Business challenge

As TenneT TSO B.V. worked to manage the less predictable flow of renewable energy into its grid and reduce costly redispatch measures, it sought to manage energy transactions from flexible sources.

Transformation

A security-rich, blockchain platform built by IBM using Hyperledger Fabric helps TenneT ensure the accuracy of thousands of energy transactions from widely distributed, flexible energy sources.

René Kermeester
Digital Transformation
Lead
TenneT TSO B.V.

Results

Millions of euros potentially saved
on costly curtailment and redispatch measures

Helps ensure accuracy and trust
in the recorded energy transfers through a shared, distributed, secured ledger

Encourages consumer participation
by rewarding energy contribution with lower energy bills

TenneT TSO B.V.

Integrating distributed, renewable energy sources into the grid with blockchain and IBM

TenneT is a leading European electricity transmission system operator (TSO) headquartered in Arnhem, the Netherlands. Its main activities are in the Netherlands and Germany. With 22,500 km of high-voltage connections, TenneT ensures a secure supply of electricity to 41 million customers. TenneT employs approximately 3,000 people and has a turnover of EUR 3.2 billion and an asset value totaling EUR 20.3 billion. TenneT is one of Europe's major investors in national and cross-border grid connections on land and at sea, bringing together the Northwest European energy markets and enabling the energy transition.

"We believe that blockchain could potentially form the basis for a new European energy system and become a standard for other European countries."

—René Kerkmeester,
Digital Transformation Lead,
TenneT TSO B.V.

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Undertaking energy transition

Europe is undergoing a wide-scale energy transition, replacing fossil fuels and nuclear power with low carbon, renewable energy sources such as wind and solar power. The European Commission's Clean Energy for All Europeans package sets a collective target of at least 20 percent renewable energy by 2020 and 27 percent by 2030.

This energy transition is changing the energy supply chain landscape. Increasingly, decentralized and distributed smaller producers—such as farmers with a wind turbine or small businesses and even consumers with solar panel arrays—supply electricity, feeding it in to the main electrical grid.

At the same time, as René Kerkmeester, Digital Transformation Lead at TenneT, mentions, larger fossil-fueled and nuclear power plants are gradually disappearing as the transition to renewables continues. He anticipates that even in the near future, there will be times when conventional energy sources will be unable to fully meet the demand for electricity or provide sufficient flexibility in energy production.

As a TSO, TenneT plays two pivotal roles in the energy system. First, the company is responsible for long-distance transport of electricity within countries and across borders.

Second, TenneT must precisely balance supply and demand, or load, to guarantee a continuous supply of electricity at 50 Hz, 24 hours a day. Unexpected surplus power can exceed grid constraints, while unmet electricity demand can cause brownouts or blackouts.

The commercial market parties responsible for supply and demand ensure that right up to one hour before delivery all demand and supply is balanced. In the final hour, until the moment of delivery, TenneT controls this balance. TenneT either increases or restricts electricity supply to the grid, as needed. "In the past, we could easily rely on large power plants to give us a bit of extra power, or ask them to produce less in order to secure system balance," says Kerkmeester. "It was a very predictable system."

As renewable electricity generation accounts for a growing share in the overall power supply, the electricity grid is becoming more volatile. "Wind and solar power are largely weather-dependent. There is a big impact if the sun does or doesn't shine, or if the wind does or doesn't blow," says Kerkmeester. "Furthermore, we also see much more volatility on the demand side than in the past. For example, we now have electric cars whose batteries need charging, but we don't know exactly where and when that power supply will be needed."

In addition to responding to these unpredictable fluctuations in renewable energy supply and demand, TenneT faces other challenges. For example, congestion in and capacity limits of the grid sometimes restrict the ability for electricity to flow where needed. At times, TenneT must curtail the flow of renewable energy into the grid in one location while firing up coal or gas-fired plants elsewhere to respond to another area's higher demand. The cost of this redispatch process is now approaching EUR 1 billion annually; it is passed on to consumers as part of the grid fee households pay in their electricity bills.

Unlike some grid operators that believe the sole solution to reducing the need for and costs of redispatch is to expand the capacity of the power grid, TenneT has developed an additional sustainable approach that better fits with the overarching energy and utilities (E&U) goal of the energy transition. TenneT's goal is to develop new ways to control the volatility in a highly weather-dependent electricity system by tapping in to the flexibility that decentralized generation and consumption offer.

"We developed an initiative we refer to as 'crowd balancing,'" says Kerkmeester. The aim is to source electricity from, and store electricity in, distributed flexible units such as household electricity storage batteries and electric vehicles.

However, before integrating these smaller electricity sources into the grid, TenneT realized that it would need to implement new technologies to support this change and solve two critical issues. Kerkmeester explains: "We needed a way to manage the electricity flow to and from these small, individual electricity sources. Furthermore, we needed a solution to accurately record and monitor those energy transactions to ensure they actually occur as reported, and to use that information as a basis for payment."

Launching an energy blockchain

TenneT found the right technology to accomplish its goals in blockchain and by teaming with IBM. Blockchain can help securely and intelligently manage flows of electricity in networks with decentralized, distributed energy sources.

Together with IBM, TenneT has embarked on a first-of-a-kind implementation of blockchain technology in the E&U industry in Europe. The blockchain platform built by IBM is a cloud-based, distributed, permissioned ledger system that provides an immutable record of transactions communicated between TenneT and its energy partners.

Scalable and security-rich, it provides transparency to participants on the blockchain, in line with regulatory requirements. The platform uses Hyperledger Fabric, a blockchain framework implementation and one of the Hyperledger projects hosted by the Linux Foundation, to verify and document the transaction values of distributed, flexible energy devices integrated into the electricity grid.

The security-rich blockchain platform provides the accountability that allows TenneT to team with two relatively new renewable service providers in the energy landscape for two initial implementations of a blockchain technology-supported energy network, one in Germany and the other in the Netherlands.

IBM® Global Business Services® is providing project management and blockchain and architecture expertise to jointly design, build and launch the blockchain initiative in close cooperation with the TenneT team and TenneT business partners. A Global Business Services team is also helping TenneT and its partners integrate their infrastructure with the blockchain platform.

In Germany, TenneT is working with sonnen GmbH, a leading manufacturer and provider of home battery and energy-storage systems.

The sonnen batteries store energy generated by home solar panels or collected directly from the electrical grid when rates are lowest. Typically, homeowners use the stored energy from these batteries to power their home or sell it back into the electricity grid when rates are highest.

For this project, sonnen created the sonnenCommunity, a network of home energy-storage systems that form a virtual energy pool for TenneT to tap in to. The blockchain solution designed and developed by IBM with TenneT records the transfer of energy between the grid and the flexible devices so that TenneT always has visibility into the pool of available energy and storage capacity. TenneT can then use the devices to absorb or discharge excess power within seconds when and where required, helping reduce transmission bottlenecks in the grid.

"The project is the first of its kind using blockchain technology and leads the way to the future integration of renewable energy sources. We clearly see a potential to develop new possibilities of flexibility through blockchain technology. Ultimately, this helps limit the use of expensive curtailment of wind turbines, which is needed to stabilize the grid," says Lex Hartman, Corporate Development Officer and board member of TenneT.

This alternative to redispatch measures, particularly in areas of higher power demand, helps reduce the occurrence and associated costs of increasing the energy output of fossil-fuel or nuclear power plants. It also helps boost the use of renewable energy by decreasing the need to curtail wind energy generation at times of insufficient transport capacity. Homeowners benefit from lower electricity costs and can earn money each time they provide their flexibility to the grid. The process is transparent to the homeowner, and the blockchain ledger helps ensure transaction accuracy and transparency between sonnen and TenneT.

In the Netherlands, TenneT is working with Vandebron Energie B.V., a marketplace provider of renewable energy. Vandebron links small-scale energy producers, such as farmers, with energy-conscious consumers. Vandebron's approximately 100,000 customers get their power from this marketplace of more than 120 local sources. Many of the company's customers also drive electric vehicles, charging them at their homes.

In the Netherlands blockchain project, TenneT will obtain flexible power from Vandebron to supplement the power on the grid in times of highest demand. Participating Vandebron customers will make the flexible capacity of their electric cars available as distributed energy

sources to help TenneT balance the grid. The process will be transparent to the car owner, who will simply plug in the car to charge it, as usual. When TenneT needs to increase power in the grid, charging will briefly stop, and the car owner will be compensated for the interruption. The blockchain records each car's energy availability and every transaction in response to signals from TenneT.

In both projects, the energy service providers manage their networks of distributed devices and their relationships with their customers. TenneT interacts with sonnen and Vandebron to manage payment transactions to the companies based on the established market pricing mechanisms. So the energy companies, rather than TenneT, pay their customers.

The blockchain technology enables TenneT to manage and trust the thousands of recorded transactions with its business partners in the secure ledger. According to Kerkmeester: "Through the blockchain, we can know at any time how much flexible capacity the batteries have to offer. We know when they're activated and when their activation ends. All of this is recorded in the blockchain. We settle with Vandebron and sonnen, and it's up to them to settle with their end consumers."

Crowdsourcing energy

By implementing this blockchain for energy, TenneT is helping lead the energy transition in Europe. And through its crowd-balancing projects in Germany and the Netherlands, TenneT is paving the way for consumers across Europe to participate in the transition from fossil fuels to renewable energy. "We believe that blockchain could potentially form the basis for a new European energy system and become a standard for other European countries," says Kerkmeester. Citizens are eager to see their power bills go down and to be part of the energy transition.

Using blockchain technology, TSOs such as TenneT can better integrate renewables into the grid to help secure and balance the energy supply. The reduction of power redispatch measures could save millions of euros as the crowd-balancing network expands.

Instead of curtailing the supply of excess wind energy in northern Germany, TenneT can store it in the network of sonnen household batteries. It can then draw power from those batteries as grid capacity allows, delivering power to the industrial south without having to fire up gas or coal-fired plants there. In the Netherlands, TenneT can use electric car batteries to help balance the grid.

Blockchain provides the technology that can ultimately help connect millions of distributed energy systems and sources. As a shared ledger, it provides a single point of truth for every transaction in the chain, allowing all parties to trust the record of all energy flows to and from these sources as each transfer of energy occurs. Every transaction is auditable and traceable. Finally, the blockchain record is immutable; the blockchain platform developed by IBM helps ensure that no party can tamper with a transaction once it has been validated.

TenneT anticipates that positive results from its initial blockchain implementations with sonnen and Vandebron will encourage other energy companies, aggregators and service providers to enter the new crowdsourced energy market. Participating companies earn money each time they provide these ancillary services to TenneT. By sharing those earnings with customers, these companies provide a further incentive for people to take part in the market and energy transition. Organizations such as sonnen that sell enabling technologies like solar panels or solar batteries also stand to benefit from increased consumer participation through these services in the energy marketplace. And energy service providers such as Vandebron expect to attract new customers and further increase engagement and loyalty in their energy-conscious customer base.