The green light

Empowering participation in the energy transition with blockchain

IBM **Blockchain**

IBM

Contents

Executive summary

As we go about our mission to drive to net-zero emissions, those of us in the energy community are living the themes of decarbonisation, decentralisation, digitalisation and democratisation.

We recognise the value of exponential technologies to enable change, not least blockchain. We have glimpsed the changes blockchain can bring to the energy industry – but are we ready to make them a reality? Are we ready to scale? Is the role of blockchain what we imagined, or is there more to come?

With increasing urgency to act on climate change, these are important questions. And there is no better way to address them than by exploring real stories from the companies that are making the move from prototyping to scale.

In this report, we set out seven stories from innovative organisations that were bringing together their insights to better understand the role blockchain plays in the energy transition.

It is a diverse set of examples, but they all prove what we believe about blockchain. That it enables transparency and trust in information distributed across an ecosystem of participants. That it lowers the costs of doing business and allows operation at the scale we will need.

The benefits are clear when it comes to solving challenges in the decarbonisation and decentralisation of energy. Blockchain helps us to open up access to small, distributed energy resources. It also enables viable aggregator business models, once the relevant policy and regulation is in place. But what is perhaps most revealing is how it supports the democratisation of energy. It enables consumer choice and fairness in access to markets, and empowers participation in the energy transition.

What is most revealing is how blockchain enables consumer choice and fairness in access to markets, and empowers participation.

All the examples we explore here are united in their approach: they begin with the problem to be solved, or the experience needed, and work back from there. These platforms have been developed using the principles of ecosystem value design, design thinking and agile methodology.

We believe the projects covered in this report clearly answer the questions we set out above. Are we ready to scale? In many cases, yes. Is the role of blockchain what we imagined? Yes – in fact, it is even more diverse than we thought. IBM is proud to be playing a part in bringing together ecosystems to democratise the energy system.

Finally, a note of caution. While we focus on blockchain as a primary enabler, this should be read as a group of technologies including the Internet of Things (IoT), analytics and artificial intelligence (AI).

We would like to thank our participants: RTE from France; the City of Copenhagen from Denmark; TenneT, CertiQ and Enexis Groep from the Netherlands; BBOXX from the UK, REE and OMIE from Spain; and REN from Portugal.

Phil Spring, VP EE&U Europe
Leo Dijkstra, EE&U Markets Leader

Introduction

The energy industry is in the early stages of a transition phase like never before.

As pressure builds to invest in sustainable energy sources for the good of future generations, the need to engage and incentivise more businesses and people to participate in this radical change is becoming clear.

The traditional, linear supply chain is gradually being replaced by an ecosystem made up of more diverse participants, interacting in increasingly complex ways in response to four key disruptors: decarbonisation, decentralisation, digitalisation, and democratisation.

These four drivers are causing the dynamics of the energy market to shift towards a more ecosystem-centric model, in which parties come together in new ways to drive the transition to net-zero carbon emissions. Participants must work together more closely, as well as interact with new partners, to leverage synergies and address shared challenges across the network. Enabling trust will be essential to achieving this new level of collaboration, particularly in light of the complex nature of these interactions.

Blockchain technology has the potential to forge these trusted connections, introduce efficiencies and unlock new value in this evolving ecosystem. Its built-in traceability, immutability and transparency provide a basis for building more efficient, shared processes that are fit for scaling across multiple axes.

IBM is working with forward-thinking businesses around the world to bring their innovations to life. Through these initiatives, we can track the curtailment of wind power; aggregate buildings, electric vehicles and other distributed devices to balance the grid; enable consumers to choose their supplier in public charge stations; certify small-scale green energy and enable producers' participation in the certificates and carbon market; and efficiently share information between multiple market participants.

Explore these stories in the pages ahead.

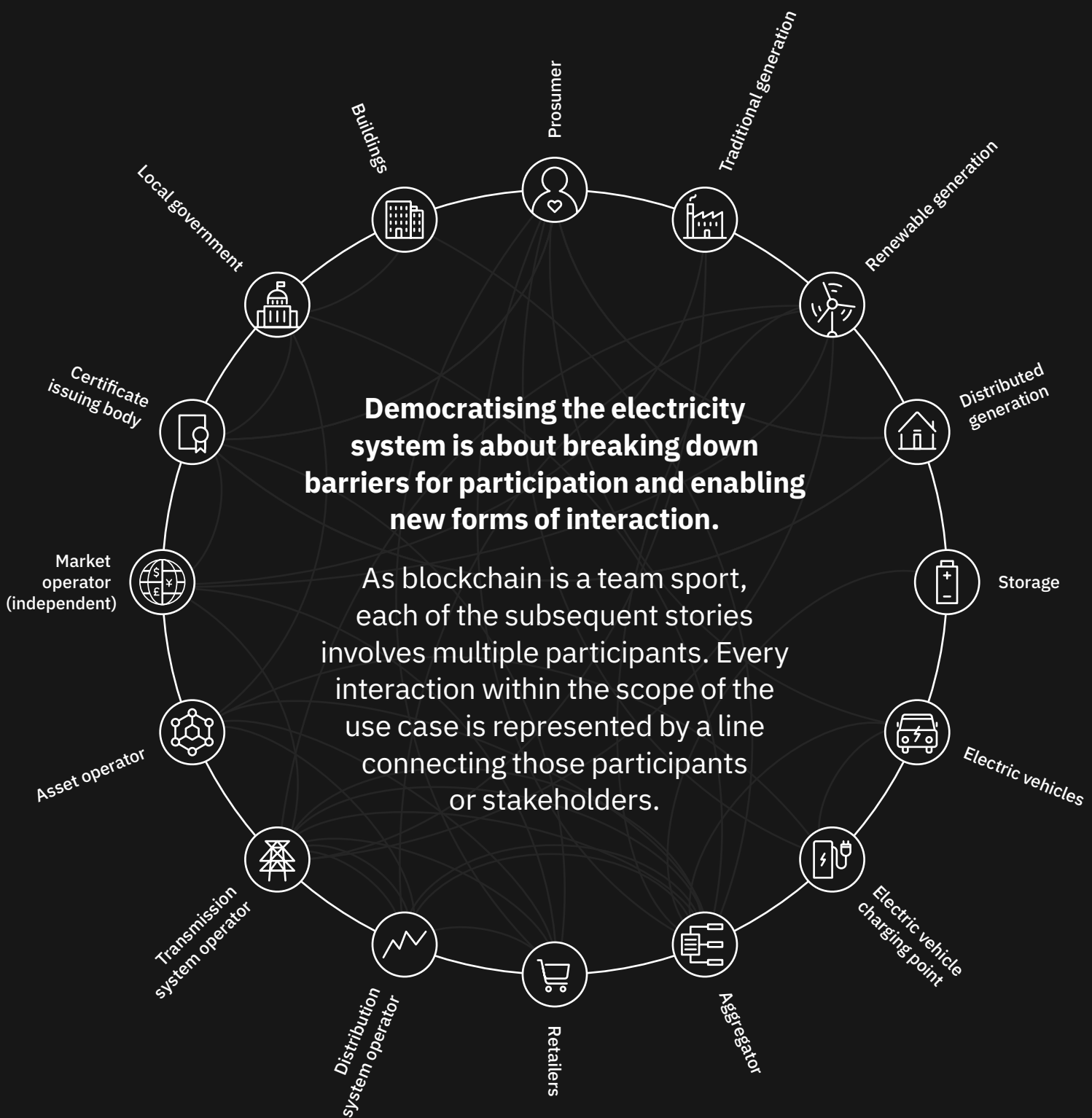
Decarbonisation
A move towards a low-carbon economy, driven by the science of climate change, public opinion and incentives created by governments.

Democratisation
Increased consumer participation and engagement, which creates a need for new interaction models.

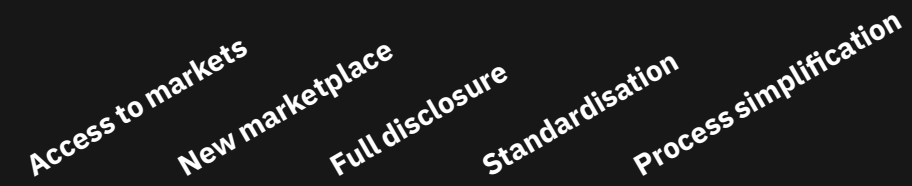
Digitalisation
The trend for exponential technologies to drive efficiencies, new experiences and new opportunities.

Decentralisation
An increasing penetration of distributed energy resources, which leads to changes in how the system is managed.

Breaking down barriers to participation



An overview of the stories presented in this report, highlighting the key themes identified throughout each.



Building power
City of Copenhagen

Driving to net-zero
TenneT

Freedom of choice
Enexis Groep

Guaranteed green
CertiQ

Delivering charismatic carbon
BBOXX

A fine balance
RTE

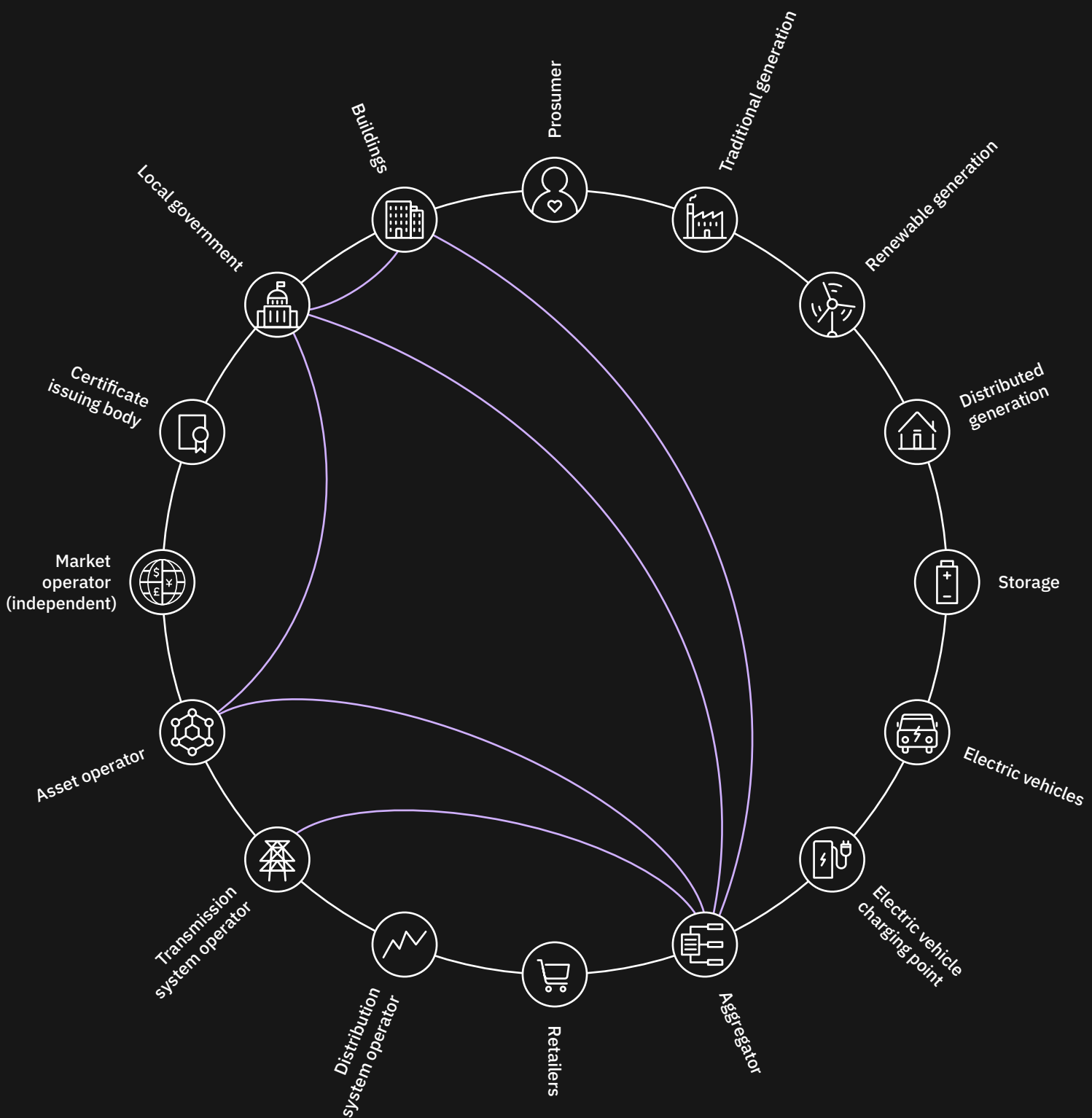
Collaborating without complexity
REE, REN and OMIE

01

Building power

City of Copenhagen with IBM

01 City of Copenhagen with IBM



01 City of Copenhagen with IBM

We all know we need to find new ways to reduce our energy consumption – and to consume it more intelligently. With cities currently absorbing around 70% of our energy use, they are a natural place to start.

The City of Copenhagen has got its public buildings firmly in its sights as it sets out to become carbon neutral by 2025. As a member of C40 Cities climate leadership group, Copenhagen is already a role model for sustainable practices. In Denmark, 50% of the electricity supply comes from renewable sources such as wind and solar. The remaining 50% will be more challenging to transition. But some smart thinking and even smarter technology is coming together to open up new routes to efficiency.

The City operates and maintains 3,600 buildings. With its 2025 goal in mind, it has set out to radically reduce the energy consumption of those buildings in the next five years. But while making buildings more energy efficient is a worthwhile endeavour in itself, it's only half the story. The City is aiming to build flexibility into its energy consumption by using its buildings as a means to respond to imbalances in the system.

The project is driven by a need to balance the flow of energy to ensure the grid remains stable as it grapples with the unpredictability of wind and solar energy.

01 City of Copenhagen with IBM

Of the total energy currently powering the City's buildings, a report has identified 20% – variously drawn from lighting, heating, ventilation and other systems – that is "flexible" and could therefore be turned up, down or off completely in response to fluctuations in supply.

On those days that renewable energy is scarce, the City would identify the systems within its buildings that could be turned down without compromising the comfort and safety of inhabitants, and instead channel that energy into other areas.

The City began laying the groundwork several years ago when it undertook a large-scale process of modernising its building management systems, adding sensors that enable them to be controlled through a central dashboard. The team's detailed efforts to describe standards and make its systems compatible and transparent was a crucial first step towards making its buildings "smart".

The City has worked with IBM to build an aggregator. An Internet of Things platform communicates with assets, devices and sensors throughout the buildings to monitor energy use. And the blockchain element acts as a virtual meter; it enables the City to predict how much each system would have used and registers how much has been saved in the time that it has been turned down. The information is stored securely and used as a basis for invoicing.

A lack of trust is one of the main reasons it has been difficult to tap into distributed energy resources as a source of flexibility. Blockchain plays an important role here in measuring the value that a number of small, disparate assets contribute when they deliver flexibility. By doing that, and ensuring all parties see exactly the same information, it builds trust and transparency into the system. And by removing the need to make lots of point-to-point integrations, it saves money for participants.

01 City of Copenhagen with IBM

The aggregator model could be instrumental in transforming the Danish energy market, addressing an explicit need to build flexibility while helping the City of Copenhagen to reach its climate targets. It could also help to expand the flexibility concept more broadly by demonstrating that there is a trusted and attractive market for it.

Anders Christian Lyngtorp, Head of the Technical Unit for the City of Copenhagen's buildings, explains: "Blockchain provides the backbone of trust and accountability for this flexibility. It creates a certificate of origin, proving where every small pool of flexible energy comes from."

The City is driven by a desire to build something that could benefit the entire region. With success running an initial pilot confined to one sporting arena, The City's aim is to roll out the same functionality to all public buildings. The next step would be to explore the potential of assets such as water-processing plants, electric vehicles and street lighting.

The aggregator model could be instrumental in transforming the Danish energy market.

There is work to be done in defining, upfront, what conditions make for a comfortable indoor climate that meets national regulations within the buildings. As a result of that, building owners can identify the components that can be switched down, or off, and when.

"We considered the cost of upgrading to centralised building energy monitoring and management systems, which would show payback in less than six years," says Lyngtorp. "This is just good business. And that's before we even consider the flexibility element, a long-term side benefit that we didn't even know about when we started out."

One major challenge in the early days of the project was explaining to stakeholders within the City what this "blockchain aggregator" was all about. The next step will be to bring together the ecosystem to realise the full potential of the concept.

01 City of Copenhagen with IBM

Lyngtorp explains that the success of the project to date can be linked back to the foundational work the City did in modernising its building management systems. “All of this relies on us being able to access data from the City’s various components. By establishing this early on, we have been able to describe the infrastructure that connects them and integrate our building management systems with the aggregator.”

While the full potential of the project is yet to be seen, Lyngtorp and his team are pleased with the reaction so far from the market.

“We know it’s going to take a lot more work to implement at a bigger scale, but it’s great to see that it’s possible,” Lyngtorp says. “Our internal business associates are interested. And our energy supplier is looking forward to testing the model.”

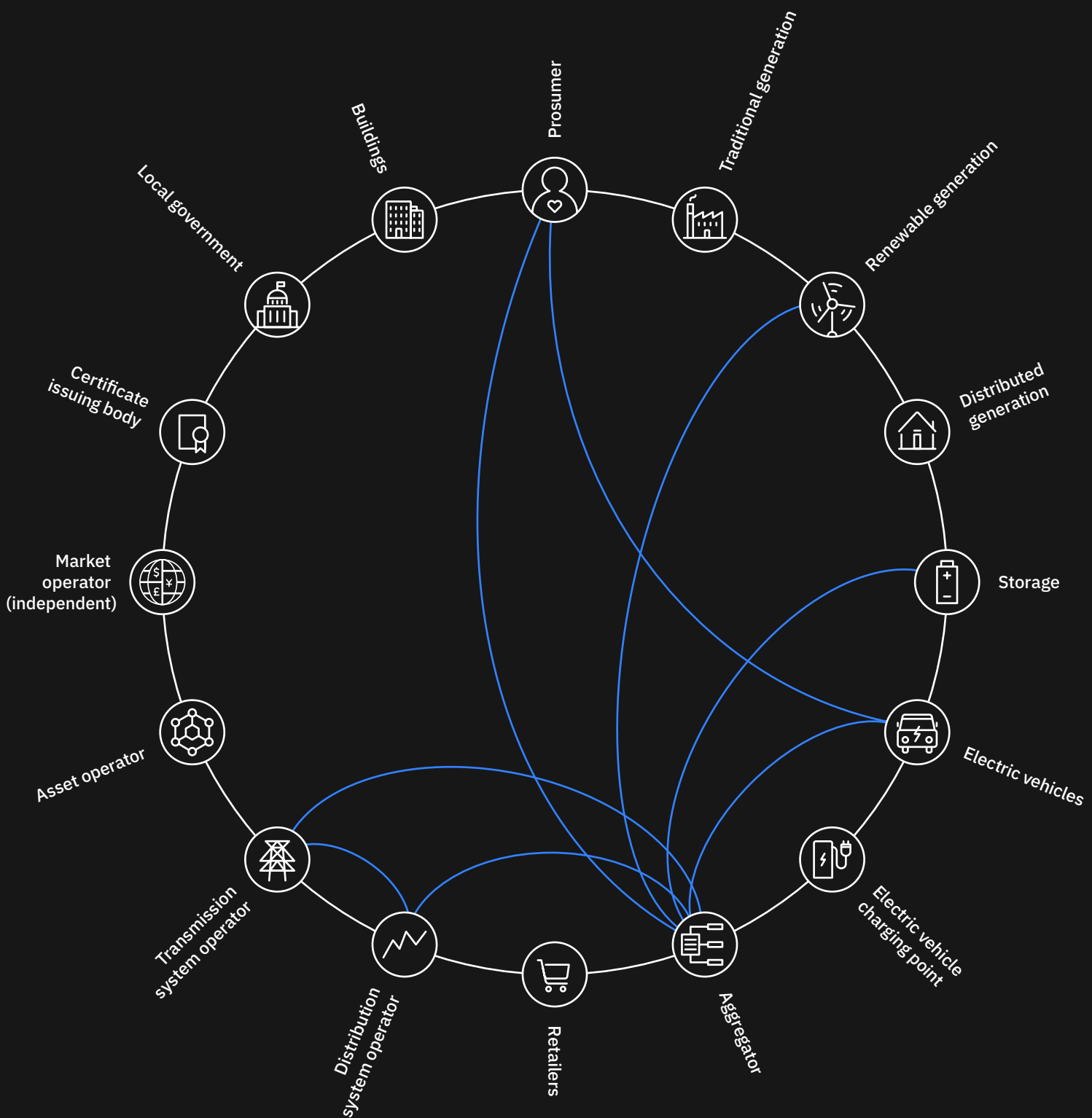
Blockchain provides the backbone of trust and accountability.

02

Driving to net-zero

TenneT with IBM

02 TenneT with IBM



02 TenneT with IBM

Sometimes, innovation in one area of an economy presents an unforeseen solution to a problem in a different area altogether.

That is the case in the Netherlands, where, in the move towards a low-carbon economy, electric cars are providing a solution to the challenge faced by electricity utilities handling renewable sources of energy. The technology that links them together is blockchain.

National grids that distribute electricity must at all times be “balanced”, meaning that the volume of supply meets demand. Too little energy in the grid, and areas suffer “brownouts” or blackouts; too much, and safety systems shut sources down, causing outages. Transmission system operators (TSOs) have the responsibility of managing electricity flow to maintain this balance.

Today, as more renewable energy inputs are brought online, TSOs handle electricity generated from wind and solar sources, which are, by nature, inconsistent and unpredictable. When electricity from renewable sources doesn’t meet demand, the balancing is provided by fossil-fuel and nuclear energy – which TSOs can increase or reduce to match demand. But balancing the grid by firing up carbon-emitting fossil-fuel plants is counter-productive and inefficient.

02 TenneT with IBM

And while it's relatively simple for TSOs to ramp energy supply up or down from a small number of large power plants, the process itself is expensive.

So, to solve the currently inefficient and expensive problem of balancing a national grid increasingly reliant on renewable energy, the Dutch TSO, TenneT, began looking at how it might control the electricity demand from car batteries. TenneT knew that electric cars connected to the grid demand more electricity than a typical household. If it could switch off demand from car charging, it would create a smart, efficient alternative to the current practice.

Calling the initiative "crowd balancing," TenneT identified two challenges it needed to solve. Could it control the electricity demand from many electric cars, widely distributed across the country? And once it controlled charging demand, could it accurately and reliably monitor the energy transaction with individual car owners for payment?

The answer to both of these problems has been provided by the powerful distributed ledger technology of blockchain. "With blockchain, we know at any time how much flexible capacity these distributed batteries have to offer," says René Kerkmeester, Digital Transformation Lead at TenneT. "We know when they're activated and when their activation ends. All of this is recorded in the blockchain."

Based on previous implementations of Hyperledger Fabric, IBM helped TenneT design, build and launch its initiative, while also helping TenneT's energy partner, Vandebron, integrate its billing infrastructure with the blockchain platform.

It is the blockchain-enabled partnership with Vandebron that bridges the gap between TenneT, which operates as an industrial utility, and the marketplace of energy-using individuals and household customers. Vandebron is a renewable energy provider in the Netherlands, and a growing number of its customers drive electric cars. So, it already had a customer base of renewable-focused drivers with battery-operated vehicles connected to the grid via home-based charging facilities.

02 TenneT with IBM

Vandebron needed to get customers to make the charging of their electric cars available to TenneT as one of the sources they can switch on and off as needed to balance the grid. When TenneT needs to increase power in the grid, it would access electric car charging units and switch them off, reducing the electrical demand. The process would be transparent to the car owner, who needs to do nothing, and is compensated for the interruption.

Vandebron manages its distributed network of car-charging stations and the relationship with their customers. TenneT transacts with Vandebron using established market dynamics to compensate customers for providing their flexibility as a service. And Vandebron, rather than TenneT, pays its customers.

The complexity of these sets of transactions (remote control of discrete-point electricity supply, accurate monitoring and recording of the usage and compensation billing) could only be accomplished by using a networked, shared ledger that records every transaction and is also verified and secured by each participating node. And it's a shining example of how emergent technology can sometimes present unexpected solutions to problems in adjacent technology sectors.

"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."

Image: Vandebron

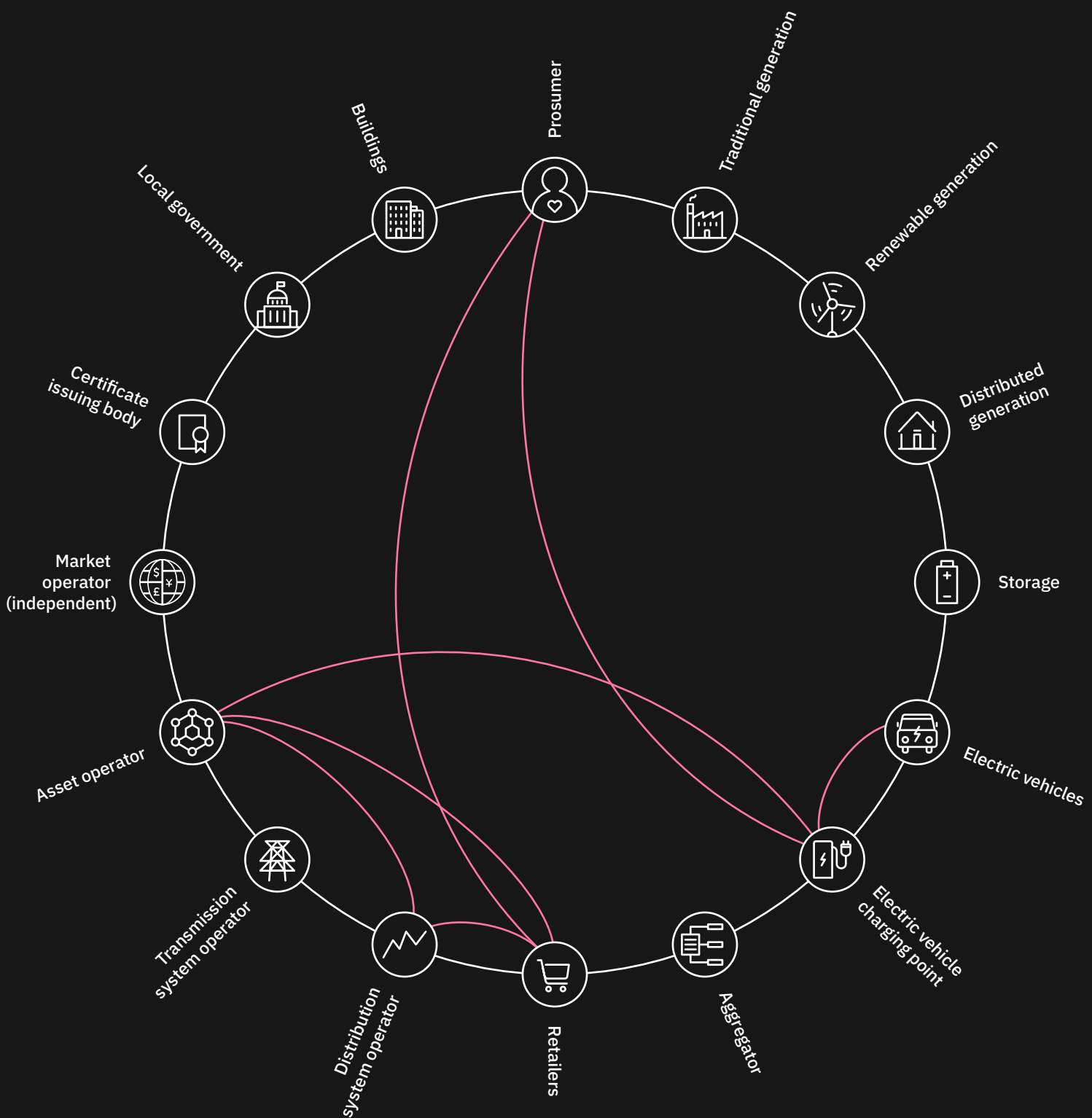
It's a shining example of how emergent technology can present unexpected solutions to problems in adjacent technology sectors.

03

Freedom of choice

Enexis Groep with IBM

03 Enexis Groep with IBM



03

Enexis Groep with IBM

When the genesis of an idea travels from rural fields to city streets to unlock an important barrier to sustainable living, you know you're onto a good thing.

In 2017, a farmer who was powering his business with rooftop solar panels realised he was generating more than enough energy to meet his own needs. It got him thinking. Could he sell his surplus energy back to an energy supplier of his choice and contribute to a cleaner power supply in his region – while creating a useful new income stream for his farm? Unfortunately, there was no mechanism to account for that kind of exchange, beyond the two-way connection with his energy contractor.

That farmer's fresh thinking was the spark behind a bold new venture for Enexis Groep, a distribution grid operator in the Netherlands. It began exploring the possibility of managing multiple suppliers behind one grid connection. Could it find a simple way to account for who holds the energy, who it is transferred to, and what the agreed price is at the time of exchange? The concept evolved over a number of months to coincide with a major priority for the country's energy regulator: the interoperability of electric vehicle charge points.

03 Enexis Groep with IBM

The journey towards a sustainable and affordable energy supply is at the heart of what Enexis does, so it had long since identified electric vehicles as a focus. Electric vehicles are steadily growing in popularity across Europe, and the Netherlands is leading the way. But charge points aren't always easy to come by – and when they are, the transaction is not straightforward.

Currently, the organisation running an individual charge point will have a lock-in contract with one energy company. Any driver can access that electricity under a general interoperability agreement, even if they are not linked to that supplier, but a complex back-office reconciliation process must take place between the suppliers. This means there is no incentive for the main supplier to open it up to others in the ecosystem – including those channelling green energy.

Enexis spotted an opportunity to make this back-office process more efficient and inclusive, while also giving customers the freedom to choose energy suppliers. Blockchain was the perfect solution to manage all the transactions involved; it didn't require any extra costs to be passed on to customers or any cumbersome investment on the part of Enexis.

The team at Enexis turned to IBM for its deep industry expertise, and was pleased to discover that its enterprise blockchain capabilities answered their challenges perfectly. Based on IBM's permissioned Hyperledger Fabric blockchain, it enables trust, transparency and accountability between all parties involved.

Enexis spotted an opportunity to give customers the freedom to choose energy suppliers.

03 Enexis Groep with IBM

As Tom van der Staak, Project Manager at Enexis Groep, explains it: “Our main challenge is facilitating energy markets in a flexible and cost-effective way. Blockchain makes complex transactions like this simpler and more flexible.”

Enexis set itself an ambitious target to release 1,000 open charge points in the Netherlands by January 2020, with more to follow. It wasn’t always a straightforward process.

The energy industry is undergoing a gradual process of decentralisation and democratisation. As new participants jostle for position in a more diversified ecosystem, traditional suppliers must face major changes to their business models. As such, it was a challenge for Enexis to get some of the larger suppliers on board with the concept. There were also legacy IT systems to grapple with. IBM was on hand to support with the partnership elements as well as the technical implementation.

Enexis is proud to be first to market with a solution of this kind. It is an important piece of the puzzle for this new, decentralised energy economy, and it takes us a step closer to cleaner, greener urban living. Van der Staak acknowledges that this comes with a responsibility to educate others.

“Everyone thinks blockchain is cool but complicated. We need to show them it can be really easy,” he says. “Ultimately, blockchain helps us to get more flexible, simple and open market solutions up and running. It has a huge role to play in a green economy.”

This is just the first realisation of the thinking behind the original concept. The possibilities for sharing surplus energy and opening up the transactions we take for granted to consumer choice are almost limitless – and could have profound implications on the future of our planet.

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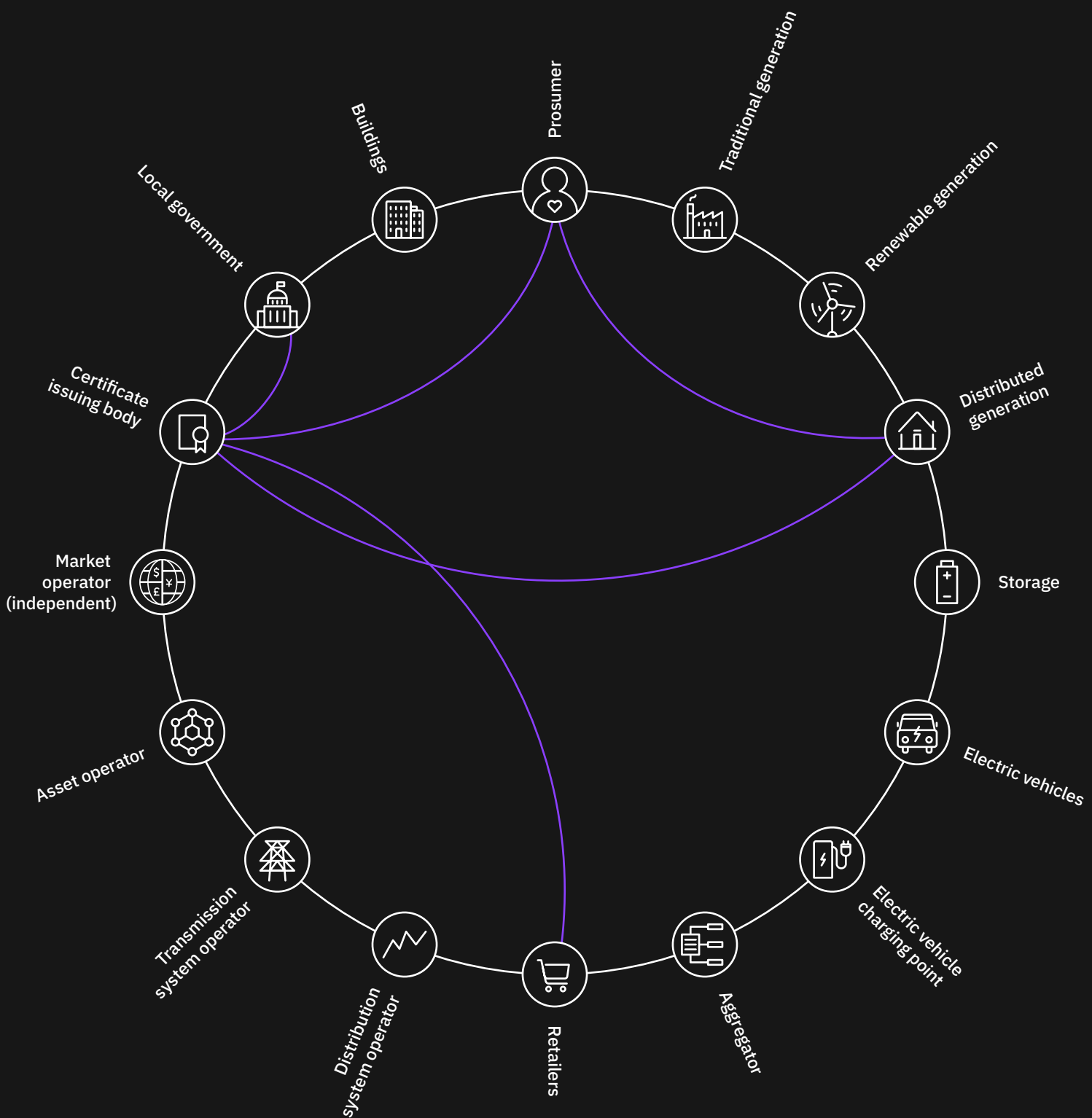
04

Guaranteed green

CertiQ with IBM

04 CertiQ with IBM



04 CertiQ with IBM

As the energy market transitions to embrace more renewable sources, traditional structures are beginning to fragment.

Large energy suppliers no longer hold 100% of the power, in both senses of the word; small operators and individuals increasingly have the option to produce and sell their own energy. But processes, technology and legal frameworks surrounding these transactions can be slow to catch on.

This is the challenge that Netherlands-based CertiQ is tackling head-on. The organisation is appointed by the Ministry for Economic Affairs and Climate Policy to certify energy through guarantees of origin – digital certificate issued per MWh – in line with international agreements to regulate the creation and trade of green energy.

This is an important process for tracking and tracing energy from source to consumer, and making a distinction between “grey” and “green” energy. It matters greatly to the ecosystem because it properly quantifies what is being exchanged; producers can sell certified wind, hydro and solar energy for a higher price, and governments can better incentivise the production and consumption of renewables.

04 CertiQ with IBM

Currently, mechanisms only exist to certify large volumes of renewable energy, so it's only an option for large operators such as established offshore wind farms. An individual generating power from a decentralised renewable source may physically feed their surplus back into the grid, but it won't currently be certified as renewable.

The number of small-scale, independent "prosumers" contributing to the grid in the Netherlands is rapidly rising; it is estimated that up to 10% of the energy mix will come from local sources in the near future. To the team at CertiQ, this seemed like a huge missed opportunity to engage and incentivise individuals to participate in the evolving energy ecosystem.

As Max Laven, Policy Adviser at CertiQ, says: "If we want to go through with the energy transition, we need to involve every citizen, every consumer, every household. We need a whole new approach."

The idea is simple at its core, but CertiQ is not currently set up to certify energy from prosumers in such vast numbers. The team enlisted IBM to help develop the solution needed to support potentially millions of prosumers, experimenting with blockchain as an enabler.

For CertiQ, the appeal of blockchain is its ability to make data fully transparent and traceable. Everyone in the ecosystem knows they are looking at the same data. This is an important shift from what is currently a fairly long, inefficient supply chain.

"Our perception of blockchain evolved throughout the process. It was a buzzword when we started, but we came to realise it might be really helpful in solving the challenges we face," Laven explains.

04 CertiQ with IBM

"When we combined it with our attempts to certify a decentralised energy ecosystem, we liked that it could capture one version of the truth for all to see. It's just a technology, not an end goal, but it could play an important role in this."

IBM built a proof of concept to demonstrate blockchain's potential for registering surplus solar energy produced on household rooftops.

Through this solution, CertiQ aims to provide a hassle-free process for prosumers. They have access to a system that gathers data in near-real time and feeds it to CertiQ. In return, they receive a guarantee of origin that helps them to generate a small financial bonus each year. But alongside the financial incentive, Laven believes there's an opportunity to generate pride among citizens by giving them a say in the future of the energy ecosystem as it becomes increasingly democratised.

If we want to go through with the energy transition, we need to involve every citizen, every consumer, every household.

The technology may well be there to put this in motion, but legislation remains a barrier. This is pioneering work, as Laven explains:

"CertiQ executes against energy laws and regulations. With this project, we are really pushing those boundaries. We're now working with the regulators to get the legislation up to date so that we can put the concept out into the world."

Beyond the immediate benefits for consumers and the energy ecosystem, the broader possibilities are exciting. It could be possible to track the energy being produced across the entire spectrum – whether from renewable, nuclear or traditional fossil fuel sources – to provide a fully transparent view of what is being produced and consumed. This full disclosure would enable consumers, prosumers, companies and even countries to meet and substantiate their sustainability targets.

04 CertiQ with IBM

As well as advising CertiQ on the technology, IBM was able to draw on deep industry expertise to galvanise support amongst consumers, suppliers and the ministry. IBM helped to make the case for change loud and clear; many ecosystem participants were enthusiastic as a result.

This project has the potential to unleash a global change, reshaping the simple model of a few dominant producers into one in which they exist alongside millions of smaller suppliers, all feeding into the grid. CertiQ is proud to be the first issuing body to take a step towards this future.

It could be possible to track the energy being produced across the entire spectrum – renewable, nuclear or traditional fossil fuel sources – to provide a fully transparent view of what is being produced and consumed.

Blockchain

"If we want to go through with the energy transition, we need to involve every citizen, every consumer, every household. We need a whole new approach."

Max Laven, Policy Adviser at CertiQ

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

René Kerkmeester,
Digital Transformation Lead at TenneT

"Blockchain allows us to implement a shared governance and confidence framework, designed to work with the physical reality of power grids, which involves all the stakeholders concerned with flexible transactions."

Lucian Balea, R&D Program Director at RTE

"Ultimately, blockchain helps us to get more flexible, simple and open market solutions up and running. It has a huge role to play in a green economy."

Tom van der Staak,
Project Manager at Enexis

"Blockchain provides the backbone of trust and accountability for this flexibility. It creates a certificate of origin, proving where every small pool of flexible energy comes from."

Anders Christian Lyngtorp, Head of Technical Section at the City of Copenhagen

"We have to keep pace with the energy transition, not block it. The idea of having to limit the development of renewables because we can't manage them is just not acceptable."

Lucian Balea, R&D Program Director at RTE

"Our main challenge is facilitating energy markets in a flexible and cost-effective way. Blockchain makes complex transactions like this simpler and more flexible."

Tom van der Staak, Project Manager at Enexis

"We were pleased to discover this is no longer really a technology issue at all: the technology is ready. The main challenge is to clearly define business and governance requirements and incorporate those into the technology."

Lucian Balea, R&D Program Director at RTE

05

Delivering charismatic carbon

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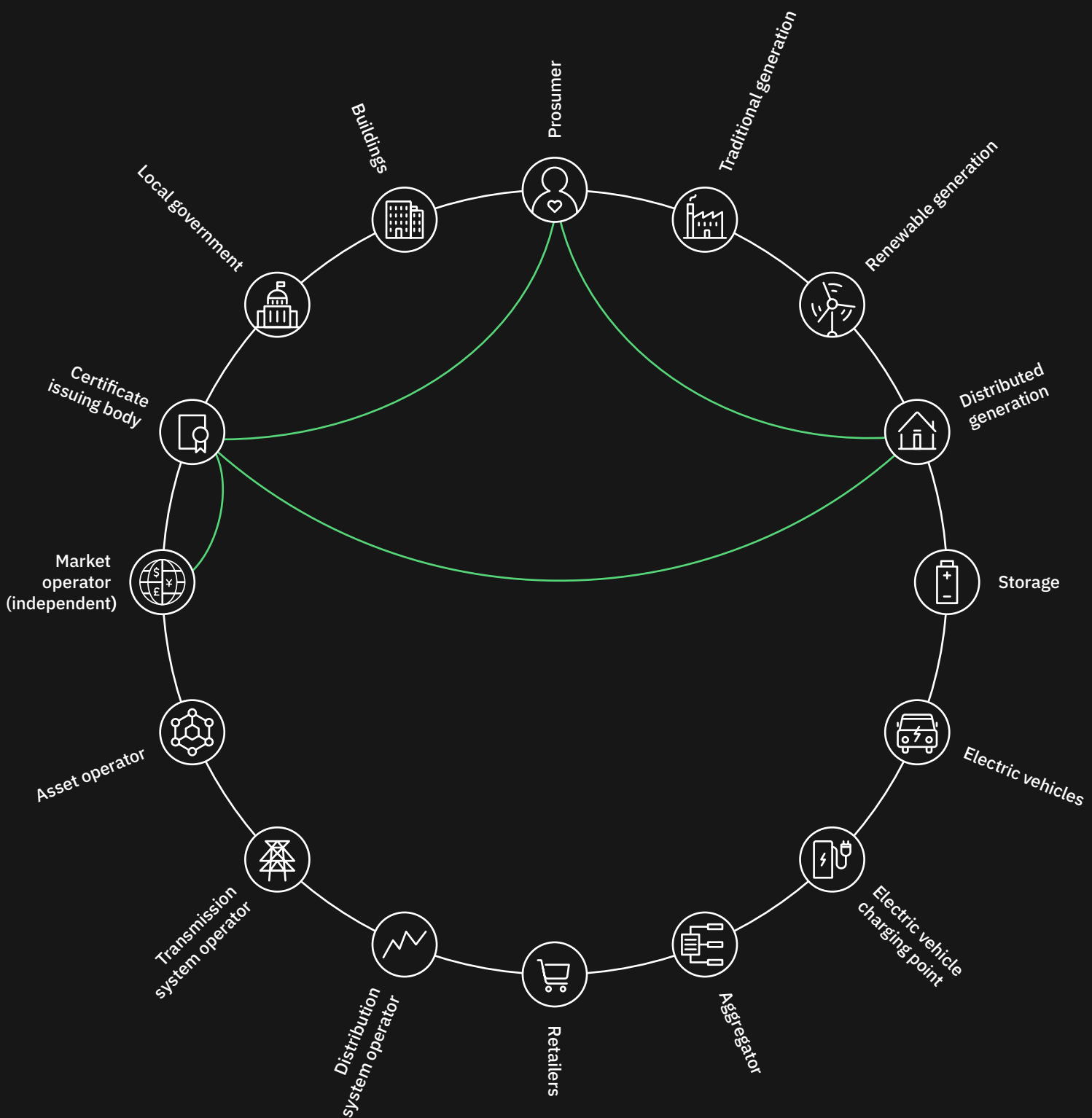
BBOXX with IBM

Image: BBOXX

05 BBOXX with IBM



05

BBOXX with IBM

A sustainable energy supply should not be a luxury reserved for wealthy nations. But all too often, innovations are slower to reach the regions that need them most. The UN aims to tackle this inequality head-on through its Sustainable Development Goals 7: “Affordable and clean energy for all”.

UK-based BBOXX, a next-generation utility, has this goal in mind as it transforms lives and unlocks potential through the provision of affordable, reliable, clean energy and other modern utilities. So far, BBOXX has deployed more than 322,000 solar home systems across 35 countries, positively impacting the lives of more than a million people.

BBOXX technology is replacing the use of kerosene and wood for clean light and energy. The company’s easy-to-install solar-home systems improve access to energy across Africa and the developing world. BBOXX uses Internet of Things technology and data to remotely monitor and manage its solar-home systems via its comprehensive management platform, BBOXX Pulse™.

By satisfying genuine needs like lighting, mobile charging and television, BBOXX technology helps families and businesses in the developing world to achieve an energy-enabled lifestyle in off-grid and rural areas.

BBOXX realised that its customers’ efforts represented “charismatic carbon”: green energy that would

05 BBOXX with IBM

be attractive to those needing carbon offsets. If the green energy produced by customers' solar panels could be certified as green, it could be sold as carbon credits on the global exchange to companies needing to offset their emissions.

The question was: how? How do you certify off-grid solar energy and get these certified green-energy credits onto the global carbon exchanges? BBOXX needed a system that could carry verifiable data from source to market in a way that was robust, energy efficient and transparent.

The team at BBOXX knew that one of blockchain's features was that it ensured digital assets could not be allocated to two different buyers. Its fundamental property as a digital asset exchange mechanism was one of trustworthiness and transparency. And it could scale to enterprise applications.

"We approached IBM because it worked with Hyperledger Fabric, a permissioned blockchain with security and trust elements combined with energy-efficiency," explains Carrie Scott, Design Lead, who manages the initiative for BBOXX. "We knew

Image: BBOXX

IBM had already built parts of a system that we needed, which we could adapt, modify and add to. And, importantly, we knew they had worked in the social-impact space, so understood our business thinking."

Blockchain represents a fundamental revolution in how digitally managed assets can be recognised, recorded, valued, transacted and reported. With blockchain, BBOXX would be able to convert its customers' sustainable energy use into carbon credits, which, on the blockchain, would be immutable and traceable.

So together with support from the Shell Foundation and green energy consultants South Pole, BBOXX and IBM set about testing three critical questions for their proof of concept. Could they send energy generation and consumption data from a single

05 BBOXX with IBM

solar home system to a blockchain energy and offset ledger? Could third-party validation of the data on the ledger generate a carbon certificate as a digital asset? And once the carbon certificate (also called a credit) was made available on a global carbon exchange and successfully sold to an offtaker, could that digital asset then be retired from the ledger?

Scott explains: “The development was rapid, and once the proof of concept was complete and we saw that our idea worked, IBM continued to offer support and consultancy on commercial viability, helping us to develop the business considerations. We were able to ask, ‘How wide could this be? What if we connected this to on-grid as well? What’s the bigger picture?’”

Hyperledger Fabric blockchain is the right technology for BBOXX because, along with its low barrier to participation, its features are uniquely able to provide three critical benefits. Its transparency and unassailability facilitate the process of gaining green classification. Its distributed nature will enable the offsets to be bought by a wider market. And its reliability, consistency and trustability will encourage more people to access the carbon markets, generate revenue and improve their quality of life.

Because of its fundamentally disruptive nature, the BBOXX blockchain and others like it could disintermediate standards bodies, because the blockchain itself provides the trust needed for the transactions to occur.

Scott concludes: “Blockchain will transform every industry it is deployed in, and it will probably replace some entirely – but for good reason.”

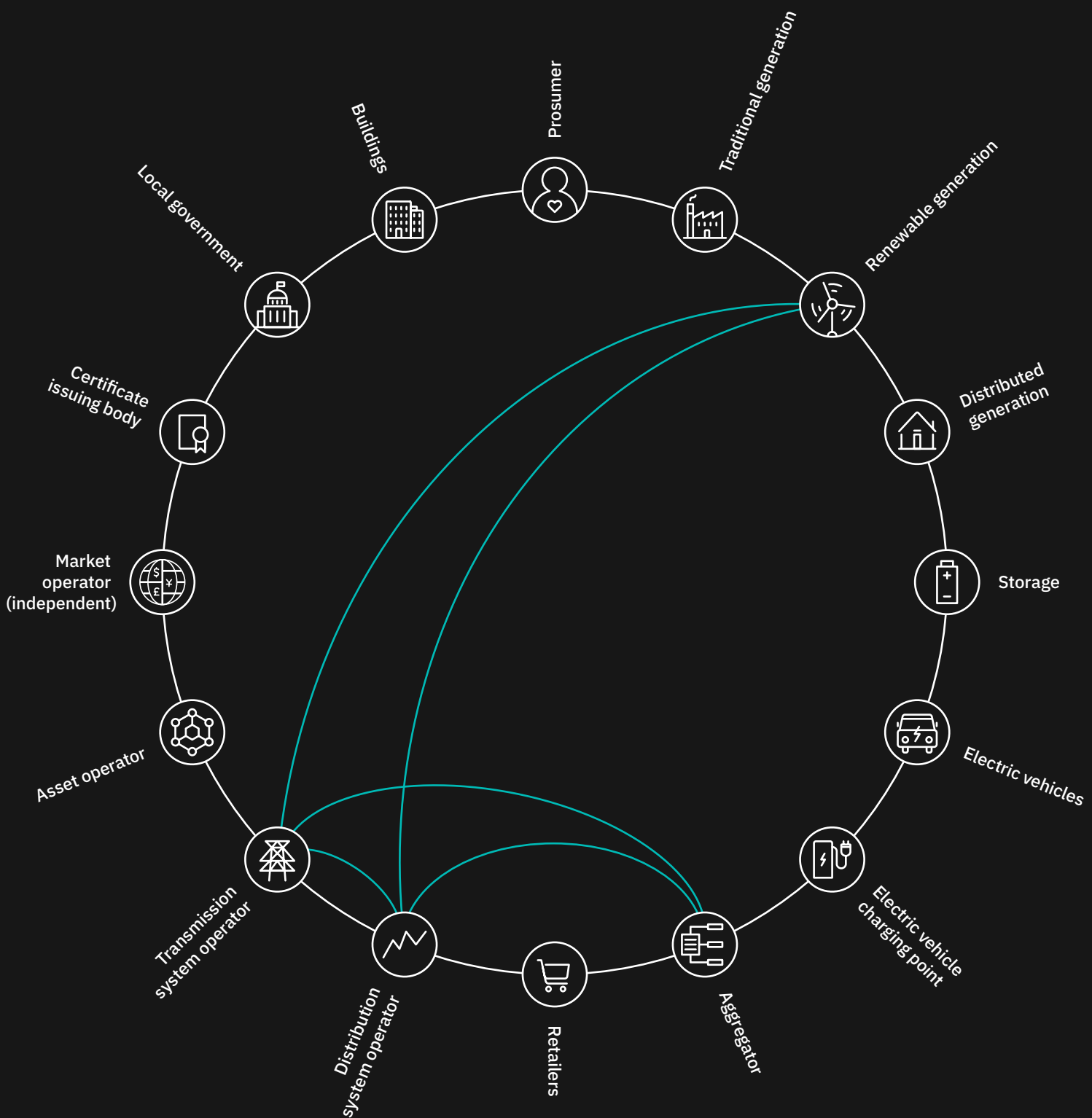
Image: BBOXX

06

A fine balance

RTE with IBM

06 RTE with IBM



06 RTE with IBM

The transformation of the global energy sector from fossil-based to net-zero carbon is an inevitability – and some businesses are choosing to lead the transformation.

Decades down the line, we will all benefit from the foresight of organisations like RTE that are unblocking channels for renewable energy and the decarbonisation of the global energy mix.

As they gear up for the energy transition, driven by increasing digitalisation and diversification, facilitating the switch to renewables while ensuring security of supply and cost efficiency is top of mind for transmission system operators (TSOs) like RTE in France.

The unpredictability of green energy remains a challenge to its wider adoption. Wind and solar power depend, by nature, on climate conditions that are beyond our control. This volatility means that operators must be prepared to adapt to both surplus and deficit. Under adverse circumstances, wind and solar power injections can cause congestion in the grid; operators need to implement remedial actions in order to avoid damaging equipment or endangering people.

One way to manage congestion is to ask a number of participants in the ecosystem to react quickly to compensate for – or halt – the power

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flow. In the case of an energy surplus, this is known as curtailment; generators are compensated for the energy that is not produced.

This congestion management mechanism, which relies on generation redispatch, has been a standard feature of the electricity industry since it began. The challenge, now, is the sheer number of highly distributed participants at play. Without an effective process to manage the many small-unit transactions attached to the curtailment of renewables, the conventional mechanism cannot scale.

To complicate things further, generation capacity is moving increasingly towards the distribution grid. Unlike large, centralised energy suppliers, most renewable energy sources (RES) generators connect to the distribution grid. This means there is an urgent need for a new governance and operational model that connects TSOs and distribution system operators (DSOs).

These were the problems the team at RTE chose to embrace as a result of an exploration process with The Linux Foundation to identify use cases for blockchain.

"The costs associated with infrastructure adaptation would clearly be lower if the grid could leverage the flexibility capabilities of renewable generation," Lucian Balea, R&D Program Director at RTE, explains. "What's more, the whole process could work much more seamlessly if the TSO and the DSO could coordinate their activities."

RTE already suspected that open-source software had a role to play, so the team was keen to hear about the impact of Hyperledger Fabric blockchain technology in industries such as finance, food tracking and shipping. Could it bring the same benefits – increased transparency, traceability and cooperation – to the energy system?

"Blockchain allows us to implement a shared governance and confidence framework, designed to work with the physical reality of power grids, which involves all the stakeholders

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concerned with flexible transactions – DSOs, TSOs, wind generators and aggregators," says Balea. "In the past, it was very hierarchical: the transmission grid controlled everything. That is no longer the case."

The team also embraced the automation capabilities of blockchain: it can track and measure activities in near-real time, and ensure everyone sees precisely the same information around a transaction. This is a huge shift from the current state in which every stakeholder has its own database, with its own quirks and variables that can require manual intervention. That's manageable between a small number of large operators, but not among a more complex ecosystem of small entities.

Following a design thinking workshop, RTE and IBM created a proof of concept to demonstrate the System for Traceability of Activations of Renewables (STAR), a blockchain shared ledger for flexibility management.

As the impact of climate change becomes more visible, there is a clear business need and political expectation for a solution that harnesses flexibility in renewable generation.

IBM was the natural partner for RTE based on its industry experience, and its strong competences with Hyperledger technology sat well with RTE's open-source strategy.

"The open-source development model allows us to share costs and R&D efforts with other industries, and so to move faster – at a pace that's suitable for the energy transition," says Balea. "Besides that, we have to design this solution to be interoperable with our stakeholders' back-office systems and technologies."

From the start, IBM worked with RTE to define its needs and goals, helping to keep the proof of concept specifications simple.

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The demonstrator model is helping RTE to better define its business processes and onboard those external stakeholders. The next step is to implement STAR with selected producers and stakeholders through a pilot. Beyond that, RTE hopes to identify options to extend the thinking to build other flexibilities into the ecosystem. The team is working in agile mode, adapting as it learns and gathers feedback.

On the discovery process, Balea says: "We were pleased to discover this is no longer really a technology issue at all: the technology is ready. The main challenge is to clearly define business and governance requirements and incorporate those into the technology."

So far, feedback has been broadly positive. As the impact of climate change becomes more visible, there is a clear business need and political expectation for a solution that harnesses flexibility in renewable generation.

"We have to keep pace with the energy transition, not block it. The idea of having to limit the development of renewables because we can't manage them is just not acceptable," Balea explains.

"Solutions like this are essential to the grid we're building to adapt to the energy transition and, ultimately, to decarbonise the global energy mix."

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Collaborating without complexity

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REE, REN and OMIE with IBM

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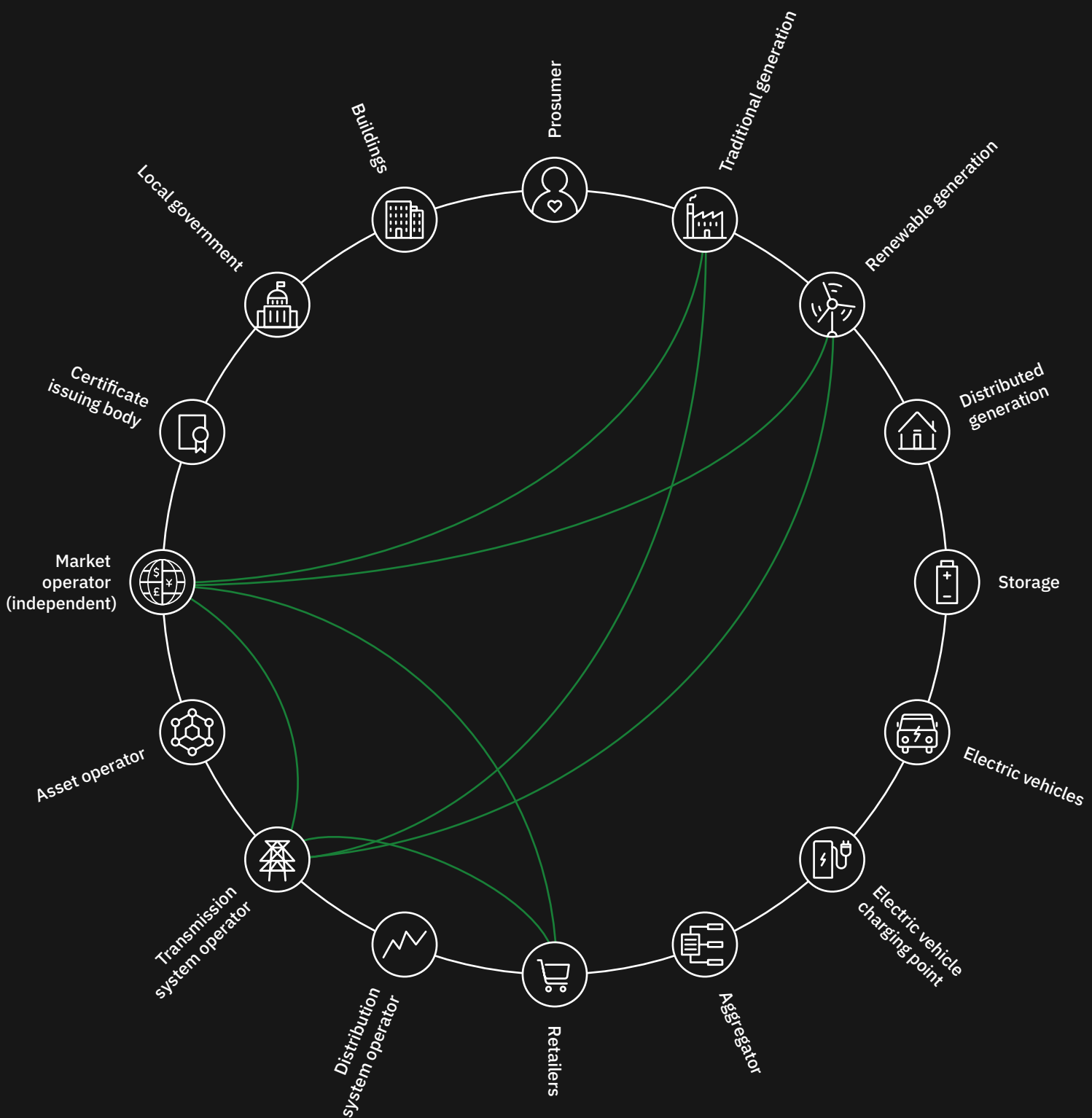
REE, REN and OMIE with IBM



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When we look back a decade or so, the electricity market was a relatively straightforward endeavour. Each country's transmission system operator (TSO) and market operator engaged a small handful of market agents, who were linked to large power plants positioned across the country.

It was fairly simple to keep on top of information about these assets, which could be stored in spreadsheets and shared by email among the small number of interested parties.

We are moving further from this model every day. The market is gradually evolving to become a complex ecosystem that increasingly takes in renewable as well as traditional sources, all of which generate power across multiple distributed locations, and involves a large number of participants. There are more moving parts than ever before.

A trio of organisations in the Iberian Peninsula has come together to address this complexity, experimenting with blockchain as a means to reimagine information sharing.

Red Electrica de España (REE) is the TSO for Spain; Redes Energéticas Nacionais (REN) is its equivalent in Portugal; Operador del Mercado Ibérico de Energía – Polo Español (OMIE) is the electricity Market Operator tasked with running the spot power markets in the Iberian Peninsula. As geographical neighbours, the two countries are bound by the integration of both the electricity markets and the electricity

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system. Known as market coupling, this arrangement enables the free movement of electricity between the countries, increases the security of their grids and keeps their prices aligned.

This arrangement requires a high level of collaboration and a constant stream of up-to-date information between OMIE and the two TSOs. That includes information about all the agents that operate in the market.

As an independent market operator, OMIE must maintain up-to-date reference information about market participants, establishing who is licensed to buy and sell electricity in which country. It uses this reference information to approve or reject supply and demand offers in order to engage or disengage generation throughout the day.

Smoothing out the communication channels among the market agents is only the first step in streamlining an increasingly complex energy ecosystem.

REE, REN and OMIE are examining the potential of blockchain in enabling a more efficient, trustworthy exchange of information about these market agents as well as the market units required for the efficient operation of the market.

At present, this information exchange is done in an ad-hoc way. Each organisation might have its own methods for storing and interpreting that information. But with high-stakes decisions being made based on these facts and figures about an increasingly complex ecosystem, this framework is no longer fit for purpose. Minor differences or inaccuracies in the way information is recorded and communicated can lead to costly misalignments in the market.

Marta Araújo, Project Manager at REN, explains: “There is a lot of sensitive information being exchanged. It currently requires several entities to ensure the integrity of the information; there are lots of approval processes. Coordinating it all is challenging.”

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Together with IBM, the organisations have designed a blockchain solution that is transparent, secure and immutable, ensuring everyone sees precisely the same information at the same time. To operational employees there's very little change – they still input the same information to the same place. But instead of extracting files to email onwards, they work with a connected system. Any changes are immediately registered, attributed and time-stamped for all to see.

Luis Chiroque, Communications Partner at REE, says: "This changes the way we trace information and define rules. We can make changes once, without needing to double up the effort at both ends."

The representatives from REE, REN and OMIE who formed the project team were new to blockchain as an enabling technology, so they wanted to work through the process of developing a proof of concept (POC) within an isolated part of the ecosystem that could demonstrate the broader possibilities at every step.

Naturally for an innovation project involving teams from three separate entities of different sizes and with different working cultures, there were challenges along the way. But good communication and an open-minded approach kept things moving along. IBM's experience in blockchain and Hyperledger Fabric was the right fit for this particular use case, but its energy expertise and ability to drive toward the bigger picture as a partner was just as important.

Sergio Muñoz, IT project manager at OMIE, reflects: "We were able to confirm that blockchain is a key solution when trusted share usage and data access are required."

With the POC now established, the team is looking to broaden the scope to other use cases. It is clear that there are ample opportunities to address small but significant frictions in the system in order to gain a clearer picture of what is happening at any time. Smoothing out the communication channels among the growing number of market agents is only the first step towards streamlining an increasingly complex energy ecosystem.

Conclusion

These stories, from a group of companies leading the way with blockchain solutions, show that, in the end, it is not really about technology. The important thing is what blockchain enables for companies, industries and society as a whole.

Together, we have experienced what it takes to initiate and grow these new use cases, business models and marketplaces, using blockchain as one of the core technologies. At IBM, we are convinced that the technology and methodology are ready for business – as are we.

These stories demonstrate the various stages that blockchain initiatives go through: from initial idea, to proof of concept, to scaled operation, to proof of business value. From these examples in the energy space, as well as those from many other sectors, we have learned that it all starts with designing for scale. We use methods and tools to create value by aligning the incentives of each involved party.

Blockchain is a team sport with typically three or more parties collaborating to create both individual and shared business benefits. It requires careful design to make it a success. This can take time – but successful collaboration is more important than the technology itself. Together, we achieve benefits that were otherwise unattainable by either party individually.

Once these initiatives take off, they can scale rapidly across borders and sectors, enabling new business opportunities and unlocking new value. These stories demonstrate how the four Ds (decarbonisation, decentralisation, digitalisation and democratisation) come together in cases that truly scale.

The pressure is on to deliver on the changes we need to transition to a low-carbon economy, but this brings about many opportunities. We hope the examples in this report not only demonstrate the art of the possible but also inspire you to bring other use cases into reality.

Blockchain is ready for business. So is IBM.

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