LECTURE 6: ENERGY
APPLICATIONS OF BLOCKCHAINS
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OUTLINE

Context

Methodology
  • An example

Applications

Conclusion
CONTEXT
Three pillars of future energy systems*

- **Decarbonization**
  - Integrate solar and wind at both utility scale and from prosumers
  - Non-carbon fuels, such as hydrogen (‘green molecules’)

- **Decentralization**
  - Breakup monopolies to allow entry of new players
  - E.g. empower prosumers

- **Digitalization**
  - Better sensing, communication, control: IoT
  - Transparency in existing markets

* World Energy Council
Players in energy systems

- Generators/Fuel producers
- Transmission system operators/Pipeline and shipping operators
- Distribution system operators
- Regulators
- EV charging station operators
- Prosumers

They may not mutually trust each other. What to do?
What to do?

- **Trusted intermediaries** (e.g. escrow agents)
  - Raises the cost of a transaction
- **Use blockchain**
  - Assuming trustworthy metering
  - Provides transparency, accountability, efficiency, and disintermediation
METHODOLOGY
METHODOLOGY

Identify players

What are their trust relationships?

For each relationship:

- Is there reason to doubt this level of trust?
  - If so, use a blockchain to mitigate issues
  - Minimize disruption to existing processes

E.G.: BLOCKCHAINS FOR EV CHARGING
BLOCKCHAINS FOR EV CHARGING
APPLICATIONS
Blockchain for Governance of Sustainability Transparency in the Global Energy Value Chain

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Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/ser

Blockchain technology in the energy sector: A systematic review of challenges and opportunities

Merlinda Andoni, Valentin Robu, David Flynn, Simone Abram, Dale Geach, David Jenkins, Peter McCallum, Andrew Peacock

Proceedings of the 51st Hawaii International Conference on System Sciences | 2018

Dynamics of Blockchain Implementation – A Case Study from the Energy Sector

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CATEGORIES

Market creation

Market-based instruments (MBIs)

Auditing
  - need to balance privacy and transparency
MARKET CREATION

1. Participation in wholesale market by prosumers
   - Consensys
   - Grid+

2. Peer-to-peer energy exchange
   - Brooklyn Microgrid
   - Conjoule

3. Storage operation market
   - sonnen/Tennet

4. Grid balancing market
   - Ponton
MARKET-BASED INSTRUMENTS (MBIS)

5. Renewable Energy Credits
   - Green
   - White
   - StromDAO, Energy Blockchain Labs, Singapore Power

   - Veridium Labs
   - Stellar

7. EV operation
8. Behind-the-meter asset management
   • Energy Blockchain Network

9. EV charging
   • share&charge
   • SWTCH

10. Community sharing
    • enyway
MARKET CREATION
1. WHOLESALE MARKET

1. WHOLESALE MARKET

Why can’t consumers participate?

Increase transparency

Decrease settlement times
2. P2P MARKET

2. P2P ENVIRONMENT

3. STORAGE OPERATION

Home electricity storage is increasingly possible (Tesla, BYD shown below)
3. GRID SUPPORT FROM STORAGE

Can use home storage to store excess renewable energy generated by local generators

Release when needed

But this can reduce storage lifetime

- Homeowners should be compensated
3. POTENTIAL CREDIT STRUCTURE

Suppose you can measure storage use

=> credit for grid support
3. ARCHITECTURE

- Local renewable generators
- Blockchain
- Proof of use
- No double selling
3. BUT...

How can generators trust storage meters haven’t been tampered with?

Do storage owners want detailed usage data to be known?
3. ARCHITECTURE

Proof of use
No double selling

Blockchain

Local renewable generators

Aggregator

Local renewable generators
4. BALANCING MARKET

https://ponton.de/focus/blockchain/gridchain/
MARKET-BASED INSTRUMENTS
5. RENEWABLE ENERGY CREDIT

Green certificate
- Certifies generation of clean electricity
- Can be traded to electricity consumers to ‘green’ them
- Clean generators get paid twice

White certificate
- Certifies reduction in usage or energy efficiency
- Can also be traded to electricity consumers
- Energy efficiency gets paid twice (why?)

Issues
- Can we trust certificates?
- How do we trade them?
5. REC TRUST

Need to have an end-to-end chain of trust from generation to sale to resale
  - Prevents greenwashing

Perfect use of blockchain!

However, requires a trusted me
  - Azure sphere

5. REC TRADING

Can use a blockchain-based market

Prevents double-spending of certificates
6. EMISSIONS TRADING SCHEME

Idea: Issue credits to emitters each year
Credits must match emissions
Can sell excess credits
The total number of credits declines over time
6. ETS USING BLOCKCHAIN

Operation of ETS requires self-reporting

- Plenty of opportunity for mistakes or outright fraud!
  - Reduces effectiveness
- Opacity is the problem
- Blockchain provides transparency
  - Storing primary information
    - Can be audited later
  - But needs regulatory support for disclosure and access
6. ETS USING BLOCKCHAIN

How to balance domestic reporting with international impact?

- Need to have a hierarchy of chains
- Per-country chain where regulators have access to details
  - And not competitors!
- International chain only for provenance
Today, EV incentives are one-time *purchase* incentives

- easy to implement
- potentially *perverse* in jurisdictions with carbon-intensive electricity generation
7. OPERATIONAL INCENTIVES?

EVs
- Reduce particulate and SOx and NOx emissions
- In areas with sufficient renewable energy production, reduce carbon emission
7. POTENTIAL CREDIT STRUCTURE

Suppose you can measure EV use and charging from green sources
=> credit for green operation

Credits can be traded just like RECs
7. ARCHITECTURE

- Blockchain
- Proof of use
- Regulators/Tax authorities
- No double selling
7. BUT...

How can regulators trust odometers haven’t been tampered with?

Do EV owners want detailed mobility data to be known?
AUDITING
8. BEHIND-THE-METER ASSET MANAGEMENT

Prosumer assets are mostly invisible to grid operators

- Type
- Capacity
- Maintenance status
- Operation limits
- Current status
- ...

Blockchain allows creation of a digital twin

Allows asset tracking and analysis
9. EV CHARGING

(already discussed)
10. COMMUNITY RESOURCES

https://www.energysage.com/solar/community-solar/community-solar-power-explained/
CONCLUSION
CONCLUSION

Blockchains can be used to build energy systems even when there is lack of trust
• And can be used to improve the operation of existing systems

Three broad areas
• Creation of new markets
• Market-based instruments
• Audits

Many plausible and important use cases.