Sankey Diagram

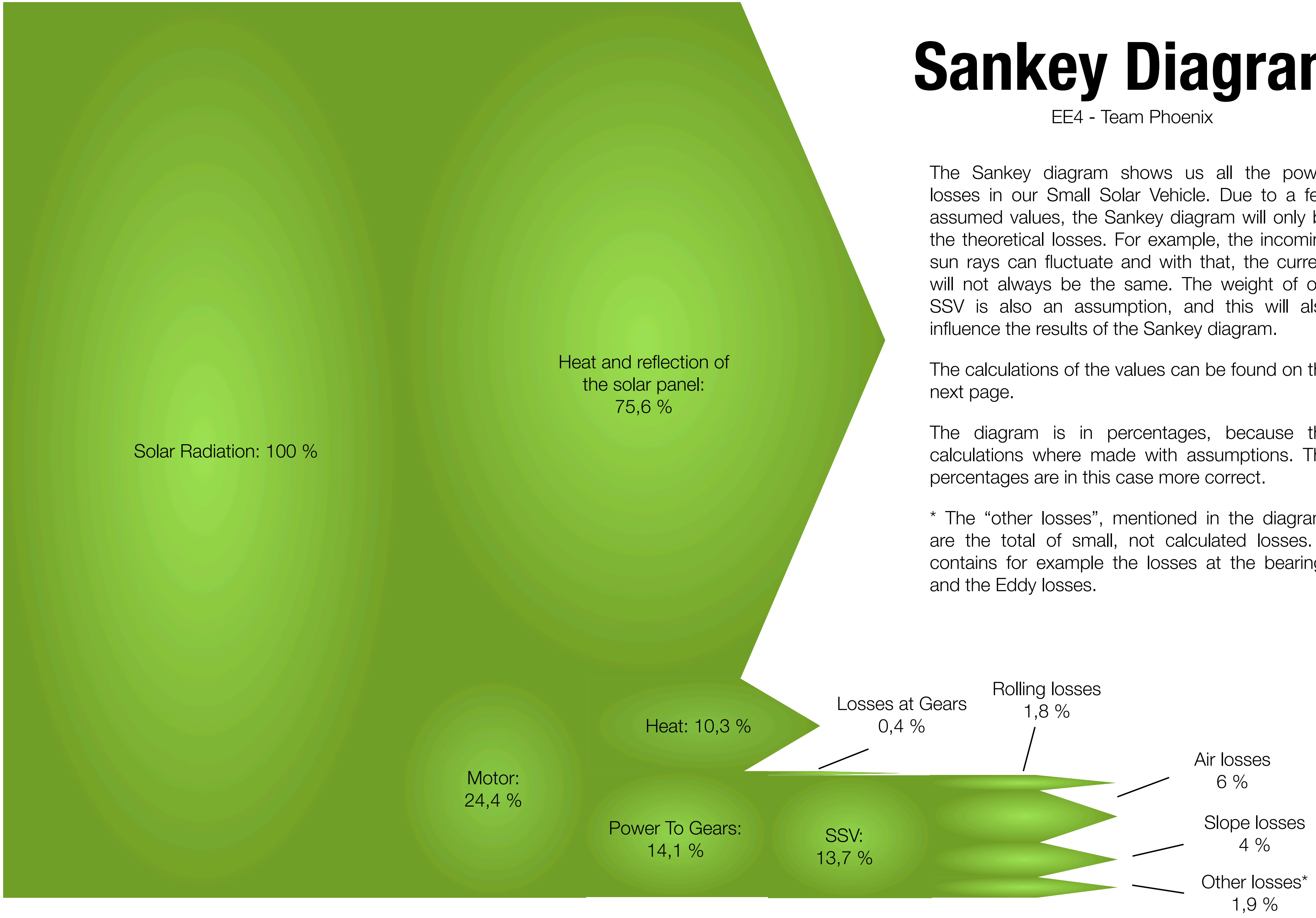
EE4 - Team Phoenix

The Sankey diagram shows us all the power losses in our Small Solar Vehicle. Due to a few assumed values, the Sankey diagram will only be the theoretical losses. For example, the incoming sun rays can fluctuate and with that, the current will not always be the same. The weight of our SSV is also an assumption, and this will also influence the results of the Sankey diagram.

The calculations of the values can be found on the next page.

The diagram is in percentages, because the calculations where made with assumptions. The percentages are in this case more correct.

* The “other losses”, mentioned in the diagram, are the total of small, not calculated losses. It contains for example the losses at the bearings and the Eddy losses.



Calculations

This page contains all the values.

The calculations where made when the SSV reached its maximum velocity.

Data:

- $U = 7,55$ V
- $I = 0,93$ A
- $g = 9,81$ m/s^2
- $m = 0,75$ kg
- $C_{rolling} = 0,015$
- $C_{air} = 0,5$
- $A_{front} = 0,05$ m^2
- Slope = 3,333 %
- $\rho = 1,293$ kg/m^3

Power to engine

$$P = U*I = 7,55 * 0,93 = 7,02 \text{ W}$$

Copper losses

These are the heath losses of the rotor, with the expected current.

$$R_{rotor} = 3,2\ \Omega$$

$$I_{rotor} = 0,93 \text{ A}$$

$$P = U*I = 3,2*0,6^2 = 2,976 \text{ W}$$

Eddy losses

Zero load losses occur when the engine has no load. Because the are so small, we can ignore them.

$$U_{clamp} = \pm 7,55 \text{ V}$$

$$I_{zero\ load} = 20,9 \text{ mA}$$

This is the current through the rotor. This gives a power of:

$$P= U*I = 8,4 * 0,0209 = 0,158 \text{ W}$$

Gear losses

Gears are nearly losses-free. Therefore we assume that they have an efficiency of 98 %. This gives:

21,8 % * 2 % = 0,4 %

Rolling and Air resistance

When the SSV is driving, it will also ‘create’ rolling and air resistance, with that their inevitable losses. The rolling losses occur between the wheels and the track. We assume that the losses due to the ball bearings can be ignored.

$$F_{rolling} = m*g*C_{rolling} = 0,75 * 9,81 * 0,015 = 0,11 \text{ N}$$

$$F_{air} = A_{front} * \rho * C_{air} * v^2 * 1/2 = 1/2 * 0,05 * 0,5 * 1,293 * v^2 = 0,0162 * v^2$$

$$F_{slope} = m * g * \% = 0,75 * 9,81 * 3,333\% = 0,245 \text{ N}$$

The total power while driving will than be as follows, assuming $v_{max} = 4,77$ m/s:

$$P_{rolling} = F_{rolling}*v = 0,525 \text{ W}$$

$$P_{air} = F_{air}*v*v^2 = 1,758 \text{ W}$$

$$P_{slope} = F_{slope}*v = 1,169 \text{ W}$$

Panel

From the measurements made at the lab, we can find the current and voltage:

$$U = 7,55 \text{ V}$$

$$I = 0,93 \text{ A}$$

The power of the sun in Belgium is about 800 W/m^2 and we know that our solar panel has an acreage of (0,03*0,04 m^2)*30. This way we can calculate the total incoming power.

$$P = 800 * (0,03 * 0,04) * 30 = 28,8 \text{ W}$$