ENERGY
CATALYST

# Blockchain for Energy Access

ENERGY CATALYST

UKRI Innovate UK

UKaid from the British people

Transforming Energy Access

# Table of Contents




*Energy Catalyst is an Innovate UK programme with co-funding from the Foreign, Commonwealth and Development Office, Global Challenges Research Fund, the Department of Business, Energy and Industrial Strategy and the Engineering and Physical Sciences Research Council. This material has been funded by UK aid from the UK government; however the views expressed do not necessarily reflect the UK government's official policies.*



**Authors:**
Ashay Abbhi, Country Specialist, Energy Catalyst
Prachi Seth, Country Specialist, Energy Catalyst

# Blockchain for Energy Access – Objectives and takeaways

*Blockchain has emerged as an **important tool for facilitating, storing, and validating transactions**, such as peer-to-peer energy trading, financing solar power projects and so forth, in the energy sector. It has **unlocked a new opportunity for energy entrepreneurs** to develop business models with blockchain at the centre of the core process, especially for improving energy access.*

**Key objectives of this research are:**

- **Knowledge and awareness creation:** This research provides comprehensive insights into the workings of blockchain within the energy sector as well as the business models and processes that define the utilisation of the blockchain technology.
- **Entrepreneur-centric analysis:** The research has been designed and conceptualised with energy entrepreneurs in mind. The various segments, case studies/use cases and business processes provided here have been analysed with the objective of providing direction to entrepreneurs on how they can leverage blockchain to generate revenue, optimise cost, and create sustainable impact.

The research has been divided into 4 sections:

- **Overview:** This section defines the blockchain technology, process and platforms used to develop blockchain applications.
- **Application dynamics for energy access:** In this section, the application of blockchain within the energy access space is explored along with key advantages and challenges associated with it.
- **Blockchain in key energy segments:** This section showcases key projects and case studies in the energy segments where blockchain application is most favourable. The case studies explore how the blockchain technology is applied in these segments to improve energy access.
- **Market dynamics:** This section provides the top-level market insights for blockchain in the energy sector. The analysis discusses the evolution and current level of penetration of blockchain within the energy sector.

ENERGY
CATALYST

# Overview of Blockchain

What is Blockchain Technology

Distributed Ledger Technology and Blockchain

Blockchain Platforms

*Return to table of contents*

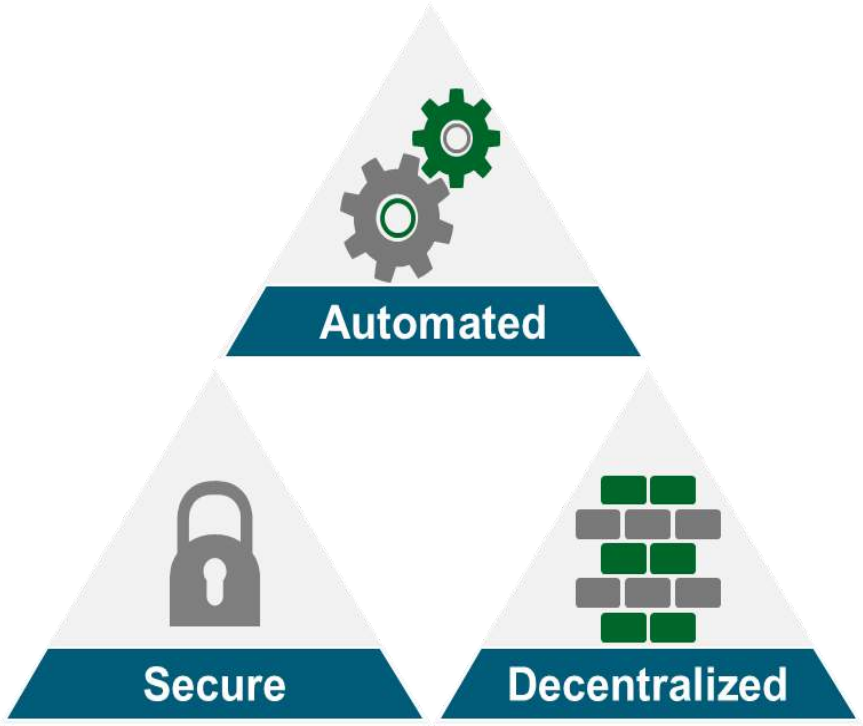
# What is Blockchain Technology?

**Blockchain facilitates self-executing contracts by electronically storing and validating transaction footprints. Blockchain acts as a distributed ledger – recording, verifying and validating each transaction carried out over the network.**

**IBM defines blockchain as** *"a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network. An asset can be tangible (a house, car, cash, land) or intangible (intellectual property, patents, copyrights, branding). Virtually anything of value can be tracked and traded on a blockchain network, reducing risk and cutting costs for all involved."*

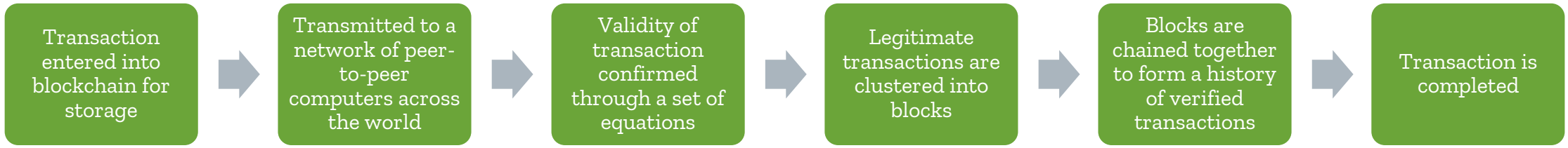
Peer-to-peer validation process makes the transaction transparent and reliable. Further, the nodes or blocks are individual entities that are independent from the rest of the chain, making the transactions virtually hack-resistant.

Its early use cases were in the financial transactions space. However, it has now extended into several sectors such as power generation and trading, climate change, healthcare, automotives, among others.



# Commonly used terms – Blockchain Technology

- **Distributed ledger technology:** Distributed ledger technology (DLT) is a set of codes and commands that enable secure storage and operation of a digital database in a decentralised manner. This helps eliminate the need for a central authority to govern or keep track of all the transactions being recorded in the ledger. Blockchain is a type of distributed ledger technology.
- **Smart contracts:** Smart contracts are self-executing contracts between the seller and buyer stored on a blockchain system as coded programmes that run when predetermined conditions are met. They are used to manage large systems through automation. In simpler terms, these are if-then statements written into the blockchain application. The contract is a clause which may indicate if certain conditions are met then a certain transaction can be carried out.
- **Transaction:** Any information that needs to be stored on the blockchain is known as a transaction. These could range from a new energy trading contract on a blockchain platform, to a copyright ownership, to new carbon credit generation. Following is a brief process visualisation of carrying out transactions in blockchain:




*A complete value chain diagram along with an explanation of the backend of the blockchain process can be found in the Annex 1*

*Source: Investopedia; Intellecap*

# Distributed Ledger Technology and Blockchain

***Distributed Ledger Technology (DLT) is a set of protocols, allowing access, validation, and record keeping, in a secure manner across a network spread across multiple entities or locations. Its various benefits include the following:***

- **Decentralised:** DLT is a decentralised technology that eliminates the risks associated with centralisation of data, such as hacking, pilferage etc.
- **Cryptic:** DLT stores all data in a secure way using cryptography which can be accessed using keys or passwords that are cryptographic signatures assigned to users.
- **Secure:** In order for an attack on a DLT to be successful, it will have to attack all nodes or entries of the ledger simultaneously, which can be extremely difficult especially with no centralisation.

***Blockchain is a subset and specific variation of DLT that provides additional security through transaction validation and verification***

- DLT only stores the transaction cryptographically so that it is secure but does not have a verified history. On the other hand, blockchain requires a set of blocks or transactions to be stored, creating a transactional history into a chain. The transactions can be stored into decentralised ledgers without distributing them across the networks, providing better scaling options.
- DLT does not require proof-of-work – validation and verification - as done for transactions in blockchain. The additional security feature of verifying transactions and needing proof of work for validation makes blockchain more secure than DLT.

***This research discusses the use of blockchain for improving energy access as blockchain is considered to be a more secure, safe, and efficient form of storing transactions into distributed ledgers.***

# What are Blockchain Platforms

***Blockchain platforms are networks that enable secure transactions by verifying and validating the details through a strong network of miners and blockchain professionals.***

These platforms allow the development of blockchain-based applications – in simpler terms, these are like the iOS or Android platforms that allow developers to create apps for use by iOS or Android users. Similarly, platforms such as Ethereum provide a ready set of networks for people to develop or host applications on the blockchain.

**Blockchain platforms are of three different types :**

- **Public:** A public blockchain platform is one where anyone can join whenever they want. Such a platform has no restrictions for participation and any joinee can see the ledger and take part in the processes for consensus. **Ethereum** is an example of a public blockchain platform.
- **Permissioned:** These blockchain platforms have an additional security system, an access control layer that allows certain actions to be performed by only authorised personnel. **R3 Corda** provides a permissioned blockchain development platform.
- **Private:** A private blockchain platforms is one where only a single organisation has access and authority over the entire network which is designed to meet the specific needs of the organisation. It is a partially decentralised system and ideally suited for highly secure transactions or internal transactions of an organisation. IBM's **HyperLedger** provides private blockchain platforms for specific functions.

*Detailed examples of existing blockchain platforms can be found in the Annex 2*

ENERGY CATALYST

# Application dynamics of Blockchain for energy access

Blockchain and the Energy Sector
Key Advantages
Key Challenges

Return to table of contents

# Blockchain and the Energy Sector

*The energy sector struggles with various challenges including inefficient operations due to heavy centralisation, lack of innovative financing, obsolete business models, lack of financially viable mechanisms for energy access, among others. Blockchain technology has provided answers to many of these challenges, and continues to penetrate into the energy sector further with innovative technologies that create operational and financial efficiencies.*

### Why does the energy sector need blockchain technology?

- **Decentralisation and energy access:** The energy sector in developing countries is often reliant on coal-based power, distributed through the expansive grid network. As the share of distributed renewable energy increases in generation, blockchain offers energy trading and project development platforms that allow seamless alternatives to grid-based power. These include examples such as verified crowdsourcing for solar project deployment and validated energy trading across solar mini-grids accessible through smartphones, which are especially beneficial for off-grid and underserved populations.
- **Security:** Blockchain's ability to verify and validate energy generated as well as energy consumed makes it secure against any spurious attacks. Moreover, no duplication across the network allows better grid management and energy distribution.
- **Value chain management:** Blockchain solutions are spread across the energy value chain, from generation to distribution and trading to payments. The advent of smart contracts makes execution of energy trading and distribution automated, leading to higher operational efficiencies. Meanwhile, blockchain is also being deployed for incentivising renewable energy generation, grid management, and other such critical operations.

*Blockchain is particularly beneficial for **prosumers.** These are energy consumers who are also engaged in energy generation, for self-consumption as well as sale of energy to other consumers. For instance, a rooftop solar power plant owner is a prosumer as they generate the energy consumed by themselves or feed it into the grid or sell it to other consumers.*

***Blockchain is being used in various segments of the energy sector, including peer-to-peer energy trading, energy access, grid management, financing renewable energy, electric vehicles, and renewable energy certificates.***

# Advantages of Blockchain for the Energy Sector

## *Transparency*

> Energy data becomes **transparent** with blockchain's **ability to verify and validate transactions**.

> The challenge of data verification and transparency for generation and consumption in billing may arise. More so, for networks that have multiple generators and consumers.

> Blockchain processes **allow for greater accessibility** of transactions by peers throughout the chain, **eliminating the threat of unauthorised edits**.

## *Trust*

> **Blockchain enables marketplaces** for sourcing power, wherein different stakeholders can transact with each other **without the threat of forgery**.

> This is true, especially for **providing energy access** in remote areas where the **level of penetration of technology** and education may **not be high**.

> To get a buy-in from such consumers, it is important to exemplify and promote solutions that are **transparent and trustworthy** in order to provide sustainable energy.

## *Efficiency*

> Blockchain enables **low-cost transactions**, especially in areas where the unit cost of delivering energy is high. Greater efficiency is brought in by lowering the energy bills of consumers through:

- *No or lower operating costs for billing*
- *No expenditure required for payment reminder, debt collection etc.*
- *No costs for bank payments*
- *Possibly lower transportation charges*
- *No certification costs for renewable electricity*

## *Control and Security*

> The blockchain is designed with **control and security as its core elements**, to avoid spurious, invalidated transactions in the system.

> **Control over transactions is more important for consumers with limited access to energy** as any fault may jeopardise their energy security.

> **Multi-layer validation and security** in blockchain processes **limit the fraud risk**. Decentralisation of the process also prevents market abuse through monopolies and requires less legislation, cost, and regulatory oversight.

# Challenges in Application of Blockchain for Energy Access (1/2)

## Process Related Challenges

### *Roles and Responsibilities*

- Energy generation, supply and transaction through the blockchain process involve multiple stakeholders, which may sometimes lead to **blurring of roles**. This may raise questions such as:
  - Who performs the meter readings to accurately provide the consumption data?
  - Who provides the forecasts and schedules to the transmission operators?
  - Which entity becomes the registered supplier – the decentralised generator or the blockchain platform?
- Further, **development of private blockchains by large distributors may prohibit small decentralised suppliers** from entering the transaction model and the market.

### *Regulatory Issues*

- Blockchain is still in nascent stage in most countries in Asia and Africa**. Regulatory agencies have, therefore, not yet standardised regulations for blockchain platforms**, especially as the government has little to no control over the direct-to-consumer transactions. In fact, countries such as India are contemplating a ban on blockchain-based cryptocurrencies.
- Lack of regulatory oversight and the fact that no central authority is required for using blockchain processes, risk-averse governments are taking time to embrace the benefits it can provide.
- Greater awareness towards blockchain and its myriad uses must be provided to all stakeholders involved.

*A detailed blockchain-based energy access value chain diagram can be found in the Annex 1*

# Challenges in Application of Blockchain for Energy Access (2/2)

## Consumer Level Challenges

### *Operational Issues*

- **Variable transaction costs for public blockchain systems may lead to increase in expenses and cost of power** as these warrant more complex transactions.
- **Blockchain platforms are highly energy intensive**, which may sometimes be counter-productive to the zero-carbon quotient of renewable energy.
- There is a **dearth of a consistent track record** given blockchain is a nascent technology. This is especially true in emerging economies, where technology penetration is still slow, networks may not be optimally strong, and off-line operation might be a challenge for blockchain processes.
- **Low flexibility of digital networks** may hamper blockchain operations in emerging economies.

### *Technological Hurdles*

- **Loss of identification can lead to loss of complete data** as blockchain requires unique IDs for peers to enter the system.
- There is a **strong risk of fraudulent activities** at the interface of the real world and the digital world of blockchain processes where smart meters, connections, etc. may be tampered with to inflate or deflate consumption.
- **Technical problems** with initial applications and set up, especially in regions with a low knowledge base, may arise, leading to inefficient processes.
- **Lack of standardisation** of processes, platforms and guidelines for consumers may lead to security risks.

ENERGY
CATALYST

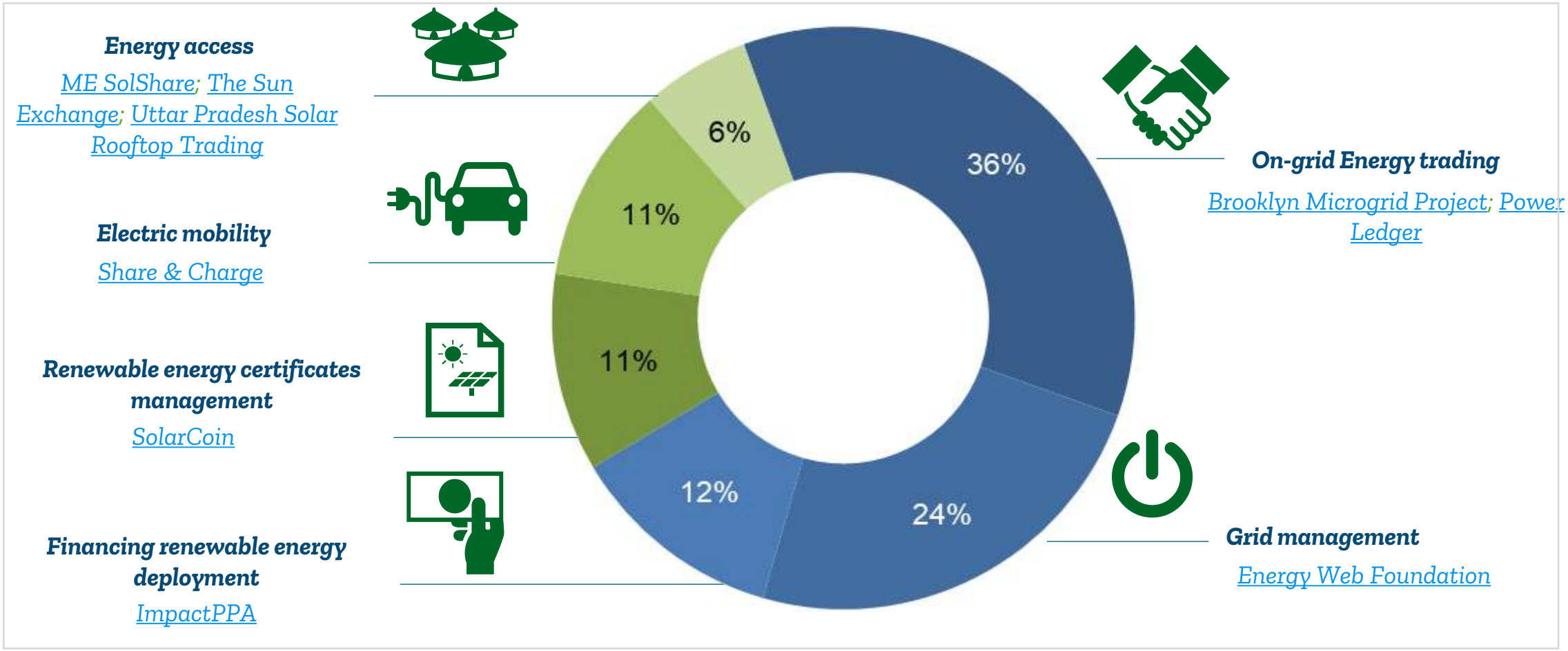
# Blockchain in renewable energy and energy access

Key Segments
Projects
Use Cases

*Return to table of contents*

# Segment-wise distribution of blockchain initiatives by energy-focused blockchain enterprises

*As of Sept. 2018, about 189 companies were working in blockchain in energy*




*The percentages represent the share of all energy-specific blockchain enterprises by segment.*

*Source: IRENA; Intellecap*

# Peer-to-Peer On-Grid Energy Trading

*Being prosumers to empower consumers – Applications and advantages of blockchain*

- **Decentralisation:** Generation of power at the site of consumption through renewable sources of energy, has turned consumers into producers who consume power – or prosumers.
- **Smart contracts:** Energy retailers and distribution companies may play a smaller role in distributed peer-to-peer models in the future as smart contracts in blockchain processes automate the energy distribution system. Smart contracts can enable the grid automatically divert a pre-determined portion of energy to a consumer at a definite time, thereby reducing the role of distribution companies and retailers.
- **Secure trading:** Blockchain enables trading of excess energy by a prosumer to another consumer in the same network through smart contracts that allow validating and securing the transaction to avoid theft of power, spurious contracts, or excess billing.
- **Applications:** Smart grids* and virtual power plants** are some of the applications that are currently in pilot stages that use blockchain technology for energy trading.
- **Optimisation:** With distributed energy resources (DER), such as rooftop solar and solar micro-grids, on the rise, blockchain and smart contracts can enable optimisation of DERs while integrating them into the local microgrids – for example, the Brooklyn Microgrid project that allows neighbouring households to trade virtual electricity using the local grid but generated by DERs.

**Smart grid: A smart grid is an automated grid which can help restore power to consumers through self-repair, is more reliable and can control outage with the help of sensors, predictive maintenance technologies and integrated Internet of Things.*
***A virtual power plant is a cloud-based distributed power plant that aggregates the collective energy generated by distributed energy resources*

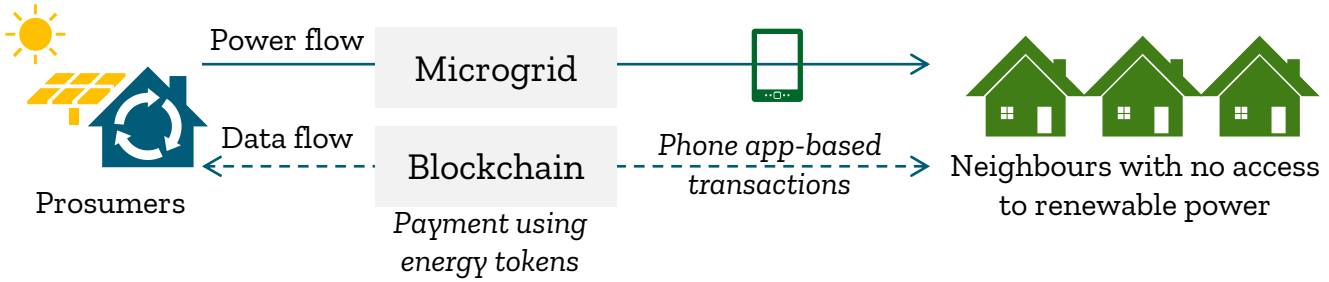
# Peer-to-Peer On-Grid Energy Trading – Key Projects

| Project/Initiative | Country | Description |
|---|---|---|
| Conjoule | Germany | Conjoule helps peer-to-peer trading of energy among solar rooftop power plant generators via a blockchain-based platform to allow public sector or institutional buyers to purchase the excess energy |
| Electrify.Asia | Singapore | Electrify.Asia provides a platform-based marketplace where electricity can directly be traded between consumers and generators or retailers through blockchain-enabled smart contracts |
| LO3 Energy | United States | LO3 Energy operates the Brooklyn Microgrid that allows consumers to generate, store, buy, and sell energy at a local level, helping the traditional grid and allowing consumers to opt for clean and renewable energy. Supported by Siemens, the microgrid makes the community more resilient during outages and emergencies along with significant climate benefits. It makes renewable energy accessible by on-grid polluting consumers or off-grid consumers who do not have access to modern energy. In March 2021, LO3 announced a Series B investment of $11 million by Shell Ventures, its existing investor |
| Power Ledger | Australia | Power Ledger is a blockchain-based platform for peer-to-peer transactions among power consumers and generators. It records, validates and verifies all transactions in real-time. It uses an Ethereum-based blockchain. Power Ledger has launched a peer-to-peer trading platform for India Smart Grid Forum and BSES Rajdhani in Delhi, India |
| Greeneum | Israel | Greeneum is a peer-to-peer blockchain network that enables energy trading in Europe, Cyprus, Israel, Africa and the United States |
| National Renewable Energy Laboratory | United States | NREL has partnered with Blockcypher for a demonstration project wherein distributed energy resources will be transacted through multiple blockchains |

# Use Case – On-grid energy trading in Brooklyn Microgrid Project, United States

### *Project*

The project is currently being developed in the USA by TransactiveGrid, a joint venture between LO3 Energy and ConsenSys. The aim of the project is to test how blockchain technology can be used to effect direct neighbour-to-neighbour sales of solar energy. The project uses Ethereum blockchain on the Exergy platform.




### *Process*

The prosumers provide clean electricity to neighbouring households who have no access to renewable-based power. Consumers are able to manage the flow of power through phone applications. Blockchain-based transactions enable payment for the power consumed through energy tokens. Blockchain allows verified and secure transactions, and each token is issued as a unique identity issued for payment against consumption of clean power that prevents transaction fraud.

### *Application for energy access*

The Brooklyn Microgrid project is an experiment to provide a clean energy alternative to grid-based communities by connecting them with those that have excess solar power (prosumers) through an energy trading platform that uses blockchain. **Over 60 participants have benefited from clean solar power at lower costs through this project.**

Blockchain allows power consumption data to be verified and validated seamlessly before the transaction is executed.

**This concept can be extended to connect off-grid areas with those that have surplus renewable energy, or prosumer hubs to provide energy access to underserved communities.**

*Source: Brooklyn Microgrid; Intellecap*

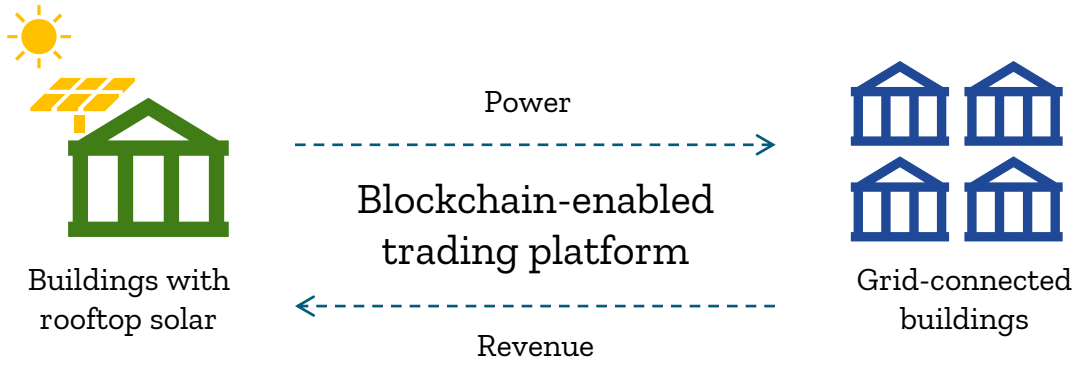
# Use Case – Peer-to-peer on-grid solar power trading in BSES Rajdhani project, India

### *Project*

The peer-to-peer solar power trading project by BSES Rajdhani is the first such initiative by a distribution company in India. It comprises 300 kW of solar power plants servicing a group of gated communities in Delhi's Dwarka area. The project is being carried out by Power Ledger, Australia. During the trial, residents with rooftop solar infrastructure were able to trade their excess energy with their neighbors as well as with higher tariff commercial customers, minimising the amount of energy that was spilled back to the grid.

### *Process*

The technology utilises a transactive layer that draws close to real-time data from smart meters to facilitate the peer-to-peer trading environment. The consumers only require access to solar power infrastructure - whether through solar power panels installed on the roof of their own house, or through solar power infrastructure within the community. The project highlighted the potential of load sharing and minimising grid peak through cheaper peer-to-peer energy trading.




### *Application for energy access*

The BSES Rajdhani project is an interesting initiative by a distribution company, which are typically reluctant to allow high-paying consumers to move to renewable energy-based power, offering commercial, industrial and residential consumers a power alternative. **A total of 25 MWh has been traded across 4 buildings for this project.**

The project enables access to renewable energy, thereby reducing the load on the grid and coal-fired power plants.

**Providing access to alternative sources of power in urban areas where grid-connection is strong through distribution companies can lead to greater penetration of renewable energy, even in areas where the solar irradiation or space is low.**

*Source: Power Ledger; BSES Rajdhani; Intellecap*

# Energy Access

*Rural electrification and increasing access – applications and advantages of blockchain*

- **Large underserved market:** About 1 billion people still lack access to modern forms of energy in South Asia, Southeast Asia and Africa. Using blockchain systems for decentralised energy generation and peer-to-peer transactions, local solar generators can sell power to other consumers with no or poor access to grid-based electricity with intermittent power supply and outages.
- **Use of mobile networks:** The level of automation with blockchain-enabled power plants is extremely high. An underserved consumer may not have the resources to navigate the web of processes with distribution companies. Blockchain-based energy can be traded through smart phone applications and micropayments can be made by the consumer through these, thereby enabling greater and easier access to energy.
- **Decluttering of traditional processes:** When a prospective generator sets up a blockchain-enabled solar power plant, they are enabling seamless processes to replace cumbersome centralised energy authorities and bureaucracy. Direct seller-buyer smart contracts are put in place, wherein the excess energy from the generator is sold to underserved consumers in off-grid areas.
- **Innovative financing schemes:** For underserved off-grid areas, innovative financing schemes will be required for payments. These could be deferred payment initiatives, pay-as-you-go systems, amongst others. However, these need to be built into the contracts for the system to recognise the payment mechanisms. Blockchain-enabled power plants can integrate this information into the smart contracts with only a few lines of code, making it seamless for the underserved consumers to pay for the energy being used to power their off-grid household.

# Energy Access – Key Projects

| Project/Initiative | Country | Description |
|---|---|---|
| Uttar Pradesh Rooftop Solar Trading Platform | India | Uttar Pradesh Power Corporation Limited has partnered with Power Ledger to provide South Asia's first solar rooftop energy trading platform that is aimed at providing access to underserved households in the region |
| The Sun Exchange | South Africa | The Sun Exchange allows investors from anywhere in the world to own a part of a solar power plant by purchasing solar panels for deployment in schools, hospitals, etc. in African countries. The returns are generated on a monthly basis and distributed among owners proportionally. The transactions are blockchain-based. It has about 1,200 kW of capacity under construction and about 3,800 kW installed already. The Sun Exchange raised $3 million in June 2020 to close its Series A funding at $4 million |
| ME SolShare | Bangladesh | In collaboration with UBOMUS, its financing partner IDCOL and research partner United International University-Centre for Energy Research, SOLshare has combined several solar home systems together and centralised mini-grids to deliver solar power at a low cost to underserved households. In July 2020, SolShare raised $1.1 million in financing for funding microgrids to underserved communities |
| MyBit | Switzerland | MyBit is a blockchain-based crowdfunding platform for deploying solar panels in underserved areas. The model works on distributed ownership of the asset and returns |

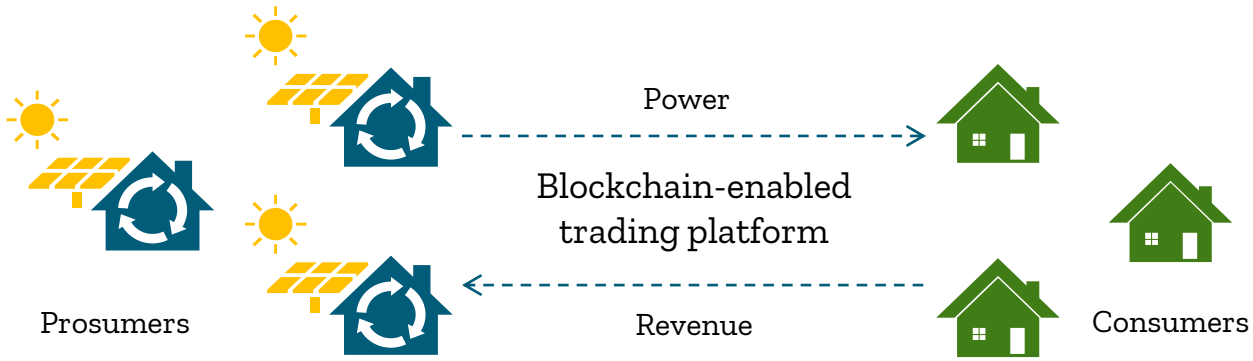
# Use Case – Uttar Pradesh Rooftop Solar Trading Platform, India

### *Project*

In December 2020, Uttar Pradesh Power Corporation Limited launched India's and South Asia's first peer-to-peer blockchain-enabled solar rooftop trading platform in partnership with Power Ledger, Australia, India Smart Grid Forum (ISGF), and Abajyon Consulting. The results of the pilot will help the state government in framing of regulations for peer-to-peer rooftop solar trading.

### *Process*

The trading platform's first 12 participants comprised of nine prosumers with rooftop solar and three customers without rooftop solar. The participants were engaged in mock trading (no money transactions) for the next three months, during which ISGF tried out different trading algorithms. At the end of the experiment period, the project is expected to be scaled up.




### *Application for energy access*

Uttar Pradesh is one of the largest states in India, with around 50% rural households still unelectrified.

The blockchain-based rooftop solar trading platform will enable energy access to the underserved rural areas with the help of a seamless transaction that can be carried out from any mobile device.

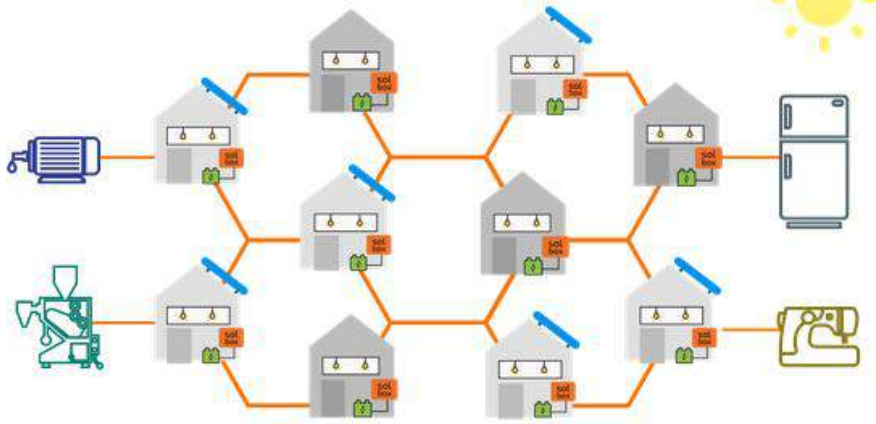
**The project will be instrumental in framing state-wide, and later nationwide, regulations around blockchain-based trading, in order to replicate the UP model to other states as well.**

*Source: ISGF; UPPCL; Power Ledger; Intellecap*

# Use Case – ME SOLShare, Bangladesh

### *Project*

SOLshare has successfully piloted the world's first ICT-enabled peer-to-peer electricity trading network for rural households with and without solar home systems in Shariatpur, Bangladesh. Along with its implementation partner, the NGO UBOMUS, its financing partner IDCOL and research partner United International Universit- Centre for Energy Research, SOLshare combines solar home systems and centralised mini-grids to enable more rural households to access renewable electricity at a lower cost.



### *Process*

The trading network interconnects households via a low-voltage DC grid and controls power flows through bi-directional metering integrated with an ICT backend; handling payment, customer service and remote monitoring. Each SOLshare meter enables the user to buy and sell renewable electricity with neighboring households, businesses and rural industries.

### *Application for energy access*

So far, SOLShare has enabled installation of **48 kW of solar power capacity, providing electricity to 2,570 off-grid people and saving about 1,756 litres of diesel per year and 4,970 kilos of $CO_2$ per year**.

The ICT-enabled trading allows the households to become more than beneficiaries of yet another rural electrification project, but become the sole controllers of their energy generation, consumption and trading.

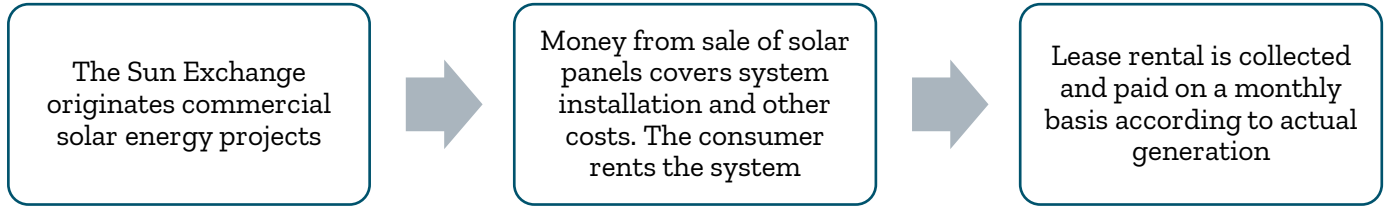
**The project enables energy access by connecting unelectrified households or businesses who do not have the resources to put up a solar home system with those who have excess power.**

*Source: ME SOLShare; Intellecap*

# Use Case – The Sun Exchange, South Africa

### *Project*

The Sun Exchange has a blockchain-based solar financing platform that allows crowdfunding of solar power plants. These projects are deployed in offgrid areas for schools, hospitals, factories, etc. It allows anyone in the world to purchase tokens that can be used to become part owner of the solar power plant. **So far, The Sun Exchange has installed about 3,800 kW of capacity with another 1,200 kW currently under construction in Africa.**




### *Process*

The Sun Exchange identifies schools, businesses and other organisations that are willing to opt for solar-powered energy and evaluate the site for economic and technical viability. A crowdsale is then initiated to allow people to purchase the solar cells to be deployed for the project. This platform enables the purchase of solar cells that will be deployed in solar rooftops etc., wherein the purchaser becomes part-owner of the solar power plant. Once the appropriate number of solar cells are purchased, the sale is closed and the project is constructed. The funding can either be done through local currency or Bitcoin. The part-owners receive a monthly income into the Sun Exchange wallet as currency or Bitcoin. The transactions are carried out through a blockchain-enabled platform.

### *Application for energy access*

The Sun Exchange model combines IPO and clean energy access through a unique blockchain platform that enables investors to invest in clean energy projects directly, unlike other traditional projects that use large institutional investments. So far, this model has enabled deployment and operation of **1.7 million solar cells generating 5,212,890 kWh of energy, funded by members in 179 countries**.

**The business model brings together environmentally conscious investors with the need to deploy clean energy solutions, providing access to energy to socially important consumers such as schools, hospitals, etc. in Africa.**

*Source: The Sun Exchange; Intellecap*

# Grid Management

*Greater control over grid integration – applications and advantages of blockchain*

- **Automated grid control:** Electricity networks with blockchain-enabled processes are easily controlled with the help of smart contracts which can trigger specific transactions at the grid. For instance, the sale of 10 kWh of power to a consumer at 6pm in the evening does not have to be manually fed into the grid code everyday and can be automated with the help of blockchain.
- **Predictability:** Blockchain-based smart contracts can send specific signals to the system that can forewarn the grid operators and producers about impending untoward incidents that can help in controlling the flow of power, in and out of the grid, automatically to balance the supply and demand.
- **Diversion to storage:** In case of excess energy being generated from renewable energy, the system will be able to route it for storage which can be used later during low generation periods.
- **Private blockchain networks:** Operators can develop private blockchain networks that can enable tracking of all transactions and provide greater control over a small/private part of the power system.
- **Avoiding accidents:** Poor grid management can result in financially damaging disasters, but these can be avoided with the help of blockchain. The blockchain-based transactions are thoroughly verified and validated before entering the system, thereby allowing only validated contracts to be executed automatically by the grid. This prevents any excess input or output from the grid, which may hamper the operations.

# Grid Management – Key Projects

| Project/Initiative | Country | Description |
|---|---|---|
| Energy Web Foundation | Switzerland | It is focused on accelerating blockchain technology across the energy sector through an open-source, energy-focused blockchain platform that provides the functionalities needed to implement energy sector use cases at scale. In April 2021, Share&Charge became a part of the EWF and launched its open charging network on the Energy Web Chain |
| Sunchain | France | Sunchain has initiated a blockchain-based platform for solar generation by private prosumers. First use case: collective or distributed self-consumption. Sunchain manages local power exchanges within energy communities, gathering producers, consumers and prosumers |
| Enerchain | Germany | Operated by Ponton, it is a blockchain-powered wholesale electricity trading platform. It has utilities such as Enel (Italy), E.ON (Germany), Iberdrola (Spain) who trade electricity between energy companies on the platform |
| Eneco | Netherlands | Eneco is developing a pilot programme for a blockchain-based application for a decentralised heating network in Rotterdam |
| Ministry of Economic Affairs and Energy | Germany | The German ministry has initiated a pilot project for a large-scale decentralised and integrated platform for renewable energy generation, transmission, and distribution infrastructure |

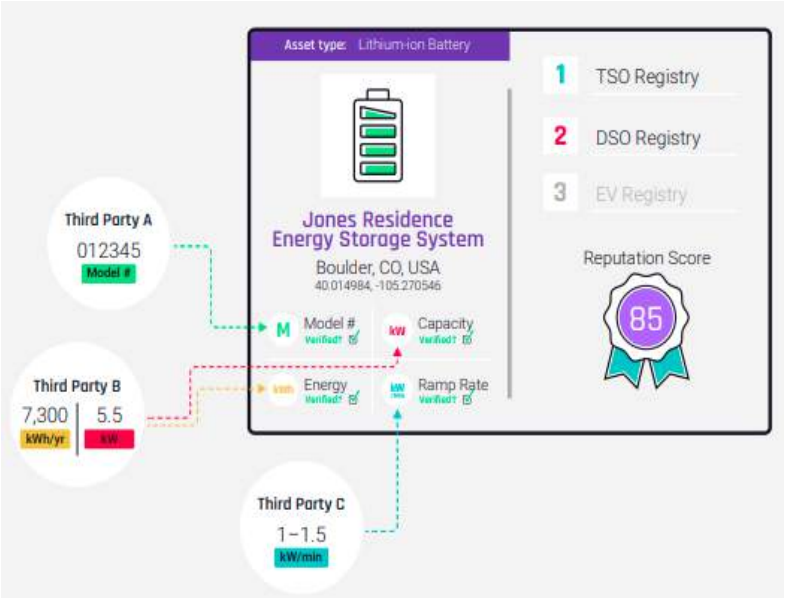
# Use Case – Energy Web Foundation, Switzerland

### *Project*

The Energy Web Foundation's Energy Web Chain – Decentralised Operating System is a tool to establish a unique identity of every customer, asset, service provider or authority in the electricity system. The identities enable relay generation data to grid operators, system integrators and authorities. It also provides open-source templates for constructing applications that include this data and facilitate renewable energy markets, e-mobility programmes, and decentralised market participation.

### *Process*

The EW Chain is a publicly-accessible network with permissioned validators hosted by EWF Affiliate organisations. It relies on a proof-of-authority consensus mechanism with lower energy consumption as compared to Ethereum. EWF also runs two test networks to support research and innovation in the energy blockchain space: Tobalaba, EWF's beta test network, is a controlled environment for experimentation; Volta, EWF's preproduction staging network, is used for testing updates to the production EW Chain client.




### *Application for energy access*

EWF has over 100 energy and blockchain affiliates that function across its permission and public blockchain network with reduced transaction costs and increased resource efficiency.

**A total of 100 million Energy Web Tokens have been allocated which are tradable as cryptocurrency across designated exchanges.** The purpose of these tokens is to fund the development of research in the blockchain segment.

**Through EW Chain, blockchain-based transactions enables integration of DERs into the grid seamlessly through verified generation and makes claiming of various digitally transactional incentives easier.**

*Source: Energy Web Foundation; Intellecap*

# Financing Renewable Energy Deployment

*Enabling deployment to improve access – applications and advantages of blockchain*

- **Connecting the unbanked consumer:** With the help of blockchain enabled financing, processes can be put in place to purchase electricity even for the unbanked consumer, thereby increasing energy access and financing renewable energy deployment. Anyone can purchase electricity through a smartphone connected to the blockhain-enabled energy generator and send it to the connected but unbanked consumer in a safe, secure and seamless manner through smart contracts.
- **Low financing costs:** Blockchain processes allow for low transaction costs, which can reduce the cost of capital for renewable energy project deployment. Its efficient processing, automated smart contracts, and impenetrable security features, prevent financing fraud which can help in deploying capital efficiently to projects.
- **Use of cryptocurrency:** With blockchain-based cryptocurrencies available in the market, people interested in deploying renewable energy projects can do so by purchasing goods or tokens for services on blockchain networks. Innovative mechanisms such as token crowd sales or pre-payment for electricity to electrify areas with no energy access can be undertaken. If the value of these digital currencies continues to increase, it can also lead to more value for the money already invested in the process.
- **Crowdfunding:** Crowdfunding can be done by providing cryptocurrency tokens, thereby cutting transaction costs when tokens change hands from buyer to seller to investor, and facilitating the validation of large number of small transactions. The investor, therefore, becomes part owner of the project and receives revenue per unit of generation. Moreover, the exchange rate of cryptocurrencies is likely increasing, which could lead to more value per dollar invested.

# Financing Renewable Energy Deployment – Key Projects

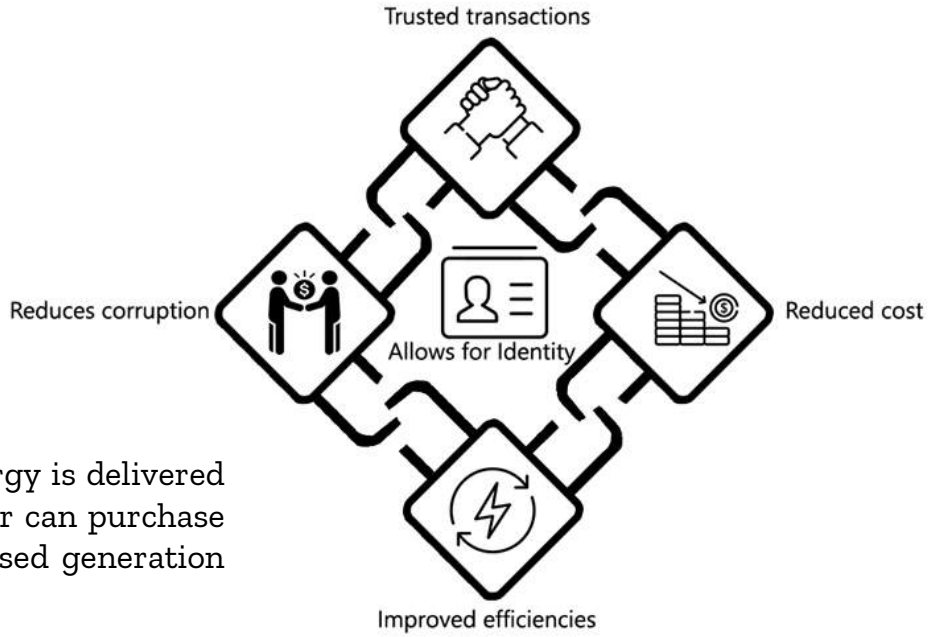
| Project/Initiative | Country | Description |
|---|---|---|
| **ImpactPPA** | United States | Impact PPA has a unique mobile-based pre-payment platform that allows anyone from anywhere to purchase electricity to be used by an off-grid consumer through a decentralised energy resource. The blockchain validates and verifies the transaction and provides access to electricity to underserved consumers |
| **WePower** | Lithuania | WePower is developing a blockchain-based platform for funding renewable energy projects by selling the tokenised energy generated by the power plant. The company has partnered with Australia-based Mojo Power in February 2021 to develop and handover a retail electricity transaction marketplace called Elemental |
| **Direct Energy** | US | The company has partnered with LO3 Energy for micro-energy hedging in the energy transaction markets |
| **Enercity** | Germany | Enercity has developed a platform for accepting bitcoins for bill payments of energy consumed |
| **Ministry of Micro, Small and Medium Enterprises** | India | ImpactPPA has set up a blockchain platform for the Ministry of Micro, Small and Medium Enterprises for managing the supply chain logistics of renewable energy powered textile looms called *Harit Khadi* |

# Use Case – Impact PPA, United States + Harit Khadi (MSME), India

### *Project*

Impact PPA allows consumers of electricity to pre-pay for their anticipated consumption through any mobile device via a blockchain-based network, creating a unique marketplace for investors, project developers, service providers, utilities, etc. This blockchain-enabled financing system allows the unbanked population, usually on-grid, to access energy by using their mobile phones for purchasing power from mini-grids in the vicinity, where the power is generated, stored and distributed.

ImpactPPA has partnered with the Ministry of Micro, Small and Medium Enterprises, India, on a project called the *Harit Khadi* to revamp the Indian textile industry.




### *Process*

The company deploys utility-scale or microgrids in the area from where the stored solar energy is delivered to smart meters connected to the blockchain at the consumer's end. The unbanked consumer can purchase power via an application, which is connected to its smart meter. It uses types of decentralised generation including vertical-axis wind turbines deployed on rooftops.

### *Application for energy access*

One of the primary benefits of this model is for the unbanked customers who lack credit. Furthermore, anyone anywhere in the world can pre-purchase electricity and get it delivered at the site, enabling access to energy. **Once fully deployed, the project is expected to transform the lives of 50 million people in India. So far, 8 solar looms have been installed and are operational.**

**With the blockchain platform mining and verifying the transactions, spurious payments and fraud can be contained and the commercial losses can be reduced, providing access to electricity to remote areas via mobile-based pre-payment.**

*Source: Impact PPA; Intellecap*

# Renewable Energy Certificates

*Managing transactions and incentivising generation – applications and advantages of blockchain*

*Renewable energy certificates are market-tradable incentives to encourage the generation of power through renewable sources of energy*

- **REC market:** Renewable energy certificates (REC) in most countries, including India, are based on generation and carbon savings forecasts instead of actual data.
- **Real-time data:** Blockchain can provide real-time verified and validated generation data to authorities for issuing RECs to users. Once the blockchain-enabled generator raises a request for RECs, the system will automatically verify the claims based on actual generation, as opposed to the certificates provided based on estimated generation. The smart contracts at the exchange or issuing authorities' end will then trigger the issuance of the REC to the generator based on the verified units generated.
- **Decentralised verification:** The process eliminates the need for a centralised verification authority which would usually take a long time and incur costs. As the generator is integrated into the blockchain platform, the units are being verified and validated by peers. With the integration of the REC authority into the system, the verified information can be made available, based on which the RECs are issued without the need for a verifying authority.
- **Reduced costs:** The costs associated with data verification and REC awarding, including trading of RECs, could be reduced drastically by moving to the blockchain platforms as the need for verification of data would be eliminated and smart contracts can remove any redundancy or double-counting of RECs.

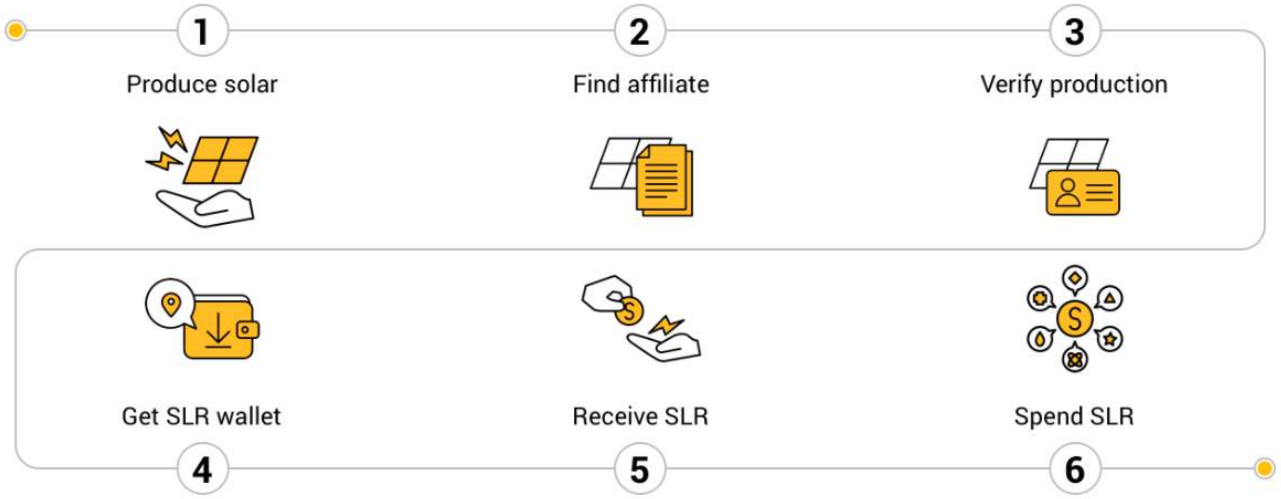
# Renewable Energy Certificates – Key Projects

| Project/Initiative | Country | Description |
|---|---|---|
| SolarCoin | US | SolarCoin is a rewards programme with 1 SolarCoin being equivalent to 1 MWh of solar electricity production. It has an asset based of 97,500 MWh over a period of 40 years. Started in 2014, its value remains low in the present and may pick up as the rewards draw closer to disbursement |
| Veridium | US | Veridium is developing EcoSmart Commodities, a new asset class to enable corporations to embed environmental replacements into the cost of their product |
| Volt Markets | US | Volt has developed a blockchain-based platform that can issue, track and trade RECs for the consumers |
| Engie | France | Engie is collaborating with AirProducts, a US-based energy solutions provider, to certify renewable energy use in associated processes for production of energy |
| SP Group | Singapore | SP Group has developed a blockchain-based platform for transacting RECs |
| Russia Carbon Fund | Russia | The RCF is developing a blockchain-based platform for auditing climate projects in collaboration with Ernst & Young |
| CarbonX | Canada | CarbonX has created a peer-to-peer blockchain-based carbon credit trading platform |
| ElectriCChain | Andorra | ElectriCChain has created a market platform for conducting audits of decentralised solar power generation |
| Energy Blockchain Labs | China | The Chinese company has developed a blockchain-based platform for trading decentralised carbon assets |

# Use Case – SolarCoins, United States

### *Project*

SolarCoin incentivises solar power generators in the form of a solar coin, identical to renewable energy certificates. A solar coin is generated upon the production of 1 MWh of solar power. SolarCoins (SLR) are cryptocurrencies that are sent to accounts in digital wallets and used as currency, or that can be stored long-term in offline (paper) wallets. Solar coins can be exchanged at government crypto-exchanges or spent at businesses that accept them.




### *Process*

SolarCoin follows a blockchain-based process wherein the generation is verified by a SolarCoin affiliate. The coins are distributed based on the actual generation, or deemed generation based on the nameplate capacity of the installed power plant. The coins are blockchain-based and transacted through peer-to-peer networks. Once the generation is verified, the SolarCoin is issued to the generator. The transactions are collected, verified, and summarised in blocks that create the SolarCoin blockchain.

### *Application for energy access*

SolarCoin attempts to incentivise solar power generation, akin to RECs, but in a blockchain-based tangible cryptocurrency that can be exchanged or used by generators. The SolarCoin is an additional incentive along with RECs, carbon credits, etc.

**Blockchain-based SolarCoins provide cryptocurrency incentives for solar generation that can offset capital costs and encourage investment into deployment of solar power plants in areas with low energy access in developing countries.**

*Source: SolarCoin; Intellecap*

*SLR wallet = Solar wallet; a digital wallet to store the cryptocurrency solar coins*
*Current SolarCoin price (May 2021) = USD 0.09*

# Electric Mobility

*Improving access to charging – applications and advantages of blockchain*

- **Charging infrastructure network:** A significant challenge facing EV owners is accessing the charging infrastructure network in real-time without having to wait in long queues. A blockchain-based system could enable adoption of EVs by improving access to the charging network and reducing range anxiety.
- **Coordinating electric vehicles (EV) and charging stations:** An integrated electric mobility system – with vehicles, charging stations, battery-swapping stations, and customers all on the blockchain platform – becomes seamless to coordinate among the various EV units. EV owners can get real-time information regarding the availability of charging stations on the platform. The blockchain platform can verify and validate the units consumed by the EV and generate the bill accordingly which can be paid through the blockchain platform in traditional money or cryotpcurrency.
- **Smart contracts:** Smart contracts enable predetermined information to trigger actions – for instance, an EV owner takes two days to completely run out of the battery, so the smart contract with the EV owner will reserve a slot at the charging station every two days at a predesignated time and inform the owner about the impending charging appointment. Further, these smart contracts can enable seamless payment directly through the blockchain-enabled wallet of the consumer.
- **Use of renewable energy:** As the solar power generator supplying energy to the charging station would also be integrated into the blockchain plaftform, the request to draw power for the station can be triggered by smart contracts only at the time of EV charging whereas the excess power can be diverted to storage.

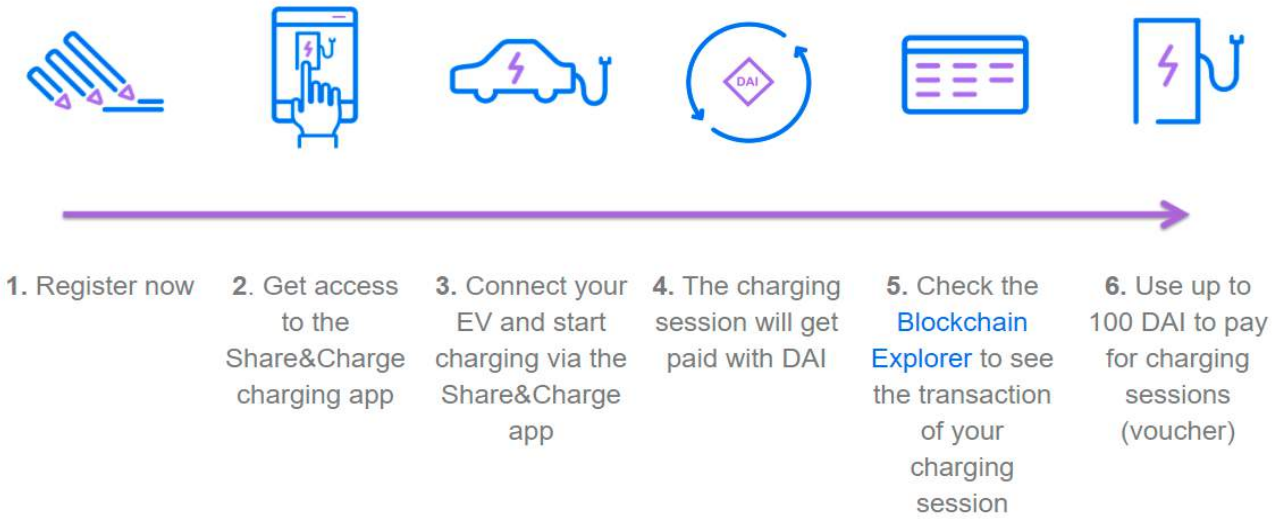
# Electric Mobility – Key Projects

| Project/Initiative | Country | Description |
|---|---|---|
| EnelX (earlier eMotor Werks) | United States | EnelX provides EV charging networks through partnership with Share&Charge peer-to-peer transaction platform |
| Share&Charge (MotionWerk) | Germany | MotionWerk has partnered with blockchain-based Slock.it on the Share&Charge platform which has a network of decentralised EV charging locations<br>Share&Charge started its Open Charging Network in April 2021, as it became a part of the global non-profit Energy Web Foundation, Switzerland |
| Chubu Electric Power Company | Japan | Chubu Electric Power Company is a Japanese utility that is now developing a pilot for a blockchain-based EV charging service |
| Enexis | Netherlands | Enexis is developing a prototype of an Internet-of-Things (IOT) enabled EV charging platform that will accept payments in cryptocurrencies |
| Pacific Gas and Electricity | United States | The US-based utility is working on an expansion plan for its 7,500 EV charging stations. It has collaborated with eMotorWerks and Oxygen to provide the platform for blockchain-based transactions |
| TenneT | Germany | TenneT is developing a blockchain-based platform that attempts to integrate household batteries and charging stations for EVs |

# Use Case – Share&Charge, Germany

### *Project*

Share&Charge has developed an open charging network wherein charging solution providers can integrate their services in a plug and play manner. In August 2019, the company conducted a pilot project for a cryptocurrency-based e-mobility wallet. Carried out in Germany, **50 EV users were able to pay for their EVs using a stable cryptocurrency* called DAI.** The pilot was conducted with Innogy, MakerDAO and Share&Charge Foundation.




### *Process*

Based on the blockchain technology, the EV owners can charge their vehicles using cryptocurrency by registering their vehicle and connecting the EV with the Share&Charge app. The charging session is paid for in terms of DAI, the cryptocurrency. DAI transactions can be tracked through the blockchain portals to verify and validate the transactions carried out. It is a stable form of cryptocurrency that does not fluctuate like bitcoin. Blockchain enables secure transactions for charging the EVs.

### *Application for energy access*

Share&Charge aims to disrupt payment solutions for e-mobility and make cryptocurrency as the primary mode of payment to create a traceable, verifiable, and secure history of units of power used and EVs charged during any given period of time.

**With the increase in blockchain and cryptocurrency-based solutions, it is important for e-mobility to embrace the technology as a future-forward mode of energy access based only on verifiable digital payment platforms.**

*Source: Share&Charge; Intellecap*

**Stable cryptocurrencies are those that remain at a fixed value, unlike bitcoins which fluctuate*

ENERGY
CATALYST

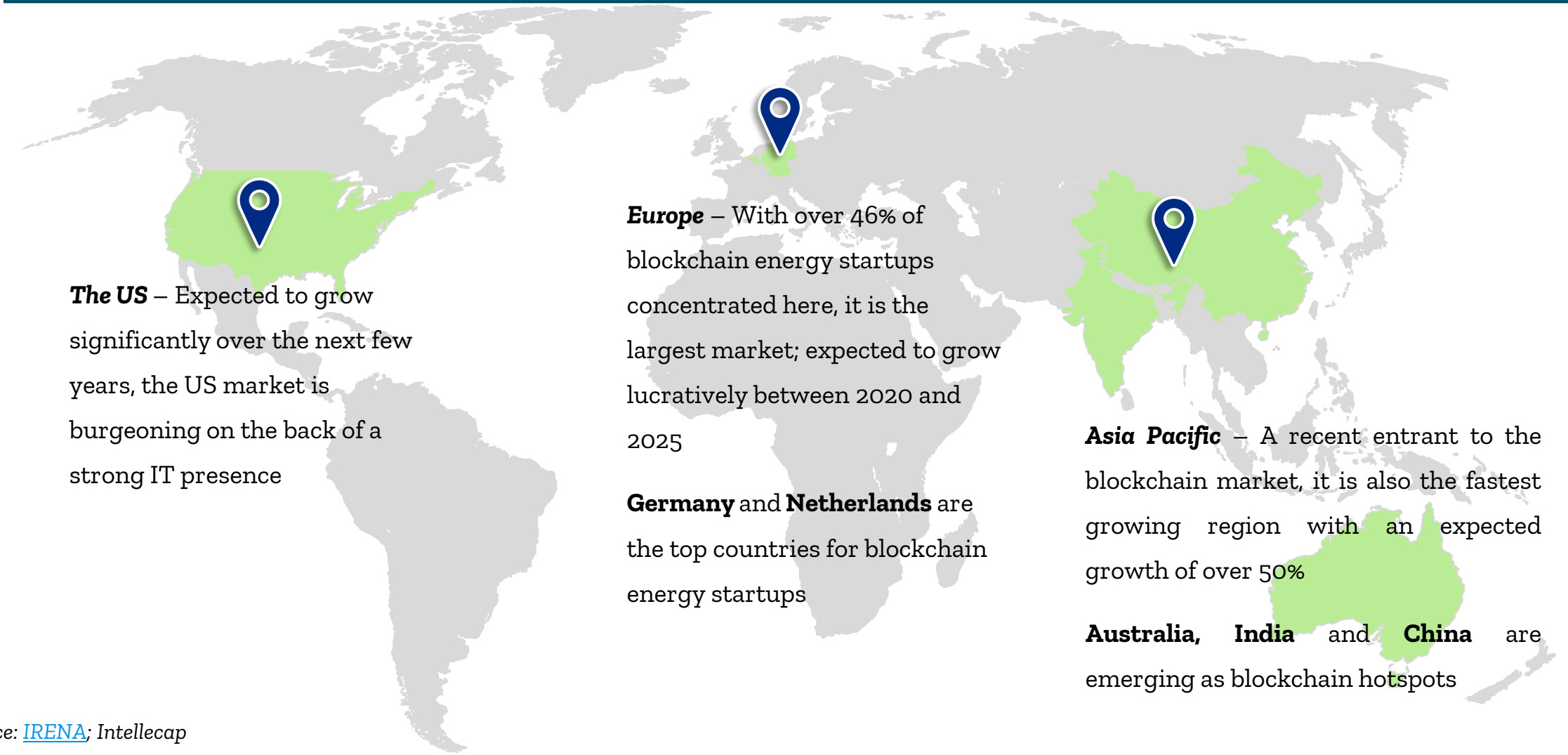
# Market dynamics of Blockchain in the energy sector

## Market Dynamics of Blockchain in Energy Sector

- Geographical Focus Areas
- Key Statistics
- Key Points of Engagement

*Return to table of contents*

# Market Dynamics of Blockchain – Geographical Focus Areas



***The US*** – Expected to grow significantly over the next few years, the US market is burgeoning on the back of a strong IT presence

***Europe*** – With over 46% of blockchain energy startups concentrated here, it is the largest market; expected to grow lucratively between 2020 and 2025

**Germany** and **Netherlands** are the top countries for blockchain energy startups

***Asia Pacific*** – A recent entrant to the blockchain market, it is also the fastest growing region with an expected growth of over 50%

**Australia, India** and **China** are emerging as blockchain hotspots

*Source: IRENA; Intellecap*

# Market Dynamics of Blockchain – Key Statistics

***Blockchain is rapidly moving into the early growth stage of the market, as the use cases and applications continue to expand beyond the realm of financial transactions. Blockchain is gaining greater acceptance in the energy access segment, and blockchain-based energy access applications are expected to grow to a global market size of $3 billion by 2025.***

**74%** companies were founded between **2016** and **2018** – *Early-stage technology*

**50%** projects use **Ethereum** blockchain platform – *Concentrated market*

**Peer-to-Peer** trading is the most common application within the energy space – *Diversification of use cases*

**300 kWh** of power consumed by each Bitcoin transaction – *Power-intensive usage*

**42.67 TWh** of power consumed annually by Bitcoin (largest cryptocurrency) and Ethereum (most common blockchain platform) combined – *0.19% of the world's annual electricity consumption*

*Source: IRENA; Intellecap*

# Blockchain in Energy Sector – Key Points of Engagement

- In the energy sector, the role of blockchain was earlier concentrated to fiscal transactions and trading.
  - In March 2018, International Energy Research Centre, launched the EnerPort project to accelerate energy trading in Ireland through blockchain.
- New use cases have emerged through startups that are applying the technology for improving energy access, e-mobility, grid management and others.
  - SolarChange has emerged as a platform for exchange of solar coins.

| | |
|---|---|
| ~200 | Number of companies working in blockchain in the power sector |
| Over 30 | Companies leading blockchain projects in Grid Edge space* |
| Over $450 mn | Capital invested** in blockchain power companies |
| ~80 | Energy projects currently underway globally |

** According to Siemens, Grid Edge refers to the advanced grid technologies that enable integration of intelligent grids, smart buildings, prosumers, blockchain etc.*

*Source: IRENA; Intellecap*

*** As of 2018, 79% of which was through initial coin offerings*

ENERGY
CATALYST

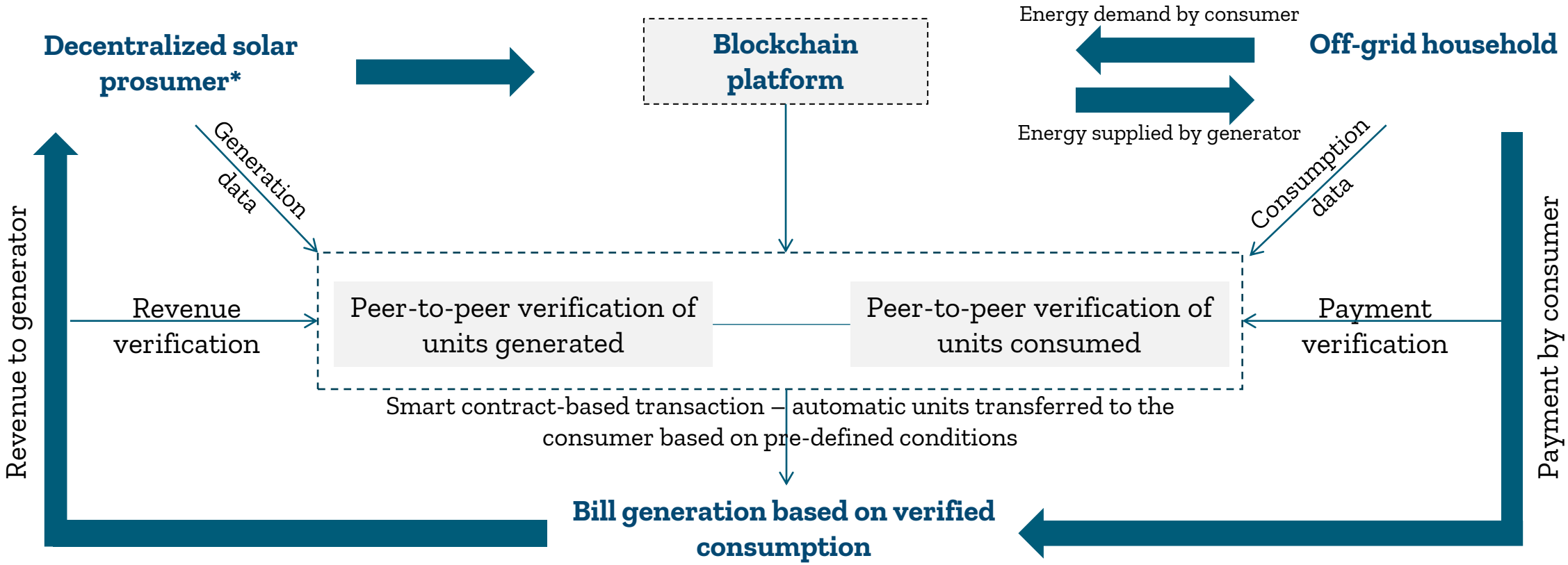
# Annex 1:

# Blockchain-based energy value chain and process of execution

Return to table of contents

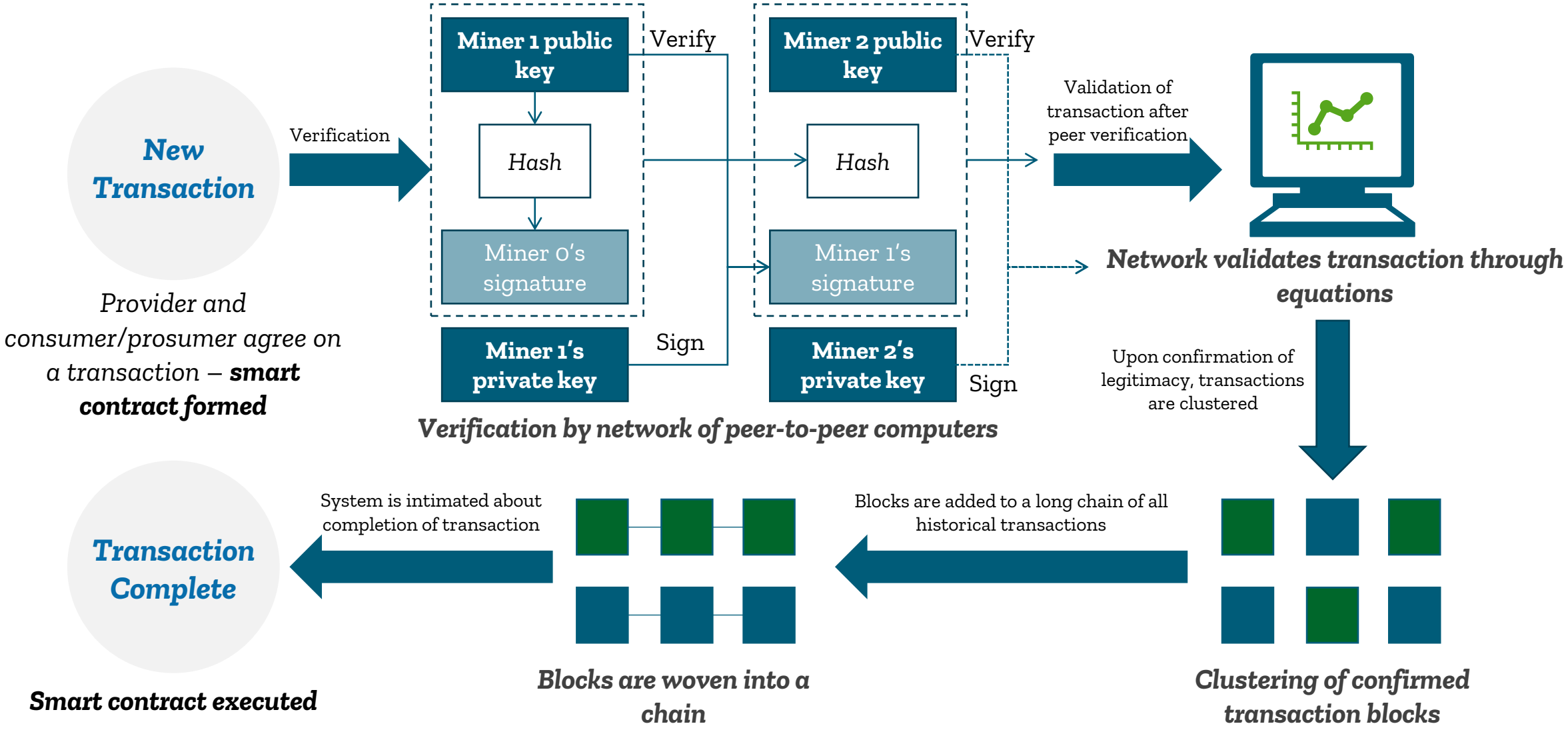
# Blockchain-based Energy Access Value Chain

*Energy access value chain model with blockchain-based transactions to electrify off-grid households through decentralised solar power generation to exemplify advantages of using blockchain*




*A **prosumer of energy** is an individual who both consumes and produces energy

# Process of Execution



# Process of Execution – Explained

- **Block:** Each chain consists of multiple blocks which has three primary elements – data in the block, a 32-bit randomly generated whole number called nonce, and a hash which is a 256-bit number associated with the nonce. The hash and nonce are unique to each block or unit of transaction.
- **Miner:** Miners create new blocks through a process known as mining. Each unique hash has traces or references of the hash of the previous block in the chain. Miners use special software to mine the unique hash that can then be added to the block. Making any change to the blocks requires re-mining of the hash and all the blocks that come thereafter, which makes the transaction extremely secure.
- **Equation:** Miners use extremely complex mathematical equations to generate the hash keys and validate the entire transaction. The equations are solved using sophisticated software.
- **Public and private key:** These are digital signatures owned by miners that are used to prove that the transaction was indeed verified and not forged. It is possible to recover a public key if one has a private key but it is impossible to recover a private key using only the public key. This makes blockchain verification a one-way process. Private keys are used for cryptocurrencies.

*Once the transaction is entered into the blockchain process, miners begin to validate the transaction. They use their public and private keys to mine or verify the hash of the blocks. A long chain of hashes with unique imprints of verification from the previous miner is created. A mathematical algorightm is then used to segregate the verified blocks for a particular transaction. The unorganised cluster of verified blocks is then organised according to the transaction. Once the blockchain of verified blocks is created and validated, the transaction is said to be complete.*

ENERGY CATALYST

# Annex 2:

# Examples of blockchain platforms

Return to table of contents

# Blockchain Platforms – Ethereum

*Functional since 2015, Ethereum is an open-source distributed computing platform which is used by over 50% of the world's blockchain transactions*

- **Enables contracts and applications:** Ethereum enables smart contracts and distributed applications to be built into the platform. It is safe, secure, and runs without any downtime or fraud jeopardising the transactions. Ethereum's customisability and diverse functionalities make it the most popular blockchain platform.
- **More than a platform:** Apart from being a blockchain application platform with its own cryptocurrency, it is also a programming language running on a blockchain helping developers to create distributed applications.
- **ConsenSys:** Microsoft has partnered with ConsenSys through the Ethereum platform which offers Ethereum blockchain-as-a-service (EBaaS) on Microsoft Azure for enterprise clients and developers to have a common platform for cloud-based blockchain developers environment. It is one of Ethereum's biggest projects.
- **Two blockchains:** Ethereum was split into two blockchains, Ethereum and Ethereum Classic in 2016 after a malicious attack led to a loss of more than $50 million that had been raised on DAO, a smart contract based on the Ethereum platform.
- **Ether:** Ether (ETH) is the name of the cryptocurrency associated with Ethereum, the second largest in the world behind Bitcoin. Ether is much faster and can be acquired in a matter of seconds as opposed to about 10 minutes usually taken for bitcoin to be processed and owned. Its current value stands at over $3,000 per ETH.

*Source: Intellecap; Ethereum*

# Blockchain Platforms – IBM

*IBM's blockchain platform helps businesses collaborate through the network. IBM has a dedicated division for blockchain which continually develops blockchain-based apps.*

- **Open and interoperable:** IBM's blockchain platform is open and interoperable across multiple environments, both physical (on-premises) and cloud-based processes. The current version is based on feedback and inputs from over 500 engagement with large entrepreneurial clients.
- **Leadership status:** IBM's position as a founding member of the Linux Foundation Hyperledger Project lends a strong experience and functionality to its blockchain platform. Hyperledger Fabric is the recognised framework for permissioned blockchain networks.
- **Business platform:** IBM's blockchain platform is built keeping in mind entrepreneurial requirements and is largely a business-specific platform that provides blockchain solutions. There is a strong and smooth integration between smart contract development and network management.
- **Bespoke elements:** The platform allows businesses to deploy only the blockchain components that are extremely necessary and required for developing the solution – such as ordering service, certificate authority, and so on. It also allows complete control over all entities, ledgers and smart contracts without a vendor lock-in system.
- **Flexibility:** It can connect to nodes running either on-premises, or on cloud or even hybrid environments.

*Source: Intellecap; IBM*

# Blockchain Platforms – Stacks

*Stacks enables decentralised applications and smart contracts that can integrate with the security, capital and network of Bitcoin.*

Stacks

- **Integrated smart contracts:** Stacks connects to the programmes of Bitcoin to enable building of applications, smart contracts and other assets into the security and safety of bitcoins. This allows the contracts to directly be integrated into the Bitcoin system – making it easier for transacting Bitcoins as per integrated smart contracts.
- **Financial system reimagined:** Stacks allows the entire financial system to be reimagined. By integrating the contracts directly into the applications and codes for bitcoins, it helps in creating a more robust and fraud-proof financial system layer on top of Bitcoin, without the need for intermediaries.
- **Bitcoin as a programmable layer:** By building on top of Bitcoin's coding layer, the applications run their logic with smart contracts which are accessible to anyone within the programme. This allows the applications to be decentralised and not controlled only be the companies.
- **Irreversible transactions:** Once the transacstion layer has settled on the Bitcoin, it becomes irreversible, which means that the transaction will have to be settled. This is critical for applications as it brings the assurance that the transaction once locked will be carried forward and settled in bitcoins as per the contract.
- **Certainty:** This could be a critical factor for energy trading companies that may look for the element of certainty for transactions. For energy startups, it could lead to a strong network leveraging the existing reach of bitcoins.

*Source: Intellecap; Stacks*

# Blockchain Platforms – OpenLedger

*Supporting digital transformation of companies, OpenLedger provides custom blockchain services and development options.*

- **Custom blockchain development:** OpenLedger allows the development of custom blockchain applications to create business tools and solutions required for problem solving through decentralised networks. It also allows companies to create private blockchain networks that can enable completely distributed and secure business processes. It has in-house blockchain developers that help create the custom blockchain networks.
- **Leveraging existing platforms:** The developers allow business solutions to be built upon platforms such as Ethereum, BitShares, EOS, and Hyperledger. The customised decentralised blockchain network helps startups in controlling data, information, security and transactions, especially in data-sensitive industries such as finance, insurance, energy, entertainment, etc.
- **Project development and management:** OpenLedger is not a traditional blockchain platform, but utilises the existing platforms to create solutions for various industries. Its project development and management teams put strong emphasis upon building customised projects that amplify the benefits of blockchain along with creating industry-based solutions for specific needs.
- **Time-locked wallets:** OpenLedger's time- or event-locked wallets allow transactions to be triggered based on specific commands that are dependent upon the completion of an event or a specific time period. This helps in easy, fast and seamless payments across the platform.

*Source: Intellecap; OpenLedger*

# Blockchain Platforms – R3 Corda

*R3's open source blockchain platform, Corda creates secure private transaction experiences and exercises a granular level of control over digital records.*

- **Purpose-built DLT:** R3 develops purpose-built or customised distributed ledger technology for businesses. It has built an enterprise blockchain platform Corda with more than 350 organisations currently using it. The R3 Corda platform is known to have shortened the time-to-market for companies while building networks and ecosystems based on the blockchain platform.
- **Unique firewall:** Corda has a unique firewall features that is built into its data centres which communicates safely with other nodes. It prevents any spurious attacks or pilferages, making it secure for sensitive transactions.
- **CorDapps:** Organisations can develop applications on the Corda platform based on their needs and customised solutions. The network, developed through R3's blockchain application and project ecosystem that brings together entire industries, is available for developers and organisations to leverage.
- **Open source and open design:** The Corda platform brings the benefits and features of open source with functionalities and services of the enterprise solutions. It provides permissioned distributed applications for organisations to build to serve their purposes. The applications built on Corda can easily integrate with systems that run most businesses, providing seamless integration and interoperability. Furthermore, its developers work directly with organisations to understand enhancements and features that can be added to the platform.

*Source: Intellecap; R3*

# Further reading

- *Blockchain Innovation Landscape Brief, IRENA (2019)*
- *Primer on Blockhain, USAID (2018).*
- *Blockchain Technologies for Energy Access, Energypedia (2018)*
- *Blockchain Opportunities for Social Impact in Developing Countries, Energypedia (2018)*
- *Using Blockchain to Enable Cleaner, Modern Energy Systems in Emerging Markets, IFC (2018)*
- *Blockchain can change the face of renewable energy in Africa. Here's how, SunConnect (2018)*
- *Navigating Blockchain and Climate Action, Climate Ledger Initiative (2018)*
- *Blockchain Innovations for Energy Access. Coinify Newsroom (2017)*
- *Effective Disruption: How Blockchain Technology can transform the Energy Sector, ME SOLshare (2017)*