

Voices

Pursuing energy security via technologies and human behavior

Securing an accessible, reliable, and affordable clean-energy future for every home and business remains a crucial sustainability challenge. In a recent Cell Press Forum on Sustainability, a diverse panel of experts assembled to shed light on the connections between renewable energy technologies, human behavior, and energy security. Following the event, the panelists were asked: what and where are the opportunities to leverage technology and human behavior to pursue energy security toward a just renewable energy future?



Johanna Mathieu
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Flexible demand to support evolving power grids

Renewable energy resources are key to a sustainable energy future, but they also bring challenges to power grid operations. Wind turbines and solar photovoltaic systems connect to the grid through inverters—power electronics devices that convert DC power to AC power—which give renewable resources different capabilities as well as constraints. High penetrations of inverter-interfaced resources change the fundamental dynamics of the grid, requiring us to rethink the way we model and analyze the grid. This calls for [new technologies and grid operational strategies](#). Further, many renewable resources, such as wind and solar, are variable and uncertain, and therefore less dispatchable than fossil fuel power plants. This makes it harder for grid operators to balance electricity supply and demand.

Enabling high penetration of renewables requires increased flexibility from a variety of resources including energy storage, flexible electric loads, and controls built into the renewables themselves. Batteries are the most commonly proposed technology for balancing renewables, but they come with their own challenges related to material sourcing and disposal. While they are likely a part of the solution, we can also choose to overbuild renewables and curtail them to balance demand. Additionally, we can better match demand with supply. Demand response (DR) programs encourage load shedding and shifting; [advanced DR](#) uses aggregations of flexible loads like [virtual power plants](#) to balance the grid. To ensure the success of advanced DR, it is crucial that DR is nondisruptive and simple to use, requiring engineers to collaborate with social and behavioral scientists on its design and adoption strategies. Lastly, given unequitable access to and harm by energy systems, engineers should develop solutions that promote energy justice.



Sebastian Berger
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Behavioral insights are key to modern energy systems

In many parts of the world, households have not had to worry about energy that has been supplied predominantly by centralized power plants. On most occasions, electricity has been readily available day and night at affordable prices. To ensure that this remains the case with renewable energy systems, which are more decentralized and digital, human behavior needs to take on a more prominent role in energy systems management. First, in decentralized energy systems, consumers will turn into prosumers: they will not only consume energy from the grid, but also make decisions to deliver energy to other members of the network. An important yet open research question is therefore how people will approach energy decisions. To answer this question, we need to better understand how factors such as cooperativeness, attitudes toward risk, or autonomy preferences affect decisions to consume energy, store it, or release it to the grid. Second, digitalization allows a more efficient use of energy. Smart devices will help us optimize our energy decisions, enable better feedback, and help manage overall grid performance. This development requires us to understand how consumers take up and respond to digital feedback, which is one way to motivate behaviors that promote certain decisions over others. Finally, as electricity markets become increasingly complex, behavioral insights will have to factor into market design so that energy systems are designed for real humans rather than an

abstract *homo economicus*. Modern energy systems open many opportunities for collaborative research between the social sciences and engineering sciences, not least about novel business models and products.



Sebastian Sterl

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Tailoring sustainable energy development for Africa

The energy challenge the Global North faces is different from that confronting African countries. These countries continue to contribute very little to global greenhouse gas emissions and, in fact, need to alleviate energy poverty by greatly expanding energy access. Each African country will, and must, embark on a path of industrialization and economic development. The question, therefore, is not, “How can we decarbonize energy supply across Africa as fast as possible?”, but rather, “Can we conceive development-oriented, clean, and just pathways that minimize fossil fuel use?”

To answer this question, we need to move beyond the simplistic notion that all African countries deal with similar challenges that demand similar solutions, such as the often-repeated idea that they could “leapfrog” straight to renewables-based or fully decentralized energy systems. It is also essential to ensure that African countries’ energy pathways are not determined by outside interests, such as those of European countries busily making plans to import “green hydrogen” to be produced in Africa with the intention to help European heavy industry decarbonize—the benefits for European countries are clear, but where exactly the benefits and risks would lie for African countries remains unclear. Some global voices have also been calling for an end to fossil fuel exploration; such calls are undoubtedly well intentioned, but they do not fully acknowledge the circumstances on the ground. The needs and requirements of the countries themselves must take on a central role.

Each African country has different needs and is at a different starting point in its energy-development pathway. Hence, I believe that country-specific solutions should incorporate the most economically feasible ways of expanding access to electricity and clean cooking, the best ways of de-risking investments to attract more finance, and the most appropriate strategies for minimizing further fossil fuel use and fostering the adoption of cleaner sources.

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A community-driven approach for resilient power grids

Prolonged grid outages that are triggered by extreme events and increasingly driven by climate change are beginning to seriously affect lives and economies, even in higher income countries with supposedly advanced [electricity systems](#). In many places, households that are unhappy with this situation, especially those with the economic means, are seeking to address this challenge through the adoption of distributed energy resources (DERs, e.g., solar and storage) often with little help from or knowledge of grid system operators. If this trend continues, then DERs might end up benefiting mostly the wealthier sections of society. Further, should DER owners come to depend less on the grid system, the system-wide resilience outcome is expected to be worse and the economic costs of that would be largely borne by the poorer sections of society.

But we don’t have to choose that pathway. An electricity system in which DERs are fully integrated into and leveraged for grid system operations could foster demand response, lower emissions, and enhance the resilience of the grid as a whole, rather than benefiting only the [adopting households](#). But doing so will require proactive policies and regulation. A key feature of policies that are successful in the long-term is how well they support and leverage local participation, learning, and trust. A genuine, localized approach can help recalibrate misplaced perceptions and biases and can build long-term trust and support for the [program](#). If communities can participate and chart a course for their energy future, then their involvement will create long-term social buy-in and support for the larger energy transition.



Jan Rosenow
The Regulatory Assistance Project

The energy transition needs to be fair and just

Although most of the world's energy is currently derived from fossil fuels, the transition to renewable energy is well underway. Indeed, most new capacity added to the global electricity systems is now wind and solar with coal and gas getting squeezed. At the same time, there is a shift from centralized to decentralized energy generation at the communal and individual levels. Coupled with the increasing electrification of end-uses such as electric vehicles and heat pumps as well as small-scale batteries, this means that people will play a much more active role in the energy system. Not only will more people produce their own electricity and inject it into the grid, but they will also be able to offer flexibility to the power system. Much of this will be automated, so it will not require active intervention all the time. But we still have a long way to go as the shift toward renewable energy and electrification can only happen if people support the transition and see real benefits. Further, while millions still do not have adequate access to energy, let alone clean energy, those in rich countries will need to find ways to minimize energy wastage through efficiency and sufficiency. Too often clean energy programs have prioritized wealthier households and not paid enough attention to those most in need. Going ahead, we need to ensure that the poorest and most disadvantaged people are not left behind and are considered first, not last. The transition to clean energy can only succeed if it is fair and just.

DECLARATION OF INTERESTS

The authors declare no competing interests.