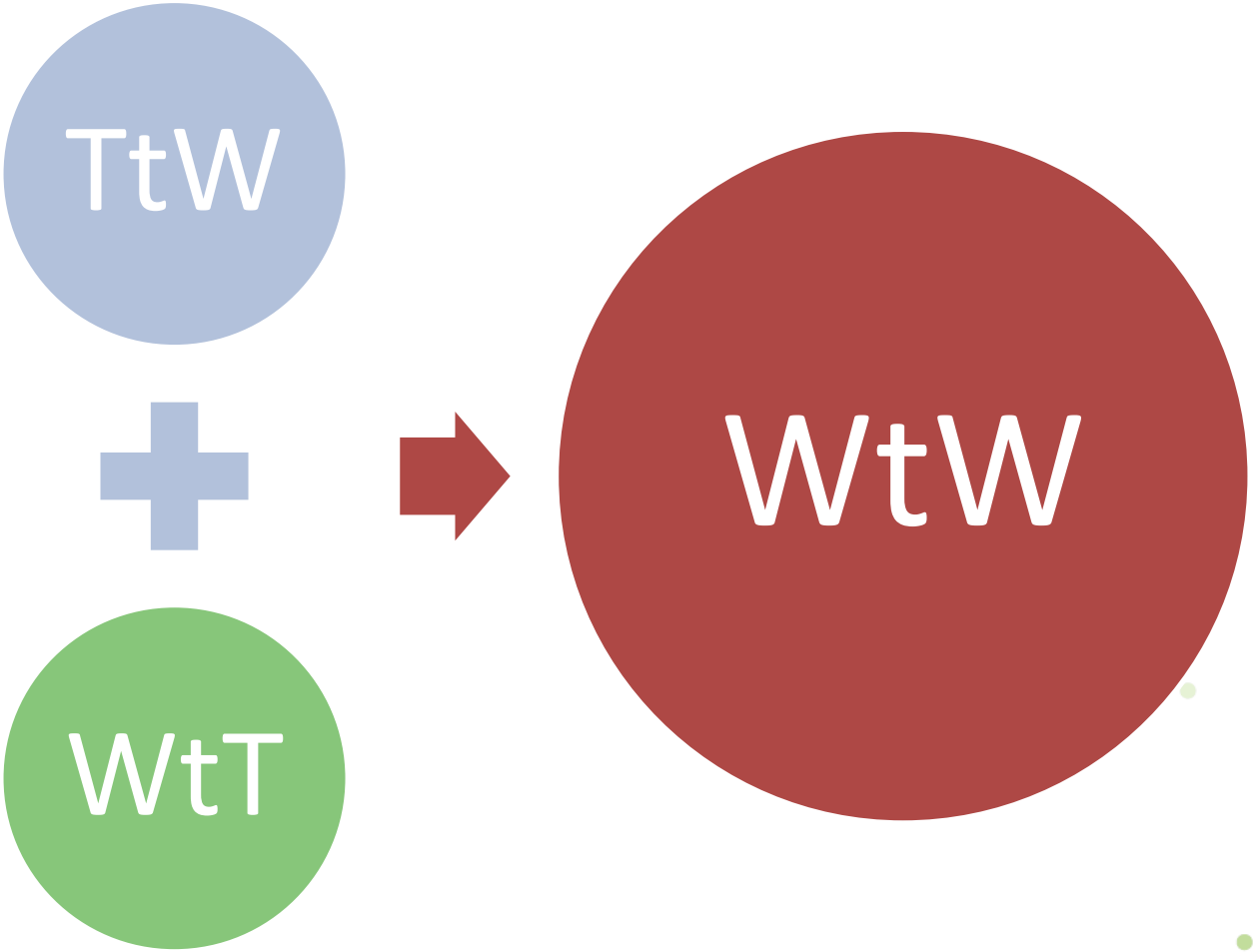


Stock equilibrium examples

- if the stock difference is higher than the baseline, extra second-hand registrations will be added to cover for the required extra stock.

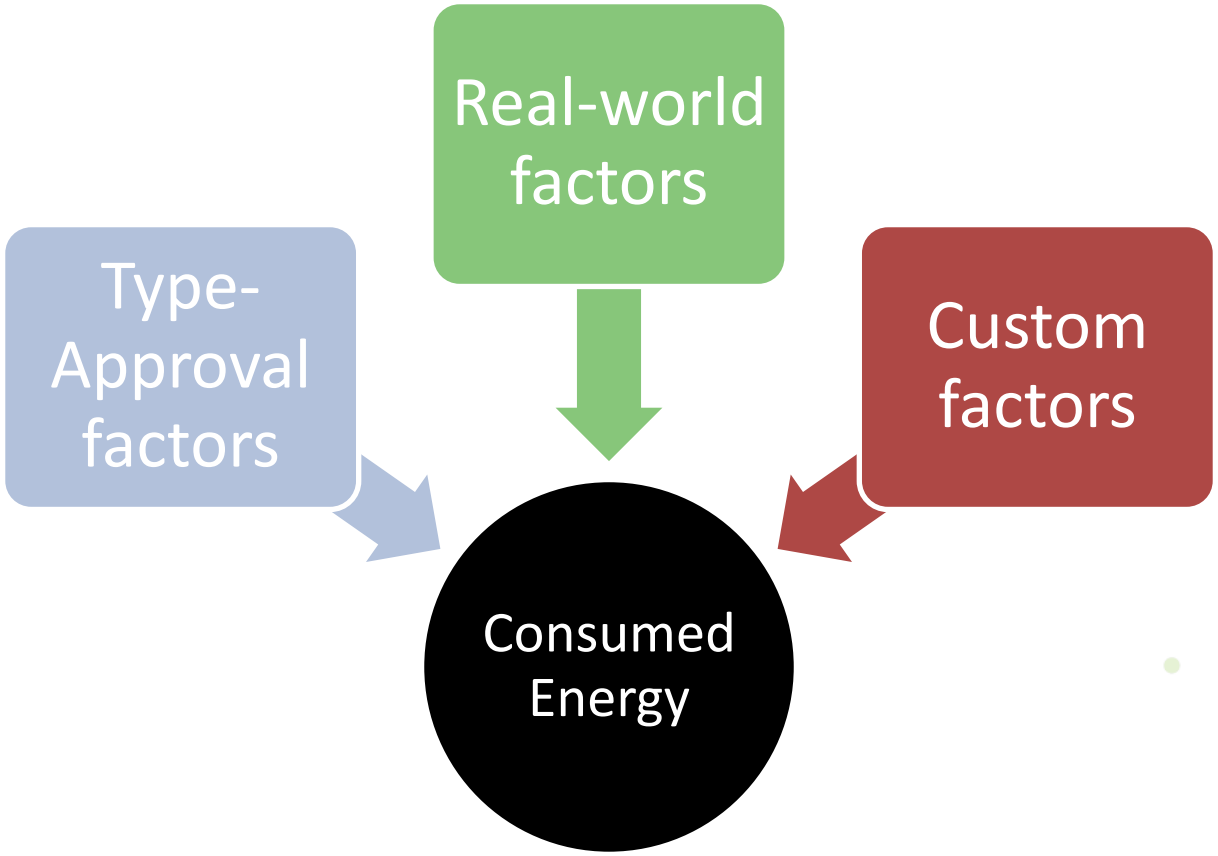
- If the stock difference is lower than the baseline, existing second-hand registrations will be zeroed and deregistrations will increase.

Energy consumption in SIBYL



Energy calculation - TtW

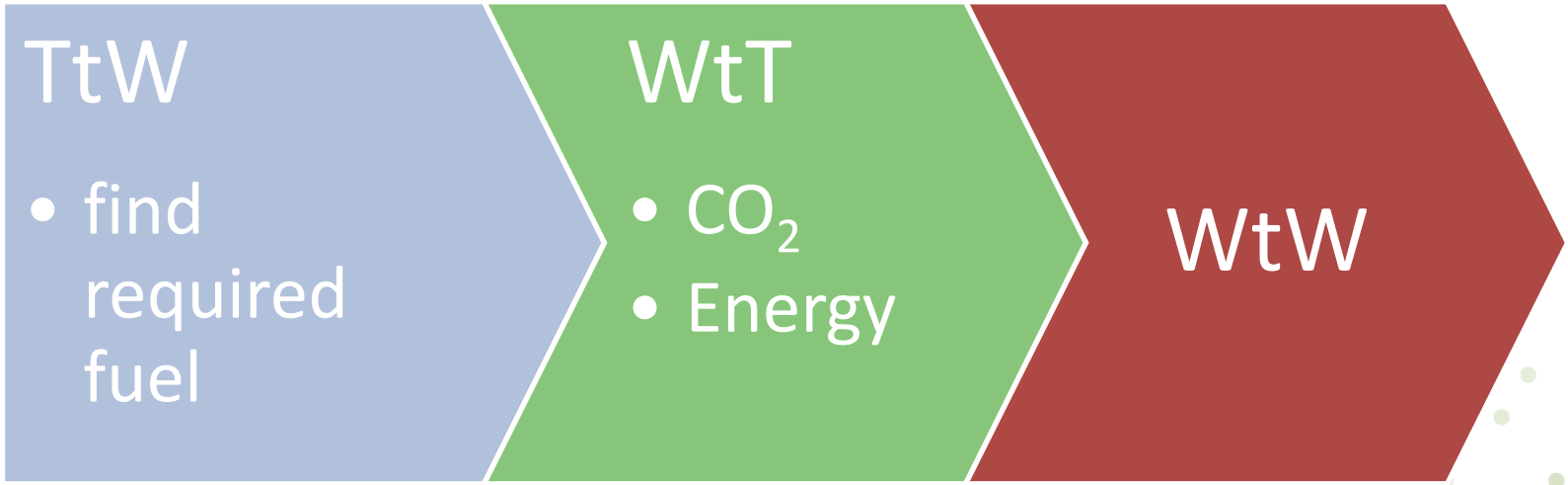
Energy consumption factors - TtW



Energy consumption factors - TtW

- Real-world factors
  - COPERT methodology
    - All conventional vehicles use COPERT methodology to calculate fuel consumption and CO_2 emissions
  - Advanced technologies modelling methodology
    - Advanced (mainly electrified) technologies use a custom consumption/CO2 calculation method
- Type-approval/custom factors
  - Instead of real-world emission factors, type-approval or even custom factors can be used

Upstream modelling



Energy/CO_2 factors - WtT

- The energy/emissions modules also consides the Well-to-Tank (WtT) energy use and CO_2 emissions for each fuel source.

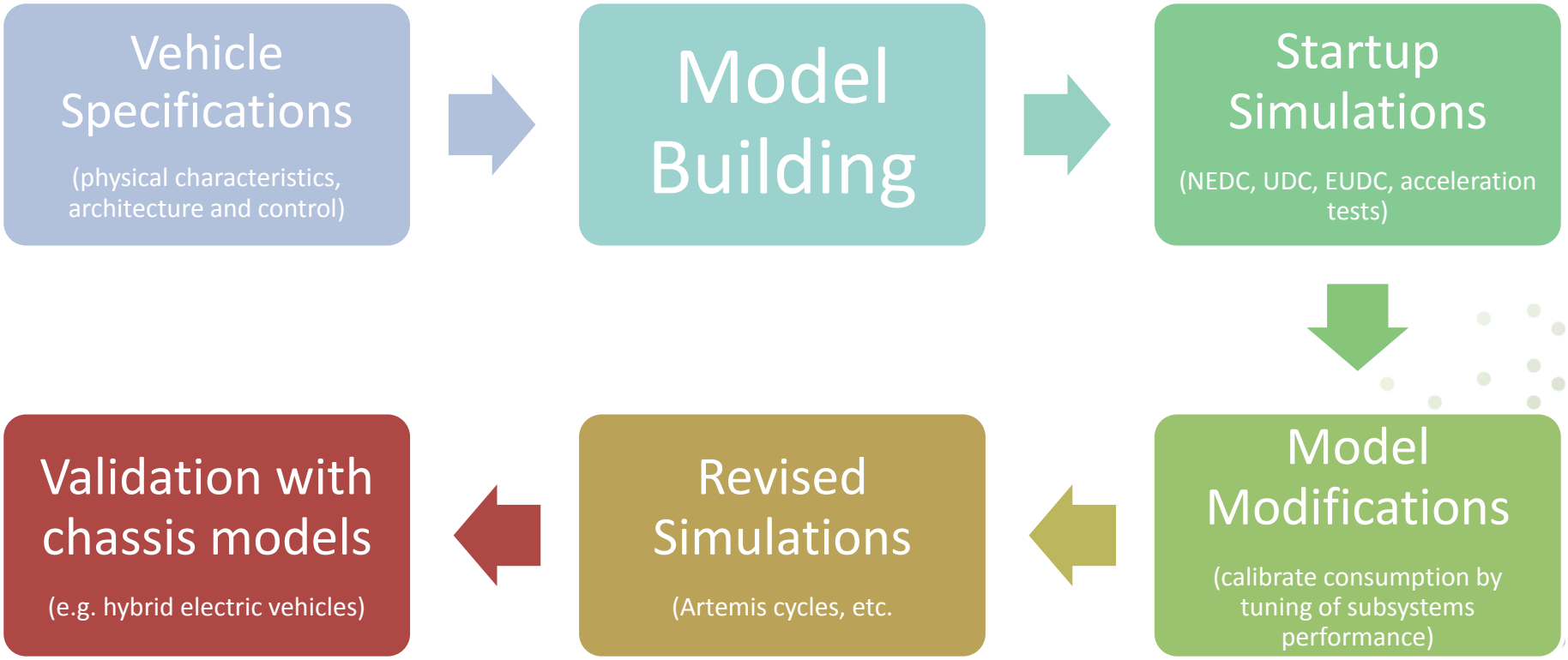
- JEC WtT CO_2 factors per unit of consumed fuel (energy) are used to calculate the corresponding WtT CO_2 emissions and WtT energy [JEC WtT Report 4a, 2014].

- These WtT factors (gCO2/MJ or Mj/MJ) are provided per fuel:
  - An array of pathways are available
  - Custom pathways may be inserted
  - Time-dependency can be used

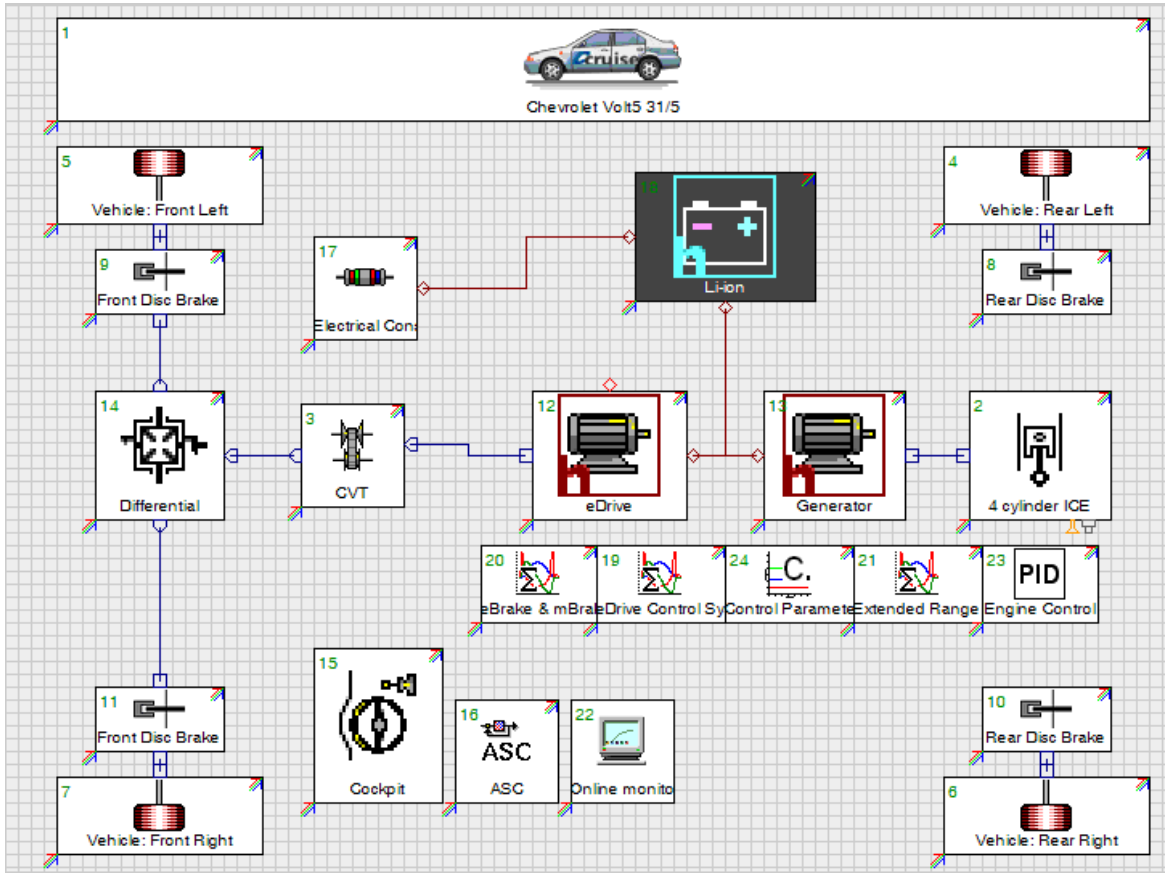
Advanced technologies modelling

- Target
  - to develop representative emission and consumption factors for complex vehicle technologies
- Modelling approach
  - use specific vehicle features to design powertrain system level simulations
  - calibrate vehicle model performance
  - extract consumption functions

Simulation process

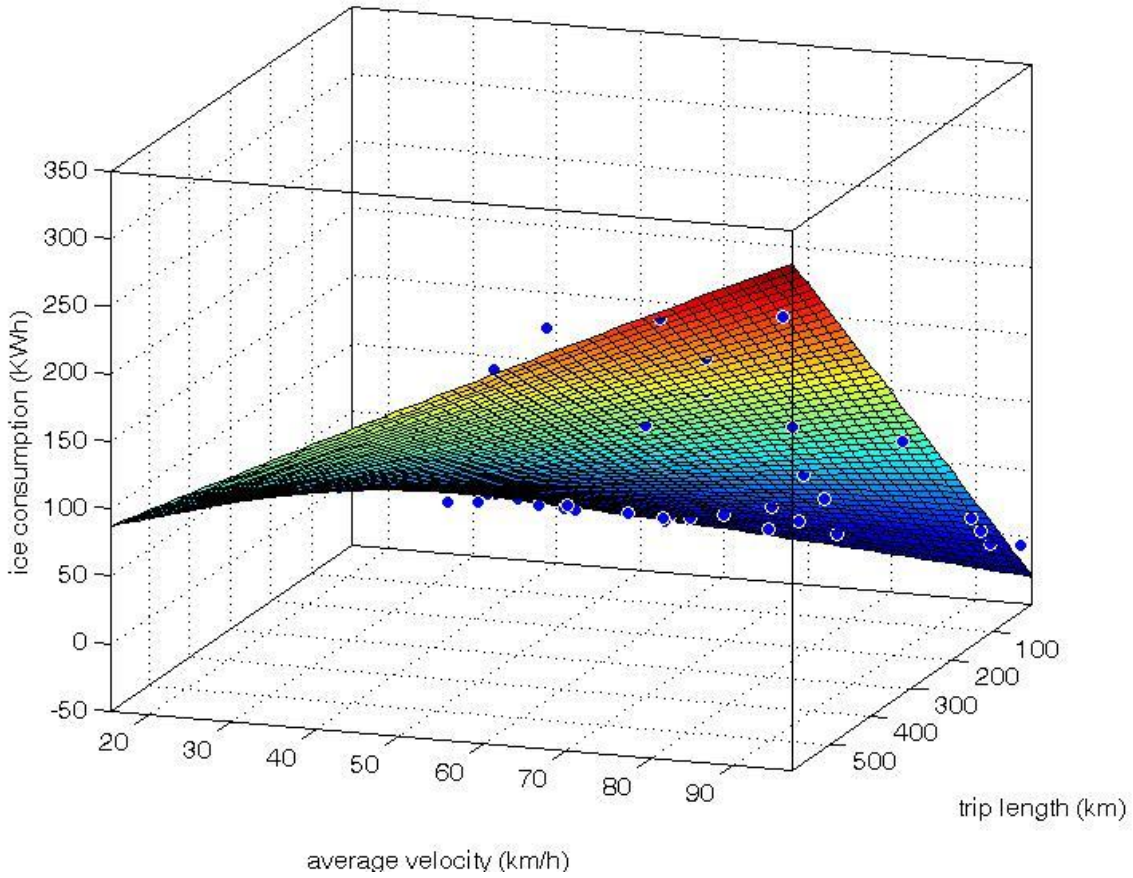


Example: Range-extender EV simulation

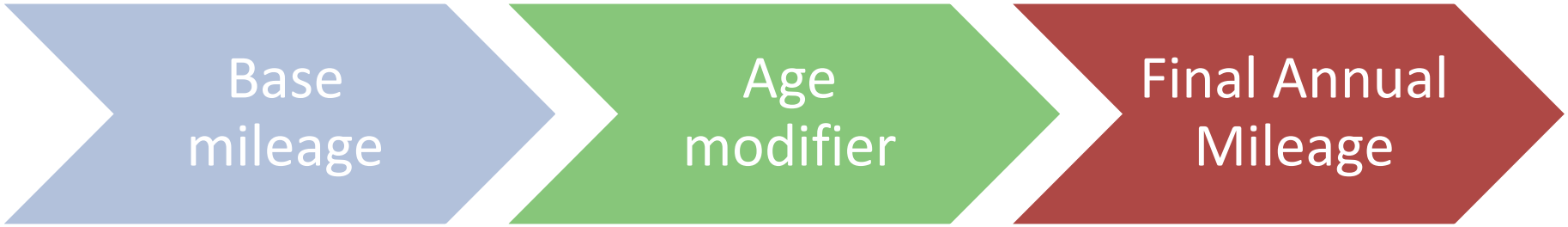


AVL Cruise model

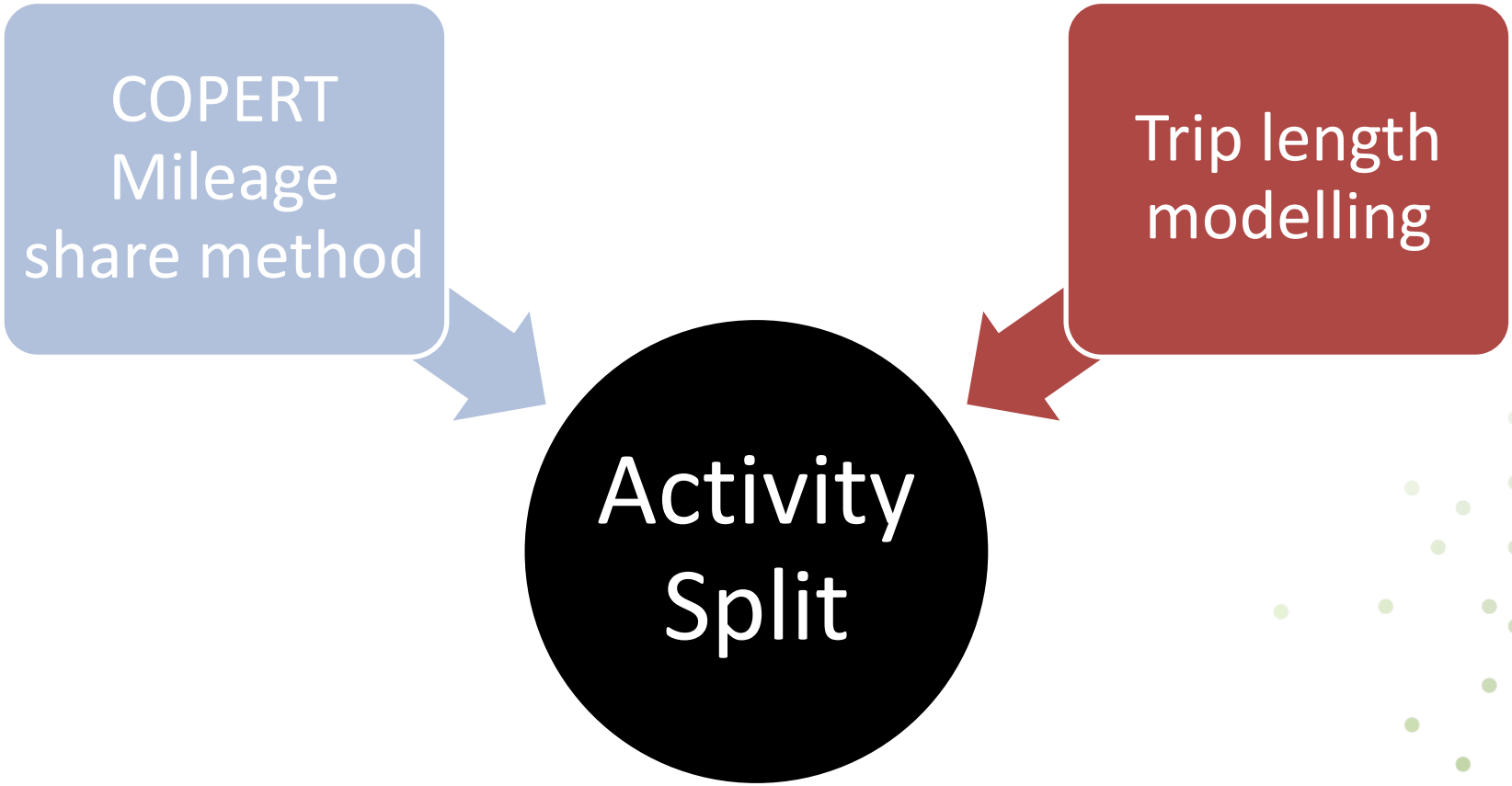
Simulation process



Basic Assumptions: Activity



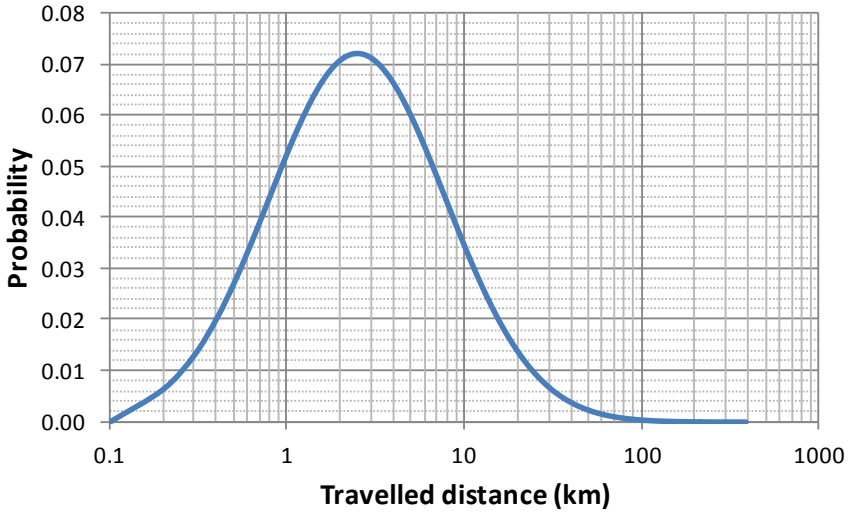
Activity modelling

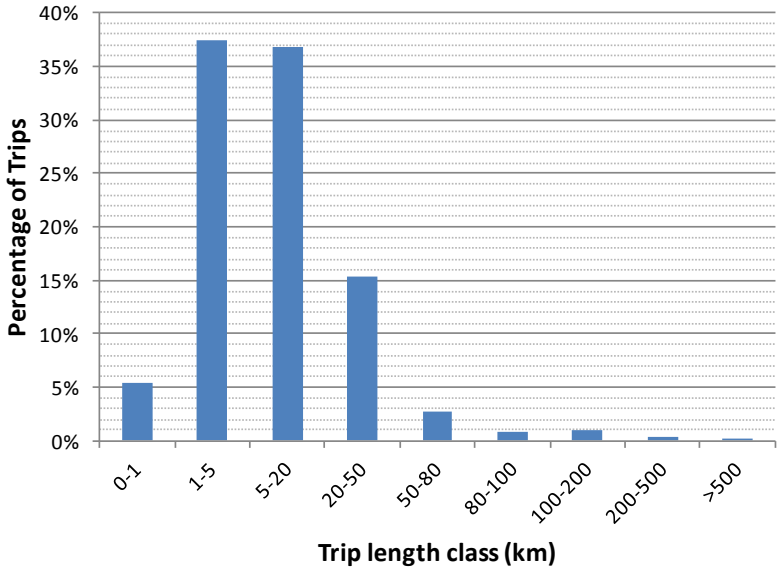


Trip length distribution

- COPERT methodology
  - Urban/rural/highway share split
- Custom methodology: trip length distribution modelling
  - Trips are characterised by length to model dual-propulsion vehicles with range limitations
  - Binned mileage allows for customization of specifications for different trips (e.g. EV, flexi-fuel, dual-fuel)
  - Mileage and trip distribution are inter-connected to simulate mobility scenarios
  - Baseline trip distribution based on statistics

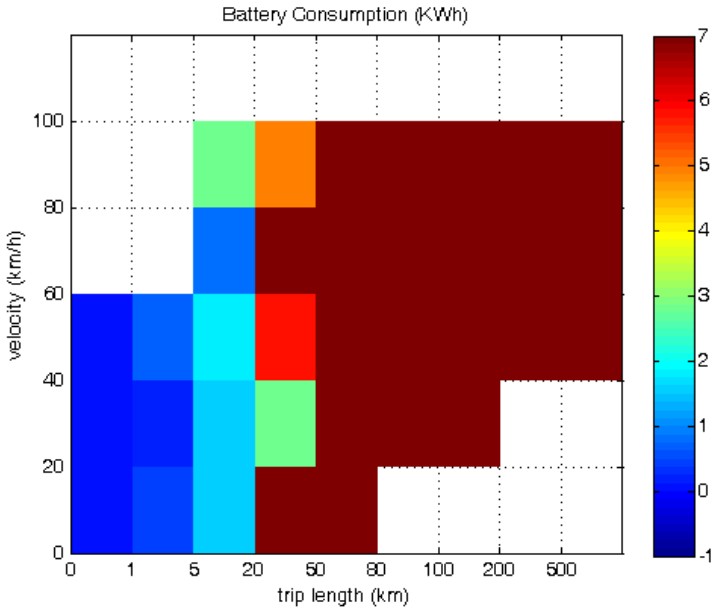
Trip length distribution



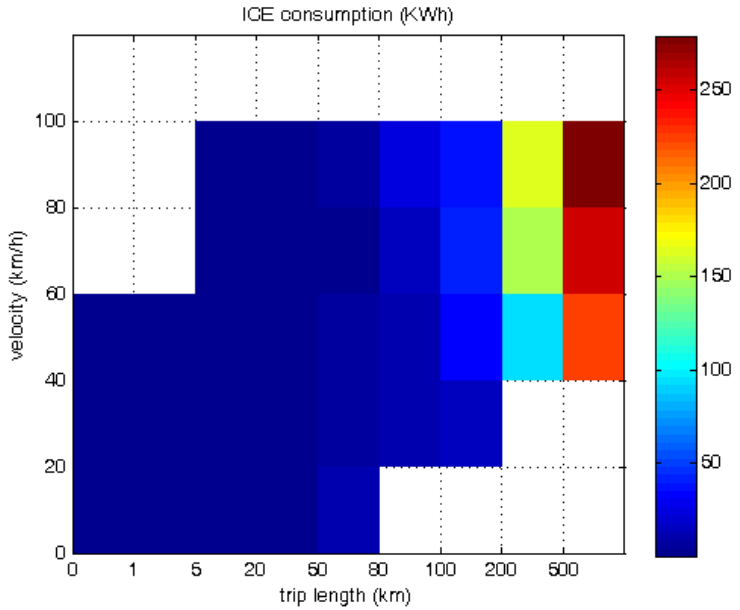


Advanced technologies modelling

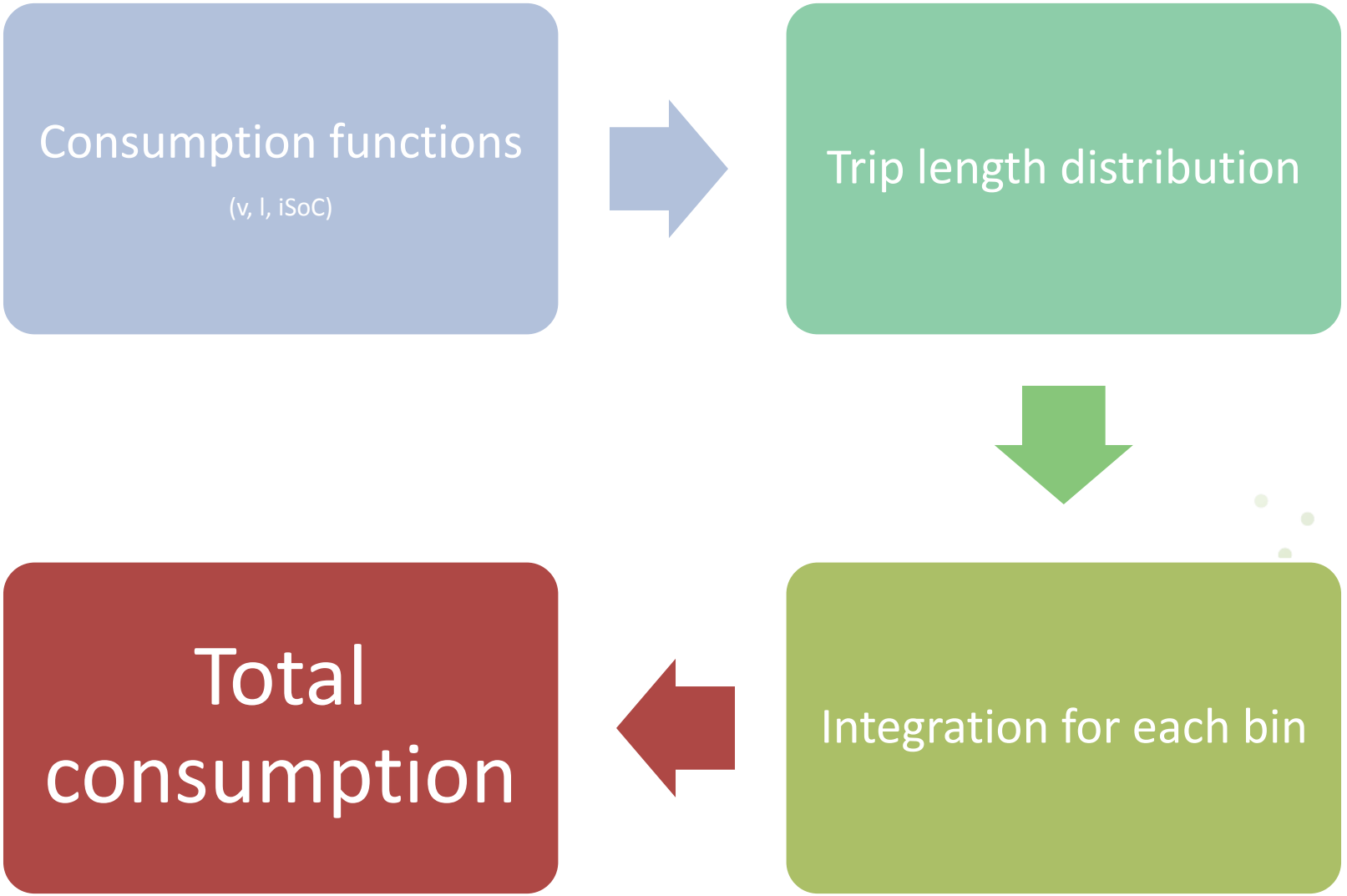
- Battery consumption



- Fuel Consumption

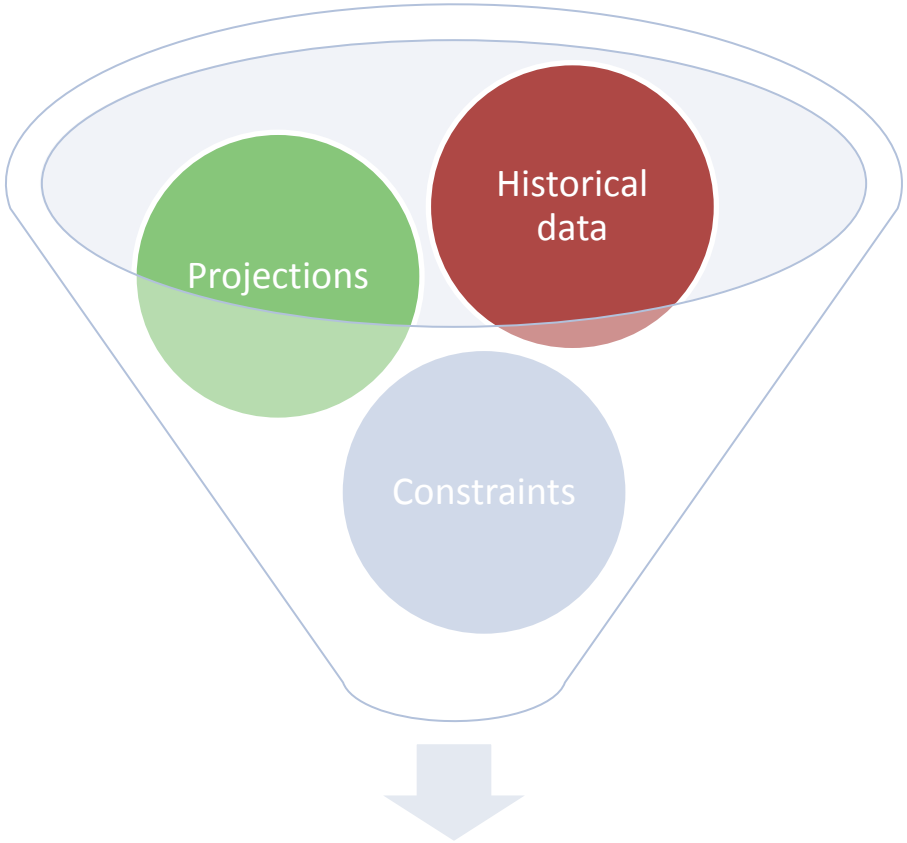


Trip length distribution modelling



BASELINE COMPILATION

Baseline building procedure



Baseline

Baseline data sources

- Baseline building in SIBYL is a process in which a set of historical and projection sources are combined with expert judgement:
  - Statistical data to setup the detailed starting year
  - Secondary statistical data used to establish the basics for following historical years
  - Assumptions and constraints defined by projection data sources
  - Detailed baseline is corrected and calibrated.

Baseline data requirements

Stock

- New regs
- Stock
- Survival rates
- 2- hand regs

Activity

- Annual mileage
- Age dependency
- Trip patterns

Energy/emissions

- Efficiency improvement
- Energy/Emission factors
- EURO standards
- WtT factors

Additional details

- Conversion coefficients
- Other

Basic Assumptions: Stock

- Statistical data sources
  - **Stock structure**: TRACCS project
    - TRACCS includes detailed fleet structure data for the 2005-2010 period for the EU-28 region plus Iceland, Norway, Switzerland, FYROM and Turkey.
    - Detailed allocation of fleet into specific vehicles classes per age. Also provides vehicle deregistrations, second-hand registrations and annual mileage data
    - Base year: 2010
  - **New registrations**: ACEA and ACEM data used to obtain reported new registrations for the 2011-2014 period.
  - **Stock** estimation for 2011: EUROSTAT data were used to set total stock trends for conventional passenger cars.

Basic Assumptions: Stock

- Data processing
  - TRACCS
    - To be inline with COPERT methodology, capacity-based vehicle classification conversion from market segments is required.
  - ACEA/ACEM
    - Disaggregation of new registrations must be performed: figures refer to broad classification only, e.g. total passenger cars.
  - EUROSTAT
    - Expert judgement is required to explain/correct unrealistic trends.

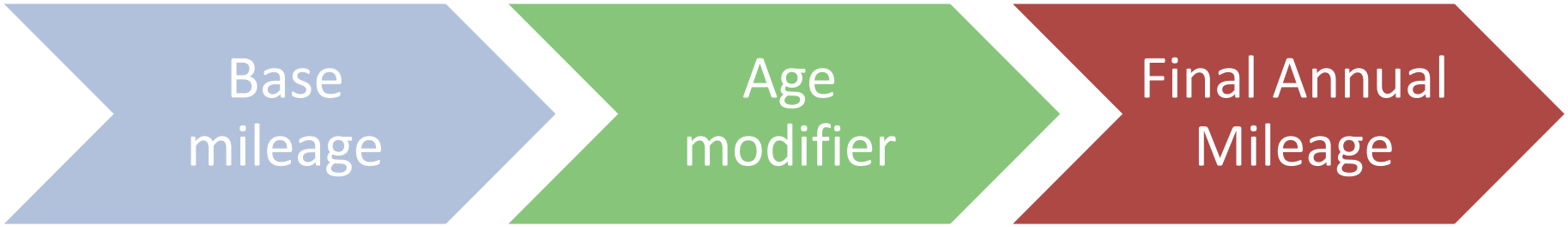
Basic Assumptions: Stock

- Stock projections
  - **PRIMES 2012 Baseline scenario with adopted measures** was used to determine total stock trends up to 2050.
- New registrations
  - After 2014, they were set to follow linear trends
- Detailed stock structure and development
  - Stock lifetime projections (survival rates) are based on an S-function approximation obtained from the 2010-2011 transition;
  - Modifications are applied to compensate for stock trend changes afterwards.

Basic Assumptions: Stock

- Data processing
  - Regarding electrified vehicles the projected market vehicle penetration rates of are based on the slightly decarbonised scenario presented by Pasaoglou, Honselaar and Thiel,
  - PRIMES data include aggregated vehicle classification based on fuels. Further disaggregation required for SIBYL is based on expert judgement.
  - PRIMES estimations were deemed very optimistic for the 2010-2013 period; reasonable stock trend deviations estimations were allowed

Basic Assumptions: Activity



- Base mileage and age effect figures based on TRACCS data

Basic Assumptions: Activity

- Data processing
  - Activity development follows PRIMES 2012 relative activity/energy development per fuel and sector
  - Baseline calibration requires that base mileage values are modified to satisfy activity match with PRIMES.
  - Up to 2013, the baseline mileage for gasoline/diesel vehicles was modified to meet the statistical consumed fuel.

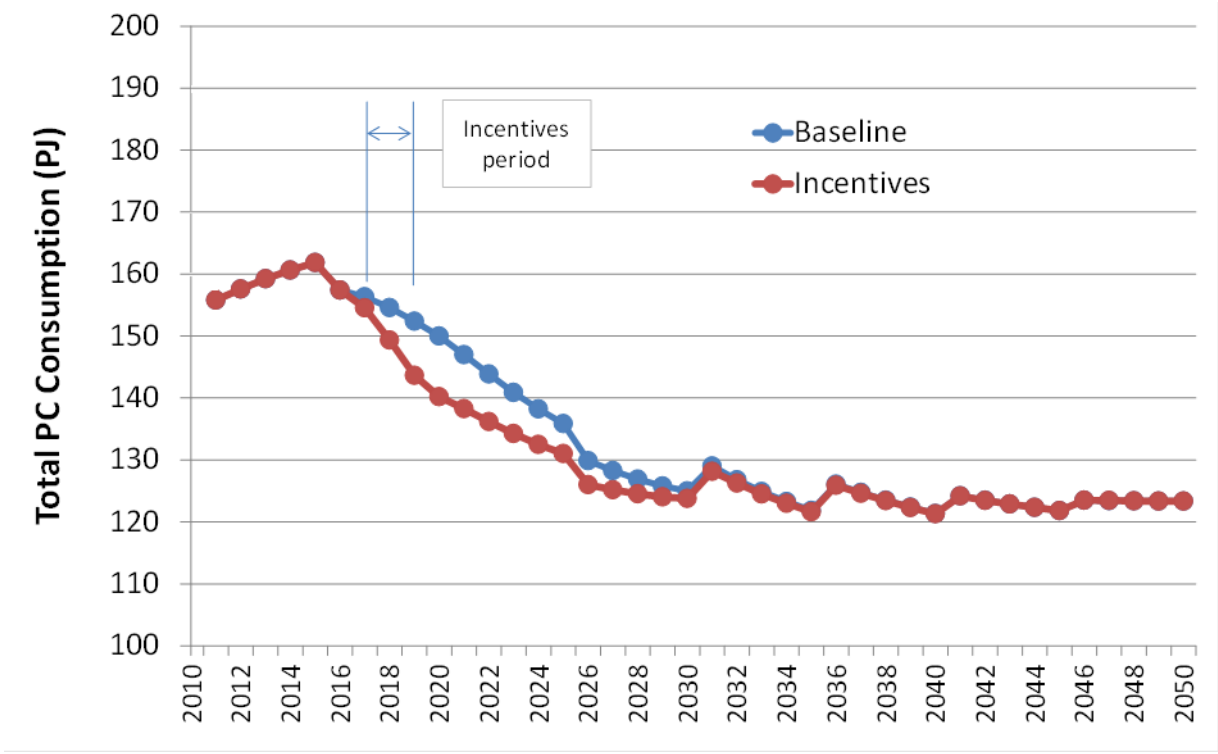
Basic Assumptions: Energy & Efficiency

- Efficiency development
  - CO_2 type-approval emission figures were used for passenger car vehicle technologies to set 2010 efficiency base
  - Imposed 2015 and 2020 CO_2 targets for PCs used to extract efficiency trends up to 2020. No efficiency development was assumed post-2020.
  - LCVs use the corresponding targets to set their own efficiency pattern
  - Mopeds, Motorcycles, HDVs and HDBs use an efficiency development rate defined by expert judgement.

INDICATIVE RESULTS

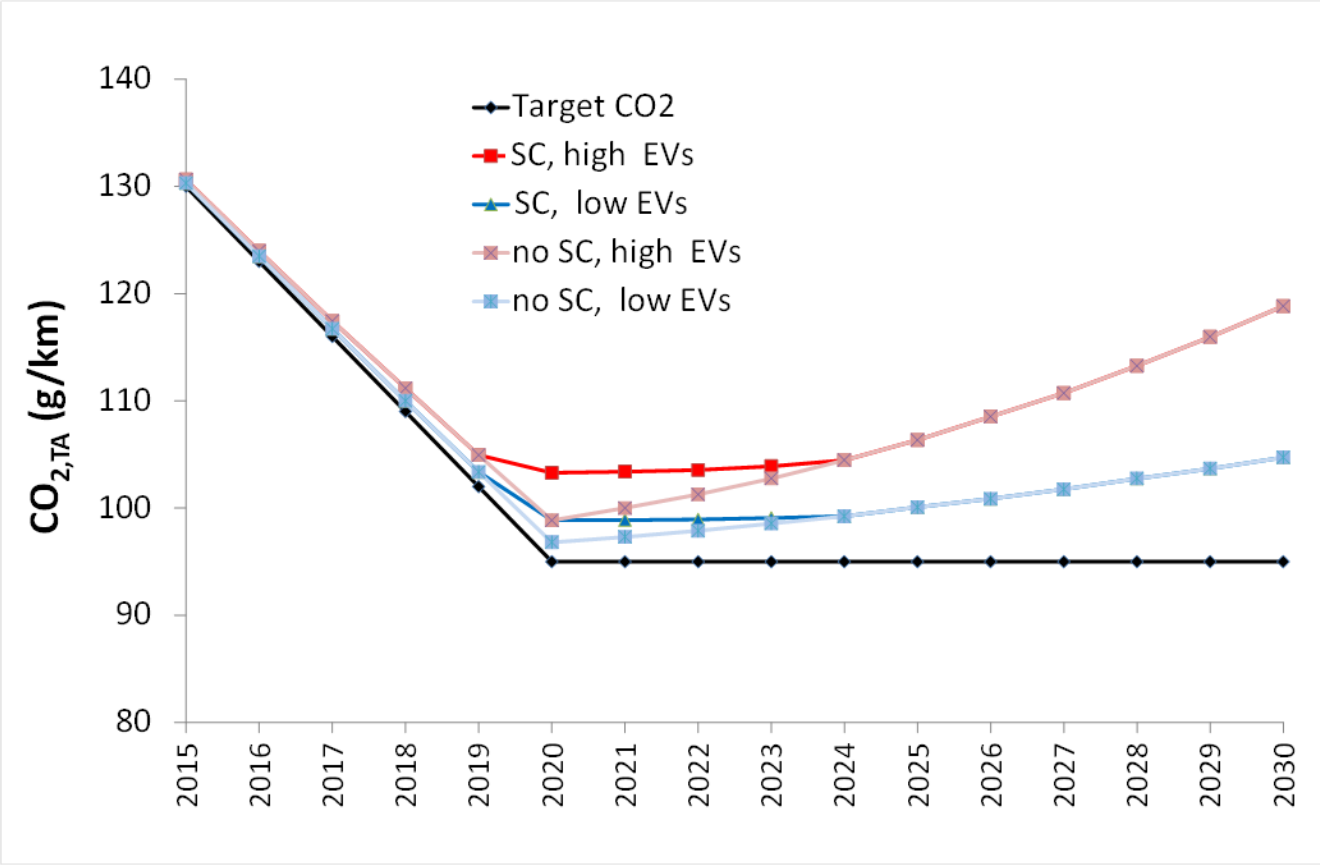
Accelerated scrappage scheme

- Accelerated scrappage scheme for PCs in Austria in the period 2017-2019 while activity (vkm) remains constant
- Total energy consumption by passenger cars:

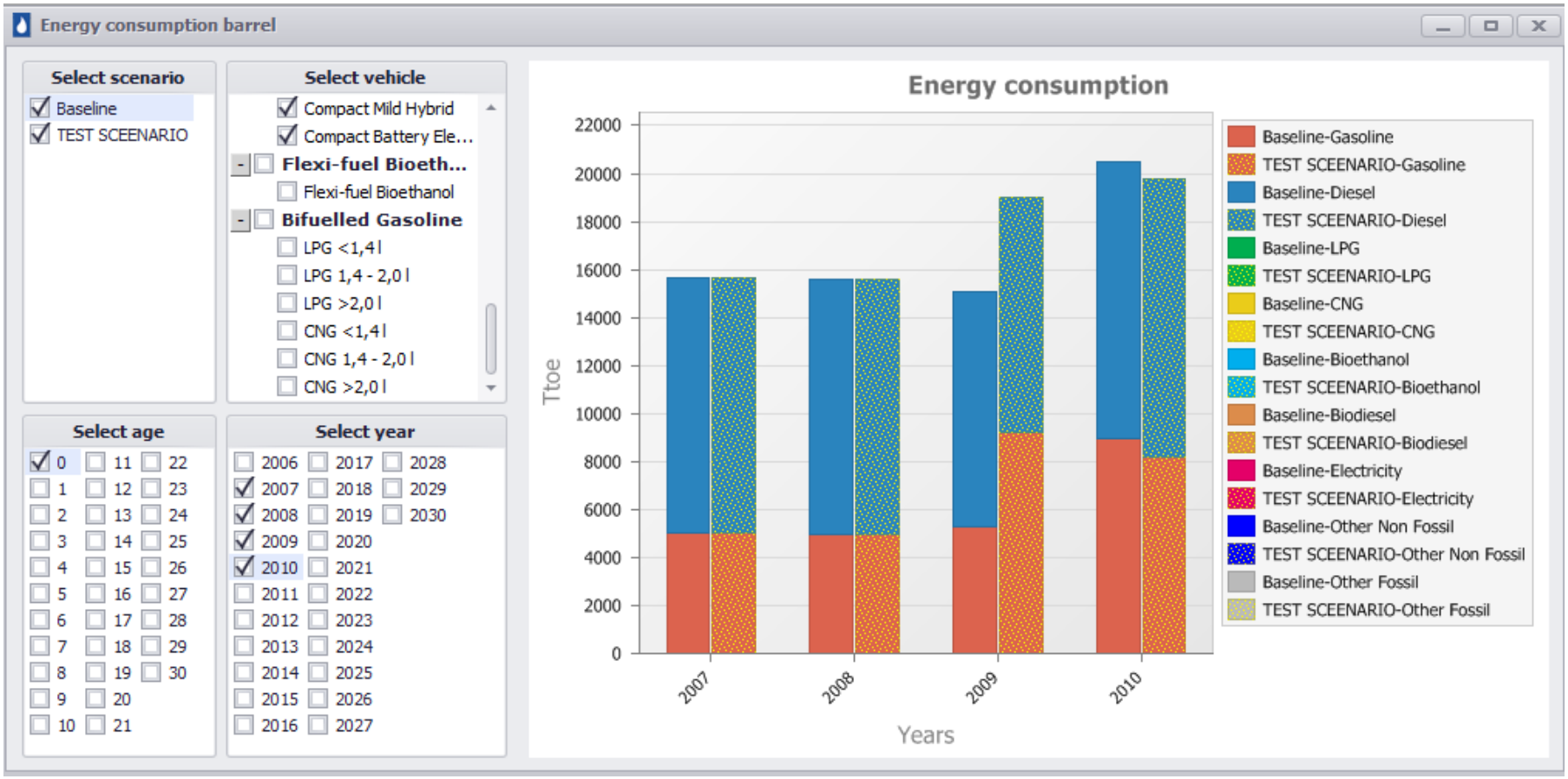


Impact of super-credits

- Impact of super-credits on conventional car $CO_{2,TA}$ emissions in the case of Germany
  - Two penetration scenarios for EVs



Average refinery fuel barrel



Indicative result

FUTURE WORK

Development plan for SIBYL 5.0 (2015)

- Model fully compatible with the upcoming COPERT 5
- Scenario building wizard (step-by-step walkthrough and examples e.g. technology replacement)
- Update based on the latest PRIMES scenario
- Customized interfacing to accommodate each user's needs
  - e.g. simplified edit options

Thank you for your attention…

Any questions…?

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