HEMLOCK SEMICONDUCTOR

August 5, 2020

Ms. Rajinder Sahota
Division Chief, Industrial Strategies Division
1001 I Street
Sacramento, CA 95814

Dear Ms. Sahota,

Hemlock Semiconductor writes to encourage CARB to incorporate considerations of embodied carbon in the solar supply chain during the Carbon Neutrality workshop series, the upcoming Scoping Plan work, and the SB 100 implementation project. Differences in embodied carbon in commercial solar panels due to the varying carbon intensities of suppliers of the most energy intensive components of the solar value chain is an important consideration in light of solar playing an increasing role in the transportation sector as a source of power for electric vehicles.

Hemlock Semiconductor, based in Hemlock Michigan, manufactures polycrystalline silicon (or "polysilicon") for the solar and semiconductor industries. Producing polysilicon is the first step in the solar value chain. It is also the most energy intensive and represents the most carbon intensive component of the solar supply chain.

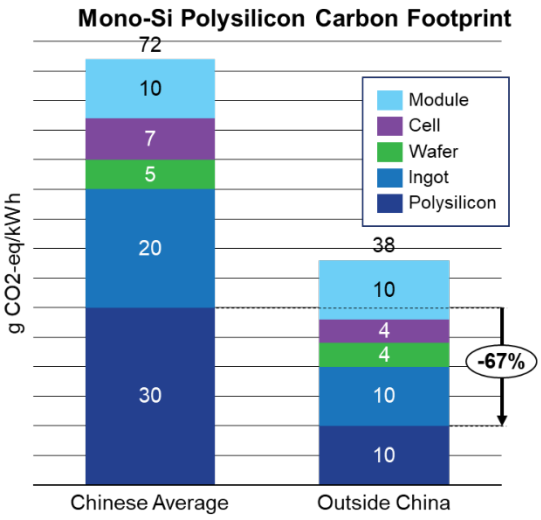
Not All Solar is Created Equal

Although the concept of accounting for "embodied carbon" is gaining credence, the market is still largely unaware of significant embodied carbon differences in the solar supply chain and the resulting solar panels. Published studies demonstrate the smaller carbon footprint of more sustainably produced materials in PV modules. This research indicates that polysilicon produced in the US and EU has considerably lower embodied carbon than polysilicon produced in China. This is primarily due to differences in the efficiency of manufacturing processes and the carbon intensity of delivered energy to manufacturers.

A study by Argonne National Labs and Northwestern University found that PV modules produced with polysilicon from China have **twice** the embodied carbon as modules made with US/EU produced polysilicon. This means that a solar project implemented with panels made with lower carbon polysilicon can avoid significant supply chain emissions. While the EU market has begun to place value on this better carbon performance, such as France's embodied carbon standard for utility solar, the US market is just beginning to recognize this value.

Energy-Intensive Manufacturing and Embodied Carbon

Polysilicon is among the key input materials for photovoltaic modules and is particularly energy intensive to produce. Because grid energy fuel mixes vary considerably across the world, the carbon intensity of that delivered power also varies significantly. China is still predominantly reliant on coal for power generation as compared to the greater use of natural gas, nuclear and renewables in the US and EU. In addition, because energy costs are a significant component of polysilicon manufacturing costs, western producers operate very energy efficient production facilities, something subsidized Chinese producers have less motivation to invest in. Accordingly, polysilicon from Chinese producers has 3-5 times the embodied carbon of polysilicon from US and EU producers. As a result, according to a study by Argonne National Laboratory and Northwestern University[1], a PV module made with Chinese produced polysilicon has more than twice the embodied carbon emissions as a module produced with US or EU inputs, largely the result of the difference in the polysilicon carbon footprint as detailed in the accompanying figure.



During the past decade, the solar-grade polysilicon market has commoditized as significant manufacturing capacity has been added in China, particularly in Xinjiang province in western China. Xinjiang now produces 50% of all polysilicon used in solar panels, and it is all based on coal fired power. In addition to carbon intensity, there are serious labor issues associated with Xinjiang manufacturing. Recently the US State Department has warned US businesses about supply chains that extend to Xinjiang because of concerns over human rights abuses of Uighurs and other minority populations, including forced labor and forced sterilizations. Sourcing solar panels made with domestic or EU polysilicon provides both superior carbon value and better transparency about labor practices. Such panels are in the market today at fully commoditized prices and simply need to be specified in a project.

Companies like US-based SunPower are sourcing lower carbon polysilicon and selling PV modules with about half of the embodied carbon as panels made from higher

[1] Yue D., You F., Darling, S. (2014). *Domestic and overseas manufacturing scenarios of silicon-based photovoltaics: Life cycle energy and environmental comparative analysis*. Retrieved from: https://www.sciencedirect.com/science/article/abs/pii/S0038092X14001935?via%3Dihub

carbon polysilicon. Some thin film PV technologies such as cadmium telluride have similarly low embodied carbon. Because solar is a commoditized market, there is no price premium associated with these attributes. There is excess production capacity at all of the low carbon polysilicon producers in both the US and EU, so increased demand for low carbon PV panels would be unlikely to lead to increased costs as multiple polysilicon producers would be competing to sell into that demand. In addition, the cost of polysilicon represents roughly 5% of PV system costs on a kwH basis, such that even if polysilicon prices were to rise it would have minimal effect on the cost of solar projects.

An Opportunity for Carbon Reductions

France includes considerations of embodied carbon in its bids for utility scale public power projects, establishing a maximum threshold for embodied carbon at the panel level and requiring life cycle analyses at each step of the solar supply chain to document embodied carbon. South Korea has recently announced its intent to implement similar provisions.[2] As the private sector becomes aware of these differences in embodied carbon, companies are considering or implementing low carbon PV specs in their project bids. Corning Inc. has recently completed several projects utilizing low carbon PV panels without paying a price premium.

Based on peer-reviewed life cycle analyses and government data, HSC estimates that if the next five years of California's projected PV growth were implemented with low-carbon solar vs. regular panels an additional 60 million tons of supply chain CO2 emissions would be avoided. Planning for low-carbon PV in integrated rooftop and vehicle electrification systems would reduce the carbon footprint of the transportation sector.

Establishing preferences or requirements for low carbon PV panels in solar installations, both utility scale and rooftop, provides an opportunity for California to make meaningful reductions in solar supply chain emissions at little or no cost, further reducing the carbon footprint of buildings and electrified transportation. Unlike the carbon benefits of ongoing operation of a PV system, reducing supply chain emissions reduces CO2 today – when it counts the most.

In the near term, a move towards preferences or requirements for the use of lower carbon PV panels would be expected to shift existing market demand within an oversupplied market from higher carbon polysilicon producers to lower carbon polysilicon producers. However, given the significant growth projected for solar energy in the coming years, we anticipate that there will be ongoing additions of polysilicon production capacity globally. A market shift towards lower carbon PV

[2] https://www.pv-magazine.com/2020/05/29/south-korea-introduces-carbon-footprint-rules-for-solar-modules/

HEMLOCK SEMICONDUCTOR

would incentivize that additional capacity to be installed in areas where that production could access lower carbon forms of electricity, serving to progressively decarbonize this growing supply chain. In the interest of reducing California's transportation footprint, establishing this preference for the lowest carbon solar early could have significant market impacts over time.

Finally, through programs such as Buy Clean and corporate purchasing, both California and the private sector are seeking to reduce supply chain emissions in globalized energy intensive industries such as steel, cement and glass. Solar PV has a more compact chain with relatively few major producers at each level of the supply chain. This makes solar an efficient industry in which to develop the tools and methodologies to both reduce supply chains emissions and to document those reductions.

Thank you for your consideration of these comments. We look forward to continuing to work with CARB and the Energy Commission to explore the embodied carbon of solar.

Sincerely,

Brooke Beebe
VP External Affairs
Hemlock Semiconductor Operations, LLC