An overall picture: The environmental impacts of a new solar cell technology

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A more efficient solar panel sounds great. But what if these new panels consume more toxic materials, or their production consumes a lot of energy? Leiden environmental scientists, together with colleagues from

the Fraunhofer ISE, address this multifaceted question in a new publication in the journal *Energy & Environmental Science*.

More efficient solar cells

"Our research helps developers focus on the most effective sustainable pathways into a brighter future empowered by renewable energy," says first author Carlos Felipe Blanco. "In order to assess the full environmental impact of a new technology, we should look at the complete life cycle from production to waste."

Current solar panels are usually made of silicon. This material is cheap and non-toxic, but it is not very efficient at converting sunlight into electricity. A more advanced type of solar cell technology (III-V/silicon tandem solar cells) incorporates very thin layers of elements such as gallium, indium and arsenic on top of silicon, allowing it to generate nearly fifty percent more electric energy from sunlight. However, some of these materials can be more toxic than silicon, and their incorporation onto the cell requires processing at high temperatures, consuming large amounts of electric energy.

Environmental impacts

Solar power plants using III-V/silicon cells have not been installed yet, as they are still in the early research and development stage. "We investigated the potential environmental impacts at every stage in the life cycle of these advanced cells," explains Blanco. This way, the researchers found that the largest environmental impact of III-V/silicon cells comes from having to manufacture them with electricity from power plants. Especially when these power plants still rely on burning coal. "This not only affects the climate through CO_2 emissions, but the toxic fumes from burning coal also affect ecosystems in various other

ways."

Frank Dimroth from the Fraunhofer ISE adds: "This impact may be overcome by developing more energy-efficient manufacturing processes and of course by moving towards more sustainable electricity. It is astonishing to note that the environmental impact of a new solar cell technology relies on the way how we are producing our electricity today from fossil fuels."

The researchers were further able to confirm that -thanks to the high conversion efficiencies of the new cells- fewer materials are ultimately required per unit of electricity generated. Blanco: "This suggests that continuous innovation in solar cell technology and more energy-efficient technologies can lower the environmental impacts of solar cells."

Trade-offs

Blanco and his colleagues relied on several models that take into account many possible industrialisation scenarios—more innovative or conservative. "This careful framing along with an unprecedented level of detail in the models allowed us to give very specific guidance for technology developers and policymakers. We found a few things that matter, but we also found many things that didn't matter as much as initially thought. For example, the use of gallium and arsenic did not pose a major environmental concern in terms of toxicity or resource depletion as only very small quantities of these elements are consumed and they are strongly bound into the crystal structure."

Complex endeavor

Designing innovation for sustainability is a very complex endeavor, with numerous unforeseen tradeoffs and opportunity costs hiding behind the

decisions of emerging technologies. Blanco: "It is of utmost importance that we carefully and systematically ponder the consequences of our decisions. This requires a large amount of data and modeling, but gives us direction on how to engineer processes and devices to avoid harmful effects. If we only look at the potential problems of a new technology, we may be missing out on important opportunities in the future. We can now say with confidence that III-V/Si tandem solar cells have great potential to increase conversion efficiencies in the future. This may lead to less material requirement and finally lower environmental impact. We hope that his technology will soon become a reality."

More information: Carlos F. Blanco et al. Environmental impacts of III–V/silicon photovoltaics: life cycle assessment and guidance for sustainable manufacturing, *Energy & Environmental Science* (2020). DOI: 10.1039/D0EE01039A

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