Blockchain-Distributed Ledgers in the energy transition

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Characterising the transition

• **Decarbonised**
  – Renewables are low density & intermittent, making the energy system more ‘supply-led’

• **Distributed**
  – Low energy density necessitates distributed generation and bi-directional energy flows

• **Digitalised**
  – Controlling supply-led, distributed, intermittent generation requires a smart grid
  – This requires a very low cost transaction layer to support energy exchanges at the grid edge

• **Disintermediated**
  – Lowering transaction costs requires automation and disintermediation
  – Growing societal demand for collaborative economy models and ‘localism’.

• **Democratised**
  – Supply-led distributed generation & control requires actively/passively engaged consumers
  – Expectations of service delivery & consumer engagement are shifting in the digital economy
  – Thus engaged consumers are at the heart of the new services based energy system

• **Differentiated**
  – By value. Energy services have multiple social and economic values
  – By place. Each of these values change by network, social and environmental context
  – By time. Each of these contextual values change over time from milliseconds to decades
## Democratised: The EU 4th Electricity Directive

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<tr>
<th>3rd Electricity Directive</th>
<th>Production</th>
<th>Wholesale Market Commodity</th>
<th>Wholesale Market Services</th>
<th>Retail Market</th>
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- **No Access**
- **Access without Special Provisions**
- **Access with Special Provisions**

Democratised: European legislative changes

- France (April 2017) amended Article D of their Energy Code to support electricity self-consumption at the grid edge.
- Germany (June 2017) amended their German Renewable Energy Sources Act (EEG 2017) to explicitly include PV tenant electricity consumption.
- Austria (August 2017) likewise begun changing its legislation to better support self-consumption.
- Luxembourg (March 2018) adopted draft legislation regulating self-consumption and promoting the active role of prosumers.
- Spain - Balearic regional government (2018): law under consultation to incentivise residents to participate in community RES projects, and share prosumer energy between residents.
Distributed Ledgers 101
(The most exciting thing since double-entry bookkeeping.)

Blockchain 101 - A Visual Demo by Anders Brownworth <https://www.youtube.com/watch?v=_160oMzblY8>

- Distributed Ledgers ≠ Blockchain ≠ Bitcoin
  - Cryptocurrencies are one application of blockchains
  - Blockchains are one class of Distributed Ledgers
  - Graphical structures will probably supersede blockchains for most applications.
    - e.g. IOTA; Hashgraph; Spectre, etc

Gartner’s latest ‘Hype cycle’ for emerging technologies puts blockchain here.
DLT-101: fundamental properties

- Distributed nature – allowing system resilience:
  - *Social resilience* through distribution of political/economic control;
  - *Cybersecurity resilience* through avoiding a central point of failure;
  - *Physical system resilience* through distributed asset control and subsystem independence.

- From trust in actors - to trust in the system – allowing:
  - Trading between unknown parties;
  - Fair trading between parties of unequal knowledge/power;
  - System action transparency.

- Immutable accountability – allowing:
  - Fair and transparent trading
  - Tracking Guarantees of Origin of renewables and carbon
  - Evidencing and authenticating Demand Side Response

- Digital asset scarcity – allowing:
  - Trading in a zero-sum pooled resource systems like money and energy
  - Creating value for non-monitised social goods
Distributed ledgers 101
(The political economy of Distributed Ledgers)

• Distributed ledgers enable users to agree on the historical record in a way that is (ideally) fast, fair and final.

• Approaches to achieving consensus
  – Controlling the means of production (Proof of Work)
    • Bitcoin; Etherium (current), etc
  – Electing/Appointing leaders (incl. Proof of Authority)
    • Paxos, Raft, Hyperledger, etc
  – Trusting free markets (Proof of Stake)
    • Etherium (future)
  – Referenda (Voting systems)
    • Hashgraph (‘virtual’ voting)
Distributed ledgers 101

• The ‘Internet of Value’
  – Internet makes copying & distributing information easy, but protecting & exchanging information assets hard.
  – Distributed ledgers create scarcity value for information assets, and protocols to support an ‘Internet of value’.
  – “The blockchain makes information look like a thing.”
    • [Joe Ito - MIT Media Lab]

• Why use distributed ledgers for energy trading?
  – DLTs made digital coins behave like physical coins.
  – Currencies require coins (e.g. £) to be recorded (in ledgers), balanced (i.e. zero-sum), and settled – i.e. just like electricity trading.
Distributed ledgers 101

• Open to all participating parties:
  – Permissioned blockchains can only be accessed by authorised users
  – Public blockchains are open to anybody (e.g. like Bitcoin)

• Distributed:
  – Ledger held by all parties & changes agreed by consensus

• Trustless & Disintermediating:
  – Require no centralised/trusted intermediary

• Cryptographically secured:
  – Privately secured with public/private key encryption
Distributed Ledgers & Smart Grids

• A smart-grid requires:
  – A data infrastructure that:
    • Can be used by mutually competing and distrustful entities
    • Ensures integrity, authenticity, commercial secrecy and customer privacy
    • Cannot be compromised by any single entity
  – A financial transaction layer that:
    • Supports product and service innovation
    • Minimises or eliminates transaction costs
  – An IoT control architecture that:
    • Is compatible with component APIs
    • Supports an ecosystem of smart-controls (smart-contracts; distributed computing, fog computing)
    • Is distributed to minimise latency and energy, and enhance privacy.
• Distributed ledgers can provide the transaction and control layer for the smart-grid
Challenges: Distributed ledgers

- Throughput/scaling (transactions per second)
- Latency (time per verified transaction)
- Security: (Inputs, coding flaws; consensus mechanisms)
- Size and bandwidth (Existing tech doesn’t scale well)
- Privacy: (reidentification and GDPR compliance)
- Smart contracts: (Correctness, predictability, legal status)
- Energy intensity: (varies widely by system)
- Usability: (Current APIs and apps are not user friendly).

DTL Energy consumption

<Ref: https://digiconomist.net>

- Energy use depends on security and consensus mechanisms.
  - ‘Mining’ = energy
    - Bitcoin ~ 60 TWh/year (~30MtC)
    - Ethereum ~ 15 TWh/year
- New ‘graphical’ DLTs like Hashgraph & IOTA use orders of magnitude less.
- Bitcoin is a dinosaur – but dinosaur’s evolved into birds. That’s what’s happening now.
Challenges: Distributed ledgers

• Blockchain governance
  – Who agrees changes to the rules governing the blockchain. Is it done by proof of work (miners); proof of stake (coin holders); or proof of authority (founders)?
  – Decred; e.os and others are working on this

• Multichains and parachains – accommodating a diversity of distributed ledgers
  – There are many blockchain and distributed ledger architectures with different functionalities. How can interoperability best be delivered?
  – Polkadot and others are working on this.

• Standards
  – Increasing calls for standards.
  – The EC is working on standards in FinTech and cryptocurrencies
  – No work yet in energy

• Regulation of Initial Coin Offerings/Token Generation Events
  – US Securities and Exchange Commission adjudication on the DAO
  – The Howey test of securities and investments
Challenges: Governance

- **Policy**
  - **Key UK Opportunities: Smart Metering Implementation Programme**
  - Moving to outcome based policies and metrics
  - Mitigating distributional impacts (e.g. grid defection)
  - Mitigating whole energy system impacts (e.g. balancing the legacy grid)
  - Building trust, salience and social value in the energy system
  - Avoiding energy data siloing - building open platforms of analysable but encrypted data

- **Regulatory**
  - **Key UK Opportunities: Ofgem Innovation Link and Regulatory Sandbox**
  - Moving to principles based regulation
  - Reducing barriers to market entry
  - Ensuring customer protection to all groups
  - Balancing economic efficiency and fairness

- **Energy codes**
  - **Key UK Opportunities: Elexon BSC P 362 Electricity Market Sandbox and BSCP 550 Shared SVA Meter Arrangements**
  - Balancing and Settlement Code alterations
  - Master Registration Agreement alternations
  - Evidencing demand response and flexibility services
DLT Use cases

- ~1000 use cases;
- ~100 start-ups;
- ~10s of PoCs;
- A few physical trials;
- Very few working business models.

Figure 7 ‘Results of potential use cases of Blockchain in the energy sector’, p.20 in Burger C, Kuhlmann A, Richard P, Weinmann J (2016) Blockchain in the energy transition: A survey among decision-makers in the German energy industry. ESMT European School of Management and Technology GmbH Deutsche Energie-Agentur GmbH (dena) - German Energy Agency
LO3 Energy
http://lo3energy.com/

- Brooklyn Microgrid (~130 sites)
  - Apr 2016 - P2P energy trading
  - Feb 2017 – P2P energy + efficiency trading through IoT device activation on the blockchain.
  - Environmental, resiliency, community and financial consumer value propositions.
Wholesale energy trading:
PONTON Enerchain

Vertical Focus on Energy

Horizontal Features & Challenges
- Access; Identity Management; Archive historic blocks
- Load; Performance; Stability; Security; Privacy

- PoC phase 2 ends March 2018, 38 companies, hand-over to new governance structure underway

Ref: <https://ponton.de>
Electron <electron.org.uk>

- Currently, bilateral trading in the DSR market precludes value aggregation across multiple beneficiaries.
- Electron are looking to release value through collaborative trading of DSR as a non-rival good.
- They disaggregate the components of DSR into its non-rival elements, and allow companies to price them individually.
- They then use blockchain to record all the trading commitments from the industry and enforce the trading protocols of the platform.

This then:
- creates fair and transparent DSR value allocation;
- facilitates trades that wouldn't otherwise happen;
- Encourages greater liquidity and participation in DSR;
- generates significant cost savings;
- leads to better investment decisions; and
- lowers carbon emissions across the energy industry.
M-PAYG

http://www.mpayg.com

- Microfinance + renewable energy company
- Allows low-income households in developing countries access to solar energy
- Cryptocurrency microfinanced via SMS mobile
- 50w PV + battery + control system hardware
- Users pay 5 USD/month up front for one month's unlimited access to power from a solar panel.
- Lease to own model – 36 payments unlocks the panel
- Repeated payments build credit rating and access to credit purchase of additional appliances
- Microfinance payments and smart contracts executed on blockchains.
- Rolling out in Tanzania, Uganda & Kenya
Green Energy Tracker

[https://greenenergytracker.eu]

- Green Energy Tracker uses DLTs to verify and track Guarantees of Origin for EU Renewables.
Start-up finance


During the GRID token pre-sale, Grid+ sold 36,422,909 GRID tokens and currently holds the following assets:

- 85,407.0 ether
- 584.8 bitcoin
- $125,000.00 USD

Using today’s prices, these assets sum to roughly $27.7M. In terms of USD collected at the time of sale, the total is $29.0M.

With the pre-sale officially finalized, this leaves 53,577,091 GRID tokens for sale in the public token sale on October 30.
Recommended reading

• Videos:
  – ‘Peer-to-peer energy trading on blockchains’ – David Shipworth <https://www.youtube.com/watch?v=AcufQeaOK1U>

• Podcasts:
  – Epicenter episode 174 – Carsten Stoker: ‘How blockchains will power the energy grids of tomorrow’, Epicenter – Weekly podcast on Blockchain, Ethereum, Bitcoin and Distributed Technologies, Duration 1:05:53

• Consultancy reports:

• Academic articles: