Date	*03.04.2025*	MOTUS SMART ENERGY MANAGEMENT
Prepared by	*Piotr Siemienkiewicz*	
Revision	*1.0*	

Table of contents

1. Abstract. 2
2. Algorithm. 3
   2.1. Overview. 3
   2.2. Description. 3
3. Input window. 5
   3.1. Overview. 5
   3.2. Widgets. 5
   3.3. Inputs description. 5
4. Simulation. 7
   4.1. Console window. 7
   4.2. Result window. 8
   4.3. Widgets. 8
   4.4. Result and graphs. 9

1. Abstract.

The simulation is a comprehensive tool designed to model and analyze the operation of an electric vehicle (EV) charging station. It integrates multiple components, including a grid, battery, electric vehicles (cars and trucks), and charging modules, to simulate real-world scenarios.

Key features include:

- Dynamic Vehicle Management: Simulates the arrival and charging of cars and trucks with varying energy needs and charging durations.
- Energy Resource Allocation: Balances power distribution between the grid, battery, and charging modules to meet vehicle demands efficiently.
- Customizable Parameters: Allows users to configure simulation parameters such as grid power, battery capacity, number of chargers, and vehicle distribution.
- Data Visualization: Provides detailed plots and statistics on energy usage, charging times, and system performance.
- Interactive GUI: A user-friendly interface for setting up simulations and viewing results.

The simulation is built for testing and optimizing EV charging station designs under various conditions.

2. Algorithm.

2.1. Overview.

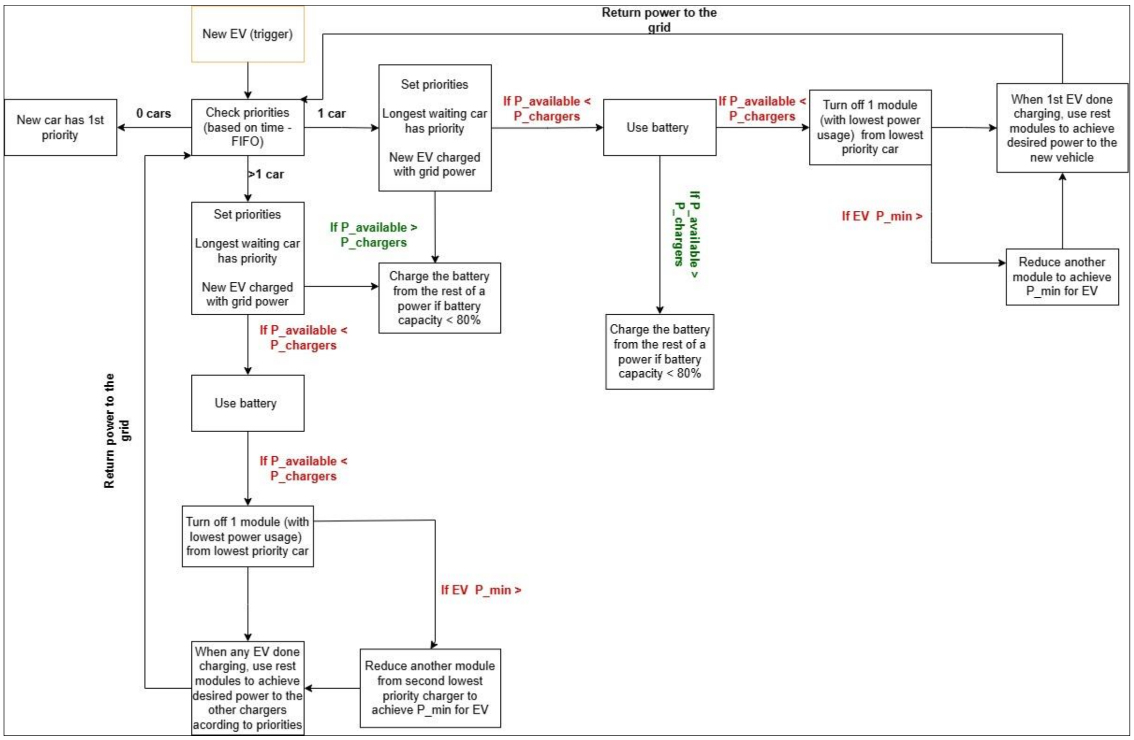

Figure 1: Main algorithm loop

2.2. Description.

General algorithm:

1. New car at the station.

2. Check power:

    2.1. If power from the network is available, charge the vehicle with it.

    2.1.1 If there is excess power and the battery capacity is less than 80%, charge the battery.

    2.2. If power from the network is unavailable - charge from the battery.

    2.2.1. If the battery power is not enough, go to module management.

Module management algorithm:

1. New car at the station.

2. Check priorities (first in first out).

3. Set priorities (new car has the last priority, the longest-staying car has the highest priority).

4. Check power:

    4.1. If power from the network is available, charge the vehicle with it.

    4.1.1 If there is excess power and the battery capacity is less than 80%, charge the battery.

5. If power from the network is not available - charge from the battery.

5.1.1. If the battery power is not enough, go to module management.

6. If the battery is insufficient, disconnect one least used module from the car with the lowest priority (except for the new car).

7. If one module does not reach the minimum charging power, disconnect the next least used module from the next car.

8. If any car releases the charger, return to step 2.

3. Input window.

3.1. Overview.

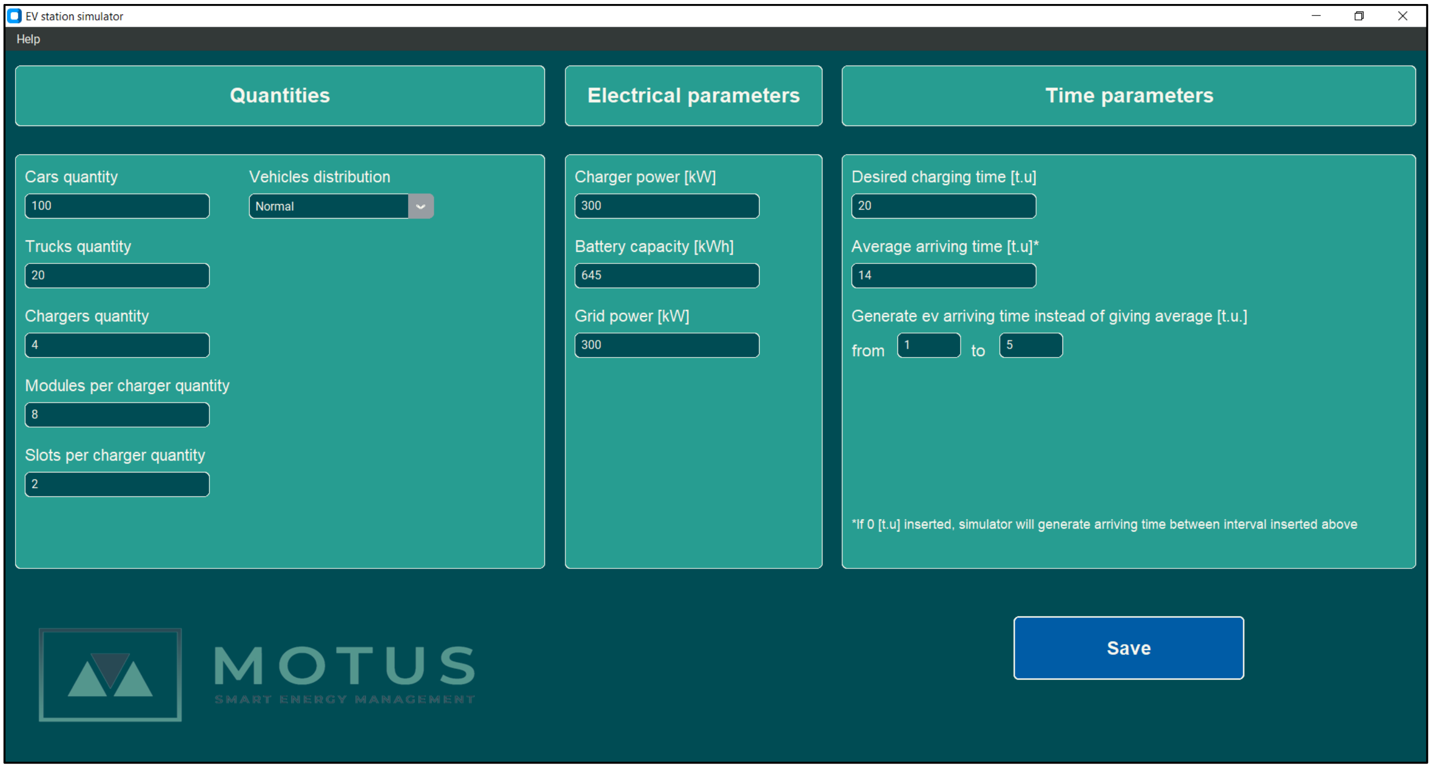

Figure 2: Input window

After starting the application, the first window that appears is a panel for entering simulation parameters. Each window has a default value that can be changed by the user. The window is divided into 3 sections and a menu bar.

3.2. Widgets.

Menu bar:

- *Help*
  - *Documentation* - contains a hyperlink to the simulator documentation.

3.3. Inputs description.

Section 1: Quantities

- *Electric cars quantity* - the user enters the number of cars arriving at the station. Energy needs are generated randomly between 20 and 70 kWh.

- *Electric trucks quantity* - the user enters the number of trucks arriving at the station. Energy needs are generated randomly between 50 and 500 kWh.

- *Distribute vehicles normal/random*- option to choose how vehicles are generated:
    - Normal: Vehicles are generated evenly (e.g. alternating cars and trucks).
    - Randoml: Vehicles are generated in a random order.

- *Chargers' quantity* - number of chargers in the station.

- *Modules per charger* - number of modules assigned to each charger.

- *Slots per charger* -number of slots (spaces) on each charger.

Section 2: Electrical Parameters

- *Single charger power [kW]* - power of a single DC charger in kilowatts.

- *Battery capacity [kWh]* - capacity of the charging station's battery in kilowatt-hours.

- *Grid power [kW]* - power available from the grid in kilowatts.

Section 3: Time Parameters

- *Desired charging time [t.u]* - the user enters the time in which the vehicles want to be charged in a time unit [t.u.] corresponding to a minute of real time

- *Give average charging time [t.u]* - the user indicate the average arrival time - a constant value.

- *Generate EV arriving time* - the user can alternatively enter the time interval in which subsequent vehicles will arrive at the station in a time unit [t.u.] corresponding to a minute of real time.

4. Simulation.

4.1. Console window.

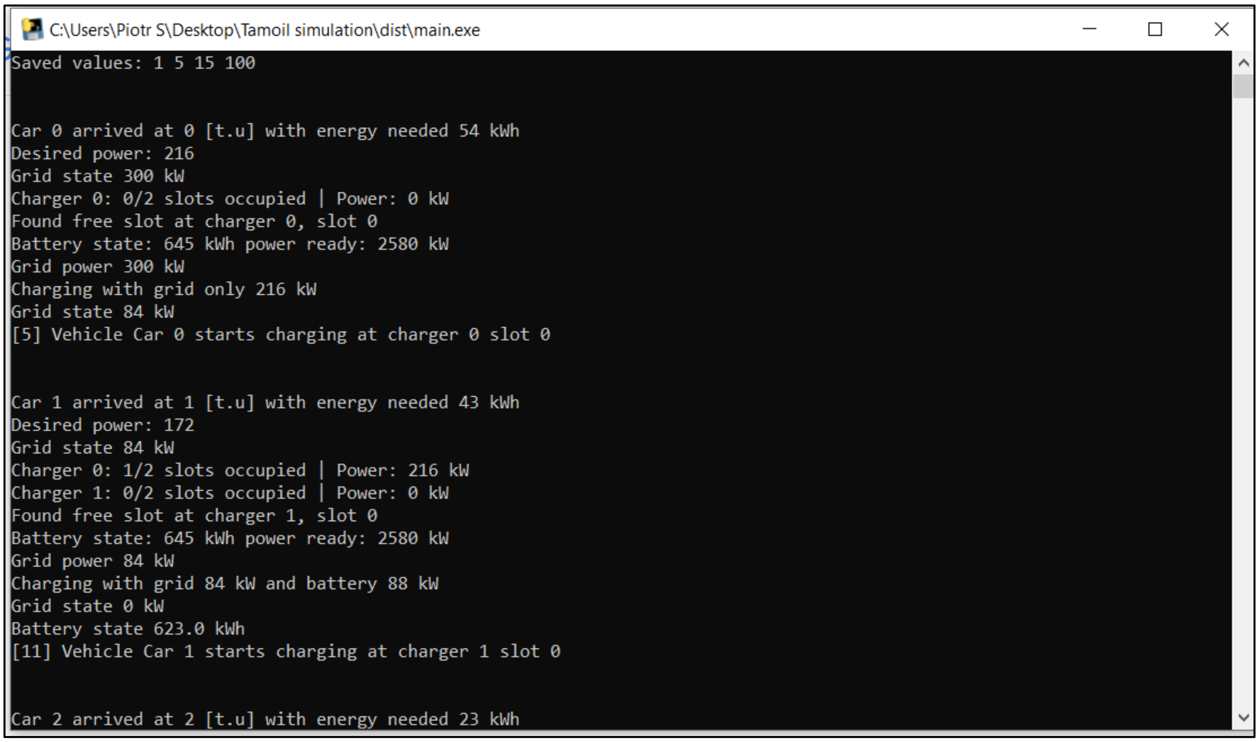

Figure 3: Helper terminal window with sample simulation

After saving the values with the save button, the simulation starts for the given values. In the auxiliary console window, the user can view the simulation log. The console window should not be closed. Results in console are not presented for interpretation purposes.

After the simulation is completed, the result window will appear.

4.2. Result window.

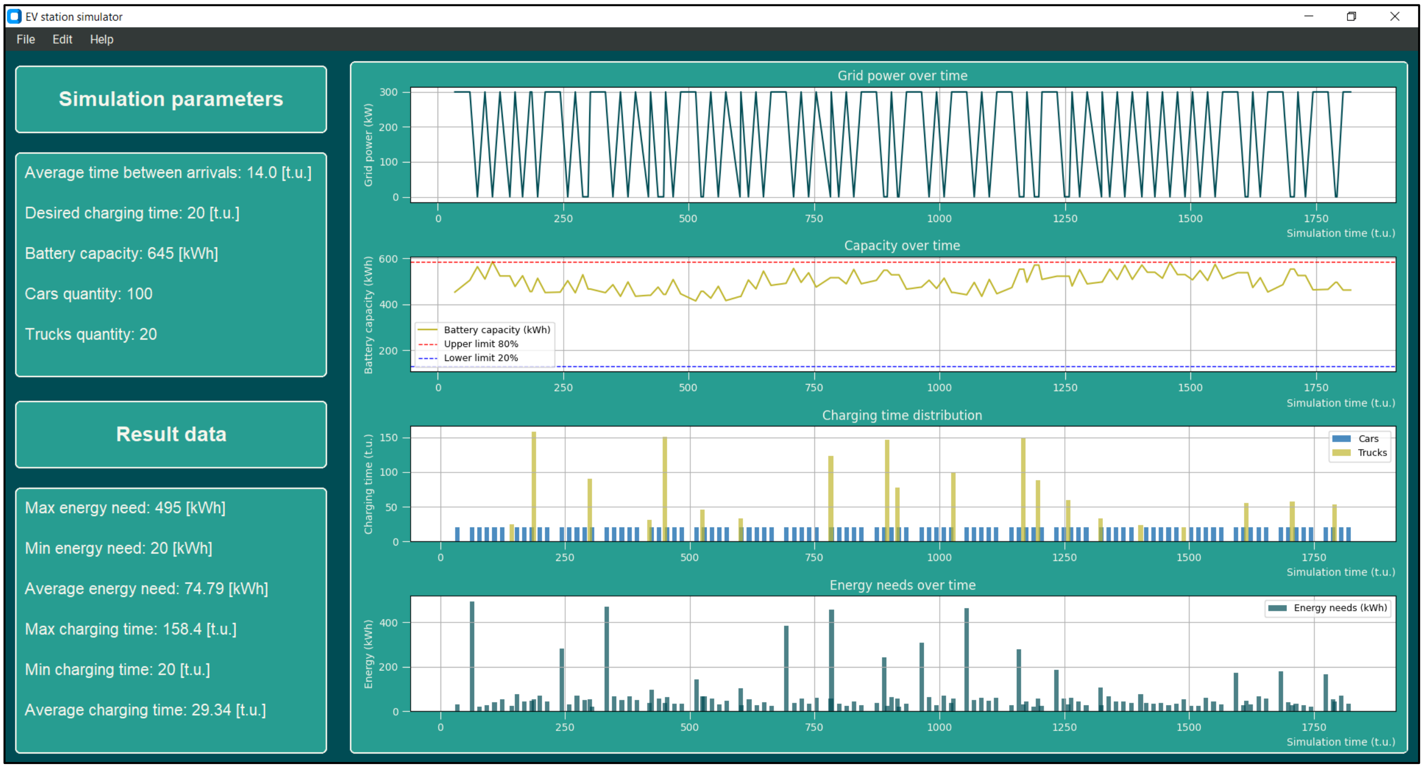

Figure 4: An example of result window

After the simulation is complete, a window with simulation results appears.

4.3. Widgets.

Menu bar:

- *File*
    - *Save* - opens a file save window. The user can export the simulation result in two files in the following formats:

      t{trucks_quantity}c{cars_quantity}{YYYY-MM-DD}.json - a file with data from the output window in JSON format.

      t{trucks_quantity}c{cars_quantity}{YYYY-MM-DD}.png - a file with graphs of the output window in PNG format.

- *Edit*
    - *Restart simulation* – the user can restart simulation with same or different parameters inserted.
    - *Close* – closes the application without saving the results.

- *Help*
    - *Documentation* - contains a hyperlink to the simulator documentation.

4.4. Result and graphs.

Result:

- Max energy need -maximum energy demand of the vehicle in a given simulation .
- Min energy need - minimum energy demand of the vehicle in a given simulation.
- Average energy need - average energy demand in a given simulation.
- Max charging time - maximum charging time of the vehicle in a given simulation.
- Min charging time - minimum charging time of the vehicle in a given simulation.
- Average charging time – average charging time in a given simulation.

Graphs:

- Grid power over time - shows the distribution of power from the grid in a time unit.
- Capacity over time - shows changes in battery capacity related to battery charging and discharging in a time unit.
- Charging time distribution - shows vehicle charging times during the simulation.

- Energy needs over time – shows the energy need of a vehicle which approached station on specific time.