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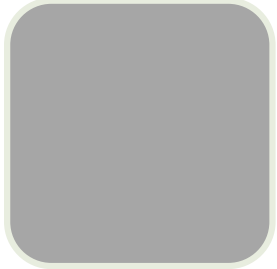
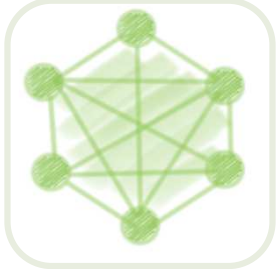
Institute of Energy Systems, Energy Efficiency and Energy Economics

A comparative analysis of using Distributed Ledger Technologies for Transactive Energy Systems



Motivation

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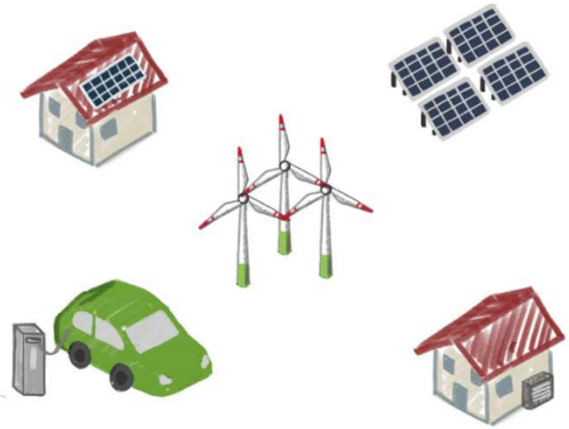
- Four D's of sustainable energy supply:

Decarbonization, **D**igitalization, **D**emocratization and **D**ecentralization

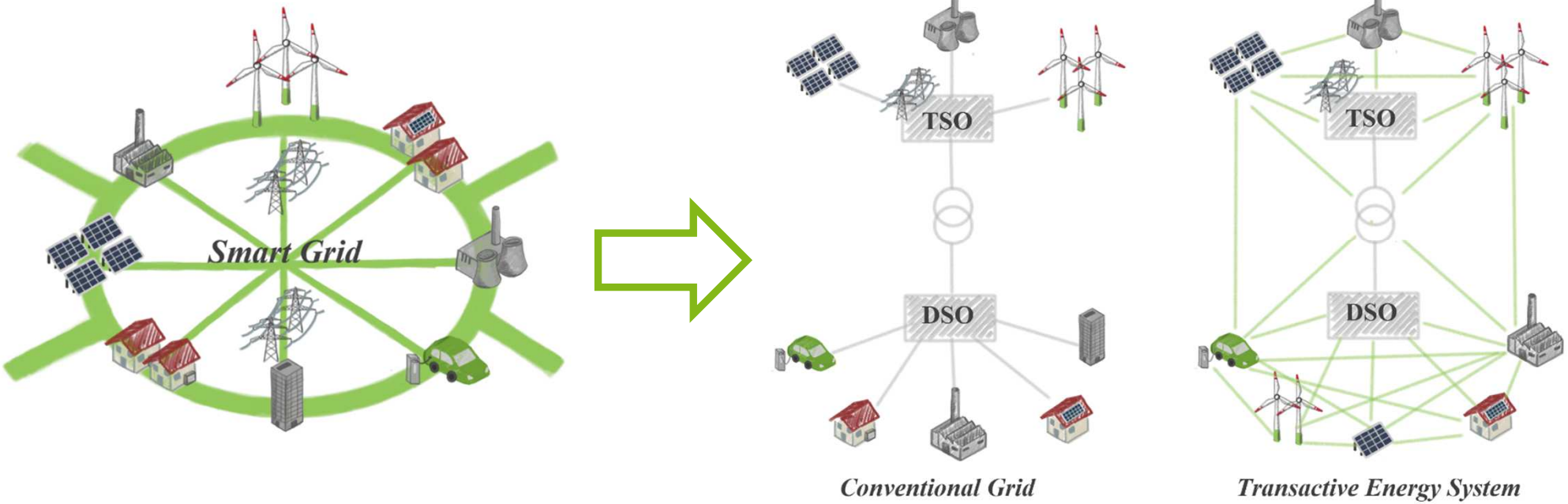


- New technologies needed to overcome obstacles regarding the implementation of distributed energy resources
- **T**ransactive **E**nergy **S**ystems (TES) unite all aspects of the four D's
- **D**istributed **L**edger **T**echnologies (DLT) can be used to achieve decentralized structure

central research question

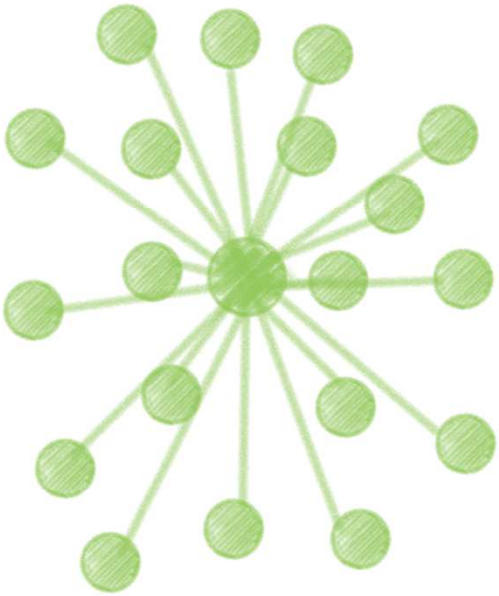
→ How effective is the application of Distributed Ledger Technologies for Transactive Energy Systems?

Transactive Energy Systems

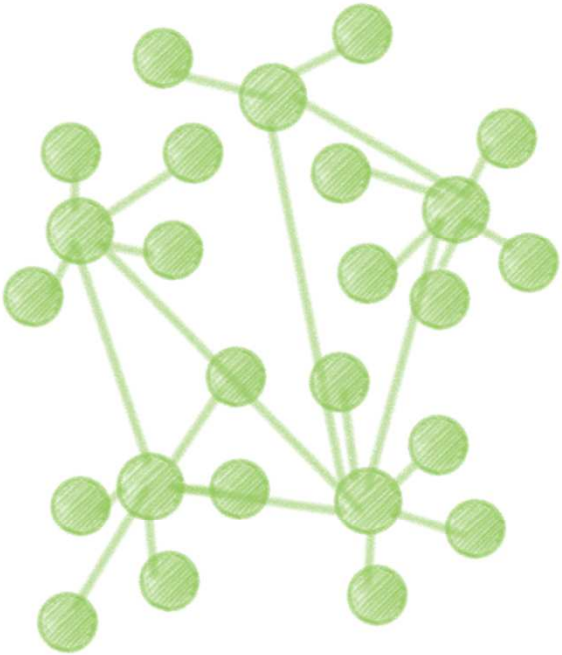


→ Enables dynamic balance between generation and load through intelligent market mechanisms

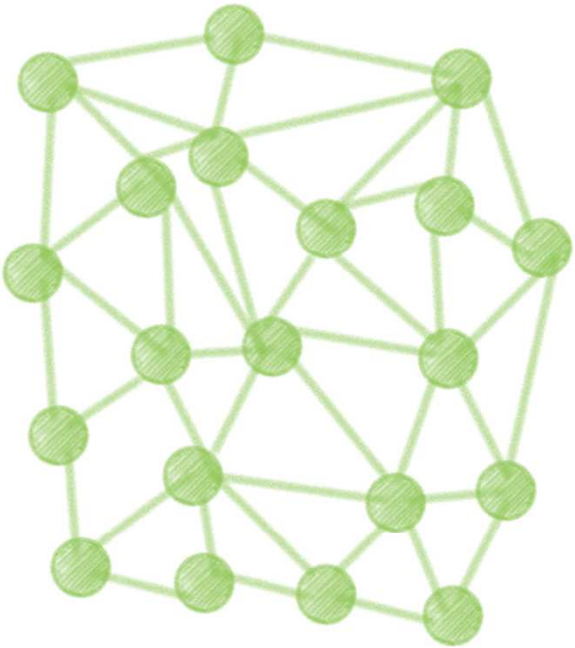
Transactive Energy Systems



Centralized TES



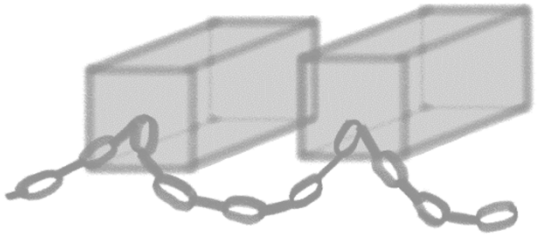
Decentralized TES



Distributed TES

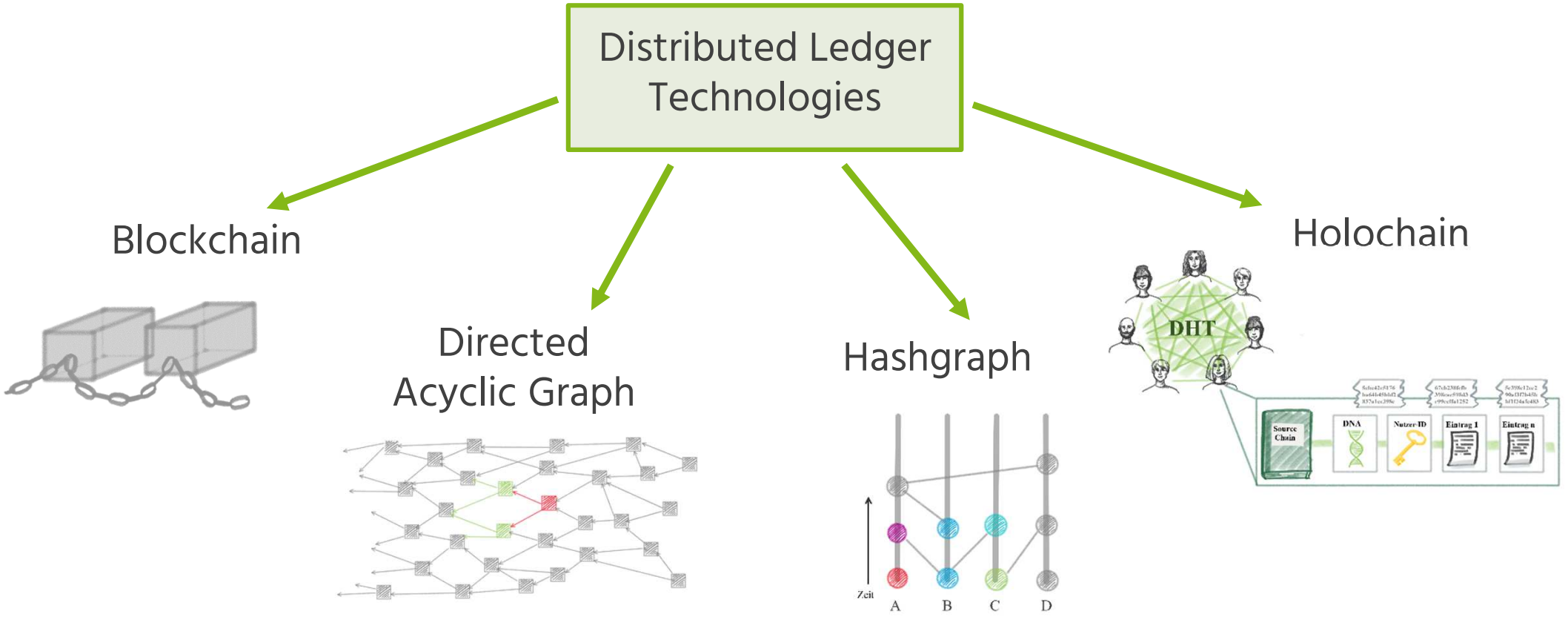
Distributed Ledger Technologies

- Known for cryptocurrencies such as the Bitcoin blockchain
- Enables decentralized transactions without the need of a third party
- consensus mechanisms and cryptographic methods

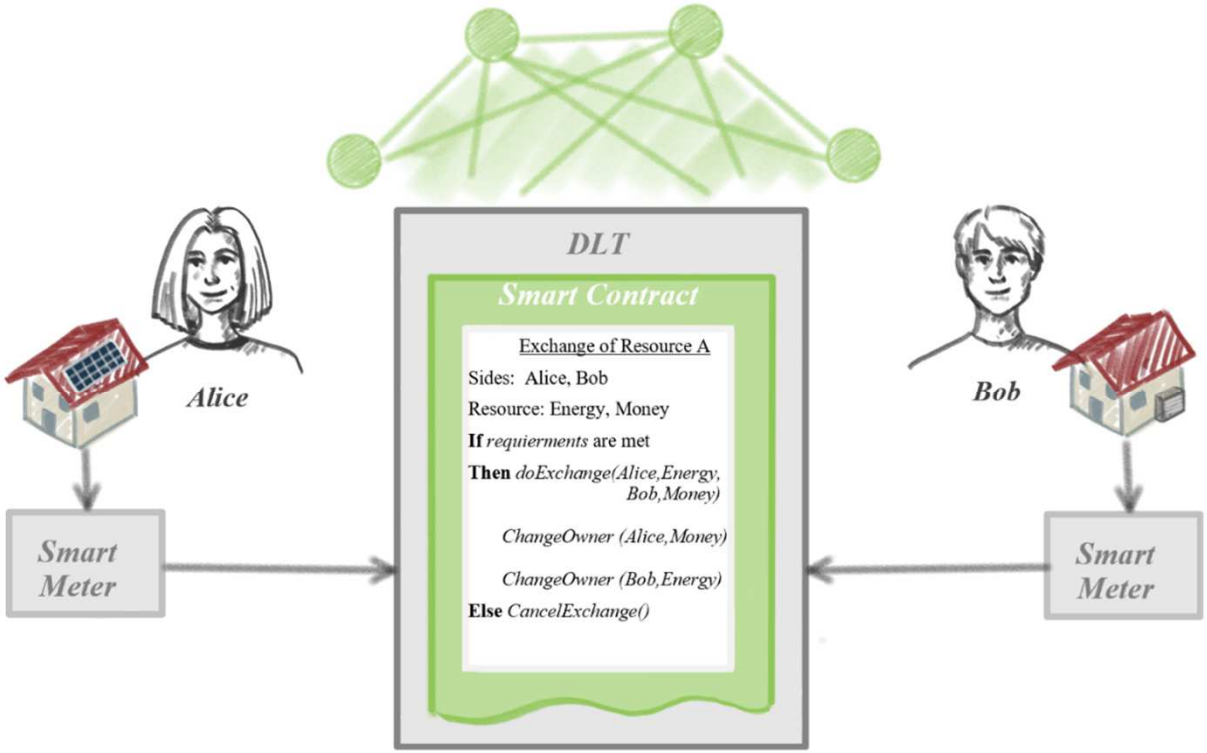


- *Proof-of-Work* — very high energy intake
- *Proof-of-Stake*
- *Proof-of-Authority*
- *practical Byzantine Fault Tolerance*

Distributed Ledger Technologies

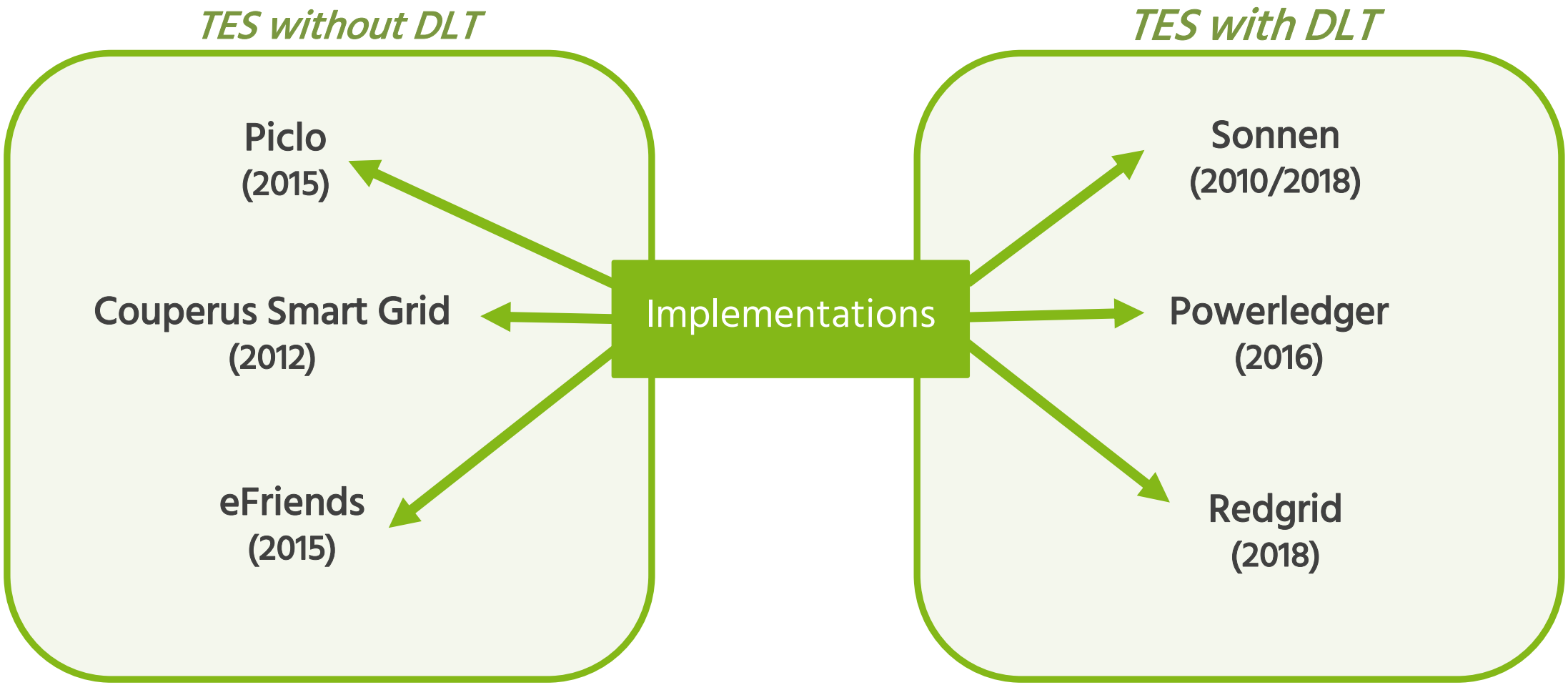


Smart Contracts

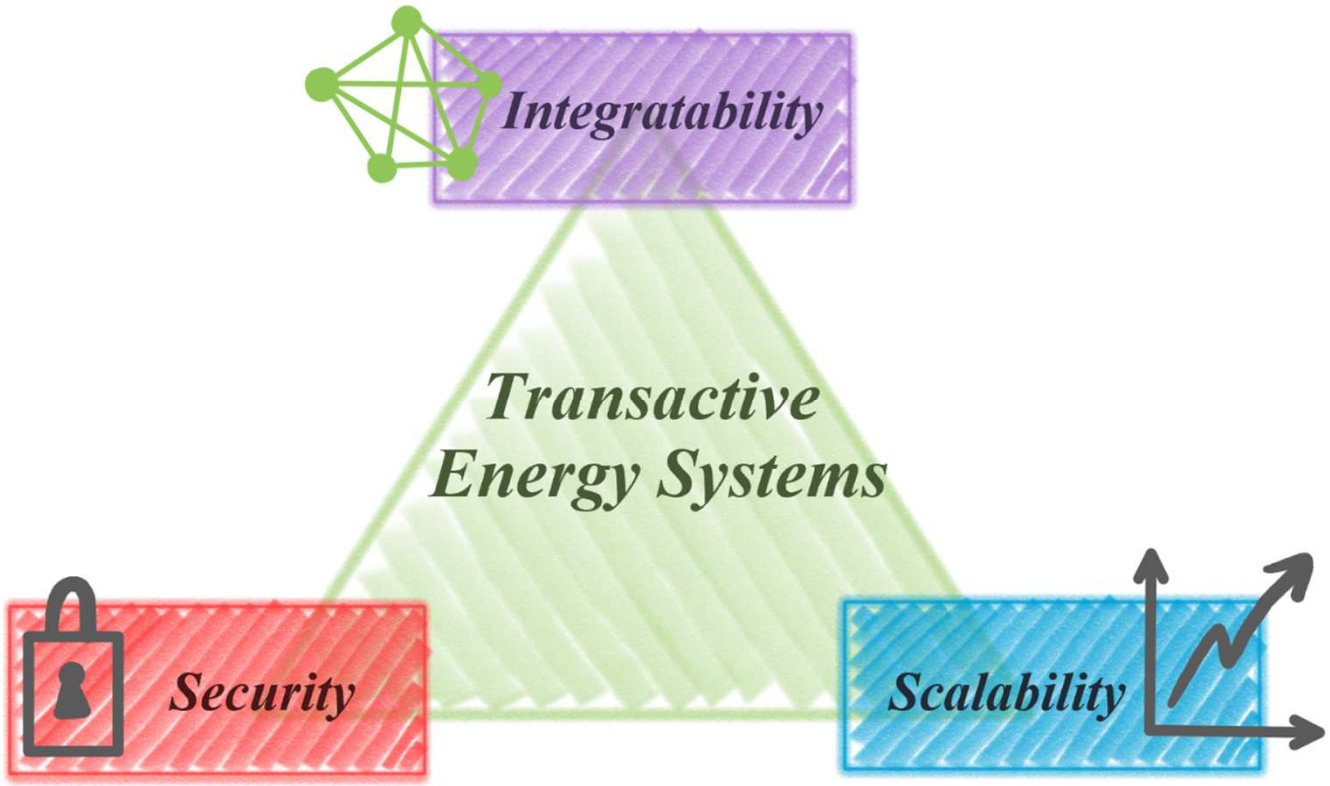


→ Enables enable a decentralized, automated, and secure execution of transactions

Implementations



Comparative Analysis of using DLT for TES



Security

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TES without DLT

- Mostly built as a centralized network
  → Can lead to centralized attacks
- Building decentralized TES challenging task
- Machine learning to detect attacks
  → Still at the beginning point of development
- High effort to obtain cyber-security

TES with DLT

- DLT enabler of decentralized structure
- Consensus mechanisms and cryptographic algorithms enables trust in the network
- Cyber-attacks against DLT networks still possible

Scalability

TES without DLT

- Mostly built as a centralized network
→ Scalability issues
- Scalable networks without DLT have already been built (VISA)
- Multi-agent based control system to achieve scalability

TES with DLT

- Using DLT does not assure a scalable network automatically
- Blockchain (Ethereum) : 10-30 TPS
- VISA : 2000-4000 TPS
- interoperability between different DLT
- Scalability varies drastically between different forms of DLT

Integratability

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TES without DLT

- fewer hurdles due to more centralized approach

⟶ Similar to conventional energy system

- Lower complexity regarding legal and governmental regulations
- Lower integration costs
- With large scale implementations scalability issues arise

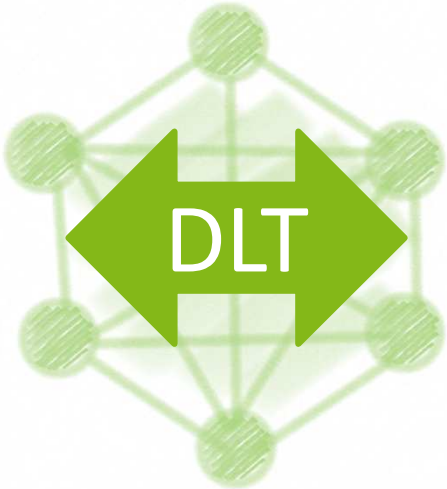
TES with DLT

- Energy system not conceptualized for the application of DLT
- Requires higher bandwidth
- Smart contracts not equal to legal contracts
- Regulatory and governmental frameworks not adapted for DLT

Key Takeaways

- due to the advancements of Ethereum and Smart Contracts in 2017 more TES based on DLT → very young technology
- publication bias regarding TES implementations

advantages of decentralized structure



new obstacles (regulatory, legaly, economically)

→ Usage of DLT needs to be questioned critically and being applied reasonably to avoid unnecessary complexity within the system

Thank you for your attention

Any questions?

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Early Transactive Energy Systems (without DLT)

Couperus Smart Grid (2012)

- apartment complex in Ypenburg (Netherlands) with heat pumps and warm water preparation
- PowerMatcher as transactive control system
- Peak shaving through marginal temperature change of +/- 0,8 °C

➢ imbalances regarding the power feed of wind energy reduced by **more than 80 percent**

eFriends (2015)

- Community based TES in Austria for P2P-Trading
- Sharing excess energy of DER
- Round based trading
- Through online plattform price preferences can be stated as well as energy gifted

➢ **Over 1000 members** in Austria

Transactive Energy Systems based on DLT

Sonnen (2010/2017)

- TES for P2P-Trading with focus on intelligent private battery storage systems
- First built without DLT
- Established Hyperledger Blockchain

➢ Advantage of being able to move away from centralised system

➢ **Lowers efforts and cost** of maintaining an **energy network**

Redgrid (2018)

- Uses Holochain as DLT basis
- „Internet of Energy“
- Intelligent coordination of air conditioning in a grid friendly way
- Very scalable form of TES due to the use of holochain

Abbildung 7

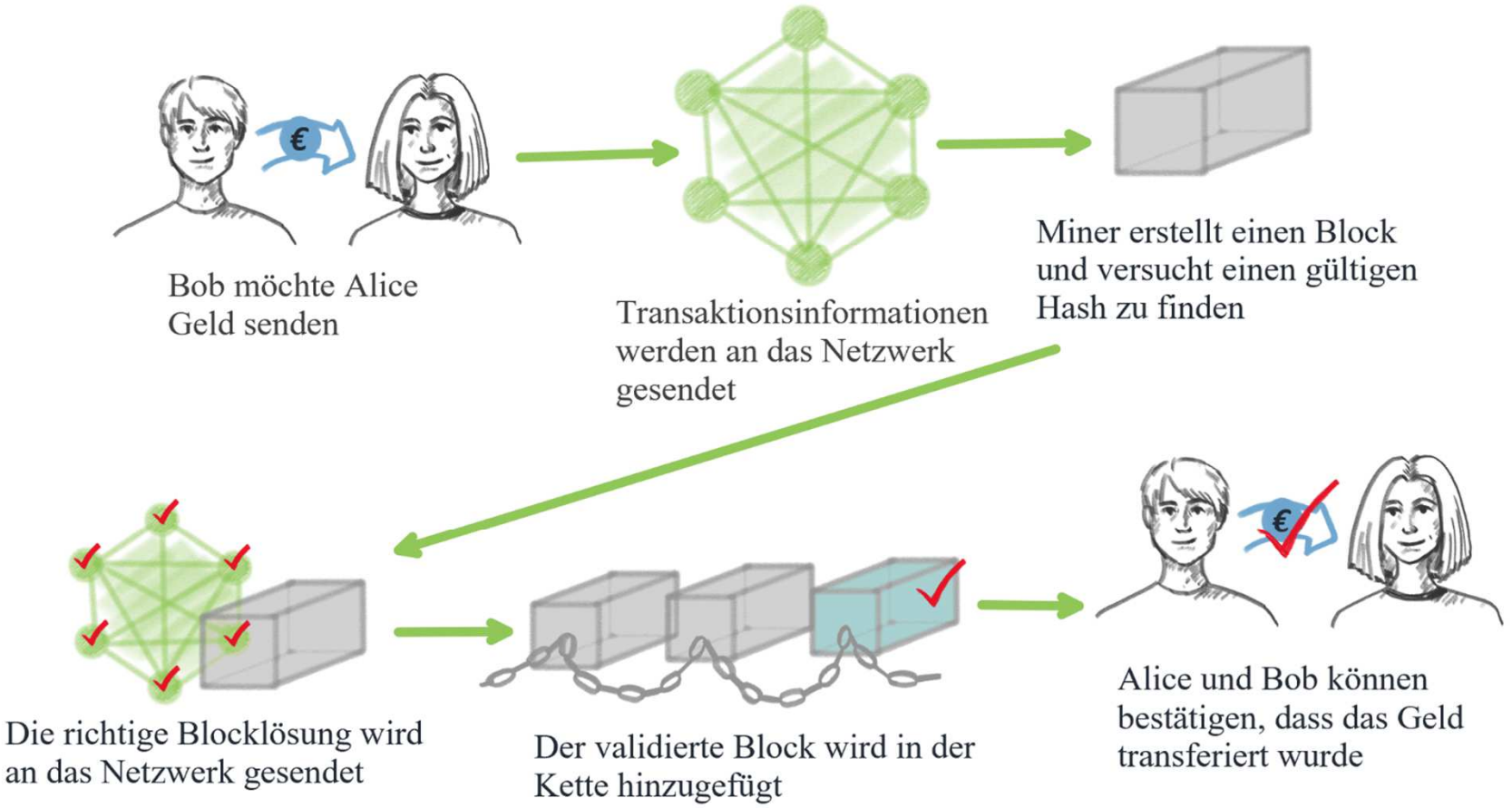
Bob möchte Alice Geld senden
Transaktionsinformationen werden an das Netzwerk gesendet
Miner erstellt einen Block und versucht einen gültigen Hash zu finden
Die richtige Blocklösung wird an das Netzwerk gesendet
Der validierte Block wird in der Kette hinzugefügt
Alice und Bob können bestätigen, dass das Geld transferiert wurde

Abbildung 21: Hype-Zyklus nach Gartner