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Design and Analysis of Tricycle Powered by Solar Energy

Jean Pierre Twajamahoro[1], Emmanuel Mudaheranwa[2], Dr Kayibanda Vénant[3]

[1]Assistant Lecturer in Department of Mechanical and Energy Engineering, University of Rwanda/College of Science and Technology, Kigali 4285, Rwanda

[2]Lecturer in Department of Electrical Engineering, Integrated Polytechnic Regional Center Karongi ; P. O. Box 85 Karongi-Rwanda

[3] Senior Lecturer in Department of Mechanical and Energy Engineering, University of Rwanda/College of Science and Technology, Kigali 4285, Rwanda

Abstract: ***This project is intended to do the design and analysis of the "Tricycle powered by solar energy ". This paper gives the details about my research related to tricycle project and includes the methods and consideration regarding the proper working principle of tricycle powered solar energy. This research includes all the information regarding the solar powered tricycle for handicapped persons and its components used on it. Nowadays, transportation is inseparable part of human life. Normal person can travel easily by utilizing the facilities such as bicycles, bikes, cars, public transports,etc…. but for disabled persons travelling is not so easy. Depending upon the disability(i.e. which part of body is not in function), disabled person can avail travelling facilities such as tricycles, wheel chairs, customized vehicles like cars,bikes,buses etc. But these facilities are not easily accessible for disabled persons due to some difficulties. This project discusses these facilities for disabled persons. The purpose of this project is to help disabled people to use less effort when moving, to protect environment and reduce fuel consumption which could be used once they are occupied with thermal engine. This system will use tricycle, solar panel, charge controller, battery, DC motor and three wheels and is designed in metal tube. This study will help the researcher to improve their knowledge in theory and practical skills about tricycle powered by solar energy. It will make them the spirit of creativity and innovation. And in this study we will have five chapters: chapter one is the introduction, the second chapter concerns literature review, the third chapter deals with design and data analysis, fourth research methodology, and the fifth is conclusion and recommendation, then reference.***

The specific objectives are:

a) Reduced the physical effort to drive the tricycle,
b) Top speed limit up to 30km/hr and average speed up to 20km/hr,
c) To developed tricycle for the longer distance traveling,

Keywords: Design, Solar power, Solar panel, Tricycle, Disability, Disabled people

1. Introduction

Most of handicapped people have a problem of moving from one place to another place here in Rwanda, in Africa even all over the world, a lot of difficulties and hassles involved with the mobility of the physically disabled people in the society. It has been observed that physically disabled people are basically using some assistive devices like, crutches, artificial limbs or legs etc. and manual wheel chairs or three-wheelers for their day-to-day movements.

But, these wheel chairs or three-wheelers are crude or of inefficient in design; not very much suitable for outdoor use or common terrain in the country like Rwanda. Undoubtedly these manual wheel chairs or the three-wheelers are the blessings for crippled people but in the question of humanity, it is just "to add insult to injury". Because, commonly found manual wheel chair or three-wheeler has a basic problem that the occupant must use physical force to turn the wheels. This action is physically stressful, can result in muscle and joint pain and degradation, torn rotor cuffs, repetitive stress injury, and carpal tunnel syndrome; which causes secondary injury or further disability reason why I choose to design solar powered tricycle for handicapped persons [by JK Nayak, 2nd edition Publishing, 1994].

A tricycle powered solar energy, also known as an e-trike or booster trike, is a tricycle with an integrated electric motor which can be used for propulsion. There are a great variety of e-trikes available worldwide, from e-trikes that only have a small motor to provide motive force to somewhat more powerful e-trikes which tend closer to moped-style functionality. E-trikes use rechargeable batteries and the lighter varieties can travel from 10 km/h to 20km/h depending on the laws of the country in which they are sold, while the more high-powered varieties can often do in excess of 45 km/h. In some markets, such as Germany, they are gaining in popularity and taking some market share away from conventional tricycles, while in others, such as China, they are replacing fossil fuel-powered mopeds and small motorcycles.[R. K. Pachuri.1993 2nd edition]

The solar assisted tricycle developed is driven by DC motor fitted in front or rear axle housing & operated by solar energy. The solar panels mounted on the carriage will charge the battery & which in turn drive the hub motor.

2. Main parts of tricycle powered by solar energy

The solar powering system of the tricycle consists of:

a) Solar Array which collects solar energy and convert it to electrical energy
b) Power trackers to achieve the proper voltage to be stored in batteries.
c) Batteries to stir power.
d) Motor controller which adjusts the power input to the motor.
e) An electric motor which drives the vehicle.[About power supply information taken by Electrical technology textbook by B.L. thereja,1999 1st edition]

This solar powered tricycle for handicapped person is composed by : Chassis/Frame, Wheels, Body, Seat, Solar panel mounting frame, Solar Panel, Charge controller, Battery, Motor, Chain, Steering System, Speed Controller, Brake System, lights etc. [Jan f. kreider,2001 1st edition]

1) Chassis/Frame of tricycle powered by solar energy

The Chassis/Frame of the presently available three-wheeler is heavy and wheels are of big sizes. So while designing, unnecessary weight were reduced to meet the requirement. The solar three-wheeler chassis is designed by using steel pipes reinforced with angle bars where necessary and covered by canvas steel. The chassis can withstand necessary loads as well as absorbs shocks. The overall length and width are also reduced to some extent. Finally, the chassis is made by steel pipes having 19 mm diameter with 2 mm thickness and covered by canvas steel. Reinforcement in bends etc. is done by 19 mm×19 mm angle bars as necessary.[B.L. thereja,1999 1st edition]

2) Wheels of tricycle powered by solar energy

Overall road condition including bumps, pot-holes etc. around the country is duly considered while choosing the wheel as well as it's size. All the three wheels are of equal size having the diameter of 68 cm each. All terrain tires are used for better traffic ability. [B.L. thereja,1999 1st edition]

3) Body and Seat of tricycle powered by solar energy

The body of the solar three-wheeler is made of pipes, covered by canvas steel of minimum possible thickness and woods for lighter weight. Two leaf springs are added to the rear axle for better suspension. An adjustable waterproof cushioned seat is attached with the chassis. [About power supply information taken by Electrical technology textbook by B.L. thereja,1999 1st edition]

4) Solar panel mounting frame and Solar Panel

The solar panel is set on the top (over head) with panel mounting frame made of light steel pipes duly attached to the main frame/chassis. [Designing Solar Three-Wheeler for Disable People/Md. Shahidul Islam, Zaheed Bin Rahman, Nafis Ahmad/ International Journal of Scientific & Engineering Research Volume 3, Issue 1, January-2012]

5) Charge controller

A solar charge controller were chosen for the solar power system of the solar three-wheeler to extract maximum power from solar panel throughout the day. This is operated by microprocessors for sensing and recording the panel voltage and current at frequent intervals for computing and adjusting the power output. This solar charge controller takes the uncertain voltage from the solar panel and conditions it to charge the lead-acid battery safely. It cuts out the batteries from the load when the lead acid batteries are depleted to prevent damage to the battery and also protect the panels from the batteries after the sun goes down. Here, it collects charges from solar panels and charges the 12 volt lead-acid battery. It has LED bar readout to show the status of the solar charging system and batteries. With the help of this solar charge controller about 20 to 30% more energy can be generated than that of a common type charge controller.[Designing Solar Three-Wheeler for Disable People/Md. Shahidul Islam, Zaheed Bin Rahman, Nafis Ahmad/ International Journal of Scientific & Engineering Research Volume 3, Issue 1, January-2012]

6) Battery, Motor and Chain of tricycle powered by solar energy

The prime mover to be used in this solar three-wheeler is a permanent magnet D.C. motor. The main reason for using this motor is that it is highly efficient and the flux density does not decrease with time. It's performance characteristics suite very well to the requirement of our solar three-wheeler. [Designing Solar Three-Wheeler for Disable People/Md. Shahidul Islam, Zaheed Bin Rahman, Nafis Ahmad/ International Journal of Scientific & Engineering Research Volume 3, Issue 1, January-2012]

7) Steering System and Brake System

Normal friction type braking system (as used in bi-cycle) were used in front as well as in rear-left wheel of this solar three-wheeler for better safety. The hand lever attached with handle/steering is used to actuate the brake. A normal handle bar decorated with brake lever, accelerator, switches etc. and attached with front wheel is used here as steering. [Designing Solar Three-Wheeler for Disable People/Md. Shahidul Islam, Zaheed Bin Rahman, Nafis Ahmad/ International Journal of Scientific & Engineering Research Volume 3, Issue 1, January-2012]

8) Speed Controller of tricycle powered by solar energy

The speed of the solar three-wheeler is controlled by accelerator through continuous change in voltage by a twist throttle.

Due to voltage change the motor power also changes and thereby speed is controlled by increasing or decreasing the voltage.[S.K. Chaudhri,2003 3rd edition].

3. Electric tricycle mechanical design

The main components of the solar powered tricycle are: Chassis/Frame, Wheels, Body, Seat, Solar panel mounting frame, Solar Panel, Charge controller, Battery, Motor, Chain, Steering System, Speed Controller, Brake System, lights etc. The Chassis/Frame of the presently available solar powered tricycle is heavy and wheels are of big sizes. So while designing, unnecessary weight is reduced to meet the requirement. Comparatively smaller wheels are selected; keeping in mind that the weight of the solar powered tricycle

should be as low as possible and must have required strength. The solar powered tricycle chassis is designed by using steel pipes reinforced with angle bars where necessary. The chassis can withstand necessary loads as well as absorbs shocks. The overall length and width are also reduced to some extent. Finally, the chassis is made by steel pipes having 19 mm diameter with 2 mm thickness. Reinforcement in bends etc. is done by 19 mm×19 mm angle bars as necessary.

To avoid accidents and ensure safety, the sharp edges, bends etc. are rounded. Total weight of the loaded solar powered tricycle (with a person) should be 50 kg.[Khurmi Gupta, Academic Press, 1999 2nd edition.]

Four iron pipes are to bear the load as frame/chassis and the maximum static deflection of the used pipes should be around 0.66 mm, which is acceptable. Due to shock, these pipes will also deflect more and act as a shock absorber.[S.P. Sukhatme, Avocet, 1993 3rd edition.]

Figure1: Prototype of a tricycle powered by solar energy
Source: Designing Solar Three-Wheeler for Disable People /Md. Shahidul Islam, Zaheed Bin Rahman, Nafis Ahmad/ International Journal of Scientific & Engineering Research Volume 3, Issue 1, January-2012 ISSN 2229-5518

Overall road condition including bumps, pot-holes etc. around the country is duly considered while choosing the wheel as well as it's size. All the solar powered tricycle are of equal size having the diameter of 40 cm each. All terrain tires are used for better traffic ability. The body of the solar powered tricycle is made of pipes, steel sheets of minimum possible thickness and woods for lighter weight. Two leaf springs are added to the rear axle for better suspension. An adjustable waterproof cushioned seat is attached with the chassis. The solar panel is set on the top (overhead) with panel mounting frame made of light steel pipes duly attached to the main frame/chassis. While modeling; sharp edges, bends, nails are avoided to avoid accidents and ensure better safety. [JK Nayak Publishing, 1994.]

The basic size and dimensions of the solar powered tricycle are set to: Length: 132 cm, Width: 86 cm, Height: 137 cm with the ground clearance of 20 cm.

A normal handle bar decorated with brake lever, accelerator, switches etc. and attached with front wheel is used here as steering. The **speed of the tricycle powered by solar energy** is controlled by accelerator through continuous change in voltage by a twist throttle. Due to voltage change the motor power also changes and thereby speed is controlled by increasing or decreasing the voltage. Normal friction type braking system (as used in bi-cycle) is used in front as well as in rear-left wheel of this solar three-wheeler for better safety. The hand lever attached with handle/steering is used to actuate the brake. One headlight, indicator lights and backlights are attached to the solar powered tricycle, which get power from the battery. High-grade wires are used to make necessary circuits/wirings for electrical system of the tricycle powered by solar energy.[R. K. Pachuri. 1993 2nd edition.]

4. Working principle of solar powered tricycle

Solar panels transfer energy to 24 Volt deep cell batteries located on the tricycle's frame just below the chair. From there, a small brushless DC motor between the front wheel hubs powers the tricycle. The whole system is on a continuous feedback loop, enabling the bike to partially recharge while in use thus extending the bike's range. A DC motor located in front wheel is controlled by the speed controller and throttle. The rider can switch from pedal power to solar power easily, and when not in use, the solar panels continue to recharge the batteries. The motor's maximum is 500 W. [Tak Kenjo. Oxford University Press, 1991 3rd edition.]

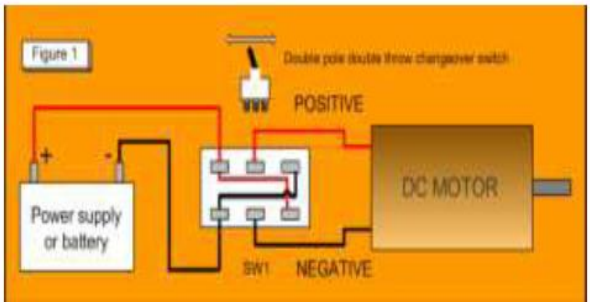

Figure 2: Working diagram of tricycle powered by solar energy
Source: Design of Solar Tricycle for Handicapped Person IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)/e-ISSN: 2278-1684 Volume 5, Issue 2 (Jan. - Feb. 2013), PP 11-24

Table 1: Number of persons with disabilities and their percentage among the resident population aged 5 years and above (Prevalence of disabilities) by sex, province and area of residence

Province and Area of residence	Total population (5 years and over)			Number of persons with disabilities (5 years and over)			Prevalence of disabilities (% of persons with disabilities)		
Rwanda	Male	Female	Both sex	Male	Female	Both sex	Male	Female	Both sex
Urban	777,994	732,386	1,510,380	27,289	21,418	48,707	3.5	2.9	3.2
Rural	3,518,825	3,946,741	7,465,566	193,861	203,885	397,746	5.5	5.2	5.3
Total	4,296,819	4,679,127	8,975,946	221,150	225,303	446,453	5.2	4.8	5.0

Kigali City									
Urban	397,446	353,111	750,557	12,232	8,818	21,050	3.1	2.5	2.8
Rural	111,255	115,421	226,676	5,705	5,415	11,120	5.1	4.7	4.9
Total	508,701	468,532	977,233	17,937	14,233	32,170	3.5	3.0	3.3
South									
Urban	105,390	96,801	202,191	4,751	3,714	8,465	4.5	3.8	4.2
Rural	943,007	1,073,307	2,016,314	54,610	59,244	113,854	5.8	5.5	5.7
Total	1,048,397	1,170,108	2,218,505	59,361	62,958	122,319	5.7	5.4	5.5
West									
Urban	127,255	129,950	257,205	4,504	3,855	8,359	3.5	3.0	3.3
Rural	854,402	984,527	1,838,929	48,194	53,479	101,673	5.6	5.4	5.5
Total	981,657	1,114,477	2,096,134	52,698	57,334	110,032	5.4	5.1	5.3
North									
Urban	67,028	73,239	140,267	2,125	2,055	4,180	3.2	2.8	3.0
Rural	636,522	718,921	1,355,443	29,282	31,713	60,995	4.6	4.4	4.5
Total	703,550	792,160	1,495,710	31,407	33,768	65,175	4.5	4.3	4.4
East									
Urban	80,875	79,285	160,160	3,677	2,976	6,653	4.6	3.8	4.2
Rural	973,639	1,054,565	2,028,204	56,070	54,034	110,104	5.8	5.1	5.4
Total	1,054,514	1,133,850	2,188,364	59,747	57,010	116,757	5.7	5.0	5.3

Source: Fourth Rwanda Population and Housing Census 2012.

The difference in disability prevalence rates observed for urban and rural areas of residence is also reflected at the district and sector level, as the lowest prevalence rates are found in districts with a large urban population. This is the case in Musanze district (Northern Province) with 3.3% of people affected by disabilities, the three districts of Kigali City with 3.2% to 3.4%, Muhanga (3.8%; Southern Province), and Rwamagana (3.9%; Eastern Province). The highest concentration of persons with disabilities can be observed in Gisagara (6.8%; Southern Province) and Karongi (6.5%; Western Province).

When distinguishing by province (Table 2), two provinces show a sex ratio higher than 100: the highly urbanised province of Kigali City and the Eastern Province. Among the population without a disability, this holds only for Kigali City, but at a lower level (108 males per 100 females) than among the population with a disability (126 males per 100 females).[Fourth Population and Housing Census, Rwanda, 2012 / Socio economic characteristics of persons with disabilities].

Table 2: Sex ratios of persons with/without disabilities by province and area of residence (aged five and above)

Province	Persons with disabilities			Persons without a disability		
Kigali City	138.7	105.4	126.0	111.9	95.9	108.0
South	127.9	92.2	94.3	108.1	87.6	89.3
West	116.8	90.1	91.9	97.3	86.6	87.9
North	103.4	92.3	93.0	91.2	88.4	88.6
East	123.6	103.8	104.8	101.2	91.7	92.4
Total	127.4	95.1	98.2	105.6	88.8	91.5
Count	48,707	397,746	446,453	1,461,673	7,067,820	8,529,493

Source: Fourth Rwanda Population and Housing Census (2012)

Data Analysis

Among 395 respondent 205 were male and 190 were female and according to the interview guidelines for 5 closed questions asked 201 males said YES it was difficult for people with disabilities to move from one place to an other place and only 4 males said NO it was not difficult ,for closed questions asked 190 female disabled people, 175 females said YES it was difficult for people with disabilities to move from one place to an other place and only 15 females said NO it was not difficult, this is for question number five as it is shown on table 3 below.

Note: The results analysis is not given in details above but both are also shown in the table 3.

From the answers of different respondent, it is very important and acceptable to design the solar powered tricycle for solving many problems met by some people with disabilities.

Table 3: Respondent who said YES and NO according to the questionnaire (See annex)

	Male		*Female*	
	Yes	*No*	*Yes*	*No*
Question 5	201	4	175	15
Question 6	199	6	170	20
Question 7	180	25	190	0
Question 8	186	19	186	4
Question 9	190	15	165	25

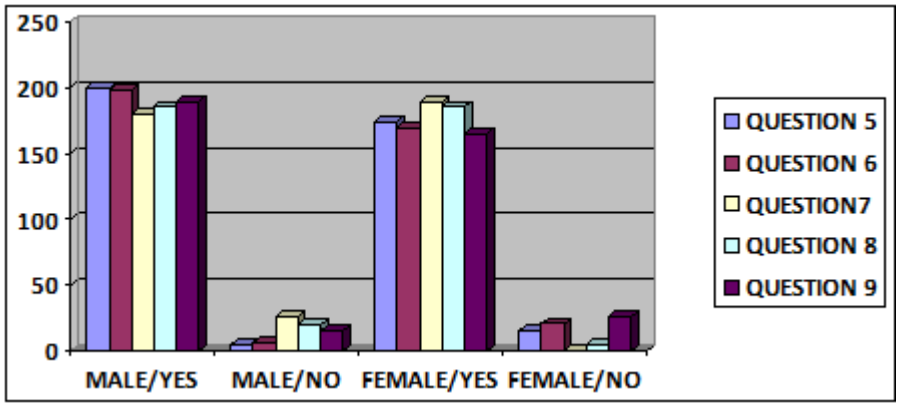

Chart of Respondent who said YES and NO according to the questionnaire (See annex)

5. Results Presentation, Interpretation, Analysis and Discussion

Interview results

According to the interview questionnaire (See annex) some results are found accordingly.

From question 1.What do you think are the reasons for people with disabilities to move difficultly?

Among 395 Respondents composed by 205 males and 190 female the 93% of both sex gave the same answer which is the lack of money for buying the means of transportation and 7% of both sex said that the problem is Government which didn't help people with disability to get the means of transportation.

From question 2.Among 395 Respondents composed by 205 males and 190 female the 98% of both sex said that is bad design of tricycle which cause the low speed of tricycle and 2% of both sex said that the low speed of tricycle is caused by lack of driving force, from this result I decided to improve the design of solar powered tricycle which able to achieve 20km/h.

	Male				Female			
	Yes	No	% of Yes	% of No	Yes	No	% of Yes	% of No
Question 5	201	4	98	2	175	15	92	8
Question 6	199	6	97	3	170	20	89	11
Question 7	180	25	88	12	190	0	100	0
Question 8	186	19	91	9	186	4	98	2
Question 9	190	15	93	7	165	25	87	13

From this table 4 above:

- 98% of male said YES for question 5 (See annex) and 2% said NO for the same question and 92% of female said YES for question 5 and 8 % said NO for the same question.
- 97% of male said YES for question 6 (See annex) and 3% said NO for the same question and 89% of female said YES for question 6 and 11 % said NO for the same question.
- 88% of male said YES for question 7 (See annex) and 12% said NO for the same question and 100% of female said YES for question 7 and 0 % said NO for the same question.

From question 3.Among 395 Respondents composed by 205 males and 190 female the 89% of both sex said that their tricycle request them high driving force and 11% of both sex said that the maintenance of the tricycle is not easy to be done by themselves. But this solar powered tricycle will be the solution of using high driving force because it has solar energy used to drive it.

From question 4.Among 395 Respondents composed by 205 males and 190 female the 85% of both sex said that they use buses and 15% of both sex said that they use tricycles when travelling to school. You see that most of people with disability don't have the tricycles which may be used for travelling to school.For remaining results are shown on the table 4 below.

Respondents identification

From a simple size is 32,170 handicapped people from Kigali city as shown in table 1 above, 395. Respondents were composed by 205 males and 190 females aged between 5 year and above some of them were married others single and they had different types of disabilities. Table 4: Respondent who said YES and NO in % according to the questionnaire.

- 91% of male said YES for question 8 (See annex) and 9% said NO for the same question and 98% of female said YES for question 8 and 2 % said NO for the same question.
- 93% of male said YES for question 9 (See annex) and 7% said NO for the same question and 87% of female said YES for question 9 and 13 % said NO for the same question.

Design calculation

Change in voltage cause change in speed for solar powered tricycle.

24V ⟶ 20 km/h
12V ⟶ 10 km/h
6 V ⟶ 5km/h
3 V ⟶ 2.5 km/h

Calculation for DC Motor

How much power do we need in watts?
Power (watts) = Total weight x g x speed x gradient
Where,

Total weight = 120 kg
Speed = 20 km/h = 20 x 5/18 m/s
Gradient = slope (assume 3%)
Power = 120 x 9.81 x 20 x 5/ (18 x .97)
= 6343.8 watt
Therefore power required approximately is 6343.8 watt.
Thus a 24 Volt, 6343.8 W motor will be enough for tricycle.

Calculation for Battery
System voltage 24 Volt,
Load current = 6343.8w/24v= 264.325A
Estimate 2 hours of tricycle running per day
Load current = 2 x 264.325 x 1.2 = 634.38Ah/day
Assume 20% overall losses,
Size of battery = 41.66 x 1.2 = 50 Ah/day
Energy required for 500 W motor = 50 Ah x24 V =1200 Wh/day.
Therefore 50 Ah/day, 24 Volt power is required for the system which can be supplied with the help of two 12 Volt batteries of 50 Ah/day. [Tak Kenjo. Oxford University Press, 1991 3rd edition.]

Calculation for whole complete solar powered tricycle
1. Determine the torque (force) that must be generated at each wheel in order to meet the functional requirement.
Mass of wheel = 6.804 kg
Acceleration = 0.9144 meter/square second
Torque = Newton/meters

Calculate required force in SI units
F = MA
$Force_{Total}$ = $Mass_{kg}$ x $Acceleration_{Meters/second2}$
$Force_{Total}$ = 6.804kg x 0.99144m/s^2
$Force_{Total}$ = 5.8 $_{Newtons}$
The Total force required to meet the Functional Requirement is 5.8 Newtons. However, the
Solar powered tricycle has 2 motors and 2wheels at rear axle, the front wheel is pushed. Therefore each motor/wheel combination needs only supply half the required force or 2.9 Newtons.
$Force_{Wheel}$ = 2.9 $_{Newtons}$ [Tak Kenjo. Oxford University Press, 1991 3rd edition.]

Specification of the Proposed Tricycle Components:
So according to the engineering design calculations the required components:
- Solar panel: 24 Volt, 6343.8 W,20A
- Brushless DC motor: 24 Volt, Power rating is 6343.8 W, 300 rpm.
- 2 Battery of 12 Volt, 40Ah.
- Maximum load capacity: 30 kg.

The block diagram of the solar power system used in the project gives the overall working structure of the system. Initially the solar panel is placed on the top of the tricycle, which converts the solar energy to electrical energy, is connected to the battery in order to charge it with the help of a charge controller, the charge controller coverts the fluctuating/pulsating flow of electric charge into constant flow of electric charge which can be supplied to the battery to charge it.

Now, the battery supplies the required amount of power to the DC motor, which is connected to the axle of the wheel. A throttle is provided to control or maintain the speed of the tricycle.

Speed of tricycle calculation
Power = mass x g x speed
Given data:
Power of solar panel=6343.8 W
Mass of tricycle and person=120kg
g=10m/s^2.
⇒ Power = mass x g x speed
6343.8 = 120 x 2.5 x speed
Speed = 6343.8 / 300
Speed = 1 m/s
Speed = (1 x 3600) /1000 = **21.146 km/h**
The solar powered tricycle maximum speed should not exceed the above calculated.

Consideration & Calculations
The total weight of the tricycle is 50 kg (including person & battery). Commercially available single solar cells normally have the dimensions of (3"× 6"), (10 cm ×10 cm) etc. A (10 cm ×10 cm) solar cell's electricity output is likely rated at 0.50 to 0.55 volts with 3 to 3.3 amps. Here, in the module, 36 cells are connected (in series) together so that in all operating conditions a PV module gives well above 12 volts, which is the required to charge a
12 V battery.
For 36 cells ⟶ 0.50x36 =18 Volts to 0.55x36=19.8 Volts

Important features and major specifications

The major specifications are summarized in Table 5.

Table 5: Major specifications of the proposed tricycle powered solar energy

General specifications	
Size: 132x86x137 cm	Steering/Drive system: Handle Bar
Height: 137 cm	Speed control: Continuous (Voltage Regulation)
Weight with battery & person: 120 kg, Load Capacity: 30 kg	Seat: Cushioned and Water proof. Frame: Steel in parts with high strength requirements.
Speed: 21 km/hr	Braking system: Friction Type
Distance per charge: 39km	Shock absorber: leaf spring at rear.
Maximum weight capacity: 120 kg	
Wheel diameter of 68 cm	
Power specifications	
Solar Panel: 6343.8 Watts ,24V	Batteries: lead acid battery, 12 V-40 A-hr. Charging time: 6 hr
Motor: Brushless DC motor, 24 volt, Maximum load current is. Power rating is 500 W, 300rpm.	Charge controller: Solar based (MPPT type).

6. Analysis

Table 6: Analysis for data of manual driven tricycle and tricycle powered by solar energy

Basic dimensions of the presently available manual driven tricycle and solar powered tricycle	
Manual driven tricycle	Solar powered tricycle
Length:97 cm =73.4%	Length:132 cm =100%
Width:56 cm = 48%	Width: 86 cm =100%
Height:71 cm = 97.2%	Height: 137 cm =100%
Rear Wheel Dia.:51cm=34.6%	Rear Wheel Diameter :68cm=100%
Front wheel Dia.: 51 cm=34.6%	Front Wheel Diameter:68cm =100%

Based on the above table 2. We see that this solar powered tricycle is the most improved according to the analysis results difference such as length difference of 26.6%; width difference of 58%; height difference of 2.8% and Rear Wheel Diameter to Front wheel Diameter difference of 65.4%

7. Conclusion

As the physical effort to drive the tricycle has been reduced and the developed tricycle powered by solar energy is able to travel long distance without being recharged and also this tricycle powered by solar energy must achieve the maximum speed which is high comparing with the old means of transportation for people with disability reason why is better for people with disability to choose and use this tricycle powered by solar energy, I can say that my project can be a success considering the changes I had to make in the country once I actually found out how the mechanical tricycles and hybrid solar tricycles were for. I can achieve my aims, and I believe that I have a system that is effective in providing mobility for persons who have disabilities with a maximum speed of 20km/h range to 10km/h and this tricycle is able to travel 4 hours without being charged. One of the major lessons I have learned is that designing an appropriate technology is a huge challenge. Appropriate is more than just availability for replication, it considers longevity, reliability, and efficiency.

The tricycle powered by solar energy was successfully developed as per the design for disabled community. This tricycle works on solar source and employs DC motor to drive the tricycle. The average and maximum speed was obtained as 20 km/h. Due to limited solar energy during cloudy/rainy days provision is made to charge the battery using external electric power source. The Chassis/Frame of the presently available three-wheeler is heavy and wheels are of big sizes so while designing, unnecessary weight were reduced to meet the requirement for this solar powered tricycle.

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Author Profile

Mr Jean Pierre TWAJAMAHORO received the B.Eng. and M.Eng. degrees in Mechanical and Production Engineering from the University of Burkina Faso/IST Burkina Faso in Automotive and Power Engineering. He is currently Assistant Lecturer at the University of Rwanda/College of Science and Technology (Department of Mechanical and Energy Engineering.