REPLACEMENT OF STRUCTURAL STEEL WITH BAMBOO IN THE SOLAR PV SECTOR TO ACHIEVE CARBON NEUTRALITY

Principal Investigator: Mr. Pranoy Lahiri Co-Principal Investigator: Mr. Tanmay Singha Mahapatra Organization: Arka Renewable Energy College



PROBLEM STATEMENT

- Solar PV Module Mounting Structure and Street light Poles use a significant amount of steel structures made of Mild Steel, galvanized iron, and cast steel.
- Production of a ton of steel results in 1.5 to 3 tons of lacksquare CO_2 emissions that contribute to climate change.
- Conventional Torches and existing solar garden lights are made of plastic bodies and steel structures. Plastic body torches are single-use ones and are improperly disposed of after usage, causing plastic pollution.





Solar Garden Lights

Conventional Module Mounting Structure

Street Light MS Poles



Conventional Torches

OBJECTIVE

- To ensure minimum use of steel in solar devices/ products which will reduce CO₂ emissions.
- Studying the different properties of bamboo fibers and devising proper chemical treatment in order to develop long-lasting, durable, and degradation-free bamboo stems.
- Replacing steel/ metal or plastic-based solar street lights, solar garden lights, and solar torches with their bamboo counterparts.
- Development of a novel bamboo-based module mounting structure for solar PV panels which will be both durable and affordable along with Integration of bamboo structure with solar panel in a rigid form.
- Conducting Workshops, Demonstrations, and training for environmental awareness as well as manufacturing, maintenance, repair, and handover of bamboo-based products to beneficiaries.
- Commercialization and Scaling Up of the fabricated units.





BASELINE SURVEY

- The primary work of the project team led by PI and Co-PI focused on finding out the availability of suitable bamboo species.
- After an extensive survey it was found that bamboo is extensively found in the North Eastern states of India.
- On the basis of the survey, four acceptable bamboo species that provides good structural stability were selected.
- The following bamboo species were selected for our project activities:-
- 1. Kanak Kaich bamboo (Thyrsostachs Oliveri)
- 2. Barak bamboo (**Bambusa Balcooa**)
- 3. Bom bamboo (Bambusa Cucharensis)
- 4. Makal bamboo (**Bambusa Pallida**)





Cutting of Bamboo



Relocating the Bamboo



Thoroughly Inspecting Bamboo



Preparing the surface of Bamboo for Treatment

TREATMENT OF BAMBOO TO ENHANCE ITS DURABILITY

- The project team found that untreated bamboo is more susceptible to insects, borers, and fungi due to the presence of high starch and moisture content.
- An extensive research was conducted to find an environmentally friendly chemical treatment method for the effective preservation of bamboo species.
- Special emphasis was also given to the selection of proper bamboo species which will be further treated to enhance its longevity.
- As our proposed fabricated products will be ready for withstanding all weather conditions, the project team proposed the following chemicals to enhance the bamboo quality.
- 1. Copper Sulphate
- 2. Sodium Dichromate
- 3. Boric Acid
- 4. Creosote



Injecting Creosote oil into bamboo nodes

Prepared chemical solution

CHEMICAL TREATMENT PROCESS

- Chemical treatment were implemented using proper safety measures. Apron, safety shoes, helmets, masks and gloves were used.
- Combination of three chemicals were used namely Copper Sulphate, Boric Acid, and Sodium Dichromate in a 10% solution with a 4:4:1 composition ratio diluted by adding 90% water.
- A bamboo treatment chamber was constructed with bricks where the untreated bamboo was immersed in the chemical solution for 24 hours.
- After this primary treatment was performed, the bamboo was left outside in a shaded area for 2 days.
- A secondary treatment was performed where Creosote oil was injected into the bamboo nodes and was left for absorption for 48 hours.
- This method is called as Nodal Injection Method. The remaining oil from the bamboo were extracted.
- The entire course of treatment got completed in 4-5 days.





Pouring the chemical solution in the chamber



Treatment Chamber



Untreated bamboo Submersed in the chamber

FABRICATION OF BAMBOO SOLAR GARDEN LIGHT

1. Bamboo-based Solar Garden Light:

- **a. Concept development**: Few prototypes were made using the treated bamboo for testing the structural joints and observing the performance of the indigenously developed circuit. Different methods were checked for fixing solar panel with the structure.
- **b.** Designing the Prototype: Among the various designs two structural design one of 'T' shaped and the other one of 'Vertical Flat Standing' shaped were finalized for its prototype fabrication considering its proper load bearing capacity.
- **c. Prototype Fabrication**: Two prototypes were fabricated by utilizing three different bamboo species. Cutting, Shaping, flattening, and designing the bamboo structures are being performed by the help of different tools.
- **d. Circuit assembling**: The circuit with all its components were fixed inside the bamboo hollow portion.
- e. Solar Panel Mounting: To achieve optimal tilt angle and to hold the solar panel firmly on the top of the structure, bamboo strips were used along with nuts and bolts.





FABRICATION OF BAMBOO SOLAR GARDEN LIGHT

f. Sealing the gaps: Water-resistant adhesives were used to fill the minor air gaps in the structure, which will prevent water from seeping inside it.

g. Applying overcoat: Varnish were used as a top coat, which enhanced the shine of the structure, making it more aesthetically appealing.

h. Prototype Testing: The fabricated prototypes were kept outdoors in rainy weather conditions for more than a month and proper functioning was observed. In the months of August-September, this prototype withstood about 400 mm of rainfall and is performing satisfactorily. The team member thus concluded that the fabricated product is water resistant.

i. Prototype to Product Development: The team member further developed two more fabricated final product, based on the data and observation of the initially fabricated two prototype structures.

j. Technology Readiness Level- The bamboo solar garden light is currently at TRL-7.





Two types of Bamboo Solar Garden Light developed Product

FABRICATION STAGE OF BAMBOO SOLAR GARDEN LIGHT





Mounting of Solar Panel

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Optimal Tilt angle observation

Light illumination testing



Circuit Assembly



Bamboo Cutting for fixing Panel



Surface Light illumination of both structure in a dark area

PERFORMANCE OF THE BAMBOO SOLAR GARDEN LIGHT

During the performance evaluation, the following were observed:

- The battery typically gets fully charged in 5 hours 25 minutes on sunny days and 6 hours 30 minutes on cloudy days, on average.
- The BMS offered proper overcharge protection and deep discharge protection. •
- While being discharged, the battery voltage drops by 0.07 V every hour. The load draws a constant power of 1 watt at all times. The • battery's cut-off voltage is 7.35 volts.
- **Technical Details:** The Automatic Dusk to Dawn Controller and SPV charging indicator are properly working. The operating time of • the load is from Dusk to Dawn i.e., for 12 hours. During Cloudy weather, an additional backup of 3 hours is achieved.
- At a distance of 1 sq. ft. in radius, with the structure in the center, 40–45 lux is attained in a completely dark area.
- **Product Cost**: The production cost of the Bamboo-based Solar Garden is approximately 9 Euros. •





PERFORMANCE OF THE BAMBOO SOLAR GARDEN LIGHT



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FABRICATION OF BAMBOO SOLAR TORCH LIGHT

2. Bamboo based Solar Torch Light:-

- **Bamboo Body**: In Solar Torch Light, only one species of bamboo (Bambusa Pallida) is used as the chosen bamboo being diametrically thinner provides good structural strength.
- **Hand-tool and Equipment**: Chisel and wood Surface Planar were used for properly shaping the piece of bamboo into a hand-held torch.
- **Dimension of the Torch**: A pocket-size bamboo torch was made having a dimension of 5 inches length with a 1.5-inch hollow diameter. A small-size bamboo torch was designed for easy carrying.
- **Circuit and Battery Assembly**: The hollow portion of the bamboo were used to hold the controller circuit and battery in a compact manner. On-off Switch along with the charging port were fixed within the torch by making appropriate holes.
- Aesthetics:- The outer frame of the solar panel were covered with bamboo strips which will also act as a stand for the panel. The outer frame of the torch is smoothened for effective gripping and comfortable holding of the torch.





PERFORMANCE OF THE BAMBOO SOLAR TORCH LIGHT

During performance evaluation the following were observed:

- The 2-watt solar panel is effectively charging a 1S Lithium Polymer battery with a capacity of 500 mAh in approximately 1 hour 30 minutes.
- The load consumes 0.5watt. The torch were tested in two intervals. •
- The torch was kept ON till it turns off automatically, and the performance data was • noted in every hour interval. It was found that it is operational for 3 hours 50 mins.
- Another approach was taken where the torch was turned on for 30 mins, and then kept • turned off. When we operated the torch for 30 minutes and observed the performance, then the total lighting hours of the LED or the battery discharging hours was 6 hours 54 minutes.
- **Conclusion:-** In one single charge, the torch can operate for 3-4 days considering 1 • hour of daily operation and can operate for 6-7 days considering 30 minutes of daily operation. 110-115 Lux is obtained at a distance of 5m.
- **Product Cost**: The production cost of the solar bamboo torch light is 4 Euros. •









FABRICATION OF BAMBOO SOLAR STREET LIGHT

3. Bamboo based Solar Street Light:-

- Selection of Bamboo: The project team has used two different treated bamboo structures for designing the bamboo poles and • light cabinet for the street light. For fabricating the bamboo pole Bambusa Balcooa were used and for the Light cabinet design, Bambusa Pallida was used.
- The total height of the bamboo pole is 9 feet out of which 1 foot will be used for outdoor fixing below the ground level. •
- Solar Panel Mounting: The light cabinet were integrated with solar panel. and fixed on the top of the structure accordingly in \bullet such a way that could withstand the high wind pressure.
- Technical Details:- A 40-watt solar panel is mounted which is used to operate a 9-watt luminary from dusk to dawn giving an emergency backup of 4 hours during cloudy days.
- Performance Evaluation: The prototype performance evaluation work and testing under different environmental conditions is currently in progress.





FABRICATION STAGE OF BAMBOO SOLAR STREET LIGHT



Cutting of bamboo for solar street light

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Solar Streetlight during the day time







Solar panel fixed in the upper section of the Street Light

Solar Streetlight Functioning at night

FABRICATION OF BAMBOO SOLAR MODULE MOUNTING STRUCTURE

4. Bamboo based Module Mounting Structure:-

a. Bamboo Structural Selection: The treated Barak Bamboo (Bambusa Balcooa) species is used to fabricate the module mounting structure. Through the desk research it was found that Bambusa Balcooa posses appropriate sturdiness and will able to provide effective structural strength.

b. Bamboo Prototype Design Structure:

i) The team designed the two frontal limbs of the module mounting structure at 1.5 feet height and the back end limbs made of 3 feet height so as to achieve the desired tilt angle for the solar panel.

ii) The horizontal channel of the bamboo mounting structure is made of 6.5 feet length and is designed with Thyrsostachs Oliveri to provide effective support for the panel.

iii) The project team is yet to carry out further tests with the prototype model.

iv) The module mounting structure is in the initial developing stage and much work progress has to be carried out.





Prototype Bamboo MMS Structure



Solar Panel Mounted onto the Bamboo MMS Structure

PROJECT OUTCOMES

- Low-cost Bamboo-based Module Mounting Structure than its Steel Variant reducing the total cost of Solar Power Plant. •
- Bamboo Solar products will have high carbon sequestration capacity replacing traditional materials with having higher carbon footprint. •
- Bamboo-based Solar Street lights and solar Garden lights will replace the use of Steel Poles reducing carbon emissions and both product ٠ costs.
- Bamboo-based solar torches will replace conventional plastic body torches and can be an alternative emergency light source for rural ۲ communities.
- A standardized eco-friendly and sustainable module mounting structure using bamboo will be developed which will be market-ready. •
- Bamboo-based solar products help to promote renewable energy by reducing carbon footprint and reliance on fossil fuels encouraging ٠ sustainable development.
- Specific Bamboo cultivation can be encouraged promoting rural development thereby acting as a source of livelihood and employment \bullet generation for unemployed youth.



SCALING UP AND COMMERCIALIZATION

- Our Fabricated two products namely bamboo solar garden light and solar torch light have been displayed in various handicraft • shops and exhibition showrooms.
- On the basis of the product display, 30 solar torch orders have been already placed thus boosting a huge market demand in purchasing the fabricated products.
- A Research Paper on the performance of Bamboo-based Solar garden lights is being submitted to an International Conference on Control, Instrumentation, Energy & Communication (CIEC) 2024.
- Promotional marketing is being carried out through the website of various vendors.
- Our tied-up project industrial partner R&D Solar Enterprise has already started large-scale manufacturing of the developed garden light and torch light.
- Colorful catalogs and technical manuals of the products will be made mentioning the highlights of the product so as to market the products on a large scale basis.
- The Project team will conduct Training and workshop programs on the fabrication of bamboo-based solar products to popularize this technology.
- Entrepreneurship Development program will be taken up and the technology will be made open source so that interested entrepreneurs can immediately start manufacturing bamboo-based consumer products.



CHALLENGES FACED DURING THE PROJECT

- The project team faced a huge challenge in jointing different bamboo structures during fabrication of the garden light.
- The team found hurdles in accommodating the circuit and the battery into the bamboo hollow portion of the solar garden light.
- The project team had to face challenges in the mounting of solar panels onto the bamboo structure as bamboo being circular in shape, firm and structural stability was not being initially achieved.

Learnings Undertaken:- The team took necessary learnings from the initial hurdles and subsequently fabricated the products taking into consideration all precautions and safety measures.





Bamboo Cracking



Ineffective Jointing of two bamboos



Improper Fish-mouth Joint

BENEFICIARIES OF THE PROJECT

In this proposed project, the beneficiaries are as follows:

- 1. Solar power plant developers.
- 2. People living in rural areas and village communities.
- 3. Governing bodies of rural areas, schools, hospitals, villages, etc.
- 4. Hotels, Resort, Guest House Owners
- 5. Small Businessmen and Entrepreneurs.
- 6. Metropolitan, Urban, and Semi-urban Households and Apartments.





Rural communities



Hotels and Resorts



Households and Apartments

FINANCIAL EXPENDITURE

Financial Expenditure

SL No	Grants Position	Amounts in (INR)	Amounts in (EURO)
1	Sanctioned Amount	380000	4940
2	Released Amount(Ist Installment)	266000	3458
3	Received Amount	260000	3380
4	Amount Utilized	226201	2940
5	Amount in hand	33799	440

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THANK YOU







