Energy and climate scientists discuss climate-smart power systems

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Unprecedented heat waves, storms, and wildfires are pushing electrical grids in the United States to their limits. To work towards a safe and reliable power system in the coming years, utilities will need to factor the potential effects of climate change and extreme climate change-driven events into their plans for power distribution, generation capacity and back-up energy storage, and infrastructure repair and replacement.

But how do you plan for the future given the wide range of plausible ways that climate change can impact "the new normal" and extreme weather events?

Liyang Wang and Andrew Jones, two scientists at Lawrence Berkeley National Laboratory (Berkeley Lab), are part of a team working to provide practical tools and guidance for grid planners. In this Q&A, Wang and Jones share findings of a review study that identifies how best practices in planning for uncertainty can be applied in the electricity sector, and discuss an upcoming project supported by the California Energy Commission that will evaluate alternative grid resilience strategies under a comprehensive range of climate futures.

Their study is part of the ongoing Department of Energy-funded HyperFACETS project that is developing new ways of evaluating and producing climate information in close collaboration with stakeholders.

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Andrew Jones is a staff scientist in the Climate and Ecosystem Sciences Division of the Earth and Environmental Sciences Area. Both are affiliated with the Energy and Resources Group at UC Berkeley.

Q. Is climate change being factored into grid planning at all, as of now?

Jones: You don't have to look very far into the recent past to find dramatic examples of how extreme weather events can stress electricity grids. These include recent wildfires, extreme heat waves that lead to high air-conditioning demands, plus direct risks to infrastructure from storms and flooding. Fire is a particularly tricky issue, both in terms of grid-driven ignitions and damages to the grid itself. So, there's certainly a lot of interest in understanding how climate change is influencing these events and their associated risks. However, the technical barriers to actually using climate science in an effective way are pretty significant.

It's not that electricity planners haven't dealt with uncertainties before, but the uncertainty that climate change presents is not one where you can just gather more and more observations until you understand the uncertainties. Climate resilient planning involves projecting multiple plausible future conditions through models. For example, we don't know how much greenhouse gas the world is going to emit in the next 30 years, so there are multiple different future emission scenarios. There are also many different, equally credible models of the physical climate processes. These are not things we can understand simply with more weather stations. So, one big change needed in grid planning is going from a framework where you're primarily using historic observations to one where you're using multiple future projections.

Wang: Yes, I think people are trying. I think particularly in locations that have experienced significant disruptions from extreme weather, utility companies and their regulators are trying to figure out how to factor climate change into their planning processes. But it's a really hard problem. For one, there's a degree of uncertainty about the future that is reflected in climate science models, yet it is not immediately clear which of those uncertainties are substantial enough to make a difference to decision-makers. Because of that, people are a bit hesitant because they're not entirely sure how to use the data in the first place. And two, I think there's also maybe a lack of innovation in how to apply principles of decision science—a field devoted to generating techniques for decision-making using statistics, economics, machine learning, and psychology—in the energy sector. Most of the time, utilities use historical weather data instead of future climate projections. The very few operators that are starting to use projections are kind of limited in the range of future scenarios. They're not considering the complete plausible range of what the future climate could look like or how it could impact the grid.

And it's very challenging; our current grid infrastructure is really old and it's not designed for both the unprecedented changing climate that we're seeing and the need to lower carbon emissions, simultaneously.

In our paper, we talked a lot about how the existing modeling tools that people are using don't have the ability to incorporate a lot of the inherent deep uncertainty of climate projections or how climate will affect consumer behavior. So, it's a lack of tools, and then also, I think it's kind of a lack of prioritizing planning for climate change—there isn't a formal process that guides utilities in how to plan for climate change.

Q. So what are some tools utility planners can use?

Wang: The main concepts that we have distilled from the decision science literature are robustness, adaptive planning, and multi-stakeholder engagement. The idea of robustness is you're trying to move away from finding one optimized solution, which is what traditional decision-making approaches focus on. Instead, a robust solution is one that will perform reasonably well across a wide range of future scenarios. And the idea of adaptive planning is actually not super new. People have been doing it for a while in conservation and in the water sector; but in the energy sector, we haven't seen it too much. Adaptive planning basically calls for more proactive planning where you monitor changes that you're seeing in the current environment. And based on those changes, what are the next steps that you can take? Concurrently, it also calls for a formalized institutional process to develop those actions and a monitoring system.

Rather than choosing a single strategy today, which may mean over-investing or under-investing in corrective measures, adaptive planning means identifying a range of appropriate actions for the range of possible conditions, then monitoring for signs that indicate which scenario is indeed unfolding. So for instance, there is some uncertainty about just how much and how quickly climate change will impact hydropower resources. If hydropower remains stable then it may be acceptable to "wait and see" while continuing to plan for possible declines; if hydropower is clearly declining rapidly then it may be time to invest in additional generation; and if hydropower is becoming more variable from year to year, then it may be appropriate to invest in additional storage. Planning for each possibility now and identifying "signposts" that indicate which path we should be on are hallmarks of adaptive planning.

Then the multi-stakeholder engagement concept is also a proven approach. This is seen pretty commonly across a lot of different sectors. The idea here is to facilitate a discussion among a range of people with different priorities and expertise.

Jones: Right, the way I think about the multi-stakeholder part is that every energy decision has multiple competing objectives. For example, if you think about electricity sector planning, you have to balance cost with reliability and sustainability. You have to think about performance under very extreme conditions versus performance on normal days. How much do you want to invest or pay for resilience during those extreme times that affect different stakeholders in very different ways? You know, for somebody who is on a ventilator, a power outage is life-threatening. That person will have a very different perspective than someone in a different situation. And so, the multi-stakeholder perspective explores how these different priorities might play out under different scenarios, to make the tradeoffs more clear, and hopefully to find the solutions that work most broadly.

Wang: Something else we highlighted is the lack of trained professionals that understand both the climate science side and the power system planning side. And that is maybe where the multi-stakeholder engagement could come in. It could facilitate an environment where climate scientists can communicate with power system engineers in a more effective way, and together, they can integrate the most up-to-date climate science in the planning process.

Q. How are you putting these ideas into action?

Wang: We have a pair of related projects starting next year, in collaboration with Energy & Environmental Economics and Eagle Rock Analytics, focused on planning a climate resilient power system for the state of California. It's a team of climate scientists, engineers, decision scientists, and modelers, and we are going to work together to develop tools that will allow decision-makers to account for uncertainties in our changing climate. So that's a work in progress now and what we are envisioning is that one of the end products will be an interactive online modeling tool. Users will be able to select different climate variables that they care about and see how they might impact a specific region. Visualizing those impacts might be helpful for long-term grid planning. And seeing how the uncertainty in climate variables such as temperature or rainfall would affect things like energy demand or other factors they care about.

Jones: Adding to that, I don't know that we can or will know exactly what the right solution is until we have more extended dialogue between climate science experts and practitioners from the electricity sector. In our ongoing DOE-supported work on the HyperFACETS project, we are developing new foundational ways of producing and evaluating climate science in close collaboration with stakeholders. Our new CEC-supported project extends that dialogue to focus on practical tools that translate the science into usable information. Together this portfolio of projects covers the full spectrum—from how we model climate-driven extreme events all the way to how we consider alternative adaptation solutions across the range of possible outcomes.

It's notable that the electricity sector is regulated in a very complex way and very differently in different states and different geographies as well. So, there are certain elements that we need to figure out, which these collaborations are going to address. But I think it's clear that, from a technical point of view, we do need tools that allow us to explore the implications of a wide range of possible scenarios and then to evaluate the implications for multiple objectives. Our hunch is that if you can do that in an interactive and intuitive way, that it will enable a different kind of planning that can account for many different possible future outcomes. So that's maybe the fundamental shift.

More information: Anna M Brockway et al, Climate-aware decision-making: lessons for electric grid infrastructure planning and operations, *Environmental Research Letters* (2022). DOI: 10.1088/1748-9326/ac7815#erlac7815s5

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