IRENA Innovation Landscape Report
The evolving role of Blockchain in the power sector
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International Renewable Energy Agency (IRENA)
The Climate Technology Centre and Network

Organisation

• Operational arm of the UNFCCC Technology Mechanism
• Consortium of organizations from all regions + Network

Mission and scope

• Mission to stimulate technology cooperation and enhance the development and deployment of technologies in developing countries
• Technologies include any equipment, technique, knowledge and skill needed for reducing greenhouse gas emissions and for adapting to climate change effects

Core services

• Technical assistance to developing countries
• Knowledge platform on climate technologies
• Capacity building and support to collaboration and partnerships
CTCN Technical Assistance

Country-driven
- Any organization from developing countries can express need
- Request endorsed and submitted by the NDE

Fast and easy access to assistance
- User-friendly access: 4-pages submission, in all UN languages
- Appraisal of request within 1-2 weeks and response design within 2-12 weeks

CTCN selects and contracts relevant experts
- Assistance provided through Consortium and Network (value up to 250,000 US$)
- Collaboration with financial organizations to trigger funding

Support to remove barriers to technology transfer (financial, technical, institutional)
- Identification of needs and prioritization of technology, depending on country context
- Technical recommendation for design and implementation of technology
- Feasibility analysis of deploying specific technologies
- Support to scale up use and identify funding for specific technologies
- Support legal and policy frameworks
Networking and Collaboration

Join our network! Easy and free of cost.

**Access commercial opportunities:** respond to competitive bidding for delivery of CTCN technical assistance services

**Create connection:** network with national decision makers and other network members to expand your partnership opportunities and learn about emerging areas of practice

**Increase visibility:** broaden your organization or company’s global reach, including within UNFCCC framework

**Exchange knowledge:** keep updated on the latest information and share via the CTCN’s online technology portal

**Examples of collaboration**
- Co-host climate related events
- Twinning arrangements with research institutions
- Engage in new technology projects
How to use the webinar platform

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2. Listen by telephone: Please select the "telephone" option in the right-hand display, and a phone number and PIN will display.

To ask a question
Select the “questions” panel on your screen and type in your questions, at any time during the presentation

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Contact the GoToWebinars Help Desk: 888.259.3826

The presentations will be made available after the webinar
A bit of background...

IRENA’s Report

Innovation landscape for a renewable-powered future
Ongoing energy transformation – Drivers

- **Policy imperatives**
  - Sustainable Development and Economic Growth (SDGs)
  - Climate and Environmental agenda (Paris Agreement)

  94% of needed emission reductions from RE and EE

- **RE Strong Business case**
  - Policy frameworks, business and technology innovation
  - Dramatic cost reduction

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
Innovative solutions to increase power systems flexibility propelled by three trends

• **Decentralisation – supply side.** Wind and PV is largely centralised today but distributed generation - notably rooftop PV, ~1% of all electricity generation today – is growing, bringing new flexibility opportunities at demand side.

• **Electrification – demand side.** It plays in two ways, may decarbonise end-use sectors through renewable electricity and, if done in a smart way, become a flexibility source to integrate more renewables in power systems.

• **Digitalisation – system integration.** Key enabler to amplify the energy transformation by managing large amounts of data and optimising systems with many small generation units.

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
Wind and PV are variable energy sources – addressing variability is crucial for high deployment.

Today’s innovation challenge – integrating high shares of wind and PV at lowest-cost in power systems.

Power-system flexibility is key to the cost-effective use of renewables.

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
### Landscape of Innovation for Power Sector – 30 innovations in Four Dimensions

**ENABLING TECHNOLOGIES**

<table>
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<th>1</th>
<th>Utility-scale batteries</th>
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<td>Behind-the-meter batteries</td>
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<td>Electric-vehicle smart charging</td>
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<td>Renewable power-to-hydrogen</td>
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<td>Internet of things</td>
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<td>Artificial intelligence and big data</td>
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**BUSINESS MODELS**

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| 15 | Community-ownership models |
| 16 | Pay-as-you-go models |

**MARKET DESIGN**

| 17 | Increasing time granularity in electricity markets |
| 18 | Increasing space granularity in electricity markets |
| 19 | Innovative ancillary services |
| 20 | Re-designing capacity markets |
| 21 | Regional markets |
| 22 | Time-of-use tariffs |
| 23 | Market integration of distributed energy resources |
| 24 | Net billing schemes |

**SYSTEM OPERATION**

| 25 | Future role of distribution system operators |
| 26 | Co-operation between transmission and distribution system operators |
| 27 | Advanced forecasting of variable renewable power generation |
| 28 | Innovative operation of pumped hydropower storage |
| 29 | Virtual power lines |
| 30 | Dynamic line rating |

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Innovation unlocks flexibility across whole power system

Smart RE-electrification supported by Digitalisation representing **62% of global energy CO2 reduction** potential by 2050

**Flexibility providers in the current power system**

**Flexibility providers in the future power system**

**Flexibility sources:** Flexible generation

**Flexibility sources:** Flexible generation; Regional Interconnections and markets; Demand response; Storage; Power to X

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
Combine Innovations to Create Flexibility Solutions

**Example 1:**
- DER providing services to the grid
  - BTM batteries / Smart Charging for EVs
  - Power-to-heat + IoT / AI & Big Data / Blockchain
  - Aggregators
  - DER participation in wholesale market
  - New products on ancillary service market
  - DSO-TSO co-operation

**Example 2:**
- Increase VRE integration while avoiding grid reinforcements investments
  - Utility-scale battery storage
  - Power-to-hydrogen / Power-to-heat + IoT / AI & Big Data
  - Virtual power lines / Dynamic line rating
Combining innovations into solutions – 11 solutions

<table>
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<tr>
<th>Supply-side Flexibility Solutions</th>
<th>Grid Flexibility Solutions</th>
<th>Demand-side Flexibility Solutions</th>
<th>System-wide Storage Flexibility Solutions</th>
</tr>
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<tbody>
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<td>I Decreasing VRE generation uncertainty with advanced generation forecasting</td>
<td>III Interconnections and regional markets as flexibility providers</td>
<td>VI Aggregating distributed energy resources for grid services</td>
<td>X Utility-scale battery solutions</td>
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<td>II Flexible generation to accommodate variability</td>
<td>IV Matching RE generation and demand over large distances with Supergrids</td>
<td>VII Demand-side management</td>
<td>XI Power-to-X solutions</td>
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<td>V Large-scale storage and new grid operation to defer grid reinforcements investments</td>
<td>VIII RE mini-grids providing services to the main grid</td>
<td>IX Optimising distribution system operation with distributed energy resources</td>
<td></td>
</tr>
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Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
Synergies between innovations that permit grid services based on distributed energy resources

Enabling technologies
- Behind-the-meter batteries
- Electric-vehicle smart charging
- Renewable power-to-heat (residential)
- Internet of things
- Artificial intelligence and big data
- Blockchain

Business models
- Aggregators

Market design
- Market integration of distributed energy resources
- Innovative ancillary services

System operation
- Co-operation between transmission and distribution system operators

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
The emerging role of Blockchain
In the energy sector, Blockchain is a solution to Disruptions:

- Digitalisation
- Decarbonisation
- Decentralisation
- EVs
The energy system is fundamentally changing
The energy system is fundamentally changing

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
Blockchain technology - Potential benefits

➢ Reduced transaction costs
➢ Increased transparency
➢ Increased security via cryptography
➢ Increased automation via smart contracts
➢ Increased participation by new/more actors via decentralisation
Key takeaways from Innovation Week 2018

Digitalisation can enable smarter, better-connected, more reliable and ultimately lower-cost energy systems

• Blockchain is a tool that can be used to accelerate the energy transformation and is not a goal in itself. Increasing energy sector complexity requires newer, smarter tools.

• Blockchain has a strong business case in decentralised systems, not suitable for all applications. When does it make sense to use blockchain (?)

• Blockchain has the potential to create new markets/value based on ‘Data Economy’ [value from data-based services]

• Challenges remain in asset registration and integration, interoperability and scalability.

• Many pilots being implemented (as of Sep 2018):
  • 189 companies working in blockchain in energy
  • 71 projects focused on blockchain in energy
  • $466 million invested in blockchain in power

https://innovationweek.irena.org/
Blockchain investment (EU vs ROW)

- **1bn invested** in Energy (71 companies), Logistics (34), IoT (24), Mobility (19), and Agriculture & Food (10) between 2017 and mid-2018

- Blockchain investment in energy sector expected to cross **$5.8 billion by 2025**

As of mid-2018

Source: Cleantech Group
Current uses of blockchain in the power sector – smart contracts at the core

When does it make sense to use blockchain or other DLT?

- Peer to peer power trade: 36%
- Grid management and system operation: 24%
- Electric mobility: 11%
- Management of renewable energy certificates: 11%
- Financing renewable energy development: 12%
- Others: 6%

Note: Data as of July 2018.
Based on: Livingston et al. (2018), Applying Blockchain Technology to Electric Power Systems.

### Extent of blockchain activity in the power sector

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of companies working in blockchain in the power sector</td>
<td>189</td>
</tr>
<tr>
<td>Number of companies leading blockchain projects in Grid Edge space</td>
<td>32</td>
</tr>
<tr>
<td>Amount invested in blockchain power companies</td>
<td>USD 466 million, 79% of which came from Initial Coin Offerings</td>
</tr>
<tr>
<td>Amount raised by start-up companies in 2017 to apply blockchain technology to power sector</td>
<td>USD 300 million</td>
</tr>
<tr>
<td>Number of projects happening globally</td>
<td>71 announced</td>
</tr>
</tbody>
</table>

**Note:** Data valid as of 31 July 2018.

*Source: Metelitsa (2018), “A snapshot into blockchain deployments and investments in the power sector”.*
### Key factors to enable deployment

Demonstration projects and regulatory sandboxes to better understand:

<table>
<thead>
<tr>
<th>Improving performance and scalability</th>
<th>Unveil benefits for regulators and other actors</th>
<th>Reduced power consumption</th>
<th>Needed infrastructure and standards</th>
<th>Cybersecurity and data privacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Increase number of TPS from &lt; 50 to &gt;100k</td>
<td>- Regulator with access to real-time data of all participants to strengthen data analytics</td>
<td>- Bitcoin 300 kWh per transaction, 2018 3.4 GW (proof of work)</td>
<td>- Connection between wet and dry world</td>
<td>- Blockchain increases data security, but any vulnerable point?</td>
</tr>
<tr>
<td>- From proof of work to proof of stake or proof authority</td>
<td>- Simplify interaction between regulators and regulated entities (e.g. DSO)</td>
<td>- New, more efficient consensus mechanisms (Ethereum is shifting, 99.9% less electricity needed)</td>
<td>- Advanced metering infrastructure</td>
<td>- Garbage in garbage out</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Interoperability based on harmonised standards and protocols</td>
<td>- Data management, analytics and PRIVACY (private data on public chains)</td>
</tr>
</tbody>
</table>

Other hurdles to overcome?

From IRENA’s Ministerial RoundTable last January – Minister and CEO discussion on disruptive innovation:

• Lack of knowledge and awareness on how to actually implement blockchain technology
• No room to fail in the energy sector, therefore little room to experiment (need sandboxes to let start-ups test)
• Waiting to see what works and what doesn’t
• Regulatory framework needed
• ?
## Regulations and gov’t buy-in, various jurisdictions

<table>
<thead>
<tr>
<th>Singapore</th>
<th>Republic of Korea</th>
<th>European Union</th>
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<tbody>
<tr>
<td>Singapore Power Group launched a blockchain-powered marketplace for RECs in October 2018</td>
<td>ROK gov’t will spend $3.5 million on a blockchain-enabled virtual power plant (VPP) in the city of Busan</td>
<td>Digital Single Market” policy strategy aims to develop a common approach to the development of blockchain tech for the EU</td>
</tr>
<tr>
<td>Open Electricity Market onboarding from Nov 2018</td>
<td>KEPCO announced a next-gen microgrid using blockchain in Nov 2018</td>
<td>EU Blockchain Observatory and Forum launched Feb 2018</td>
</tr>
<tr>
<td>Enterprise Singapore (a government agency set up to develop the startup ecosystem) announced a new blockchain accelerator programme in Dec 2018</td>
<td>WICA (gov’t agency) announced plans to establish a blockchain center in Busan in June 2018</td>
<td>Declaration on the establishment of a European Blockchain Partnership in April 2018</td>
</tr>
</tbody>
</table>
Energy players must stay informed

• New challengers can use blockchain to displace incumbents, but incumbents that use blockchain wisely stand to realise substantial benefits.
  • Unlock new revenue streams from better-coordinated markets, “smarter” hardware, and wider electrification.

• Many utilities have started to assess the potential of blockchain technology to create both internal and industry-wide efficiencies.
  • Pilots in such areas as trading, distribution, and data management.

• Europe has emerged as the leading region for blockchain innovation, with companies launching a range of initiatives.
  • RWE is piloting an electric-vehicle charging-station network based on smart contracts
  • Vattenfall has launched a pilot peer-to-peer energy-trading network.
  • In Asia, energy manager and power-marketing company Eneres is partnering with Aizu Laboratory to launch a peer-to-peer network.
  • Development in the United States has tended to be led by players outside the power industry, including the Department of Energy.

• Others?
Blockchain for developing countries

Digitalisation is also a key enabler of broadened energy access

• Local marketplaces rely increasingly on prosumers and consumer participation and engagement. Energy trading for microgrids in the developing world has a lot of room to grow and can benefit from the security/transparency/potential reduced transactional cost of blockchain.

Source: M. Andoni et al. Blockchain technology in the energy sector: A systematic review of challenges and opportunities
Blockchain for project financing in developing countries

Prospective investors can buy solar assets, which are subsequently leased to consumers in the developing world, typically local schools and small-sized enterprises. Smart contracts are used to automatically execute payments from solar producers to investors, as energy is being produced in near real-time.

• The Sun Exchange is opening up new avenues to finance the 1 kW-5MW solar market in emerging economies, which had been previously difficult to finance.

• The Sun Exchange has successfully funded 5 solar projects. With a capacity of 155 kWp so far, with one additional projects of 473 kWp in the pipeline near Cape Town, in South Africa.

Source: M. Andoni et al. Blockchain technology in the energy sector: A systematic review of challenges and opportunities
Blockchain-enabled smart metering in developing countries

Distributed ledger technologies keep track of ownership and revenues in immutable records and provide transparency required for regulatory compliance. Solutions aim to overcome issues experienced in developing countries with delayed payments, debt and large numbers of unbanked population.

• A South-African startup company, Bankymoon, is developing technological solutions that integrate Bitcoin payments into smart meters. Bankymoon is a blockchain services provider currently collaborating with Sarb, the South African Reserve Bank, to experiment with different regulatory policies on cryptocurrencies and their applications

• Smart contracts and automated transaction execution allows for real time settlement of payments for water, gas and electricity.

Source: M. Andoni et al. Blockchain technology in the energy sector: A systematic review of challenges and opportunities
Open questions on blockchain for a low-carbon electricity sector

**Governance I:** How to coordinate all actors involved (ICT, retailers, DSO/TSO, regulator, consumer), who has authority, how to ensure transparency and compliance with other related electricity regulations?

**Governance II:** Lack of blockchain procedures and global regulation also means that the procedure for disputes, wrongdoings, and transaction reversals is inconsistent and legally uncertain. It is still unclear how decentralised networks will be treated in a largely centralised world...

**Data privacy:** Comply with GDPR (EU) but foster sharing data (?). No data sharing, no open energy market... blockchain as an enabler of increased data security and privacy?

**Interoperability:** What is needed in terms of standards, how to ensure applications build on different platforms can interact?

**Front runners:** From which sectors should we look and learn, beyond energy? What do utilities need to see to move forward?

**Most interesting use cases for utilities:** Short, medium, long-term?
What to expect in 2019

• More industry players than ever will enter the market
• Blockchain attracts a new wave of energy sector investment
• Major, large-scale pilots bring blockchain closer to true commercial deployment
  • Belgian TSO Elia using blockchain for demand response, EWF Affiliate and Netherlands grid operator Stedin’s unique layered energy system model for community-based energy trading, and the aforementioned Iberdrola-FlexiDAO collaboration on renewable energy solutions
• Using blockchain technology to facilitate EV charging events will receive major focus and attention
• M&A heats up as the nascent market starts to mature
  • Pretenders will disappear while utilities and grid operators adopt viable, mature solutions
• Others?
IRENA Innovation Days

- New series of **IRENA Innovation Day** events taking place in different regions round the world.
- Aim to connect experts and policy makers, showcase emerging innovations from the region and from around the world, and to inspire and inform the transition to a renewable-powered future.
- Build on IRENA’s bi-annual Innovation Weeks - see [www.irena.org/innovation](http://www.irena.org/innovation)
- The first Innovation Day will be in **Uruguay 16th July 2019**.
- Other locations and dates and will be announced soon.
- Attendance is by invitation only. To request an invite contact innovationday@irena.org

IRENA Innovation & Technology Webinars

A new series of IRENA webinars on Innovation & Technology – sharing & discussing key insights from IRENA publications. Launching soon. Check [www.irena.org/innovation](http://www.irena.org/innovation)
Thank you!

Download our Innovation Landscape Report + Blockchain brief


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