How a smart, decentralized Energy Web is essential for managing renewable energy sources

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The Energy Web is a power distribution system designed for managing a large, widely distributed network of renewable energy sources. The figure shows the interaction of the different parts of the Energy Web, which includes incentives for "prosumers" (producers and consumers of energy) and allows autonomous self-organization of agents due to evolutionary processes. Improving the efficiency of energy distribution and consumption through decentralized design methods is crucial.

A decade ago, Gustavssen, Kazan, and other early peers-to-peer (PP) systems showed that a decentralized approach to managing large-scale, widely distributed systems could offer many essential advantages compared to the traditional centralized approach. For instance, resistance towards the desktop computer became integrated into everyday objects; two examples are electronic devices of large scale (dynamic systems that operate in open environments with many autonomous users and are constantly evolving.

In their study, the Italian team has discussed the essential features that a decentralized design approach entails in order to support large-scale networks and provide the necessary degrees of reliability and dependability. As a case in point, they showed how these new concepts could be applied to the management of the power grid, the "new" energy supplies (citizens that both produce and consume energy), and the inclusion of a large number of distributed and renewable energy sources. They call the resulting system the "Energy Web," which, as caulfeather Daneilo Morandi explains, depicts a future in which all directions of energy flow will be bidirectional and the world is moving towards a power grid in the web.

The key to the Energy Web design is the "bottom-up approach," in which appropriate laws are implemented to allow desired global behaviors to emerge from only local interactions among individual components. In contrast to the traditional top-down approach, which focuses on performance, the new approach focuses on reliability, stressing how to react to internal failures rather than attempting to avoid them. With reliability in mind, desired behaviors include the ability to self-adapt to unknown conditions, to self-heal in the case of failures, to learn from previous experiences, and to self-protect against external threats. These behaviors require that the system evolves through time in the midst of a changing environment that cannot be accounted for in advance—something that the deterministic approach of traditional methods does not do.

When applying this approach to the future Energy Web, the researchers explained how mechanisms and methods should be tuned in order to meet the nature and functional constraints of energy transport and distribution systems. Unlike today's highly centralized energy systems architecture, which for the most part consists of a few large power plants supplying energy to a large number of consumers, the future Energy Web is expected to consist of a highly diverse framework. Large numbers of widely distributed small-scale energy sources (such as wind turbines and solar panels), smart meters in homes that actively manage consumption, and the emergence of "prosumers" citizens that both produce and consume energy) will shape the future Energy Web much like it is shaped by the Internet. By managing our future energy consumption, the researchers hope to bring about cost and energy savings, as well as a reduction in the overall electricity demand.


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