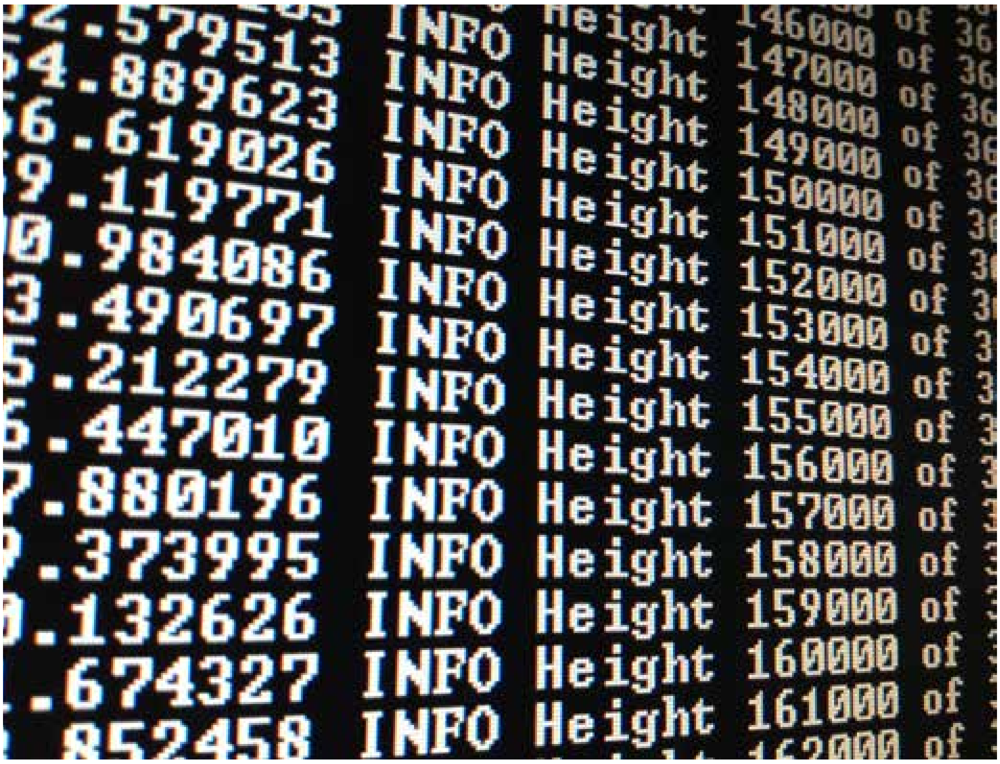
Look beyond the hype: to really disrupt the energy world, we need a Yin to blockchain's Yang

Smart grid | Blockchain technology is being touted as the next big step forward in the digitalisation of the energy system. But storage and storage management software are the critical pieces of the puzzle needed to maximise its potential, writes Carsten Reincke-Collon



Credit deavmi/Wikimedia Commons

Not a day goes by without another article, conference, LinkedIn post or tweet, praising the revolutionary nature and countless blessings of introducing "blockchain" into the energy sector. And yes, the technology behind the Bitcoin cyber-currency has the potential to fundamentally alter the way energy is being procured and traded. But for all its potential, blockchain is, and always will be, limited to the purely commercial aspect of any energy transaction. To be truly transformative, the $-bits need to be matched by software that links it the other side of the proverbial energy coin: the physical world of electrons.

What blockchain does do is bring the market much closer to the electrons – and thus the economic and physical dimensions of the energy world closer together. Remember that essentially the energy world is split in two. First, it has a physical dimension, in which electricity is being generated and distributed through an infrastructure we call the power grid. For electricity to be transported safely, this grid must be kept in balance at all times, which essentially means that power production needs to equal load demand every instance.

On the other hand, there is a market – or some other arrangement – by which those that consume power pay for its production and safe transport. Generally, payments are made to a utility. This utility in turn either produces power or procures it – and, depending on where you are in the world, either pays a grid operator or maintains grid stability itself.

Blockchain has been greatly talked up for its use in the future energy system

Today, the commercial transaction is only very indirectly linked to what happens in the physical world. That's because electricity is essentially being traded via the great "ocean" that is the grid. Yes, producers feed an agreed amount into that ocean at any given time, typically in hourly intervals, and consumers pay for the amount of energy they use, but it's impossible to say where the kilowatt-hour (kWh) of power that just kept your lights on really came from. Most likely it just comes from the closest power plant.

Blockchain changes that – to a degree.

The ABCs of blockchain

What is blockchain? Well, it's basically a continuously growing list of records, or "blocks", which are linked and secured using cryptography. Each block typically contains a link to a previous block, a timestamp and transaction data. That makes blockchains inherently resistant to modification of the data.

A blockchain can serve as "an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way" according to the Wikipedia definition [1]. "For use as a distributed ledger, a blockchain is typically managed by a peer-to-peer network collectively adhering to a protocol for validating new blocks. Once recorded, the data in any given block cannot be altered retroactively without the alteration of all subsequent blocks, which requires collusion of the network majority."

Blockchain became famous as the technology behind the Bitcoin digital currency. But its decentralised nature, fault tolerance and security also make it suitable for many other applications, ranging from identity management to food traceability.

Energy trading is a great fit too. Blockchain allows for the creation of an automated trading platform that links producers and consumers in real time and lets them engage – via "smart contracts" – in a (quasi-) direct transaction.

The electrons thus sold still don't go straight to the buyer, but both parties know that at the (exact) time in question, one party is producing just the amount of energy that the other party needs. Provided both parties are also physically close (which is a big if), this transaction has relatively little impact on the grid.

As almost all contributions on the subject point out, blockchain has the potential to make a utility redundant by enabling consumers and (independent) producers or prosumers to trade directly without any intermediary.

While it's hard to argue with that, sceptics try to temper the hype around blockchain by pointing to (i) the volume of data storage required, (ii) the correspondingly huge requirement for energy that would be needed, as well as (iii) the absence of any industrial standards. There's also the ubiquitous complaint that "the current legal and regulatory framework in no way matches the requirements of a decentralised energy grid".

And, indeed, at present the energy aspect of blockchain is, unfortunately, a reality. To be disruptive, blockchain will have to become a lot leaner: right now a single transaction "costs" the equivalent of a full charge of an electric vehicle. Obviously, "paying" in energy the equivalent of a full Tesla charge is not sustainable. But the good news is that there are many promising avenues to significantly reduce the energy cost of using blockchain in grid transactions. It's much easier to limit and validate participants, for instance. Given sufficient interest, it seems certain that blockchain will scale – just as emails did – even though there were many that warned sending an email would prove to be much costlier than sending a fax [2].

Blockchain's stumbling block

There is a much bigger obstacle out there, however, that gets far less attention. Someone – or something – needs to make sure that the energy being transacted actually moves from A to B – and that it doesn't tear down the "roads" it travels on, i.e., the grid, in the process. So, yes, blockchain might make the utility superfluous – but only insofar as the utility acts as a commercial intermediary between consumers and producers. While blockchain brings the physical and the economic dimensions of electricity much closer together, it doesn't – and will never – "fuse" them in any shape or form, even if some would have us believe that.

To truly link kilowatt-hours to dollars (or euros or renminbi) in the same virtual dimension, another piece of equally ingenious code is required: energy management software in general – and energy *storage* management software in particular.

Why? Think about it: in a way, the ability to store something has always been a pre-requisite for trading it. If you have to pass the "hot potato" immediately, you're not in a very good position to make demands about price. In fact, that's the reason the shortest interval in energy markets today tends to be 15 minutes – because that is exactly the time it takes a (warm) gas turbine to power up to cover added demand. In deregulated energy markets, anything less than 15 minutes is usually organised in balancing markets or through "re-dispatch", where those resources that – either via power up or down – provide short-term grid stability get compensated by some type of grid operator or regulator. In monopolies, the incumbent utility balances supply and demand directly, but of course that's not really a market at all.

> "The real value of storage and distributed energy resources management systems software is that they enable applications like blockchain-based trading"

Gas turbines used to be the fastest units in the energy system. But just as email has replaced fax machines, we now have much faster units for moving energy. The power electronics embedded in solar PV and wind turbines allow for partial – that is, "downward" or limiting, but nonetheless real-time – control of these decentralised clean energy generation assets. Add battery energy storage to that mix and it becomes possible to balance short- and medium-term fluctuations within milliseconds, and do so fully automatically.

This ability to effectively stop and control electrons or, in more common terminology, store them, enables us to trade energy in real time. Unless you can "hold back" power in some way, you're required to sell it (or lose it) at the moment it's produced. Conversely, if you don't need to sell at the exact moment you produce, you have a lot more control over the market. This flexibility allows you to exactly match a given customer's demand profile, for example, and likely extract a higher price for such precise targeting and delivery.

Of course, having this level of control in turn requires software that manages both the storing and provision of power within milliseconds. But that is only the beginning. The real value of storage and distributed energy resources management systems software (DERMS) is that they enable applications like blockchain-based trading in the first place. DERMS provides blockchain applications with an interface into the physical world, which they need to translate the cyber revolution into the real world. DERMS is the Yin to the Yang of blockchain – or indeed any other automated energy trading protocol.

Both technologies, or rather types of software, have high value in and of themselves. But only when you take them together can they become truly disruptive – and dramatically increase the efficiency of how energy is being supplied. Put these pieces of the puzzle together and it becomes possible to trade energy peer-to-peer and keep the grid stable at the same time. That combination, indeed, has the potential to set off a "chain" reaction that will transform the utility industry.

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References

[1] See https://en.wikipedia.org/wiki/Blockchain
[2] see http://www-formal.stanford.edu/jmc/harmful.html

Blockchain in action: stabilising the grid in Germany and the Netherlands

Case study | Blockchain technology is being put to the test in northern Europe, writes John-Baptiste Cornefert

A quick view into the future: it is the year 2030 and Paul, a homeowner with his own photovoltaic system and battery storage, checks his electricity bill. His neighbour Sam got 12kWh of solar power from Paul's house roof today. Amanda, the elderly lady a few blocks away, has consumed 5kWh of solar power from Paul. Both charges Paul sees on his online portal. The transactions are registered with a blockchain and the compensation is immediately credited to Paul's bank account.

Those energy transactions happen thousands of times every second, and are continuously and consistently registered on a myriad of single computers around the world with a blockchain. A blockchain is a database that is organised decentrally. A main server that stores all operations is no longer needed. All distributed computers store the information that Sam got 12kWh of solar power from Paul. After a certain time, all accumulated information is then combined into a block and provided with a kind of checksum. This checksum is then included in the data of the next block. This makes the blockchain very secure against subsequent manipulation. If an individual transaction is subsequently modified on a computer, this is immediately noticeable because a whole chain of checksums is no longer correct.

For the energy supply of the future, the blockchain is the key technology. It digitally links up millions of decentralised generators of clean energy and documents their output, even at the smallest level between Paul's PV system and his neighbour Sam.

Finally, Paul produces and consumes his electricity himself and sells the surplus energy that he does not need himself. Miles of transmission networks that transport electricity over long distances are needed in a much lower scale.

Electricity is more and more being produced in decentralised and climate-friendly ways. Instead of individual large power plants, energy is generated where it is being consumed: for example on private houses with photovoltaic systems. Of course, there are also wind turbines, on land and at sea, hydroelectric power plants and biogas plants. All contribute to the sustainable electricity mix that supplies society, industry and consumers.

This decentralised generation has a positive effect on our energy system in many ways. Electricity is produced and consumed directly or stored in batteries for later use. As a result, the necessary basic supply in the power grid is drastically reduced, which in turn means only a few central power plants are needed.

Nevertheless, the switch to renewable energy also has its own challenges. A nuclear or coal-fired power plant can theoretically deliver constant power around the clock. Wind and solar power, on the other hand, are influenced by external circumstances. If there is a lot of sun, the share of solar power is correspondingly high. At night, this will disappear completely. Wind energy depends on the weather. This wind is sometimes constant, sometimes it fades and in a storm, a lot of electricity is produced.

Such fluctuations are referred to in the jargon as volatility. The energy transition, and thus the change to a decentralised supply, is still a few years away. But the more renewable energy is integrated into the electricity mix today, the greater the need for solutions, so-called grid services, for this new form of electricity production.

A pilot project for offering grid services in whole new way has just started in Germany. In a cooperation between IBM, German transmission system operator, TenneT, and battery supplier, sonnen, decentralised home storage systems are being integrated into the power grid with a blockchain for the first time.

What does a grid service via blockchain look like? Imagine a windy day over the North Sea that makes the wind turbines in the area rotate heavily and produce large amounts of electricity. Now there are two problems: the power consumption in northern Germany is not high enough to take all that electricity. Secondly, the power lines to southern Germany or other parts of Europe are not strong enough to transport that huge excess of energy. To bridge that bottleneck the grid operators have to act with the so-called 'redispatch'. Usually they turn off the wind turbines in the north and activate gas or coal fired plants in the south for keeping the balance.

Credit TenneT

German TSO, TenneT, is one of the partners in the blockchain trial

The pilot project with TenneT and sonnen has found a new approach. If too much wind energy is produced in the north it is stored in the virtual connected battery storage systems in that region. At the same time, decentralised storage systems in the south discharge energy into the grid for compensating the lack of energy from the north. So the bottleneck is bypassed via a virtual power line that is by the way the first green solution for the redispatch.

The amount of energy each individual decentralised battery has charged or discharged is registered and stored by a blockchain. The process starts automatically within seconds, no phone calls between grid operator and power plants have to be made. The collected information is encrypted and stored on thousands of computers. Every participating party, such as storage providers or grid operators, has full access to all data, making it very transparent.

sonnen is providing its virtual battery pool that can deliver exact forecasts how much energy will be available in a certain region and within a certain time.

For the grid and society, this form of redispatch has significant advantages. On the one hand, the decentralised storage units are already available to homeowners and serve as a battery for their own energy supply. In addition, all people benefit. Less wind energy has to be wasted and the costs for grid operations like the redispatch can be reduced significantly.

In addition to their own, clean and free electricity production, the individual owners of the storage are looking forward to additional revenue they can obtain by participating in those scenarios.

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