Sankey diagram (Jet Solar Team)

Based on calculations of the mechanical parts, we decide to use a Sankey diagram to analyze the efficiency of the solar vehicle. Here we use the calculation for a gear ratio of 8.

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)

Area of the solar cells: 21 cm * 19 cm = 0,04 m²

Total energy of the sun to the solar panel: 800 W/m² * 0,04 m² = 31,92 W

Total energy given by the solar panel: P = U * I = 6,15 W

Electricity: $\eta = \frac{6,15}{31,92} * 100\% = 20\%$

Reflection and heat: 80%

From all the energy of the sunlight, we can only use 20 percent for the electricity part. The rest of energy is lost due reflection and heat.

Motor and gear losses

Motor and gear always bring some losses to the system, especially internal resistance and heat losses. Here we assume the motor loss is 30% and the gear loss is 5%.

Motor final energy: 6,15 W * 70% = 4,31 W

Gear final energy: 4,31 W * 95% = 4,10 W

Other losses

When a car 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.

Aerodynamic losses

Aerodynamic losses are associated with some important factors, which are expressed to a formula.

Drag force: $F_D = 0,5 * \rho * C_D * A * v^2$.

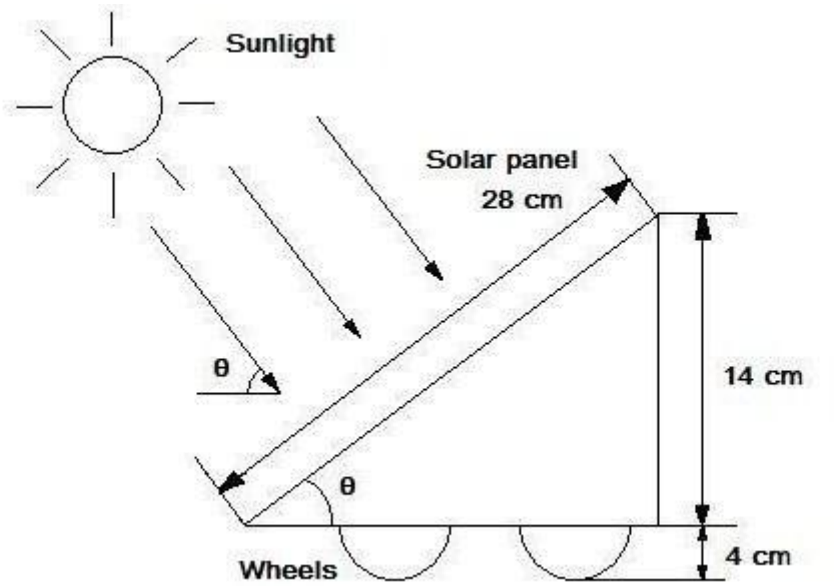
Density of the fluid (air): $\rho = 1,204\ kg/m^3$

Drag coefficient: $C_D = 0,09$ (Streamlined Half-body)

Reference area (frontal area):

Size of solar panel: 22 cm * 28 cm, $\theta = 30°$

A = 14 cm * 22 cm + 4 cm * 1 cm * 2 = 0,0316 m^2



Maximum velocity at the maximum power: $V = P_{real} / F_{wheel} = 4,31 / 1,36 = 3,17$ m/s

According to the formula, drag force: $F_D = 0,5 * 1,204 * 0,09 * 0,0316 * 3,17^2$

$$F_D = 0,017\ N$$

Power of drag force at the maximum velocity: $P_A = F_D * v = 0,017\ N * 3,17\ m/s = 0,055\ W$

$\eta = (P_A / 4,0964) * 100\% = 1,34\%$

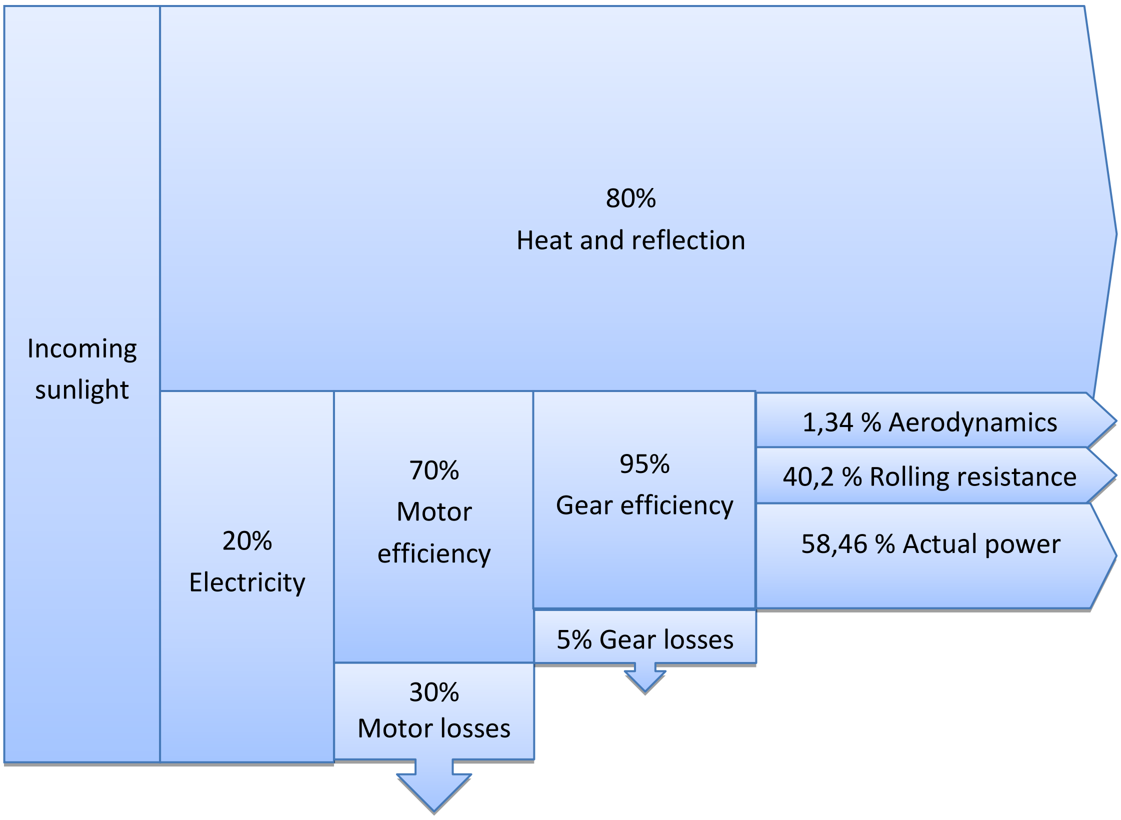
Rolling resistance

According to calculation of mechanical part, rolling resistance: $F_{rolling} = 0,52$ N

Power of rolling resistance at the maximum velocity: $P_r = F_{rolling} * V = 0,52 * 3,17 = 1,65$ W

$\eta = (P_r / 4{,}0964) * 100\% = 40{,}2\%$

Sankey diagram



When we analyze the last three parts, we see that the aerodynamics is just a small loss of the total energy. Due to the rolling resistance, we almost lose the half of our energy. The energy that's left is used to move the car forward so we can call it the actual power of the car.