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Novel Production of Green Solar Energy in Power Systems

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Abstract:
This research paper provides limited information on green energy development for power systems. The production of green energy from renewables in power systems plays a crucial role in meeting growing energy demands while reducing environmental impact such as reducing greenhouse gas (GHG) emissions, improved air quality and health. Renewable sources such as solar, wind, hydropower, biomass, and geothermal energy offer sustainable alternatives to fossil fuels, enabling cleaner electricity generation. Green hydrogen sources can alter the shift to electrification from integrating into the transportation industry. Integrating these resources into power grids enhances energy security, reduces greenhouse gas emissions, and supports global decarbonization goals. The production of green energy from renewables in power systems plays a crucial role in meeting growing energy demands while reducing environmental impact. This analysis lays a method to calculate the environmental impact from installation of large renewable energy systems, equivalent savings and reduction in GHG emissions. The results were indicative of smoother decarbonization from solar energy usage in major areas across the globe. Since various types of industries produce differentiated emissions, this research establishes how much reduction is possible from each of the industry type when off-setting with solar energy.

Keywords: green energy, greenhouse gas, power generation, renewable energy.

1. Introduction

Combined use of green energy comes from using renewable energy resources, reduction on reliance on fossil fuels, and emission reduction at industries. Industrial emissions are typically classified into two categories: direct and indirect emissions. Direct emissions arise from energy consumption within industrial facilities, mainly through the combustion of fossil fuels such as coal, natural gas, and oil. These fuels provide the heat and power necessary for manufacturing processes, but their combustion releases large amounts of carbon dioxide, the predominant greenhouse gas linked to global warming. Additionally, some industrial processes themselves generate emissions as by-products. For example, the production of cement releases carbon dioxide when limestone undergoes chemical transformation at high temperatures. Similarly, steel manufacturing almost inevitably involves considerable carbon emissions due to the carbon-intensive nature of the process. Each of the industries is responsible for different types of emissions. This paper studies steel, textile, glass, and plastics manufacturing processes for obtaining equivalent greenhouse gases by evaluating energy utilization for various activities in [1].

Indirect emissions come from the electricity that industries purchase from external sources. If this electricity is generated using fossil fuel power plants, it contributes to the overall carbon footprint of industrial operations. Hence, even if factories use electricity instead of on-site fuel combustion, their emissions may remain significant if the power grid relies heavily on fossil fuels. Methane and other potent greenhouse gases, such as nitrous oxide and fluorinated gases, also contribute to industrial emissions but to a lesser extent than carbon dioxide. Methane can leak from processes involving natural gas and oil, while nitrous oxide and fluorinated gases are often by-products of specific chemical manufacturing processes. Though these gases are emitted in smaller quantities, their global warming potential is substantially higher than that of carbon dioxide, making their control an important aspect of overall emission reduction efforts. The indirect emission becomes pivotal in determining how much can be saved from emissions by developing technologies renewable energy. In research papers [2] and [3], solar panels have proven economic viability and safer install for communities.

The scale of industrial emissions varies between sectors. Energy-intensive industries like cement, steel, chemicals, and refining are among the largest emitters because their processes demand high energy input and produce emissions intrinsically tied to their chemical or physical transformations. In comparison, less energy-demanding industries typically have a lower emissions profile. As global populations and economies grow, the demand for industrial products rises, often leading to increased energy consumption and emissions unless efficiency gains or cleaner technologies are implemented. The challenge is especially pronounced in developing economies, where industrial expansion is rapid, but access to clean energy technologies and efficient infrastructure upgrades may be limited. Energy consumptions for lighting and their equivalent controls for reduction of energy demands in [4], [5], and [6]. In [6], a novel application in energy savings was project initiation on filtering the lighting luminaires deficiency, replacement with light emitting diode (LED), and industrial premises safety.

To address these challenges, multiple strategies are being pursued worldwide to reduce industrial emissions. One foundational approach is improving energy efficiency within industrial processes. This can include upgrading to more efficient machinery, optimizing operational practices, and recovering waste heat to reduce overall energy requirements. By lowering the energy input needed for production, emissions are correspondingly reduced. Switching from fossil fuels to renewable energy sources is another critical strategy. Many industries are beginning to adopt electricity generated from solar, wind, and hydropower, which produce no direct greenhouse gas emissions. Electrification of industrial processes, where feasible, helps decouple industrial energy consumption from fossil fuels. However, for industries requiring extremely high temperatures or chemical reactions that inherently produce emissions, renewable electrification alone may not be sufficient.

Innovation in alternative production methods is essential for such sectors. For example, research is ongoing into the development of low-carbon cement, steel made with hydrogen instead of coke, and carbon capture and storage technologies that can trap and store carbon dioxide emissions before they reach the atmosphere. These emerging technologies, although promising, often require significant investment and time before achieving widespread adoption. In addition to technological solutions, policy and regulation play an important role in curbing industrial emissions. Governments worldwide are setting increasingly stringent emissions standards and providing incentives for industries to adopt cleaner technologies and practices. Carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems, create economic motivations for emissions reduction and innovation.

Corporate responsibility and sustainability initiatives are also influential. Many companies have embraced environmental goals, recognizing that reducing emissions aligns with long-term economic performance, brand reputation, and social responsibility. Transparency in emissions reporting and participation in sustainability certification programs motivate industries to track and reduce their environmental impacts. Another impactful measure involves supply chain management and circular economy practices. By optimizing material use, promoting recycling, and designing products for longevity and reuse, industries can reduce the demand for raw material extraction and associated emissions. This holistic approach extends emission reduction efforts beyond individual facilities to entire production networks.

Despite these efforts, significant challenges remain. Many industrial processes are inherently carbon-intensive, and transitioning to low-carbon alternatives requires overcoming technical, economic, and infrastructural hurdles. The intermittency of renewable energy sources can disrupt continuous industrial operations if adequate energy storage or grid management solutions are not in place. Moreover, developing countries, which contribute increasingly to global industrial emissions, often face constraints in financing and accessing advanced technologies. Figure 1 uses monocrystalline materials for electricity production from solar energy. The paper prepares a method to calculate the GHG emissions from different industries. Equivalent solar energy generation from location in the northern India suits the need of reducing the indirect emissions.

Sankhwar (2024) [7] posited that commercial and residential areas with available unoccupied roof space, ground space, or water bodies, untapped solar potential offers reduced emissions and reduces dependence on non-renewable power resources. As such the renewable energy systems in many parts of the world are successful in harnessing solar energy without increasing risks to the environment and residents. Integrated homes running on direct current (DC) can reduce energy conversion losses common with AC, boosting overall efficiency. Solar power works perfectly fine in southern areas of India [8]. This DC system setup simplifies the direct use of power from sources like solar panels and batteries, which naturally produce and store DC power [9].

2. Methods

Green energy in this paper has been proposed using solar energy at northern India. Calculating emissions, and solar output as green energy have been expanded in the methods. Calculating greenhouse gas (GHG) emissions for an industry involves multiplying the quantity of activity by the appropriate emission factor. Activity data can be fossil fuel consumption from the processes, electricity usage, or production volume, while emission factors represent the average emissions per unit of activity engaged into the processes involved in manufacturing. The units for each of the variables is shown in equation (1):

$$\text{GHG (mt } CO_2e) = a \text{ (gallons)} + b \text{ (kg } CO_2/\text{ gallon)} + \text{GWP (mt/ } CO_2e) \quad (1)$$

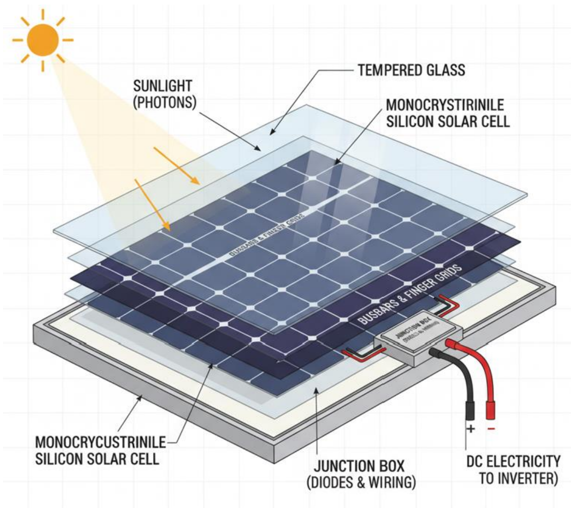

Figure 1. Solar Panel Components

To calculate the total energy output for multiple panels, multiply the output of one panel by the number of panels installed. Over a month, the energy output can be estimated by multiplying the daily output by the number of days.

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Additional considerations include geographic location, weather, shading, and panel orientation, which all influence real-world energy production. The performance ratio, accounting for losses in the system, can further refine accuracy. This method provides a practical way to estimate expected solar electricity generation from a given installation. Figure 2 graphically GHG emission reduction from renewable energy.

Energy Output (kWh) = Solar Panel Rating (Watts) . peak sunlight (hours) . efficiency (%) (2)

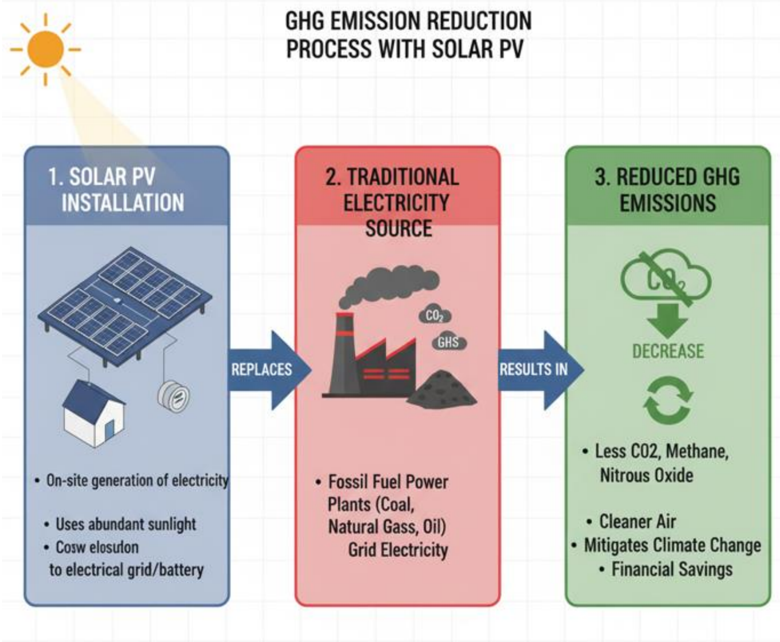

Figure 2. Process Flow for GHG reduction

Figure 2 slow chart shows how on-site electricity generation uses abundant solar energy. Grid utilization of battery energy storage system normalized the curves especially the undue dips during early mornings. Energy management systems working in close proximity of electric vehicles and equivalent energy storage in the modern systems as described in [6] [7] improved the overall system efficiency in GHG emission reduction. At step number 1, the grid tied systems with integrated homes presented in [9] makes the system resilient from compromised power quality and stability [10] [11] [12] [13] [14]. Electrical power systems in such instances plays pivotal role from increased dependence on energy management systems of grid tied solar energy and electric vehicles [15].

3. Results

The results for GHG emission from industries based on equation (1) and energy output from solar energy usage from equation (2) at a typical location in the northern India is shown in Table 1 and Figure 3.

Table 1: Emissions Data Calculations

S. No.	Industry Name	Metric Tonnes (mt) of CO_2e / Tonn
1	Cotton Textile	0.51
2	Plastics	1.81
3	Glass	0.49
4	Steel and Cast Iron	2.10

Solar energy generation profiling is shown in Figure 3.

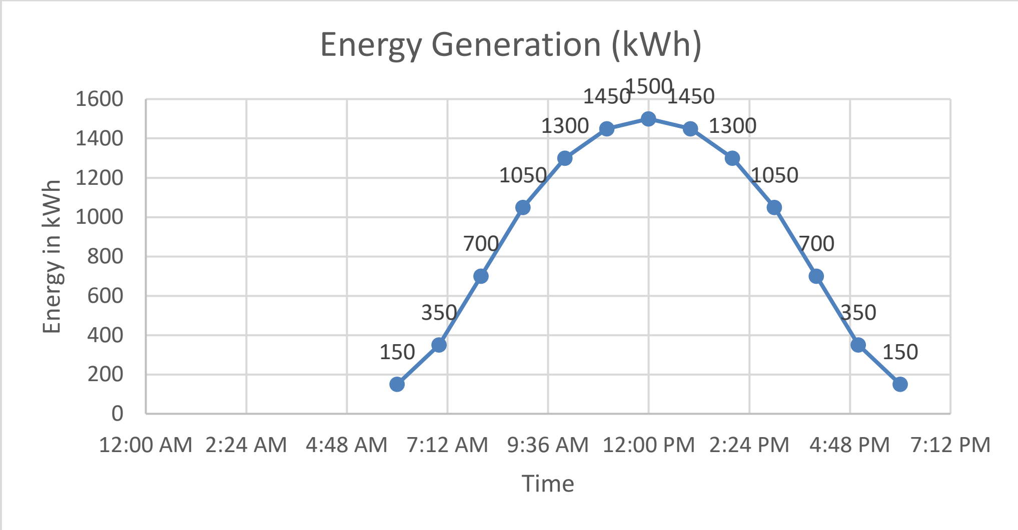

Figure 3. Solar Energy

4. Conclusion

- The paper first understood the major implications of direct and indirect emissions from the industry. Most people see direct emissions as health hazard as they can come into contact with the same immediately. Whereas the indirect emissions are concerning researchers developing technologies in energy management, increased decarbonization from renewable energy and electric vehicles.
- There was a process flow chart developed in methods section for green energy from solar energy. The total emission from different industry is astonishingly high but the top on the list per Table 1 were Steel and Cast Iron; and Plastics manufacturing.
- There were governing equations explained in the methods section for energy output. Solar energy output curves from northern India are strongly supportive of the feasibility. The energy output follows a bell shape curve during the day from 6AM to 6PM as shown in Figure 3.

5. Conflict of Interest

No conflict of Interest involved for this research paper.

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