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Powered by blockchain

Reimagining electrification in emerging markets

A report by the Deloitte Center for Energy Solutions

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- **Project development and innovative finance:** energy project design and execution; transaction structuring/derisking

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Introduction

The power sector—in its electricity sourcing, production, and delivery—provides multiple opportunities to test blockchain technology. Across advanced economies, small businesses leveraging the technology are standing up microgrids in areas as dense as New York City, developing energy trading platforms in Tokyo and Australia, and driving supply chain efficiencies around the world.¹ Larger utility companies, from the United Kingdom to Illinois, are also funding research and testing blockchain applications on their systems.²

WHILE TOKYO AND New York City have extremely developed, capital-intensive transmission and distribution networks, and the utilities that serve those networks are large organizations with intricate supply chains, where is blockchain's place in the developing world's electrification puzzle? The two geographic areas that account for most of the global electrification deficit—sub-Saharan Africa and India, which represent 57 percent and 25 percent, respectively, of the approximately 1.14 billion people worldwide without access to electricity³—present quite a contrast to Japan and the United States. Can systems that lack some of the most fundamental of physical electrical assets, such as generation plants, substations, and transmission and distribution cables, effectively leverage an advanced technology such as blockchain?

Not only could emerging markets deploy blockchain technology to meet their electrification goals, but they may in fact be the *optimal markets* in which to push the limits of blockchain's capabilities in the power sector. There are potential risks associated with a less traditional electrification path, but there are also possible benefits to working in an unbuilt environment—a technological “white space.” For

instance, revising policy and regulatory frameworks in developed markets may prove too cumbersome to create attractive opportunities for blockchain solutions;⁴ also, many advanced economies already have systems in place to ensure payment for service, while developing countries may lack the same structures.

In emerging markets, governments and businesses can utilize blockchain to potentially advance the future of their grid—a distributed, nimble, adaptive, and transparent network—by unlocking three functionalities:

- Bridging the financing gap
- Enabling energy transactions
- Unleashing radical transparency

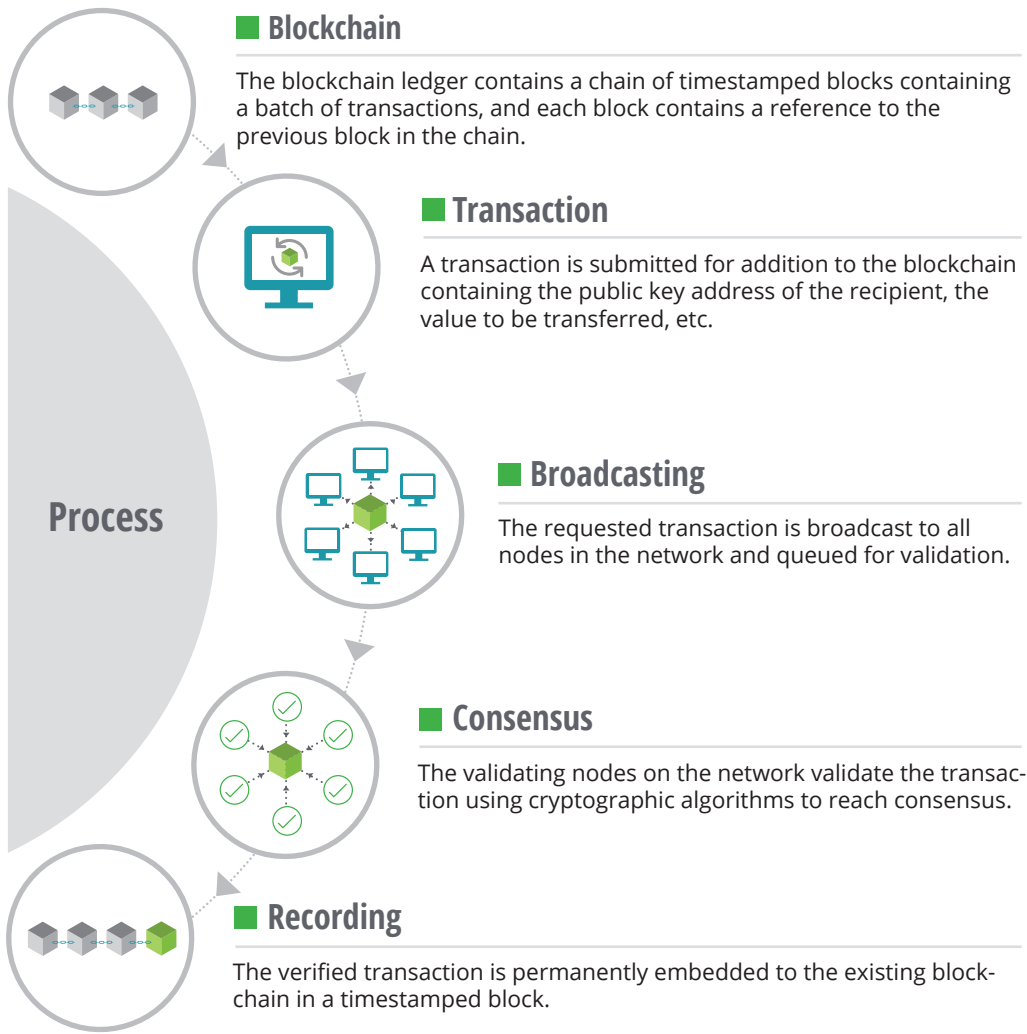
This article considers thought-provoking applications of the technology in both advanced and emerging economies, with potential implications for meeting electrification goals in the developing world. Development institutions and their stakeholders should be encouraged by the range of possibilities, and should consider blockchain as a foundational technology to enable future business processes.

WHAT IS BLOCKCHAIN?

Blockchain, at its core, is a technology that can facilitate transactions, or any transfer of value. It is a transparent and shared transaction ledger that can substitute for centralized general ledgers in most current accounting systems. Rather than developing this ledger on a typical, centrally managed database software, the database or ledger is replicated across other devices and confirmed by its participants. Each transaction is broadcast to parties subject to the transaction as it occurs, and certain devices work to build consensus about, validate, and record the transaction—after which it is irreversible (see figure 1). Due to this distributed, consensus-driven validation model, blockchain does not require intermediaries; each recorded transaction’s validity is evident to all on the chain. To better understand the technical aspects of blockchain technology, please refer to *Blockchain: A technical primer*.⁵

FIGURE 1

Understanding blockchain



Source: Deloitte Consulting.

How is blockchain improving access to electricity?

ELECTRIFICATION IS AN expensive process that faces both physical and financial challenges, such as the installation of power lines and costs associated with generating and transmitting power. Developers need to recoup the money they invest; countries and generators that trade power need confidence they will be paid; and regulatory bodies that oversee the sector need transparency to monitor transactions. Blockchain potentially offers approaches to address these challenges.

Bridging the financing gap

While developers and financial institutions have advanced innovative approaches to financing power projects, capital remains scarce for generation assets in developing markets. The main reason for this scarcity is that developers need long-term (15–20-year) power purchase agreements (PPAs) with creditworthy off-takers before they can obtain financing. In many developing countries, the off-takers are state-owned utilities, and, unfortunately for developers, capital markets do not typically consider these off-takers to be sufficiently creditworthy. As a result, development bank funds and donor guarantees buttress short-term development with the goal of improving utility creditworthiness over time. One innovative approach to expanding project financing sources is to allow local or international direct retail investors to purchase future energy production (either for resale or direct consumption) in the form of energy tokens—providing discounted capital now for energy delivery once the projects have been developed.

For example, WePower, a Lithuanian firm, is using blockchain technology to sell future energy

production from planned renewable generation to raise capital (see sidebar, “The cost of trust” for a further explanation of the business model).⁶ Developers market their future contracts through WePower’s online trading platform, and receive funds from investors in exchange for energy tokens that can be traded or used to receive power later as agreed. While the concept is like that of a more traditional PPA, WePower’s approach includes

THE COST OF TRUST

The problem: There are real costs and risks associated with state-owned, vertically integrated power system operators in developing countries. When developers seek capital, financiers typically charge premiums to access funding based on the risk profile of those system operators—premiums that may be prohibitively high, but are the cost of doing business in some markets. In April 2016, for instance, the Tanzania Electric Supply Company was US\$300 million in arrears in payments to its suppliers.⁷ That is a difficult environment in which to get projects funded: When developers don’t get paid, their investors don’t get paid, so investors typically stop injecting capital.

Looking to blockchain: Can the power sector intermediary as institutional off-taker and capital markets be decentralized? WePower is testing this idea. Its model in a developing world context would allow retail investors to fund projects by purchasing its coin, and allow for a network of distributed holders of those coins to become direct ratepayers to the project, circumventing centralized market operators.

two innovations. First, it “distributes” the PPA by tokenizing it, avoiding reliance on the utility on whose creditworthiness financial markets traditionally price a loan. Second, it liquidates the market for electricity, allowing WePower’s token purchasers to fund the project, and then sell the right to consume the electricity generated either to the end consumer or to a utility/retailer. Although initial coin offerings (ICOs) are as yet an imperfect and lightly regulated investment vehicle, one measure of WePower’s traction in the market is that it raised US\$ 40 million in a public ICO in February 2018,⁸ and it is currently exploring blockchain-enabled national-scale energy tokenization in Estonia. While WePower currently operates in Europe, its application may hold some promise for developing countries. As noted in the sidebar “The cost of trust,” any tool that helps displace the centralized and opaque system that is often present in developing countries has the potential to free up capital in otherwise capital-starved markets.

Enabling energy transactions

Most emerging markets need the kind of nimble electricity grid that exists in more developed countries—for instance, one that can effectively leverage highly energy-productive regions to power less productive regions in real time (for more information on the value of this functionality, see sidebar, “Fighting variability with nimbleness”). For example, India has set highly ambitious renewable energy targets that would result in great quantities of variable renewable energy generation, but the addition may prove to be problematic for the grid in those regions in which intermittent wind and solar resources are likely to dominate. Cross-regional energy trading may alleviate the intermittency issue because it allows a region whose production has dropped to purchase power from another to cover that deficit. Blockchain can provide a smoother, more efficient environment for this type of trading through programming logic known as a “smart contract”—one that leverages consumption and production data on the shared ledger to trigger automated transactions.

Smart contracts also offer an opportunity to automate the renewable energy certification process. The Indian Energy Exchange opened a market for Renewable Energy Certificates (REC) in 2015, but requires state and central agencies to participate in the accreditation, registration, and issuance of RECs—a time-consuming but necessary process. Smart contracts can not only automate this process, but also increase transaction speed, while creating an immutable record that supports REC authenticity and audit. In a blockchain ecosystem, state and central agencies would still govern and operate the system, but the smart contracts would facilitate more seamless and transparent transactions. It is worth noting that for the above-mentioned use cases to apply, grid infrastructure may need to meet minimum standards; blockchain’s facilitation of interregional energy trading and REC recordation may therefore better fit more advanced emerging markets such as India.

Trading automation and transparency can not only strengthen the existing grid, but may also lower operational costs generally, and particularly for isolated small or rural microgrid solutions (for an explanation about the value proposition of

FIGHTING VARIABILITY WITH NIMBLENESS

The problem: Countries such as India are in the process of installing large quantities of variable renewable energy generation onto its still maturing grid. The additions add stress to existing grid operations, as unexpected dips in wind or solar production tend to require last-minute dispatch of conventional energy.

Looking to blockchain: Grids in emerging markets are often extremely regionalized. Enabling peer-to-peer energy transfer between regions to balance renewable energy ebb and flow can mitigate the stress variability causes. Smart contracts that leverage open-ledger production data offer one potential solution to help even variability and drive overall grid stability.

blockchain applications in microgrids, see sidebar, “The grid edge”). Traditionally, microgrid developers often struggle to find an attractive return while providing reasonable electricity prices. Innovative entrepreneurs active in emerging markets are driving blockchain-based scalable solutions. Companies such as LO3 are testing peer-to-peer trading on a microgrid scale in neighborhoods within New York City,⁹ and Power Ledger is working to deploy a similar solution in India’s urban areas.¹⁰ This peer-to-peer trading deploys blockchain-based smart contracts that automatically net out production and consumption across a microgrid. This type of automatic settlement between a microgrid’s peer consumers and peer producers reduces the microgrid’s operational costs; keeping costs down is particularly important in developing countries where profit margins are often low. Both LO3 and Power Ledger offer potentially promising new technology, but after proving the concept, they will need to champion regulatory reform, whether at state or provincial-level governments, such as in New York, or even nationwide in a country such as India.¹¹

Bankymoon is exploring another innovative approach in South Africa; the company is enabling

THE GRID EDGE

The problem: Extending electrification to the least served has been a persistent problem in many developing countries. Smaller and less affluent populations’ usage rates and ability to pay often do not allow utilities to recoup the capital-intensive costs of the additional generation, transmission, and distribution capacity required to extend the grid.

Looking to blockchain: Microgrids and solar home systems are rapidly becoming cost-effective. Solutions such as peer-to-peer trading can reduce operational costs with blockchain-enabled automated settlement; prepaid meters can be built to accept cryptocurrencies, widening the rate-paying base.

pre-paid meters for isolated solar home systems or rooftop power generation.¹² Installing pre-paid electric meters can ensure that suppliers recoup their capital expenses since consumers pay for what they use in advance. Further, Bankymoon enables its pre-paid meters to accept digital currency payments, which allows individual donors worldwide to pre-pay for electricity usage by Bankymoon-metered schools and other social institutions. Those payments are, in turn, settled automatically through blockchain-enabled smart contracts.

Unleashing radical transparency

In emerging market power sectors, opaque rule setting, poor compliance by utilities and other market participants, and insufficient regulatory oversight can deter investment. Where regulatory oversight is effective, costs of compliance can be a hardship for market participants. Poor transparency can present opportunities for corruption, one of many hidden costs that can damage a generation project’s profitability. Even the best-intended regulation in emerging markets can fall prey to a market’s lack of standardized processes, lagging IT systems, and concerns about inappropriate influence by special interests. The uncertainty often leads project developers to demand high premiums for projects to move forward; many simply do not advance.

Although currently (as of mid-2018) there are no known use cases for blockchain-enabled regulatory reporting in the energy sector, financial services sector participants in Europe recently implemented a proof-of-concept called RegChain.¹³ RegChain helped industry participants not only reduce the administrative investment and costs associated with regulatory reporting but also improve compliance and increase transparency among participants, by means of capturing transactions and managing reporting requirements through smart contracts. Using RegChain, compliance procedures are automated for industry members and the processes and

SHINING A LIGHT

The problem: The perception of corruption, arbitrary rulemaking, and the corresponding market and black-market costs of compliance seem to be some of the most oft-cited reasons for the lack of energy sector capital investment in emerging markets.

Looking to blockchain: Open ledger technology offers a radical view of what the future of regulatory oversight could look like: open. Transparent industry data on a blockchain and smart-contract-enabled automated compliance can lower both the cost of compliance and the risk of graft, opening these markets to greater investment.

procedures are auditable by regulators.¹⁴ Automated reporting to regulators could have broad implications, but one of the most powerful could be the ability to turn developing countries' power sectors into data-rich rather than data-poor environments. Strengthening regulatory oversight while driving better real-time response to power sector challenges could benefit citizens, power market participants, and investors alike across emerging markets.

Evaluating blockchain's potential in emerging markets

WHILE BLOCKCHAIN APPEARS to have tremendous potential for developing country power markets, the technology is not necessarily appropriate for all uses. Stakeholders should keep in mind the following factors when considering developing country blockchain applications:

- **Building a consortium:** In emerging markets, developers, utilities, operators, regulators, and customers often operate in an opaque system. Most participants are not aware of others' activities, with reports on energy sector transactions due only quarterly at best, or even annually. Much of blockchain's value rests in the technology's ability to provide transparency while maintaining transaction security—both of which are not currently available in many developing markets. While transparency and security represent a long-term net gain for all participants, that gain likely requires major short-term investment to establish the necessary level of cooperation to set up a blockchain-driven system. Building these systems, or consortia, require stakeholders throughout the entire value chain to understand local market stakeholders' positions, as well as local policies, rules, and regulations that govern the energy sector.
- **Designing with scale in mind:** While blockchain solutions may provide value at all levels within the power sector—from microgrid to regional cross-border trade—broader blockchain applications will likely have greatest impact on existing systems that are already in place. Blockchain adopters will need to decide whether to develop lower-cost local or national systems that will require future integration into a larger regional framework, or incur the significant upfront cost associated with developing a comprehensive system that will work across borders and regions immediately. The historical spread of networking innovations suggests that local and national systems may develop before cross-border regional solutions. Some markets will recognize outsized value from blockchain solutions early; others will lag. Eventually both will likely integrate into regional systems; international development institutions should reflect this reality in their planning and build a vision of distributed ledger technology to support this transition.
- **A continuing need for centralized utilities:** Most countries envision a more nimble and distributed power grid, but the reality is that centralized utilities will likely continue to meet most electricity needs. Centralized utilities should explore how blockchain solutions can benefit them before they agree to advance IT modernization, train staff, and invest in IoT technologies required to implement blockchain. Centralized utilities are increasingly vulnerable to catastrophic cyberattacks; the December 2015 Ukrainian power grid hack provides a sobering example.¹⁵ Designing the system with blockchain in mind can help mitigate security vulnerabilities and help provide consumer data privacy. Successful blockchain solutions could incentivize utility participation—along with that of other market stakeholders—and demonstrate the potential for utilities to streamline operations and reduce costs.
- **Attracting capital:** Potential investors may be skeptical of applying a nascent technology such as blockchain in an emerging market power



sector context when it has not yet found widespread applicability in more sophisticated power markets. That skepticism, however, is likely informed by the traditional notion of an optimal power market—featuring centralized administrators and clearing houses dispatching power from base load assets requiring 30-year fixed investments. Forward-thinking venture capital investors, along with financial institutions with a development mandate, could re-envision this status quo and leverage the opportunity in *unbuilt* environments to test what a more decentralized, nodal, cleaner, and networked grid might look like, and more specifically, which pilot projects might advance this vision.

What next?

THESE CHALLENGES NOTWITHSTANDING, blockchain appears to have the potential to help overcome obstacles that keep millions of people in the dark worldwide. To get started, development practitioners can chart out an implementation road map to help solutions grow in scope, scale, and complexity (for more details, read *Blockchain to blockchains: Broad adoption and integration enter the realm of the possible*).¹⁶ We recommend that development institutions consider this road map to progress from use case, through proof-of-concept, to ultimately scaling blockchain solutions in their countries of interest.

Use case: As this article illustrates, blockchain power sector applications seem nascent in all markets, including emerging markets, with many more opportunities likely to come. Development institutions should engage developers, utilities, operators, regulators, and customers broadly to help understand where business challenges can be disrupted by blockchain solutions, and build an entrepreneurial environment that can deliver more impact, for lower cost, at a sustainable scale.

Proof-of-concept to pilot: As the first solutions reach market, the role of international

development institutions could change from building local capacity and understanding to establishing a sustainable enabling environment along with advancing solutions that align with development goals. Providing support through pilot tracking, collaboration on standards, and retrospective analysis can provide early entrepreneurs with access to essential data and training to make informed decisions, as well as an understanding of the nontechnical components required to successfully deploy a blockchain application.

Scale: If and when pilots have proven the technology, it will be time to grow. Here international development institutions could be well-positioned to provide value in establishing consortia across the power sector with robust membership, leadership, funding, and governance given their penetration in emerging market power sectors.

Development partners may have different roles to play at each stage along the road map, as defined by the consortium's operating model. With their intervention, blockchain has the potential for tremendous impact on bridging the financing gap, enabling energy transactions, and unleashing radical transparency in the power sector.

Endnotes

1. Jason Deign, "15 firms leading the way on energy blockchain," Greentech Media, October 27, 2017.
2. Ian Allison, "EDF Energy and Shell join Electron's blockchain energy consortium," *International Business Times*, February 2, 2018; Kevin Stark, "In Illinois, blockchain startups seek to work with utilities on grid software," Energy News Network, April 25, 2018.
3. The World Bank, *State of electricity access report 2017 (vol. 2)*.
4. The New York Public Service Commission's Reforming the Energy Vision initiative offers an example of how much work may be involved in such a reform effort.
5. Deloitte Insights, *Blockchain: A technical primer*, February 6, 2018.
6. BusinessWire, "WePower selected as one of Fast Company's top 10 most innovative companies in energy for 2018," February 20, 2018.
7. International Monetary Fund, "Tanzania: Letter of intent, memorandum of economic financial policies, and technical memorandum of understanding," June 28, 2016.
8. BusinessWire, "WePower raises \$40 million for blockchain-based green energy trading: The largest ICO in the energy space ever," February 2, 2018.
9. Diane Cardwell, "Solar experiment lets neighbors trade energy among themselves," *New York Times*, March 13, 2017.
10. *Economic Times*, "Tech Mahindra and Power Ledger to conduct tech trials in microgrid-as-a-service," September 29, 2017.
11. Robert Walton, "Grid complexity is increasing exponentially. Is blockchain the answer?," Utility Dive, February 4, 2018; Jennifer Bisset, "Blockchain helps us take green power into our own hands," CNET, May 23, 2018.
12. Christoph Burger, "Blockchain and smart contracts: Pioneers of the energy frontier," *International Business Times*, December 15, 2017.
13. Deloitte, *RegChain reaction: Revolutionary reg. reporting in the funds world*, 2017.
14. Ibid.
15. Kim Zetter, "Inside the cunning, unprecedented hack of Ukraine's power grid," Wired, March 3, 2016.
16. Eric Piscini, Darshini Dalal, David Mapgaonkar, and Prakash Santhana, *Blockchain to blockchains: Broad adoption and integration enter the realm of the possible*, Deloitte Insights, December 5, 2017.

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