

The Developing Role of Blockchain

WHITE PAPER

VERSION 1.0

IN COLLABORATION WITH
PRICEWATERHOUSECOOPERS

ABOUT THE WHITE PAPER

White Papers are a new series of working papers developed by the World Energy Council (the Council). They facilitate strategic sharing of knowledge between the Council members and other energy stakeholders and policy shapers in a fast-paced era of disruptive change.

This paper is developed by the Council in collaboration with PwC and with the support of the Council's Future Energy Leaders. The paper is informed by interviews with 15 companies and organisations that are actively involved in blockchain projects in the energy industry, based in the US, Europe, China, Japan and New Zealand. They are drawn from an expanding universe of projects across the energy sector and some from within the oil and gas industry. Our interviews include start-up technology companies as well as energy incumbents and an energy regulator.

The findings from the interviews are combined with insight from the Council and PwC subject matter experts, as well as inputs from a dedicated session on blockchain organized at the World Energy Leaders Summit (Lisbon, Portugal, October 2017), to provide a basis for ongoing discussion within the sector.

We list the entities that participated in the interviews below, and we would like to take this opportunity to thank them for taking part.

Entities interviewed for this White Paper

| | |
|------------------|---|
| Filament | German Energy Agency (DENA) |
| Powerco | Tokyo Electric Power Company Holdings, Inc. |
| Electron | Innogy innovation hub, Innogy |
| Stromnetz Berlin | Ofgem |
| TenneT | Statoil |
| BLOC | Energy Blockchain Labs |
| Ponton | China Cinda Securities |
| LO3 Energy | FinTech4good |

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INTRODUCTION

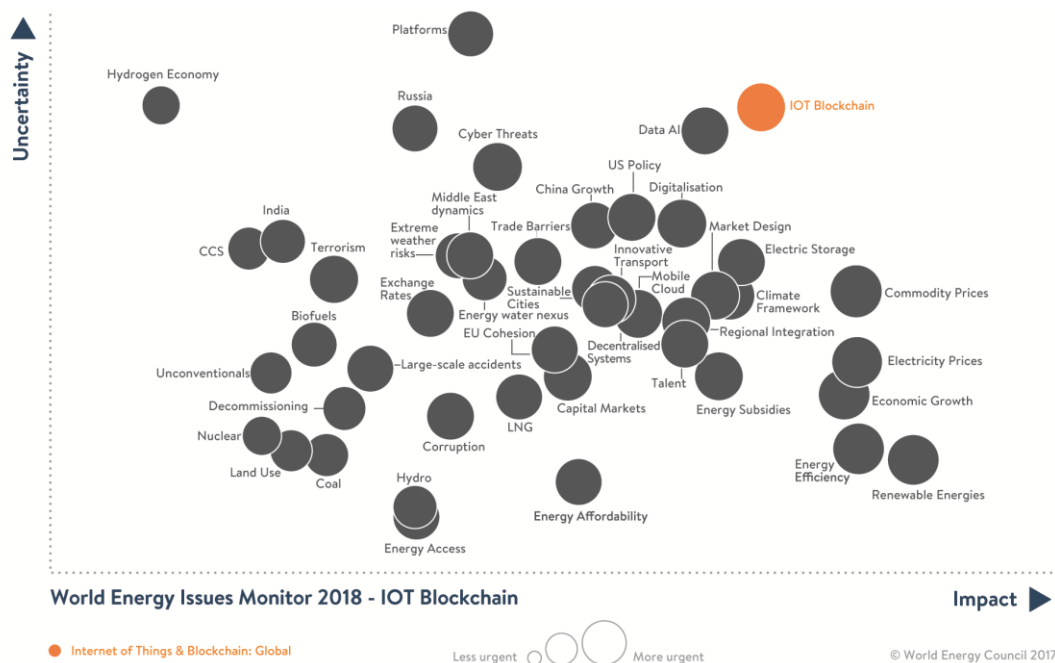
In the latest World Energy Issues Map (Figure 1) produced by the Council, blockchain is identified as one of the most critical uncertainties within the digitalisation elements and is perceived by energy leaders globally to be an issue of both relatively high impact and uncertainty.

Blockchain has the potential to change the way we arrange, record and verify transactions, with the underlying model shifting away from a centralised structure (exchanges, trading platforms, energy companies) towards decentralised systems (end customers, energy consumers interacting directly). It is no surprise then that, outside of the financial sector, the energy sector is seen as one of the industries where blockchain could have the biggest transformative and disruptive impact.

But there are still a number of uncertainties in the way of blockchain which still could limit or even stall its growth due to a combination of technological, regulatory and other practical challenges. Among the big questions surrounding blockchain are: Will its early potential translate into robust and reliable practical applications? How sure can we be that its promise of greater cybersecurity will be fulfilled and that it won't introduce new, possibly bigger risks? Will industry-wide protocols and standards be needed before blockchain can become truly industry-wide and transformative rather than niche and fragmented? How far away is widespread deployment of blockchain in the energy sector?

These are questions that are as relevant for energy policy-makers as they are for energy companies. This white paper is designed to start a dialogue on these and a number of other issues that are relevant to anyone concerned with the development of blockchain in the energy sector. It is a starting point for discussion of what might happen but doesn't seek to define what should or will happen.

Figure 1: World Energy Issues Monitor map (2018)



Source: World Energy Council

EXECUTIVE SUMMARY

SUMMARY OF KEY MESSAGES

Expectations of disruption from blockchain are high

All but one of the interviewees (93%) think that blockchain will be able to disrupt the functioning of the industry and contribute toward accelerating the speed of the changes taking place in the energy system such as decarbonisation and the move to more decentralised energy sources. And they are fairly bullish about the likely timescales with 87% anticipating that the most disruptive impact is less than five years away.

Energy is ahead of many other industries in adopting blockchain

Blockchain is in an early stage of the innovation process but the energy industry is quite advanced compared to other industries. Behind financial services, the sector is among the most advanced in its current adoption of blockchain. The senior executives that we interviewed as part of the preparation of this paper see considerable potential benefit from blockchain, not just for the greater efficiency of existing processes but to support and speed up the transformation of energy towards more decentralised business models.

New business models lie ahead as the technology potentially speeds up decentralisation and disintermediation

Blockchain is expected to lead to much more direct relationships between energy producers and consumers, and to strengthen the market participation opportunities for small energy providers and prosumers. In a decentralised energy system, blockchain could enable energy supply contracts to be made directly between energy producers and energy consumers, and for them to be carried out automatically. Every single interviewee pointed to the disintermediation potential of blockchain as a strong benefit, opening up the way for business models that do not need a central intermediary.

Neighbourhood electricity trading, flexible grid management and energy trading over the blockchain emerge as the most relevant use case categories

At this very early stage of development, the range of cases under investigation is very broad. The most promising applications for blockchain identified in our discussions with senior executives are: architecture for managing grids, energy trading, peer-to-peer trading platforms for a specific neighbourhood, but also payment systems particularly those associated with renewable energy and electric vehicle charging.

Provenance use cases are also likely to emerge

Other potentially significant deployments include the area of asset management and energy transportation. Strength of blockchain technology is its application in situations where the provenance of an asset and the data from it needs to be interrogated and updated by multiple parties. Such applications could range from liquefied natural gas cargoes all the way through to static assets such as smart meters.

Big uncertainties still lie in path of blockchain

Significant obstacles remain in the way of blockchain, with regulation, technological uncertainty, energy consumption, cybersecurity and integration with existing systems highlighted as key issues. Blockchain will need to overcome these obstacles as well as prove that it can work in practice and overcome scale, speed and other constraints that currently hinder its applicability in many situations.

Opinion divided on blockchain energy consumption

Blockchain is potentially very energy-intensive, driven by very complex validation algorithms and the mining system (particularly those used by Bitcoin). However newer blockchain platforms (e.g. Hyperledger) will operate at much lower energy costs and work on improvements for blockchain technology. The senior executives interviewed were divided on whether blockchain will contribute to net energy saving or whether it will add to energy demand; 47% said energy would be saved in net terms while 40% anticipate it will increase overall energy consumption.

Blockchain remains early-stage and is not the only game in town

Blockchain remains at a relatively early stage of development with most projects still at the pilot stage. Proof of concepts is only just being carried out and is still limited in scope. It still has significant limitations compared to existing technology in many situations, such as energy trading, and there is also the potential for rival technologies to emerge and leapfrog blockchain. Still, putting all distributed ledger technologies in one pigeon whole, wouldn't make sense, as there are too much differences.

Regulatory concerns present an opportunity not an obstacle

Regulatory concerns stood out as a significant obstacle in the view of two-thirds of the senior executives interviewed. But although blockchain presents regulatory challenges, there are also hopes that it could help meet regulatory goals. Blockchain has the potential to deliver greater transparency, improve access to information and simplify regulatory reporting. The regulator could have real-time access to data via blockchain. Immutability of data is one of the key characteristics of blockchain technology and is also a strong plus for regulators and supervisory bodies.

Cybersecurity remains a key uncertainty

There is ambivalence about the cybersecurity impact of blockchain. Nearly as many expect it will introduce new risks as think it will strengthen security. And these views were not necessarily in opposite camps. A third of those who felt it would strengthen cybersecurity also thought it would herald new cybersecurity risks in the future.

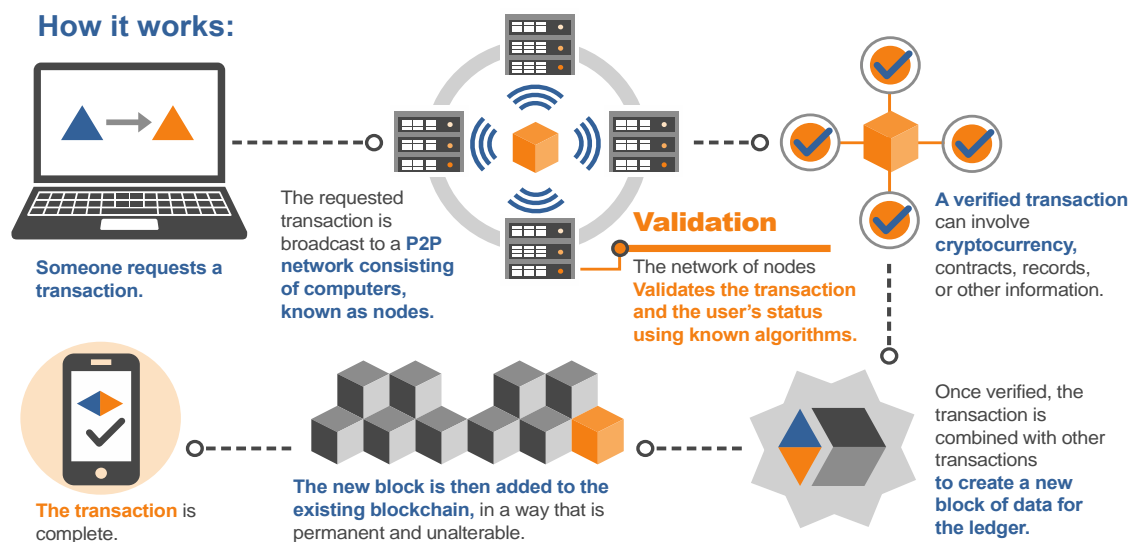
Future direction – blockchain could become a table stake for future market success but doubts remain

There is momentum gathering behind blockchain in the energy sector. It carries many implications for a wide range of stakeholders – consumers, businesses, regulators and policy-makers. Already, nearly half of those interviewed are deploying blockchain in real customer contexts.

Many of those familiar with blockchain see it becoming a key enabling technology, not just underpinning decentralised energy systems but also intensifying the scope for disintermediation in the sector. In such a future, blockchain capability will be not just an added advantage for market participants but it will be a table stake for market success. But there are still a number of uncertainties in the way of blockchain which still could limit or even stall its growth due to a combination of technological, regulatory and other practical challenges.

We conclude the White Paper with a look at the key questions companies and other players in the energy sector need to address as they weigh up decisions on blockchain.

Figure 2: Blockchain and key features at a glance



KEY FEATURES¹

Mutual – blockchains are shared across organisations, owned equally by all and dominated by no-one;

Distributed – blockchain is inherently multi-locational data structures and any user can keep his or her own copy, thus providing resilience and robustness;

Ledger – blockchain is immutable, once a transaction is written it cannot be erased and, along with multiple copies, this means that the ledger's integrity can easily be proven.

Source: Based on [PwC Next in Tech infographic](#)

¹ PwC/Long Finance, Chain Reaction: How Blockchain Technology Might Transform Wholesale Insurance, 2016.

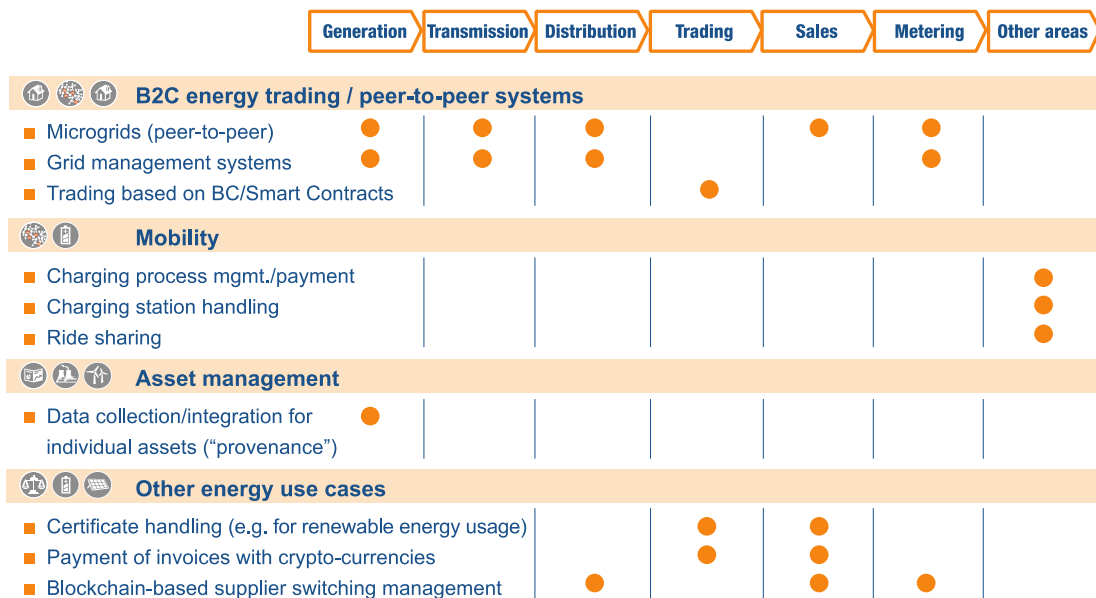
TODAY'S FOCUS

WHERE IS BLOCKCHAIN BEING USED IN THE ENERGY SECTOR?

The number of blockchain projects in the energy sector is ever-increasing. The range of potential applications reflects the characteristics of the technology (Figure 3). A blockchain is a decentralised tamper-proof ledger of all transactions in a network. Using blockchain technology, participants in the network can confirm transactions without the need for a trusted third-party intermediary.

This makes it particularly applicable to situations where multiple parties share, and update data and they need to trust that the actions that are recorded are verified as valid. In the energy sector this includes areas such as B2C energy trading, distributed energy and the emerging field of peer-to-peer energy systems. Other potentially significant deployments include electric vehicle charging, payment systems and asset management. Strength of blockchain is its application in situations where the provenance of an asset and the data from it needs to be interrogated and updated by multiple parties. Such applications could range from liquefied natural gas cargoes all the way through to static assets such as smart meters.

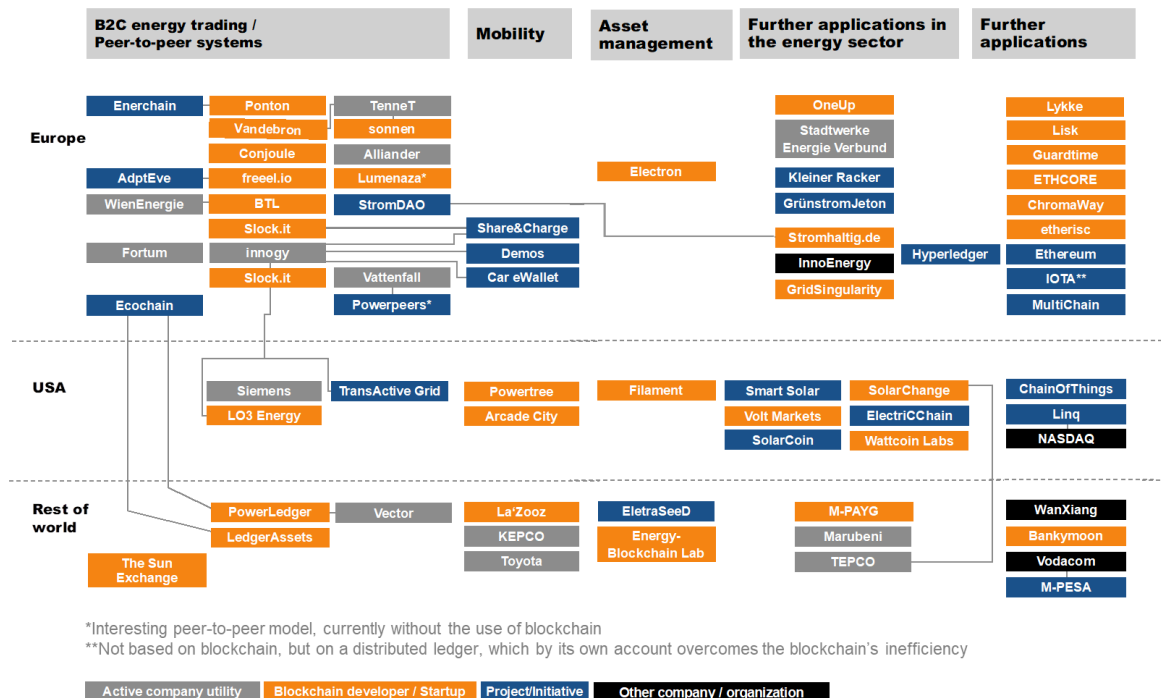
Figure 3. Several blockchain use cases along the energy value chain are currently investigated



Source: World Energy Council, PwC

Figure 4 provides an overview of some of the blockchain initiatives underway in the energy sector. It is illustrative of the range of projects and is a partial snapshot of one moment in time and certainly not a complete list. The overview highlights the mix of technology and power companies developing blockchain, sometimes in competition with each other but often in collaboration. Interestingly, many projects and initiatives have their origin in Europe or Asia, rather than the US, in contrast to many other digitally-driven developments.

Figure 4. Overview over currently active companies, projects and initiatives



Source: PwC Research, companies' statements

A number of collaborative partnerships are being forged. In the field of energy trading, 23 European energy trading firms have joined forces under the project name "Enerchain" in order to conduct peer-to-peer trading in the wholesale energy market using a blockchain-based application. This blockchain project, initiated by software developer Ponton, is at proof of concept stage and is designed to find out whether a decentralised solution can support the trading volumes and transactional speed required in existing markets. Other examples of collaboration include startup companies. For example, Australian energy retailer Origin is partnering with blockchain startup Power Ledger to trial an energy sharing platform that uses blockchain technology to create an immutable record of energy generation and consumption.

Many projects are already live. In New York as early as April 2016, for instance, decentrally generated energy was sold directly between neighbours via a blockchain system for the first time in a collaboration between startup LO3 Energy and Siemens. In the Netherlands, Alliander is piloting a blockchain-based energy token enabling consumers to manage and share their own renewably generated energy. In Germany, Innogy recently launched Conjoule, a startup developing peer-to-peer energy markets enabled by blockchain technology.

In May 2017, Innogy also launched Share&Charge across Germany with what it says is the first deployment of blockchain technology in the area of e-mobility providing a central registration platform for electric car owners and charging station operators. A number of startups are creating digital currencies. Both SolarCoin and Wattcoin, for example, hope their digital currency can become a payment platform for renewable energy consumption and its trading.

Figure 5 provides an overview of the stage of development of blockchain in the energy sector compared to other industries. The greatest progress is in the financial sector which we see as being

in transition between the ‘explore’ and ‘growth’ stages. We believe that the energy sector is following closely – some two thirds of the way through the initial exploratory stage.

Figure 5: The innovation curve – blockchain is still at the early stage but energy is ahead of most other industries.



Source: World Energy Council, PwC

SNAPSHOT: BLOCKCHAIN ACTIVITY IN THE ENERGY SECTOR

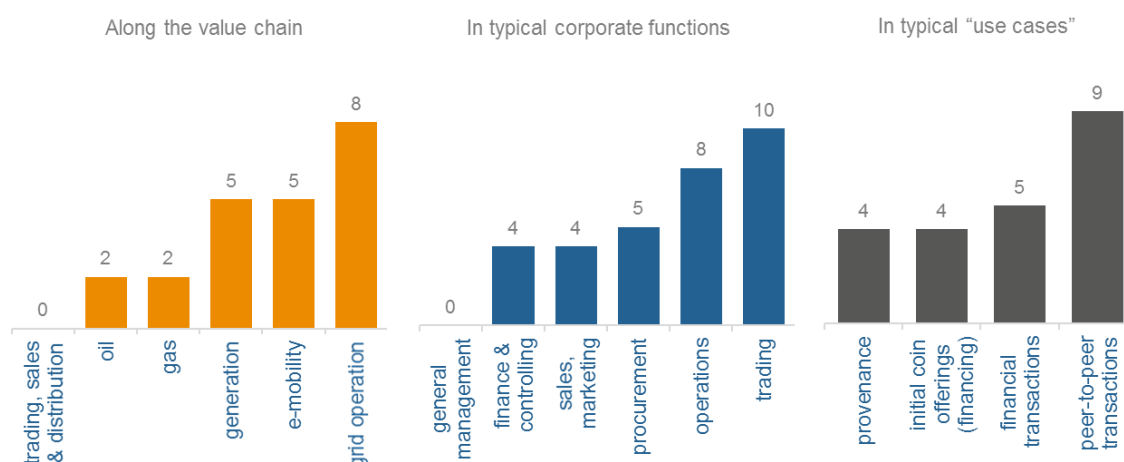
We interviewed senior executives in 15 companies and organisations about blockchain in energy. They come from a variety of different activities and involvement in the energy sector and 13 of the 15 are more or less equally split between energy companies themselves and blockchain technology companies. The blockchain technology companies are a variety of start-ups and incubators working on energy projects, in most cases in partnership with energy companies. Among the energy companies, one is an oil and gas company with the others being in the energy sector. In addition, we conducted two interviews, one with a national energy agency and one with a national gas and electricity industry regulator.

Most of those we interviewed describe themselves as either very familiar or extremely familiar with blockchain technology (12 of the 15), although three said they were only moderately (two) or slightly familiar (one) with it. When asked to identify the functional activities where blockchain could bring most value, trading and operations (accounting for 18 mentions out of 33) stood out.

Already, seven of our 15 interview participants reported that they have blockchain applications that are in use with ‘real’ customers (Figure 6). These seven included three energy companies, two in the energy sector and one oil and gas company. Another two interviewees expected customer roll-outs to take place within the next three months. So around half of the interviews were with people who are not just expert in blockchain but are at a fairly mature stage in today’s terms in applying blockchain to energy use cases. But this is balanced by others who are at much less advanced stages or who are, indeed, less familiar with the technology.

The areas of the value chain considered to have the greatest potential benefit from blockchain reflect the industry mix of our interviewees with a bias towards applications in the energy sector (grid operations, e-mobility and generation) rather than oil and gas. Asked about use cases, blockchain’s potential to support peer-to-peer transactions produced the most use case mentions (ten out of 26). Other use cases, such as in the field of provenance, financial transactions and initial coin offerings (ICOs), received a fairly equal number of the remaining mentions.

Figure 6: In which area of your business can blockchain bring the most value?



Source: World Energy Council, PwC, interviews results

OPPORTUNITIES: WHAT ARE THE POTENTIAL BENEFITS?

Blockchain's benefits include reduced costs, elimination of data duplication, increased transaction speed and greater resilience. The key capabilities of blockchain technology spring from its potential to provide tamper-proof record keeping, replace central authorities with decentralised processes and to facilitate 'smart contracts' – essentially computer code which executes automatically in response to an appropriate trigger.

These capabilities mean that blockchain's transformative potential reaches beyond the transformation of existing processes. The removal of the need for intermediaries opens up the possibility of new business models while the scope for 'smart contracts' enables blockchain to play a powerful role underpinning automation and the 'internet of things', increasing greatly, for example, the scope for energy efficiency and demand response pricing in the energy sector.

Blockchain is expected to lead to much more direct relationships between energy producers and consumers and to strengthen the market participation opportunities for small energy providers and prosumers. It is possible to envisage a decentralised energy system in which blockchain enables energy supply contracts to be made directly between energy producers and energy consumers and carried out automatically.

One consequence is that intermediaries previously operating in the market, among them trading platforms, traders, banks or energy companies, might no longer be needed at all, or they would be reduced to a considerably smaller role. This could lead to a significant decrease in the cost base of the sector as well as changing its structure.

Certainly, the senior executives that we interviewed as part of the development of this paper see considerable potential disruptive impact coming from blockchain. All but one of the interviewees (93%) thinks that blockchain will disrupt the functioning of the industry and contribute toward

accelerating the speed of the energy transition. And they are fairly bullish about the likely timescales with 87% anticipating that the most disruptive impact is less than five years away (Figure 7).

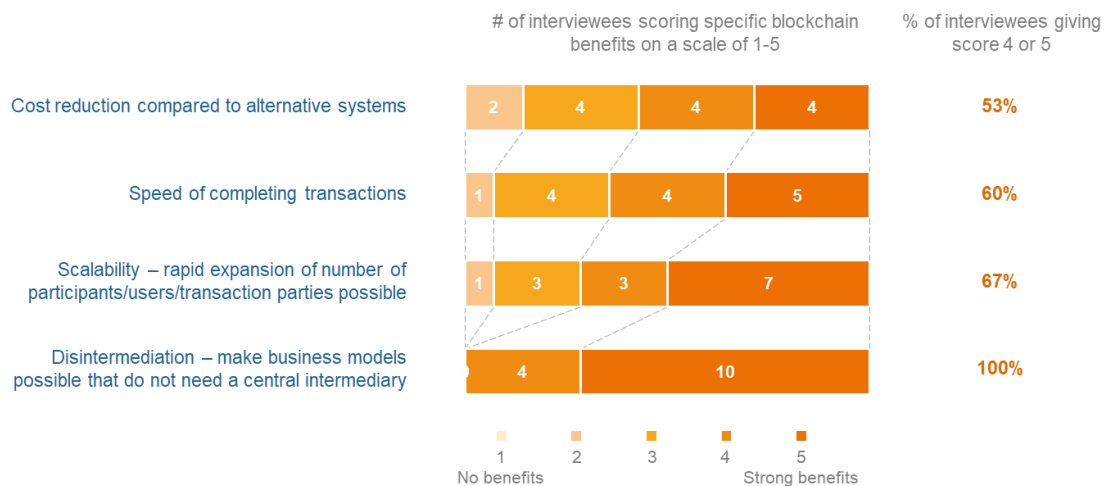
Figure 7: Timescale of the most disruptive impact that blockchain can make on the functioning of the industry



Source: World Energy Council, PwC, interviews results

This view of the transformative potential of blockchain for energy is reflected in the reasons that interviewees cite for developing blockchain technology (Figure 8). Every single interviewee pointed to the disintermediation potential of blockchain as a strong benefit, opening up the way for business models that do not need a central intermediary. Interestingly, though, the senior executives we spoke to were slightly more lukewarm towards other blockchain claims, most notably its cost reduction potential, and there were also concerns about scalability and the technology's ability to cope with fast transaction speeds.

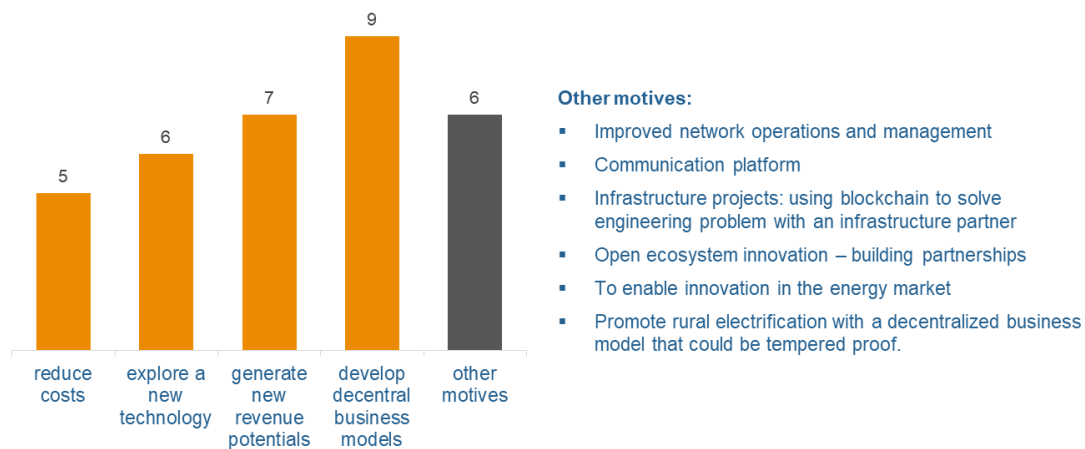
Figure 8. Overview of specific blockchain benefits



Source: World Energy Council, PwC, interviews results

When it comes to company motives for using blockchain technology, nearly two thirds (nine of the 15) see it as a technology that can help them support new decentralised business models and around half (seven of the 15) see it as a driver of new revenues (Figure 9). A number of other reasons were mentioned and the wide variety of possible blockchain applications is reflected in the list of 'other' motives for pursuing blockchain listed in the figure. They include, for example, a specific application in a large infrastructure project with a railway company to solve an engineering problem, using blockchain as a platform or ecosystem for communications and collaboration, and as a technology to support rural electrification projects.

Figure 9. Motives to use blockchain



Source: World Energy Council, PwC, interviews results

But awareness of the wide potential for blockchain in energy needs to be rooted in a firm appreciation of the right conditions that need to be in place for it to be successful. Unless these conditions apply, companies may be better advised to pursue solutions other than blockchain. There are, for example, alternative solutions capable of ensuring the functioning of a decentralised energy supply system. Blockchain technology is not a necessary requirement for the operation of such a decentralised model and its associated data flows and transactions. Both transactions and data flows could just as well be recorded in conventional databases which could be faster and less costly to operate, with the added benefit of being largely already available.

THE NECESSARY CONDITIONS FOR BLOCKCHAIN AS A SOLUTION²

If the following conditions apply, then blockchain has strong potential to provide a solution:

- Multiple parties share data – multiple participants need views of common information.
- Multiple parties update data – multiple participants take actions that need to be recorded and change the data.
- Requirement for verification – participants need to trust that the actions that are recorded are valid.
- Intermediaries add cost and complexity – removal of ‘central authority’ record keeper intermediaries have the potential to reduce cost (e.g. fees) and complexity (e.g. multiple reconciliations).
- Interactions are time sensitive – reducing delay has business benefit (e.g. reduced settlement risk, enhanced liquidity).
- Transaction interaction – transactions created by different participants depend on each other.
- If you can’t tick at least four out of six, ask “why blockchain?”

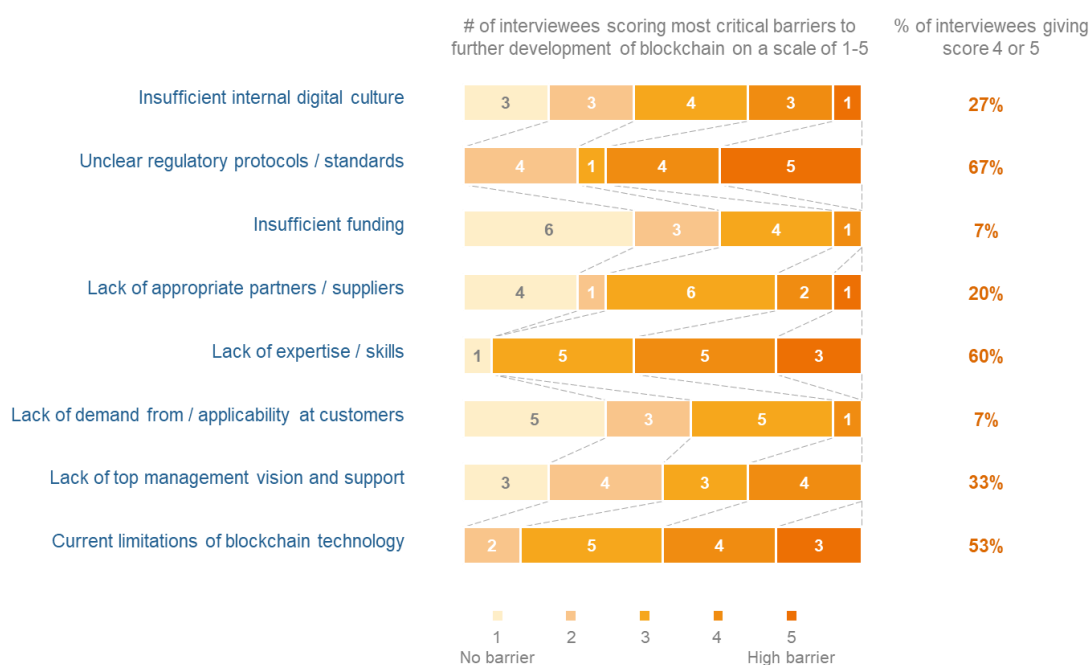
² PwC/Long Finance, Chain reaction: How blockchain Technology Might Transform Wholesale Insurance, 2016

OBSTACLES: WHAT ARE THE BARRIERS?

Although blockchain has the potential to deliver significant cost reductions, increase efficiency and transform business models, many obstacles currently lie in its way. Some exist at the level of detailed technical challenges. It is not the role of this short white paper to examine all of these. Instead we focus on wider, overarching issues such as regulation, technological uncertainty, energy consumption, cybersecurity and integration with existing systems.

Some of these concerns were foremost in the minds of our interviewees when we invited them to discuss barriers in the way of blockchain development in the energy industry. Regulatory issues topped the list of barriers, just ahead of other significant concerns around skills shortages and worries about the limitations of the technology (Figure 10). On the other hand, concerns such as funding for projects, customer demand, internal digital cultures and leadership support scored relatively low in the list of possible barriers to blockchain.

Figure 10. Overview of the most important barriers to the further development of blockchain in the sector



Source: World Energy Council, PwC, interviews results

REGULATORY UNCERTAINTY

The energy sector is heavily regulated with detailed requirements flowing from a mix of consumer, competition, safety and other concerns, affecting all parts of the value chain. The approach by regulators to blockchain remains unclear. In addition, there is the challenge that regulation varies from country to country and even where cross-national regulation is an objective, such as in the EU, actual harmonisation is limited. In some territories, jurisdictional boundaries are sub-national such as in the US where individual states play a lead role in energy regulation.

If blockchain is to reach its full potential greater coordination between regulators may play an important role. On a positive note, the existence and development of blockchain may act as a spur

for such coordination. The development of the technology may also directly benefit the goals of regulation and its operation. Blockchain has the potential to deliver greater transparency, improve access to information and simplify regulatory reporting. The regulator could have realtime access to data via blockchain. Immutability of data is one of the key characteristics of blockchain technology and is also a strong plus for regulators and supervisory bodies.

So although blockchain presents regulatory challenges, many also see it as a regulatory opportunity. Companies can act in concert with regulators to address regulatory concerns by incorporating regulatory requirements directly into the design and specification of blockchains. Certainly, this is how some of our interviewees viewed this potential obstacle. For example, Lawrence Orsini, founder and CEO, LO3 Energy, emphasised the importance of “good proof points to help regulators”. Another interviewee, Pamela Taylor, partner for enforcement, compliance and innovation at UK energy regulator, Ofgem, said: “We will be active in finding out what is happening in the market, considering the regulatory implications and seeking to remove the barriers. We could also look to see where it could be used in our own processes, for example in our E-serve scheme.”

BLOCKCHAIN: SOME KEY REGULATORY QUESTIONS IN THE ENERGY SECTOR

There is a myriad of complex issues that arise from blockchain technology in energy. For example, if energy is to be supplied directly from a power producer to a consumer, followed by a financial transaction between the parties, and all of this is to be affected on the basis of blockchain technology, consider the following questions:

- Who performs the meter operator role?
- Who is responsible for submitting schedules and forecasts to the transmission system operator?
- Who is the registered electricity supplier?
- Who performs the balancing group manager role?

This white paper can only begin to touch on some of the many detailed issues that blockchain raises. For a more in-depth look at blockchain in the energy sector, including a discussion of these specific questions, see PwC report, *“Blockchain – an opportunity for energy producers and consumers? (2016)”*.

TECHNOLOGICAL UNCERTAINTY

A key issue is that blockchain remains at a relatively early stage of development with most projects still at the pilot stage. Proof of concepts is only just being carried out and is still limited in scope. Rival technologies are also emerging which their proponents claim could have leapfrog potential, overcoming potential limitations of blockchain. Among them is IOTA, based on the tangle algorithm, which describes itself as “next generation blockchain” and says its no-fee system is more suitable for the micropayments needed for the internet of things. A white paper from IOTA’s developers

claims: “In the currently available (blockchain) systems one must pay a fee for making a transaction; so, transferring a very small amount just makes no sense since one would have also to pay the fee which is many times larger. On the other hand, it is not easy to get rid of the fees since they serve as an incentive for the creators of the blocks³.”

But set against rival claims, blockchain is itself developing and limitations that may be a concern today might be addressed as the technology develops. Companies working with decentralized systems have a few requirements: frequent and small transactions, flexibility in transaction time (in some cases it doesn't matter whether the transaction takes 1 or 10 minutes, in other we need a real-time system), high level of integrity and access to historical data. IOTA seems to fulfil requirements 1 to 3. Regarding the last one, it's unclear whether a state (without historical data) as it's described by IOTA would be sufficient or not. In contrast to this, one basic principle of blockchain is using the history as evidence for the actual state of ownership. This makes data permanently accessible. So even if many people are still getting headaches when talking about blockchain, speed of mining, security against attacks and reliability, only the theory shows that IOTA would solve some of these issues. A long term successful implementation under real world condition is missing.

Of course, companies cannot be certain of this and, so it is not surprising that half of those we interviewed said they had significant concerns that the limitations of blockchain could be an obstacle to its development in the energy sector. Some observers, for example, question whether blockchain can cope with the pace of some power trading environments but, as Allison Clift-Jennings, CEO, Filament, commented: “Speed is a current limitation but transactions will become faster as smarter developments get rolled out, that a few people are testing now.”

ENERGY CONSUMPTION

Since every blockchain is a ledger (and therefore a file or database) that exists in many copies, the computer resources and the energy required for the calculation, transmission and storage of the information increases as the blockchain grows in complexity and use. One academic study showed that the cost of bitcoin mining was comparable to the whole of Ireland's electricity consumption⁴.

The energy footprint, therefore, needs to be a significant consideration in decisions on whether and how to roll out the technology. The senior executives we interviewed were divided on whether blockchain will contribute to net energy saving or whether it will add to energy demand. 40% of interviewees believe that blockchain adds to total energy demand, while 47% think that it brings net saving on energy demand (the rest of interviewees did not answer).

The actual costs of how blockchain applications will develop cannot, of course, be fully projected today. Improvements in the technology may reduce energy costs. And there are cost differences between private and public blockchains. Private blockchains usually involve lower transaction costs and operate on the basis of simplified verification processes (for instance, proof-of-work verification uses up more energy than the proof-of-stake process), which decreases costs.

³ The tangle, Serguei Popov for Jinn Labs, April 3, 2016. Version 0.6.

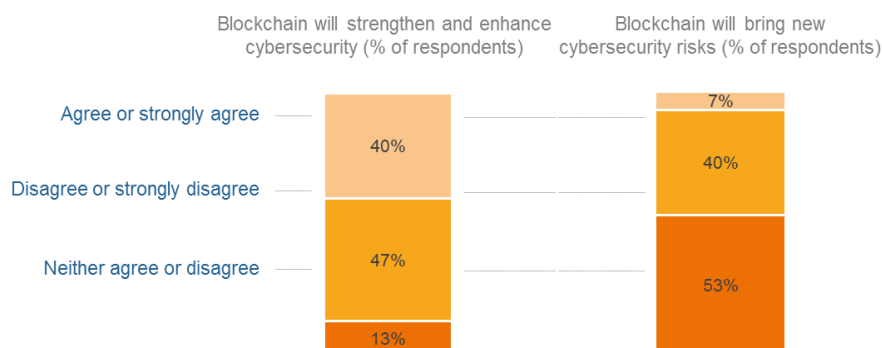
⁴ Karl J. O'Dwyer and David Malone, Bitcoin Mining and its Energy Footprint, Hamilton Institute, National University of Ireland Maynooth, 2014

CYBERSECURITY

A key benefit that is assumed to be inherent to blockchain design is that the decentralised storage of transaction data increases security, the structure of the blockchain makes it more 'tamper proof' and the technology can provide better encryption levels for transactions, increased data protection and can limit fraud risk. But it is also accepted that blockchain is in its infancy and that these claims can only truly be judged after many years of operating blockchain.

Certainly, the senior executives we interviewed for this paper were ambivalent about the cybersecurity outlook for blockchain. Although three fifths (60%) agreed that it would strengthen cybersecurity, over half (53%) thought that it would introduce new cybersecurity risks (Figure 11). And these views were not always in opposite camps. A third of those who felt it would strengthen cybersecurity also thought it would herald new cybersecurity risks in the future.

Figure 11. Blockchain impact on cybersecurity



Source: World Energy Council, PwC, interviews results

Blockchain has not been immune to security concerns, most notably with the DAO (Distributed Autonomous Organisation) hack. Based on Ethereum, the DAO had the ambition of creating a humanless venture capital firm that would allow the investors to make all the decisions through smart contracts. Launched in April 2016, it raised a reported US\$150 mln but a few months later on June 2016 it was hacked and approximately US\$60 mln was diverted into the hacker's account.

The so-called 'hard fork' solution, in which the blockchain was effectively rolled back or replaced with an entirely new version, proved divisive and raises many questions about the management of and response to security issues in a blockchain community⁵.

⁵ How a \$64M hack changed the fate of Ethereum, Bitcoin's closest competitor, CBC News, 28 August 2016. Everything you need to know about the Ethereum "hard fork", Quartz, qz.com. Ethereum bailout complete. Long live Ethereum! FT Alphaville, 20 July 2016. US investment firm plans launch of first ever ethereum classic private fund, Reuters, 6 March 2017.

INTEGRATION WITH EXISTING SYSTEMS

One of the key challenges for companies considering blockchain is to assess its value over existing alternatives and to also assess how it can integrate with existing systems. Where there are already advanced systems set up, for example in energy trading, the effort and cost of migrating to blockchain might not be viable even if the technology was able to support the speed and scale of transactions needed in an energy trading environment.

In other contexts, where companies judge that blockchain investment could be beneficial, the interaction with the legacy environment is crucial. Ofgem's Pamela Taylor observed: "When blockchain is used to enable different transactions, such as for peer-to-peer traded energy platforms, the main challenge for innovators is for the blockchain systems to interface with existing systems."

The relationship of blockchain to legacy systems can take a number of guises: blockchain may become a component of existing systems, it may replace some or all of the current systems or it may become a separate system which will sit alongside current systems. It is important that when making choices about blockchain technology that companies consider how it will integrate with the current architecture, and make the appropriate product selections and designs in accordance with this.

LOOKING AHEAD – WHAT MIGHT HAPPEN TO BLOCKCHAIN IN THE ENERGY SECTOR?

Although many obstacles lie in the path of blockchain development, the overall sentiment of these we interviewed for this paper is that the prospects for the technology are positive. The disruptive potential of blockchain is firmly recognised and it is widely expected to accelerate the speed of the transition to more decarbonised and decentralised energy sources. Already, nearly half of those we interviewed are deploying it in real customer contexts.

TAKING ROOT WITHIN FIVE YEARS

Most expect blockchain's disruptive impact to occur within five years. And the energy companies we spoke to thought that blockchain technology would be used by up to 25% of their business within three years. At the moment, the teams working on blockchain and the level of investment are quite small but, as Dr. Carsten Stöcker, senior manager, Innogy innovation hub, said: "We believe we need to mobilise people around this now and have the courage to build the capability even though the technology is still quite new."

A number of companies are adopting similar approaches, deciding to abandon a 'wait and see' attitude and develop capabilities. In doing so, they are particularly mindful of the fit between the decentralised characteristics of blockchain and the decentralised future for energy systems. In such a context, blockchain projects can advance company learning about the solutions to optimise decentralised energy systems and leverage new business opportunities in a new distributed energy environment.

PROMISE VERSUS UNCERTAINTY

The potential energy use cases of blockchain technology show a lot of promise. In addition to reducing transaction costs across the system, increasing the efficiency of processes and thus delivering cost benefits for customers, the technology can enable direct interactions between all parties involved. This ensures that existing generation capacity is utilised optimally, whilst energy is made available at the best price. The role of prosumers is strengthened considerably under such a model.

But this potential for blockchain in energy also has to be weighed against the significant obstacles that lie in its way. It is quite realistic to envisage a future in which blockchain has a limited growth path or even stalls due to a combination of technological, regulatory or other practical challenges. Blockchain still needs to prove that it can work in practice and overcome scale, speed and other constraints that currently hinder its applicability in many situations.

Nonetheless, there is momentum gathering behind blockchain in the energy sector and it could become a key enabling technology, not just underpinning decentralised energy systems but also intensifying the scope for disintermediation on the sector. In such a future, blockchain capability will be not just an added advantage for market participants but it will be a table stake for market success.

NEXT STEPS – ISSUES FOR STAKEHOLDER DISCUSSION

The intention of this white paper is to start a dialogue between different stakeholders in the energy sector about the future for blockchain. The range of projects is indicative of the momentum that is already gathering behind blockchain within the energy sector. The variety of senior executive viewpoints given in response to a number of our survey questions shows that blockchain development is still subject to much debate. Many questions need further discussion. Among them:

- **Promise versus uncertainty:** Are you confident that the current uncertainties around blockchain will be overcome sufficiently for the technology to play a breakthrough role in the future of the sector?
- **Accelerating energy transformation:** Do the characteristics of blockchain fit with your organisation's view of the future of energy, and could blockchain projects accelerate your part in that future?
- **Business models and strategy:** Will blockchain disrupt your organisation's market and operating environment and, if so, how should you adjust your business strategy and business models?
- **Improving internal operations:** Are there opportunities for blockchain technology to reduce cost or improve customer service?
- **Purpose and suitability:** Do you have a clear understanding of potential blockchain business applications and is blockchain the right technology?
- **Resilience:** How can you ensure the technology is resilient, scalable, secure and recoverable?
- **Learning:** Is the energy sector looking sufficiently at the more advanced development of blockchain in financial services and learning from that?
- **Co-operation:** Is there a need to step up cooperation with others in order to fully realise the benefits that blockchain can bring?
- **Governance:** How will it be governed and administered? Who will control identity, roles and rights?
- **Regulation and industry networks:** Are initiatives in place to ensure the regulatory framework evolves in an appropriate way around blockchain, and is dialogue taking place to develop industry-wide critical mass around the use of the technology?

These and other questions will be addressed and further developed in the next version of the white paper. We are interested in your views and perspectives on these key questions about blockchain and the role it can play in disrupting the energy sector. If you would like to provide any feedback or share your insights, please send us an e-mail via the contact details provided on the next page.

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