# GBBC Open-Source Ideas:

# Global Energy

## Part I: Blockchain Technology in Energy Markets:

## Spotlight on Power Ledger

**28 January 2021**

**Perth, Australia**

***"I always prefer the creative solution to an expensive solution."***

***Keenen Ivory Wayans***

## Introduction

About two years ago, a company based in Hicksville, New York best known for selling iced tea changed its name to the Long Blockchain Corp. The stock value of this company rocketed up 275 percent even though it planned to maintain iced tea as its principle offering.[1]

This was blockchain mania at its height. Like the California gold rush in the 19th century or the dot-com bubble at the turn of the millennium, it tells us much about the psychology of humans when dealing with the heady mix of new and exciting things, combined with the chance of making easy money.

Part of the legacy of blockchain mania is skepticism; many will question whether a product really needs a blockchain in its system. After the hype, false promises, and disappointment of so many projects birthed during blockchain mania, one cannot blame skeptics for asking: "Why don't you just use a normal database in this application?" This report will explain why blockchain is such an important component in the Power Ledger system, and why a normal database would not suffice. In other words, why Power Ledger took the 'creative' blockchain route rather than the traditional route.

### *Power Ledger and Blockchain*

To understand Power Ledger and blockchain, we first must offer a brief explanation of what Power Ledger's platform does. One of Power Ledger's features is a peer-to-peer (P2P) energy sharing platform for people to trade their excess solar power with each other. Individuals cannot easily store electricity, making transferring their excess energy to someone who needs to use it a better option. This is part of what Power Ledger offers: P2P sharing to optimize the management of a grid.

There are many reasons why blockchain plays such an important part in the Power Ledger system, let us examine them one by one.

### 1. Exchanging value over distance

When ordinary homeowners trade their rooftop solar power, they are effectively disintermediating energy companies. That means the job of billing many thousands of low value transactions falls to Power Ledger. This use case — exchanging value and transmitting it over a distance — is a classic one for distributed ledger technology (DLT).

[1] https://www.bloomberg.com/news/articles/2017-12-21/crypto-craze-sees-long-island-iced-tea-rename-as-long-blockchain

2. **No one wants to become a centralised authority**

Power Ledger does not want to become a centralised authority, subject to annual audits and compliance with old fashioned financial organization and its annual headaches.

3. **Security**

The reality of dealing with a large number of public accounts is all too sobering for classically configured blue chip energy corporations, who are sitting targets for hacks. DLT can protect the platform when it is targeted by a hack, including a distributed denial of service (DDOS) attack.

4. **Frictionless trading**

If each transaction costs a certain amount to log, and there are numerous low value transactions (sometimes over 600 per second) in P2P solar electricity trading, total financial losses accruing over a period will be significant.

5. **Scalability**

Business scalability is the holy grail for entrepreneurial ventures, and this ultimately depends on the solution's scalability. Therefore, Power Ledger was keen to find a highly scalable solution. For example, using a regular database guarded by high trust people in a well-regarded accountancy might sound like a good alternative.

Better scalability applies as you build not just a dedicated application, but a whole platform or suite of solutions working together in a trustless environment. For Power Ledger, using blockchain was unquestionably the better and more scalable route in the long term.

6. **Instantaneous settlement**

Instantaneous settlements and transparent transactions, both contributing to higher trust in the system, are increasingly important. Transparent transactions also reduce various regulatory concerns, meaning Power Ledger can focus on its core service.

7. **Transformation**

Perhaps with all these benefits it is possible to lose the real meaning and value of building blockchain-enabled systems. Power Ledger sees blockchain and P2P sharing as analogous to a barcode scanner in the supermarket. A barcode scanner does not define a supermarket, which is a shop with a high-volume, low-margin model of business. Instead, barcode scanners facilitate higher volumes and lower margins and help supermarkets function. You do not need to have barcode scanning to make a supermarket, but it certainly helps.

This is the case for P2P peer sharing of rooftop photovoltaic energy and blockchain technology. You can theoretically have one without the other, but together they work synergistically.

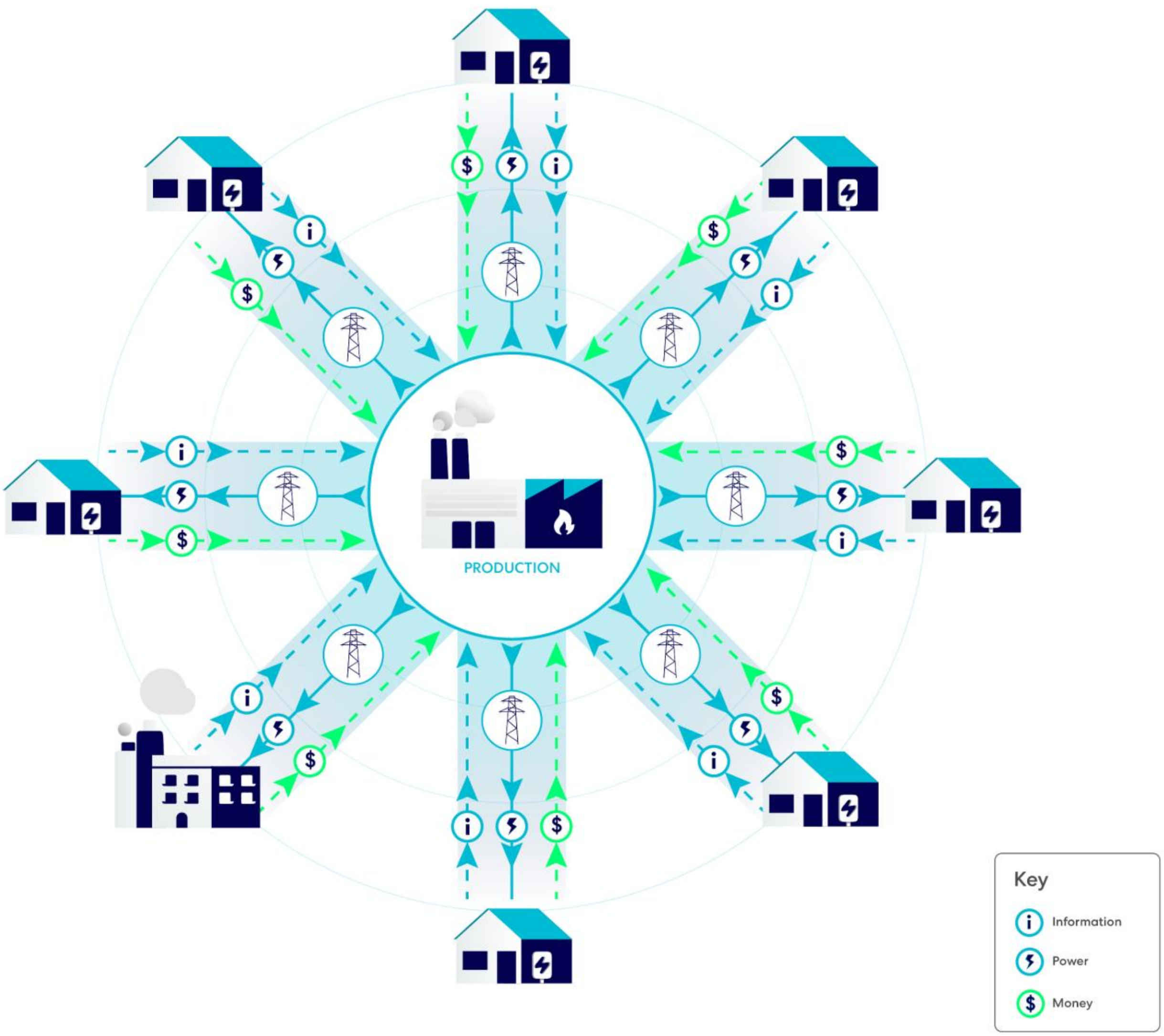
In the following report we will further explore how blockchain technology helps facilitate transparent, disintermediated, and distributed platforms for energy systems.

## Blockchain, money, energy markets and the grid

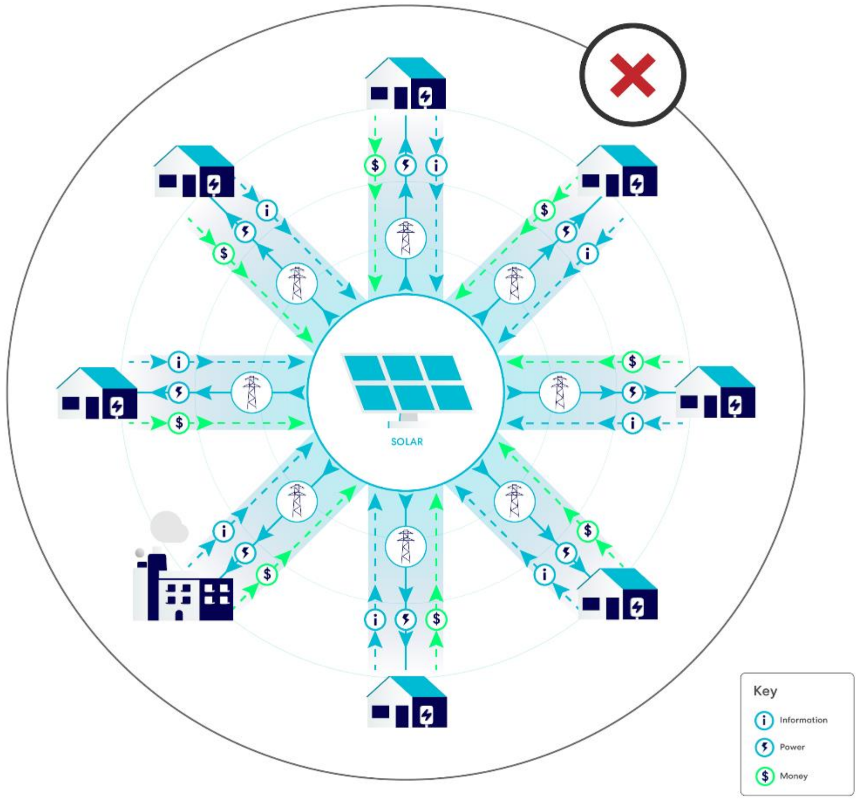
To fully understand where transactions of value are involved in the energy business, you must first understand something of the electrical workings of the grid, both old and new. What follows is a high-level introduction to the architecture of the grid, and how it is set to change.

### *Decentralising grids*

The old grid revolves around a relatively simple paradigm: a central dispatchable generator of energy at the centre of a system of peripheral users.

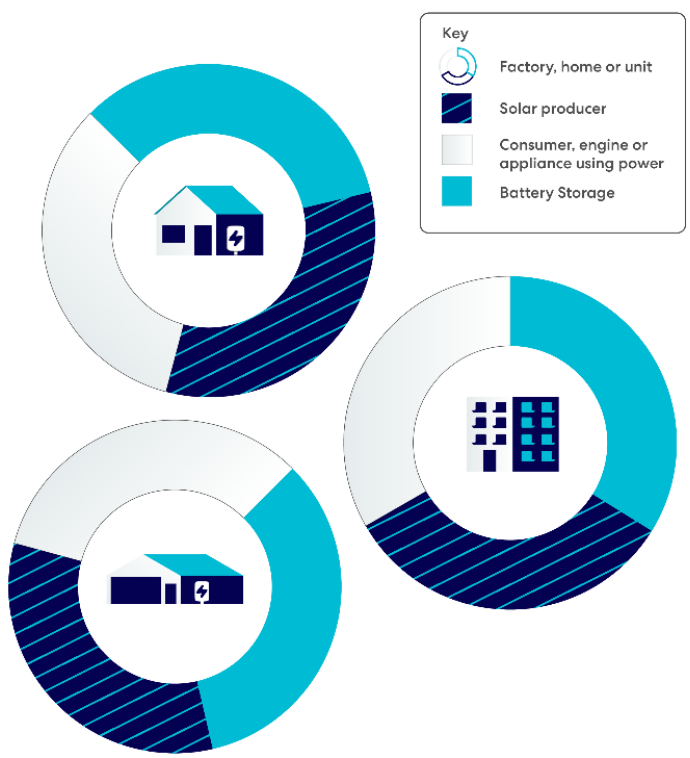


When the generator in the middle is substituted with forms of renewable energy like wind turbines and solar panels it soon becomes clear that it is necessary to change more than just a few wires, regulators, and transformers. To take full advantage of new sources of energy, one must rethink the entire architecture of the grid.




The reason for that is simple: renewables produce highly variable outputs. Some days there is too much power and some days there is almost none. The traditional grid architecture of a central hub (producer) and spoke (consumer) simply does not work, being that the hub requires near 100 percent reliability. Without the reliability, it is not a successful hub.

Instead, to facilitate renewables, a different architecture must be employed. The new architecture revolves around a set of distributed cells; this distributed structure manages the vagaries of renewable sources. These distributed cells could be homes, factories, universities — any entity which is engaged in creating, using, storing, and transmitting power.




This cellular unit might have an array of solar rooftop photovoltaic cells, some battery capacity, and some load that it runs from this capacity. This is the basis of P2P sharing, in which different cells transact power with each other.

In this cellular structure it is possible to create properties that arise out of the aggregation of the entire network. These include the shifting of demand for power by organizing various loads to come on at a different times in response to the supply (Demand Response, or DR).


It is also possible to shift supply. Provided there is sufficient battery capacity in the system, the system can store electricity for later. By shifting demand and supply it is possible to match up supply and demand so there is never a surplus or a shortage of electrical power.

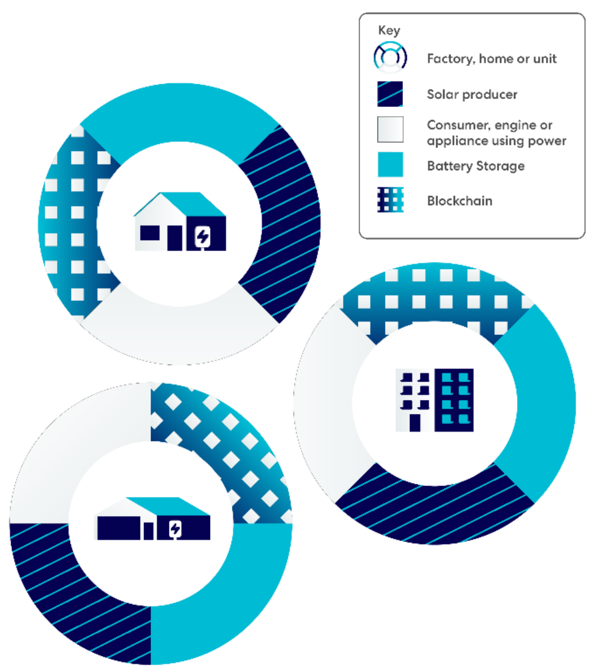
The shift from hub and spoke architecture to a distributed, cellular architecture also necessitates a change in financial transactions, which will be described in the following section.

***Decentralising financial structures***

The centralised nature of traditional energy systems is further reflected in their financial structures: centralised generator-retailers (known as "gentailers") have complex deals with banks, must put up bonds to show they are good for cash, and must be auditable by centralised authorities. Everything in this paradigm is centralised hub and spoke architecture, without exception.

When this financial trust architecture switches from hub and spoke to cellular, and consumers become prosumers, no individual cell has enough financial probity to act as a bank.

The trust instead must come from a network of cellular elements acting together. In this case they are known as "nodes," and this is the reason blockchain becomes an important part of the decentralised grid. Blockchain facilitates a trustless way of doing business in which small players can come together to create a system that is even more trustworthy than a traditional bank.




In addition to the solar panels, batteries, and electrical loads, each cellular unit's data and transaction is written to the blockchain. The blockchain has many nodes and each can be thought of as a decentralised back office billing unit and bank, responsible for handling and validating all the transactions, with their own built-in audit system.

In the next section, we look at the main four services that are emerging in the new grid architecture.

## **Four Power Ledger transactions that use blockchain**

The grid and blockchain work together in four transactional services:

1. Peer-to-Peer Energy Trading
2. Virtual Power Plant and Flexibility Services
3. Power Purchase Agreements
4. Renewable Energy Certificates

### *1. Peer-to-Peer Energy Trading*

In the old system Alice would buy some power from the grid and pay for it at the end of the month in fiat currency. She would have an account with the gentailer, and money would come out of her bank account as some sort of direct debit to pay off her electrical account. But not anymore.

In the new P2P system, Alice, who has a pool that needs electricity for its pump on a particular afternoon for a particular 15-minute session, buys electricity from Bob, who has solar panels and is out that afternoon. He has no need for those kilowatt hours at that time, and his power account is happy to trade with Alice's power account.

Bob sends Alice the electricity, and this is part of a smart contract[2] whereby Alice pays Bob in cryptocurrency. For example, this might be done in POWR, Power Ledger's brand of cryptocurrency, with the transaction recorded on the blockchain.

Neither Bob nor Alice need to go through a bank, because the blockchain makes banking via a central organisation redundant. The transaction between Alice and Bob is also recorded on other nodes, like those of Charlie, Dan, Ella, Frank, and Gary. These could be people on the electrical network or just people on the same blockchain system. The sheer number of nodes make it difficult to forge or tamper with transactions, which creates trust. Because each of these nodal players observe, record, and check the transaction between Alice and Bob, no central entity is required: the system is self-auditing.

Because the process is totally automated, there are no significant costs associated with carrying out a transaction. This is important because Alice, with her 15 minutes of pool pump usage, may have only carried out a transaction worth a few cents. If this were to be processed by a bank, bank charges would eat up much of the value of the transaction. This speaks to the primary reason for using blockchain in this space: while all transactions could be done using a central billing agency, the banking charges of transactions would inhibit renewable energy from being feasible.

[2] Smart contracts are automated contracts that, in this case, execute payment when certain conditions are met.

## 2. *Virtual Power Plant and Flexibility Services*[3],[4]

In the old system, electrical demand generally follows well-established patterns based on time of day, season, etc. To the extent that these patterns are known, the grid can plan for them using its main generators. In the pictures of old, these are men in boiler suits checking voltages and turbine speeds and adjusting levers. To the extent that demand "fly ups" are unexpected, special gas turbines (i.e. fossil fuel-powered generators, called "peakers") are kept on hand to provide booster amounts of power that fill in the gaps.

These short-term pieces of generation are essential to maintain the stability of the grid and are governed by a patchwork of contracts that have been established to provide this service. In any electrical grid, the shortage and surplus of electricity manifests itself as several metrics that come in and out of their prescribed limits and must be monitored constantly. Even short outages can be highly damaging. Too little power going into the grid, or too much coming out of it, creates a lower frequency of alternating current, reduced voltages, and introduces a phase difference between voltage and current. This results in lower power being delivered and requires extra power to be injected into the system. Conversely, too much power going into the grid, or too little being drawn, leads to a higher frequency of alternating current[5], higher voltages and reverse flows of power.

Both scenarios can damage equipment and cause chaos, and in the old grid different metrics became the subject of different contracts with different suppliers responsible for maintaining the metrics within their limits. Maintaining these metrics is generally a highly lucrative service, and plenty rides on getting them right. In the old system, companies (like Drax in the UK) maintain grid frequency at 50 Hz, plus or minus just 1 percent.

The new decentralised grid achieves the same result as the old peakers by using an aggregation of batteries and solar-derived electricity, also known as "synthetic frequency control."[6] What is called a Virtual Power Plant (VPP) is really decentralised aggregation. Frequency stability can also be achieved using the inertia of the rotors in a wind farm. Whatever the technology to stabilise frequency, congestion levels, and voltage, there will be contracts specifying performance. There will also be payments to people and groups of cells willing to perform those services, which are known in the electricity industry as *flex* services.

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[3] https://www.drax.com/energy-policy/need-whole-country-frequency/

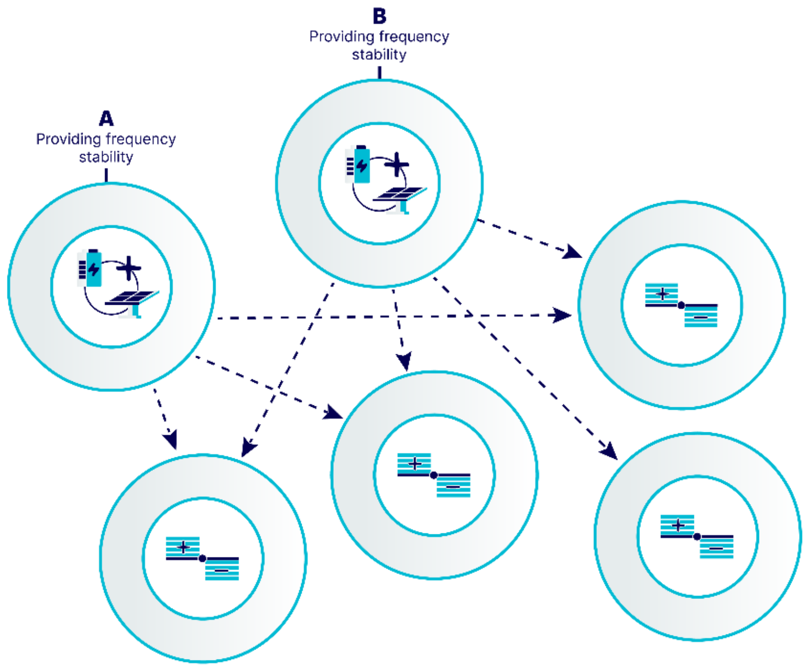
[4] https://www.drax.com/technology/what-are-ancillary-services/

[5] An example is the UK National Grid's recent Enhanced Frequency Response tender, which asked for a solution that can deliver frequency stabilisation in under a second – 20 times faster than the Primary Response provided by existing thermal power stations. Drax was the only participating thermal power station, however all contracts were all won by battery storage projects.

[6] https://www.drax.com/technology/shock-absorbers-keeping-grid-stable/

In the diagram, cells A and B are guaranteeing stability for the other cells. Once again, the back-office verification and accountability of the transactions and payment for these contracts are provided by a blockchain system.

In the new architecture, there is no centre of frequency stabilization, just as there is no centre of payment or centre of generation. Every aspect of the grid, whether it be money, trust, information, power, or frequency stabilisation itself has become distributed.




It is also worth noting that the distributed grid will see larger price fluctuations than the old grid ever did, due to a more elastic price that reflects supply and demand. This elasticity will help maintain the supply of electricity when there is too much or too little. Somewhere between demand shifting, battery storage, inertial systems, and elasticity of price lies the work of stabilization. It is Power Ledger's contention that elasticity of price will be an important factor in facilitating battery storage.

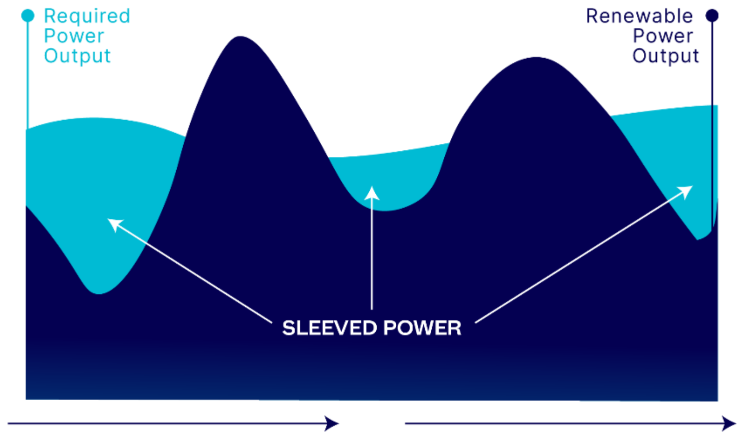
### *3. Power Purchase Agreements*

Another related energy application for blockchain is Power Purchase Agreements (PPAs). These are contracts by companies that wish to buy their electricity in bulk ahead of time as part of a fixed-rate deal.

This might be a brewery, bakery, office, or university striking a deal with a solar or wind farm. Very often the deal itself is a way of raising capital to build the solar farm. Because a PPA forms such a strong incentive for the creation of new green energy plants, PPAs are often regarded as the power contract of choice for green-minded companies.

One obvious question is what happens when the solar farm does not provide enough power for the organization that has contracted it. At this point a 'sleeving' agreement with a fossil-based utility company might provide the answer. The fossil or nuclear-based utility makes up the difference in power and provides the missing kilowatt hours when needed.

When the sleeving agreement is invoked, a smart contract is chained in with an automatic payment in cryptocurrency to pay for the sleeved kilowatt hours. The trio of blockchain, crypto, and smart contracts is the natural toolset for managing and stabilizing these ad hoc arrangements.




It is important to note that sleeved kilowatt hours generally will not be cheap because they are required at short notice. There are various ways to hedge and manage those high costs and a full discussion of these can be found at the link in the footnote.[7] The broader point is that sudden shortfalls and surges can make using renewable electricity more expensive, even though renewable electricity itself is usually cheap.

**Tokenising kilowatt hours and commoditizing the agreements**

In practice, the kilowatt hours are "tokenised," meaning there can be a unit of digital currency associated with each one of them and they can then be traded on an open market. The benefit of being able to trade is that one can easily off-load any surplus energy from their PPA in a secondary market. Another benefit is the kilowatt hours and the tokens that represent them are visible in an open, transparent, and traceable way.

Transparency is the reason companies like the tokenised approach. Over the coming years, PPAs rather than just being bespoke arrangements for big companies with deep pockets and sophisticated buying departments, will commoditize them into something more accessible. This is because the process of procurement, servicing the cost, and billing a PPA will become more automated, thanks to platforms like those Power Ledger is providing.

As the use of this technology increases around energy finance, so too does the sophistication of the financial instruments that surround it. Just as there are numerous insurance policies, interest rates, penalty clauses, and mortgages in today's world, there are decentralised ways of doing the exact same things. This is sometimes referred to as DeFi, or decentralised finance, a space which is relatively new but could ultimately have large effects on the energy market.

### *4. Renewable Energy Certificates*

The final blockchain energy product is Renewable Energy Certificates (RECs). RECs are essentially a badge of quality for any zero-carbon produced electricity. RECs were originally created as an accounting tool to see how much carbon emissions were taking place in different parts of the world, but its use has since evolved. RECs are now seen as a useful tool for trading, and therefore sending market signals that favour clean electricity over fossil-derived electricity.

[7] https://www.forbes.com/sites/jemmagreen/2020/11/10/when-high-voltage-meets-high-finance/?sh=6aa3309e5004

RECs provide useful income for people producing zero-carbon electricity; this income stream helps to stimulate further investment in renewable sources.

As these certificates are actively traded, they are maturing into more complex ways to include more information about the provenance of the kilowatt hours they represent. This newer form of REC trading is well-suited for a blockchain-based system, as the REC is represented by a token which creates a far more secure instrument that cannot be duplicated. This means the process of creating and 'retiring' a REC can be automated with smart contracts. It also allows for servicing another important emerging need. Increasingly, buyers of RECs want to precisely match their REC with their usage. These buyers want to be able to buy RECs that refer to generation of electricity at very specific points in time and space. A blockchain system that is also transacting the energy is best suited for this level of complexity. For a full discussion of how RECs are evolving see the link included in the footnote.[8]

**Conclusion**

If blockchain did not exist, RECs could still work, so to that extent blockchain is not critical to their existence. However, blockchain and tokens make RECs' provenance far more trustworthy. For the other products, including Virtual Power Plants, P2P trading, and Power Purchase Agreements, blockchain is indispensable. Could a distributed version of the grid work without blockchain? It is highly unlikely. The sheer number of transactions between different cellular metered units would be astronomically high and all at relatively low margin.

For anyone hoping to integrate renewable energy into the future of energy production, blockchain is a vital tool. Blockchain may be a fad to some, but the world of energy will soon find it is the game changer for which we have been waiting.

Future reports in this Open-Source Ideas Series will explore the possibility of tokenising carbon credits and green bonds, and the further blockchain-enabled expansion of the green economy.

[8] https://www.forbes.com/sites/jemmagreen/2020/10/07/the-rise-of-renewable-energy-certificates/?sh=7dfb442f3710