2023/2024

Bibliographic report

Solar Commuter quad

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ROB 3

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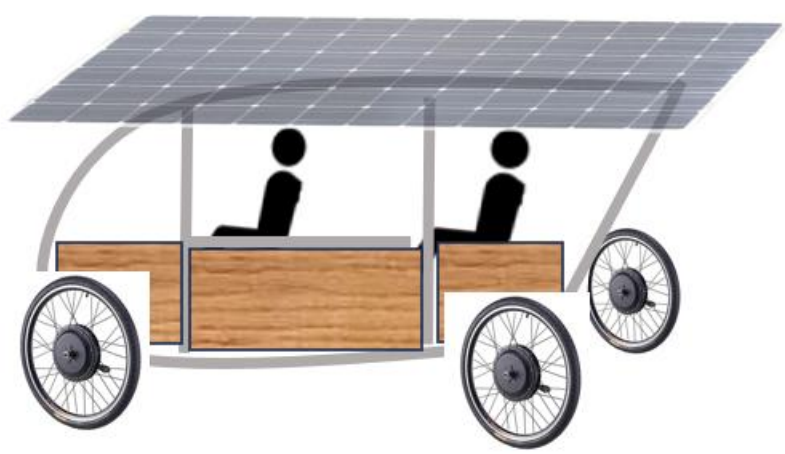
1. Introduction

This report aims to give a first look at the solar commuter quad project, giving an idea about what its mission is, its components as well as the making process.

"The solar commuter quad" *(P.1)*, as its name suggest, is an on land four wheels vehicle capable of transporting up to two people with their luggage, as long as it's within 100Kg. It is powered by solar energy through a solar panel on top of it. It will be able to power any household using the excess of energy contained in its batteries. As this project takes part in the ADEME initiative, the solar commuter quad is roughly ten times lighter than a common car, with a speed reaching 45km/h, consuming between 40 and 50Wh per kilometer, and made from common and local material and easily assembled even without the aid of a professional. Its price is estimated to be under 4000€.



P.1

2. Requirements

What are the tasks required from the vehicle to perfectly do his job?

This segment aims to answer this question. It will contain the individual actions that the vehicle is able to perform along with the components and materials required for each of those actions, in order to fulfill its final task.

a. Mobility

This product is a vehicle made to transport people. Therefore, it requires four motor wheels to ensure its mobility. There exists a variety of motors than can be used depending on our intended usage and objectives:

- Electric motors, both AC and DC.
- Internal combustion engines.
- Hydrogen fuel cells.
- Compressed natural gas engines.
- Propane engines.
- Micro gas turbines.
- Steam engines.
- Electric-assist motors.

The main purpose of this project is to conceive a vehicle with no ecological drawbacks. As a result, using internal combustion engines or steam engines isn't possible.

We aim to have an easily assembled vehicle as light as possible with the lowest cost possible, so we won't be using neither hydrogen fuel cells, as they are too expensive, nor micro gas turbines, compressed natural gas and propane engines as they are heavy and too complex to work with.

The vehicle is limited to a speed of 45km/h. Having more than 5kW motors wouldn't add any value to the product. It is then preferable to have electric-assist motors, which are less expensive and just as efficient as needed, instead of the more expensive electric motors.

With that being said, we have chosen to use standard electric-assist motors, "EA motors" for short. Moreover, for further simplicity and efficiency, we will be using EA wheel hub motors *(P.2)* instead of separate motors and wheels, which are the same type often seen in electric bikes *(P.3)*.

The total power output of the EA wheel hub motors will be around 5kW. Furthermore, a braking regeneration technology is to be implemented in those.

P.2

P.3

b. Energy Collecting

As its name suggests, the solar commuter quad will be relying mainly on solar energy. In order to collect this energy, three solutions seem plausible:

- Photovoltaic solar panels.
- Solar thermal systems.
- Concentrated solar power.

Both solar thermal systems and concentrated solar power require going through many steps, such as producing steam or using a heat engine, which will make the whole solar energy collecting process way more complex.

We're left with the photovoltaic solar panel solution, a method widely used and already proven to be effective for collecting solar energy.

For this purpose, we've chosen to use a flexible photovoltaic solar panel *(P.4)* with a power of 300W. It will be roughly 1m in width and 1.50m in length.

P.4

c. Energy storing

The solar energy collected through the solar panel *(P.4)* is to be stored in a battery. In our case, multiple types of batteries may be used:

- Lithium-Ion batteries.
- Lithium-polymer batteries.
- Nickel-Metal Hydride batteries.
- Sealed Lead-acid batteries.

Seeing as we envision a light vehicle, both Nickel-metal hydride and sealed lead-acid batteries are not adequate, as they are both considered heavy batteries.

When comparing both lithium-ion and lithium-polymer batteries, it becomes clear that lithium-ion has higher energy density, which means that it can store a considerable amount of energy relative to its size. Moreover, it has a longer cycle of life compared to lithium-polymer batteries, thus making lithium-ion batteries the best choice for our vehicle.

For this reason, we've chosen to use lithium-ion batteries *(P.5)* with a total capacity of 2.4kWh.

P.5

d. Movement control

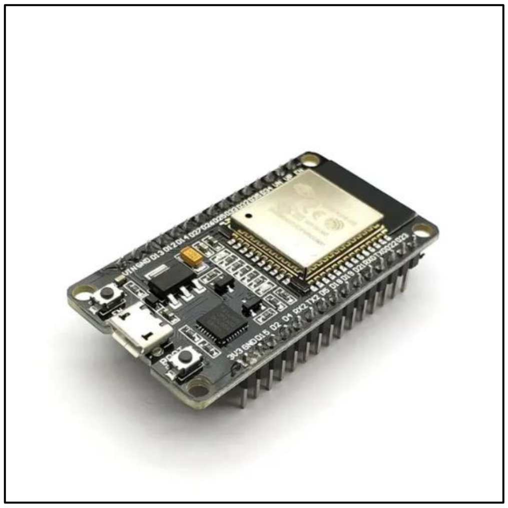
While having wheel hub motors gives the vehicle mobility, it is still necessary to adjust the power supplied to those motors according to the user's will. For this purpose, we are using a micro-controller, more specifically a motor controller, that will adjust the power supplied to motors. Moreover, it will be able to accurately measure the velocity of the vehicle and the power and energy supplied to it its motors. This data will be shared with the user. To complete this complex task, a controller with high processing power that can handle the communication with other devices is necessary.

However, as we are constrained by the low-cost criteria, our processor must be a low-cost one that can handle the aforementioned tasks. Therefore, using processors typically found in common electrical cars is out of question.

With all those constraints, the choices are limited, and the corresponding processors are listed here:

- Arduino boards.
- Raspberry Pi Pico.
- ESP8266/ESP32.
- STM32 blue pill.
- PIC microcontroller.

There is no significant gap between these microcontrollers. But we've chosen to work with the ESP32 microcontroller *(P.6)*. The reason being that the team working on the project is already familiar with this particular processor and therefore needs no time familiarizing with a new one.



P.6

e. Energy control

It is necessary to adjust and optimize the charging of batteries. The user must also be able to visualize the battery charge level as well as how much energy is being absorbed by the solar panel. Moreover, as the surplus of energy is to be injected in the household, the user must be capable of manually switch on the domestic self-consumption mode. Therefore, we will be using a “Solar energy micro-controller”. It is responsible for multiple tasks, and so it is composed of multiple components, each fulfilling a specific role:

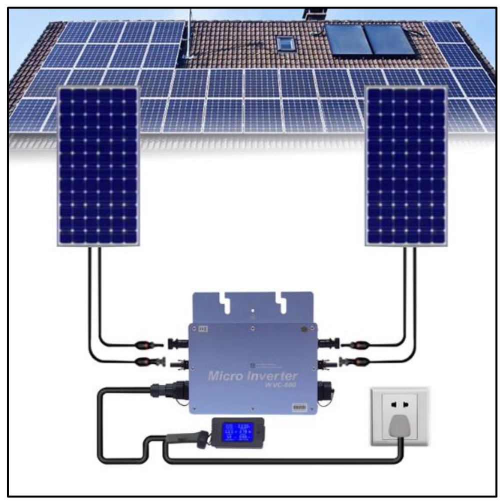
- First, adjusting power flowing between the solar panel and the batteries for maximum current and therefore optimal charging. This role is fulfilled by a “MPPT” charge controller *(P.7)*. After checking the output of the solar panel, it adjusts the voltage taking into consideration the batteries’ voltage tolerance.

- Second, enabling the user to manually turn the domestic self-consumption on. This task will be fulfilled by a micro-inverter *(P.8)*.
- Third, collect data on the amount of energy absorbed through the solar panel, and share it with the user. This task is fulfilled by a data recorder.

In order to succeed in those tasks, we need a micro-controller able to fulfill them simultaneously. Fortunately, the same micro-processor used for motor control can be used for this job too, as it already comes with the needed features and contains all the necessary components.

As a result, we chose to use an ESP32 microcontroller *(P.6)* for this mission as well.

P.7



P.8

3. Work schedule

The necessary work will be divided into multiple tasks, each taking around 8 hours, or two sessions of 4 hours, for a total of 32 hours, or 8 sessions.

First/Second session

Documentation phase: How many motors do we need for a max power of 5kW? Two of 2.5kW or four of 1.25kW? How to inculde regenerative braking technology?

Third/Fourth session

Documentation phase: How to make and program a motor controller: Electronics (which component to add to the main part for velocity and power measurement, how to connect the components to one another), and Code.

Fifth/Sixth session

Make a first prototype of the motor controller, and the code that goes with it.

Seventh/Eight session

Test the motor controller code and its code. Make adjustments to both of them if the result is not good enough.

4. Conclusion

To summarize, our goal is to conceive a vehicle that respects the following criteria:

- Powered mainly by solar energy.
- Light-weighted (max 450kg).
- Speed reaching 45km/h.
- Cheap and affordable.
- Simple to assemble.
- Long cycle of life.
- Energy efficient.

To succeed in that mission, the material needed, along with its characteristics, is listed below:

Material	***Type***	***Number***	***Capacity***	***Power Output***	***Size***
Motor	Electric-Assist	2 or 4		1kW or 2kW	
Solar panel	Photovoltaic	1		300W	1.50x1m
Battery	Lithium-ion	1, 2, or 4	1.2, 2.5, or 5Wh		
Motor controller	ESP32	1			
Energy controller	ESP32	1			