

# Open for Power: How Open Science Can Forge a Just and Sustainable Energy Future

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The world stands at a critical juncture, facing the dual crises of a rapidly changing climate and a persistent lack of energy access for billions. The global energy transition is underway, but it is a monumental task that involves far more than simply replacing fossil fuels with renewable technologies; it is a process of profound societal change that carries deep ethical implications. To navigate this transition successfully, we must recognize that the "how" of our research and development is just as important as the "what." In the face of the climate crisis, the global energy transition demands not only technological innovation but a fundamental shift in research and development ethics. By embracing open science—from transparent data and methodologies to the collaborative creation of open-source appropriate technologies (OSAT)—the energy research community can dismantle inequitable, top-down models and foster a more just, sustainable, and community-empowered energy future.

The dominant paradigm in energy research and development has long been a "closed" one, characterized by proprietary technology, secret data, and siloed knowledge. This model is not only ill-suited for the complex, global challenges we face; it is rife with ethical failures. As Miller [2014] argues, energy transitions are social and political reorganizations that inherently redistribute wealth, power, and risk. When these decisions are made behind closed doors, they frequently fail the basic tests of justice. *Distributive justice*, which concerns the fair allocation of benefits and burdens, is often violated when projects are optimized for profit without regard for the communities they impact. Similarly, *procedural justice*, the right to have a voice in decisions that affect you, is denied when communities are excluded from the planning process. The controversy surrounding the Dakota Access Pipeline, as analyzed by Bethem et al. [2020] through a Lakota ethical lens, is a stark example of this failure. The pipeline's approval prioritized corporate benefit over the sacred land and water rights of the Standing Rock Sioux Tribe, demonstrating a profound lack of both distributive and procedural justice. This opacity extends into the research itself, where a lack of transparency hinders replication, slows innovation, and erodes public trust at a time when it is most needed [Alonso Pedrero and Van de Sande Araujo, 2025, Fell et al., 2024].

The necessary alternative is a paradigm shift towards open science. This is not a radical new idea, but a return to the foundational principles of scientific inquiry: transparency, collaboration, and the free exchange of knowledge. Open science provides a practical framework for embedding ethics directly into the research process. It encompasses a suite of practices, including making data and publications openly accessible, using and developing open-source

software and hardware, and fostering a culture of collaboration. By making research processes transparent, open science allows for independent verification, which builds trust and accelerates the pace of innovation—a critical need in the race against climate change [Fell et al., 2024]. It directly addresses the ethical shortcomings of closed models by making the inputs and outputs of research visible and accountable to the broader community, thereby upholding scientific integrity and reinforcing procedural justice.

The most powerful manifestation of this open paradigm in the energy sector is the rise of Open Source Appropriate Technology (OSAT). OSAT moves beyond the abstract principles of open data and software to the tangible hardware of the energy transition. It is here that the ethical promise of openness becomes concrete. Consider the case of solar photovoltaic racking. As Rana et al. [2023] demonstrate, an open-source design allows for local adaptation based on material availability and cost. In one region, metal may be the most economical choice; in another, it may be wood. A proprietary, one-size-fits-all product cannot account for this local context. By providing a flexible, open framework, OSAT empowers local communities to become active participants and decision-makers in their own energy future, a clear embodiment of procedural justice. This approach also enhances distributive justice by reducing costs and allowing more economic value to be retained within the community. Similarly, the development of a low-cost, solar-powered, open-source ball mill by Mottaghi et al. [2023] shows how OSAT can democratize the very tools of scientific research, making them accessible in regions that have historically been excluded. These are not just technological improvements; they are reconfigurations of power.

In conclusion, the path to a sustainable and equitable energy future cannot be paved with the closed, proprietary models of the past. The ethical challenges of the energy transition are inseparable from the technological ones, and they demand a new methodology rooted in openness and collaboration. By embracing the full spectrum of open science, from transparent research practices to the development of community-focused Open Source Appropriate Technology, the energy research community has a profound opportunity. We can move beyond a paradigm that imposes solutions and creates injustice, and instead foster one that empowers communities, democratizes technology, and collaboratively builds a cleaner, more just, and truly sustainable world for all. The responsibility to lead this transformation rests with us.

## References

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