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Potential Legal Risks Associated with by Cadmium Telluride Solar Cells in India: A Literature Review

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Abstract

'The Report of the World Commission on Environment and Development: Our Common Future' promulgated in 1987 is the fundamental document envisaged sustainability. The mission for sustainability has resulted into Rio Declaration, Agenda 21, Rio+5 Summit, which formulated Millenium Development Goals (MDGs) in 2000 by the United Nations. Gaps in Implementation of MDGs led formulation of Sustainable Development Goal (SDG) in 2015 by the United Nations with 17 detailed and specialized goals. The equity of resource availability and utilization intergenerationally is to be ensured, by addressing environmental degradation, decrease in natural resources, poverty and hardship through reinforcement of economic interest, survival imperatives of people, reduction of poverty by alleviating environmental degradation, inequalities, inclusion of multiple stakeholders for deciding the welfare of economy, society, environment to minimize any adverse impact on planet earth by 2030. Goal-13 of SDG, ensures responsible action by addressing climate change for climate justice. The Inter-governmental Panel of Climate Change (IPCC) has come up with report on increasing temperature in the environment causes global warming and climate change due to increased concentration of carbon dioxide. This led many countries including India to sign Paris Agreement, 2015 for its reduction. This implied researchers to reduce the amount of carbon dioxide in the environment by reducing its emission, storage and removal of carbon dioxide by physical and chemical means. Reduction of emission of carbon dioxide through adoption and resultant transition to renewable energy systems from conventional non-renewable energy systems as one of the ways for climate justice is recognized by the United Nations Framework Convention on Climate Change (UNFCCC). In which solar photovoltaics is a convenient form of renewable energy. Solar photovoltaics accounts for 9.61% percent energy mix of India on 30th April 2025, whereas, coal-fired thermal power accounts for approximately 74.58%. This difference is evident as there are many challenges associated with solar energy documented in academic literatures. The availability of coal in diverse geographically locations and its domestic access made many developing countries, like India to preclude them from geo-political meddling by any foreign power. However, coal is non-renewable energy resource, and its adverse impacts has led to agreements that compels India for energy transition. The review will outline those challenges and legal implications of adopting Cadmium Telluride Solar Cells pertaining to central legislature of India. The issues related to Cadmium Telluride solar cells with respect to life cycle analysis that includes laws enacted from extraction to end-of-life. Here, laws required to adhered at the time of installation during usage of solar cell is considered. The literature review will provide a narrative for challenges delineated by law as well as technology to achieve Goal-13 of SDG.

Keywords- sustainability, climate change, risks, solar cells, first generation silicon, cadmium telluride, energy transition, central legislature, life-cycle analysis

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Introduction

Sustainability is to be addressed by 2030. The stakeholders involved in achieving the sustainability have limited time of less than five years to address socio-economic-environmental aspects. A pathway for safe and sustainable energy is highly required for development.[1] Renewable energy resources are the safe and sustainable resources perceived by many stakeholders. Since, these resources are able to address societal and economic development, access of energy, mitigating climate change, crises of environment and energy crisis.[2] Many industries are utilizing energy in the form of electricity. The electricity is chiefly derived from thermal power. The generation electricity from thermal power, has led to emission of too much of carbon dioxide in the atmosphere.[3]

Electricity is a vital requirement for people. Industries like lighter industrial sector, digital technologies, services as well as heavy engineering are fully dependent on electricity, along with lighting, cooling, heating required for residential sector.[4] In India at 2025, the electricity produced from thermal power has share of 72.30%, whereas renewable energy has approximately 22% of energy consisting of 10% of solar energy, 5% of wind energy and 7% of hydel or hydro-electric power.[5]

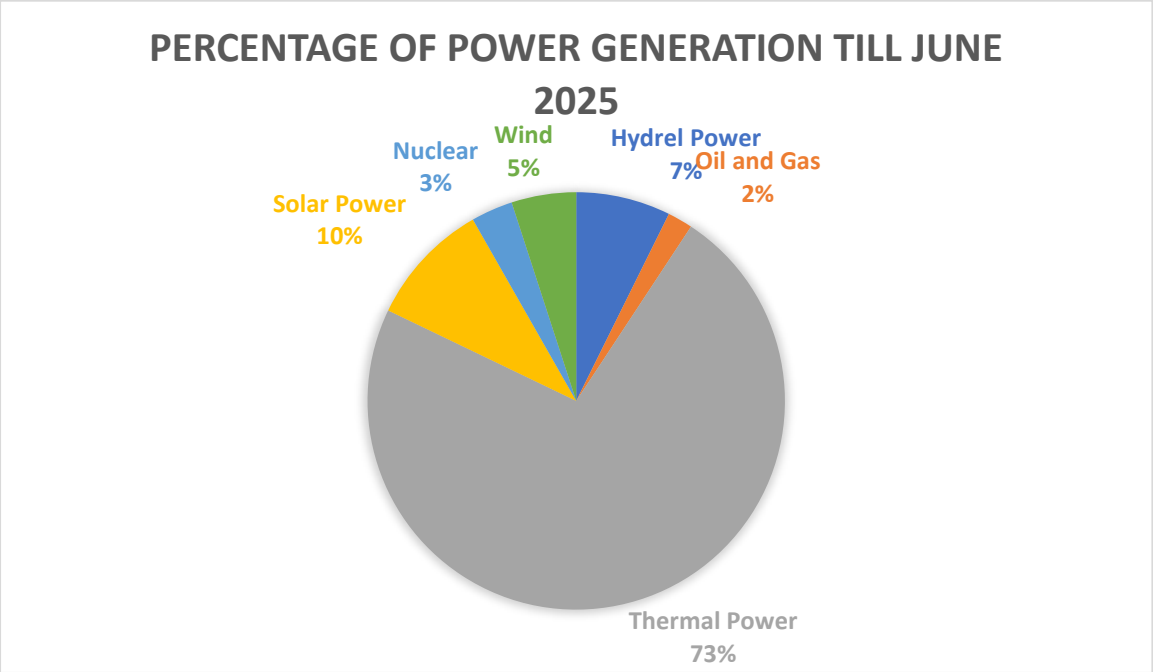

Figure 1: - Power generation mix in 2025 till June [6]

In order to implement renewable energy, solar energy is one of the promising and easiest sources of renewable energies. In these solar photovoltaic converts solar energy into electricity by photovoltaic cells, commonly known as solar cells. These are semi-conductors in which elemental atomic or compound molecular structure contains

[1] Gro Harlem Brundtland, *Our Common Future*, UN A/42/427 (March 20, 1987)
[2] Fotuhi-Firuzabad, et al., *Upcoming challenges of future electric power systems: sustainability and resiliency*, 23 SCI 1565, (2015)
[3] Madadkhani & Ikonnikova, *Toward high-resolution projection of electricity prices: A machine learning approach to quantifying the effects of high fuel and CO2 prices,* 129 En. Eco. 1, (2023)
[4] Utthara Draupadi Neelawela, *Policy Tools for a Secure and Sustainable Electricity Sector,* Griffith University, (September 10, 2020), https://doi.org/10.25904/1912/3955
[5] India Climate and Energy Dashboard, *Source-wise Electricity Generation Trends,* NITI Aayog (July 02, 2025), https://iced.niti.gov.in/energy/electricity/generation/power-generation
[6] India Climate and Energy Dashboard, *Source-wise Electricity Generation Trends,* NITI Aayog (July 02, 2025), https://iced.niti.gov.in/energy/electricity/generation/power-generation

four electrons in their outer orbit. The technology of solar cells has researched and developed in multiple generations. First generation crystalline silicon solar cells are commonly used because of high power efficiency, however, it has high degradation rate, low optical conversion efficiency and low spectral response. This cause heaviness and excessive heat generation during operation.[7] The photovoltaic solar energy is research and developed to second generation out of which Cadmium Telluride Solar Cells are one of them. These cells have equivalent power output efficiency, low degradation rate, less materials required, high optical conversion efficiency and spectral response.[8]

The renewable energy is sustainable however its acceptability needs to be freed from risks involved from its extraction of such resources and end-of-their life so that any further situation of unsuitability will create new forms of crises.[9] Risk means there is a possibility of having something bad, danger or loss.[10]

The rationale for doing this review is based on the quote of Henry David Thoreau from his literary work of Walden as "We must learn to reawaken and keep ourselves awake, not by mechanical aids, but an infinite expectation of dawn, which does not forsake us in our soundest sleep. I know of no more encouraging fact than the unquestionable ability of man to elevate his life by a conscious endeavour."[11] It means that we do not act or proceed about thinking what are we doing. We must wake our own potential by encouraging ourselves to trust on our wisdom, rather than solely on external sources of direction. So that, we can make our life richer, and purposeful. According to Confucius, as ancient Chinese philosopher said, "By three methods we may learn wisdom: - First, by reflection, which is noblest, second by imitation which is easiest; and third by experience, which is the bitterest."[12] The review will make the pathway for a careful thinking, i.e., reflection on the risk associated with Cadmium Telluride Solar Cells.

Renewable energy, like solar photovoltaics has a purpose to address the sustainability and climate justice. However, it should not lead to "Ignorantia juris non excusat"; means mistake of law. That person is liable for further proceedings as per Section 17 of Bhartiya Nyaya Samhita, 2023. There are many laws subjected to solar photovoltaics, enacted by the Central Legislation and State Legislations, enforced by various ministries of central and state governments in India. These laws need to be adhered meticulously to achieve sustainability and climate justice, otherwise the risk will increase due to the non-adherence of laws.

The life cycle analysis is the systematic approach on evaluation of environmental impact of the product, process, or activity from acquisition of raw materials to final disposal. It helps us in understanding the environmental consciousness and enables strategic planning for future activities.[13]

The review will act as synchronising the goal of Life Cycle Assessment with laws enacted from Parliament and sustainability. It is organized to review sustainability, solar cells, Life Cycle Management, and related laws along with comparison on laws applicable on first-generation silicon and cadmium telluride solar cells.

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[7] Mukhopadhyay & Gupta, *Assessing the Susutainabilty Impact of Cadmium Tellride Solar Cell Deployment in Delhi-NCT,*12 IJAIR 404, (2025)

[8] Scarpulla, et al., *CdTe-based thin film photovoltaics: Recent advances, current challenges and future prospects,* 255 SEMSC, (March 28, 2023)

[9] Jaya Dindaw, Centre of Policy Research, Planning Climate Futures: Why One Size Doesn't Fit All in Indian Cities (May 27, 2025)

[10] *Risk,* Cambridge English Dictionary, https://dictionary.cambridge.org/dictionary/english/risk, (July 02, 2025)

[11] Ahuja & Poddar, Legal Pedagogy & Research Methodology xx, 2023

[12] Lakshminath & Lele, *Legal Education – Post-Modernist Perspectives*, *in* Legal Pedagogy & Research Methodology, 3, (Ahuja & Poddar ed. 2023)

[13] *Life Cycle Analysis,* ScienceDirect, https://www.sciencedirect.com/topics/earth-and-planetary-sciences/life-cycleanalysis#:~:text=Life%20Cycle%20Analysis%20is%20defined,strategic%20planning%20for%20future%20activities. (July 02, 2025)

Method

There are no scholarly articles pertaining to (TITLE-ABS-KEY(life cycle analysis) AND TITLE-ABS-KEY(law) AND TITLE-ABS-KEY(crystalline silicon) AND TITLE-ABS-KEY(cadmium telluride) AND TITLE-ABS-KEY(solar cells)), in Scopus database. The same search query has resulted into varied outcomes that are not directly related to cadmium telluride solar cells and first-generation silicon solar cells, while searching in ProQuest database.

So, the review is based on the publicly available standard documents on Acts of the Honourable Parliament of India, documents from the United Nations on sustainability and climate justice, ISO 14040:2006 and ISO 14044:2006, and scholarly articles on first generation silicon and cadmium telluride solar cells. ISO 14040:2006 and ISO 14044:2006 are standard document on Life Cycle Assessment of product on the basis the environmental management concern.

Discussion

Sustainability

Sustainability was primarily addressed by Dr. Gro Harlem Brundtland, through the report named "Our Common Future", published from World Commission of Environment and Development, it is also known as Brundtland Commission, 1987. The commission has submitted and published within 900 days to the United Nations since its inception in October, 1984 and concluded in April, 1987.[14] This report was based on the outcomes of the United Nations Conference on Human Environment held at Stockholm, in 5-16 June, 1972.[15] Sustainability was termed physically as social equity among generations, a concern that must logically be extended to equity within each generation. The report has acknowledged that modern day humanity has inability to fit its activities in line with changing planetary systems. For that reconciliation, human activities should be in parity with natural laws to thrive the processes. The report has recommended to make policies to address resource base by expansion and sustenance, by relieving people from poverty. The decisional conditional action would begin by management of environmental resources to sustenance in human progress and survival. The infant mortality has fallen, increased human life expectancy, capable of reading and writing by people, rising enrolment of children in schools, and faster increase of global food production has made considerable success in development. However, it has caused increased number of hungry people, without safe water access, access of homes based on safety and soundness, and shortage of wood fuel. The gap is widening between rich and poor nations due to nonuniform prospects have been given on present trends and institutional development. The development has becoming threat to lives of many species on planet earth, due desertification, acid rains, global warming, increased toxicity in human food chain and underground water tables. The governments and multi-lateral institutions are realising the impossibility on separation of economic development and environmental issues, because development is eroding the environmental resources and undermining economic development. For this, human progress should be made sustained not in few years but entire planet into distant future. The present development has led to interlocking crises, across nations, across energy, agriculture, trade, within concerns of environment, economics, social. The development has impact on biosphere, where world would invest in houses, transport, farms, industries. For that raw materials are derived from forests, soils, seas, and waterways. A new technology should mainstream which has potential for slowing the dangerous rapid consumption of these resources. The increase in pressure on resources is due to rapidly growing population. Along with institutional gaps due to narrow pre-occupations, reluctance from governments to recognize change as they are working on relatively narrow mandates with closed process of decision-making. Anticipation and prevention environmental damage can addressed by sustainability.

[14] Gro Harlem Brundtland, *supra* note 1

[15] *United Nations Conference on the Human Environment, 5-16 June 1972, Stockholm*, United Nations | Environment and Sustainable Development (July 02, 2025), https://www.un.org/en/conferences/environment/stockholm1972

A sustainable energy is crucial for development which is not even finalized. The demand of more energy due to industrialization, agricultural development, rapidly growing populations is pervading with time. The non-renewable resources should not be solely relied upon for the development. For this, energy efficiency and adoption of renewable energy must require well-programmed coordinated research and development. The energy mix required to be sustainable will not be achieved by increasing market pressures but by role of government as producers and consumers, making explicit goals on energy pricing that encourage adoption with long term view on weighing costs and benefits. Furthermore, a dialogue should be encouraged between consumers and producers to have energy pathway that is safe, environmentally sound and economically viable. So that, a political will and institutional cooperation should be ignited for achieving sustainability.[16]

With the objective of satisfying human needs and aspiration, a sustainable development is "The process of change in which exploitation of resources, direction of investments, the orientation of technological development and institutional change are all in harmony and enhance current and future potential."[17]

The sustainability is re-iterated through Rio Declaration and Agenda 21 in 1991. Rio Declaration has given due stress on human beings at the centre of concerns of sustainable development. Since, humans are entitled for healthy and productive life with harmony in nature.[18] Whereas, Agenda 21 has given due stress on environmentally sound use of new and renewable energy, with research, development, and dissemination of environmentally sound technologies. This will happen with informed decision-making among individuals, households, governments, and multilateral institution. It should constitute information on consequences of consumption choice and behaviour, health and environmental impacts, encouragement for recycling and deposal systems. Stewardship in management is required by business enterprise with more efficiency in the process of production, strategies for prevention, technologies and procedures for cleaner production. Here, benefit to all stakeholders is considered with profit, while considering stewardship in management. For this, inventive, competitive voluntary initialitiations are necessary for stimulating more varied, efficient and effective options.[19]

Rio+5 Summit happened in 1997 which led to formulation of Millenium Development Goals in 2000, in order to achieve sustainability by 2015.[20] Due to gap in implementation to achieve the sustainability, it resulted into seventeen specific and interconnected themes to achieve sustainability by 2030. These goals are known as Sustainable Development Goals (SDGs).[21]

Inter-governmental Panel of Climate Change (IPCC)

IPCC, a committee formed under the United Nations Framework Convention on Climate Change (UNFCCC), an affiliated organization of the United Nations, has illustrated and published the report mentioning the increased concentration of carbon-dioxide in atmosphere has resulted into global warming, that is inducing irreversible climate change in the earth. It has recommended to arrest the increasing concentration of emission of carbon dioxide in the atmosphere.[22] That's why India as a member of the United Nations has agreed and signed in Paris

[16] Gro Harlem Brundtland, *supra* note 1
[17] Id.
[18] Mukhopadhyay & Gupta, *supra* note 7
[19] Id.
[20] Id.
[21] Id.
[22] Id.

Agreement in 2015, to transform its economy to net zero carbon economy from its present status by 2050.[23] This report has been included within goal thirteen of SDG, which is themed on 'Climate Action'.[24]

The concentration of excess carbon dioxide can be reduced by reducing carbon dioxide emission.[25] The reduction of carbon dioxide can be done by implementing new and renewable sources of energy as they emit less amount of carbon dioxide. Solar photovoltaics in solar energy is one of the clean sources of energy. Since, it does not emit carbon dioxide while in production of electricity.

Solar Cells

Solar cells are known as photovoltaic cells. The energy present in the light is converted into electricity through a process of photovoltaic effect. In these semi-conducting materials like silicon and germanium in chemical elements as well as molecular compounds cadmium telluride, copper indium gallium selenide (CIGS), and gallium arsenide.[26] In these semi-conducting materials, impurity of electron-rich materials and electronic-deficient materials are mixed in such a manner that it should have enriched with electrons on one side and deficit on another side. This process is known as doping. A diode is formed by this type of doping. This can be used to conduct electric current in one direction because a barrier is formed at the junction of electron-deficit and electron rich materials. The electrons require additional potential energy to cross the barrier, which can be delivered by external sources. In this case of photovoltaic electric cells, when sunlight is incident on this junction, it gets energy to overcome the potential barrier. As a result, electrons with energy move towards electron deficit-side. These electrons constitute current in the electrical circuits and systems.[27]

Recently, cost of generating electricity has reduced to 77% from 2010 to 2018 and further cost reduction techniques has resulted its increased deployment by 100-folds from 2005 to 2018. In this scenario, first and second generation of photovoltaic technology, first generation of photovoltaics is consists of mono-crystalline silicon and poly-crystalline silicon, whereas, second generation consists of amorphous silicon, cadmium telluride, copper indium gallium selenide, and gallium arsenide. Out of which, only first-generation photovoltaics has 95% of market share and remaining 5% is taken by cadmium telluride for commercial purposes.[28]

Here in cadmium telluride solar cells, the energy required by an electron to cross the barrier is as same as the amount of energy present in light. This implies that, it has good light conversion efficiency. It requires less amount of semi-conducting material to manufacture, along with no generation of excess heat due to mismatch of energy required by semi-conducting materials and energy present in the sunlight.

As per the standard document of International Electro-technical Commission i.e., IEC-61274-1; there are 10 important parameters that define the characteristics of solar cells. These are, reference yield, array yield, final yield, performance ratio, capacity utilization factor, photovoltaic module efficiency, inverter efficiency, system efficiency, array capture loss, thermal capture loss. Also, factors affecting the performance of any solar cells are solar irradiance, ambient cell temperature, tilt angle orientation, dust accumulation and shading. In market, performance ratio and system efficiency are seen as primary parameters to select any technology. This creates the preference of first-generation silicon over the cadmium telluride solar cells. However, solar irradiance at that place, ambient cell temperature, tilt angle orientation can play important role for getting the enhanced performance

[23] IPCC, Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (Cambridge University Press, 2018)

[24] *Paris Climate Agreement Comes into Force Today*, Press Information Bureau, (November 04, 2016) Paris Climate Agreement Comes into Force Today (July 02, 2025)

[25] *Action on Climate and SDGs,* United Nations Framework Convention on Climate Change (July 03, 2025)

[26] Mukhopadhyay & Gupta, *supra* note 18

[27] Id.

[28] Singh, Powar & Dhar, *End of life management of crystalline silicon and cadmium telluride photovoltaic modules utilising life cycle assessment,* 197 RCR, (2023)

from cadmium telluride solar cells as the type of the material. Solar irradiance means amount of energy present in the sunlight; ambient cell temperature means the temperature of solar cells during operations, here 25 degrees Celsius is considered standard. Tilt angle is angle subtended by installed solar cells with respect to the ground, this angle should be in such way that sunlight falls vertically on the surface of solar cells. Latitudinal angle is considered as tilt angle. The deviation of 15 degrees in northwards as well southwards from its latitude has to be considered so that sunlight would fall vertically on the surface of the solar cells.[29]

The first-generation solar cells which are installed in Delhi-National Capital Territory, has faced many challenges as a result 10 million units of electricity are lost due to the underperformance. This has happened due to hotspots, cracks, uneven tilt angles, shattering of glass, soiling and shadowing occurring on solar cells, cable damage, and malfunctioning of inverters. This problem is happened due to low awareness on system maintenance with no proper documentation. This has recommended that proper standard of procedures have to be undertaken by consumers, increased accountability on developers for proper performance after purchase by consumers, guidelines must be conveyed in very simple manner, and increasing the role of annual maintenance checks.[30]

This has happened due to lack of information required to implement the sustainability through solar cells. Stewardship in management entails benefits must be provided along with profits. These benefits are different for different stakeholders. Risks associated with consumption choice and behaviour, health and environmental impact and encouragement of recyclability has legal interpretations. So that, competitiveness, efficiency and effectiveness, inventiveness and voluntary initiative taken by any business should have prior knowledge with respect to rule of law governed in any region.

In this, life cycle assessment of these solar cells has been taken as a reference for informed decision-making, where risks in goal and objectives are framed by reviewing the laws enacted by central legislative body of India, i.e., The Honourable Parliament of India. The life-cycle assessment is standardized by International Standards Organization (ISO) and documented as ISO 14040:2006 and ISO 14044:2006.

Life cycle assessment is a technique for assessing the environmental aspects associated with any product over its life cycle. It comprises of four stages; goal and scope, inventory analysis, impact assessment, and interpretation, respectively. Goal and scope define the area that is to be covered in product life cycle. The criteria of system comparison and specific stages of product life cycle are defined. Inventory analysis gives a description of material and energy flows within the product systems. Impact assessment indicates the results of all impact categories. Interpretation involves critical review, determination of data sensitivity by presenting these results. Its applications include, product development, strategic planning for marketing and formulation of public policies associated with the product.[31]

Here, risk is identified in goals and scope of life-cycle analysis with its use at the time of its installation. The life cycle of first-generation silicon solar cells and cadmium telluride solar cells on terrestrial grid-connected configuration is reviewed.

First approvals of ‘No Objection Certificate’ is required from respective State Pollution Control Boards for declaring the solar photovoltaic power plant in White Category. This White Category is usually granted when solar power plant usually has power generating capacity of less than 25 MW. When power generation capacity has more than 25 MW then ‘Consent to Establish’ and ‘Consent to Operate’ are required from respective State

[29] Aslam et al., *Advances in Solar PV Systems; A Comprehensive Review of PV Performance, Influencing Factors, and Mitigation Techniques,* 15 energies, (2022)
[30] Tyagi et al., *kWh from kW: Achieving Optimum Energy Generation from Rooftop Solar Systems Insights from Field Visits in Delhi,* CEEW, https://www.ceew.in/publications/achieving-optimum-energy-generation-from-rooftop-solar-systems-in-india-ceew-bypl-study, (2023)
[31] *Life Cycle Analysis, supra* note 13

Pollution Control Board. This is mandated by Central Pollution Control Board, Ministry of Environment, Forests and Climate Change, Government of India.[32]

Approvals from Land Revenue Department is required based on permissions from Panchayat Pradhan to District Collector of the particular district in any state. This stages of permission varies with state to state. The permission required to change the category of land as revenue land (government agency owned), private land (ownership by the individuals), forest land under the jurisdiction of Department of Forests), and community land (owned by Panchayat). Revenue land is sold on lease to solar project developers. Private land needs to be purchased from land owners on commercial terms. It is based on long-term growth plan of resource potential, techno-economic feasibility, renewable purchase obligation and energy markets nodal agencies that developing renewable energies in national and state levels. Identification of amenable site for installation should be based on Solar Atlas developed by National Institute of Solar Energy. Verification of that land must be done with respect to existing use and type of land; it should be facilitated by the Department of Revenue or Office of District Collector. Essential criteria for installation are based upon availability of resource, efficiency and effectiveness of equipment used, location primarily constitute latitude and altitude, and topography of the site. Ratio of direct current and alternating current must be mentioned at the time of installation. Detailed Project Report must be submitted to State Nodal Agency of renewable energy development for allotment of site for installation of solar power plants by paying registration fees through online mode. Once the project is approved, then digitalization of land records in order to ease of locating coordinates, detailing the trends of existing usage t, and establishment of ownership tittles so that easy updating of particulars can be done. Land and Revenue department should ensure selling price of that land with current market value of the land in sync with prevailing circle rates. If private land is taken on lease, then the developer has to furnish 'Model Land Lease Agreement' taken into concerns of stakeholders like who developed the project, owned the land and land users besides financial institutions. Social Impact Assessment has to be undertaken by developer to ensure their capacity of installation of solar cells and its electricity generation within threshold limit. This threshold limit has to be set by Empowered Committee headed by Principal Secretary (Energy), along with members from Department of Land and Revenues, renewable energy development agency, department of rural development, state transmission utility, state distribution utility, department of industries, and state pollution control board of the respective state.[33] Land-related matter are the subjects of state conferred by The Honourable Constitution of India, under Secdule-VII, passed by the Parliament of India on 26th January, 1950.[34]

The approvals for connecting with grid is also relied on respective state electricity regulatory commissions. Here, the detailed approvals are required for sending electricity from solar power plants to grid. In case of State of Maharashtra, the installed capacity should be within 10 MW that can be transmitted to voltage level up to 33kV and can be connected with 33/11kv or 22/11 kV sub-station of Maharashtra State Electricity Distribution Corporation Limited. The grid connectivity is non-transferrable and valid for one year, with the fees of ₹1,00,000. The concerned official from the Distribution Company (DISCOM) should carry joint survey with the applicant who is either developer or owner of that solar plant. The concerned officials will submit the technical feasibility report to their office along with documents from land and revenue departments, environmental departments like pollution control board, and water linkage to state renewable development agency. The DISCOM will issue the grid connectivity permission letter to set up transmission lines of above-mentioned specifications along with distribution sub-station. Then permission to commission of solar plant has to be obtained from state electricity regulatory commission with energy development agency registration certificate, approvals and clearance for land and revenue department, respective pollution control board, purpose of permission to commission mandated as per state renewable electricity policy, supporting documents for intended sale of energy, special energy meter

[32] Letter from Bharat Kr. Sharma, Member Secretary, CPCB, to The Chairman, SPCB/PCC (February 12, 2025) (on file with the authors)
[33] SHAKTI SUSTAINABLE ENERGY FOUNDATION, MODEL GUDIELINES FOR LAND PROCUREMNET ON GRID CONNECTED SOLAR AND WIND ENERGY PROJECTS, (DECEMBER 2017)
[34] INDIA CONST., sched. VII

installation report as per state DISCOM, work completion report, and provision to provide real-time monitoring of electricity generation. The above document will be processed by competent authority of DISCOM. Once the project is approved by the competent authority, then it should be forwarded to Field Officer of DISCOM as well as solar power generator to commission their plant within stipulated time from the issuance of the approval. [35]

All royalties and taxes must be paid by developer or contractor for construction and installation of solar power plant. [36]

The technical provisions of Central Electricity Authority (CEA) and Central Electricity Regulatory Commission (CERC) are to be followed by the developer during installation of solar power project.[37]

(i) CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007
(ii) CEA (Technical Standards for Construction of Electrical plants and Electrical Lines) Regulations, 2022
(iii) CEA (Grid Standard) Regulations, 2010
(iv) CEA (Safety Requirements for Construction, Operation and Maintenance of Electrical Power Plants and Electric Lines) Regulations, 2011
(v) CEA (Measures relating to Safety and Electric Supply) Regulations, 2010
(vi) CEA (Installation and Operation of Meters) Regulations, 2006
(vii) CEA (Technical Standards for Communication System in Power System Operations) Regulations, 2020
(viii) CERC (Communication System for Inter-State Transmission of Electricity) Regulations, 2017
(ix) CERC (Indian Electricity Grid Code), 2017
(x) CEA (Cyber Security in Power Sector) Guidelines, 2021
(xi) CEA (Manual of Communication Planning in Power System Operation), 2022

Adequate and seamless insurances have to be covered to mitigate all sorts of risks associated during engineering procurement and construction (EPC), and Operations and Maintenance (O&M)[38]

The developer has to comply following acts of Central government[39]

(i) Wages Act, 1936
(ii) Minimum Wages Act, 1948
(iii) Employer's Liability Act, 1938
(iv) Workmen's Compensation Act, 1923
(v) Industrial Disputes Act, 1947
(vi) Maturity Benefit Act, 1961
(vii) Employees State Insurance Act, 1948
(viii) Contract Labour (Regulations & Abolishment) Act, 1970
(ix) Electricity Act, 2003
(x) MNRE guidelines

[35] PROCEDURE FOR GRID CONNECTIVITY IN ACCORDANCE WITH MAHARASHTRA ELECTRICITY REGULATORY COMMISSION (DISTRIBUTION OPEN ACCESS) REGULATIONS, 2016, Apau -2015/pra.kra.49/part- 8/Eng-7, (March 30, 2016)
[36] Balance of System Tender for Setting up of Grid Connected 200 MW Ground mounted Solar PV plant at Dhar, Madhya Pradesh, Solar Energy Corporation of India, (June 30, 2025) https://www.seci.co.in/tender-details/ZjNjMTE3MTI5ZWMzNzM4NWRkMmJjZTM5OTQ2NmRiN2Q3MDA0YTdiMGU2MTlkY2ZhYTJjMzMxNjQwYTdmNTk1ODkxMmNjMmExYTFlNWY5OTYzYWZiMTBhNGNmNmEyMmI2MDFhMWNmYjU3ZTllMzEwYTk4NzcyNjM5ZjI5YmZhNTlPdy9FNjIzcjhOYWhtMUlNQS9GMkhGWTJUK3dmb2dtTGVPZzhuL2REL2ZzPQ,, (July 1, 2025)
[37] Id.
[38] Id.
[39] Id.

In addition to these, cadmium telluride solar cell is patented product from FirstSolar, Inc. This company is based in the United States, which has enforced its patent under Patent Cooperation Treaty in India. This is the final product, and it doesn't register any process further in terms of installation and maintenance, so it does not require any approval or agreement while using the cadmium telluride solar cells.

There is a perception to discourage the use of these cells for avoiding environmental degradation. However, principle 15 of Rio Declaration clearly states, "In order to protect the environment, the precautionary approach can be widely applied by the States, according to their capabilities. When there are threats of serious and irreversible damage, lack of full scientific certainty shall not be used for postponing cost-effective measure to prevent environmental degradation."[40]

Honourable Supreme Court of India[41], accepted the precautionary principle as legally enforceable maxim and elaborated as:

(i) Environmental measures must be anticipated, prevented, and attack the cause of environmental degradation.

(ii) Lack of scientific certainty should not be used for postponing measures to prevent environmental degradation where there is serious implication of environmental degradation.

(iii) It has to be proved by the actor or developer/industry that their activity is environmentally benign. Honourable Court stressed[42], "*with major threats to the environment, such as climate change, depletion of natural resources, the eutrophication of water systems and biodiversity and global warming, the need to protect the environment as priority."*

As per Patents Act, chapter XVI, Section 83(d), if any intellectual property act as a principle of promoting public health by reducing carbon emission. It can be used.[43]

Conclusion

In order to achieve sustainability and climate justice, the stakeholder should provide required benefits from the cadmium telluride solar cells along with profit. And the consideration of above permission, approvals, clearance and statutes enacted by central legislation will enable informed decision by management with respect to law. So, that risk of penal action may be averted to accelerate the adoption of technologically more advanced second-generation Cadmium Telluride Solar Cells to reduce the amount of carbon dioxide. Also, framework may be recommended for adherence of above-mentioned legal processes for smooth energy transition from carbon-intensive to net-zero carbon neutral economy to ensure climate justice as per Paris Agreement, 2015 by 2050 and Sustainable Development Goals (SDGs) to achieve sustainability by 2030.

[40] Jose Felix Pinto-Bazurco, *STILL ONLY ONE EARTH: Lessons from 50 years of UN sustainable development* policy (2020) https://www.iisd.org/system/files/2020-10/still-one-earth-precautionary-principle.pdf (July 03, 2025)

[41] Vellore Citizen Welfare Forum v. Union of India, (1996) SC 2715.

[42] Bombay Dyeing and Mfg. Co. Ltd. (3) v. Bombay Environmental Action Group, (2006) 3 SCC 434.

[43] Mukhopadhyay & Sharma, *Legal Aspects of Electricity Produced by CDTE Solar Cells, in* Paradigm Shift in Business Management Challenges and opportunities of Quality Sustenance and enhancement in Higher Management Education 12 (Singh, Sahay & Satsangi, I, UAB Publishers and Distributors, 2024)