Sankey diagram (Umicar)

Total energy

As everyone knows, the sunlight is diffuse on its way to the earth. As a result, solar panels at different position get different intensity of light. Besides, the energy is also related to the area of the solar panel.

Intensity of light in Belgium: 800 W/m² (25 °C)

Umicar has two kinds of solar cells. They are 280 RWE solar cells whose average efficiency is 30% and 2578 Emcore solar cells with a 24.5% average efficiency.

Total area of the solar cells: A = 7.94 m^2

RWE solar cells A_1 = 280 cells * 30.18 cm^2/cell = 0.845 m^2

Emcore solar cells A_2 = 7.94 m^2 – 0.845 m^2 = 7.095 m^2

Total energy of the sun to the solar panel: 800 W/m² * 7.94 m² = 6352 W

Total energy given by the solar panel:

P = 800 W/m² * 0.845 m^2 * 30% + 800 W/m² * 7.095 m^2 * 24.5% = 1593.42 W

Electricity: $\eta = \frac{1593.42}{6352} * 100\% = 25\%$

Reflection and heat: 75%

From all the energy of the sunlight, we can only use 25 percent for the electricity part. The rest of energy is lost due reflection and heat.

Motor and controller losses

Umicar uses the motor *New Generation Motors - smc 150* with 95% efficiency and the controller *Tritium Gold* with 99% efficiency.

Motor final energy: 1593.42 W * 95% = 1513.75 W

Controller final energy: 1513.75 W * 99% = 1498.61 W

Other losses

When a vehicle is running on the road, there are some frictions which lead to losses in energy. Here we just consider the two most important ones: aerodynamic losses and rolling resistance.

Total maximum power: $P = P_r + P_D = F_r * v + F_D * v$

Aerodynamic losses

Drag force: $F_D = 0.5 * \rho * C_D * A * v^2$

Density of the fluid (air): $\rho = 1.204\ kg/m^3$

Drag coefficient: $C_D = 0.2$

Frontal area: $A = 0.81\ m^2$

Rolling resistance

Rolling resistance force: $F_r = C_{rr} * N$

Rolling resistance coefficient: $C_{rr} = 0.0056$

Normal force: $N = \mu * m*g = 0.8 * 225\ kg * 9.81\ m/s^2 = 1765.8\ N$

Total maximum power: $P = F_r * v + F_D * v = C_{rr} *N * v + 0.5 * \rho * C_D * A * v^2 * v$

$1498.61 = 0.0056 * 1765.8 * v + 0.5 * 1.204 * 0.2 * 0.81 * v^3$

Maximum speed: $v = 23.5\ m/s$

➢ At the maximum speed

The Umicar is riding at the maximum speed v = 23.5 m/s

Aerodynamic losses: $P_D = F_D * v = 0.5 * \rho * C_D * A * v^3 = 1265.65$ W

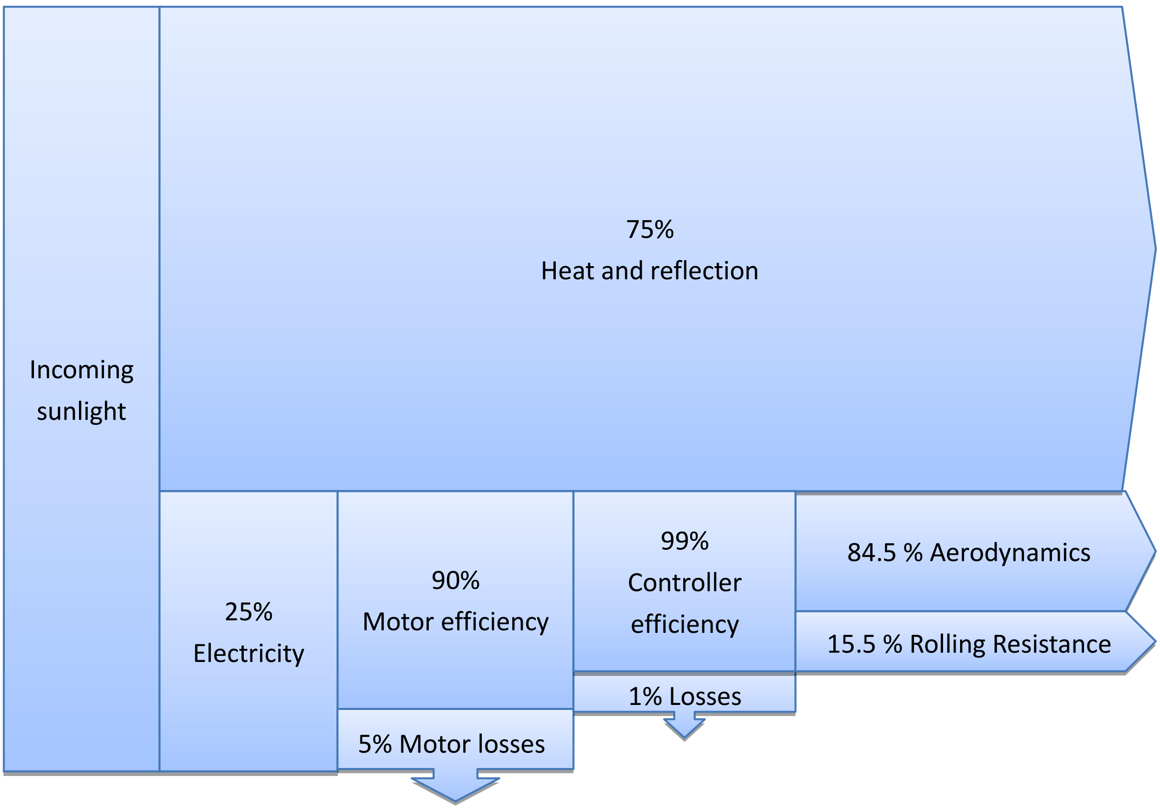
$\eta = (1265.65 / 1498.61) * 100\% = 84.46\%$

Rolling resistance: $P_r = F_{rolling} * v = 9.89$ N * 23.5 m/s = 232.38 W

$\eta = (232.38 / 1498.61) * 100\% = 15.51\%$

Sankey diagram

When the vehicle is running at the maximum speed, all the effective power is used for aerodynamics and rolling resistance. In this condition there is no power left to accelerate the vehicle, so that it runs at the top velocity.



➢ At the half of maximum speed

The Umicar is riding at the half of maximum speed v = 11.75 m/s

Aerodynamic losses: $P_D = F_D * v = 0.5 * \rho * C_D * A * v^3 = 158.21$ W

$\eta = (158.21 / 1498.61) * 100\% = 10.56\%$

Rolling resistance: $P_r = F_{rolling} * v = 9.89$ N * 11.75 m/s = 116.21 W

$\eta = (116.21 / 1498.61) * 100\% = 7.75\%$

Sankey diagram

When Umicar is running at the half of the maximum speed, the loss of the frictions is a quite small part of the total energy. It means that Umicar has a good performance. The rest of the energy, so-called “Actual power”, is large enough to move the car forward.