PLATON –

Planning Process and Tool for Step-by-Step Conversion of the Conventional or Mixed Bus Fleet to a 100% Electric Bus Fleet

Deliverable 6.1: **Application**

Part of milestone M5

Main work package WP 6 Application of the Planning Tool

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Contents

1 Introduction

The Deliverable 6.1 describes the methodology of application for each of the developed tool components denoted as The PLATON Toolkit in the integrated planning process. The data used for the application for each of the developed tool components was selected exemplarily from dedicated cases of public transport in municipalities related to the consortium partners. Similar as pursued in the previous deliverable, the content of this deliverable is written to fulfil the user's need for an easy step-by-step instructable to follow-up the necessary activities of retrieval, installation and application of each tool component including the required input data.

The deliverable is organized in chapters for each of the developed PLATON Toolkit components. The collection of chapters contains the instructions for retrieval, the installation, the required preconditions, the necessary processing steps executed by the user, and the further utilization of the results with caveats and hints for trouble shooting. The order of the chapters is oriented towards a likely workflow for use of the components although the adherence to this order is not necessarily required. For the appropriate use of the toolkit and its components, the availability of the referring input data set is essential.

2 DataProc (Jaworzno case)

2.1 *Download of DataProc*

- Download the DataProc tool component here:
  http://platon.publictransport.info/ => Download => DataProc

2.2 *Installation of DataProc*

- Unzip the `Dataproc.zip` file into the working directory holding your bus route data such as comma separated files obtained from the VisualGrids tool component.
  Example: `373-Cmentarz-Szpital-st.csv`

2.3 *Preconditions for DataProc*

- Make sure Octave Forge is installed or install it from:
  https://octave.sourceforge.io/
- Open `Dataproc.m` in Octave
- Make sure mapping module of Octave is installed or install it from:
  https://octave.sourceforge.io/
- Make sure JSON module of Octave is installed or install it from:
  https://octave.sourceforge.io/
- Modify `addpath("")` accordingly to installation path of JSON module
- On Line 15 modify the name of `importdata()` file
  Example: 373-Cmentarz-Szpital-st.csv

2.4 *Processing of Dataproc*

- In Editor Menu press [Run] or [F5] to start processing of data.
- After processing is finished the velocity profile is displayed for reference.

2.5 *Results of DataProc*

- Obtain the following files from the working directory:
  `vplan.mat`
  `gplan.mat`
- Rename `vplan.mat` to `vplant.mat` in case the processed bus route is defined a towards direction (e.g. from Terminal 1 to Terminal 2).

- Rename `vplan.mat` to `vplanb.mat` in case the processed bus route is defined a backwards direction (e.g. from Terminal 2 to Terminal 1).

- Review the file `route.csv` containing column-wise: longitude, latitude, elevation, web-Mercator X, web-Mercator Y, azimuth, distance, grade, radius, distance, accumulated distance

2.6 *Further use of DataProc results*

- The renamed result files are used in the tool component BusVehicleSimulation as input files.

- The file `route.csv` can be used for any further calculation, display, and mapping reasons.

2.7 *Caveats/Hints*

- If alternate trips to different terminals are related to the simulated vehicle repeat the process with a second bus route file. Rename the resulting files `vplan.mat` and `gplan.mat` to alternative filenames. A maximum of two alternatives can be simulated with BusVehicleSimulation .

3 CellParameters (LFP Battery Cell)

3.1 *Download of CellParameters*

- In order to open the project file of CellParameters without license in SIMBA#. Please download the SIMBA# classroom (`InstallSIMBA#3.2.21classroom.exe`) at this link: https://nextcloud.ifak.eu/s/simba3?path=%2FSoftware

3.2 *Installation of CellParameters*

- Run the installation file (`InstallSIMBA#3.2.21classroom.exe`) in a demo mode.
- By this way, you can only view and run CellParameters, for more functions you need a license.

3.3 *Preconditions for CellParameters*

- Please download the project file (`Parameter_Estimation_3step_LFP&ErrorAnalysis.simu`) beforehand at this link: https://nextcloud.ifak.eu/apps/files/?dir=/PLATON/ToolKit/CellParameters&fileid=199152
- You can use your own measurement voltages of a battery cell and name it as `Voltage_LiFePO4_A123RoundCell(5Hz)` or directly download the given measurement file at this link: https://nextcloud.ifak.eu/apps/files/?dir=/PLATON/ToolKit/CellParameters&fileid=199152

3.4 *Processing of CellParameters*

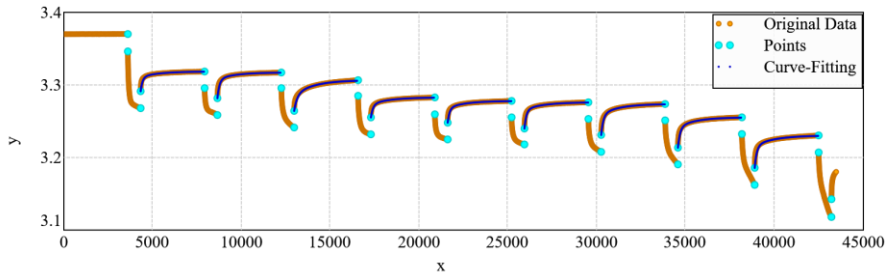
- Run simba classroom in a demo mode, then open the project file of `Parameter_Estimation_3step_LFP&ErrorAnalysis.simu`.
- Then the algorithm will be shown in a form of a flow chart. Double click on the block of "PLOT" 

, and click on the button of "Run" in the bottom menu bar to proceed the algorithm of parameter estimation for a LFP battery cell.

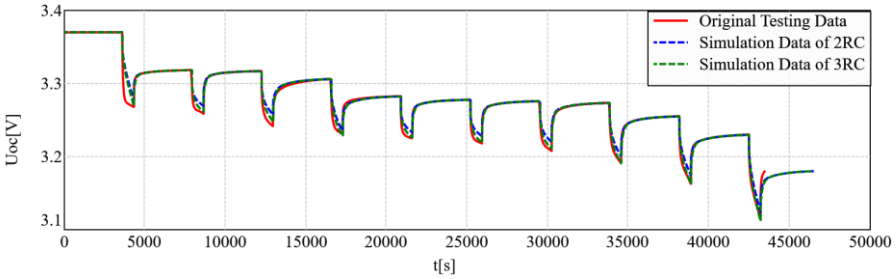
3.5 *Results of CellParameters*

- After execution of "PLOT" function, the following figures can be obtained:

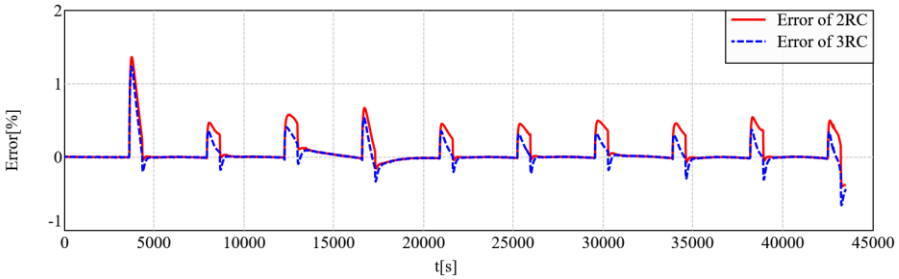
1. Curve-fitting result for hysteresis response of the battery:



2. Simulation results of 2RC and 3RC methods compared with measurement data:



3. Errors of 2RC and 3RC methods.



- All result figures can be saved as PNG, and data can be saved to Excel or CSV by clicking on the “File…” button on the top left corner of the figure.
- After execution of “Output” function, the estimated parameters of the equivalent circuit elements for SOC=1.0…0.1 are written in the Console window.
- e.g.: C3
  25830.19
  23884.97
  25076.28
  27951.54
  23017.49
  18322.70
  21120.84
  18200.30
  17236.21

3.6 *Further use of CellParameters results*

- The result files could be used in the tool component BusVehicleSimulation as input files.
- They can be also used for a further battery model simulation.

4 CollectApp (Magdeburg case)

4.1 *Download of CollectApp*

- Download the DataProc tool component here:
  http://platon.publictransport.info/ => Download => CollectApp

4.2 *Installation of CollectApp*

- Transfer the APK-file `CollectApp.apk` to an Android device such as a smartphone or tablet into the directory `/storage/emulated/0` using a USB cable between PC and phone
- Install the app by tapping on the file `CollectApp.apk` and confirm with [Install]
- Open the app

4.3 *Preconditions for CollectApp*

- On installation confirm the request for providing access to GPS with yes
- GPS must be switched on and enabled
- Allow a few minutes for GPS to receive the first position fix

4.4 *Processing of CollectApp*

- Press [Log GPS track] to start logging of the track of the bus route
- Press [Log GPS position] to save the current position in the bus stop

4.5 *Results of CollectApp*

- Obtain the following files from the smartphone's directory `/storage/emulated/0`:
  `GPSlog.txt`
  `BusStoplog.txt`
- Transfer both files to a PC using a USB cable between PC and phone
- It is suggested to rename both files according the following scheme `YYYY-MM-DD-hhmmss.txt` while using the date and time from the first line of the file. Distinguish between track and stop log file names.

4.6 *Further use of CollectApp results*

- The renamed files are used in the tool component DataProc in the script section `%data input` as input files for bus route tracks and stop locations.

4.7 *Caveats/Hints*

- The time resolution of GPS data of the smartphone app is 1 second. For the higher resolution of 200 ms a solution using a Raspberry Pi can be provided on request.

5 SyntheticalTrips (Magdeburg case)

5.1 *Download of SyntheticalTrips*

- Download the DataProc tool component here: http://platon.publictransport.info/ => Download => SyntheticalTrips

5.2 *Installation of SyntheticalTrips*

- Unzip the `SyntheticalTrips.zip` file into the working directory.

5.3 *Preconditions for SyntheticalTrips*

- Make sure Octave Forge is installed or install it from: https://octave.sourceforge.io/
- Open `SyntheticalTripsGenerator.m` in Octave
- Make sure JSON module of Octave is installed or install it from: https://octave.sourceforge.io/
- Modify `addpath("")` accordingly to installation path of JSON module
- Modify the sample file `distances-route53.json` according to desired input variables: maximum acceleration, maximum speed, total route distance, intersection distances, bus stop distances, bucket width of distance interval, and minimum bus stop distance

5.4 *Processing of Dataproc*

- In Editor Menu press [Run] or [F5] to start processing of data.
- The main program calls the functions `InverseTransformation.m` and `SyntheticalTrip.m` from the working directory.

5.5 *Results of DataProc*

- Obtain the following file from the working directory: `report.csv` and `report.xlsx`
- Display the synthetically generated velocity profile using the following command from the Octave console: `plot(t,v)`
- Review the file `report.csv and report.xlsx` in MS Excel or similar file editor.

5.6 *Further use of DataProc results*

- The result file `report.xlsx` is used in the tool component ECBus+ as input file for the speed profile.
- The file `report.xlsx` can be used for any further calculation, display, and mapping reasons.

5.7 *Caveats/Hints*

- The time step of generated velocity samples of the speed profile is 0.25 seconds. Change this time step to any value in the file `SyntheticalTrip.m` on line 4.

6 BusVehicleSimulation (Jaworzno case)

6.1 *Download of BusVehicleSimulation*

- Download the DataProc tool component here:
  http://platon.publictransport.info/ => Download => BusVehicleSimulation

6.2 *Installation of BusVehicleSimulation*

- Unzip the `BusVehicleSimulation.zip` file into the working directory.

6.3 *Preconditions for BusVehicleSimulation*

- Make sure Octave Forge is installed or install it from:
  https://octave.sourceforge.io/

- Open `BusVehicleSimulation.m` in Octave

- Modify common parameters, road conditions, vehicle parameters, motor parameters, and battery parameter between lines 14 and 70 according to values of the individual use case.

- Modify drive plans for velocity and grade (line 72ff / line 87ff) for the toward trip (vplant) and backward (vplanb) trip. Maximum 2 alternate trips to split terminals are allowed. Use filenames as defined and obtained from DataProc

- In case pull out/in trips are available load/modify the DataProc prepared mat-files accordingly on lines 191f and 105f

- Modify the trip plan (line 138) for the daily trips according to schedule. Use the following valued to describe the trip movements and charging times: 1=towards, -1=backwards, 2=towards alt route. -2 =backwards alt route, 300=charge time in seconds, 99=pull out trip, -99=pull in trip

6.4 *Processing of BusVehicleSimulation*

- In Editor Menu press [Run] or [F5] to start processing of data.

6.5 *Results of BusVehicleSimulation*

- Figure 1 displays the simulated state variables of velocity, motor torque, rotational speed, motor current and state of charge for one select trip. The trip cycle for data collection can be modified in lines 111-123.

- Figure 2 displays the full daily cycle for the state of charge including all return trips and recharge operations according to the trip plan.

- Obtain the following file from the working directory: `SOC.txt` for and display again the SOC profile using the following command from the Octave console: `plot(SOC)`

6.6 *Further use of BusVehicleSimulation results*

- Review and save any state variable of interest for further analysis from the Octave console.

- Use select state variables for analysis of Kinetic intensity as basis for Bus route electrification priority.

6.7 *Caveats/Hints*

- The simulation time step `dt` is 1 second. Change this time step to any value in the file `BusVehicleSimulation.m` on line 20.

7 TCO Module (Sosnowiec case)

7.1 *Download of TCOModel*

- TCOModule is a web-based application and is available at: http://projektplaton.polsl.pl/#/tco

7.2 *Installation of TCOModel*

- There is no need for installing the TCOModel on a local computer. The calculation takes place online.

7.3 *Preconditions for TCOModel*

- TCO calculation includes:

  a) Capital expenditures on the purchase of buses and purchase or construction of the appropriate charging infrastructure,

  b) Different and diversified models of investment funding (electric buses and charging infrastructure) including self-financing, subsidies, different types of bank credit and leasing,

  c) Changes in the values of variables in subsequent years of the analysis period, including buses operating costs, external costs and purchase prices of infrastructure and buses.

- Choose between the static and dynamic calculation of TCO. The main difference between them is that dynamic one is much broader and gives the user opportunity of analysis of purchases spread over time in subsequent batches.

- Fill in the wizard on the website. Some fields are mandatory.
  http://projektplaton.polsl.pl/#/tco/start/static
  http://projektplaton.polsl.pl/#/tco/start/dynamic

- Alternatively, use the *.csv* or *.json* input files:
  http://projektplaton.polsl.pl/#/tco/import

- You may find the template here:
  http://projektplaton.polsl.pl/#/tco/docs

7.4 *Processing of TCOModel*

- After completing the form (wizard), at the bottom of the page, press "submit". The variables entered will then be validated. If the variables are incorrect or incomplete, this will be indicated in the respective message.
- The calculations are carried out in the background online according to the methodology presented in Deliverable 5.4.
- One may also use API to calculate the TCO
  - Allowed HTTPs requests
    - GET – retrieve existing TCO
    - PUT / PATCH – update existing TCO
    - POST – create new TCO calculation
    - DELETE – remove existing TCO
  - HTTP Responses
    - 200 – request was successful
    - 201 - the request was successful and a resource was created.
    - 402 – wrong input format
    - 404 – resource was not found
    - 405 – method is not allowed
  - All of API routes are located in common endpoint : http://projektplaton.polsl.pl/api/
  - TCO:

Method	Route	Description
GET	/tcos	List of all stored TCO calculations
POST	/tcos	Creation of new TCO

Method	Route	Description
GET	/tcos/{tco}	Details of TCO with provided TCO number
PUT/PATCH	/tcos/{tco}	Update of TCO with provided TCO number
DELETE	/tcos/{tco}	Delete of TCO with provided TCO number

- Other:

Method	Route	Description
GET	/tcos/form_structure	JSON template that is used to compose TCO wizard
POST	/tcos/upload	Endpoint to load file (JSON/CSV) that are parsed to TCO
GET	/tcos/{tco}/download	Endpoint for down-loading TCOs in JSON format
GET	/tcos/{tco}/down-load_csv	Endpoint for down-loading TCOs in CSV format
GET	/docs	Endpoint for listing all documents
GET	/docs/{filename}	Endpoint for down-loading document of given {filename}
GET	/clear-cache	Removing server Cache data

7.5 *Results of TCOModel*

- The results of TCOModel are displayed on a separate subpage `Calculation Summary` which contains the results of the calculation of the total cost of ownership (TCO). The latter is divided into the following tabs:

  a) Summary

  b) Electric bus fleet acquisition costs

  c) Electric bus fleet infrastructure costs

  d) Operating costs of electric bus fleet

  e) External Costs

  f) The liquidation value of bus fleet

- Each tab presents the performance of the above-mentioned cost categories during the analysis period. These results are also displayed in the form of graphs

- TCO calculation is returned in the following template

```
{
id: {tco number},
input:
{
       settings: {tco_name: "name of TCO"},
       bus_batches: [array of bus batches details],
       infra_batches: [array of bus batches details],
       spare_batteries: [array of spare batteries],
       discount_rates: [discount rates used in TCO]
}
form_data [array used to generate right-side summary available on
application TCO summary],
output: {
       pvbus: {PVBus calculation details},
       pvinfra: {PVBus calculation details},
       pvocbus: {PVOC Bus calculation details},
              pveexter: {PVE Exter calculation details},
              pvlliq: {PVL Liq calculation details},
              tco: {TCO calculation details},
},
updated_at: "date when TCO was updated",
created_at: "date when TCO was updated",
}
```

- Calculation Summary may be saved and downloaded in .json (PKMSosnowiec.json) and .csv (PKMSosnowiec.csv) formats. Each module of the TCO in JSON and CSV is divided into the following parts:

    - Financing structure – total costs of bank credit, subsidies, self-financing and leasing (for PV Bus and Infrastructure)

    - Yearly summary: total value of costs that are calculated for each year of TCO

    - Summary: Total cost for each TCO part (PVBus, PV Infra, PVE Exter, PVL Liq, PVOC Bus)

7.6 *Caveats/Hints*

- One may use default values for some economic analysis parameters. This can be used both in the static projektplaton.polsl.pl/#/tco/start/static and dynamic projektplaton.polsl.pl/#/tco/start/dynamic calculation. This button is located in the upper right corner of the website

- One can edit the data and recalculate the data by using the 'Edit' function available in `Calculation Summary` or by editing the .csv or .json files

- Each calculation is ale saved on the `projektplaton.polsl.pl/#/tco/list` website. If the user does not wish the file to be saved, this can be permanently deleted in two ways:

    a) By clicking on 'options' in the upper right corner of the `Calculation Summary` website and then 'delete'

    b) By clicking on to the grey arrow to the right of 'Summary' (in every record) and then 'delete'

8 ECBus+ (Minsk case)

8.1 *Download of ECBus+*

- Download the ECBus+ tool component here: http://service.ifak.eu/PLATON-Web/ECBus+.zip

8.2 *Installation of ECBus+*

- Unzip the ECBus+.zip file into the working directory. After unarchiving three folders are created: "`1 ECBus v4`", "`2 EC-Compare`", "`3 ECPro`".

8.3 *Working with ECBus v4.0*

8.3.1 *Preconditions for ECBus v 4.0 (if you want to work with this tool)*

- Open the folder "`1 ECBus v4`"
- Read and understand user's manual
- Prepare the main input file in which the data for the route and the bus are set (many data can be accepted by default). This file is similar to the file `test_program_ECBus_v4.0.xls` (See your working directory "`1 ECBus v4`"). You can modify the file `test_program_ECBus_v4.0.xls`
- Prepare the input file with a speed profile set up similar to `profile_speed.xls` (see your working directory "`1 ECBus v4`")

8.3.2 *Processing of ECBus v4.0*

- Run the `ECBus v 4.0.exe` file. Next, work with the menu
- Click File-> Open, and select a file prepared in advance, similar to the file `test_program_ECBus_v4.0.xls`
- Click File -> Open file containing speed profile prepared in advance, similar to the file `profile_speed.xls`, which contains the speed profile corresponding to the characteristics of the route downloaded earlier.
- Go to the "Speed profile" tab and click the "Calculate" button.

8.3.3 *Results of ECBus v 4.0*

- After calculating and switching to the tab "Calculated energy costs", the main results of calculation are presented. The data for the diesel bus is presented as if it was driving

along the same route and air pollution from this. The following data are displayed: path length, calculated according to the speed profile, energy expended for movement, recuperated energy, total energy consumption for movement, specific consumption, energy consumption for heating / cooling the bus compartment and driver's cabin, energy costs for heating / cooling and movement, the total energy taking into account heating / cooling as well as the specific energy consumption in this case, diesel energy consumption (kWh), fuel consumption (litres per route), fuel consumption (litres per 100 km), pollutant emission (g) for the route: CO, HC, NOx, PM. The results of the calculations of these parameters are presented in Fi. 7.1.

- After switching to the tab "Energy graph", the graphs of changes in the consumed, recovered, total (resulting) energies for electric and diesel energy consumption are displayed (Fig. 7.2)

- To view the graph of change in the traction force, you must go to the tab "Traction Force Graph" (Fig. 7.3)

- A histogram of the speed distribution is displayed after the switching to the tab «Speed range» (Fig. 7.4)

- After switching to the tab "Acceleration range", a histogram of the distribution of accelerations is displayed (Fig. 7.5)

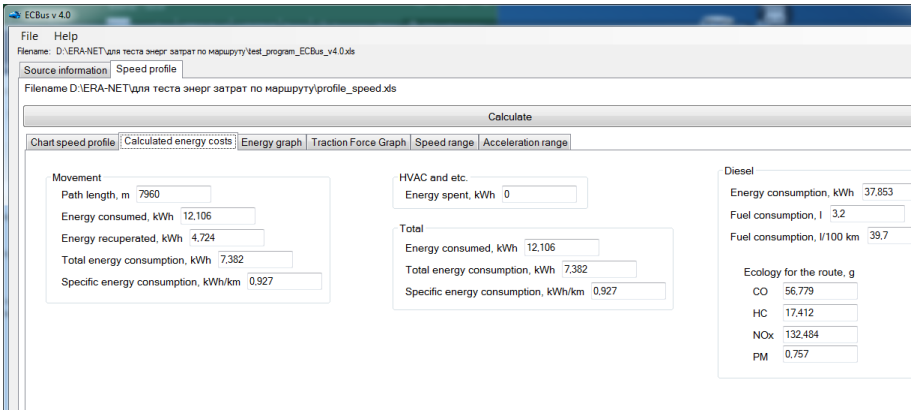


Figure 7.1 Main results of energy and environmental calculations in ECBus v 4.0

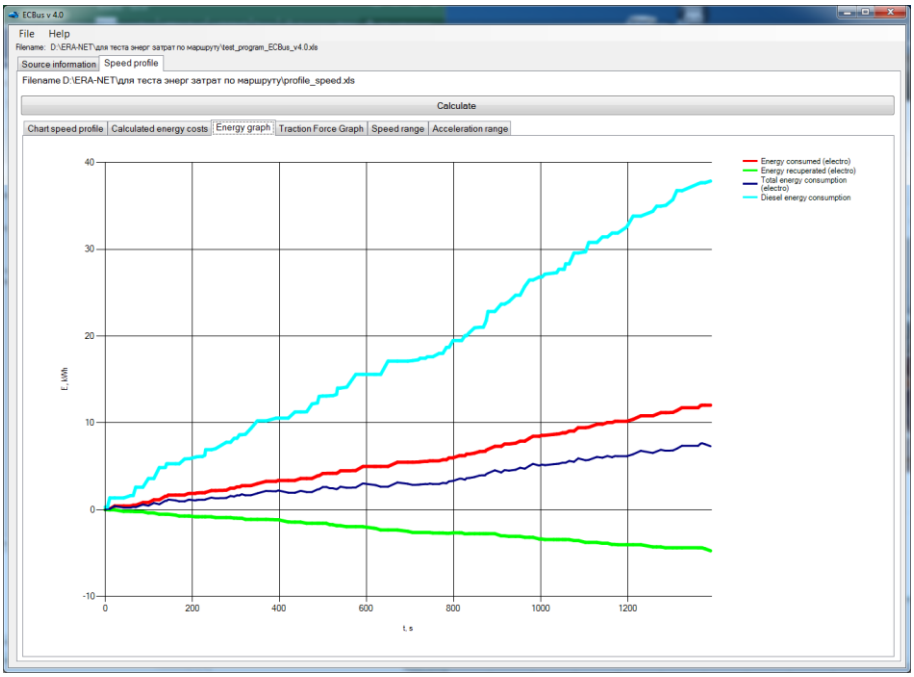


Figure 7.2 Graphs of energy changes

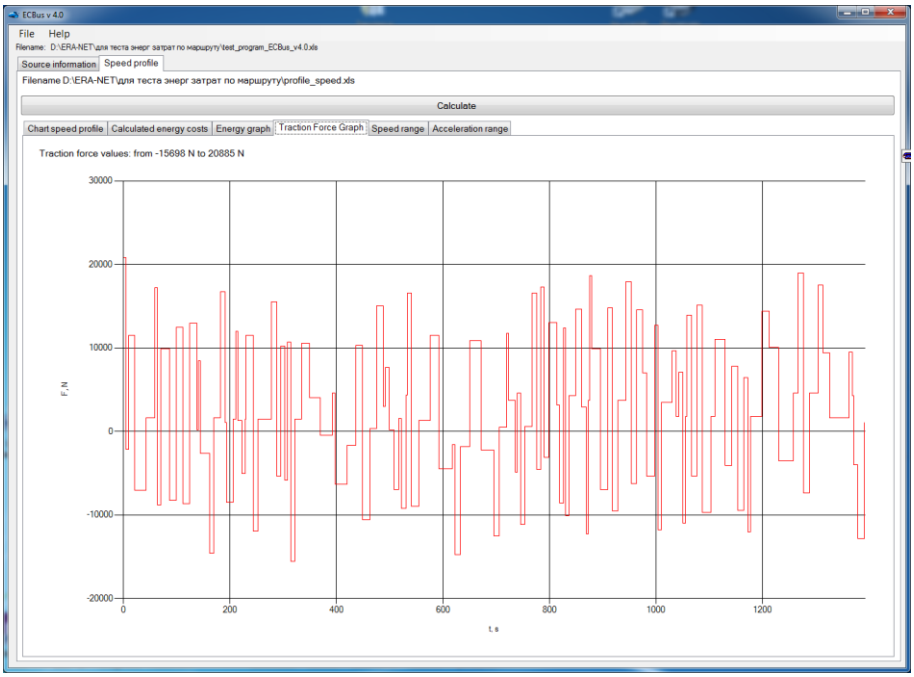


Figure 7.3 Graph of change in traction force

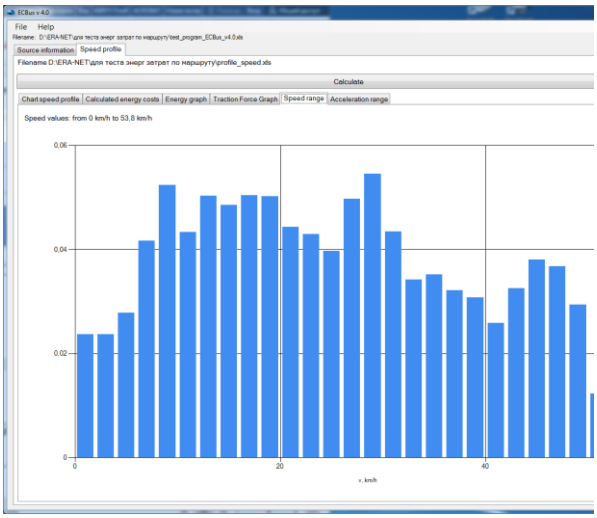


Figure 7.4 Histogram of the speed distribution

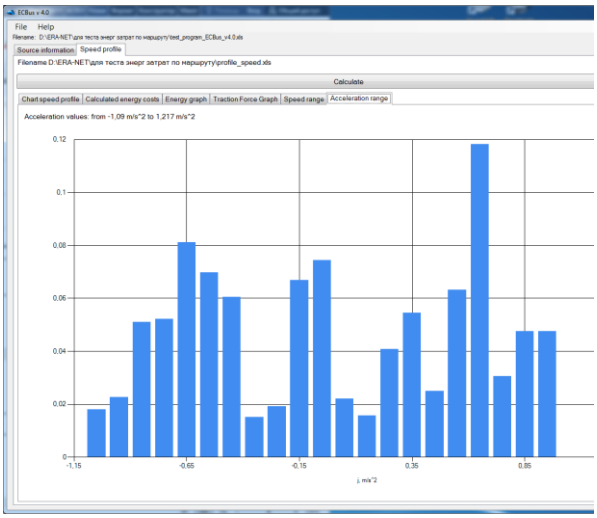


Figure 7.5 Histogram of the accelerations distribution

8.3.4 *Further use of ECBus v 4.0 results*

- The data obtained do not need further processing and are suitable for various analytical tasks using the bus energy consumption

- These data are local (particular) results for the bus and route in question. They can be used as input for a probabilistic approach, which is implemented in the ECPro procedure to obtain the calculated value of the bus energy consumption

8.3.5 *Caveats/Hints ECBus v 4.0*

- The program searches for the distance to speed value equal to 0, and verifies it with the segment length. If the distance falls within the range of ± 10% of the segment length, the program proceeds to search for a new segment. In some cases, as a result of a useless search, part of the speed profile during the calculation may be skipped, and the energy consumption value will not be accurately calculated

- In order to take into account all zero-points of the velocity profile for sure, only one segment can be filled in the source information, the length of which is equal to the length of the route. At the same time, the process of determining energy consumption will not take into account changes in altitudes of the route profile and bus loading by passengers on each segment. The altitudes at the start and end points of the route can be specified. But this description of the input data does not take into account changes in the altitude profile and passenger load on the route.

8.4 *Working with EC-Compare*

8.4.1 *Preconditions for EC-Compare (if you want to work with this tool)*

- Open the folder "`2 EC-Compare`". It contains a file for calculating (`EC-Compare.xlsx`) and a user's manual (EC-Compare_Description and user's manual.docx)
- Read and understand user's manual

8.4.2 *Processing of EC-Compare*

- Open the file for calculating (`EC-Compare.xlsx`). Its worksheet contains the input data set by default, as well as intermediate and final results for this input data (Figures 7.6—7.8). All this data is specified by default!
- Correct the input data field in the worksheet

	A	B	C
1	**EC-Compare**		
2			
3	**Input data**		
4	1) Route data		
5	Route length, m	7960	
6	Total driving time, including stops, s	1390	
7			
8	2) Bus data		
9	(Remark. Diesel and electric buses should be about the same weight!)		
10	2.1 Diesel bus		
11	Effective efficiency of the diesel (default is 0,23)	0.23	
12	Transmission efficiency (default is 0,90)	0.92	
13	Coefficient taking into account the diesel power consumption for equipment drive (by default 1.05)	1.05	
14	Calorific value of diesel fuel (default is 43.12 MJ/l)	43.12	
15	Diesel bus fuel consumption (default is 37.40 l/100 km)	37.40	
16	2.2 Electric bus		
17	Maximum electrical power of auxiliary system or its subsystems with battery energy consumption, kW	6.00	
18	Average efficiency of the invertor (default is 0.98)	0.98	
19	Average efficiency of the motor (default is 0.95)	0.95	
20	Average efficiency of the transmission (default is 0.95)	0.95	
21	The degree of energy recuperation on the route (default is 10%)	0.10	
22			

Figure 7.6 Input data for EC-Compare

22		
23	**Intermediate calculations**	
24	TTW1 (diesel)	0.212
25	The energy expenditure of a diesel bus per km of the route, MJ/km	16.127
26	Energy for movement, MJ/km	3.250
27		
28	TTW2 (electric bus)	0.884
29	Energy consumption of the electric bus for movement	
30	MJ/km	3.307
31	kWh/km	0.919
32	Energy consumption for the entire auxiliary system of the electric bus	
33	kWh/km	0.291
34		

Figure 7.7 Intermediate calculation

34		
35	**Final result**	
36	Total energy consumption of the E-bus (for movement and entire auxiliary system), kWh/km	**1.210**

Figure 7.8 Final result of the EC-Compare

8.4.3 *Results of EC-Compare*

- Final result is total E-bus energy consumption, kWh/km (Fig. 6.8). To get a custom (own) result, the user must correct the input data field in the Excel worksheet

8.4.4 *Further use of EC-Compare results*

- Data on energy consumption of the electric buses are used in wide range of problems. For example: changing diesel buses based on principle “one-to-one”, evaluation of TCO and solving optimization tasks. In these cases, data on energy consumption are used as inputs or limitations

- This procedure can be used in addition to complex software, such as ECBus v 4.0, for a preliminary and simplified assessment of the energy consumption of electric buses on routes. To use EC-Compare, data on the bus speed profile (this is most problem informational component) is not needed

8.4.5 *Caveats/Hints EC-Compare*

- Basic idea is to calculate the energy consumption of an electric bus on a route by means recalculating fuel consumed of diesel bus taking into account the calorific value of diesel fuel to energy of bus movement and then to energy consumption of electric bus of the same weight. The result is energy consumption by the electric bus for the

same conditions and the same full weight of the diesel bus-analog. Therefore, it is important to use data on the compared electric bus and diesel bus of the same weight

- If the user does not know the data on the fuel consumption of a diesel bus, he can use the regulatory data on the energy consumption of different bus models that exist in each country

8.5 *Working with ECPro*

8.5.1 *Preconditions for ECPro*

- Open the folder "`3 ECPro`". The folder contains a file for calculating (`ECPro.xlsx`) and a user's manual (ECPro_Description and user's manual.docx)
- Read and understand user's manual
- Open the file for calculating (`ECPro.xlsx`). Its worksheet contains the input data (Fig. 6.9) set by default, as well as intermediate and final results for this input data. Correct the input data field in the worksheet

8.5.2 *Processing of ECPro*

- In the open Excel sheet, generate Table 3 based on the auxiliary data from Table 1 or 2 (Fig. 6.10)
- As an intermediate result, the calculated value of energy consumption in relative (dimensionless) form is determined (see Fig. 6.11)

8.5.3 *Results of ECPro*

- The results are presented in the final table shown in Figure 6.12. This table contains all the parameters accepted by the user during the calculation and the target value, which is the calculated energy consumption E_C.

8.5.4 *Further use of ECPro results*

- The obtained calculated value of energy consumption of electric bus on the considered route may be used as follows:
    - Selection of bus battery capacity for a specific set of routes
    - Determining the distance that a bus with a known battery capacity can travel along a given route after charging (to plane the location for the next charger)

- Evaluation of TCO and solving optimization tasks. In these cases, data on energy consumption are used as inputs or limitations

8.5.5 *Caveats/Hints ECPro*

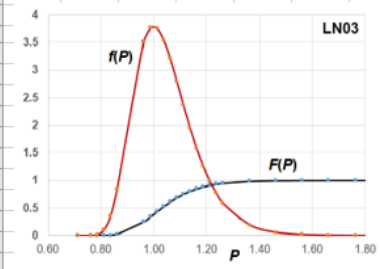
- Cells E35, E36 and E37 must contain one value=1 and two values=0
- The data dimension can be any (it may not be specified at all)

ECPro

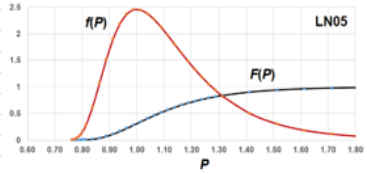
Input data

		Value	Dimension
1) The obtained (accepted) value of the **parameter** for a particular condition	E_x=	1.64	kWh/km
2) Selection of distribution type: case 1 (narrow) LN03 or case 2 (wide) LN05			
2.1) LN03=Yes: I_{LN03}=1 & I_{LN05}=0; 2.2) LN05=Yes: I_{LN03}=0 & I_{LN05}=1)	I_{LN03}=	0	
	I_{LN05}=	1	

Case 1 $F_{LN03}(P)$



Case 2 $F_{LN05}(P)$



Parameters of distributions

Distribution	Modal value P_0	Average P_A	Standard deviation	Variation coefficient	Min/Average
LN03	1.00	1.05	0.12	0.11	0.76
LN05	1.00	1.13	0.22	0.20	0.71

$P=E/E_0$ is relative value, where E_0 is certain base value, for example, modal value = most probable value

3) E_x status in distribution LN03 or LN05 ("1" can only be once):			
E_x is the modal value (Yes: I_{mod}=1, No: I_{mod}=0).	I_{mod}=	0	
E_x is the average value of LN03 (Yes: I_{av1}=1, No: I_{av2} =0).	I_{av1}=	0	
E_x is the average value of LN05 (Yes: I_{av1}=0, No: I_{av2} =1).	I_{av2}=	1	
4) The desired probability associated with the calculated (rated) value of the **parameter** in question			
(Recommended probability is F_C=0.8…0.9)	F_c=	0.9	

Figure 6.9 View of the working window of the ECPro. Field of input data

Auxiliary data: Tables describing distributions

Table 1	Case 1											
$F_{LN03}(P)$	0.021	0.248	0.340	0.434	**0.525**	**0.610**	**0.685**	**0.749**	**0.803**	**0.847**	**0.882**	**0.910**
P	0.86	0.96	0.99	1.01	1.04	1.06	1.09	1.11	1.14	1.16	1.19	1.21
Table 2	Case 2											
$F_{LN05}(P)$	0.280	0.342	0.402	0.460	**0.515**	**0.566**	**0.614**	**0.657**	**0.695**	**0.730**	**0.762**	**0.789**
P	0.99	1.01	1.04	1.06	1.09	1.11	1.14	1.16	1.19	1.21	1.24	1.26

Figure 6.10 Data to describe the distributions

51									
52	**Calculation**								
53									
54	**1) Form Table 3 of values F1(P1) and F2(P2) closest to selected probability for the selected case**								
55	Example:	F_C = 0.8		Case 1		Table 3			
56	F1=	**0.749**	F2=	**0.803**		F1=	**0.836**	F2=	**0.901**
57	P1=	1.11	P2=	1.14		P1=	1.31	P2=	1.41
58									
59	**2) Read the relative calculated value**						P_C=	1.41	
60									

Figure 6.11 Forming Table 3 and determination of relative calculated energy consumption

60							
61	**Results**						
62	I_{LN03}= 0	I_{LN05}= 1	E_x= 1.64	For F_C= 0.9			
63	Parameters	Relative values		Absolute values		Dimension	
64	Modal value	P_0=	1.00	E_0=	1.45	kWh/km	
65	Average value	P_A=	1.13	E_A=	1.64	kWh/km	
66	Accepted (given) value	P_x=	1.13	E_x=	1.64	kWh/km	
67	**Calculated value**	P_C=	**1.41**	E_C=	**2.04**	kWh/km	
68							

Figure 6.12 Final table containing input and main results including the calculated energy consumption E_C

9 OptimSched (Minsk cases)

The OptimSched tool component consists of three sub-components named Opt, OptSched and DepOpt and devoted to solving three different optimization problems with the same names.

9.1 *Download of OptimSched*

- Download the OptimSched tool component here:
  http://service.ifak.eu/PLATON-Web/OptimSched.zip

9.2 *Installation of OptimSched*

- Unzip the OptimSched.zip file into the working directory.

9.3 *Preconditions for OptimSched*

9.3.1 *Preconditions of Opt*

- In file `probl.ini`, edit line 1 with keyword `dir` replacing *`data\Opt\magdeburg`* with `the full name of directory with the input data`.
  Example: dir=d\optimsched\data\opt\Minsk

9.3.2 *Preconditions of OptSched*

- In file `sched.ini`, edit line 2 with keyword `dir` replacing *`data\Sched`* with `the full name of directory with the input data`.
  Example: dir=d\optimsched\data\sched

9.3.3 *Preconditions of DepOpt*

- In file `charge.ini`, edit line 1 with keyword `dir` replacing *`data\DepOpt`* with `the full name of directory with the input data`.
  Example: dir=d\optimsched\data\depopt

9.4 *Processing of OptimSched*

9.4.1 *Processing of Opt*

- Run `moboptv.exe` to start data processing.
- After processing is finished, the output data or an error message is displayed.

9.4.2 *Processing of OptSched*

- Run `schedulev.exe` to start data processing.

- After processing is finished, the output data or an error message is displayed.

9.4.3 *Processing of DepOpt*

- Run `chargev.exe` to start data processing.
- After processing is finished, the output data or an error message is displayed.

9.5 *Results of OptimSched*

9.5.1 *Results of Opt*

- If there are no errors in the input data, then the results are placed into the files `solution.out` and `solution.json` in the directory with the input data. Otherwise, the error details are placed into the file `errors.out` in the directory with the input data.

9.5.2 *Results of OptSched*

- If there are no errors in the input data, then the results are placed into the files `sched.out` and `sched.json` in the directory with the input data. Otherwise, the error details are placed into the file `errors.out` in the directory with the input data.

9.5.3 *Results of DepOpt*

- If there are no errors in the input data, then the results are placed into the files `solution.out` and `solution.json` in the directory with the input data. Otherwise, the error details are placed into the file `errors.out` in the directory with the input data.

9.6 *Further use of OptimSched results*

- The results of Opt, OptSched and DepOpt are final. OptSched is used inside Opt to obtain the balanced schedule for routes.
- The results can be used to support the decisions related to solving the problems Opt, OptSched and DepOpt

9.7 *Caveats/Hints*

- Upper bound on the running time of the software for Opt or DepOpt can be specified by using the keyword `max_time` in the files `probl.ini` and `charge.ini`, respectively. The value should be given in seconds.
  Example: `max_time=600`.

10 VisualGrids (Bus 73 in Magdeburg)

10.1 *Open VisualGrids*

- Open the online VisualGrids tool component with the following link:
  http://service.ifak.eu/PLATON-Tool/

10.2 *Preconditions for VisualGrids*

- Make sure the name of the bus route is known:
  e.g.: 73 (Bus 73 in Magdeburg)

10.3 *Processing of VisualGrids*

10.3.1 *Shape Files*

- Press the "search" button  to input the city name (e.g. Magdeburg), and make sure the location of the bus route is included in the visible area of the map.

- When the bus routes are shown on the map, you can edit the shape of the routes by pressing on the button of "Show editable points"  . Then by means of "add, delete or drag" operations of the red editable points, the routes can be adjusted. After editing, please press the button again to deactivate the editing function.

- Press the "Download shape files" button  to download the coordinates data of the bus routes. If one return trip includes n directions, n shape files can be downloaded as followings:
  `Bus 73_ Olvenstedter Platz =_ Wissenschaftshafen.csv`
  `Bus 73_ Wissenschaftshafen =_ Olvenstedter Platz.csv`

10.3.2 *Measurement Function*

- Click the "Turn on PolylineMeasure" button  to measure the distances for any drawn path.

- After drawing a measurement path, press "ESC-key" to download the distance file, which is named: `pull-out.csv`

10.4 *Results of VisualGrids*

- The following shape and distance files can be obtained from VisualGrids:
  `Bus 73_ Olvenstedter Platz =_ Wissenschaftshafen.csv`
  `Bus 73_ Wissenschaftshafen =_ Olvenstedter Platz.csv`
  `pull-out.csv`

- The name of the shape file indicates the name of bus route and direction between terminals. In the csv file, the data of latitudes, longitudes and stop_ids are listed respectively.

- In the file of `pull-out.csv`, the data of longitudes, latitudes, distances between points and total distance are listed in the columns.

10.5 *Further use of VisualGrids results*

- The result files are used in the tool component DataProc as input files.

- They can be also used for any further calculation, display, and mapping reasons.

10.6 *Caveats/Hints*

- If there some bugs to show the user interface of VisualGrids, which could be resulted by the compatibility issues of web-browsers. The problem can be solved by changing to another web-browser (e.g. Chrome).

11 ReportGenerator (Magdeburg case)

11.1 *Download of ReportGenerator*

- Download the DataProc tool component here: http://platon.publictransport.info/ => Download => ReportGenerator

11.2 *Installation of ReportGenerator*

- Unzip the `ReportGenerator.zip` file into the working directory holding your result files: `veh-ch-inp-data.json, veh-eff.json, energy-cost.json, fleet-data.json` from other toolkit components.

11.3 *Preconditions for ReportGenerator*

- Make sure Octave Forge is installed or install it from: https://octave.sourceforge.io/
- Open `ReportGenerator.m` in *ReportGenerator*
- Make sure mapping module of Octave is installed or install it from: https://octave.sourceforge.io/
- Make sure JSON module of Octave is installed or install it from: https://octave.sourceforge.io/
- Modify `addpath("")` accordingly to installation path of JSON module
- On Line 8, 16, 22, 27 modify the name of prepared `veh-ch-inp-data.json, veh-eff.json, energy-cost.json, fleet-data.json,kinetic-intensity.json` file.

11.4 *Processing of ReportGenerator*

- In Editor Menu press [Run] or [F5] to start processing of data.

11.5 *Results of ReportGenerator*

- Obtain the following files from the working directory:
  `report.txt`
- Review the file `report.txt` containing section wise: input data, bus routes data, results of a simplified approximated TCO estimation.

11.6 *Further use of ReportGenerator results*

- The report file can be used in a concise form of a management board decision support. Detailed analysis instead is available from TCOModel component results.

12 Enhanced NMEA Measurement Based Bus Operation Modelling (Graz case)

12.1 *Download*

- On Line Service at: http://simulation.publictransport.info

12.2 *Installation*

- N/A

12.3 *Preconditions*

- Valid clean NMEA Data set at 1 to 5 Hz

12.4 *Processing*

- In the upper right corner menu click on Tab [NMEA]
- In section “Select another NMEA data file” click [File select] and upload NMEA File
- Enter technical and economic data for vehicle and charging infrastructure
- Modify charging pauses in section “Input data for opportunity charging”
- Input data can be stored and retrieved locally in section “Data Input” with [Store data locally]
- The JSON representation of input data can be used for seamless data exchange
- Press [Calculate]

12.5 *Results*

- Results are presented On-line and can be copied from web browser
- Provide a filename for saving data

12.6 *Further use of NMEA Measurement Based Bus Operation Modelling results*

- On-line simulation

12.7 *Caveats/Hints*

- Altitude measurements are not good enough to be used most of the time