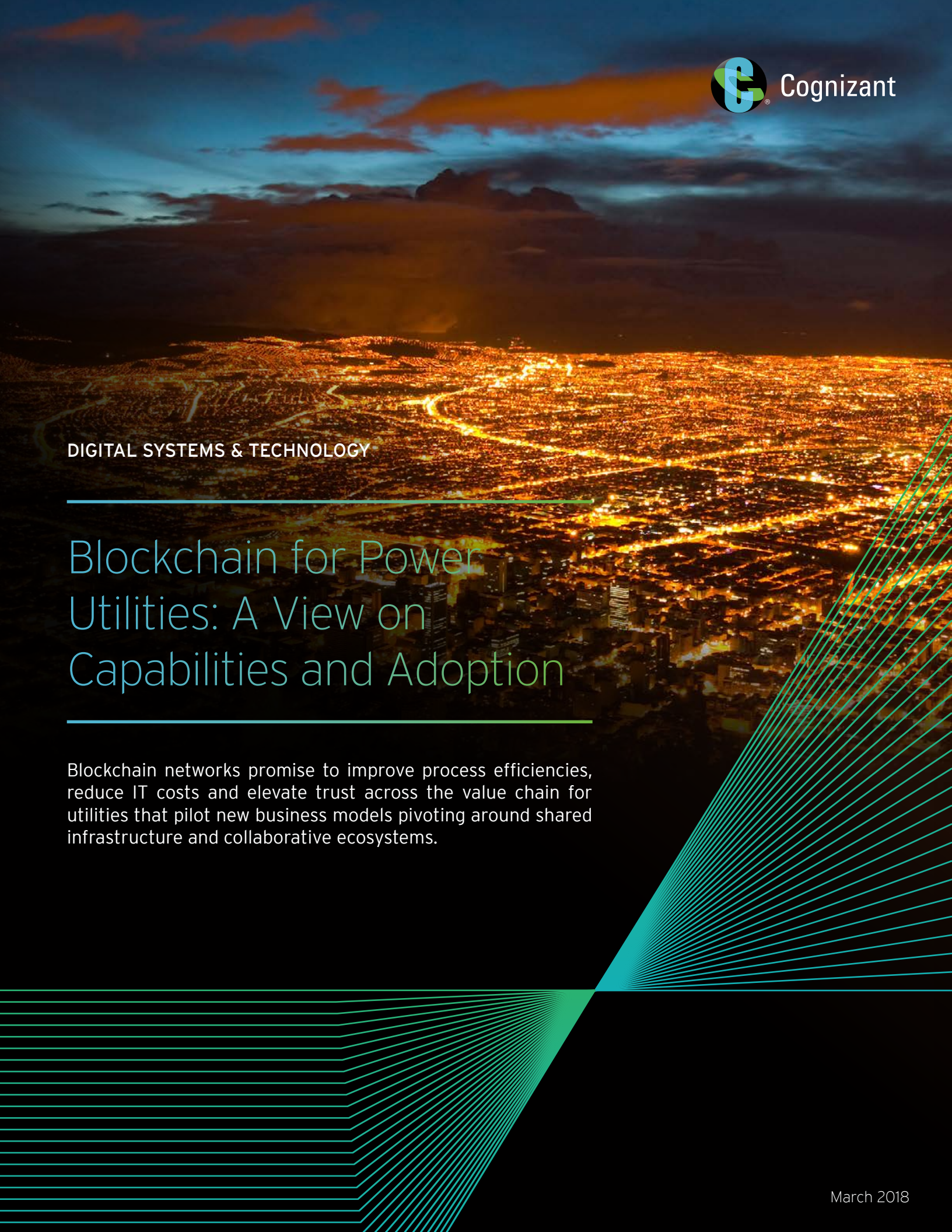

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DIGITAL SYSTEMS & TECHNOLOGY

Blockchain for Power Utilities: A View on Capabilities and Adoption

Blockchain networks promise to improve process efficiencies, reduce IT costs and elevate trust across the value chain for utilities that pilot new business models pivoting around shared infrastructure and collaborative ecosystems.

March 2018

EXECUTIVE SUMMARY

The utilities landscape is evolving into a distributed and smart power grid. Customers (both residential and business) are leading initiatives toward distributed power generation. Simultaneously, utilities are investing in smart meters and upgrading grid infrastructures to turn the distributed and smart power grid into a reality.

In short, the industry faces two fundamental challenges:

- The rapid move to distributed generation resources, with a focus on sustainability.
- The penetration of smart devices and appliances such as smart thermostats, electric vehicles, etc.

As a result of these trends, along with the emergence of service providers focused on consumer empowerment and demand response aggregators, the utilities industry ecosystem is expanding. In response, utilities are exploring new business models and technologies to address challenges to their continued relevance.

As the grid expands and becomes more distributed — with many disparate stakeholders — establishing trust between stakeholders is fundamental to maintaining effective operations. Blockchain, a distributed ledger technology built on a shared network infrastructure and public key encryption, is one way for utilities to provide a trustworthy and secure platform for distributed grid and smart device usage. While no individual technology can "do it all," it's vital to identify which technologies can help utilities address their current challenges. (For more on what blockchain is and how it works, see Quick Take, page 4.)

Blockchain is already proving its ability to provide secure transactions by applying smart contract technology. With its trustless network, blockchain can also be implemented when establishing trust is a key criteria for the success of the business model. Considering this strength, the banking industry is leading the way with blockchain experimentation, primarily with permissioned, private networks focused on payments, fraud reduction, know your customer compliance and credit management. (For more on this topic, see our white paper "Financial Services: Building Blockchain One Block at a Time" and visit the blockchain section of our website.)

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green energy, asset optimization, payments within microgrids, prepaid smart meters and payments to distributed generation asset owners. These are among the many use cases that industry players are exploring via pilot projects.

We believe blockchain-based networks can help utilities disintermediate suppliers and even retailers throughout the electricity market. Over time, all import and export electricity meters could be fitted with blockchain nodes, and these meters will be able to plug into a single power exchange to directly transact electricity among themselves. This power exchange would run on top of a more scalable and permissioned blockchain platform, thus creating a more efficient market. Currently, blockchain scalability is a challenge for industry-wide applications.

Before embarking on any IT initiative, including blockchain, however, it is critical to understand the strengths and weaknesses of the technology and how it can be best applied to solve business challenges and achieve strategic objectives. This whitepaper will evaluate blockchain as a technology option for streamlining operations, decreasing costs and delivering on the promise of the distributed smart grid. It also provides guidance on a framework approach that we believe will enable utilities to move forward with blockchain.

QUICK TAKE

Blockchain Technology at a Glance

To dispel the confusion surrounding blockchain and the complexity of the technology, we offer two definitions: (For more details on how blockchain works, also see our e-book "Demystifying Blockchain.")

- "Blockchain is an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value."[1]
- "A system in which a record of transactions made in Bitcoin or another cryptocurrency are maintained across several computers that are linked in a peer-to-peer network."[2]

Blockchain is only one of many types of distributed ledgers that provide secure, distributed transactions. Bitcoin is currently the largest blockchain network, followed by Ethereum, Bitcoin Cash, Ripple, Dash and Litecoin.[3]

Blockchain has the potential to solve the following common business/IT pain points:

- **Trust:** Blockchain eliminates the need for intermediaries and enables direct transactions among organizations. It establishes a distributed system that can be trusted inherently.
- **Security:** Blockchain ensures superior security for transactions compared with more traditional IT security mechanisms such as firewalls, encryption, intrusion detection systems and packet filters.
- **IT infrastructure overhead:** Because disparate systems today hold different copies of the same data, redundant effort is spent ensuring integration and reconciliation between IT systems. Blockchain-based solutions hold the potential to reduce this overhead significantly.
- **Integrated business process implementation challenges:** Blockchain could enable the next level of integrated business processes. For example, a metering solution based on blockchain could ensure a meter-to-cash business process without third-party intervention.

EXPLORING THE RELEVANCE OF BLOCKCHAIN FOR UTILITY BUSINESS FUNCTIONS

To get started with exploring the use of blockchain within their organizations, utilities need to consider how the technology could enhance business processes across the industry value chain. By comparing and matching utility business process attributes and blockchain technology capabilities, as well as evaluating the incremental business benefits, utilities can decide on whether blockchain is a viable technology option for a particular business challenge.

The evaluation process can begin with a detailed business process view linked to incremental cost and benefits related to blockchain usage. This view will help utilities prepare a blockchain adoption roadmap.

It's then important to define utility-specific capability levels for blockchain technology to ensure systematic and logical adoption decisions.

DEFINING BLOCKCHAIN CAPABILITY LEVELS FOR THE UTILITY INDUSTRY

There are three broad levels for how blockchain capabilities could meet utility industry requirements, for both permissioned and private ledgers (see Figure 1). These capability levels are defined in terms of distinct technology attributes, which can drive mainstream utility adoption.

Assessing Blockchain Capability Levels

Utility-Specific Capability Level	Capability Definition	Flag
1. FOUNDATIONAL TECHNOLOGY	• Tested and proven technology elements. • More than sufficient for utility data security requirements. • Ensures data reliability. • Ensures process integrity and structure.	
2. VIABLE FOR SUSTAINING BUSINESS	• Lower transaction costs; parity with existing transaction alternatives. • Market players agree on interoperability standards. • Regulatory compliance. • Tested and proven integration with other utility systems.	
3. ROBUST AND SCALABLE FOR BUSINESS	• Capable of serving utility scale of operations. • Low cost of hardware and software components. • High transaction speed/low completion time. • Conformity with data privacy requirements. • Achieves lower energy consumption for transactions.	

Figure 1

Blockchain can be viewed as a foundational technology with great potential for disrupting the existing utilities industry ecosystem.

Level 1: Foundational Technology

Blockchain can be viewed as a foundational technology with great potential for disrupting the existing utilities industry ecosystem. Its core capability is transactional security and reliability, in the form of immutable records. As such, a permissioned blockchain technology network can be readily adopted for relevant utility processes.

Blockchain applications relevant for utilities include:

- **Bill pay:** A number of start-up platforms have emerged to solve basic problems related to bill settlement and prepaid recharge of smart meters using cryptocurrencies. An example is Bitconnect-enabled utility bills using Bitcoins.[4]
- **Solar renewable energy certificates:** Blockchain can be effectively used for authenticating and trading renewable energy credit certificates. SolarCoin is an example of a cryptocurrency earned by generating solar electricity.[5]
- **Electric vehicle charging:** BlockCharge is a company that's working on blockchain-based charging, authentication and billing for electric vehicles.[6] Similarly, Innogy enables digital payments for charging electric vehicles over Ethereum blockchains.[7]
- **Customer switching:** UK-based Electron has built a blockchain-based platform to facilitate faster switching of suppliers.[8]

All of these applications rely on blockchain's superior security and transaction traceability (i.e., validation that parties are who they say they are, without the need for an intermediary). In a traditional utility scenario, utilities must trust the market regulator and balancing/settlement mechanism. Thus, for the existing utility business (small and large), blockchain at a Level 1 capability will not significantly transform the existing business other than impacting financial transactions and customer contract benefits. This fact is equally applicable in regulated and deregulated markets.

Blockchain is viable for utilities that can envision a way to overcome the investment and systems integration challenges inherent in implementing the technology as a business-critical service.

Level 2: Viable for Sustaining Business

Blockchain (including permissioned, private ledgers) is viable for utilities that can envision a way to overcome the investment and systems integration challenges inherent in implementing the technology as a business-critical service. At this level, the traditional utility technologies must coexist with blockchain and drive customer/internal business units to sustain the investments made in the technology.

Once the technology delivers business services to a critical mass of users in retail and commercial markets, associated regulatory oversight will be a challenge, as currently, a very loose regulatory framework exists for blockchain. This will need to change to ensure appropriate support models and peer groups are represented to protect the interests of the utility businesses that would invest in blockchain.

A market regulator leading the way is the Energy Market Authority (EMA) of Singapore, which has launched a regulatory sandbox to encourage energy sector innovations, including blockchain.[9] Similarly, Australian regulators are expected to include blockchain-powered energy in their wheeling access arrangements.[10]

Examples of experimental permissioned blockchain applications with relevance for the utilities sector include the following, keeping in mind that applications are still in pilot mode across the industry, with reduced scope:

- **Microgrids:** Distributed energy systems such as microgrids function independently from a centralized grid. Because the scale of operations is limited for microgrids, blockchain networks are increasingly becoming more relevant for managing transactions within the microgrid. For example, LO3 Energy has established Brooklyn Microgrid, which is enabled by blockchain technology to manage internal energy transactions.[11]
- **Independent power producer (IPP) settlements:** Austrian utility Wien Energie is taking part in a blockchain trial focused on energy trading with two other utilities.[12]
- **Grid settlements and wholesale market trading:** These are the logical next steps after IPP settlements. The IPP and microgrid link a small number of participants/players. Grid settlements and wholesale market trading, meanwhile, involves many participants and thus consists of a large number of nodes. Moreover, the processes must comply with industry regulations. As a result, this use of blockchain technology requires more scalability and regulatory compliance to support these processes.

Over the long term, blockchain is expected to add business value to the structure and market models of emerging utility markets such as local energy markets, virtual power plants and energy communities, in which a traditional utility or supplier plays the role of business facilitator.

Level 3: Robust and Scalable for Business

Over the long term, blockchain (including permissioned, private ledgers) is expected to add business value to the structure and market models of emerging utility markets such as local energy markets, virtual power plants (VPP) and energy communities, in which a traditional utility or supplier plays the role of business facilitator.

The vision for Level 3 is not yet clearly defined and needs additional data points before a definitive or calculated bet can be placed on how blockchain will become a mainstream technology, coexisting and eventually replacing existing systems.

The utility use cases envision new industry processes. The following applications are still in pilot mode, with reduced scope:

- **Local energy market/P2P energy networks:** Brooklyn Microgrid's pilot project demonstrates blockchain's applicability in the peer-to-peer (P2P) energy market.[13] The Energy Networks Association in the UK recently announced a plan for a £17 billion investment in a smart grid network to power local energy markets.[14]
- **Decentralized exchange:** Austrian start-up Grid Singularity is experimenting with a decentralized energy exchange platform using blockchain technology.[15]
- **Retail trading and settlement:** New York-based start-up Drift is experimenting with a distributed ledger similar to blockchain for retail energy trading.[16] Similarly, Wepower is building a blockchain-based green energy trading platform.[17]

Figure 2 (next page) illustrates the expected progression of blockchain-based technology in the utility landscape.

Blockchain's Projected Industry Evolution

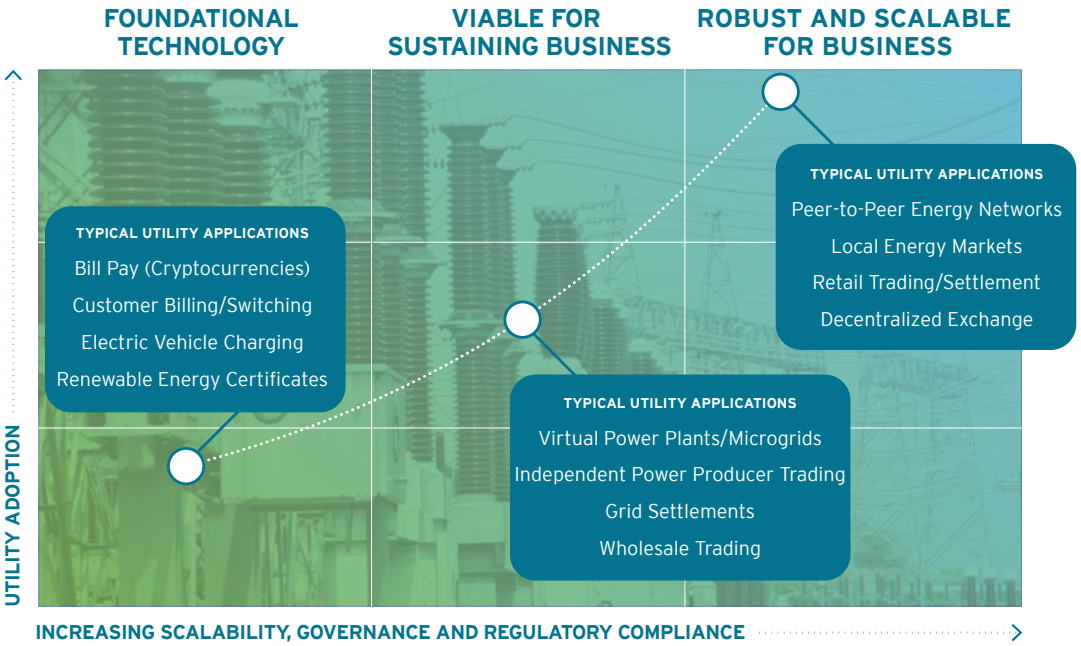

Figure 2

AN APPROACH TO DECIDING ON BLOCKCHAIN AS A TECHNOLOGY OPTION

We recommend that utilities stay apprised of blockchain ideas and use cases emerging worldwide, with a particular watch on developments in their own geographies. Investing in blockchain proofs of concept is the only reliable way to understand the effectiveness and applicability of the technology.

We also advise utilities to perform three critical activities to objectively assess blockchain applicability for their business processes (see Figure 3).

Assessing Blockchain's Applicability

ASSESSING BLOCKCHAIN FOR UTILITY BUSINESS PROCESSES

1. **Evaluate suitability of utility process** for applying blockchain technology.
2. **Evaluate alternative technology options** vs. blockchain for utilities applications.
3. **Cost/benefit analysis for technology options** vs. blockchain.

SAMPLE BLOCKCHAIN PROJECT

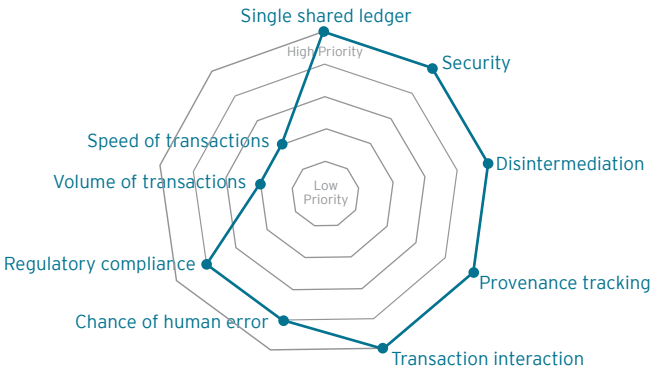

Figure 3

First, utilities need to decide on a composite metric for evaluating blockchain-based technology for key business processes and applications. A typical composite metric should consist of parameters such as process security, criticality, risk, frequency, overhead/transaction costs, speed, etc. The composite metric for each business process must be compared with technology options, including blockchain, to understand how well each option could support the process requirements.

QUICK TAKE

Overcoming Blockchain Barriers

Predominant roadblocks to adopting blockchain technology include:

1. **Computational power and span of distributed ledger:** Blockchain requires enormous amounts of computational power and energy, both for functioning and maintenance. As the blockchain grows, maintenance becomes more difficult. Forking the chain is one way of working around this issue, but this approach requires careful management.[18]
2. **Performance:** One of the current pressing issues with public blockchain technology is the time required to validate and append to the chain. Improvements are in progress for private/permissioned blockchain implementations, and several methods have proved to alleviate performance issues, such as deviation from proof of work verification to another less resource-intensive verification method, including proof of stake, proof of burn, etc.
3. **Enterprise integration:** Fundamental changes to the current enterprise technology stack are required to ensure that blockchain-based solutions can be integrated into the organization's application landscape.
4. **User and regulatory adoption:** There is an ongoing shift required in the user community to understand the uses of blockchain and accept the validity of a so-called trustless network. Most countries are still developing mechanisms to regulate blockchain technology implementations.[19] (For more on this topic, watch our video on blockchain regulations.)

Utility business processes that are highly aligned with blockchain-based technology should then be put through a second screening process, looking at a cost/benefit analysis for technology alternatives.

After the first level of screening, the utility will likely find there are many business processes that are well-aligned with the blockchain delivery option, such as customer switching, renewable credit trading, etc., given that these are the early use cases already running in blockchain pilot mode in the industry. The blockchain capability level for utilities is expected to improve over time as customer adoption rises and the regulatory picture becomes more conducive and supportive of the business benefits of trustless networks. At that point, more utility business processes will become viable for blockchain-based technology.

A FRAMEWORK FOR EVALUATING BLOCKCHAIN APPLICABILITY FOR UTILITY PROCESSES

Utilities can evaluate potential process candidates for applying blockchain-based technology using the framework depicted in Figure 4.

Before contemplating blockchain implementations, it's essential to determine whether the business process or solution requires blockchain-based technology to effectively deliver important outcomes. Force-fitting blockchain may work at the pilot execution stage, but it can pose serious challenges when scaled.

Framing Blockchain's Fit

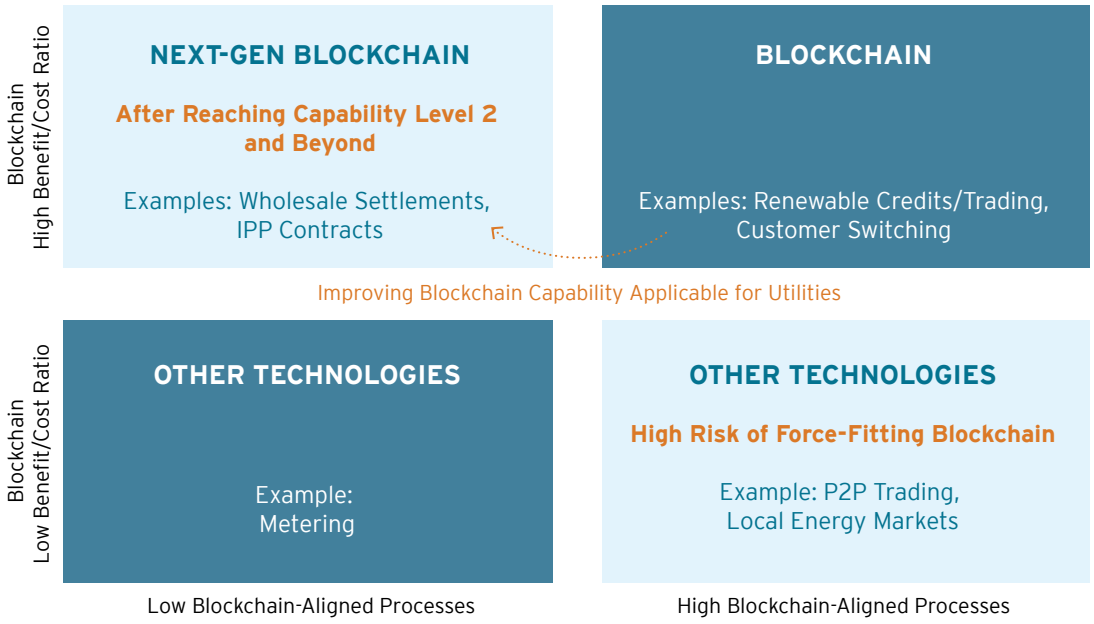

Figure 4

BLOCKCHAIN APPLICABILITY FOR CRITICAL UTILITY PROCESSES

Blockchain technology is a moving target, but in its current shape and form, it can address a specific set of utility processes. As the technology capability improves, more processes will come into scope. Figure 5 (next page) depicts critical utility processes and their applicable blockchain capability level.

QUICK TAKE

A Blockchain Checklist

The following are the typical considerations for blockchain as the right technology choice:

- **Can the problem be solved efficiently with traditional methods?**
  - » If yes, then blockchain may be a force-fit.
- **Will there be multiple writers to the database?**
  - » If yes, then evaluate blockchain as one technology option.
- **Do these writing entities lack trust?**
  - » If yes, strongly consider blockchain as one technology option.
- **Will there be any dependency between transactions?**
  - » If yes, blockchain-based solutions may be appropriate.
- **What are your settlement/transaction requirements (security vs. volume vs. speed)?**
  - » Blockchain offers superior security features. The settlement times may not be as quick as on traditionally distributed databases. The technology is not suitable for rapid sharing of data or data that requires complex controls.
- **Have you considered regulatory compliances and privacy?**
  - » If not, the data in the blockchain network may be exposed to multiple entities.

Keeping Up With Blockchain's Brisk Pace

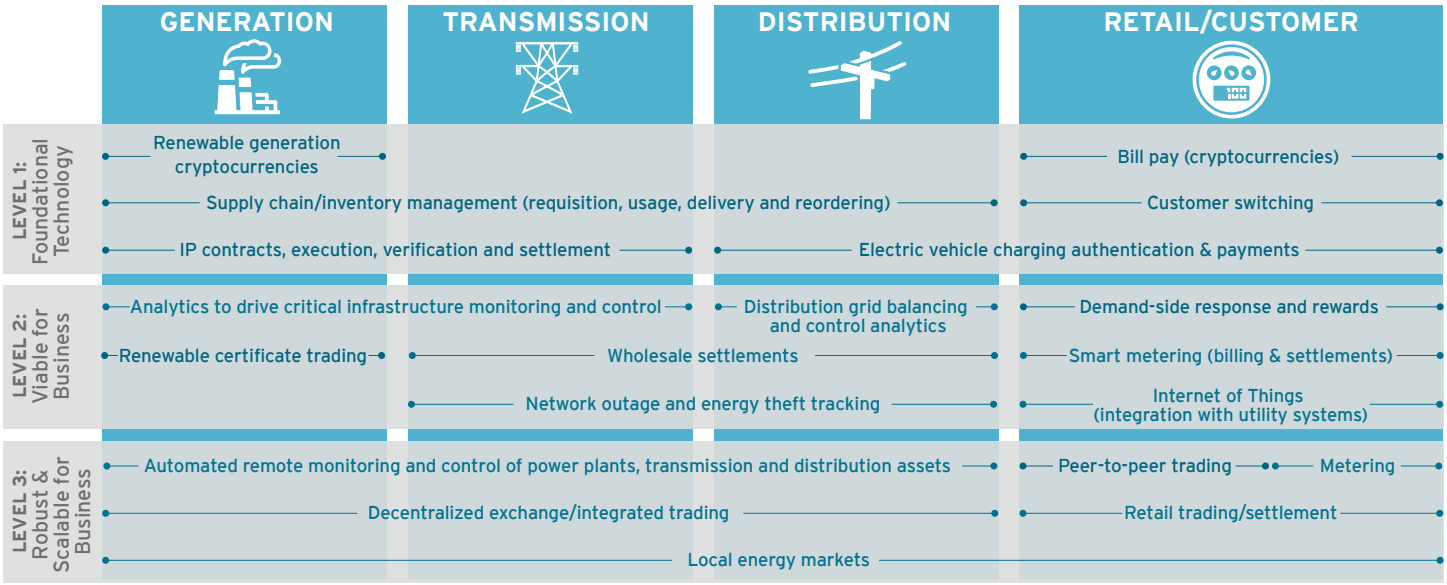

Figure 5

LOOKING FORWARD

Blockchain has the potential to disrupt the existing value chain for power utilities and fulfill the future vision of a distributed energy-sharing economy. While the distributed ledger technology remains five to 10 years away from mainstream adoption, utilities should begin experimenting now with blockchain to determine the best way to leverage it to their business advantage. As they do so, we offer the following recommendations:

- **Don't overcommit, and be selective.** Utilities should focus on evaluating and selecting a minimal set of blockchain-based solutions that address their existing business challenges and are financially viable.
- **Start slow, fail fast.** By testing out blockchain with pilot projects, utilities will get a front-row seat to new and emerging developments in the space.
- **Remain vigilant on the regulatory front.** In the highly regulated utility environment, we expect that utilities will endure a short- to medium-term period of transient regulatory changes across the globe until a manageable set of regulations emerges that is applicable and agreeable to worldwide utility organizations.
- **Build alliances/partnerships.** Utilities need to proactively partner with niche technology, consulting firms and leading universities to continuously explore blockchain options and ensure they stay ahead of the curve.
- **At a minimum, evaluate blockchain as a potential business opportunity to build competitive advantage.** New-age utilities leveraging blockchain technology will directly compete with traditional utilities, especially in the supplier and retail markets. Utilities can proactively build a competitive advantage by offering a blockchain-based capability (such as cryptocurrency payments, electric vehicle smart contracts, demand response, local energy market, etc.) or at least assessing where it fits in their business model, and then positioning themselves accordingly.

FOOTNOTES

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