Hybrid Bicycle

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Abstract— **The Hybrid Bicycle System is a systems project that incorporates three different ways of charging a lithium-ion battery: the 220VAC wall outlet, regenerative braking, and solar power; which is used to power an electric hub motor running a bicycle. In this electric hybrid bicycle, the front wheel has a compact & light weight hub motor. It will be having regenerative charge system and solar panels, which enables substantially longer distance power assist cycling by regenerating power from pedaling energy (human energy) and solar energy and charging it in the battery.**

I. INTRODUCTION

In present scenario, with increasing number of automobiles the need for petroleum products is reaching the peak point. These petroleum products are non-renewable sources and it has a danger of exhaustion in future, so it is better to move to an alternate energy sources. The price of crude oil has increased significantly over the past few years and there seems to be no turning back. The environment has also been more of a focus throughout the world in the past few years, and it seems that cleaner alternatives have been steadily on the rise with no end in sight.

The term "hybrid" usually implies that more than one energy source is used to power all or part of a vehicle's propulsion. Solar power may be also used to provide power for communications or controls or other auxiliary functions. Rechargeable battery is used with long life for charging. DC electric motor is also used in this project. The hybrid bicycle is a project that can promote both cleaner technology as well as a lesser dependence on oil. It will run on clean electric power with the ability to recharge the battery 3 separate ways: through the charger, by generating power through the pedals of the bicycle, and by solar-cell generative power.

II. PROBLEM DEFINITION

Energy Requirements

The external forces acting on the bike include drag due to the wind, the rolling resistance of the tires, and the force due to gravity. In order to expedite selection of the motor and the batteries, we neglected the drag forces acting on the system, and focused more on energy relationships, specifically the transfer of electrical energy into kinetic and potential energy.

In order for the bike to accelerate from a cold start, a sufficient amount of torque needed to be delivered by the motor and transmission components. As a result, we expected the motor to draw a large amount of current during the period of acceleration. We were able to approximate the amount of current required using the following set of energy relationships. On flat terrain there is no change in potential energy which would cause the motor to need to deliver a counter torque to the force of gravity. As a result we only looked at kinetic energy for acceleration.

Equation 1:

(1) Kinetic Energy = $\frac{1}{2} m \Delta V^2$
(2) Electrical Energy = $V \times I \times T$
(3) K.E. = voltage rating motor × current required × time to accelerate

The acceleration of electric bicycle dose not remains constant with respect to time. The acceleration requirement is different at different time and at different conditions, such as at starting time, at leveled roads, at inclined roads etc. Based on the electric bicycles available in the market we have found the acceleration requirement at different time and in different conditions, which are described in the table below:

Table1: Power requirements for various accelerations

Time to accelerate(s)	Δ Velocity	Voltage available(V)	Mass	Current required (amp)	Power consumed(watt)
20	25mph (11.2m/s)	24	260lbs (117.9kg)	15.4	369.6
40	25mph (11.2m/s)	24	260lbs (117.9kg)	7.7	184.8
60	25mph (11.2m/s)	24	260lbs (117.9kg)	5.1	122.4

Equation 2:

$$\text{Gradient} = \sin\theta = \Delta H / \Delta x$$

It is clear that the system will draw the most current during hill climbing. Fig1 below shows the hill climbing condition.

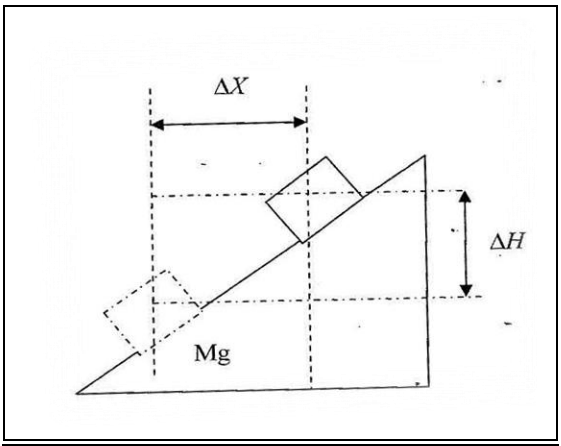

Figure 1 model of hill climbing

Below table shows the hill climbing power requirements.

Table 2: Hill-climbing power requirements

Speed(max)	Voltage available(V)	Mass(lbs/kg)	% Gradient	Current (amp)	Power(watt)
25 mph(11.2m/s)	24	260lbs/117.9kg	5	27.3	655.2
25 mph(11.2m/s)	24	260lbs/117.9kg	10	54.6	1310.4

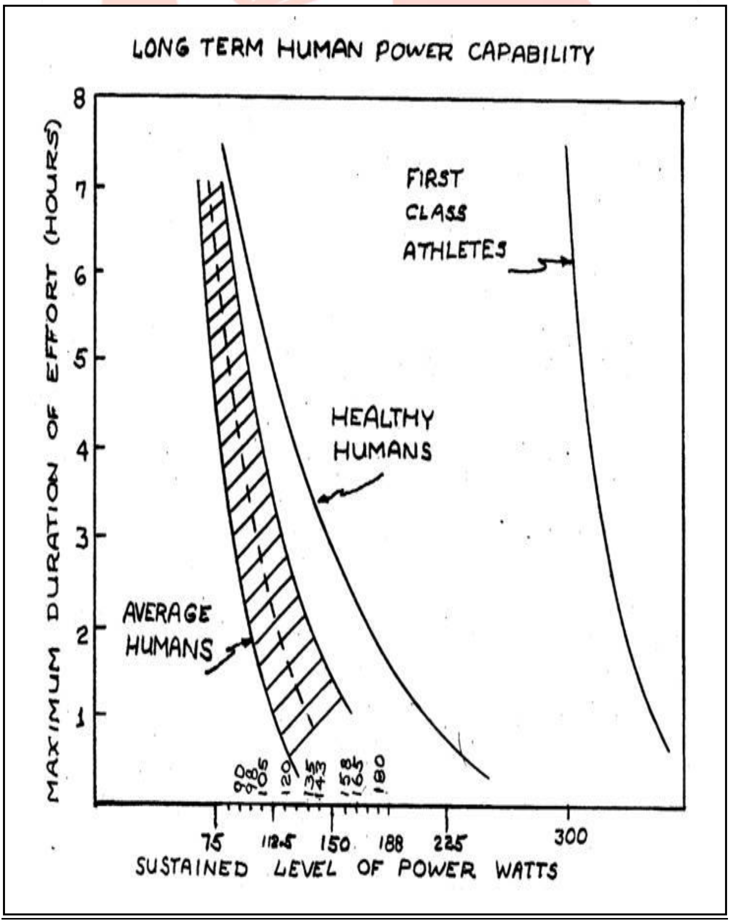

Figure 2 A graph of the long term human power capability

SOLAR Panel

The placement of solar panel is a critical aspect. If the panel is placed on the stand behind the rider the shadow of the rider will affect the output power of the panel. And if it is placed above the rider as the roof, the wind aspect is of greater consideration.

Wind Aspects

The air drag is low for a flat plate that is horizontal to the apparent wind. But when the panels are pitched by just a degree or two, this leads to a significant increase in force. In essence we have two inefficient aircraft wings that will generate some lift. This lift will act at a vector that is perpendicular to the apparent wind, not perpendicular to the surface of the solar panels, so will act to unbalance the bike. It will also create induced drag that is proportional to the lift generated, adding to the form drag we have from the projected frontal area of the panels.

Cross winds are the problem here, or more specifically, the vector sum of the side wind and the apparent wind caused by the motion of the bike. The force needed to unbalance a bike, by taking it outside the range of corrective moments that the rider can provide by shifting body weight is pretty small. The lift force vector will change direction extremely rapidly as the bike rolls, going from a maximum positive to a maximum negative value in a short time interval as the panels go from a positive to negative angle of attack relative to any side wind component. A known issue at racing bicycles is the severe impairment of the steering that comes from using a disk wheel in a crosswind.

III. COMPONENTS

Table 3 Components of hybrid Bicycle

Sr. no.	Components
1	Motor.
2	Batteries.
3	Solar cells.
4	DC-DC boost converter.
5	Controller.
6	Throttle.
7	Frame.

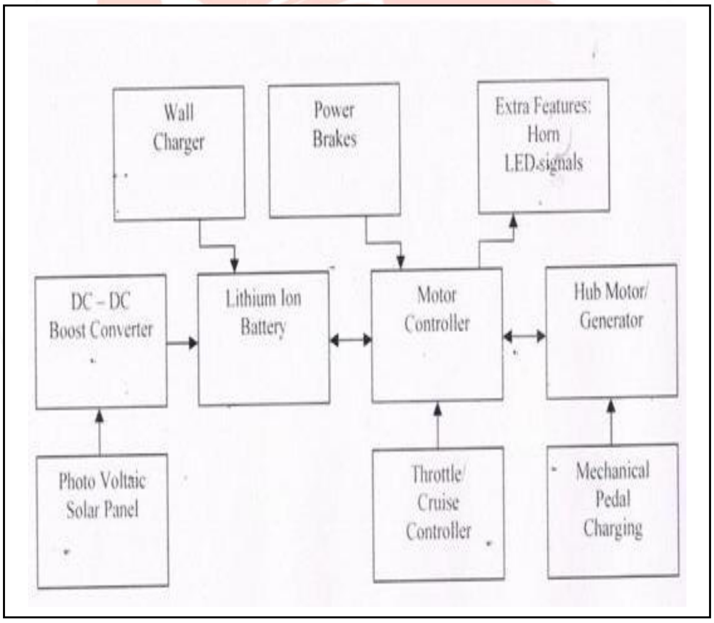

Figure 3 System block diagram of components

IV. WIND ASPECTS

In the ideal situation of the absence of side wind and where the panel is horizontal to the wind, the air drag of the PV panel is quite low. The skin friction drag is negligible with air. The shape should be aerodynamic like the fig. 4 shown below:

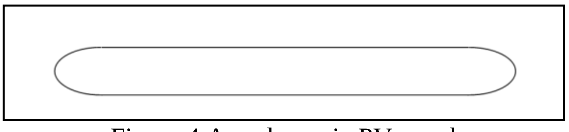

Figure 4 Aerodynamic PV panel

The higher we go, the higher the wind speed. On the ground the wind speed is zero. The wind profile is logarithmic, but close to the earth surface it is linear, see the wind gradient graph below:

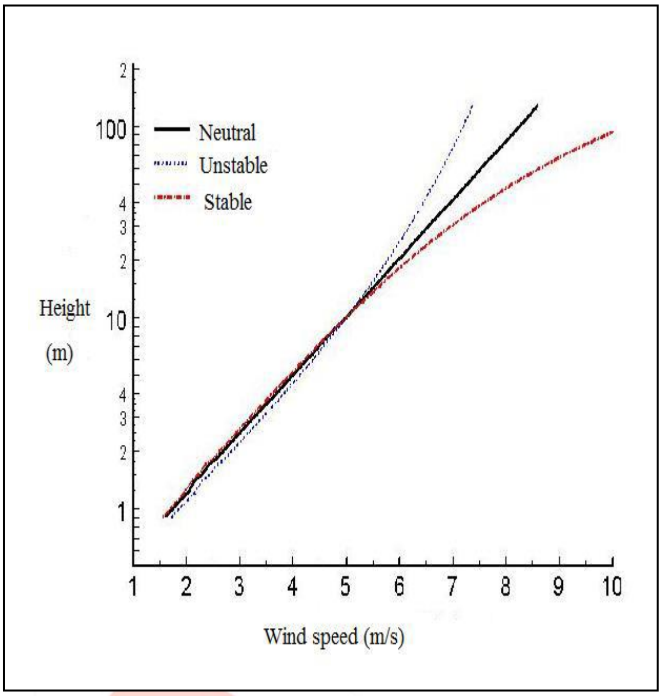

Figure 4 Aerodynamic PV panel

So, it is important to place the solar panels as low as possible. Also, the moment of the wind load on the bike is larger at high mounted solar panels as a roof. The worst case situation is on bridges because here there the distance to the ground is high. The bicycle is not feasible. The size of the panels is limited and cannot be increased further.

V. CONCLUSION

This project is a way of using the outgoing power. The concept of the project is providing ease to the rider while riding a bicycle and also to conserve energy by all possible means. When the solar electric bicycle is kept under sunlight then the solar rays charge the battery through the solar panel. The battery powers an electric motor in the motor of wheel. It also lowers the resistance in pedaling to make it easier to go up hills. When there is no sunlight, the bicycle can be charged by mains electricity. The hybrid bicycle approach is different. It works in normal day as well as in cloudy day. We have designed an electric hybrid bike with a minimal amount of additional weight, an integrated control system, based on the decision-making of the rider and microcontroller, and that is capable of greater efficiency than typical hybrid bikes through its use of regenerative motor control and various other feedback control mechanisms.

VI. REFERENCES

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