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UNIVERSITATEA TEHNICĂ A MOLDOVEI

Project EMS-ENI, code 2SOFT/3.1/54

”Improving the cross-border public transportation using electric buses supplied with renewable energy (ELBUS)”

Work visit at „Gheorghe Asachi” Technical University of Iasi, Romania

Implimentation of scientific and research activities from UTM

UTM project manager,
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UTM research experts,
Dr.ing. Cazac Vadim
Drd. Ing.Burduniuc Marcel

Iasi, 01.10.2021

Activities planned for implementation of scientific and research activities

GA3. Analysis of the electric bus optimal functionality

Activity 3.1. *Analysis of the electric buses*

D3.1.1 Technical report related to the using of the electric buses

Activity 3.2. *Analysis of the auxiliary loads*

D3.2.1 Automation system for auxiliary loads

Activity 3.3. *Thermal model of the indoor climatic environment*

D3.3.1 Thermal model

D3.3.2 Thermal map for the indoor climatic environment

Activity 3.4. *Renewable energy for the batteries.*

D3.4.1 Technical report related to the recharging of the batteries by renewable energy

Activity 3.1. Analysis of the electric buses

D3.1.1 Technical report related to the using of the electric buses

Different types of electric vehicles (EV's) are put to the market:

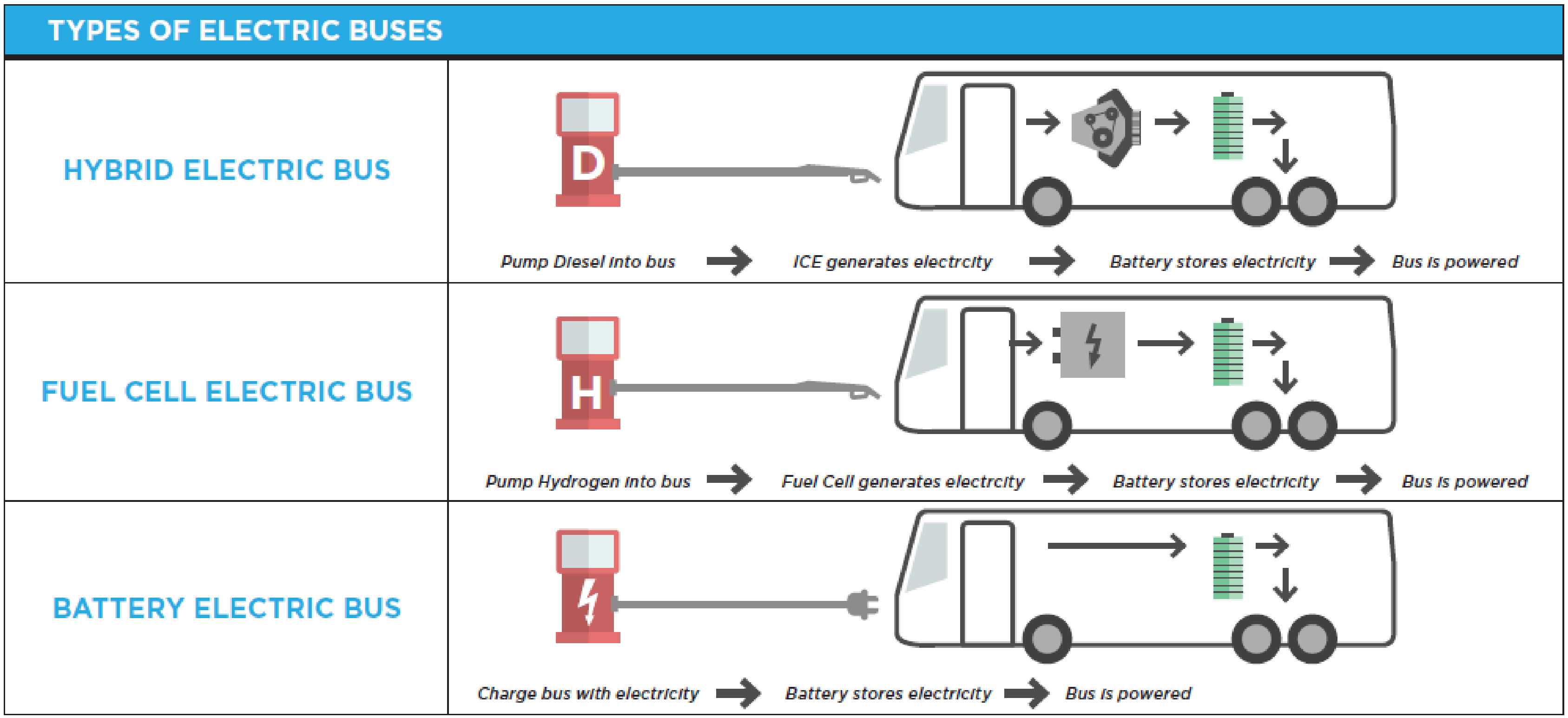
- Fully Electric vehicle (FEV): a vehicle that drives using an electric driven engine.
- Hybrid electric vehicle (HEV): a vehicle that drives partly electric and partly on gas.
- Hydrogen vehicle (HV): a vehicle that drives using a hydrogen driven engine.

The main future trends and tasks are, related to electricity and public transport:

- ✓ Losing dependency on fossil fuels and increasing the amount of energy produced by renewable sources. Smoothing the peaks and valleys of the electricity demand and supply.
- ✓ Creating flexibility at both the demand and supply side of electricity.
- ✓ Increasing the amount of electric transport, and therefore the amount of EB's.
- ✓ Placing and using charging stations in a smart and conscious way, to avoid unnecessary costs.

Activity 3.1. Analysis of the electric buses

D3.1.1 Technical report related to the using of the electric buses



Activity 3.1. Analysis of the electric buses

D3.1.1 Technical report related to the using of the electric buses

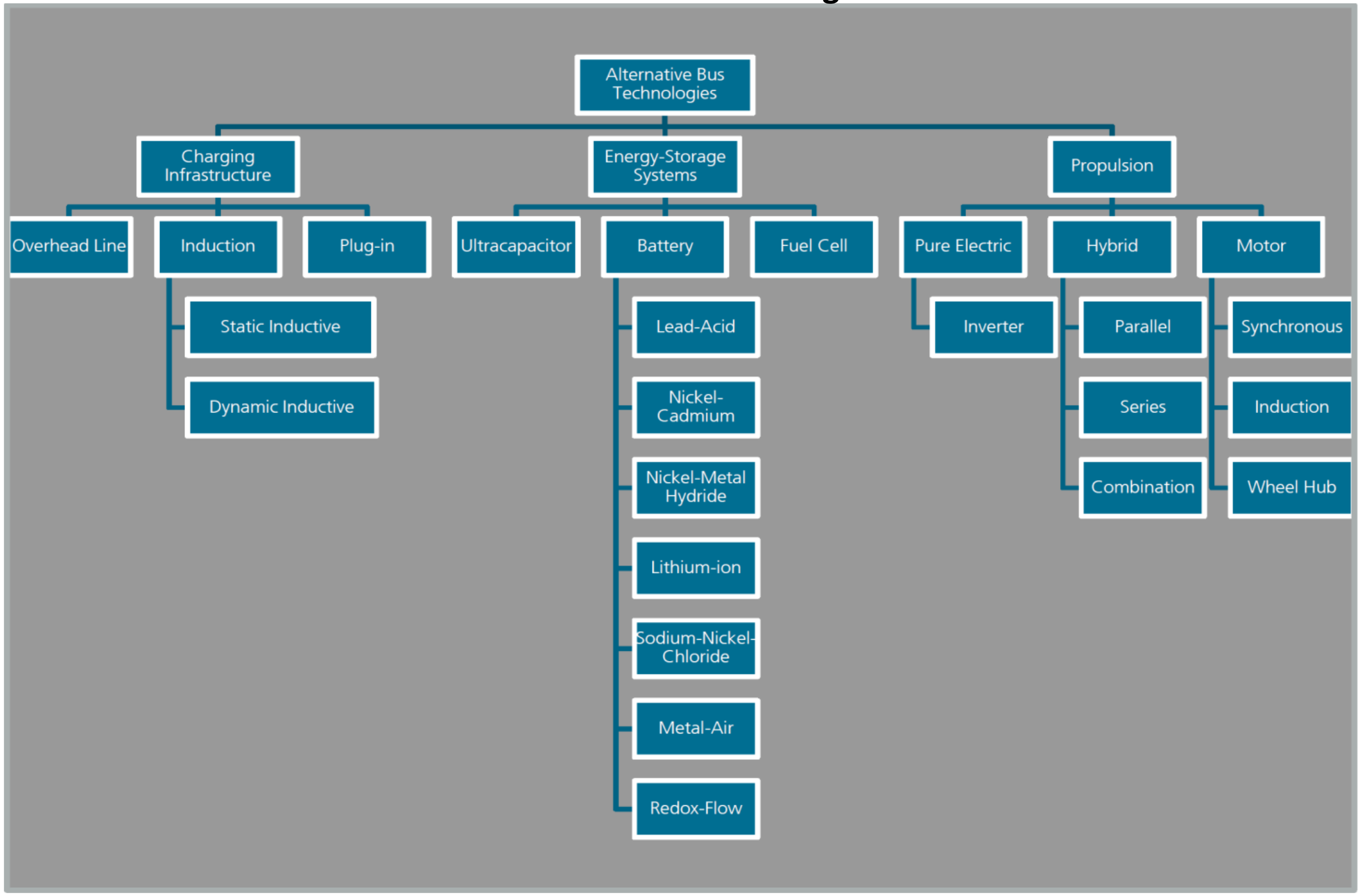
Environmental Impact from Operation of Electric Buses

	WELL-TO-TANK				TANK TO WHEEL	WELL-TO-WHEEL ($g\ CO_2 eq$)
	EXTRACTION		TRANSPORTATION	DISTRIBUTION		
DIESEL	Extract	Refine	Drive	Pump	Engine	1222
HYDROGEN	Electrolysis (H_2O → H_2, O_2)		Drive	Pump	Reverse Electrolysis	320
ELECTRICITY	Hydro Power	Wind Power	Power Grid	Charge	Battery	173

Activity 3.1. Analysis of the electric buses

D3.1.1 Technical report related to the using of the electric buses

Alternative bus technologies



Activity 3.1. Analysis of the electric buses

D3.1.1 Technical report related to the using of the electric buses

OVERVIEW OF CURRENT CHARGING STRATEGIES AND TECHNOLOGIES

- Low power charging through cable and plugin (overnight)
- High power charging through conductive charging with physical connections
- Fast charging through inductive charging with a transfer of energy through a magnetic field for fast charging

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Activity 3.2. Analysis of the auxiliary loads.

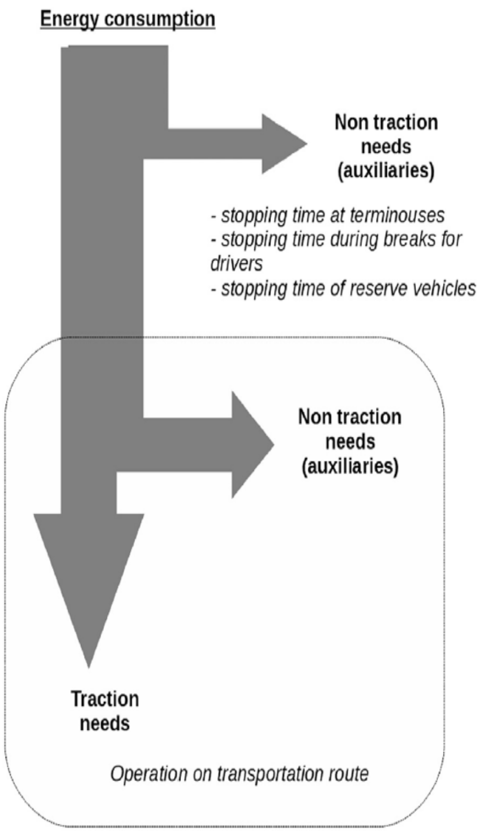
D3.2.1 Automation system for auxiliary loads

The following elements can be included in auxiliary systems:

- *compressor and hydraulic pump motors*
- *supply of low voltage equipment*
- *air conditioning*
- *heating*

System	Nominal power
Lightning	1-2 kW
Passenger information systems, ticket vending machine	1-3 kW
Charging of 24 V board batteries	0,5 - 2 kW
Air compressor	3-6 kW
Hydraulic pump	2-4 kW
Air condition	10-16 kW
Heating	5-25 kW

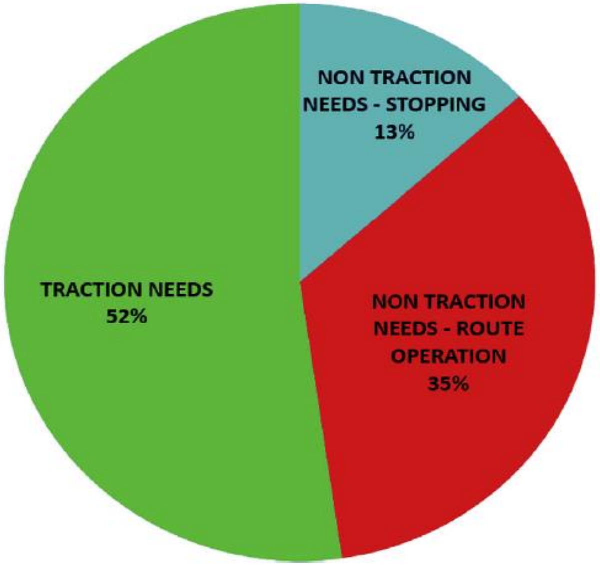
The distribution of electric energy consumed by vehicles



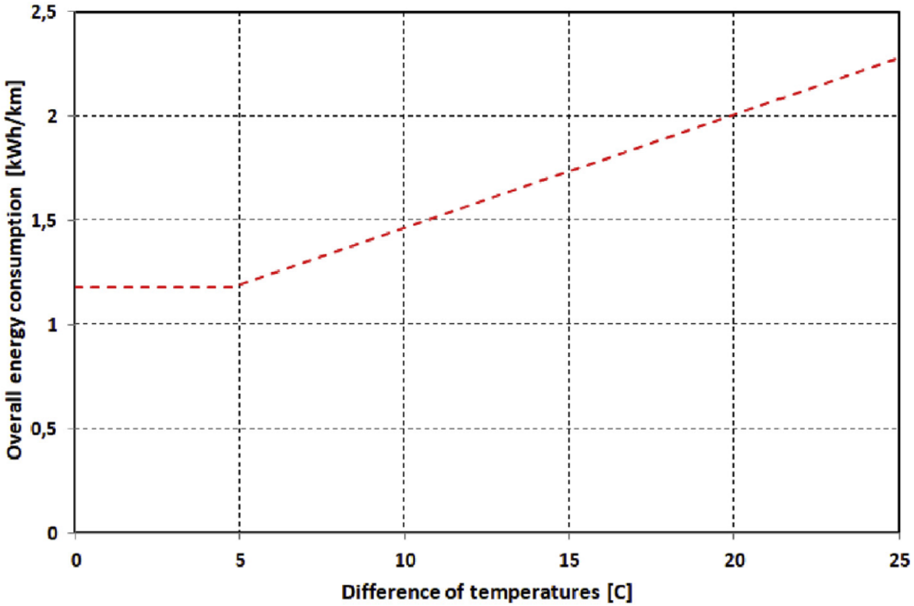
Activity 3.2. Analysis of the auxiliary loads.

D3.2.1 Automation system for auxiliary loads

The overall annual structure of energy consumption.



Overall vehicle power consumption in function of difference between ambient and internal temperature



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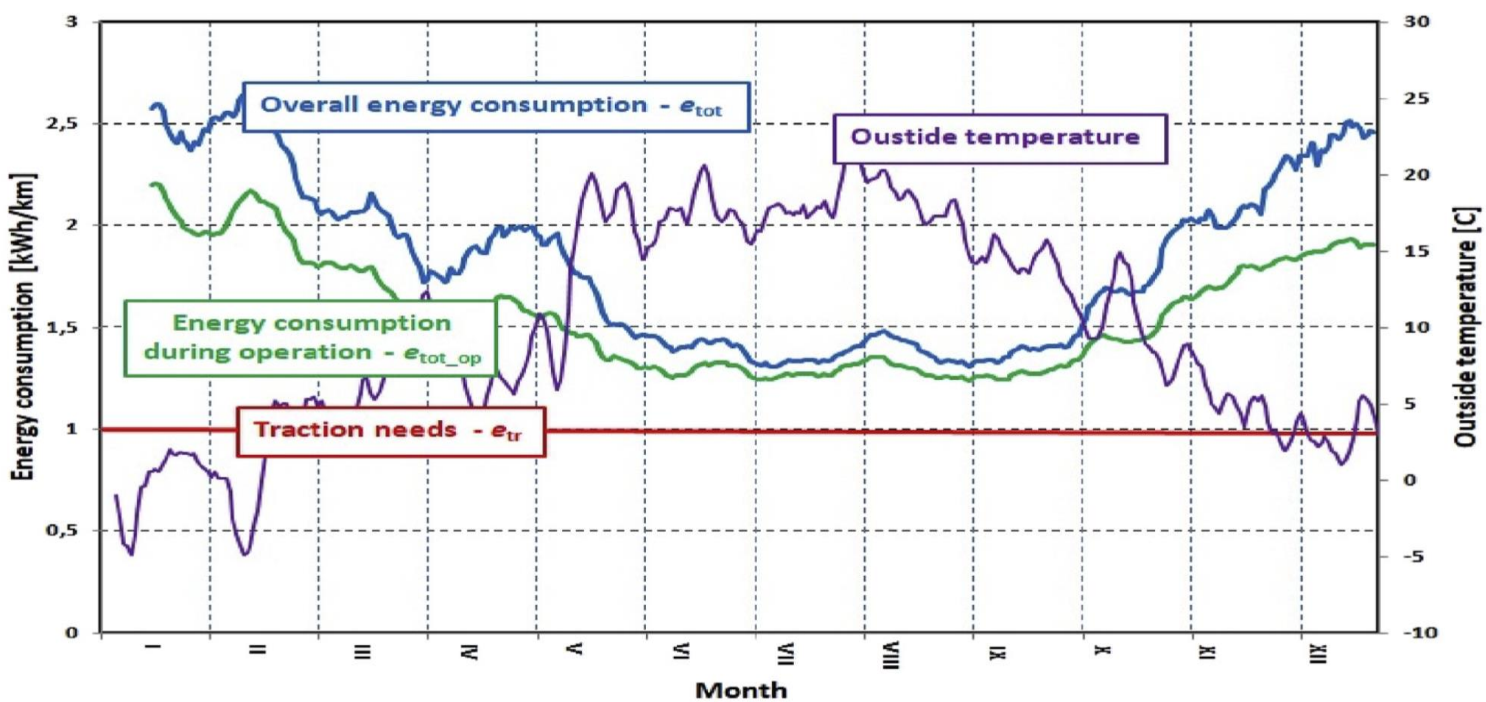
Activity 3.2. Analysis of the auxiliary loads.

D3.2.1 Automation system for auxiliary loads

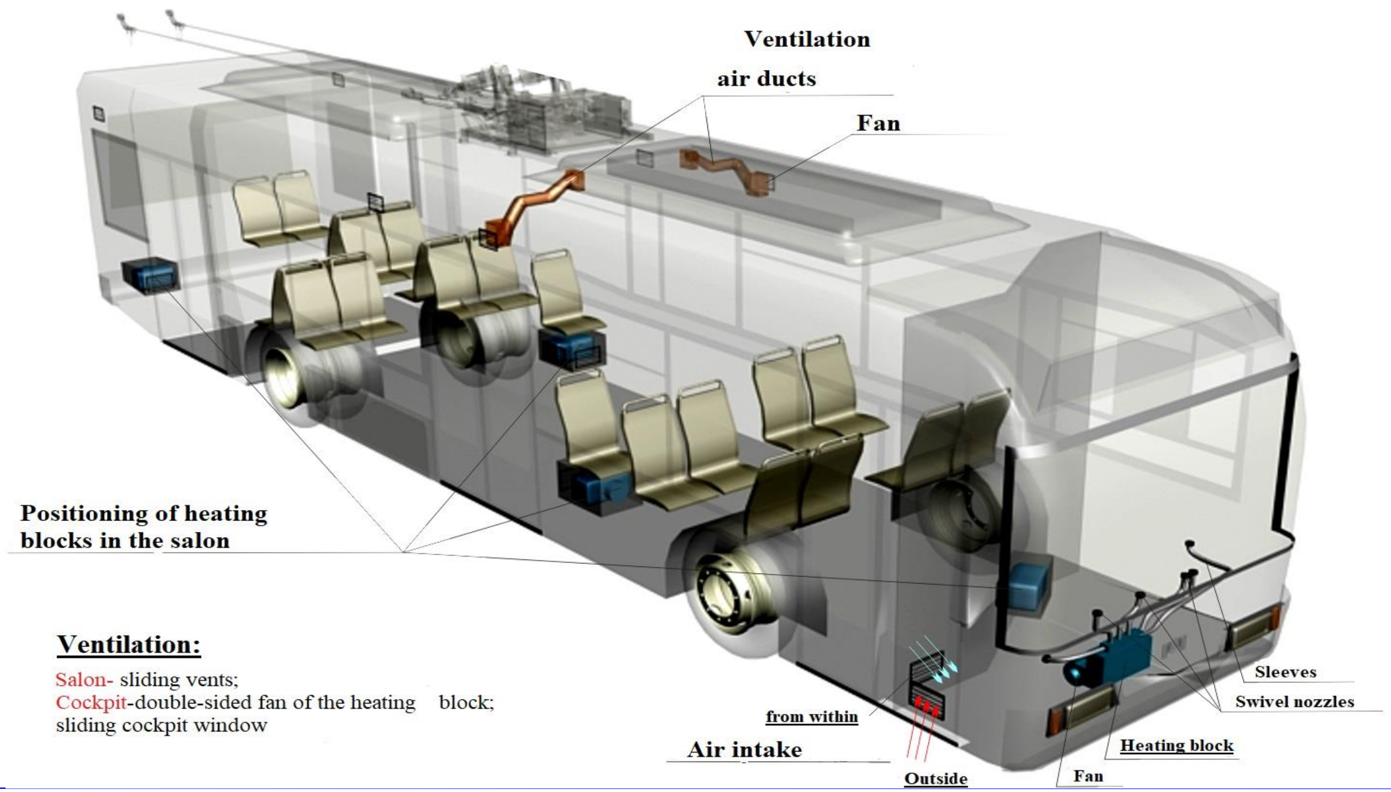
The values of average energy consumption and daily average outside temperature in annual scale



Activity 3.2. Analysis of the auxiliary loads.

D3.2.1 Automation system for auxiliary loads

The E321 BUS heating and ventilation system



Ventilation:

Salon- sliding vents;
Cockpit-double-sided fan of the heating block;
sliding cockpit window

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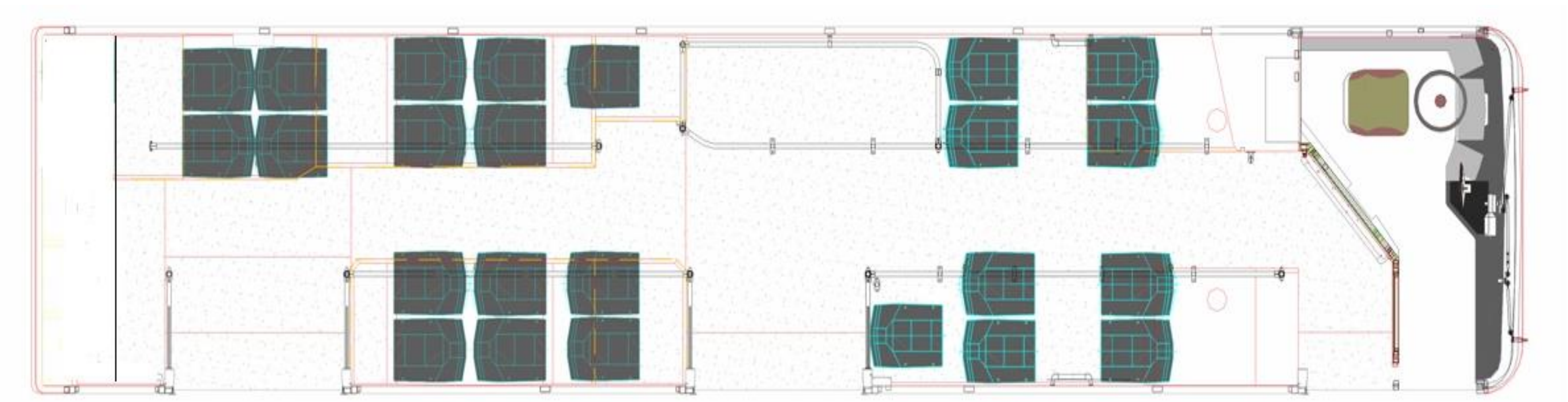
Activity 3.2. Analysis of the auxiliary loads.

D3.2.1 Automation system for auxiliary loads

Location of the seats



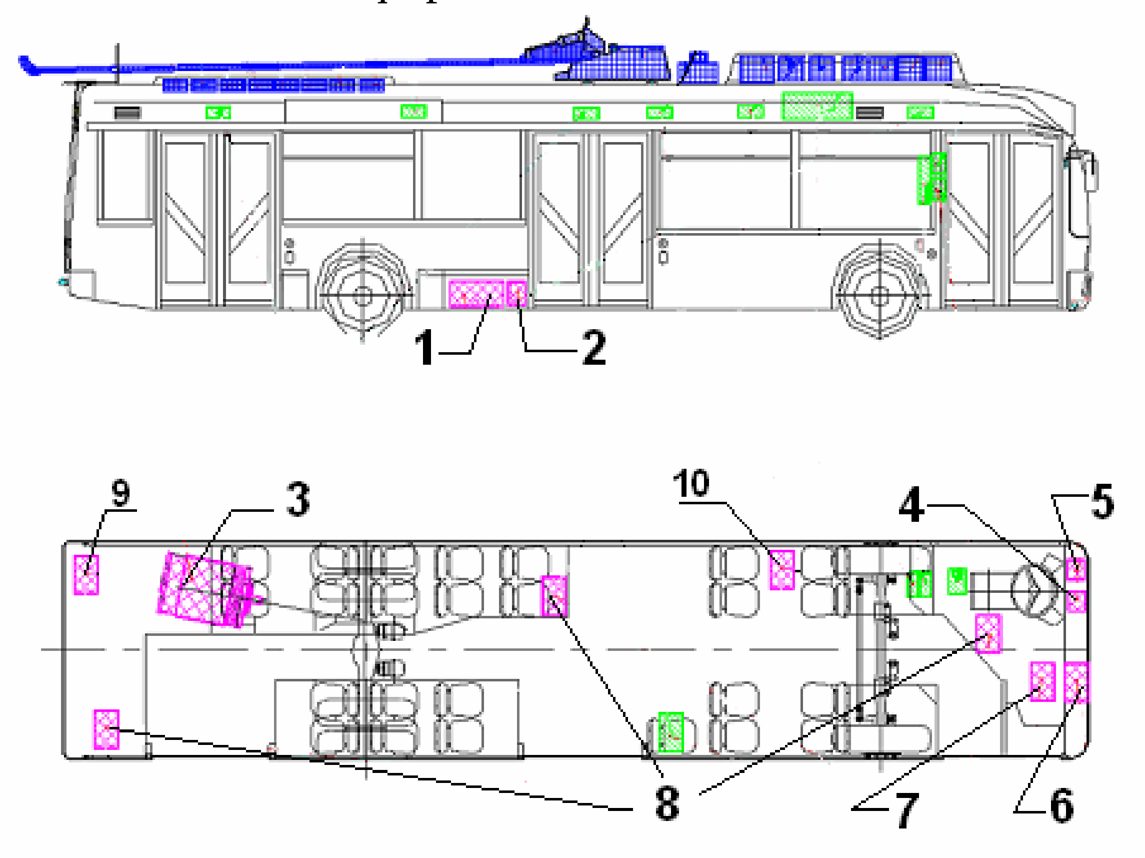
Power of heating system

Nr .	Equipment destination	Rated power, kW	Nr. unit	Total power, kW
1	Cabin heating	9	1	9
2	Saloon heating	6	4	24

Activity 3.2. Analysis of the auxiliary loads.

D3.2.1 Automation system for auxiliary loads

Electrical equipment under the ebus floor



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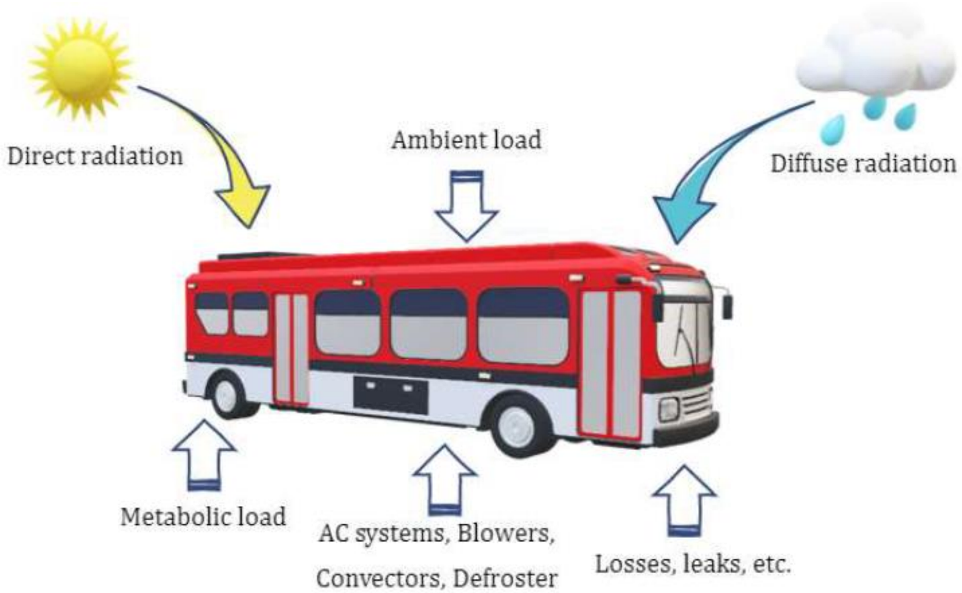
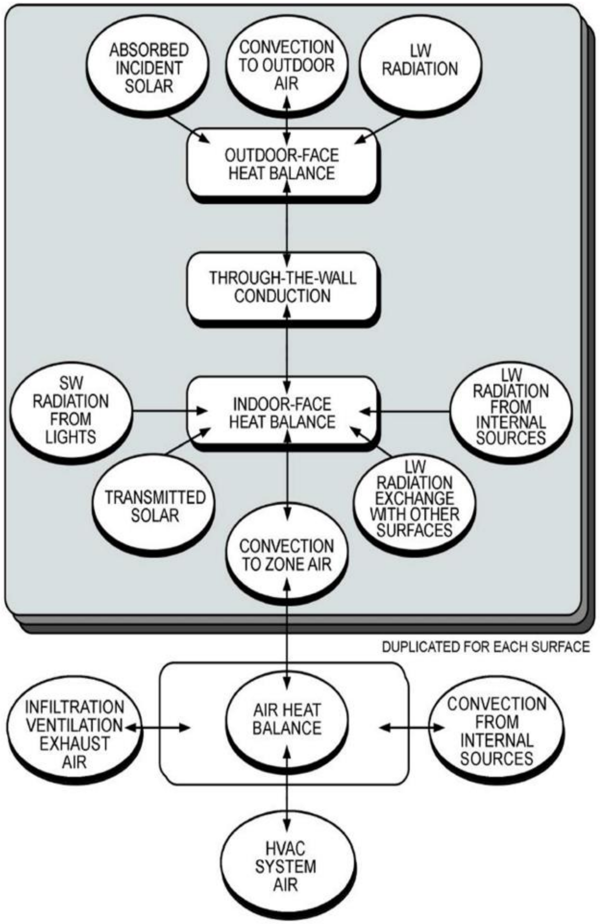
Activity 3.3. Thermal model of the indoor climatic environment

D3.3.1 Thermal model

Heat balance method for an electric bus





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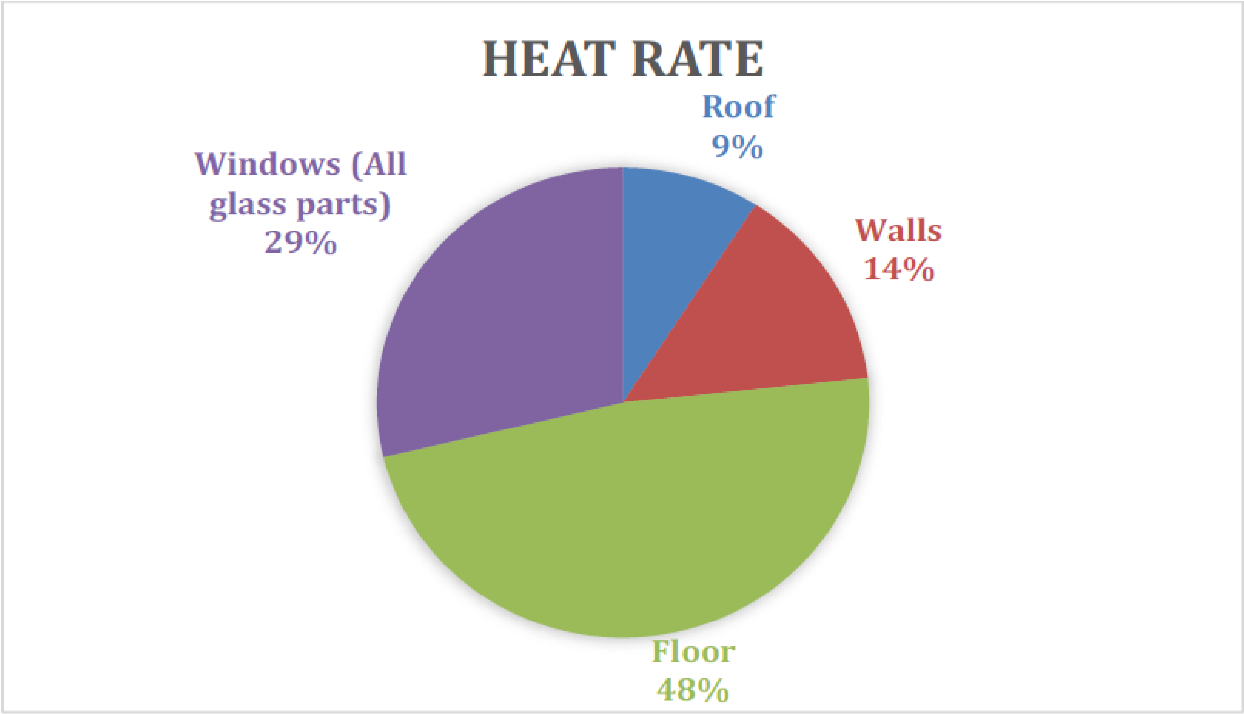
Activity 3.3. Thermal model of the indoor climatic environment

D3.3.1 Thermal model

Calculation of U-Value for bus's part based on the heat rate results



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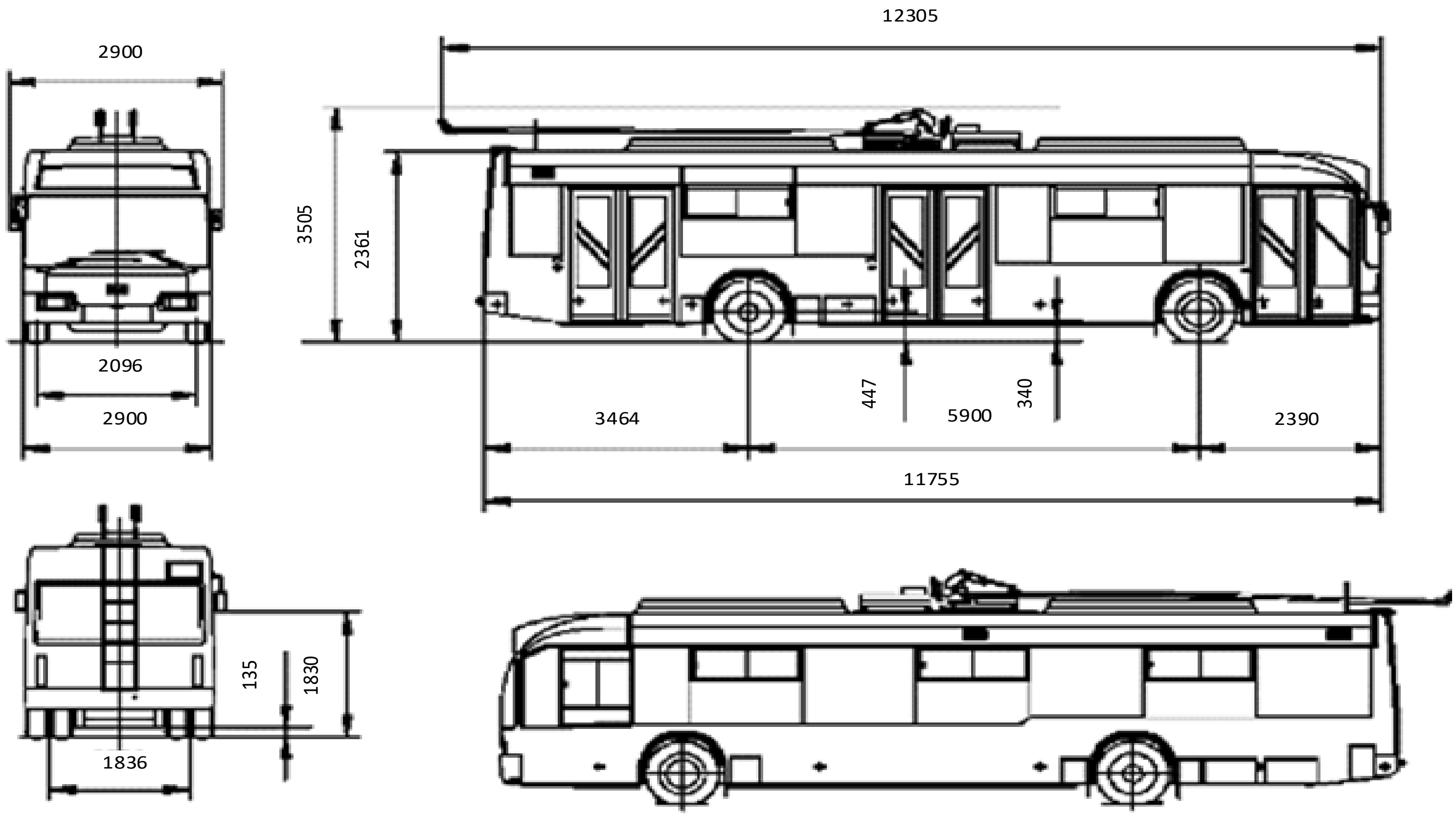
Activity 3.3. Thermal model of the indoor climatic environment

D3.3.1 Thermal model

The main dimensions of the ebus



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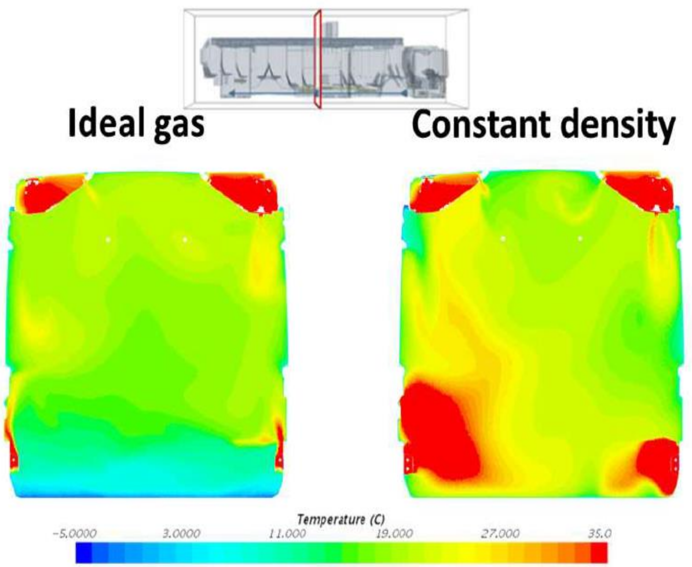
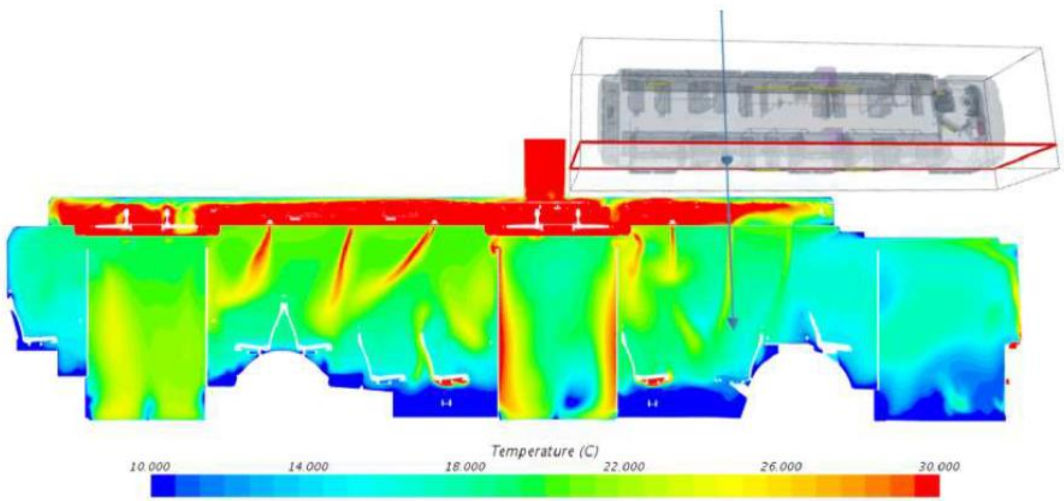
Activity 3.3. Thermal model of the indoor climatic environment

D3.3.1 Thermal model

A CFD results shows temperature distribution for a similar case results from GT-SUITE





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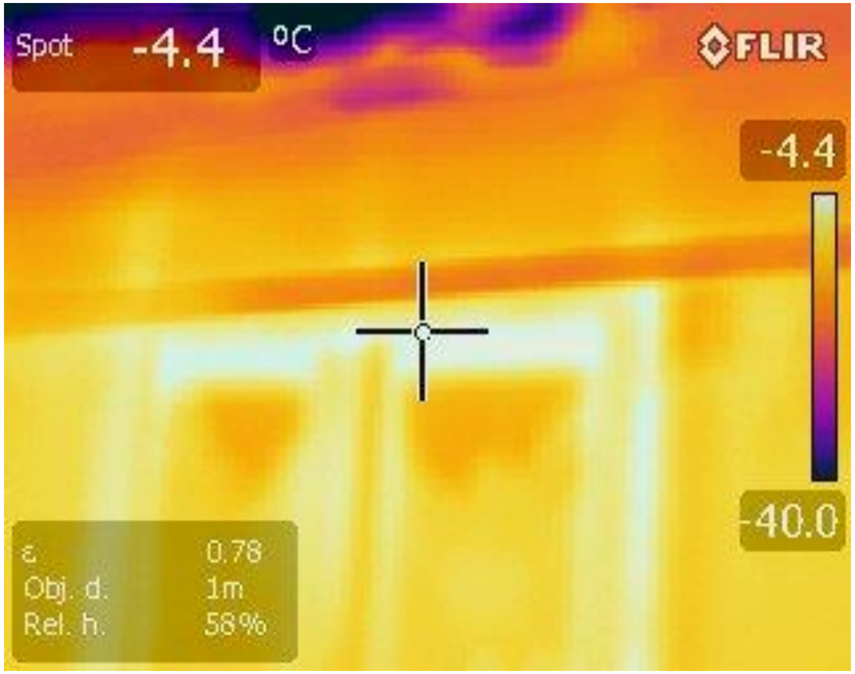
Activity 3.3. Thermal model of the indoor climatic environment

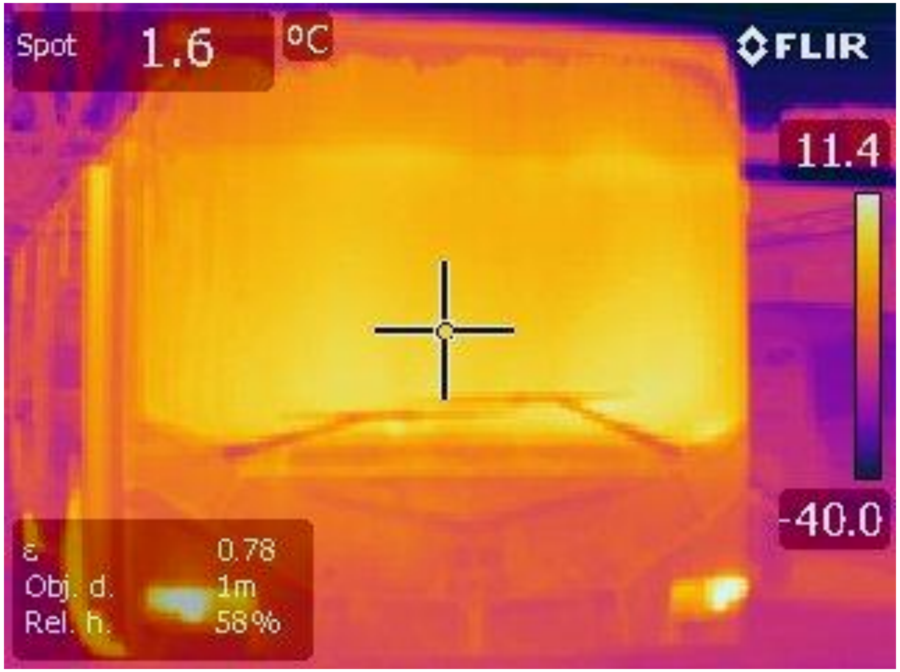
D3.3.2 Thermal map for the indoor climatic environment

Thermal image for detection of high temperature and (potentially) high energy loss areas in an ELECTRIC BUS E321 which is exploited in Chisinau city.

The back door of the bus



Temperature map of the front side of the bus



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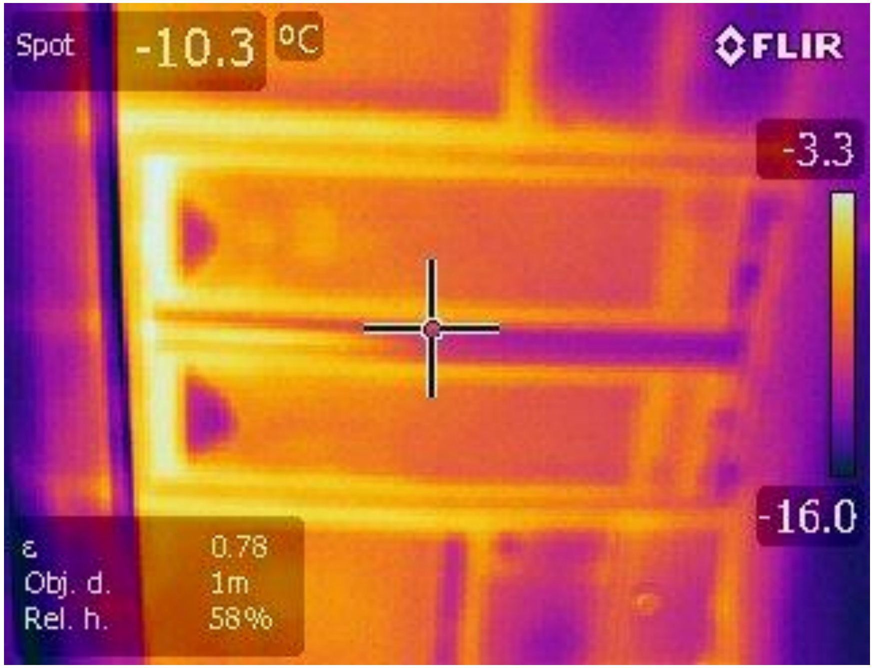
Activity 3.3. Thermal model of the indoor climatic environment

D3.3.2 Thermal map for the indoor climatic environment

Thermal image for detection of high temperature and (potentially) high energy loss areas in an ELECTRIC BUS E321 which is exploited in Chisinau city.

General view from the right side of the bus

Temperature map at the middle door of the bus



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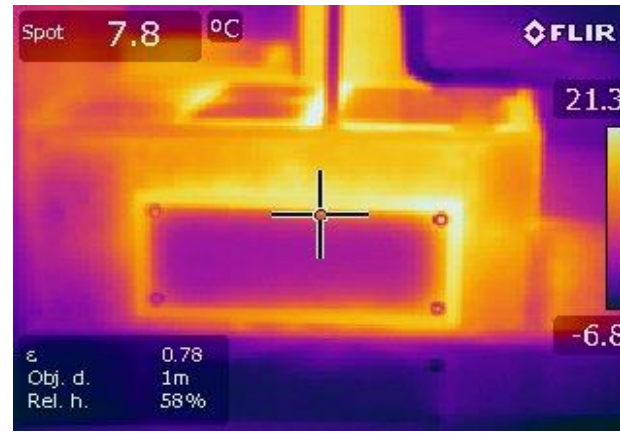
Activity 3.3. Thermal model of the indoor climatic environment

D3.3.2 Thermal map for the indoor climatic environment



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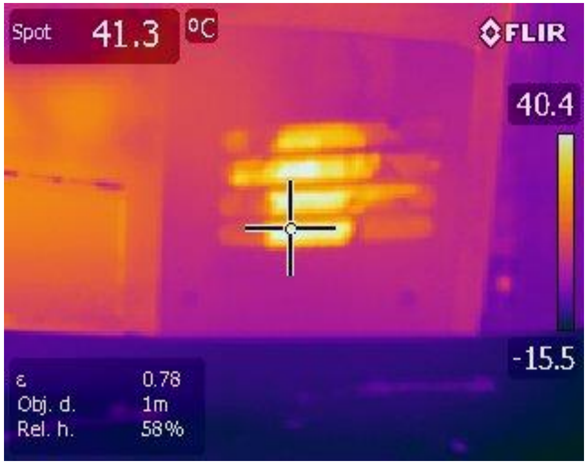

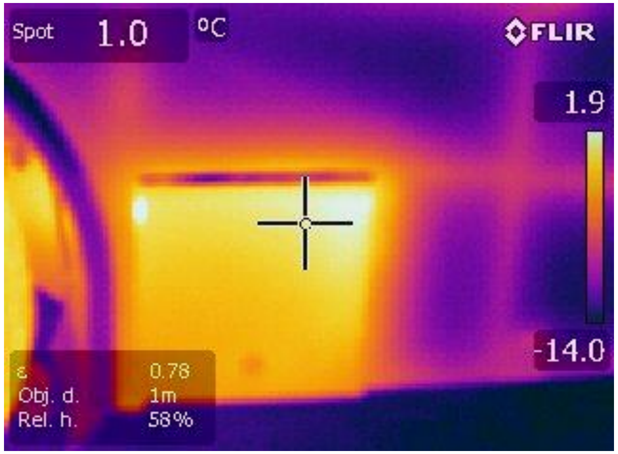

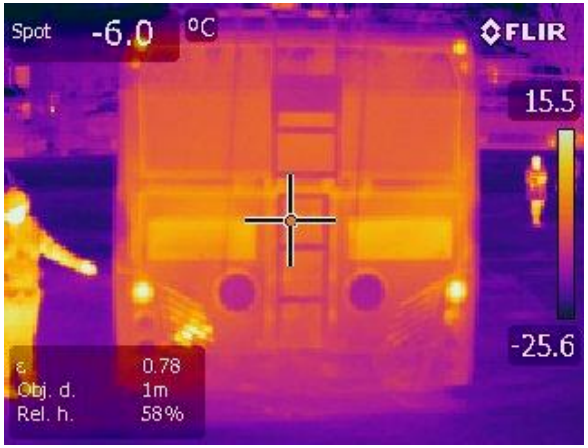

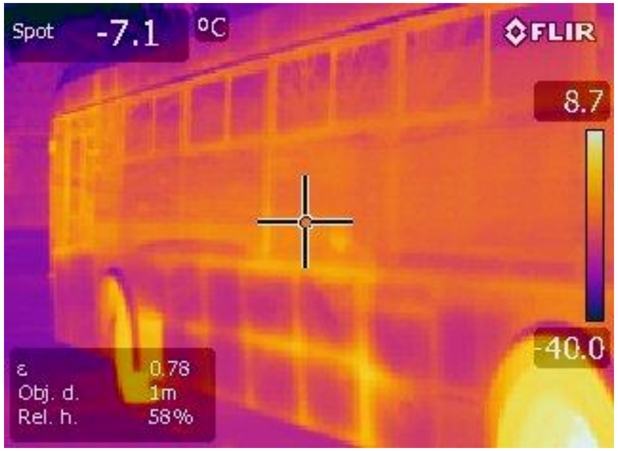

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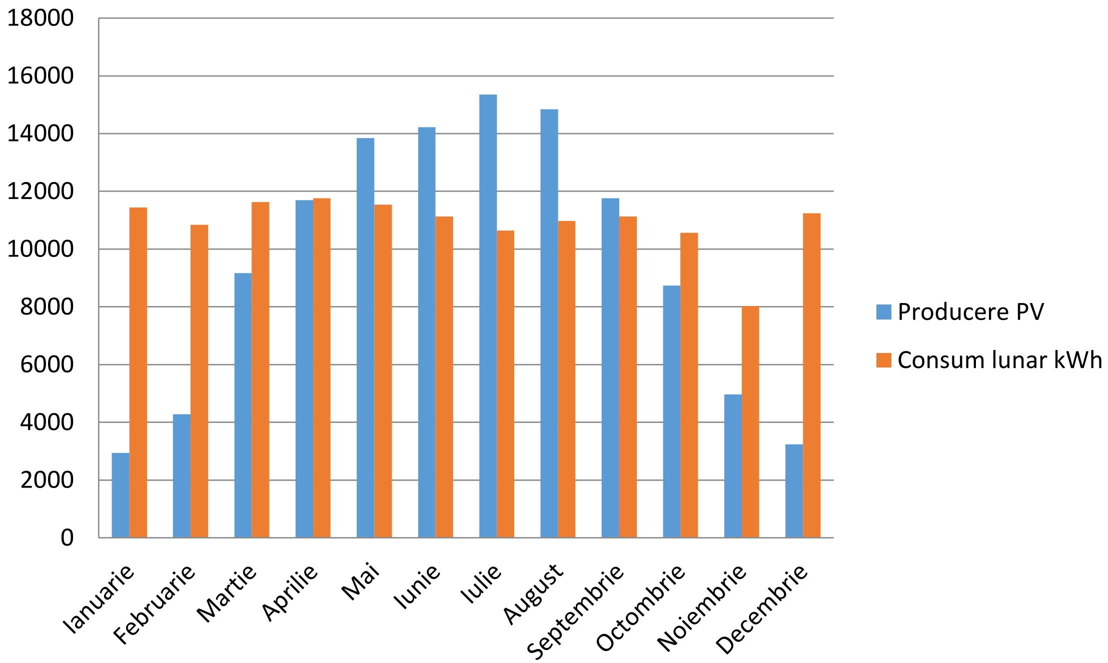
Activity 3.4. Renewable energy for the batteries.



$Q_{tot.\ Consumat}$=130900 kWh/an

$Q_{gen.PV}$=115036 kWh/an

$dQ_{com.PV}$=87,8%

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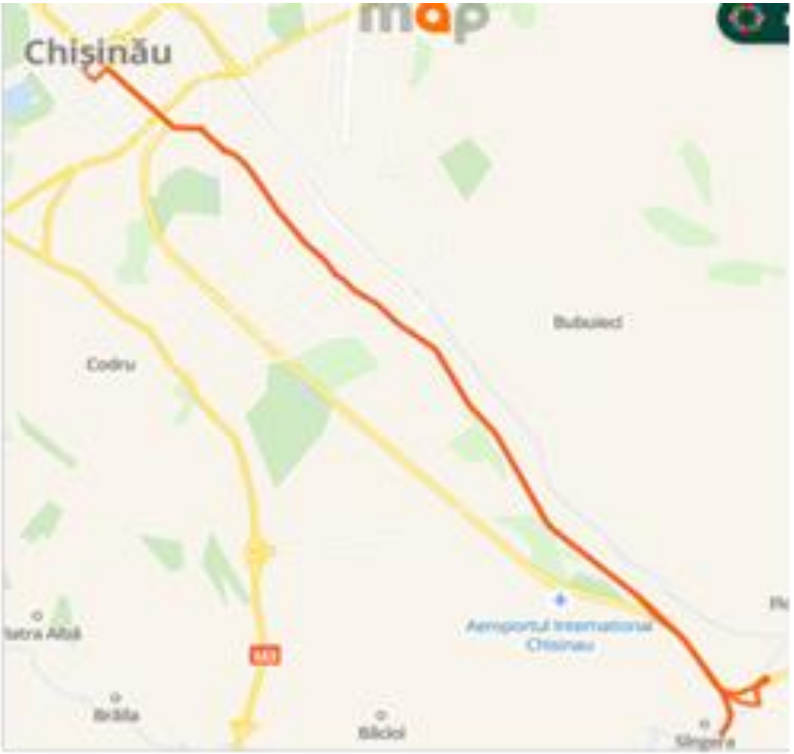
Activity 3.4. Renewable energy for the batteries.



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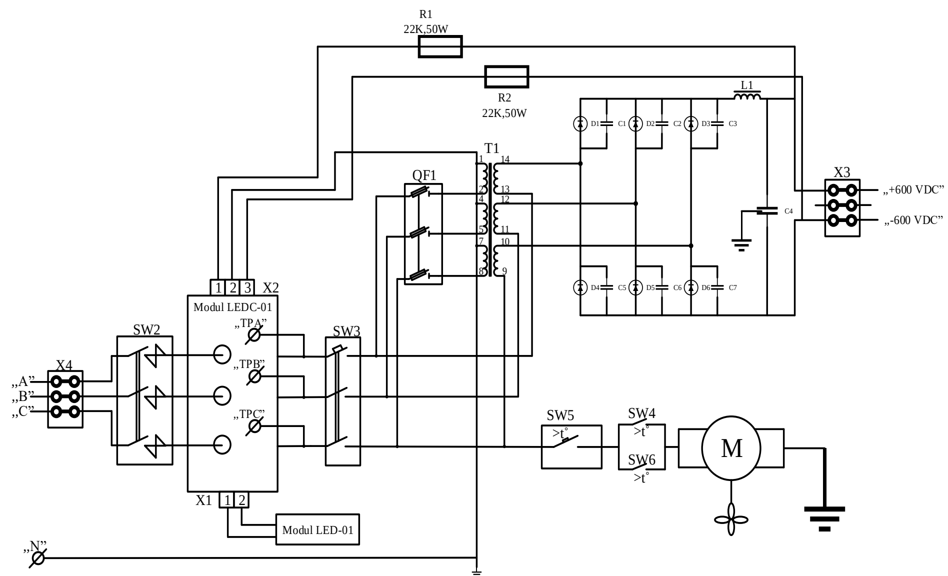
Activity 3.4. Renewable energy for the batteries.

Parameter	Value
AC input voltage[V], frequency [Hz]	380, 50
VDC voltage, [V]	600
The current, [A]	100
The power, [kW]	60



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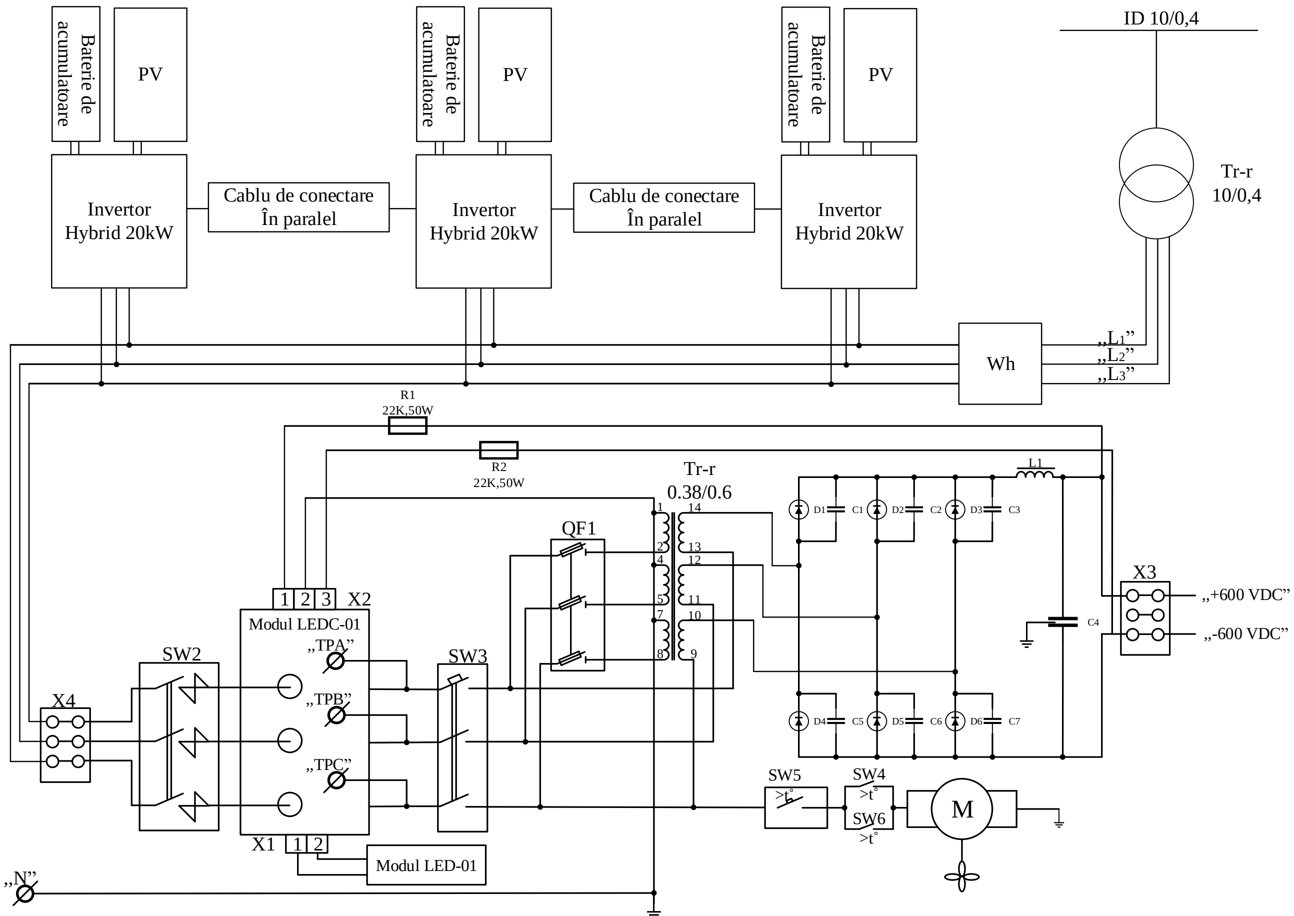
Activity 3.4. Renewable energy for the batteries.



Conclusions

- Energy consumption for auxiliaries accounts for almost half of total energy consumption, and in the winter it reaches 70% in daily scale.
- Optimization of non-traction needs consumption allows to reduce the capacity of traction batteries by 20-50%. This brings with it a reduction in the vehicle price and an increase in passenger capacity.
- An important issue is also increasing the smooth flow of public transport traffic. This can be done by giving priority to buses, the use of dedicated lanes for public transport and the use of intelligent traffic control systems (ITS).
- In cities with a very cold climate, an alternative can also be dynamic charging, in which it is possible to increase the heating power on sections equipped with traction cathenary (or another linear charging system) and its limitation on sections without the cathenary. In other words, dynamic charging of electric buses is a method of reducing the capacity of traction batteries.

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Conclusions

- Following the analysis of the current state of the station in the Sângera town, an average of energy consumption about 320 [kWh/day] was estimated and this consumption depends on the route taken by the electric bus, and the season.

- According to the analysis of the annual electricity consumption of the charging station currently located in the town. Bleeding, this being 130900 [kWh/year]. Based on these data, a park with an installed capacity of 90[kW] was calculated. The designed park provides both the charging station with electricity, and the surplus is injected into the network.

- 4For energy injection into the network and for the charging station operation in autonomous mode, 3 Hybrid inverters of 30 [kW] were selected. The division of the entire park into 3 fields was dictated by the nominal power of these inverters.

- To ensure the offGrid mode of the charging station it is necessary to add buffer batteries. The battery pack that stores the energy generated by the photovoltaic panels has a total capacity of 150 [Ah].