Expert Insights

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Revive aging power grids with blockchain

A new model
for energy flexibility

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Data communications pioneer Alex Bausch co-founded Bausch Datacom in 1988, and welcomed the recent merger of Bausch Datacom with Ritter Starkstrom Technik, a leader of solutions to the utilities industry. He believes the power grid requires a development similar to the internet revolution that transformed the telecommunications industry. A mentor to blockchain start-ups and frequent publisher and speaker on the topic, Alex views blockchain as key enabler for collaboration in complex utility and other ecosystems.

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An autonomous decentralized system is more resilient to general system failure. If one part goes down, the rest of the system can be shielded.

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Talking points

Centralized electricity supply is becoming less controllable with more of the balancing effect coming from the demand side
Blockchain can help marshal thousands of small energy sources, making them responsive to controls from utilities through market mechanisms, some already functioning and some yet to be created.

Blockchain-enabled autonomous resilient grids create trust by validating energy generated on and by devices connected to the grid
Used to manage the energy generated and consumed on these future grids, blockchain makes self-sovereign identity possible and can assist in national security.

The autonomous resilience model matches centralized, large-scale power generation with decentralized small-scale power generation
Blockchain is an enabling technology on which new markets can be created, allowing previously unusable distributed resources to actively participate in grid stability services.

When the signal goes down, society comes to a halt

Current power grids are structured for a world that no longer exists. A world where a limited number of large, controllable power plants continually generate power, and distribution system operators (DSOs) deliver megawatt power loads through a traditional top-down grid structure. Adding to the problem is a rapidly aging power grid at risk of cyber-attacks and other disruptions. In the design of a network that serves a major region or an entire country, even rare calamitous events must be avoided.

In the best interests of society, systems operations balancing across multiple transmission and distribution grids should be managed holistically. This makes the grid more resilient by unlocking decentralized assets. As more and more intermittent energy sources stress a power grid that's not prepared for new energy patterns, blockchain and other technologies can offer relief. By applying intelligence, transparency, and automation to existing systems, these new digital technologies can help to mitigate the massive capital investments that would be required to re-architect the physical grid.

Power to the people

Energy delivery is ever-evolving with more distributed choices and electricity produced where it's needed, at the right time and with the right resource. But decentralized energy resources, such as solar cells, wind turbines and batteries often can't provide energy during a grid blackout. These devices are controlled at the edge, or not at all. They lack the functions and intelligence to properly respond. Should a grid or communication network failure occur, decentralized power generation equipment, control systems, and phones are often disconnected and ineffective.

As more and more blackouts affect society globally, blockchain can help combat failures on overworked grids and in stressed energy systems.

Consumers have taken to producing electricity themselves, *en masse*, installing decentralized energy resources that turn wind, sunlight, and other energy sources into electric power, and into batteries that store it. By doing so, large numbers of relatively small kilowatt sized loads are fed into the grid at low and medium voltage points that traditionally only consumed electricity. These "prosumers" come in all shapes and sizes, including:

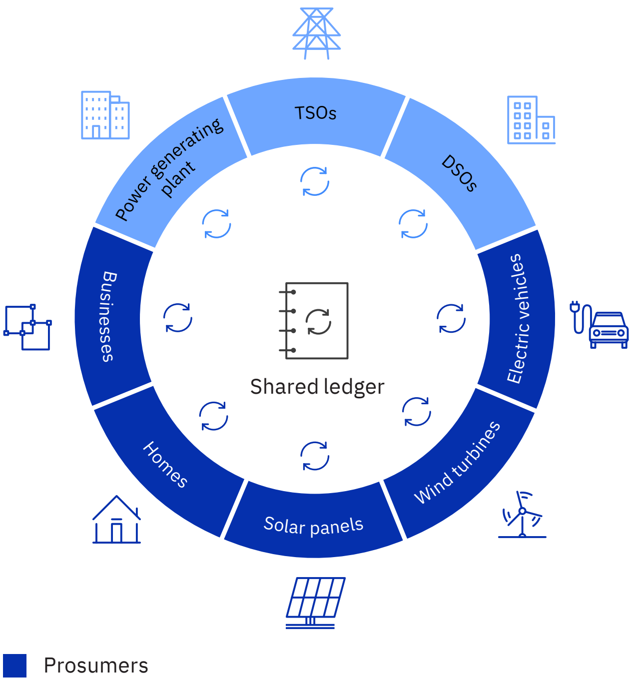
- family households
- businesses using their rooftops to install solar panels
- farmers installing windmills and solar panels on parts of their land where electricity generation is more profitable than traditional agricultural activities
- companies that used to discharge heat generated by their primary production process, but now use it as a valuable by-product that generates electricity delivered to the grid.

Decentralized energy producers usually deliver their power to the grid, where it flows to those who consume it. When a disruption occurs, delivery of decentralized power to the grid is halted, as uncontrolled flows in the grid can lead to hazardous situations. Those generating the power can't use it themselves. However, in the autonomous grid model, decentralized network management capabilities are automatically activated at lower levels in the networks, allowing for matching local generation and consumption. Blockchain can manage device identity, payment, and communication between parties in an increasingly decentralized power network (see Figure 1).

Transmission system operators (TSOs) are charged with stability of the grid across borders. Traditionally this meant matching the continual megawatt loads produced by a limited number of plants with the millions of modest kilowatt demands of small consumers, as well as some large commercial and industrial loads. With the emergence of the prosumer and renewable energy, small generation enters the grid via distribution utilities on an intermittent basis, leaving the traditional top-down grid management model under stress.

Figure 1

Balancing power supply and demand on the blockchain



DSOs lobby heavily for control of decentralized microgrids and local balancing regimes. The DSO-centric viewpoint is to first balance in the street, then the neighborhood, and then the city as it will reduce transmission. It also means taking over TSO responsibilities.

TSOs and DSOs must act as gatekeepers to all parties delivering power to the grid, both large central power generators and prosumer equipment. Prosumers want broader market access, allowing them to get their energy to and from any source, not just their neighbors or DSO. Perhaps via an energy community of family and friends, or from different locations.

In this model, DSOs could create an additional "flex market," managed with the current TSO market. The entire grid system becomes more resilient due to the addition of decentralized energy resources. The dot on the horizon for grid operations is a technically more distributed and resilient system that retains holistic systems operation at the TSO level. The end result is that DSOs can buy flex from prosumers, just like TSOs. And prosumers get more access to new flex markets.

Toward an electricity internet

The pressure on the power grid from growing decentralized power generation and storage can't be resolved by tweaking the current centralized model. As happened in the telecommunications industry, a decentralized, "internet type" approach will need to replace large, centrally operated grids. Doing so will reinvent the power grid as a network of micro electricity networks that can autonomously balance production with the demand for power. When the central grid suffers an outage, microgrids can internally keep functioning and reconnect with the central grid when it's back online.

In the short term, autonomously resilient networks can help reduce societal vulnerability to outages caused by central systems going down, or the ripple effect—rolling blackouts—of power grid failures.

TenneT: Grid balancing continues after successful pilot

A platform pilot by European transmission operator TenneT showed how blockchain could be effectively applied to stabilize the grid using storage systems, including car batteries. Drawing on a network of residential solar batteries, when a power increase is needed on the grid, electric vehicle charging is briefly stopped, and the car owner compensated for the interruption.[1]

Bausch-Ritter: The virtualization of processing power

Smart grid innovator Bausch-Ritter envisions future technology to sustain Virtual Power Plants (VPP). A network of decentralized, medium-scale power generating units, VPP allows individual power generation points to collaborate as a power plant, working as a sub-grid or microgrid. The technology applies to both individual power generation and consumption. For example, VPP can enable washing machines and electric heaters to switch on and off at specific times, depending on the cost and availability of power. Doing so enhances grid stability rather than decreasing it.

Microgrids can connect to existing larger power grids. The current model doesn't need to be replaced in one massive undertaking.

This model can also eliminate the possibility of large-scale outages that lead to collateral damage. If the communications grid goes down, electronic payments for goods and services aren't possible, the internet is inaccessible, travel and navigation become difficult if not impossible, and emergency services are possibly overloaded.

With autonomous microgrids, even in the unlikely event of a major catastrophe striking one microgrid, it can't affect any others. All are immune to disasters happening outside their perimeters.

Microgrid enabling technologies include:

TCP/IP. Unlike TCP/IP for telecom, where data can be tagged, identified, stored, and addressed, electrons that move throughout power grids and energy that powers devices can't be individually routed. With support on the Internet of Things (IoT) level, the devices that generate, transmit, and consume power become uniquely identifiable to correctly guide power through the network.

Blockchain. A distributed ledger that can't be manipulated independently and requires consensus for transactions, blockchain can verify the identity of devices on the grid. One way is to assure a meter consumes only the amount of energy it's entitled to. Blockchain technology enables trust in the network by providing device identity and controlling flexibility to create a stable microgrid. Therefore, a blockchain implies integrity and trust in the system by design. Through smart contracts that digitally facilitate, verify, or enforce the performance of a contract, microgrids can balance decentralized power generation with demand. And blockchain can provide mechanisms to settle transactions that balance decentralized power produced in the microgrid.

Artificial intelligence (AI). With multiple data streams from IoT devices, and near real-time response requirements, AI will be essential to predict and drive the demand-supply balance, and other requirements of autonomous microgrids. During a grid blackout, autonomous AI-enabled agents embedded in distributed control systems down to the device level, with the use of mobile phones can form *ad hoc* mesh networks to match locally available power from decentralized generation equipment to the needs of a community.

IoT. Power generating equipment, distribution stations, smart power meters, and control systems are the "things" in microgrids. So are power consumption devices, but they must be able to communicate and identify themselves in order to control their energy behavior. Insights derived from data collected from IoT devices can connect people in need of energy to micronetworks and microgrids.

A stable, greener, and more flexible power grid

While the electricity grid has retained the same basic characteristics for nearly a century, telecommunications changed completely over the last 30 years. The internet spurned a revolution in telecom as it evolved from a centrally organized telephone system to a network-centric internet protocol.

The decentralized structure of the current communications network makes it resilient, able to adapt easily to changing situations, and allows for "self-healing" mechanisms when disruptions in the network occur. Self-healing is a process of recovery where a device or system can perceive when it's not operating correctly and, without human intervention, make necessary adjustments to restore itself to normal operation.

California Rule 21's smart inverter requirements were created to allow better hosting capacity with minimal infrastructure upgrade.[2]

The self-healing network architecture found in wireless communications networks could be applied to microgrids, but this will take longer to come to pass. In order to have the capability to withstand a failure in its transmission paths, current equipment needs to be re-manufactured and grid codes updated to be compliant. These "smart grids" must be able to deliver a level of quality equal to or greater than that delivered before the actions were taken. And if "cloud-to-healing"—automatic healing of services in a cloud computing environment—is the goal, there must be remote control in all physical aspects to contribute to a stable decentralized autonomous grid when the main supply is failing. It would be a highly technical and multidisciplinary undertaking and, since utilities are government owned, likely take a good deal of time.

For example, in California, regulation and technology have met head-on in new codes to improve energy efficiency in the form of renewable energy. California is the first US state to require the use of smart inverters in solar systems, increasing interoperability and security of solar inverters on the connected smart energy grid.[3] Effective January 1, 2020, solar inverters must work in support of the grid, and not be forced to disconnect if there's a problem. Getting there required a combination of new inverter design, code and regulatory changes, and convincing regulators that a clean energy future is better for the grid.

When the power grid fails

In June of 2019, all of mainland Argentina lost power in an unprecedented blackout that left many of the country's 44 million citizens in the dark.[4] It's believed that inclement weather, one of the leading causes of blackouts globally, was to blame. Localized blackouts in the US, most due to massive forest fires and extreme weather, have increased in both frequency and duration in recent years.[5]

The growth of decentralized power generation and decentralized power storage runs counter to the traditional system of central power grid management, which requires grid operators. Blockchain can manage all asset and device identity, and police that grid devices are authentic and connected.

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Are you ready to secure the grid of the future?

— The market structure and regulatory framework of power grids needs to be geared toward enabling autonomous resilience in grids. Policies that incentivize decentralized generation are needed to thrive, as is requiring an electricity internet and boasting autonomous features.

— Major players need to unite around a clear technical vision, act like a flywheel for adoption, and lead the way. Parties should understand the benefits of creating trust without a trusted third party, and how this could benefit their role in the electricity ecosystem.

— A well-functioning market will be one where cooperation isn't managed based on individual deals between parties, but by transparent agreements implemented in algorithms and autonomously executed on the blockchain as smart contracts.

Contributors

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About Expert Insights

Expert Insights represent the opinions of thought leaders on newsworthy business and related technology topics. They are based upon conversations with leading subject matter experts from around the globe. For more information, contact the IBM Institute for Business Value at iibv@us.ibm.com.

Notes and sources

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