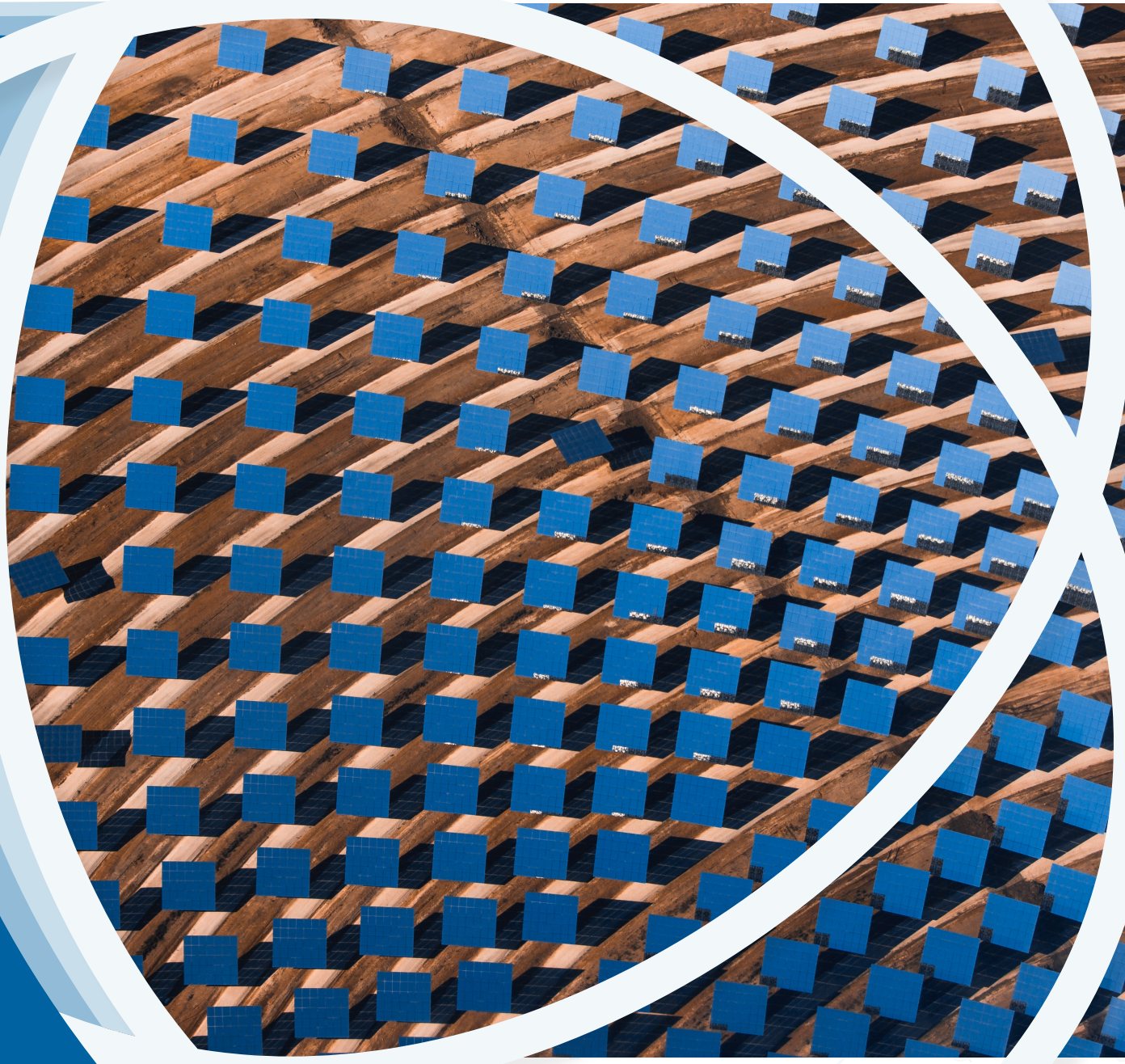
PRIMER

LOW-CARBON SOLAR

ENABLING SUSTAINABLE GROWTH AND RAISING THE INDUSTRY STANDARD



CEBI
Clean Energy Buyers Institute

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AUTHORS & ACKNOWLEDGMENTS

Authors

Kyla Aiuto
Clean Energy Buyers Association

Marielena Alcaraz Rios
Clean Energy Buyers Association

Mark Porter
Clean Energy Buyers Association

Jennifer Snook
Clean Energy Buyers Association

ABOUT THE CLEAN ENERGY BUYERS INSTITUTE

The Clean Energy Buyers Institute (CEBI) is a non-profit organization that leads transformational research and education to ensure all organizations have a viable, expedient, cost effective path to drive a resilient, zero-carbon energy system.

To learn more about CEBI, visit

https://cebi.org/

The Clean Energy Buyers Institute developed the Low-carbon Solar Primer through funding provided by **Breakthrough Energy**.

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I. OVERVIEW

Energy customers that leverage solar photovoltaics (PV) could help avoid over 14-18 gigatons (Gt) of CO_2 emissions over the next 20 years by making no-cost asks about the environmental attributes of the solar equipment employed in solar projects, using specific RFP language to strengthen requests of equipment suppliers, and leading in the market with public statements prioritizing low-carbon solar.

This opportunity stems from greenhouse gas (GHG) emissions along the solar PV supply chain and limited awareness of carbon-differentiation of equipment in the solar PV market. Some solar PV equipment has lower embodied carbon than others, which can be meaningful, especially as the industry is projected to grow at an impressive rate.

Energy customers are in a prime position to drive a holistic understanding of the electricity-related GHG emissions along the solar PV supply chain and position the industry for sustainable growth.

IT IS IMPORTANT TO NOTE THAT:

- The information provided in this document and the actionable items presented are based on feedback and input from key energy industry stakeholders.
- This document is designed to introduce concepts and show easy, first steps that companies can take to increase the impact of solar PV procurement, and work in collaboration with peers.

THE PURPOSE The purpose of the **Low-carbon Solar Primer** is to raise awareness of the need and opportunity to decarbonize the solar PV supply chain and introduce actionable items energy customers can implement to send market signals for low-carbon solar PV.

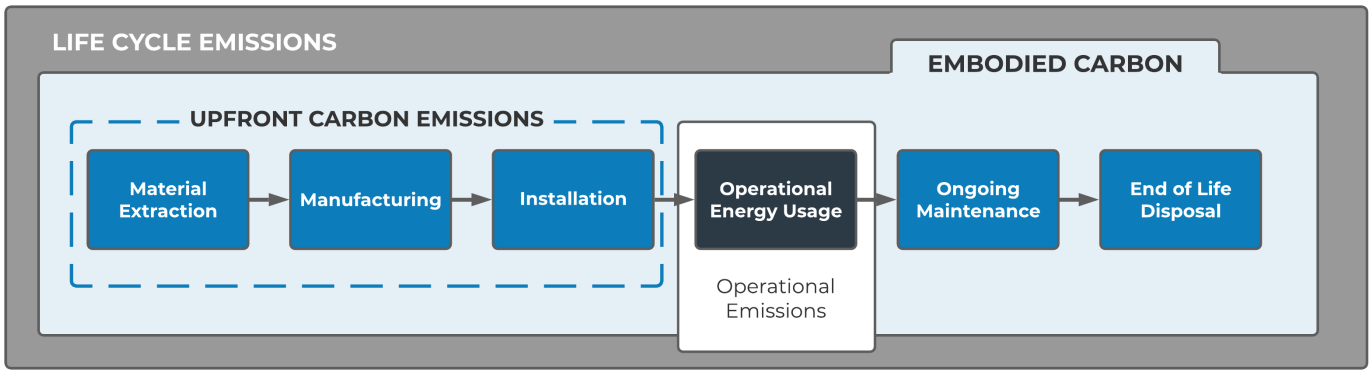
INTENDED AUDIENCE: The **Low-carbon Solar Primer** is intended for energy customers pursuing large-utility scale renewable energy procurement, and key stakeholders along the solar PV supply chain that want to optimize the environmental impact of new solar installations and support a low-carbon growth of the solar market.

II. ISSUE ANALYSIS

Renewable energy deployment is critical to decarbonizing the global economy and solar PV is part of that solution. Energy customers are a leading source of demand for new, large utility scale renewable energy and are well-positioned to raise the bar for new industry standards. Between 2014 and 2020, 24% of new U.S. renewable energy capacity was driven by corporate energy customers. [1] In the six quarters between 2020 and the first half of 2021, over 100 corporate solar transactions resulted in over 11.5 GW of new solar installation. [2] Increasingly, energy customers are considering **broader, non-financial attributes** for renewable energy projects. **The Low-carbon Solar Primer** looks at one of these considerations, the carbon emissions that are integrated in solar PV equipment before entering service in the operating period.

CLEAN ENERGY IS PRODUCED BY SOLAR, NOT ALL SOLAR IS PRODUCED BY CLEAN ENERGY.

In addition to the more commonly discussed GHG emissions from energy generation, every energy source has carbon emissions associated with the manufacturing and installation of new generation assets. These **upfront carbon** emissions are sometimes referred to as embodied carbon. They include everything from the emissions required to mine and extract raw materials to the energy spent manufacturing parts and creating the finished resource – essentially everything that it takes to bring an energy generation resource into existence before it becomes operational. Upfront emissions, combined with operational emissions, ongoing maintenance and end-of-life disposal collectively are considered total **life cycle emissions**. For solar PV, 60-70% of life cycle emissions come from upfront emissions. In contrast, over 98% of coal life cycle GHG emissions come from the operational process of coal-based energy production. [3]

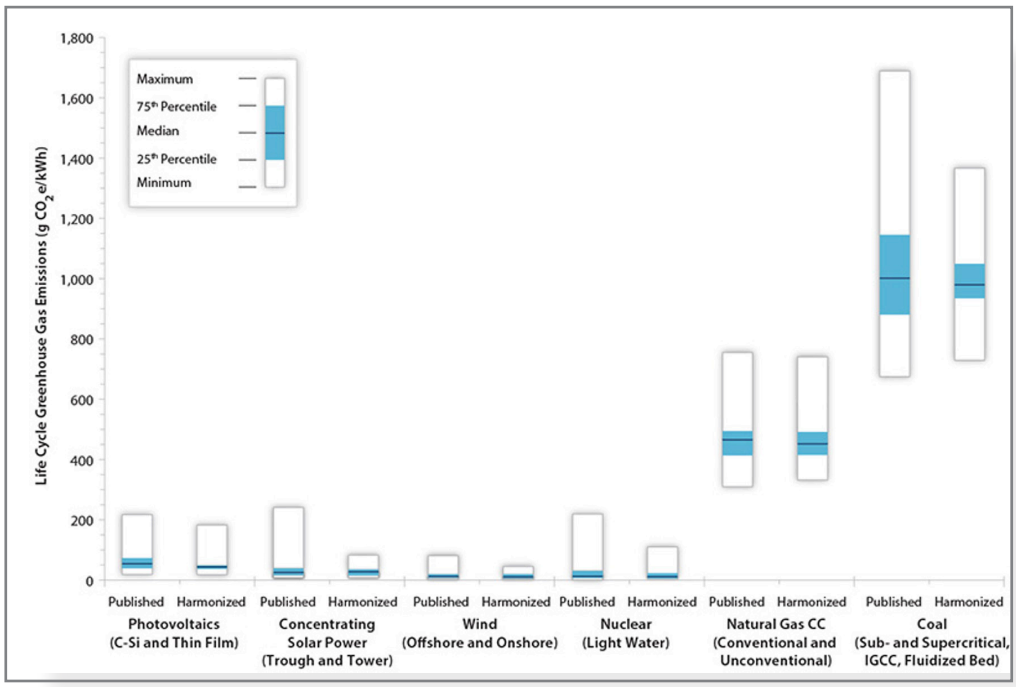


[1] The Business Council for Sustainable Energy and BloombergNEF, Sustainable Energy in America 2021 Factbook, accessed 24 August, 2021. https://bcse.org/factbook/; REBA deal tracker

[2] REBA deal tracker

[3] NREL, Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics (Fact Sheet) accessed August 24, 2021. https://www.nrel.gov/docs/fy13osti/56487.pdf

NREL COMPARISON OF LIFE CYCLE GHG EMISSION ESTIMATES FOR ELECTRICITY GENERATION TECHNOLOGIES



Source: NREL, Life Cycle Greenhouse Gas Emissions From Electricity Generation 2012 (Fact Sheet)

Solar PV, and renewable energy more broadly, has significantly lower total life cycle GHG emissions than fossil fuel-based counterparts. According to an expansive study by the National Renewable Energy Laboratory (NREL), total life cycle GHG emissions from renewables and nuclear energy are much lower than those from fossil fuels, and based on median estimates for each technology, coal-fired electricity releases about 20 times more GHGs per kilowatt-hour than solar, wind, and nuclear electricity.[4]

Over half of the upfront carbon emissions in silicon-based solar PV are attributed to electricity inputs required during the manufacturing process.[5] The majority of upfront carbon emissions from solar PV manufacturing occur in the early supply chain stages, specifically in the processes of polysilicon production and ingot extraction. Being electricity based, solar PV's upfront carbon emissions can be addressed with existing technology, such as solar PV itself and other renewable energy sources.

The majority of PV modules are manufactured in Asian regions with carbon-intensive electricity grids. In 2019, China alone produced 68% of polysilicon, 96% of ingots and wafers, 76% of cells, and 71% of modules for solar PV.[6] The embodied carbon in the average Chinese-made solar module is twice as large as one produced outside of China. [7]

[4] NREL, Life Cycle Greenhouse Gas Emissions From Electricity Generation 2012 (Fact Sheet) accessed August 24, 2021. https://www.nrel.gov/docs/fy13osti/57187.pdf

[5] A. Müller, et al. A comparative life cycle assessment of silicon PV modules: Impact of module design, manufacturing location and inventory (2021). accessed 24 August 2021. https://www.sciencedirect.com/science/article/abs/pii/S0927024821003202

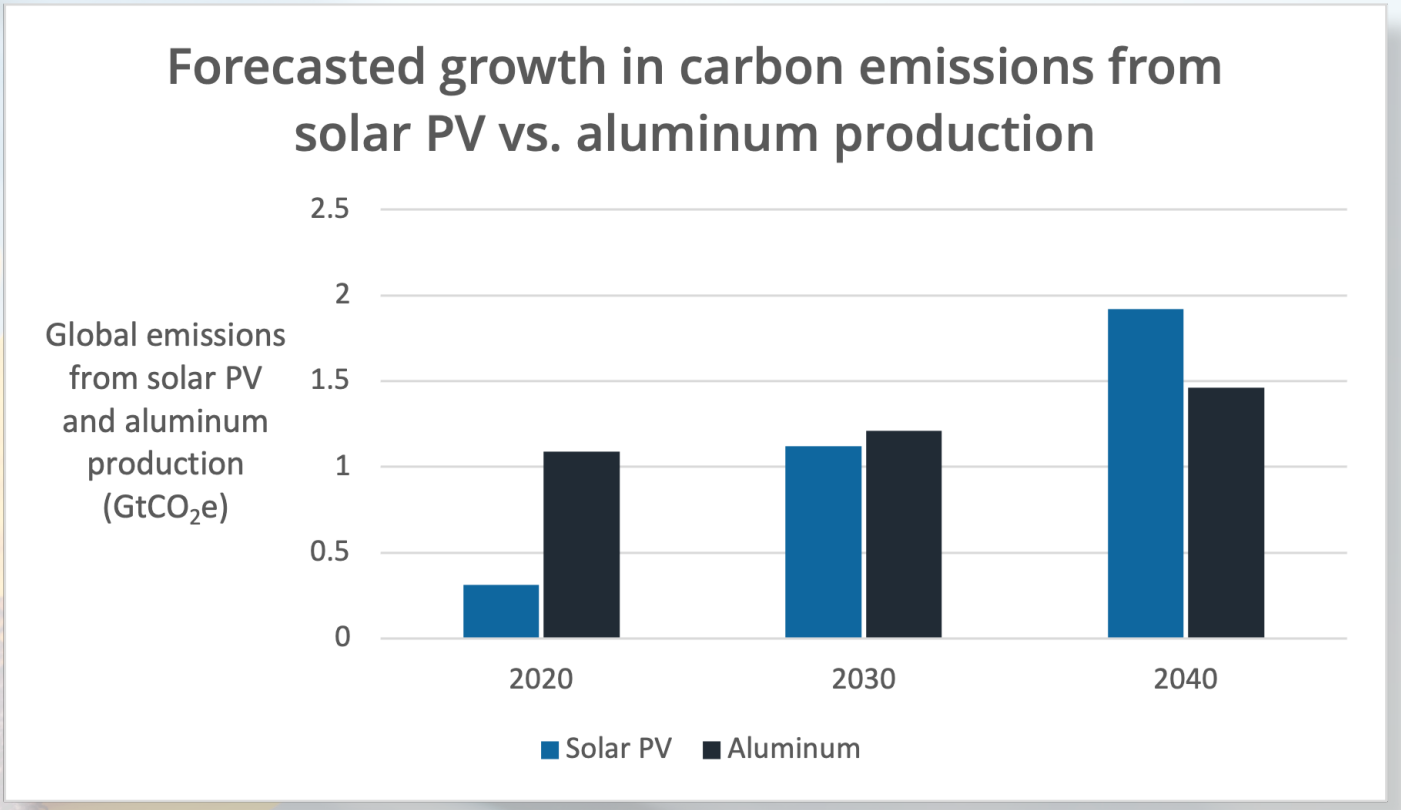
[6] G. Masson, I. Kaizuka, Trends in Photovoltaic Applications IEA Report (2020) accessed August 24, 2021. https://iea-pvps.org/wp-content/uploads/2020/11/IEA_PVPS_Trends_Report_2020-1.pdf

[7] Yue, You, Darling, Domestic and overseas manufacturing scenarios of silicon-based photovoltaics: Life cycle energy and environmental comparative analysis (2014) accessed August 24, 2021. https://www.sciencedirect.com/science/article/pii/S0038092X14001935

SHUT THE SOLAR PV DOOR BEFORE THE CARBON-HORSE BOLTS

Solar installations are expected to grow significantly over the upcoming decade as more companies and countries make commitments to zero-carbon energy to take climate action and meet key emissions reductions goals. The DNV GL's Energy Transition Outlook forecasts that new solar PV installations will triple by 2030.[8]

Today, solar PV manufacturing represents a small percentage of global emissions. However, a continued business-as-usual approach, including the forecasted solar PV growth, will increase the carbon emissions from solar PV production and exceed aluminum manufacturing by 2040. For perspective, aluminum is currently the fourth largest industrial commodity from an emissions standpoint. [9]



There is a time bound opportunity to raise the industry standard for the procurement of solar PV by establishing low-carbon solar as the new market norm. Leveraging outsized market demand for low-carbon solar could help avoid over 14-18 Gt of cumulative CO2 emissions over the next 20 years.[10] This is meaningful given the current global emissions rate is 51 Gt of CO_2e. [11]

[8] DNV Energy Transition Outlook (2018) accessed August 24, 2021. https://eto.dnv.com/2018#Energy-Transition-Outlook-2018-

[9] Yue, You, Darling (2014); NREL Factsheet; DNV (2018); EIA. Electric Power Monthly. accessed 11 August 2021. https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b; NASA POWER Data Access Viewer. accessed 11 August 2021. https://power.larc.nasa.gov/data-access-viewer/; IEA PVPS Snapshot of Global PV Markets (2020). accessed 11 August 2021. https://iea-pvps.org/wp-content/uploads/2020/04/IEA_PVPS_Snapshot_2020.pdf; IAI Aluminum Sector Greenhouse Gas Pathways to 2050 (2021). accessed 24 August 2021. https://international-aluminium.org/resource/aluminium-sector-greenhouse-gas-pathways-to-2050-2021/

[10] Ibid

[11] Breakthrough Energy, Getting to Net Zero, accessed 11 August 2021 https://www.breakthroughenergy.org/our-challenge/getting-to-zero

TERMINOLOGY

UPFRONT CARBON:
The emissions associated with the material extraction, manufacturing, and installation phases of a product or infrastructure before it is in use or operational. [12]

EMBODIED CARBON:
The emissions associated with upfront carbon, as well as the maintenance, end of life and disposal associated with the product or infrastructure. Does not include operational emissions.

LIFE CYCLE ASSESSMENT (LCA):
A technical method to account for the environmental aspects and potential environmental impacts (e.g. use of resources and the environmental consequences of releases) throughout the life cycle of a product from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal. (ISO 14040, 2006)

ENVIRONMENTAL PRODUCT DECLARATION (EPD):
A third-party verified document based on an LCA of a product to enable comparisons between products fulfilling the same function.

REQUEST FOR PROPOSAL (RFP):
A business document that solicits bids from qualified contractors to complete a project, often including extensive technical calculations.

[12] Definition reference: The Institution of Structural Engineers, How to calculate embodied carbon (2020) accessed 24 August 2021
https://www.breakthroughenergy.org/our-challenge/getting-to-zero

III. OPPORTUNITY FOR IMPACT

The business case for energy customers of solar PV equipment and/or electricity to prioritize low-carbon solar PV procurement rests on three pillars:

01

MITIGATE RISK

Energy customers are seeking to get ahead of changing national policies and accounting mechanisms that are considering embodied carbon, and working to increase transparency in energy procurement practices to mitigate carbon exposure associated with the production of goods purchased. French and South Korean programs already favor low-carbon solar PV in public procurement, and the European Union is working to add embodied carbon disclosure for solar PV into its Green Public Procurement system.

02

DEMONSTRATE CORPORATE LEADERSHIP AND INCREASE IMPACT

Companies are setting increasingly bold targets, as seen with the significant increase in companies announcing approved science-based targets, which surpassed 800 signatories five years after the launch of the Science Based Targets Initiative, [13] and seeking to stand out in the growing group of organizations proactively working towards a zero-carbon future. Companies can maximize impact through individual transactions and be recognized as leading the way to a sustainable green economy by bringing embodied carbon into the solar PV project selection process.

03

STRENGTHEN THE SOLAR INDUSTRY

Low-carbon solar energy customers help secure the sustainable growth of the solar industry by shifting the industry to address sustainability risks and foster further innovation of new technologies, business practices, and processes to meet low-carbon demands.

[13] Science Based Targets , accessed 11 August 2021. https://sciencebasedtargets.org/companies-taking-action

LOW-CARBON SOLAR BRINGS POSITIVE EXTERNALITIES

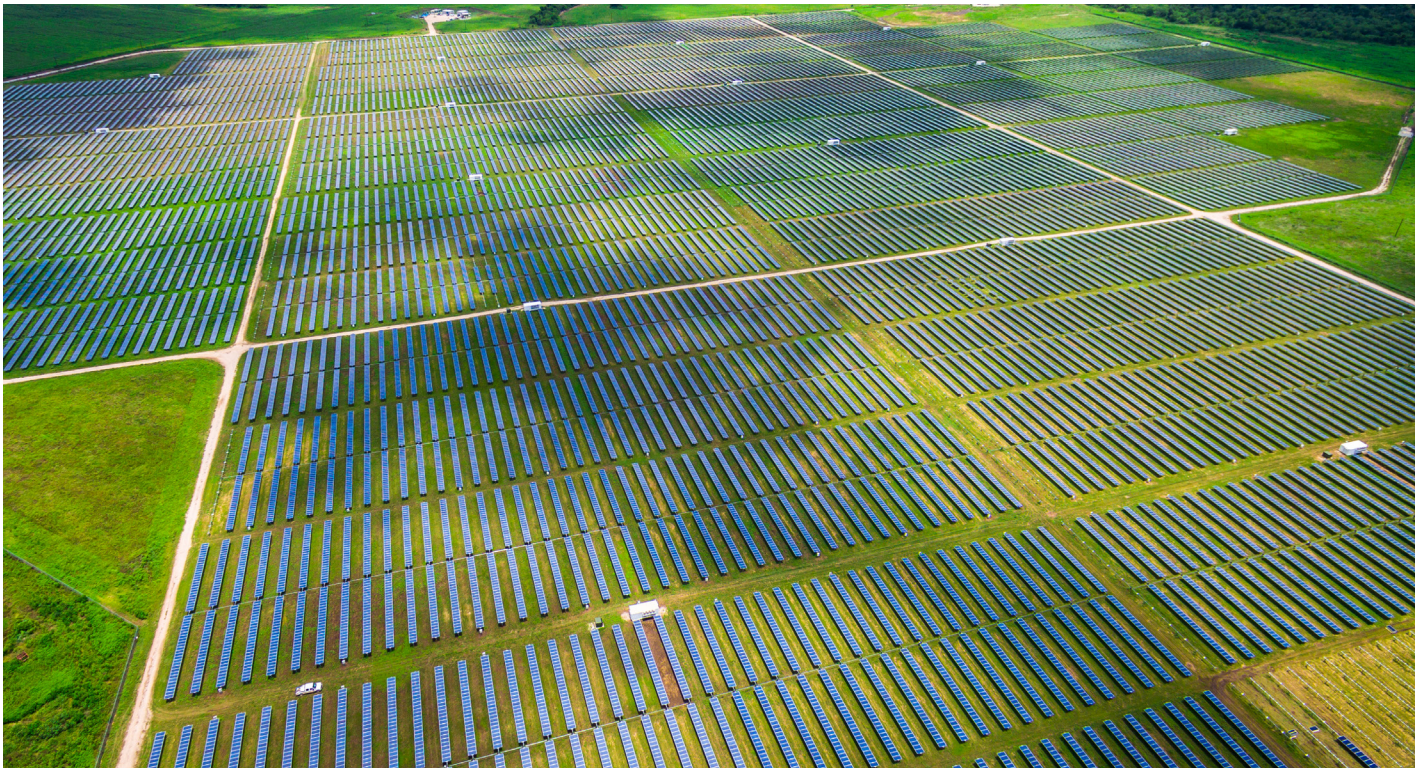
The benefits of increased demand for low-carbon solar extend beyond energy customers.

JOBS IN LOW-CARBON REGIONS

Solar PV forecasts suggest that employment in the solar industry could grow three-fold within the next decade to meet climate ambitions.[14] Additionally, studies show that new investment in solar creates nearly three times as many direct and indirect jobs on average as fossil fuel energy sources.[15] Low-carbon solar PV demand will spur new associated value chain production capacity in regions where carbon from the processes can be eliminated, such as in the U.S. or Europe, where manufacturers can access renewable energy for operations.

FUTURE-PROOF MANUFACTURING

Solar PV component manufacturers and their investors are building new assets today that will support the industry for decades to come. Optimizing facility and supplier networks for a low-carbon industry standard can mitigate future risks as expectations and demands from energy customers and regulators evolve. Additionally, locating new facilities into clusters will help reduce supply chain interruptions while creating innovation hubs and further reduce the levelized cost of electricity from solar PV.



[14] IRENA, Future of Solar Photovoltaic (2019), accessed 24 August 2021. https://www.irena.org/publications/2019/Nov/Future-of-Solar-Photovoltaic

[15] Garrett-Peltier, Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model (2017), accessed 24 August, 2021. https://www.sciencedirect.com/science/article/pii/S026499931630709X

IV. ENGAGE FURTHER

Energy customers can positively influence the solar PV supply chain by using their company's purchasing power to signal preference for low-carbon equipment, either as individual entities or in collaboration with industry peers.

01

ASK FOR ENVIRONMENTAL PRODUCT DECLARATIONS (EPDS) OR LIFE CYCLE ASSESSMENTS (LCAS)

Ask your solar PV supplier for information about the embodied carbon and other environmental attributions of the equipment being employed in projects. Asking the question can have a ripple effect in the supply chain and, as EPDs and LCAs become more readily available, the information can feed databases to improve procurement decision making strategies for the broader industry.

02

UPDATE LANGUAGE IN YOUR REQUEST FOR PROPOSAL (RFP) OR PROJECT SPECIFICATIONS

Use RFPs and product specifications to inform suppliers of your priorities to strengthen your ask for low-carbon solar. As multiple parties respond to RFPs, these requests can extend across the industry to a wide audience and send clear demand-signals to the market.

03

MAKE A PUBLIC STATEMENT

Public statements not only inform the general market on valuable business decisions, but also demonstrate a company's leadership towards a zero-carbon future.

04

JOIN A COALITION

A unified demand-signal from multiple energy customers increases the likelihood of company preferences reverberating down to the base of the key supply chains. The REBA Institute's **Decarbonizing Industrial Supply Chain Energy** (DISC-e) program has launched a Low-carbon Solar Community of Practice comprised of energy customers and other solar supply chain stakeholders committed to the decarbonization of the solar PV supply chain.

05

DEVELOP A DEEPER UNDERSTANDING

Use available training and educational resources to further enhance your understanding and ability to make informed business decisions. Speak with peer organizations that also seek impact from renewable energy transactions to increase your understanding of current best practices.

ADDITIONAL RESOURCES

Complementary efforts to low-carbon solar:

- Global Electronics Council's EPEAT standard for solar modules and inverters, which is currently being revised to increase attention to low-carbon solar modules.
- Ultra-Low Carbon Solar Alliance's work to expand awareness and deployment of ultra low-carbon PV.
- Solar Energy Industries Association (SEIA)'s work on solar supply chain transparency with a focus on labor and human rights.
- CEBI's Beyond the Megawatt Project, which builds upon Salesforce's grounding work in **More than a Megawatt**, with focus on Climate & Emissions, Frontline Community Co-Benefits, and Diversity, Equity, Inclusions and Justice (DEIJ).

ABOUT THE CLEAN ENERGY BUYERS INSTITUTE'S DISC-e PROGRAM

The **Decarbonizing Industrial Supply Chain Energy (DISC-e)** program organizes energy customers with Scope 3 GHG commitments to use their purchasing power to create demand-signals that reverberate down supply chains. The Low-carbon Solar Community of Practice informs the strategic direction of efforts to accelerate the decarbonization of the solar PV supply chain and the development of frameworks, tools, and educational products that support a company's journey towards a truly zero-carbon future. Collectively, companies can make a meaningful impact through a clear market signal for low-carbon solar PV and raise the standard for all global solar PV manufacturers to follow.

Interested in joining? To learn more, email **communications@cebi.org**

CEBI
CLEAN ENERGY BUYERS INSTITUTE

Address
Clean Energy Buyers Institute (CEBI)
1425 K St. NW, Suite 1110, Washington, DC 20005

Phone
1. 888. 458. CEBI

Email / Web
info@cebi.org
www.cebi.org