Electrical powertrain - ISEP

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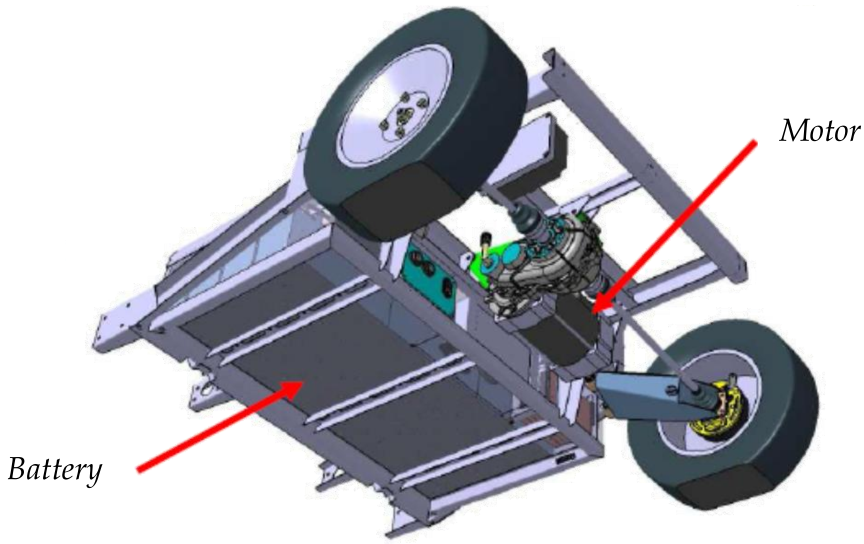
F-CITY : ELECTRIC VEHICLE FROM FAM AUTOMOTIVE



A) Energy of the battery rack

From a route profile and specifications, you are asked to calculate the embedded energy in the battery rack.

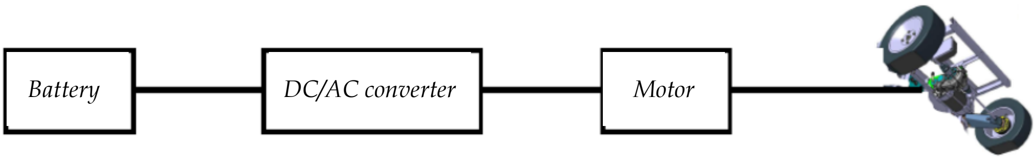
Specification:

- Mass of the vehicle excluding battery: 400 kg
- Maximum battery power: 24 kW
- DOD: 80%
- Average power accessories (lights, heating, wipers, ..): 250 W
- Desired autonomy: 100 km
- Voltage rack: 72V DC

Distance: 10.6 km and period: 23 min
The transmission efficiency is equal to 77%.

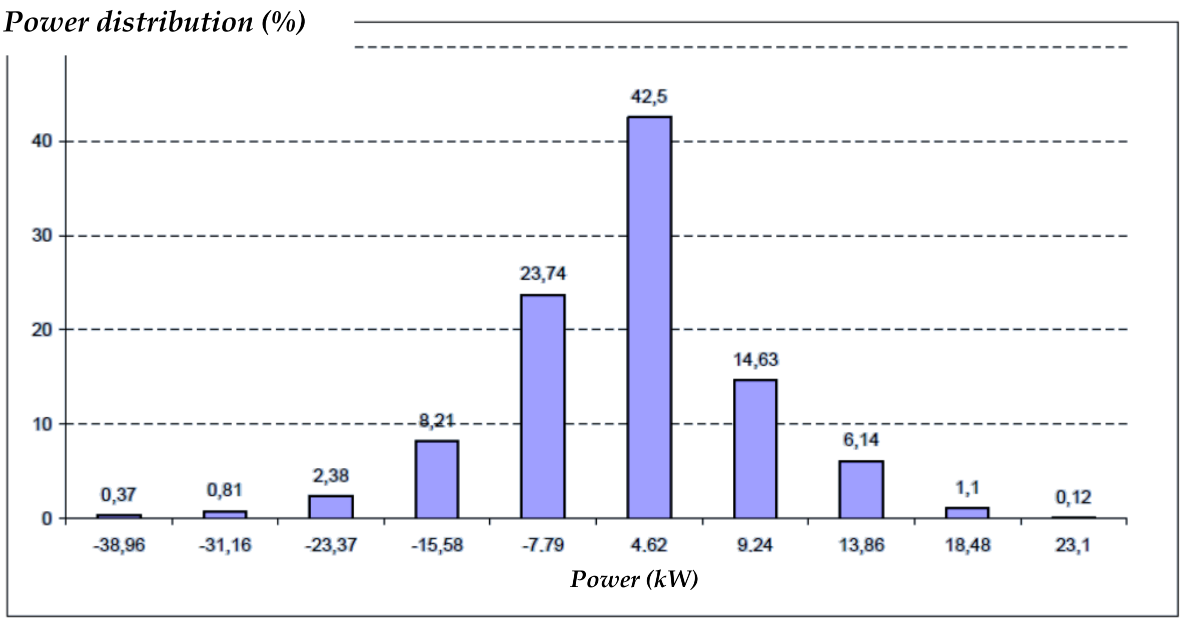
1) Indicate by using arrows the direction of the power for propelling and recovery

Traction



Recovery

We give you below the power distribution recorded at the axle during the journey.



Example: for 42.5% of journey time, the axle has developed 4.62 kW

2) Give the power P1 that must provide the battery when the mechanical power on the axle is equal to 9.24 kW

3) Give the power P2 restored to the battery when the mechanical power on the axle is equal to -15.58 kW

4) Give the average power Pbat of the battery for the journey

5) Calculate the required energy W_{BAT1} in kWh for the 23min of the cycle and W_{BAT2} for an autonomy of 100km

6) For the both autonomies (23km and 100km), give the energy W_{ACC} consumed by accessories

7) Deduce the total energy W_T (autonomy + accessories) required to the battery

8) For warranty reasons, the depth of discharge tolerated by the builder is 80%, give the energy of the battery rack W_{RACK}.

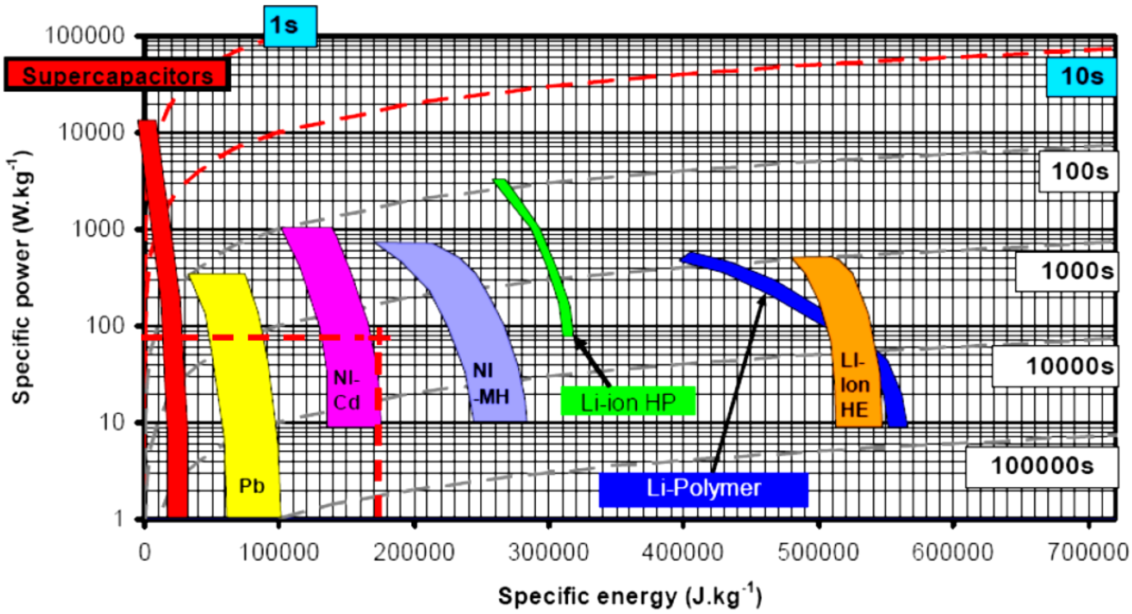
B) Selection of the battery technology

Technological battery selection requires knowledge of the specific power (W/kg) and the specific energy (J/kg).

1) We take the minimum energy of the battery rack equal to 14.4 kWh, give the specific energy W_S knowing that the weight of the rack is 300 kg

2) Knowing the maximum power of the battery rack, give the specific power P_S

We give you below the Ragone diagram to choose the adequate technology for the battery rack.



3) Based on your answers to question 1 and 2, choose the adequate technology for the battery. Plot the operating point on the diagram

4) We choose a Ni-MH technology. Using the manufacturer documentation DTC1, specify a reference of a module and specify the number to use

5) Following of the answer above, represent the circuit diagram of battery rack

C) Economic survey

1) Knowing that electric energy consumed by the vehicle for an autonomy of 100 km is 10.2 kWh, give the energy cost for a kWh price equal to 0.11€

2) Knowing that an ICE vehicle consumes 5L/100 for a diesel fuel price of 1€/L, give the energy cost for the desired autonomy and compare it to the electric one

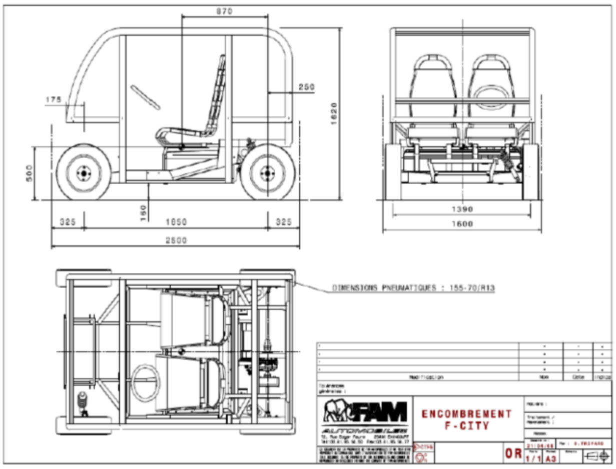
The manufacturer wants to offer several versions to diversify its customer base. We give you below the battery characteristics of different technologies.
(We want to preserve the autonomy of 100 km with onboard energy of 14.4 kWh)

	Lead acid	**Ni/MH**	**Li-Ion**
Specific energy (Wh/kg)	35	60	110
Max power (kW)	24	24	18
Price (€/kWh)	150	250	400

3) Give the mass of the batteries in the 3 cases.

4) The Economic solution chosen by the manufacturer is the Pb-acid technology. What are the implications of this choice compared to the specifications of the vehicle

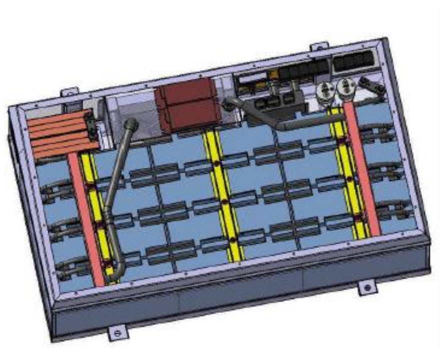
D) Energy recovery system



Description of the vehicle :

- Compact car (L x W x H: 2.5 x 1.6 x 1.6 m)
- Heavy quadricycle,
- Maximum weight of 400 kg excluding battery,
- Powertrain in the rear: Pn = 8 kW,
- Maximum speed of 60 km / h on the flat,
- Removable battery system

The mass of the removable rack is 273 kg. It is fixed in 4 points to the structure and contributes to the rigidity of the vehicle. The maximum energy is 14.4 kWh.

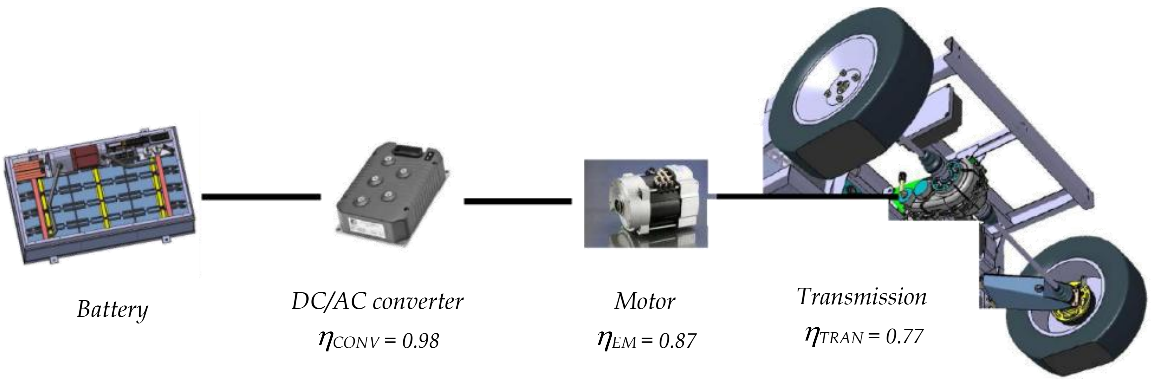


During the development of the vehicle, the maximum mass (2 persons + Luggage) was estimated at 200 kg.

We assumed that the recovery phase of the electrical energy will be studied for a slowing velocity from 50 km/h to 20 km/h. From 20 km/h until the complete stop, it is estimated that the kinetic energy is dissipated by the mechanical brakes of the vehicle. The force of air resistance is neglected.

1) Give the value of the kinetic energy variation at a slowdown phase (vehicle full charged is assumed)

The F-City being powered, all of the kinetic energy recovered by the motor is transmitted to the rear axle. The general block diagram of the traction chain is as follows:



2) Using the general block diagram of the energy chain provided above, calculate the value of the electrical energy that can be recovered by the battery

3) Compare with respect to the maximum power of the battery

NHE Module
High energy
Nickel-metal hydride module

Saft's NHE Ni-MH batteries are specifically designed for applications requiring enhanced energy density and maintenance-free operation.

NHE modules are available in two configurations:

- **NHE 10-100: 12 V, 100 Ah**
- **NHE 5-200: 6 V, 200 Ah**

Applications

Energy applications for all-electric vehicles, rail and mass-transit equipments, telecom central offices, offshore installations,...

Main advantages

- Maintenance-free operation
- High power/energy ratio
- Excellent safety and resistance to abuse
- Fully recyclable
- Liquid cooling system available as an option depending on the application

Technology

- Sealed - 100% recombination
- Foam positive electrode
- Nickel metal hydride negative electrode (AB_5 alloy)
- Alkaline electrolyte
- Chemically treated polypropylene separator

Module characteristics

High energy modules	NHE 10-100	NHE 5-200
Electrical characteristics		
Nominal voltage (V)	12	6
Rated capacity at C/3, after charge at constant current (Ah)	100	200
Specific energy (Wh/kg)	66	66
Energy density (Wh/l)	137	137
Specific power (W/kg)	150	150
Power density (W/l)	310	310
Dimensions		
Height (mm)	195	195
Length (mm)	390	390
Width (mm)	120	120
Weight (kg)	18.6	18.6

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