Northumbria University NEWCASTLE

Picture of a solar farm. Credit: Adobe Stock.

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Scaling-up global solar panel manufacturing sustainably

Pioneering research led by Northumbria University shows how the renewable energy sector can scale-up the production of solar energy technology while further reducing environmental impacts.

As solar energy rapidly expands to meet urgent climate targets and increasing demand for electricity, the key challenge is to ensure that this transition is not just scalable but sustainable.

Published in Nature Communications, the study demonstrates that solar panels – which are already a powerful tool for reduced carbon dioxide emissions – will become even more environmentally friendly as the industry adopts next-generation technology.

The study reveals an encouraging trend: improvements in the efficiency of solar cells can simultaneously drive environmental benefits that extend beyond just reducing greenhouse gas emissions.

The research is a collaboration between Northumbria and the Universities of Birmingham, Oxford, and Warwick. The work involves using life cycle assessment to quantify the environmental impact of photovoltaics from extraction of raw materials out of the ground to the production of state-of-the-art silicon solar panels that will dominate the market up to 2035. This timescale is critically important as we take decisive action towards Net Zero and significantly scale-up our demand for electricity across the world.

First authored by Bethany Willis, a ReNU PhD student at Northumbria University, and directed by Neil Beattie, Professor of Energy Innovation at Northumbria University, the research reveals that the composition of the electricity mix used to manufacture solar panels strongly affect the environmental impact of production. Realistic decarbonisation of global mixes offers savings of up to 8.2 gigatonnes of equivalent carbon dioxide emissions. To put in context, that represents approximately 6.3% of the total remaining carbon budget to stay on track with the Paris Agreement and limit global warming to 1.5 °C.

“Solar photovoltaics is a critical technology that can be used globally now to significantly reduce greenhouse gas emissions and create energy security,” said Professor Neil Beattie. “This is especially important as our demand for electricity soars over the next decade driven by applications in transport, heating and digital infrastructure for AI.

“As we scale-up photovoltaics to multi-terawatt levels to meet this demand, it’s important that we do so sustainably. Our research demonstrates that significant savings in environmental impact – including carbon dioxide emissions – are possible through manufacturing.

“More specifically, we find that this impact is sensitive to the composition of the electricity mix where the solar panels are made and we should work to

decarbonise this as much as possible."

Professor John Murphy, co-author and Chair of Electronic Materials at the University of Birmingham, said: "Silicon-based photovoltaic technologies have immediate relevance to the UK and already play a major role in our strive for Net Zero. This groundbreaking study originates from a new collaboration between four leading UK University research groups who intend to work on all aspects of sustainability in the photovoltaics supply chain from raw materials through to end-of-life."

Sebastian Bonilla, Associate Professor of Materials Science at The University of Oxford and co-author, added: "We are at a critical moment where solar power is rapidly scaling to become a significant portion of global electricity generation. This work uniquely identifies the environmental impacts of the ongoing solar energy revolution, helping us guide the choices of materials, technologies, and manufacturing locations that will minimise harm while maximising the benefits of terawatt green electricity."

While carbon dioxide emissions remain the most widely considered environmental impact, the study quantifies 16 different environmental impact categories.

An important impact from the work is that industrialists and policy makers can use it to pinpoint where further innovation is required. For example, next-generation technology reduces climate impact by 6.5% but increases critical mineral depletion by 15.2% due to higher silver consumption in the electrical contacts to the solar cell. This motivates research and development into alternative materials, such as copper. It also emphasises the need to avoid simply shifting environmental burdens from one category to another but rather consider sustainability as a system problem.

The study forecasts that solar panels installed by 2035 could avoid at least 25 gigatonnes of CO_2 emissions compared to conventional power sources in less than half of their operational life.

Study co-author, Dr Nicholas Grant, Associate Professor, at The University of Warwick said: "Terawatt-scale photovoltaic manufacturing demands a sharper focus on its full environmental footprint. Our paper shows how targeted improvements across the supply chain can deliver sustainable manufacturing at the terawatt-scale, avoiding gigatonnes of manufacturing-related CO_2

emissions if installed by 2035, while supporting rapid global deployment".

As Professor Beattie also notes: "Even when manufacturing impacts are considered, solar photovoltaics remains one of the lowest-impact and most sustainable electricity generation technologies available over its whole life cycle and we should concentrate on deploying it at scale, now."

Ends.

Notes to editors:

Energy Research at Northumbria University:

The world faces an unprecedented challenge in getting to net zero carbon emissions by 2050. Northumbria's energy research uses fundamental physics, chemistry and engineering to develop new ways to generate and store renewable energy - to help deliver a cleaner and greener future.

More information: https://www.northumbria.ac.uk/business-services/research-and-consultancy/energy/

Renewable Energy Northeast Universities (ReNU)

Northumbria University leads two EPSRC Centres for Doctoral Training in Renewable Energy Northeast Universities (ReNU/ReNU^{+}), delivered in collaboration with Durham and Newcastle universities. These programmes will collectively train 117 doctoral carbon champions between 2019 and 2032 with a key focus on interdisciplinary systems thinking and research excellence required for the transition to Net Zero. More information: https://www.northumbria.ac.uk/research/postgraduate-research-degrees/studentships/renewable-energy-northeast-universities/

About the University of Birmingham:

Ranked among the world's top 100 institutions, the University of Birmingham is built on a foundation of world-class research, while also being the most targeted UK university by top graduate employers. Its work brings people from across the world to Birmingham, including researchers, educators and

more than 40,000 students from over 150 countries. Birmingham researchers drive global thought leadership, and their work helps shape our future by advancing knowledge, shaping policy change, and inspiring the next generation of scholars, policymakers, and industry leaders.

About the University of Warwick:

Founded in 1965, the University of Warwick is a world-leading institution known for its commitment to era-defining innovation across research and education. A connected ecosystem of staff, students and alumni, the University fosters transformative learning, interdisciplinary collaboration, and bold industry partnerships across state-of-the-art facilities in the UK and global satellite hubs. Here, spirited thinkers push boundaries, experiment, and challenge convention to create a better world.

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Northumbria is a research-intensive university that unlocks potential for all, changing lives regionally, nationally and internationally.

Two thirds of Northumbria's undergraduate students come from the North East region and go into employment in the region when they graduate, demonstrating Northumbria's significant contribution to social mobility and levelling up in the North East of England.

Find out more about us at www.northumbria.ac.uk

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