Impact of Alternate Energy Sources in improving Carbon Rating: Special Case of Solar Energy

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1. Introduction

Carbon dioxide is a natural byproduct of life's cycle. Plants consume it, and oxygen creates and releases it by mechanisms including animal respiration, natural degradation, and caused by human activity fossil fuel combustion. The balance between these processes determines the global CO2 level. CO2 is generated when hydrocarbons such as oil, coal, and gas are burned. It cannot be entirely replaced from the burning process, although it can be substantially minimized at a significant expense. Carbon emissions are largely driven by economic activity.

According to the Environmental Protection Agency's World Energy Outlook 2000, carbon Dioxide emissions will grow to 29,575 million tonnes in 2010 and 36,102 million tonnes in 2020 [1]. The rapid deposition of CO2 in the environment would have an immediate force on the earth environment by warming the soil. This influence is linked to CO2's emission of long wavelength radiation, which is higher than that of other GHGs. Indeed, as anthropogenic carbon dioxide contribution reaches several billion tonnes, equal to a 60 ppm raise in attention from today, the northern hemisphere's atmosphere will be 1°C colder. [2].

According to the International plate on atmosphere alteration (IPCC), the earth’s overall indicating face high temperature has enlarged by 0.3 to 0.6 degrees Celsius since the late

1800s. According to Giorgi and Hewitson [3, a doubling of CO2 will raise temperatures by 2–4°C and reduce rainwater by 10–20% (>1 mm day-1). Since the beginning of the industrial revolution, carbon dioxide levels have risen by30% [4].

Because of the increased CO2 content in the environment, the world's atmosphere retains an increasing amount of heat, resulting in higher global temperatures. This rise in air temperature is concerning because even a small increase in temperature can have significant regional consequences, such as sustained drought conditions, crop loss, Changes in cropping patterns,greater desertification, and polar ice melting have resulted in ocean floods and the engulfment of enormous swaths of low-lying oceans and coastal regions. Human activity, climate change, the occurrence of natural disasters such as floods, and rising sea levels are all on the rise, and all of these phenomena are attributed to rising carbon dioxide levels and human activity, which mostly include carbon emissions from fossil fuel combustion. [3]. One of the most important inputs for financial growth and progress has long been known as strength. Economic growth and energy use have a strong two-way relationship. On the one hand, the supply of cost-effective and environmentally safe energy supplies is critical to an economy's global competitiveness, and on the other hand, the level of economic production has been shown to be contingent on energy demand.

India's yearly average electricity usage is still among the worlds lowest, at about 630 kWh per person, but it is anticipated to rise to 1000 kWh in the not-too-distant future. In 2008, the maximum energy consumption was 120 GW, but only 98 GW could be provided, according to the Central Electricity Authority (CEA). According to Aston Field, an Indian PV plan developer, the shortage is projected to hit 25 GW. The department of Energy has set a goal of supplying "Power to everyone."

Solar energy is manifested in the shape of wind. Wind gusts are caused by the sun's rough heating of the environment, disturbances on the soil's shell, and the revolving of the ground.

The earth's landscape, water bodies, and plants all influence wind patterns. People use wind patterns, or movement of energy, for a range of uses, as well as kite flying, sailing, and even power generation.

The technique of using the wind speed to create automatic Energy or electricity is referred to as offshore breeze or storm speed power. Wind turbines change the wind's kinetic energy into automatic energy. This automatic energy can be secondhand for basic activities (such as grinding granule or pushing water), or it can be transformed into control by a generator.

2. Literature Review

2.1 Introduction

When compared to traditional power generation, renewable energy power generation produces significantly less carbon. Both renewable energy systems contribute to climate change in some way. This is due to the fuel used in their construction and as a backup source of energy when they are in service. It's difficult to calculate conservatory vapor releases per kilowatt hour of power accurately, but it's a vital part of policy and planning. Wind energy, solar energy, and waste to energy generation systems are among the numerous clean energy technologies that are still developing and have a lot of potential in the world.

Figure 2.1 depicts conservatory gas releases starting different power cohort schemes. In comparison to other power generation systems, wind energy systems emit less greenhouse gases over their lifetime [5]. The current paper addresses wind oomph and astral photovoltaic system strategies and growth in India. In India, a life-cycle evaluation was conducted on some existing wind turbine power plants and solar roof-top PV systems. The carbon strength and carbon reimbursement passé for the above method were measured in order to determine the ecological effects energy reimbursement historical.

2.2 Wind energy

The majority of GHG emissions from wind turbines occur during turbine generation and plant construction, accounting for 72-90 percent of total emissions [6]. Offshore wind turbines, for example, need considerably more steel and cement in their construction than their on-shore counterparts. The processes of repair and control, decommissioning, infrastructure management,emissions [6]. Since the production processes for onshore and offshore wind plants are very similar, life cycle analysis reveals that the carbon footprints of onshore 4.64 gCO2eq /kWh and offshore 5.25 gCO2eq /kWh are nearly identical [7].

2.3 Electricity Generation System

Due to the extreme cubic relationship between wind velocity and power production, GHG releases from wind turbines are very location exact and responsive to wind speed situations. The results show that wind regimes differ significantly by geography, ranging from 8-30 gCO2eq/kWh for onshore turbines to 9-19 gCO2eq/kWh for off-shore turbines [8-12].

Since no CO2 is free during the generation of electricity, wind turbine electricity is considered a renewable energy source. However, when considering the life cycle, only a smallamount of CO2 is released at the other stages. As compared to the international average electricity (504 g CO2/kWh), the installed c4a8pacity of wind turbines will minimise CO2emissions by around 1.2 lakhs Mg per year [13]. The CO2 savings achieved are equivalent to Hungary's annual CO2 emissions [14].

Several educations have been showed on the environmental belongings of renewable energy [15-18]. Numerous studies have looked at the energy supplies and performance related with wind turbines in instruction to calculate the carbon emissions from the systems [19]. The results of these studies differ a lot depending on a few main variables, such as the embodied energy evaluation approach used, the device border, and the life cycle stages measured.

2.4 Solar Photovoltaic energy

Usually, four systems have been evaluated from different life-cycle educations for PV arrangements, which vary between 43 and 73 CO2eq/kWh [6]: mono-crystalline, polycrystalline, non - crystalline, and CIGS (Copper Indium Gall5iu2m Diselenide). Monocrystalline species, on typical, release the most GHGs of the four processes, ranging between 43 and 62 gCO2eq/kWh[6]. Over the course of their GHG life-cycle, many PV structures can release among 50 and 73 gCO2eq/kWh. Differences in the results can be accredited to a variety of variables, counting silicon quantity and grade, network to generate and lifespan, and irradiation situations.

Thailand has a 500KWp solar farm. For such power plant, two kinds of heat cells are regarded: Photovoltaic made of scatter graph (m-Si) and thin film carbon nanotubes (a-Si) [9]. According to studies from the Netherlands and the United States, major environmental expenses were not primarily related to the energy use of renewable power electricity production, but rather happened during module progress [8]. In Japan and Thailand, the ecological impressions of nuclear plant constructions were examined using the Nonlinear Ecological Total Specification (NETS) tool and the Life Cycle Assessment (LCA) approach.

Alsema E.A. studies the energy demands of PV components and devices, calculating the Dynamism Payback Time for two main PV presentations. For current technology, he calculates the required energy for a-Si to be 1200MJ/m2. The BOS in granite roof-top systems and grid solar systems have also had their current and potential energy requirements calculated. Current grid-connected systems have an approximate energy payback period of 38 years (less than 1700 KWh/m2 contamination) and 1-2 years for future models. These devices emit 60-150 grammes of CO2 per kilowatt-hour now and 20-30 grammes per kilowatt-hour in the future. For more than 7 years, the battery in solar home systems is the source of a reasonably high EPBT. CO2 emissions are now projected to be between 250 and 400 grammes per kilowatt hour, with potential emissions expected to be about 200 grammes per kilowatt hour.F. Sherwani investigated the life cycle assessment (LCA) of a 50 kW solar photovoltaic (SPV) device in the Punjab town of Bazak (Bhatinda) (India). PV modules are the most costly items in the SPV system in terms of both energy and environmental costs. The normalized greenhouse gas (GHG) releases were predictable to be 55.7 g-CO2eq/kWh, and the energy pay-back period (EPBT) was found to be 1.85 years. These findings were compared to those of other SPV power generation systems. The production of PV modules was discovered to have the highest power consumption and GHG emissions. 8.4 percent of overall embodied power and GHG emissions were accounted for by theinverter and power wire. In addition, transportation financial records for 1% of overall personified energy and greenhouse gas release [16].

3. Methodology

3.1 Life cycle assessment

LCA is a device for measuring manufactured goods or system's environmental implications through its complete lifecycle, usually from abstraction of underdone resources from side to side disposal site. When contrasting the LCA GHG emission outputs of different vigor restraints, it's important to remember that the power generation options aren't always actual alternatives.

A Life Cycle Approach is passed out in four different stages, as indicated in figure 3 to the correct, according to the ISO 14040 [21] and 14044[20] standards. The phases are frequently interrelated in that the outcomes of one phase influence the completion of subsequent phases.

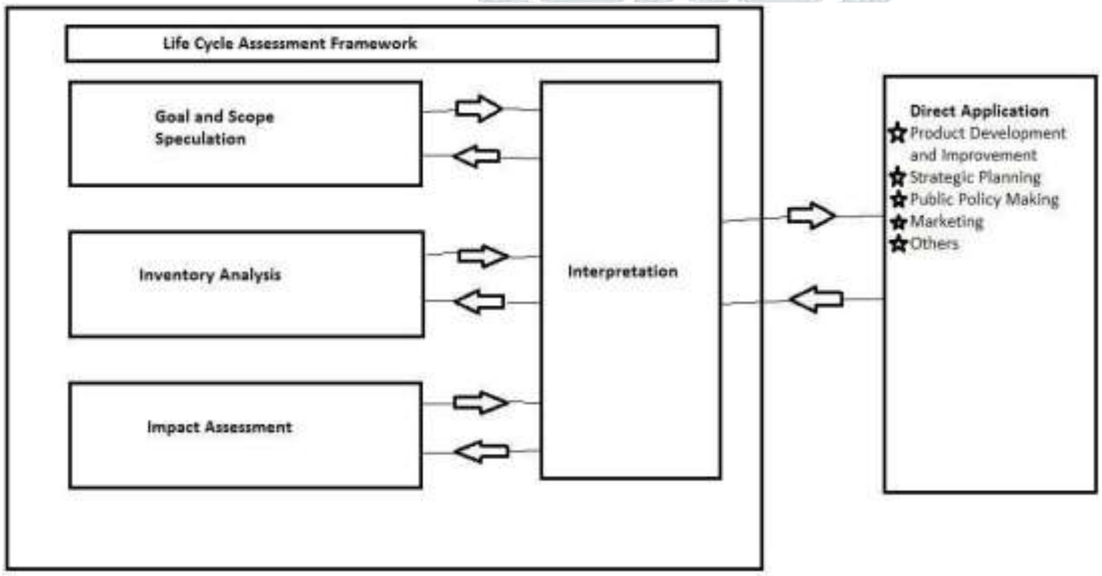

Figure 1 Life cycle assessment framework

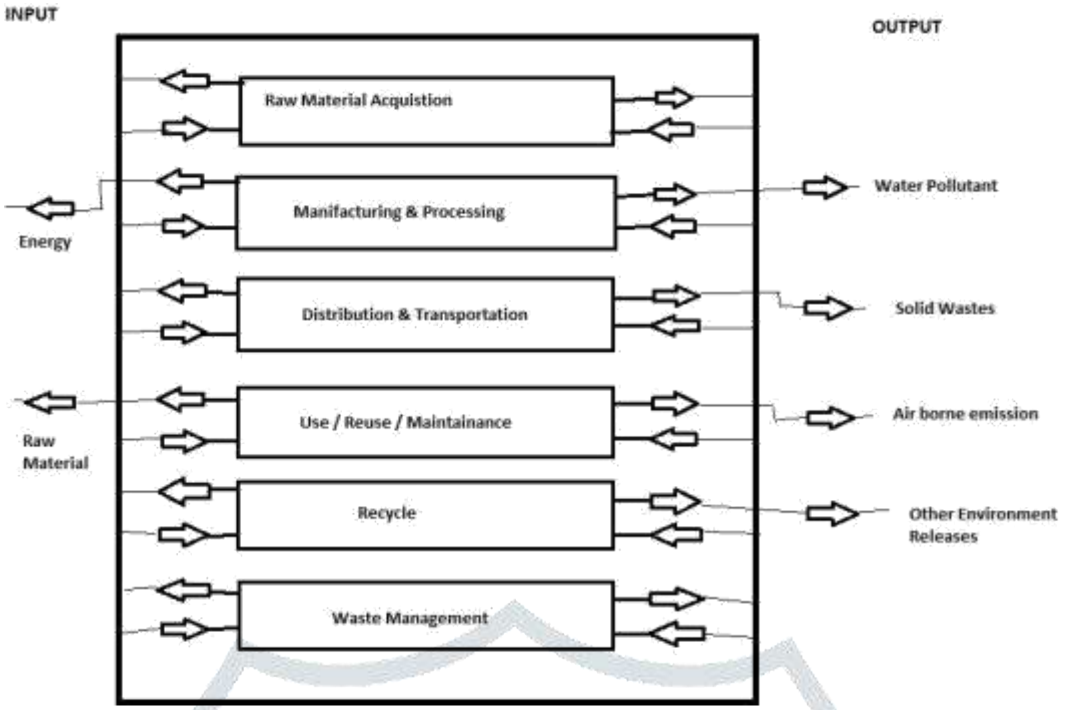

Figure2 Life cycle assessment

3.2 Goal and scope

An LCA begins with a clear declaration of the study's purpose and scope, which establishes the learning's context and specifies how and to whom the findings will be conveyed. The aim and scope of an LCA must be clearly stated and compatible with the envisioned use, according to ISO standards. As a result, the aim and scope paper provides technical information that will guide future development [22].

The useful unit, which postulates what is being inspected and enumerates the package providing by the creation system, allowing the contributions and manufactures to be correlated. Besides, the useful unit assists as a serious establishment for comparing and analysing various merchandises orservices.

3.3 Life cycle inventory

For a production process, a Life Cycle Inventory (LCI) analysis entails accumulating a list of currents from and to environment. Involvements of water, power, and rare materials, as well as liberations to air, land, and water, are included in warehouse flows. A design method of the technical system is built data derived on efforts and productions to generate the inventory. The design method is often depicted as a flow chart that comprises the actions that will be evaluated in the related supply chain and shows the mechanical scope of the system clearly.

All actions within the system boundaries, including the supply network, are gathered for the input and output data required to build the model (mentioned to as inputs from the techno-sphere).

3.4 Interpretation

A methodical approach for recognizing, enumerating, examination, and calculating information from the findings of the life cycle survey and/or the life cycle effect analysis is known as life cycle exploration.

One of the most important goals of life cycle analysis is to assess the near of trust in the final outcomes and to convey them in a rational, comprehensive, and correct method. It's not as straightforward as "3 is greater than 2, hence Variant A is the best choice" to verify the data of an LCA! Understanding the correctness of the outcomes and safeguarding they see the study's objectives are the first steps in interpreting LCA data. This is performed by identifying the data items that have a major impact on each input factor, examining the sensitivity of these major data components, reviewing the study's integrity and accuracy, and providing findings and suggestions based on a clear knowledge of how the LCA was performed and the results were obtained.

3.5 Type of LCA Methodology

Processing Sector Analysis (PCA) and feedback (I/O) are the two most common LCA methodologies; however hybrid examining the application (combining components of both) is also common. PCA is a horizontal underside method that takes into account outputs from specific industrial processes and systems, as well as a restricted number of providing companies and their related emissions, and is thus a precise but source of energy method. When entire material catalogues weren't always accessible, PCA heavily relies on GHG digital information for all key manufacturing processes. In this situation, a hybrid strategy may use PCA for component analyses and I/O to create data with certain systems operation and maintenance (O&M), manufacturing procedures, and other operations where full information is not accessible [23]. The I/O technique is a top-down statistical methodology that splits an economy into discrete sectors.

I/O creates vitality streams and related releases based on financial outputs and inputs between sectors [23]. For example, a well-established I/O database predicts the amount of vigor needed to create various product classes and gives service categories. Specific sectors, on the other hand, do not appear in the I/O table and must be modelled using PCA. In comparison to results acquired by the PCA approach, LCA based only on I/O examination has apparently yielded findings that are 30 percent higher, and in the event of a nuclear power, the deviation might be close to an issue of two [23].

As a result, it's been suggested that a hybrid strategy joining LCA and I/O be used. The techniques, in which the I/O approach is utilised primarily for measuring activities of extreme position, such as power needs arising from contributions from high-order source restraints. By controlling for all processes, hybrid features require the analysis' boundaries to be enlarged. This is especially true when a system contains a large number of processes and process steps. A mixture of PCA and I/O is the most feasible technique to LCA in most circumstances [23]. With tiny truncation errors, PCA is highly trustworthy and will be utilized wherever possible. However, data on energy usage is not effectively captured for many processes. The accessibility of price statistics in these conditions allows for assessment using the I/O line of attack. The I/O approach will be used to assess various aspects of installation, process, repair, and mothballing. As a result, the GHG release approximations given here are based on a mix of I/O, PCA, and hybridmethods.

4. Life Cycle Assessment of Solar PV System

4.1 Introduction

The purpose and scope of the life cycle assessment, as well as the life cycle inventory (LCI), life cycle impact assessment (LCIA), and evaluation [24], are all based on the ISO 14040 standard. Since the early nineties, LCA has been used in a variety of industries to evaluate the green effect of a product's entire life cycle, including its production, use, and waste. The LCA is based on a list of the raw resources, capital goods, industries, transportation, energy, and fuels that are required to make a product. [25]. the steps of the life cycle are depicted inFigure 3. Environmental factors or processes are the energy and material inputs, modifications, and outputs.

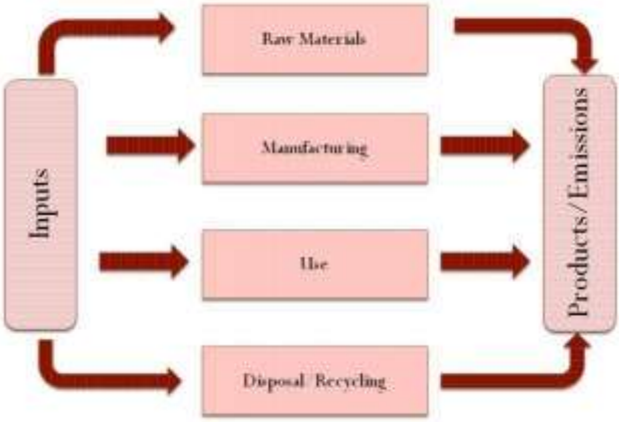

Figure 3 Stage wise life cycle assessments

Figure 4 depicts a tablet schematic of the Poly – Si PV module manufacturing procedure. For the production of solar cells, a crucible technique was created, which is continually cast in ingots using electromagnetic casting technique. Multi-wire maxims are used to change the alloys into wafers. Several PV panels are coated in EVA between a pane and a Tedlar sheet before being finished with metal frames.

With the current state of technology, a complete LCI for polycrystalline silicon panels has been created, which comprises polycrystalline silicon substrate purification, cell processing, wafering, crystallization and panel assembly. LCA studies for PV systems have a more than 15-year history. There is a lot of variance in the outcomes and conclusions of the studies that have been published. The key explanations for disparities in LCI outcomes were investigated in the late 1990s [26]. The intricacy of the system, the materials involved, as well as the power intake and carbon emissions during the life cycle stage have all been investigated.

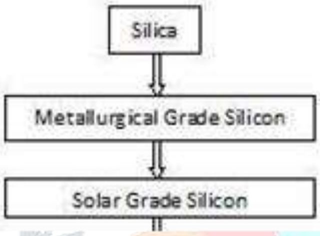

Figure 4 Block diagram of solar panel production.

4.2 Life cycle inventory

The results of the LCA of a solar project have been separated into three categories: material assessment, carbon stock and energy stock. In the case of a solar project, the most significant environmental cost will occur during the production of the solar battery pack. On the other hand, the operating stage does not have a huge impact on the environment. For solar power plants of various capacities, there are several life cycle studies available. Although the breadth and climatic conditions of the studies vary, they all reveal that material assembly has an important influence on the environmental efficiency of solar power plants.

4.3 Case Study I (25KW Solar PV project)

4.3.1 Description of the system

The Grid Dynamic Roof Top 25KW Solar PV Power System in SewaBhawan,R.K.Puram, and New Delhi [Figure 5] is used in this study. The site's specifics are recorded in Table 1.

Figure 5 25KW Solar PV power plants at SewaBhawan, R.K.Puram, and New Delhi

Table 1 Technical details of the SewaBhawan Roof Top 25KW Solar PV plant.

1	**Location**	
I	Name of Building	SewaBhawan
II	Latitude	77o 12'
III	Locality	West Block , R.K.Puram
IV	Longitude	28o 32'
V	State	NCT Delhi
2	Area for SPV Plant	
I	Width	13.0m

II	Length	25.5m
III	Location	Terrace of NorthWing of SewaBhawan (Easternside of terrace)
3	SPV Power Plant	
I	Output	25KWp
II	No. of modules	150

4.3.2 Material inventory

Table 2 shows the polycrystalline PV panel's product in order. The basic information was gathered from a literature review [14]. Glass accounts for half of the entire weight. Glass and aluminum account up 88 percent of the overall weight, as seen in graph 5. Table 2 Material inventory for the poly crystalline solar panel

Material	**Weight (kg/module)**
Silicon Cell	1.57
Glass	8.50
Aluminium	6.54
EVA	0.26
Copper	0.13
Total	17.00

4.3.3 Energy inventory

Table 3 displays the energy stock for the Poly-Si component, with the silicon cleaning process consuming the most energy. Aluminum and glass both consume a great deal ofenergy.

Table 3 Energy roster for the poly crystalline solar panel

S. No	**Process**	**Energy Consumption (kWh/Module)**
1	High purity silicon production	128.96
2	m-Si wafer production 12	21.06
3	m-Si module assembly	20.58
4	Glass production	33.12
5	Copper production	0.62
6	Aluminum production	98.2
7	Tedlar production	5.14
8	EVA production	12.264
9	Solar cell production	26.56
Total Energy consumption		346.38

4.3.4 Carbon Inventory

The carbon inventory data for the solar panel is shown in Table 4. Carbon emissions can be assessed using these primary data [27]. The more aluminium is produced, the more carbon is released.

Table 4 Carbon release per module manufacturing of solar cell

S. No	**Process** **12**	**kg CO2 emission per Module**
1	m-Si module production	5.09
2	Glass production	1.87
3	EVA production	0.46
4	Copper production	0.66
5	Tedlar production	2.31
6	Aluminum production	62.26
Total CO2 emission		72.48

4.3.5 Balance of system

The component has been helped in changing solar energy into electricity. In the LCA, the element contributed to energy and carbon emissions. Table 5 shows the array maintenance per square metre of cable and the needed power to produce the inverter. In Table [5], the comparable co2 emission is also shown.

Table 5 Energy and carbon emission for the BOS

Material	**Energy Input (KW)**	**CO2 emission (kg)**
Array support + cabling	527.82	1159
Inverter	14472	3375

4.4 Matlab Simulink for Wind and Solar PV system

For the past 40 years, researchers have been studying a generic mathematical description of I-V system output for a PV cell. MPPT technologies mostly use such an identical circuit-based approach. The basic model's equivalent circuit, which includes of a photo a current, a diode, line losses, a parallel resistor, and a photo resistor describing Figure 10, depicts a resistivity to current flow. The voltage-current pattern is number one.

5. Conclusion

The results of the LCA of windmills, solar power, and waste-to-energy systems in India are presented in this paper. The energy payback period for the entire system has been computed. When compared to conventional systems, the EPBP of a solar outdoor lighting system is higher. The EPBP of a 1.65MW wind turbine is higher than that of a 1.8MW wind turbine.

This is owing to the system's poor power output in the Udumalpet area. When analyzing the EPBP of the 25KW and 11KW solar PV systems, the EPBP of the 11KW project is higher. This is because the system is on battery backup. When contrasting wind and solar systems, the solar PV system has a higher damage of energy in the DC to AC converter, which affects the EPBP.

Solar power plants have higher carbon intensity than wind power plants. Carbon emissions are higher during the PV module and battery production stages. Carbon intensity will be lowered in the future by boosting Module productivity. When CDM benefits are applied to renewable energy projects, a significant amount of money can be repaid, and the MBPB is also reduced. The government is providing further incentives to solar PV power plants, bringing the MPBP close to that of wind energy. The money invested in a solar street light cannot be refunded over time. However, this approach is extremely beneficial for rural electricity and carbon reduction.

In comparison to all other systems, solar water heaters can return the money spent in a relatively short amount of time. According to the findings, energy, economy, and carbon payback may all be lowered by choosing the right site and working condition for the system. And it may be lowered by improving the manufacturing process, minimising energy loss in the circuit, and boosting the PV cell and converterefficiency.

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