Blockchain for commodities

Trading opportunities in a digital age

September 2018

Cutting costs
Big Oil backs post-trade transformation

Wholesale approach
Europe tests peer-to-peer gas and power trading

Going local
Microgrids exploit prosumer potential

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This report explores the challenges and opportunities for commodity markets from this innovative technology, and how it has the potential to make commodity trading simpler, faster, and cheaper.

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This report explains the technology, examines the projects, and looks at real-life cases where blockchain is being applied today.

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Foreword

Martin Fraenkel
President
S&P Global Platts

Digital revolution

If you're reading this on a phone, tablet or laptop, instead of paper, you're part of the digital revolution that is transforming society.

The shift to electronic documents and data in all areas of life is one of the key economic developments of this century, bringing new efficiencies, cost savings and opportunities far beyond anything that could be achieved with paper records.

That shift is about to hit commodity trading, which has traditionally relied on vast paper trails to execute, authenticate, and process each transaction.

Digital technologies like blockchain, the distributed ledger technology best known for its association with cryptocurrency Bitcoin, are creating new options for streamlining and simplifying paper processes, and for disrupting long-established business models.

Blockchain has attracted serious interest from some of the biggest names in commodity trading, like Gunvor and Mercuria, as well as oil-and-gas majors like BP and Shell, and big banks like Societe Generale and ING.

But blockchain also creates opportunities for smaller players by potentially reducing the cost of trading, making it cheaper to enter a market.

Regulators are also interested in how blockchain can help them make markets more transparent and so more efficient. This again helps new entrants.

In Fujairah, for example, S&P Global Platts uses a blockchain platform to collect and publish weekly aggregated oil terminal stock levels on behalf of the Fujairah Oil Industry Zone authority and data committee FedCom.

This is one of the first commercial live applications of blockchain in the energy sector.

Trade finance, which underpins all global commodities trading, is another sector that blockchain could transform.

Increased transparency in trade workflows could make fraud much easier to detect, but a secure blockchain system with trusted counterparties also threatens the role of banks as trusted intermediaries.

In electricity, the role of utilities and grid operators is threatened by the shift to decentralization, as more and more distributed energy sources, such as rooftop photovoltaics and battery storage in electric vehicles, come into play.

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Blockchain can support this decentralization by enabling peer-to-peer trading in microgrid communities between prosumers – retail consumers who also produce small quantities of power.

It is blockchain's ability to process frequent micro-transactions that helps to make such trading technically possible.

But physical and regulatory constraints mean that utilities and grid operators will still have major roles in delivering power for many years to come.

Virtual peer-to-peer power trading, however, which sits on top of existing structures, is possible and potentially viable now.

One of the challenges for both virtual and physical peer-to-peer trading is pricing this power.

S&P Global Platts is bringing its years of experience as a trusted price reporting agency to bear in solving this problem.

It is working with the Port of Rotterdam on a project to offer transactive pricing for peer-to-peer power trading in a microgrid community of port-side businesses.

Blockchain faces many other challenges to becoming a big part of commodity trading, including cost, privacy, liability, and achieving mass participation.

It is also just one part of a new digital trading infrastructure, with artificial intelligence, machine learning, and robotic process automation all set to play a role.

It goes beyond the scope of this report, but S&P Global is active in all these areas, including through Kensho Technologies, which it bought in 2018.

I'm excited by the opportunities blockchain creates for commodities trading, and this report is an excellent introduction into what they are.

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Executive summary

Blockchain is a distributed ledger technology that could make trading commodities simpler, cheaper and more transparent. It is best known for its association with the cryptocurrency Bitcoin, but it can be used in any process involving transactions and exchanging data.

Blockchain works by verifying and recording transaction data in a permanent way on a single, secure digital ledger shared by trusted counterparties. It creates a system where parties can connect directly with each other, without the need for intermediaries like banks, brokers or utilities, for example.

Pilot projects using blockchain to support commodities trading are springing up all over the world, but there are very few live commercial applications as of mid-2018.

Cutting post-trade processing costs is one of the main potential uses of blockchain in commodity trading, with savings of up to 40% across operations, accounting, settlements and IT, according to blockchain developers. Big energy traders are backing blockchain post-trade projects, like Vakt for oil and OneOffice for gas, that are expected to launch in the coming months.

Wholesale peer-to-peer trading is another application being developed by big European gas and power companies in the Enerchain project. The partners hope to enable large-scale trading, making the project unique in its focus, size, and disruptive potential.

Exchanges will remain core to wholesale power trading, however, as trade matching is only one part of what exchanges offer, according to Peter Reitz, CEO of the world's largest electricity exchange, EEX. But blockchain could help link the wholesale markets to smaller regional and local ones.

Prosumer power drives blockchain-enabled peer-to-peer trading at the micro-scale, enabling households in a microgrid to exchange small quantities of locally-sourced power directly with each other. This challenges the traditional utility and grid business models, but regulatory constraints are likely to limit development in the near term.

Singapore is emerging as a strategic base for digital startups in Asia, with several of these developing blockchain platforms for energy and commodity businesses. With a digital-friendly government and regulator, Singapore is poised to show what's possible under the right conditions.

Derivatives trading is also a key target for blockchain developers. Blythe Masters, CEO of Digital Asset, sees blockchain's ability to offer a common record of transactions as enabling huge efficiency gains for trading in any asset class, whether that is a commodity derivative or an interest rate swap.

Tackling trade fraud, particularly trade-based money laundering, is another activity blockchain can help with. This is a particularly difficult financial crime to track and investigate, but blockchain's common record could help parties spot invoice irregularities, carousel transactions, and unusual shipping routes, for example.

Taking stock of storage levels and other key supply-and-demand data helps make markets more efficient. Blockchain can be used to provide aggregated data while fully respecting individual commercial confidentiality. It could also be used to run auctions and electronic tenders for physical bulk commodities, for example.

Breaking the rules might be needed to help blockchain develop, particularly for peer-to-peer trading at the household level. Developers are seeking regulatory waivers to test concepts that are not allowed under systems designed for centralized energy production.

Keeping safe from cyberattacks should be a priority for every business, according to Tobias Feakin, Australia's first Ambassador for Cyber Affairs. He argues governments and the private sector must work together to mitigate the risks, safeguard cross-border digital trading, and avoid a "digital divide" splitting global trade.

A reality check is always useful as blockchain moves from the initial hype and proof of concept to having to prove commercial value at scale. Cost, privacy, and liability are all potential deal-breakers, while other technologies such as artificial intelligence and machine learning may compete as well as complement.

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How blockchain works

Blockchain works by verifying and recording transaction data in a permanent way on a single, secure digital ledger shared by trusted counterparties.

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Head of Architecture for Risk Services
S&P Global Market Intelligence

Siobhan Hall
Editorial Lead, EU Energy Policy
S&P Global Platts

Blockchain emerged in 2009 as the distributed, decentralized digital ledger underpinning cryptocurrency Bitcoin, recording transactions in an immutable way.

It works like this – an individual, or a machine, registers as a member of a blockchain, which can be public, like Bitcoin, or private, like a street of householders or a group of traders.

The individual/machine can then transact with other members registered to the blockchain.

Computers – nodes – on the blockchain's peer-to-peer network check each transaction, using the same consensus algorithm, to agree that the transaction is true and valid.

Verified transactions are then added to other transactions to create a new block of data that is added to the existing chain of blocks. This creates a permanent data entry in the digital ledger.

No one can change the ledger – it is immutable. It is shared with all members at all times and, if the blockchain is public, anyone can become a member.

Since the initial concept, developers have created automated code-based processes, known as smart contracts, which can interact with and update the data on the ledger without direct human intervention.

Consensus struggles

Bitcoin is a public blockchain that as of mid-2018 was still using a "proof of work" consensus algorithm to verify transactions. Proof of work relies on computers solving cryptographic puzzles for the right to add the next block in the chain. This "mining" method uses a lot of electricity to run the computers and is slow.

Developers are looking at alternative consensus algorithms for the private, permissioned blockchains being explored for commodity trading applications.

For example, the Energy Web Foundation is working on an open-source, scalable blockchain platform called Tobalaba, specifically designed for the energy sector, which uses a proof of authority consensus algorithm to verify transactions.

The EWF is a global non-profit organization supported by a wide range of energy companies and developers, such as California's Pacific Gas and Electric, Japan's Tepco, Norway's Equinor and energy major Shell.

EWF's proof of authority algorithm uses a specific group of nodes – computers on the peer-to-peer network – to validate transactions.

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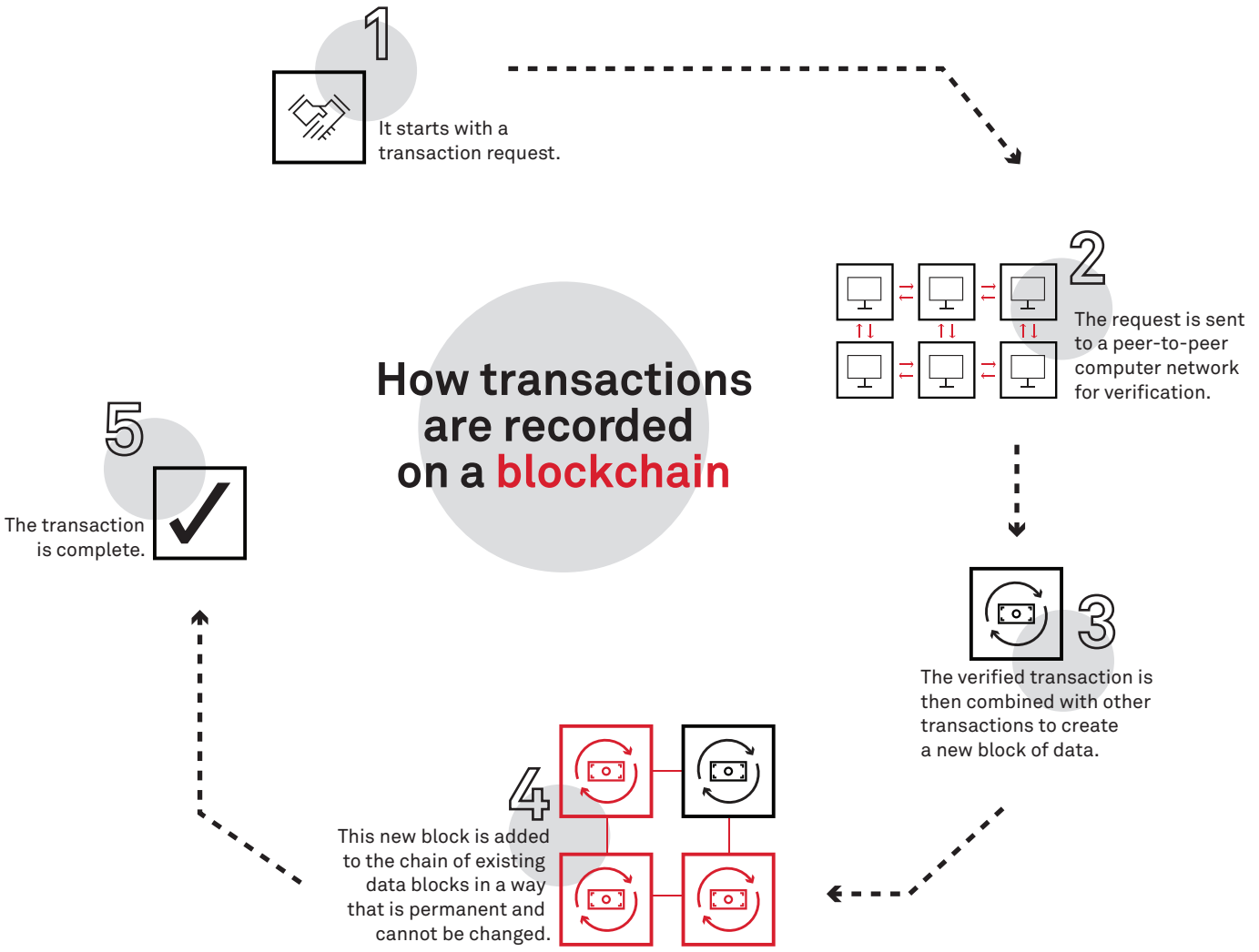

Source: S&P Global Platts

These authority nodes, or validators, are governed by a smart contract. The aim is to verify transactions more quickly using less energy than with proof of work.

Another consensus algorithm type is proof of stake, where a set of potential validators take turns to propose and vote on the next block. The weight of each vote depends on how much of the blockchain's base cryptocurrency the validator owns and has put up as a locked deposit. Again, this is less-energy intensive than a proof of work consensus.

A fourth type is practical byzantine fault tolerance, which can be used on the private, permissioned Hyperledger Fabric blockchain platform. PBFT enables replica transaction files to communicate with each other, so that if the first copy becomes corrupted it can be replaced by the replica.

Watch our video explainer

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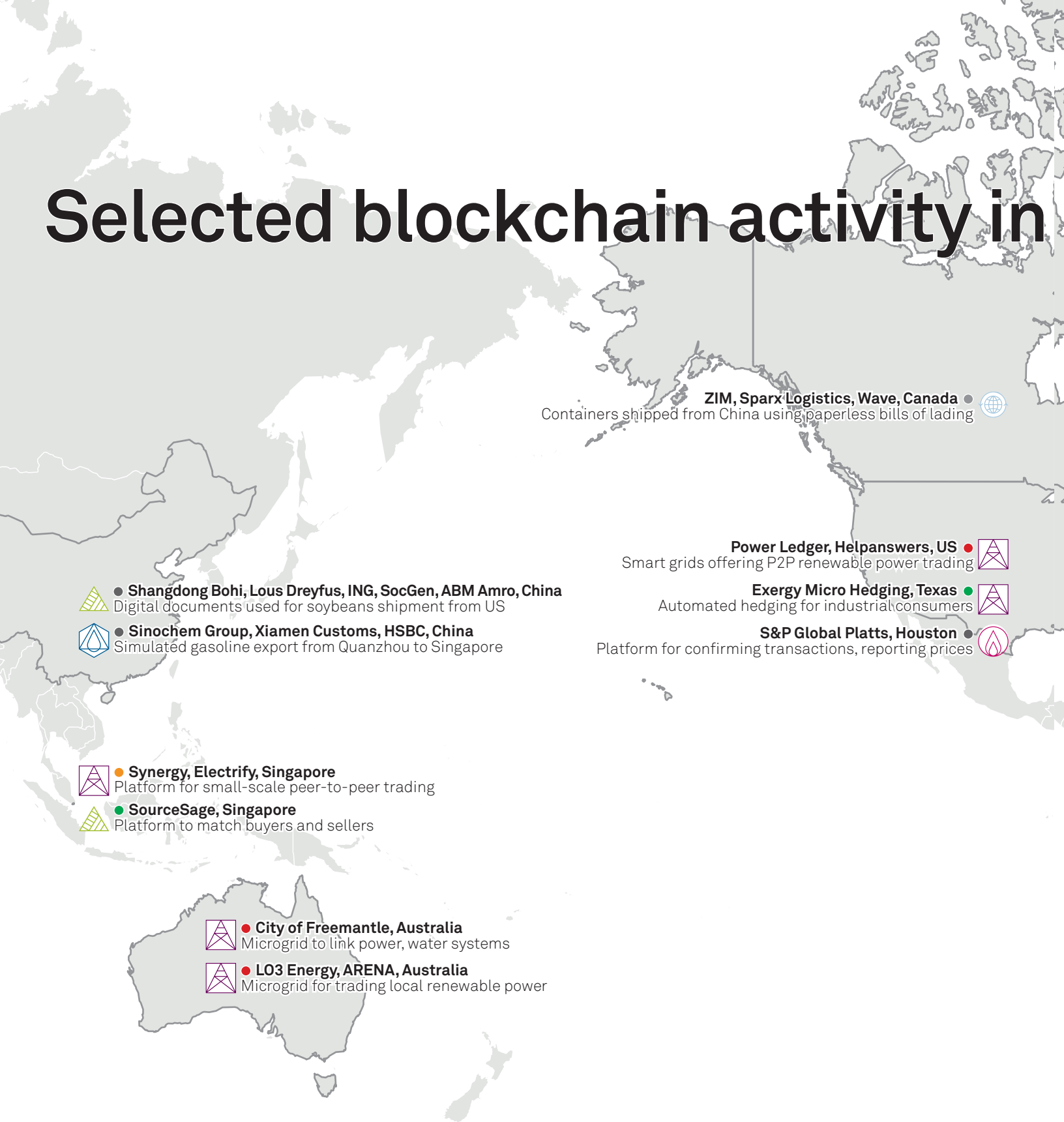
Selected blockchain activity in



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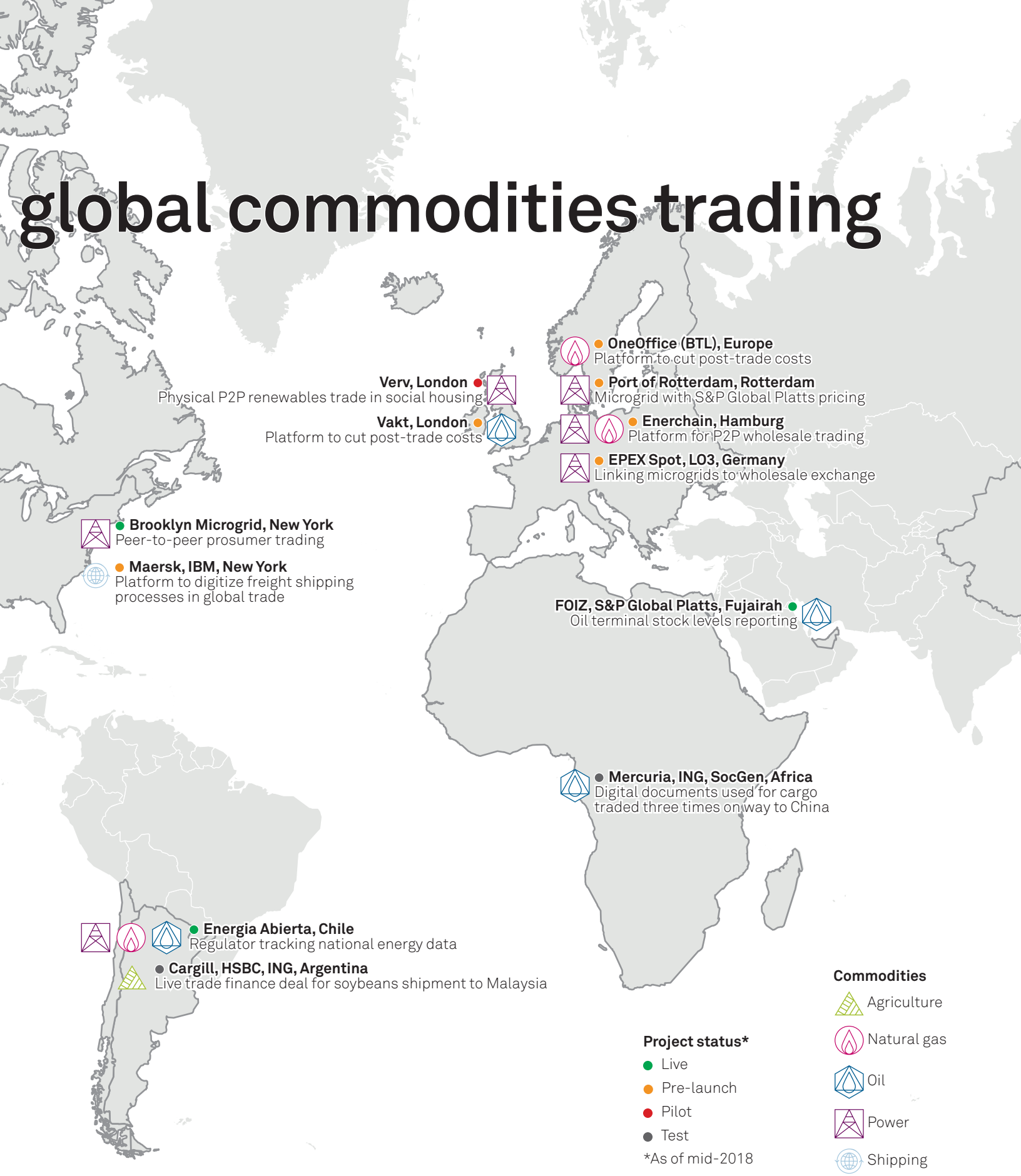
global commodities trading



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Cutting trade costs

Digitizing post-trade processes for commodities could cut costs by up to 40% across operations, accounting, settlements and IT, according to blockchain developers.

Eric Yep
Senior Editor, ASEAN Content
S&P Global Platts

Rosemary Griffin
Oil and Gas Editor, EMEA
S&P Global Platts

Modern commodity trading still relies heavily on manual, cross-checked, paper-based administrative tasks to process individual trades through to settlement and delivery, but that looks set to change with the advent of new IT options, including distributed ledger technologies like blockchain.

"The question of whether blockchain will change the way we do business is already answered for BP," Iain Lawson, BP's head of structured products for the Eastern Hemisphere, said at the S&P Global Platts Digital Commodities Summit in Singapore in July 2018.

"There's a full acceptance in the front office of any trading room in Singapore that blockchain will change not just how we trade, but potentially what we trade and who we trade with," he said.

BP is a founding partner of London-based consortium Vakt, with other oil majors Equinor and Shell, trading houses Gunvor, Koch and Mercuria, and banks ABN Amro, ING and Societe Generale.

Vakt is developing a blockchain-based platform for post-trade processing that is intended to eliminate paper, improve efficiency and transform trade finance options.

It is focusing on oil to start with, looking at North Sea crude, Amsterdam-Rotterdam-Antwerp product barges and US pipeline crude.

The plan is to go live in November 2018 with processing BFOE North Sea crude trades for consortium members, Vakt's interim CEO John Jimenez told the conference.

It will follow this by expanding to include pioneer users – organizations that are ready to engage in a blockchain service. By the end of first-quarter 2019 it hopes to make the service available to other potential participants.

> *"There's a full acceptance in the front office of any trading room in Singapore that blockchain will change not just how we trade, but potentially what we trade and who we trade with."*
>
> *— Iain Lawson, BP's Head of Structured Products for the Eastern Hemisphere*

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How blockchain can add value

Accessibility: Blockchain improves accessibility by storing data in an encrypted, digital distribution ledger that can be accessed by every party in the blockchain.

Scalability: The blockchain can be scaled up or down based on the number of parties involved, without any increase in paperwork, thereby improving the system's efficiency.

Digital verification: Implementing electronic know-your-customer (e-KYC) activities for the parties involved is viable and helps detect potential red flags.

Security: Using cryptography and key-based encryption, it is impossible to tamper with the documents and contracts within the blockchain.

Ease of regulatory validation: The relevant regulator can be given access to the blockchain to verify processes at every step of the transaction.

Source: CRISIL

Vakt's ambition after these three initial markets is to scale up and enter many other markets, like Singapore, the rest of Asia, the Middle East and US natural gas, Jimenez said.

"The first challenge is to prove that we can do this at enterprise grade and bring it to operation this year," he said.

Rivals for gas

While Vakt is focusing first on oil, Canadian technology company BTL is developing a post-trade reconciliation service for natural gas called OneOffice, using its Interbit blockchain platform.

BTL is working with Eni Trading and Shipping, Freepoint, Gazprom Marketing & Trading, Mercuria – which is also a partner in Vakt – Petroineos, Total and Vattenfall on a service that could cut back office costs for processing wholesale gas trades by 30-40%.

"We believe there could be even greater cost savings, given the reduction in technical infrastructure that's required to build and support a blockchain application," BTL director Brian Hinchcliffe told S&P Global Platts.

The service aims to enable companies to deal with mismatched trades more efficiently. "A trade reconciliation blockchain application can streamline this process by raising disputed trades at the outset and therefore save a huge amount of time, thus enabling faster payment and settlement times, larger trading volumes and an immutable audit trail," he said.

Blockchain also reduces reliance on backup servers and IT hardware, and provides greater protection against cyber threats, Hinchcliffe said. "In all manner of transactions, it is this immutability and consensus that protects against compromise," he said. "Any data is kept totally private and secure amongst all the relevant counterparties."

BTL's Interbit blockchain platform is designed to allow any application using it to scale to enterprise requirements. As of mid-2018, the trade processing service was still in the testing phase with the initial partner companies. "Any future collaboration is likely to look very different to this current phase as we move towards a production live application," Hinchcliffe said.

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Wholesale P2P trading

Europe's Enerchain project aims to enable large-scale peer-to-peer trading for wholesale natural gas and power – making it unique in its focus, size, and disruptive potential.

Henry Edwardes-Evans
Associate Editorial Director,
Power in Europe
S&P Global Platts

More than 35 companies are involved in the Enerchain wholesale trading project, including big European gas and power traders such as E.ON, Enel, Iberdrola, and Vattenfall.

The volumes these big beasts could bring to a new marketplace could disrupt the business model of the brokers and exchanges that facilitate wholesale power and gas trading today.

The project also embraces smaller, regional players – those grappling with a boom in distributed energy that want to trade without the fees, settlement risk, and clearing associated with the conventional market.

German technology company Ponton came up with the Enerchain idea in 2016, and demonstrated a first test trade on a prototype blockchain in November of that year.

It set up a small early mover group of companies to work on the idea and, by February 2018, it was able to carry out several live trades using the Enerchain software powered by open source blockchain engine Tendermint. The trades involved Endesa and Gas Natural Fenosa, Energie AG and Stadtwerke Leipzig, and Verbund and Salzburg AG, and demonstrated proof of concept.

But, with no fixed launch date set for commercial trading, Enerchain's challenge to the existing order remains a vision for the future.

As of mid-2018, the companies involved still had to agree to governance, form a legal entity, and then actually start trading in earnest. The software itself is evolving and has limitations in transactional speed. Several participants are there to observe and learn, and it remains to be seen who among the big beasts are really serious.

Participants are believed to be setting up a registered not-for-profit cooperative, similar to a Genossenschaft in Germany or a Stiftung in the Netherlands. This entity could carry out commercial operations for the benefit of its members if those operations reduce barriers to entry and are in the public interest.

> *"Enerchain is one of the very rare projects, outside the financial sector, which has real potential for disruption."*
>
> *— Thorsten Kuehnel, E.ON's Vice President Future Lab Digital Transformation*

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While some participants say their interest in Enerchain is more about understanding the potential for blockchain, not spearheading a revolution, others are genuinely keen to turn concept into reality.

"The potential of blockchain technology lies in disintermediation," E.ON's Thorsten Kuehnel told S&P Global Platts. "This creates true disruption; everything else is incremental innovation or optimization. Enerchain is one of the very rare projects, outside the financial sector, which has real potential for disruption."

Speed restrictions

A key issue for participants is how fast the Enerchain software can add transaction data to the blockchain.

The products must "suit the software," Ponton's Rex Kempcke told S&P Global Platts. "This is a young technology, with a block-building time of one second [per block]. There are restrictions with regards to speed of transaction, and we need to build trust within organizations – they are not going to trade all their assets over new technology."

The potential is there to boost block building time to more than 100 per second, and perhaps as high as 300, depending on how much computing power is available.

While 100 blocks a second is not fast enough for high frequency spot trading, it is enough for many, if not all, the forward and specialist load curve contracts that several Enerchain participants have in mind for the platform.

Enerchain is focused on testing and offering physical spot and forward power and gas products for any European delivery zone, including standard and non-standard products. But there is scope to extend this to post-trade reconciliation services.

Once a deal is executed on Enerchain, it is pushed to the electro-technical information model systems of the company, from where it goes down the traditional reconciliation cycle.

"We've started at the front end because there is less integration with legacy systems," said Kempcke. "Once the blockchain framework is in place, however, it can be extended along the trade cycle."

The idea is for Enerchain to cover the entire cycle from pre-trade through reconciliation, with third-party platforms or services (such as screen vendors) linking to the blockchain infrastructure.

Lower risk

One of the benefits of blockchain is reducing settlement risk, removing the need for clearing. The moment a transaction is executed, value is transferred using a digital currency or token. This makes it easier for smaller players to join a private blockchain, like Enerchain, because of lower collateral requirements.

"Fiat currencies, like the euro and the pound, are not digital yet – you can't transfer euros or pounds via the blockchain, so you need a cryptocurrency token," Kempcke said.

A trustee issues the token and holds the equivalent in a fiat currency in trust. The transfer and settlement are done by the token currency. In the longer term, fiat currencies themselves may have digital versions, although central banks are proceeding with understandable caution.

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Exchanges still core

Peter Reitz, CEO of EEX, the world's largest electricity exchange, talks to S&P Global Platts about how blockchain is an opportunity, not a threat.

Peter Reitz
CEO
EEX

Andreas Franke
Editorial Lead, European Power
S&P Global Platts

How can EEX make use of blockchain?

Looking at blockchain – where do we come from? We ask ourselves how we can improve our services as an exchange and clearing house in the context of the challenges in the energy industry, which are mainly referred to as the 3 Ds – decentralization, digitalization and decarbonization.

In doing so, we think about exposure to price risk and risk management, and where we see that changing, we see opportunities for EEX Group.

In this context, we see blockchain as one technology among many others. As far as the application of blockchain technology in the financial sector is concerned, our mother company Deutsche Boerse is involved, looking into applications in dialogue with industry stakeholders.

Will P2P wholesale trading make exchanges redundant?

Peer-to-peer wholesale power market trading – for example, trading on the day-ahead market – would not make sense.

This is because the core function of the day-ahead market is to gather liquidity by aggregating the total power production and consumption, on a systemic level, but not on an individual level. On the power derivatives markets it's all about providing attractive prices for traders based on a large liquidity pool.

But an exchange is more than a matching engine. Fundamentally, exchanges create transparency through reliably calculating and publishing prices and volumes.

In addition, exchanges have further core functions, such as the admission of trading participants, market surveillance, the implementation of regulation, and risk mitigation through the central clearing counterparty.

In a nutshell, we see blockchain not as a threat, but as an opportunity. And I'm convinced that the core function of exchanges and central counterparties are valid also in the future.

How can blockchain connect microgrids to wholesale markets?

One initiative in this field is the cooperation of EPEX SPOT, the power spot exchange within our group, with the Brooklyn-based startup LO3 Energy.

LO3 develops so-called microgrids at the neighborhood level using blockchain. This implies that prosumers producing electricity through individual devices such as solar panels are connected to each other, enabling them to trade the produced electricity peer to peer using blockchain technology.

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The partnership of EPEX SPOT and LO3 aims at plugging local microgrids into the wholesale power market. This will increase liquidity and give more market opportunities. It will determine a real value for the electricity generated in the microgrid.

Participants of the microgrid can sell excess electricity or buy electricity in case of shortfall or low prices, and consumption patterns can be adapted according to the wholesale price signal.

How could blockchain change European power markets?

We observe many initiatives for peer-to-peer trading, but on a very local level without influencing power trading on a European wholesale level yet.

If we look beyond the pure trading layer, there are fields in which blockchain could create added value.

For example, this could be secondary services such as a registry service for emission allowances or guarantees of origin. By using blockchain for tracking renewable power generation at a local level, the documentation of power production could become more reliable.

What other digital technology changes do you see coming?

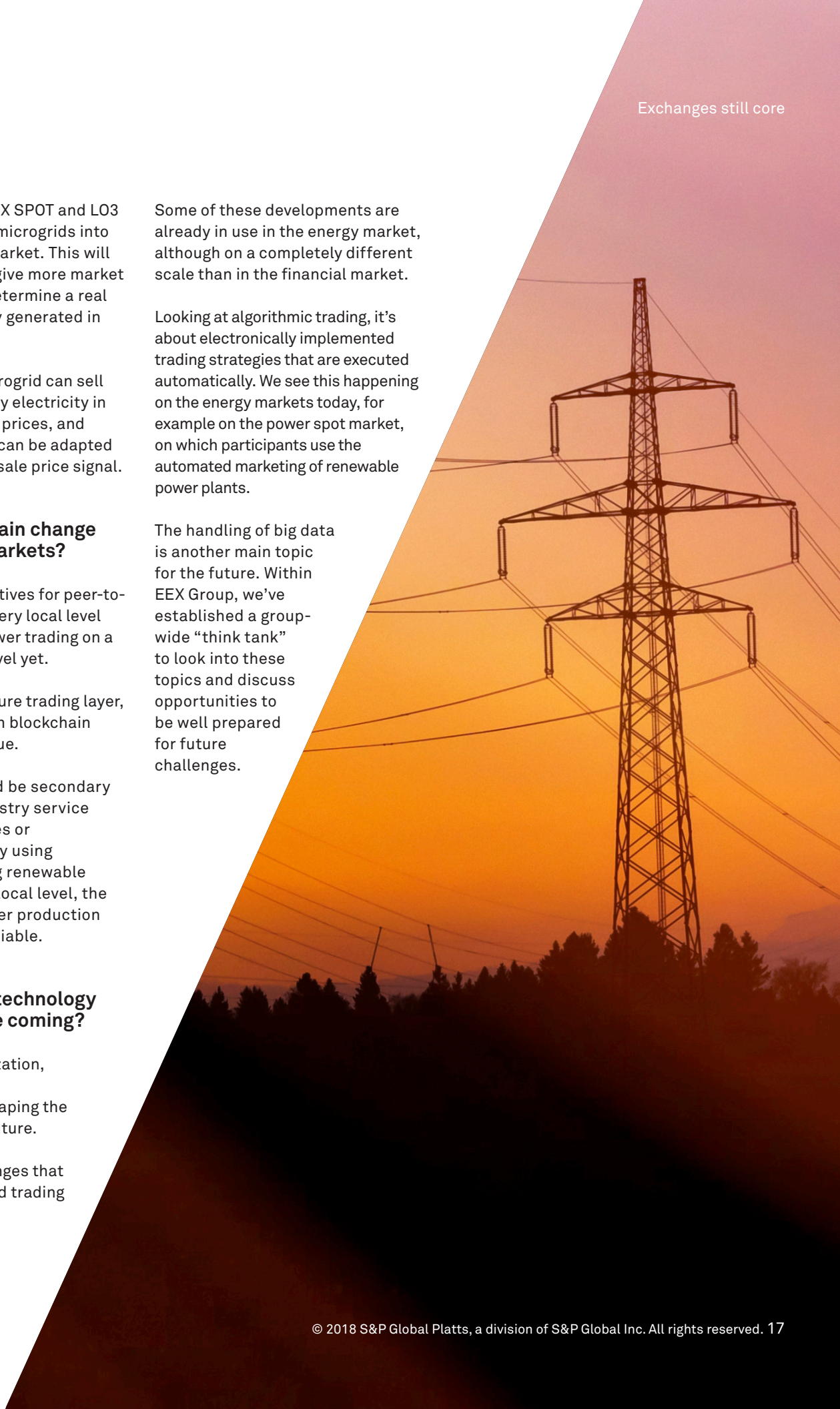
Trends such as digitalization, decentralization and decarbonization are shaping the energy trading of the future.

Digital technology changes that will arise are automated trading solutions and artificial intelligence.

Some of these developments are already in use in the energy market, although on a completely different scale than in the financial market.

Looking at algorithmic trading, it's about electronically implemented trading strategies that are executed automatically. We see this happening on the energy markets today, for example on the power spot market, on which participants use the automated marketing of renewable power plants.

The handling of big data is another main topic for the future. Within EEX Group, we've established a group-wide "think tank" to look into these topics and discuss opportunities to be well prepared for future challenges.



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Prosumer power

Microgrids that enable households to trade small quantities of locally-sourced power directly with each other using blockchain could disrupt traditional business models.

Anu Ramanathan
Managing Editor, European Power
S&P Global Platts

Remember the days when you borrowed a cup of sugar from your neighbor? Now imagine if you could buy or sell small amounts of sugar to your neighbor whenever the need arises.

Such peer-to-peer micro-transactions may well be the future of energy trading.

The global push to cut carbon has helped distributed energy resources like solar and wind to grow rapidly, reducing dependence on large-scale, fossil fuel power generation.

The latest statistics from UN-backed renewables policy network REN21 show 98 GW of solar photovoltaic capacity was added globally in 2017.[1]

This was nearly double wind power's extra 52 GW and more than the combined net additions of coal, gas and nuclear.

The traditional power supplier-hub model is at risk of losing its prominence.

Environmentally conscious prosumers with smart meters, rooftop solar PV installations, backyard wind farms or battery storage placed within a smart-technology-driven microgrid are emerging as the newest market players.

Smart microgrids are scaled-down versions of a traditional power network, but differ in their objectives. The microgrid is able to operate autonomously – off-grid – or in parallel to the larger network it connects to, creating a community energy system.

Such transactive energy systems look to integrate locally-sourced renewables more effectively, increase efficiency and grid reliability, cut carbon emissions and encourage end-user participation with smart energy meters and apps.

The US National Institute of Standards and Technology defines transactive energy as "a system of economic and control mechanisms that allows the dynamic balance of supply and demand

> *"Transactive energy is a system of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter."*
> *— US National Institute of Standards and Technology*

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across the entire electrical infrastructure using value as a key operational parameter."

In effect, prosumers and consumers get price signals that encourage them to balance their supply and demand more frequently, which can be a cost-effective way to use power more efficiently.

Disruptive potential

In principle, microgrids have the potential to disrupt utilities' traditional business model for supplying small end-users, which is often based on static pricing with infrequent billing.

They also change the environment for the existing distribution system operators, who manage the physical flows to the end-user.

Eurelectric, the European trade association for utilities and DSOs, published a downbeat assessment of blockchain's near-term value to the electricity sector in May 2018.[2] It argued that the currently available technology has high costs, slow transaction speeds and may be difficult to scale, among other things.

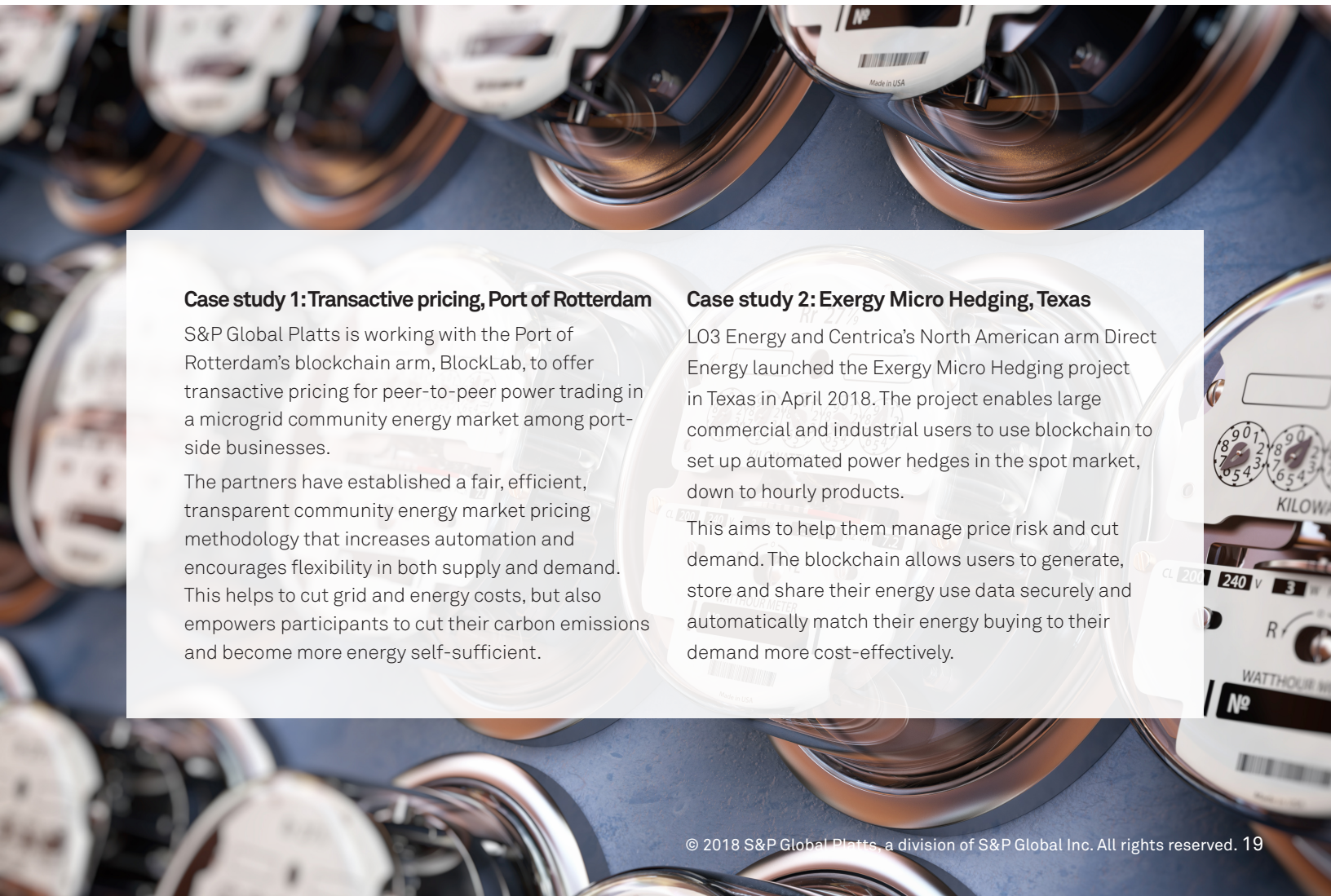
But the key constraint for microgrids is likely to be regulatory rather than technological.

The current rules in most jurisdictions were written with a centralized system involving large enterprises in mind. For many prosumers, the cost of complying with the standard licensing rules and obligations is likely to outweigh the profits of peer-to-peer micro-transactions, unless regulators can be persuaded to offer exemptions or change the rules.

For more information:

[1] http://www.ren21.net/gsr-2018/pages/summary/summary

[2] https://cdn.eurelectric.org/media/3115/paper1_blockchain_eurelectric-h-CB8D6920.pdf



Case study 1: Transactive pricing, Port of Rotterdam

S&P Global Platts is working with the Port of Rotterdam's blockchain arm, BlockLab, to offer transactive pricing for peer-to-peer power trading in a microgrid community energy market among port-side businesses.

The partners have established a fair, efficient, transparent community energy market pricing methodology that increases automation and encourages flexibility in both supply and demand. This helps to cut grid and energy costs, but also empowers participants to cut their carbon emissions and become more energy self-sufficient.

Case study 2: Exergy Micro Hedging, Texas

LO3 Energy and Centrica's North American arm Direct Energy launched the Exergy Micro Hedging project in Texas in April 2018. The project enables large commercial and industrial users to use blockchain to set up automated power hedges in the spot market, down to hourly products.

This aims to help them manage price risk and cut demand. The blockchain allows users to generate, store and share their energy use data securely and automatically match their energy buying to their demand more cost-effectively.

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Strategic Singapore

Singapore has emerged as a strategic base for digital startups in Asia, and several of these are developing blockchain platforms for energy and commodity businesses.

Eric Yep
Senior Editor, ASEAN Content
S&P Global Platts

Digital startups see opportunity in Singapore's position as the largest trading hub in Asia as well as the lack of digitization in physical commodities trading, a business that has not changed in decades. Some shippers still fax bills of lading to each other.

When Singapore decided to deregulate its power sector and introduce electricity trading on its stock exchange, it was one of the first countries in Asia to do so. Most other Asian countries still operate government-controlled power utilities and grids.

Businesses in Singapore can already pick their source of electricity supply from a laundry list of retailers, and, by the end of 2018, small consumers like households will also be able to do so. The problem is that there is no common platform where this can be done.

Enter Electrify, a local startup that raised $30 million through initial coin offerings to create an online marketplace for buying electricity, and executing the trade through smart contracts. It is backed by cyptocurrency exchange OmiseGo's CEO Jun Hasegawa, Ethereum co-founder Wendell Davis and Japanese venture capital firm Global Brain.

Electrify's blockchain platform for small scale peer-to-peer power trading is called Synergy.

Using blockchain introduces security and transparency, automates the contracting and settlement process, and cuts transaction times and service costs by as much as 30%, said Electrify's co-founder and CEO, Julius Tan.

He plans to bring Synergy online between late 2018 and early 2019, in time for Singapore's launch of the Open Electricity Market, and proof-of-concept trials are scheduled in the third quarter.

Another commodities trading platform planning to use blockchain is SourceSage, a homegrown startup that began as an app to

> *"We are in the process of utilizing blockchain in the areas of document generation, trade financing and also verification of suppliers and buyers."*
>
> *— Sim Jian Min, SourceSage Co-Founder*

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crowdfund prices of palm oil and its products in Southeast Asia. It then evolved into an online platform to match buyers and sellers in a very fragmented industry spread across Malaysia and Indonesia.

“We are in the process of utilizing blockchain in the areas of document generation, trade financing and also verification of suppliers and buyers,” SourceSage co-founder Sim Jian Min said.

Sim said it all started with a simple request from his father, who was an old school petrochemicals trader, to build a website for his trading business.

Multiple options

Startups in Singapore have been adamant that blockchain is not the only solution.

TradeCloud, an online platform created by a group of ex-Trafigura executives for the metals and minerals space, is designed to connect traders, match bids and offers and even standardize and share contracts.

Co-founder Simon Collins considers it “the Airbnb” for commodities trading. He said TradeCloud’s first challenge is to bring commodities trading into the digital space, before even attempting to introduce technologies like blockchain.

“We see multiple areas in commodities trading where they [distributed ledger technologies] can be leveraged, and TradeCloud will use more than one type of blockchain – applying each where it is most appropriate,” co-founder Justin Wilson said.

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Digital derivatives

S&P Global Platts interviewed Blythe Masters, a derivatives pioneer who serves as CEO of Digital Asset, a New York-based start-up hoping to rewire global finance.

Blythe Masters
CEO
Digital Asset

Mark Pengelly
Digital Content Leader
S&P Global Platts

Why have you invested in blockchain?

We see distributed ledger technology, or blockchain, as being a transformational technology with extraordinarily powerful implications.

For the first time, it allows for entities that have a common interest in a workflow or process to be able to intentionally share a common record of that for the premising of value – not just information, but units of value, whether that is securities, derivatives or transfers of money, commodities, or anything else.

By allowing a reliance on a shared golden record of that activity, it enables several very important things.

One is enormous efficiency gains, because the traditional process of trying to reconcile all the complexities associated with those activities is materially reduced. The number of errors that lead directly to reconciliation differences has been reduced, because you're operating from a common record.

At the same time, you don't have to compromise by blindly trusting your counterparty or a third party to provide you with the truth of that record. You're able to independently validate it with mathematical certainty.

You're also not required to compromise on the privacy and confidentiality of your proprietary activity. The efficiency gains for financial markets use cases – both in terms of the cost and material-risk reduction – can lead to margin and liquidity-need reductions.

What does your blockchain solution offer?

Let's start with the problem: the problem is that there are significant bodies of transactional load and there are multiple counterparties to those activities, who have a shared interest in correctly reporting the transactional arrangements between them.

Often, it is multi-party: there are clearing entities involved, there are regulators who have reporting requirements, there are many different inputs to the correct processing of derivatives or trading activity.

We have a full-stack solution, in that we provide a distributed ledger platform and extensive tooling for the modelling of business logic into applications that reside and run on top of that platform.

Those applications vary, but they include the likes of supporting end-to-end lifecycle services; streamlined account structure, creation and governance; improving risk management; modeling and automating product structuring; modeling and

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automating collateral requirements and margin terms; performing regulatory reporting and providing regulators with supervisory tools.

The tooling we provide is based on a smart contract modeling language called the Digital Asset Modeling Language, or DAML. That facilitates straight-through processing and automated execution by the multiple parties that are participants in these transactions.

Often, there are more than two interested parties in any given transaction—and, in many cases, many interested parties. So that eliminates duplicative systems, reconciliation requirements and other manual processes, and this, in turn, reduces risk. The result is huge efficiency gains.

Notice that I haven't mentioned a particular asset class, because these solutions are asset-class agnostic. They vary depending on the instrument and on the market rules, but the basic concepts are the same, whether you're talking about an interest rate swap or a commodity derivative.

Can blockchain move beyond the hype?

The short answer is yes.

While I certainly agree there was a lot of hype in the early days that preceded real substance, the hype was born by the power of the idea of decentralization and the close affiliation of the space with cryptocurrencies, which were part of the original invention.

Bitcoin came about because of blockchain, and blockchain came about because of Bitcoin: they are inherently linked.

> *"We've now had three or four years of extensive industry-wide research and development, which has gone into making enterprise deployments of this technology viable."*
>
> *—Blythe Masters, Digital Asset CEO*

We've now had three or four years of extensive industry-wide research and development, which has gone into making enterprise deployments of this technology viable.

That has addressed some of the design differences needed to diverge from the public blockchain concept, in order to actually deploy this technology in an enterprise context, particularly around financial services that are regulated and involve the transfer of large amounts of value. That work is not complete, but it is materially advanced.

For example, an organization like the Australian Securities Exchange is a top-10 national equities market. It is designated as systemically consequential to its market and is highly regulated.

ASX is replacing its entire post-trade infrastructure for the processing of cash equities with Digital Asset's distributed ledger technology. That is a material development, not just for us and ASX, but for the industry as a whole.

It's an instance in which, in the most demanding of environments—one that is highly regulated, with extraordinarily high volumes, high contingency requirements and high availability requirements—the technology has been tested and validated by a very tough customer.

Like all market infrastructures, ASX has no capacity for adding risk given its responsibilities, nor do its regulators have any appetite for that happening. The fact this technology has earned the credibility with an organization like ASX probably answers your question.

How do you keep regulators onside?

We interact with regulators the world over. These conversations very often start with concerns that blockchain technology means something that looks like the Bitcoin blockchain.

Once you've alleviated the concern that the world stock markets or bond markets are going to be operating on a peer-to-peer basis with no regulation, no visibility and anonymous actors, the conversations actually become quite constructive, because there's a lot of upside in this for regulators.

They often don't get to see market data until hours, days or weeks later, and then from multiple, disaggregated sources.

Blockchain can give regulators the chance to have a real-time, or near real-time, window into market activity, making their supervision job much easier.

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“The potential of blockchain technology lies in disintermediation. This creates true disruption; everything else is incremental innovation or optimization.”

— Thorsten Kuehnel, E.ON’s Vice President Future Lab Digital Transformation

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Tackling trade fraud

Using blockchain for trade finance could smooth manual processes and detect a form of financial crime that is difficult to track and investigate.

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Director, Financial Crime and Compliance Analytics
CRISIL

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Lead Analyst, Risk and Analytics
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Senior Analyst, Risk and Analytics
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Trade finance involves extending credit to facilitate global trade, such as commodity imports and exports. This activity is crucial to the world economy and also susceptible to illegal trade-based money laundering.

TBML is likely the most complicated and intricate method of money laundering, and investigating it is a daunting, labor-intensive, and time-consuming task.

Blockchain is a distributed ledger technology that has the potential to help detect instances of TBML, as well as provide solutions for many challenges including irregularities in invoices, carousel transactions, unusual shipping routes, involvement of unrelated third parties, and a lack of transparency in processes.

In large economies with high inflation in food and essential commodities, TBML is difficult to track and hard to investigate.

Money launderers can invoice for imported essential commodities at an inflated price, while receiving the actual value from the importer. This inflated value can be adjusted against illicit gains through various illegal activities, and the illegitimate funds can be converted to legal currency.

According to think tank Global Financial Integrity, a staggering $950 billion has been moved out of economically underdeveloped countries since 2011. Furthermore, it estimates that four-fifths of TBML is directly linked to drug trafficking, illegal arms dealing, terrorist financing and corruption.

Blockchain benefits

One of the major benefits of blockchain for trade finance is that banks and financial institutions can overcome regulatory reporting hurdles by presenting consolidated data and generating reports automatically.

Another major advantage would be reducing due diligence costs for different parties in the transaction.

A letter of credit is the most common and favored method of trade finance, accounting more than 40% of global

> *"Looking forward, we expect banks will invest in distributed ledgers and use smart contracts for all trade finance transactions."*
> *— CRISIL*

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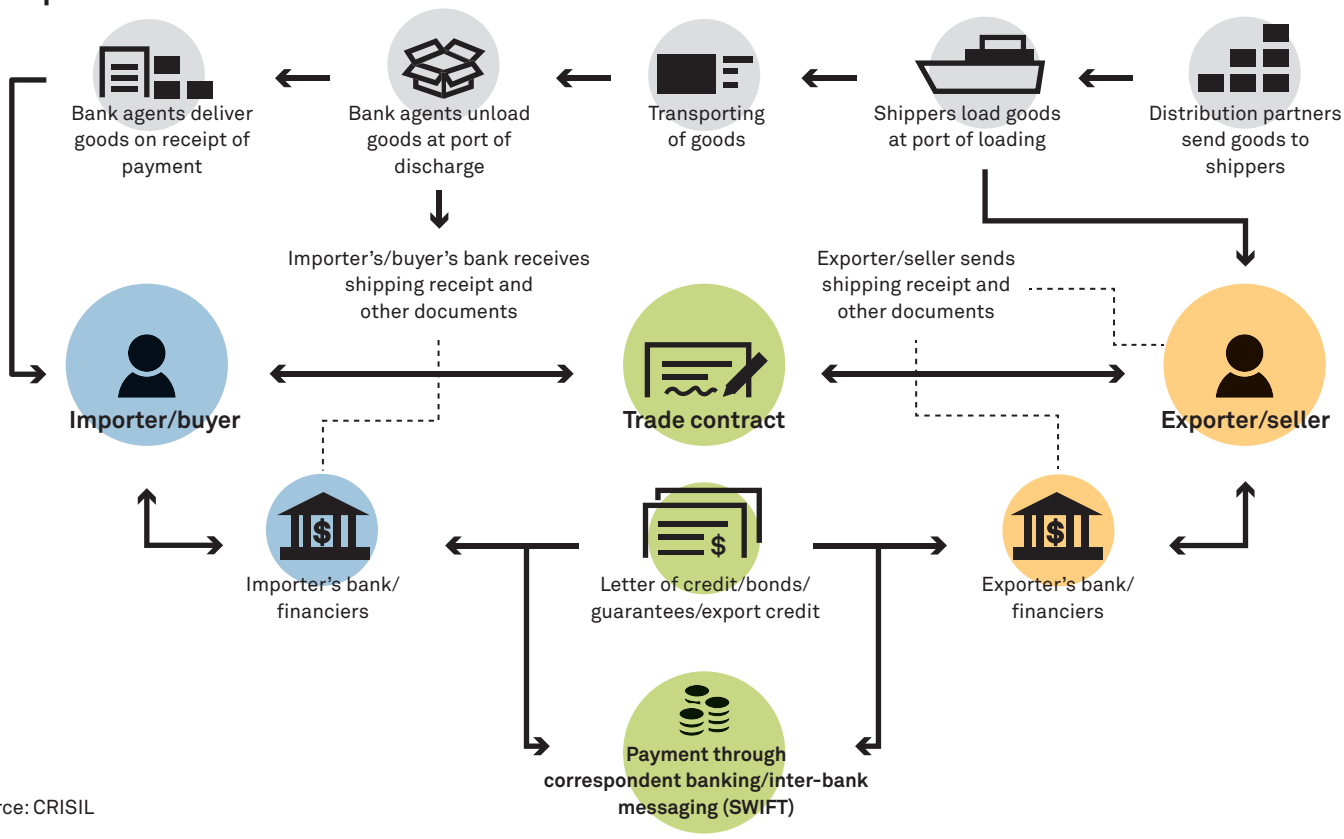
Example of a traditional trade finance transaction workflow



Source: CRISIL

trade financing, according to a 2017 International Chamber of Commerce survey. But the current trade finance landscape is burdened with complex processes and delays in validating invoices and other documents.

Additional challenges include increasing compliance costs and a lack of standardization, both in due diligence requirements and risk assessments for all involved parties.

Blockchain is an advanced network of systems that effectively encrypts all the records involved in trade finance activity between two parties and stores them in a distributed ledger.

Once the record is verified and distributed, tampering with the recorded data is very difficult and can easily be detected by other participants in the network.

Other blockchain benefits include:

- Issuing banks being able to analyze customer data for potential sanctions screening and adverse media issues for stakeholders involved in the transaction.
- Issuing banks being able to reconcile the documentation shared in the distributed ledger with actual shipping receipts, and can identify any discrepancies before payment is made to the seller.
- Storing data over the blockchain helps banks identify patterns in trading activities and allows them to detect emerging money laundering schemes in transactions.

Through blockchain technology, processes can be simplified and efficiencies built in to the system, reducing overhead costs for firms.

Banks and trading companies will integrate blockchain with their services, allowing financial firms and regulators to more easily spot instances of TBML, securely parse data and improve efficiencies across regions.

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Taking stock

Stock levels are important for commodity traders, and permissioned blockchains can be used to provide useful aggregated data while respecting commercial confidentiality.

James Rilett
Global Director of Innovation
S&P Global Platts

Permissioned blockchains are restricted to participants who have permission to join them, and the data on them can be shielded from both other participants and the blockchain administrator.

This solves the problem of how to share information to produce an anonymous aggregate figure without revealing individual positions to external parties, such as database administrators.

Potential uses include anything needing secure data submission with adaptable privacy options and a clear audit trail. It could be particularly useful for complying with regulatory requirements to make market fundamentals – like stock levels – more transparent while protecting commercial confidentiality.

One example of this is the S&P Global Platts blockchain project at the Port of Fujairah in the United Arab Emirates, which launched in February 2018. Platts uses a permissioned blockchain to collect and publish weekly aggregated data on oil terminal stock levels on behalf of the Fujairah Oil Industry Zone authority and data committee FedCom.

Publishing stock level data – a key supply data point for traders – is part of FOIZ and FedCom's efforts to develop Fujairah as a trading venue, not just a physical hub. The oil terminal operators submit the data, and the blockchain replaces a more laborious method involving spreadsheets and email chains with a quicker, more transparent, and secure process.

The project shows how blockchain can be used to create networks for natural partners – like trusted trading counterparties, regulators, and publishers – to securely share potentially confidential information.

This could include using blockchain to run auctions and electronic tenders for physical bulk commodities like crude oil and agricultural products, for example. These are often done now with sealed bids through email, and processed manually by the counterparties.

Blockchain is still a very new option – the S&P Global Platts project at Fujairah was one of the first live commercial applications in the energy sector. Regulators and market participants around the world are still in a fact-finding phase, with some entities more interested than others.

But the basic technology is proven, particularly for relatively simple tasks such as aggregating inventory data. How quickly it gets taken up for these tasks will depend on costs, regulatory attitudes and market reactions.

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Breaking the rules

From giving power trading prosumers special privileges to removing requirements to use paper documents, regulators will play a key role in developing digital trading.

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Senior Writer, North America Power
S&P Global Platts

Siobhan Hall
Editorial Lead, EU Energy Policy
S&P Global Platts

The Brooklyn microgrid in New York is a good example of how blockchain-based peer-to-peer trading can work in practice, having allowed participating households to generate, store and trade electricity locally since 2016.

The project was only possible with a regulatory waiver, and the developer, LO3, is talking to the New York Public Service Commission about rule changes to allow smaller volumes of power to be traded, LO3 founder and CEO Lawrence Orsini told S&P Global Platts.

The challenge is that regulation around the world is not usually set up for decentralized peer-to-peer trading. In most US markets, for example, only approved providers can sell power, and in retail-choice states, like New York, you have to register as an energy service company to do so.

"So are neighbor A and neighbor B going to do that? Probably not," Benjamin Tejblum, an associate at law firm K&L Gates, told an industry event in March 2018. Neighbors cannot trade freely with one another without a utility involved, he said.

At the large commercial and industrial consumer level, LO3 launched a project with Direct Energy Business in April in Texas to enable micro-level energy hedging. The developers were attracted by Texas's strong historical energy focus and its "pretty progressive regulator," Orsini said.

Over in California, however, blockchain project developers want more support from regulators. Demand aggregator Leap plans to supply 90 MW of demand response capacity to Southern California Edison and Pacific Gas and Electric in 2019 through a traditionally contracted aggregation program.

"We want to aggregate devices [for demand response] and could use smart contracts to verify identity without using a traditional contract," Leap CEO Thomas Folker told S&P Global Platts. Using the blockchain platform Ethereum could allow Leap to scale from hundreds of participants now to millions. Leap would need a waiver from the state utility commission to do peer-to-peer transactions.

Most US regulators Folker speaks with look favorably on blockchain. For example, the California Air Resources Board has a low-carbon fuel credit program, but it's challenging to track. Tokenizing and digitalizing their credit register could improve what is currently a "vague and inefficient market" and CARB may look at that in 2018, he said.

EU cares and shares

EU regulators are also interested in blockchain's potential, and the European

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Commission set up an observatory in February 2018 to monitor projects, share information and make recommendations.

Its draft list of topics to research includes: energy and environment use cases; financial services use cases; the legal status of blockchain registries and smart contracts; scalability, interoperability and sustainability; and cybersecurity.

The EC could have a role in setting EU standards to ensure interoperability between platforms and programs, and across borders, according to Peteris Zilgalvis, head of the EC's digital innovation and blockchain unit in its digital department.

Any potential EU legislation will be technology-neutral and not specifically about blockchain, he told a digital energy event in Brussels in February 2018. "We should move away from legislative requirements for paper records ... and do smart contracts need to be made legally binding across borders?" he said.

European power sector trade body Eurelectric has urged regulators to offer startups and project developers "regulatory sandboxes" – a controlled space to test ideas under regulatory supervision without fear of costly compliance breaches.

"One of the greatest frustrations for companies testing pilot projects is when they can't replicate them in different countries because of different legal rules," Eurelectric's innovation advisor Anna Dimitrova told the event.

Singapore plans new market

In Singapore, digitalizing commodities trading comes under the financial regulator Monetary Authority of Singapore and the Singapore Exchange. There is also a plan to build a cross-border trading system with Hong Kong and industry bodies are looking to create new digital standards for the industry.

The MAS plans to build a multi-tiered market that will complement existing commodity exchanges, giving startups the flexibility to launch new decentralized trading platforms and new products with minimal regulatory hurdles. This is expected to pave the way for blockchain-based businesses and cryptocurrency exchanges, a pioneering move for an Asian regulator.

The move has been prompted by new business models emerging in trading platforms, such as using blockchain technology, or peer-to-peer trading without intermediaries, which lower the entry cost for market participants that do not pose a systemic risk, according to law firm Allen and Gledhill.

Singapore's existing laws on securities trading and corporate governance provide enough guidance to set up and run a disruptive business venture, Yvonne Zhang, cofounder of trade financing platform Aquifer Institute, told S&P Global Platts. But they may not yet accommodate the new asset classes, instruments and business models that the disruptive ventures are working toward.

"MAS and SGX Regulation have been working actively with the market participants to come up with new ways of regulating up-and-coming market places, as well as adapt to new asset classes being created," she said.

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Keeping safe

Australia's cyber affairs ambassador Tobias Feakin talks to S&P Global Platts about how this major commodities producing country is tackling cyber risks.

Tobias Feakin
Ambassador for Cyber Affairs
Australian government

Andy Critchlow
Head of Energy News, EMEA
S&P Global Platts

What are the risks of going digital?

The recent explosion of digital technologies has been a key driver of economic growth and innovation. However, while more digitization and connectivity provide more opportunities, they also expose businesses and consumers to heightened cyber risk from a range of state and criminal actors.

Like the broader financial sector, digitized commodity markets are likely to remain a key target for malicious cyber activity, and government and the private sector will need to continue to collaborate and invest in innovative technologies to mitigate these risks.

What can governments do to help?

The Australian government publishes cybersecurity advice, including through its Stay Smart Online campaign.[1] The Australian Cyber Security Centre's 'Essential Eight' also sets out key steps that businesses can take to mitigate most cyber threats to their organization.[2]

As the ACSC noted in its 2017 Threat Report, while "increasingly sophisticated exploits are being developed and deployed against well protected networks... the ACSC continues to observe many adversaries, particularly criminals, compromising networks using publicly known vulnerabilities that have known mitigations. Too many of the incidents the ACSC responds to could have been prevented had organizations employed established and relatively straightforward cybersecurity measures."

Many businesses underestimate the significant toll, both financial and reputational, that malicious cyber activity can take, and ultimately cybersecurity risk needs to be considered as a high priority across all organizations.

Businesses might also consider the UK government's advice, as well as its Cyber Essentials Scheme, which encourages companies to adopt five basic technical controls which are designed to protect organizations, whatever their size, against the most common cyberattacks.

What specific issues does Australia face?

We are seeing a greater push to 'digitize' markets, with traders seeking to use new technologies like machine learning to more accurately predict price movements. As a major commodities producer Australia will continue to face challenges associated with this trend.

We know that malicious cyberactivity against Australian organizations is continuing to increase in frequency, scale, sophistication and severity. The reach and diversity of our cyber

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adversaries is both expanding and constantly evolving, and this trend is unlikely to change.

Blockchain technology has been touted as offering an unparalleled level of information assurance. However, there have already been a number of high profile incidents of cryptocurrency thefts. Investors and traders alike will therefore need to remain aware that increasing digitization is likely to prompt criminals to pursue increasingly sophisticated methods to get at an ever-increasing digital pie.

> *"Digitized commodity markets are likely to remain a key target for malicious cyber activity, and government and the private sector will need to continue to collaborate...to mitigate these risks."*
> *—Tobias Feakin, Australian Ambassador for Cyber Affairs*

Could a "digital divide" split global trade?

We know that digital technologies are profound enablers of sustainable development and inclusive economic growth, and we're working to improve connectivity and access to the internet across the Indo-Pacific.

The region is home to countries which play a leading role in developing new technologies, digital economics and cybersecurity. It's also home to some of the world's least connected countries, where digital opportunities are yet to be fully harnessed. We are therefore committed to working bilaterally, regionally and multilaterally to bridge that divide.

Australia is supporting a number of pilot projects through the Australian aid program that use blockchain in innovative ways to improve economic and development outcomes by increasing financial inclusion, bringing smallholder farmers into global supply chains and improving transparency in government and business.

The Department of Foreign Affairs and Trade's Aid for Trade program is partnering with CSIRO's digital research network, Data 61, to develop a prototype blockchain platform to assist developing countries to trade more efficiently and securely.

The prototype will aim to reduce the steps and costs of moving goods and services around the world, which could provide new ways for disadvantaged groups, such as women, small and medium enterprises, and smallholder farmers to market their goods and services and buy and sell across borders.

How can digital trading be secured across borders?

This is a shared problem between government and the private sector.

From a government perspective we want to enable digital trade and back global rules that support digitizing trade-related practices. The aim is to build trust and confidence in the online environment, and reduce barriers.

We work through organizations such as the UN, the WTO, the OECD, G20, APEC and standard-setting bodies. We also approach most of our trade negotiations with a strong focus on digital principles which can be found in our International Cyber Engagement Strategy.[3]

We work hard to uplift cybersecurity internationally, as we recognize that we are only as strong as our weakest link.

By investing in capacity building with nations that are still developing their approach to cybersecurity, we help create a more stable digital environment for all. Much of this work is being done with the Australian private sector, including some of the big banks, as together we can have a greater reach and impact on the cybersecurity ecosystem as a whole.

Traders might consider the example set by the banks, which have come together under the Financial Services Information Sharing and Analysis Centre (FS-ISAC), a member-driven not-for-profit organization, which helps members share time-critical cybersecurity threat information.

For more information:

[1] https://www.staysmartonline.gov.au
[2] https://acsc.gov.au/publications/protect/essential-eight-explained.htm
[3] https://dfat.gov.au/international-relations/themes/cyber-affairs/aices/index.html

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Reality check

Blockchain still has to prove its worth at scale for energy and commodity trading, with issues such as cost, privacy and liability all potential deal-breakers.

Sebastian Lewis
Content Director, Greater China
S&P Global Platts

Siobhan Hall
Editorial Lead, EU Energy Policy
S&P Global Platts

Probably the biggest challenge facing all industry-level blockchain trading projects is simply achieving the critical mass of participation needed to make using a new system commercially viable.

Companies that already have procedures in place – however inefficient – will not save money if they start using parallel systems, and yet they are unlikely to commit large volumes to a new system until they are confident it works and enough of their counterparties are on it.

Without critical mass, costs per transaction will be higher and efficiency gains limited.

Another risk identified by European power industry association Eurelectric is that a blockchain's security remains unproven until it is big enough to be worth trying to hack.

So while scaling up improves the efficiency and viability of a project, it may also increase its risk of attack.

Another key concern is the privacy of the data involved. Most, if not all, of the commodity blockchains being trialed are private, permissioned distributed ledgers.

Participants on these blockchains need permission to join, typically from the consortium or companies that set them up. This makes sense in an industry where competitive advantage often lies in being able to exploit price arbitrages over product specifications, location and time.

You don't want your suppliers or buyers, let alone your competitors, to have access to transaction data that can be used to uncover your trading strategies.

Blockchain developers like R3, Hyperledger and Vakt all stress that their systems can be configured so that only the counterparties involved have access to the transaction data, with all data fully encrypted.

While a big part of the blockchain mantra is that it is a secure system, companies may need a lot of reassurance before transferring their confidential trade data on to a blockchain platform in viably large quantities.

Transparency threat

Blockchain's ability to create real time records of location and ownership of commodities could greatly increase transparency across the supply chain.

The immutable digital record of ownership could facilitate securitization of commodities in storage and in transit, potentially revolutionizing the way capital is deployed across the industry.

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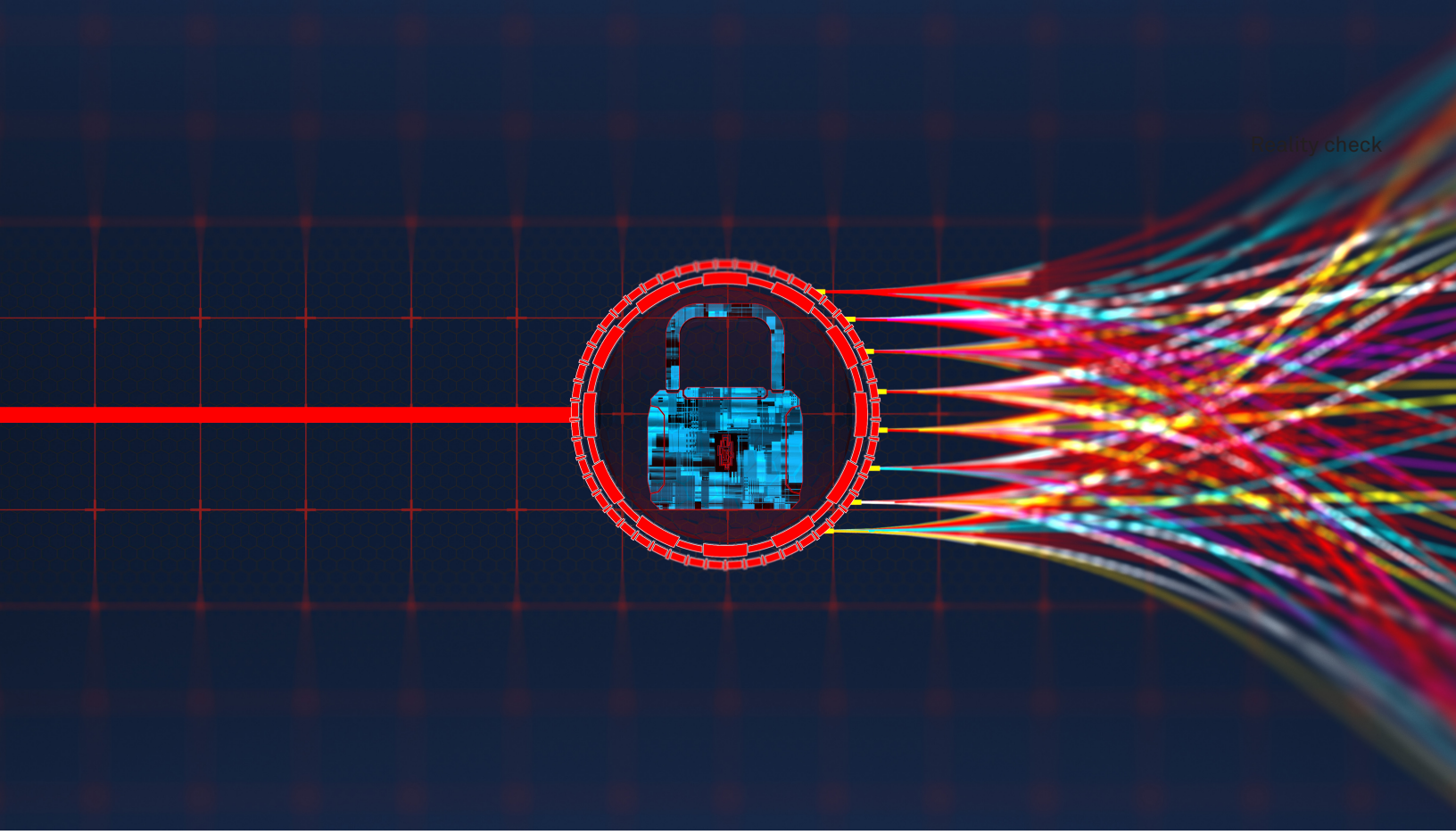

But it also poses a significant threat to current actors in the market.

Many of those involved in pilot projects are the existing industry players, like banks and traders. They may be involved to see what the risk is to their current business model, reserving judgment on actually committing to a blockchain system.

A system that successfully cuts costs, for example, also lowers barriers to entry, potentially bringing in more competitors to challenge the incumbents and their margins.

Legal headaches

Then there are the legal issues, such as which law should govern a blockchain contract that can exist virtually on a computer or a cloud located anywhere in the world? Who is liable for mistakes in a private decentralized network?

Other issues include defining the legal status of a smart contract which executes automatically according to a set of pre-defined rules. Is it a legal person or a contract? Is the programmer of the smart contract liable for its operation if it executes automatically?

These are problems for companies, regulators and governments to resolve, and the answers may be different in different jurisdictions, leading to legal interoperability problems.

Many different blockchain platforms developing in many different ways could also lead to system interoperability problems.

Agreeing to common industry standards is the usual way to avoid this, but the pace of technological change could make it particularly challenging in this sector.

AI, machine learning

Blockchain also is not the only game in town. At a day-long digital electricity conference in Copenhagen in May 2018, the possibilities and rewards of artificial intelligence and machine learning dominated the presentations and discussion, with blockchain only mentioned in a question from the floor late in the afternoon.

The London-based Vakt consortium, which is developing a blockchain post-trade reconciliation service for the oil markets initially, is opting for an open source system to be able to respond to technological and market changes.

It is also limiting the blockchain portion of its system to 20-25% and fulfilling the rest with apps on top. This is a risk-mitigation strategy against potential future interoperability issues, and shows how blockchain is just one part of the new digital trading infrastructure.

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Glossary

Artificial intelligence:	The ability of a machine to learn from experience and perform human-like tasks.
Bitcoin:	A cryptocurrency developed on a public blockchain using a "proof of work" consensus algorithm.
Blockchain:	A type of distributed ledger technology for verifying transactions or data exchanges and recording them permanently on a shared ledger.
Consensus algorithm:	A mechanism for verifying transactions/data on a blockchain.
Cryptocurrency:	A digital token representing value on a blockchain that uses encryption to regulate generating new tokens and transfers.
Distributed ledger technology (DLT):	A technology for verifying transactions or data exchanges and recording them permanently on a shared ledger.
Machine learning:	A way of analyzing data so that systems can learn from it and take decisions with minimal human input.
Microgrid:	A scaled-down local version of a traditional grid for delivering power. It can be autonomous or connected to a larger grid.
Mining:	A process of validating and submitting transactions as a block to a shared ledger on a public blockchain like Bitcoin. Computers solve cryptographic puzzles for the right to add the next block. This typically uses a lot of electricity.
Node:	A computer on a peer-to-peer network. It may have different or multiple roles, such as acting as a validator and/or taking part in transactions.
Peer-to-peer trading (P2P):	Trading directly between two counterparties without using trusted intermediaries like banks, brokers, exchanges or utilities.
Practical byzantine fault tolerance (PBFT) :	A verification process involving replica transaction files that can be used on the Hyperledger Fabric blockchain platform.
Proof of authority:	A verification process that uses a specific group of nodes – computers on the peer-to-peer network – to validate transactions.
Proof of stake:	A verification process that gives more weight to participants who own more of the blockchain's base cryptocurrency.

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Proof of work:	A verification process that relies on computers solving cryptographic puzzles for the right to add the next block in the chain, a method known as “mining”.
Prosumer:	An electricity user who also produces small quantities of power, usually renewable, to use or sell.
Private, permissioned blockchain:	Users need permission to join the blockchain, and access to the shared, digital ledger can be controlled to protect privacy.
Public blockchain:	An open, anonymous system that allows anyone to take part.
Robotic process automation (RPA):	A way to configure software to carry out repetitive, routine tasks automatically.
Smart contract:	An automated code-based process which can interact with and update data on a shared digital ledger with or without direct human intervention.
Smart grid:	An electricity grid that uses smart meters to allow two-way communication of data between users and suppliers.
Transactive energy:	Electricity systems where demand and supply are balanced dynamically across the whole system by using value as a key operational parameter.
Transactive pricing:	Dynamic retail pricing that varies according to the different values of electricity at different points in time.

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