FYP Meeting Presentation

Spring 2022

Tuesday March 22nd

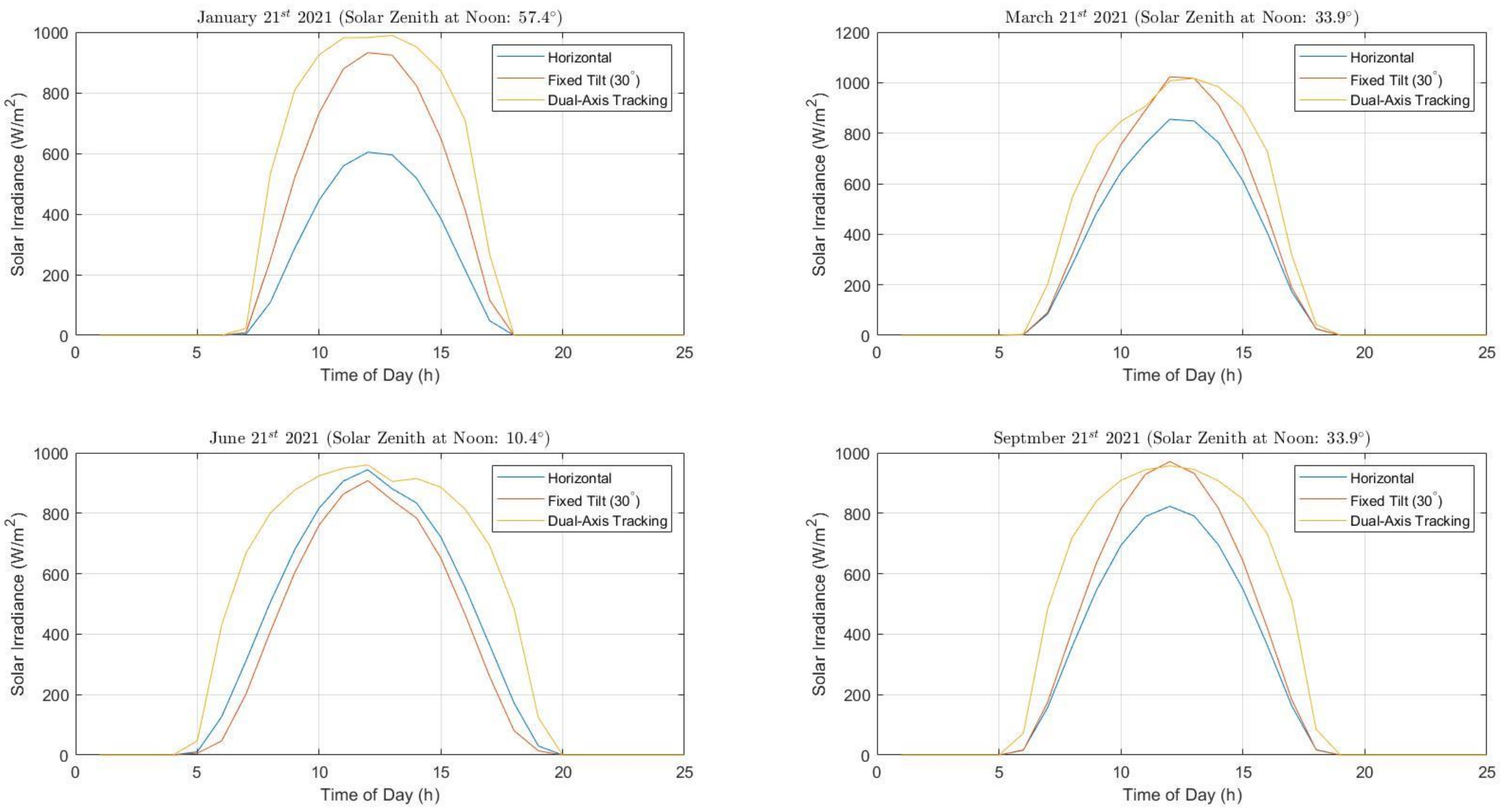
Contents

Part I: Solar Irradiance and Related Analysis

Solar Irradiance Data for Beirut

- The SOLCAST API online software tool was used to generate forecasts for the hourly solar irradiance in Beirut for the year 2022.
- The application relies on huge amounts of data collected by several weather satellites to calculate the solar irradiation at various times at a specific geographic location.
- The data supplied by SOLCAST in given in a timeseries format, where the average solar irradiance (in Watts) is given for every hour of the year.
- The tool was configured to provide hourly irradiance data for the whole year of 2022 at the coordinates of AUB (33.9°N, 35.5°E).
- The data was then exported to MATLAB for analysis.
- The data was later used to compare the irradiance incident on a flat horizontal surface, a surface given a fixed tilt, and a sun-facing surface.

Solar Irradiance Data for Beirut



Data Validation

- For validation, the data was compared to solar irradiation data presented in a 2020 LCEC report [1].
- To do that, the yearly-averaged daily Global Horizontal Irradiation (GHI) in $\frac{Wh}{m^2}/day$ was calculated as follows:

$$\overline{GHI} = \frac{1}{365}\sum_{h=1}^{8760} GHI_h$$

Where:

- GHI_h is the hourly GHI estimated by SOLCAST
- $8760 = 24 * 365$ is the number of hours in a year

- The obtained value of $\overline{GHI} = 4991\frac{Wh}{m^2}/day$ was compared to the value of $4855\frac{Wh}{m^2}/day$ reported by the LCEC, suggesting that the value obtained using SOLCAST overestimates the LCEC reported value by 3%.

[1] LCEC, “Solar Irradiation Data for Lebanon”, Beirut, 2020.

Average Daily Energy Yield

- The SOLCAST irradiation data was used to estimate the average daily energy yield of the sun-tracking solar panel.
- A solar panel with a rated power of P_{rated} produces $E = 1 \times P_{rated}\ Wh$ of electricity for every $1000\ Wh$ of incident solar energy.
- For a sun-tracking panel, the yearly-averaged solar irradiance falling on the panel was calculated as:

$$\bar{I} = \frac{1}{365} \sum_{h=1}^{8760} I_h$$

Where:

- I_h is the hourly irradiation falling on a sun-facing surface estimated by SOLCAST
- $8760 = 24 * 365$ is the number of hours in a year

- Here, it is assumed that the solar irradiance on a sun-facing surface remains constant during the one-hour time intervals, which means that the total irradiation falling on the given surface is $I_h = S[W] \times 1[h]$ where S is the average hourly irradiance provided by SOLCAST.

Average Daily Energy Yield

- Performing the previous calculation in MATLAB yielded, for a sun-tracking surface:

$$\bar{I} = 6900\,\frac{Wh}{m^2}/day$$

- From this value, for a solar panel rated at $P_{rated} = 5\,W$, the average daily energy yield is:

$$E_{daily} = \bar{I} \times \frac{5}{1000} = 34.5\,Wh/day$$

- For a fixed panel, the corresponding daily energy yield is:

$$E_{daily,fixed} = 26.8\,Wh/day$$

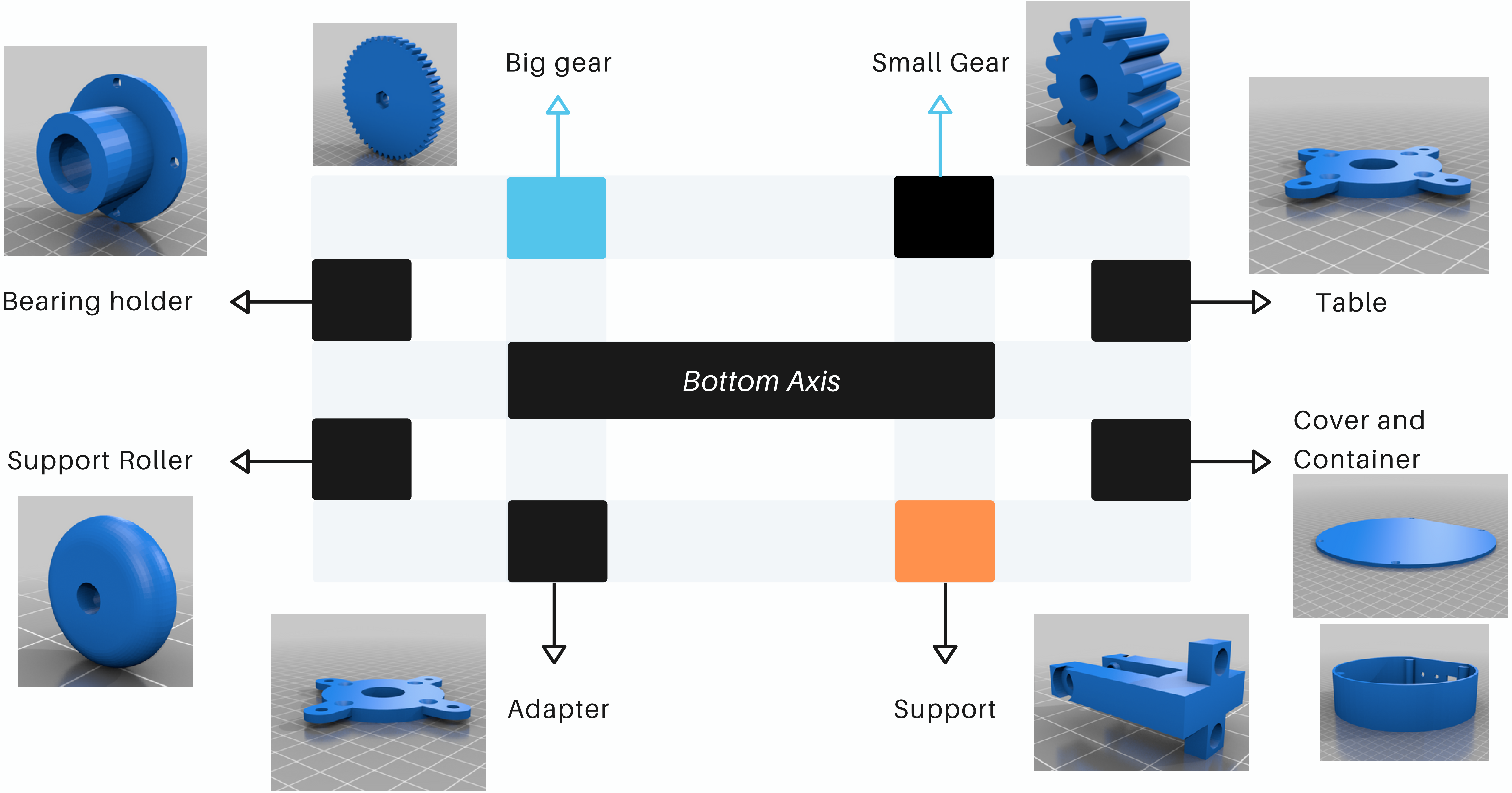
- Which means that dual-axis sun tracking improves the energy yield by 29%.

Power Requirements Analysis

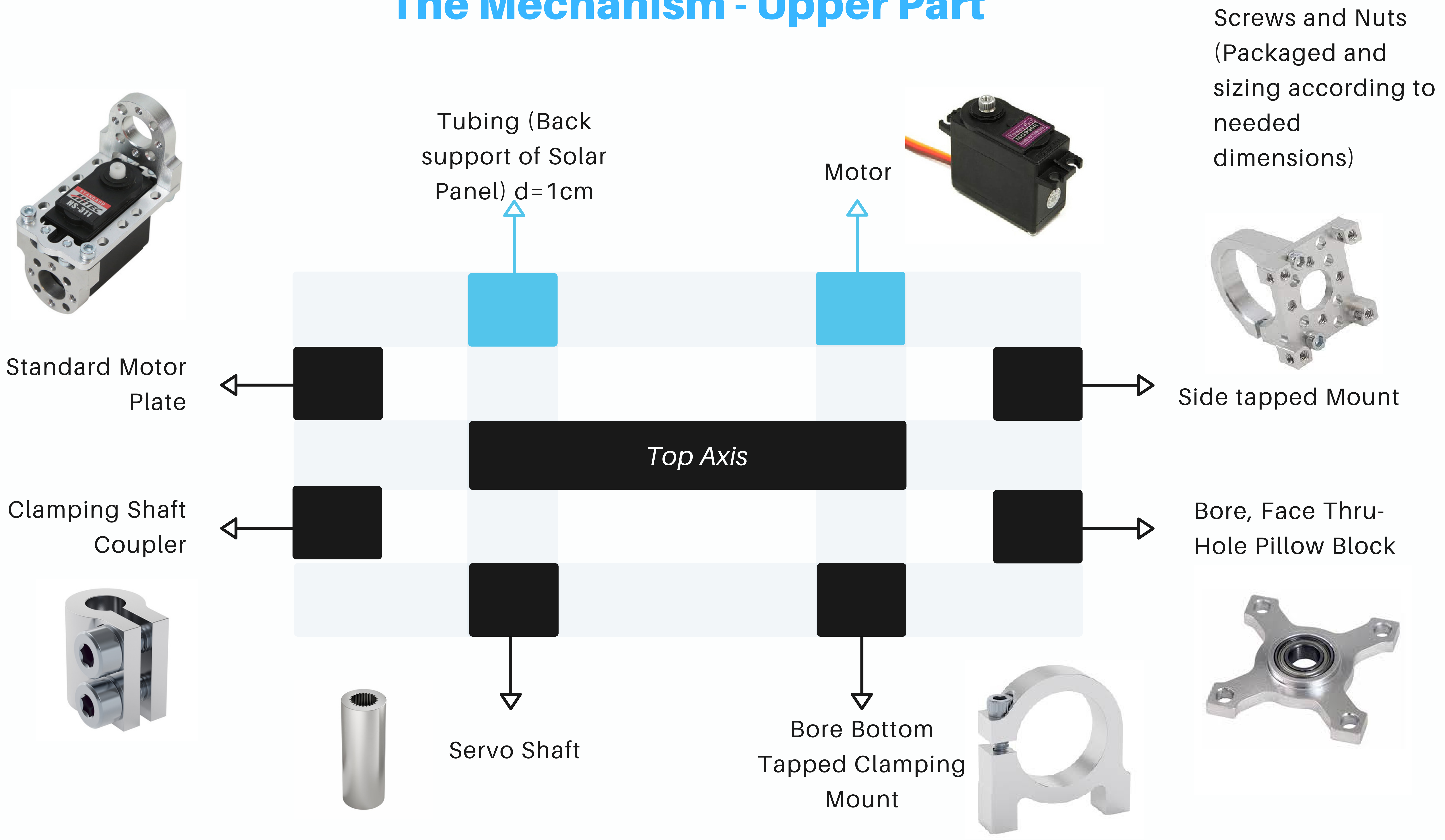
- The following are typical power requirements for the tracking system's components:
  - Servo Motors: at most 1 W each amounting to 2 W for two motors.
  - Arduino Board (Microcontroller): at most 1 W
  - Other Electronics: at most 1 W
- Thus, the system requires at most 4 W to operate at any time.
- Assuming the tracking system operates for an average of 7 hours a day, it will consume $E_{req.} = 4 \times 7 = 28\, Wh/day$ of energy on average.
- Therefore, on average, the energy generated by the solar panel covers the requirements of the tracking system.
- However, special cases such as cloudy days in the winter should be appropriately treated.

Part II: Mechanical System Design

The Mechanism - Lower Part



The Mechanism - Upper Part



The Advantages of 3D Printing