Fraunhofer FIT

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The Need for a Digital Spine: How Web3-Technologies Unlock DER Flex Potential

Spotlight: The future of EVs in mobility and energy

The transformative impact of digital infrastructures

The cross-sectoral deployment of **digital infrastructures** orchestrates a seamless transition towards electrification and sustainability at nexus of the **energy** and **mobility sectors.**

Seamless bidirectional charging infrastructure access

EV integration in smart energy applications

bidirectional charging Services enabled by digital authentication

cross-sector collaboration

Spotlight: The future of EVs in mobility and energy

Current challenges and (digital) public infrastructure gaps

Challenging EU-wide access to charging infrastructure

Energy opportunities are not deployed due to lack of data

Difficult identification of people and EVs in the electricity grid

Focus on sector-specific solutions

Due to lack of cross-sectoral deployment of **digital infrastructures and orchestration,** a seamless transition remains a challenge and a vision of the future**.**

The cost of data silos in the German energy sector

An informed back-of-the-envelope estimate

Manual synchronization of **master data**

Conservative Assumptions:

- **6.7m** electricity generation units (today[1]), 13.4m (2030 estimate[2])
- **2m EVs** (today[3]), 10.7m (2030 estimate[4])
- **2m heat pumps** (today[5]), 4m (2030 estimate[6])
- Each year **25%** change relevant master data (ownership, supplier, technical specification)
- At least **5 data silos** (MaStR, TSO, DSO, BRP, supplier)
- **20 minutes** of manual work per change

= approx. **4.5m hours/year** (11.7m by 2030) work over all stakeholders

Inefficient communication of **transaction data**

Conservative Assumptions:

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- **2m EVs** (today[3]), 10.7m (2030 estimate[4])
- **2m heat pumps** (today[5]), 4m (2030 estimate[6])
- Average **365 communications** per year (eq. one per day)
- **3 sequential communications** with service providers
- **1.6s** per communication step

= **5.2m hours/year** (13.7m by 2030) waiting time over all stakeholders

€ 55 / hour personnel cost

	master data	overall	transaction data
today	€ 245m	**€ 531m**	€ 286m
2030	€ 640m	**€ 1.392m**	€ 752m

[1] see MaStR
[2] based on increase in RES according to NEP
[3,4] see ADAC
[5] see BWP
[6] see dena

Cost estimates do **not consider** possible **changes in market roles** (e.g., switching between energy supplier and consumer) of FDs, **relevant additional data** (e.g. geographical information of EVs for flexibility services), and **incorrect data entry and communication errors** that **cause asynchronous information**.

OEMs decide whether and by whom their DERs offer flexibility.

The vision: open-sourced DER data infrastructure

Unlocking data access restriction unlocks a vast portion of flexibility potential

Aim: Establishing an open infrastructure for DER data and ensuring direct access for owning households.

We think that verifiable and trustworthy data is essential for unlocking the flex potential of DERs.

A digital orchestrator is necessary to leverage cross-sectoral use cases

Cross-sectoral perspective on advancing the integration of digital technologies in existing infrastructure

Overarching target

Leveraging decarbonization through renewable power and a flexible demand-side

Cross-sectoral use cases

- Energy ↔ Mobility
- Energy ↔ Agriculture
- Energy ↔ Industry
- Energy ↔ Hydrogen
- Energy ↔ Building

Digital Spine

- Building Block #1
- Building Block #2
- Building Block #3
- Building Block #4

Digital technologies

Set of established and emerging digital technologies and their respective design

Data Spaces & Ecosystems	Automated data sharing	Enforced governance
	Open, agile, and user-centric architecture	Connectors
Digital Identities	Digital wallets, agents & hubs	
	Data sovereignty	One (machine) identity
	Decentralization (e.g., decentral identifiers)	
Digital Ledgers	Immutability	Decentral network
	Tracability	No intermediary
Artificial Intelligence	Continuous learning & adaptability	
	Recreating human cognition (e.g., language)	(un)super-vised
Edge Computing	Fast & automated problem solving	
	Resilience and redundancy	Decentralized processing & reduction of latency

Link zur Studie:
https://s.fhg.de/leveraging-twin-transformation

The tension between data verifiability & sovereignty

On the pathway to an open DER data infrastructure

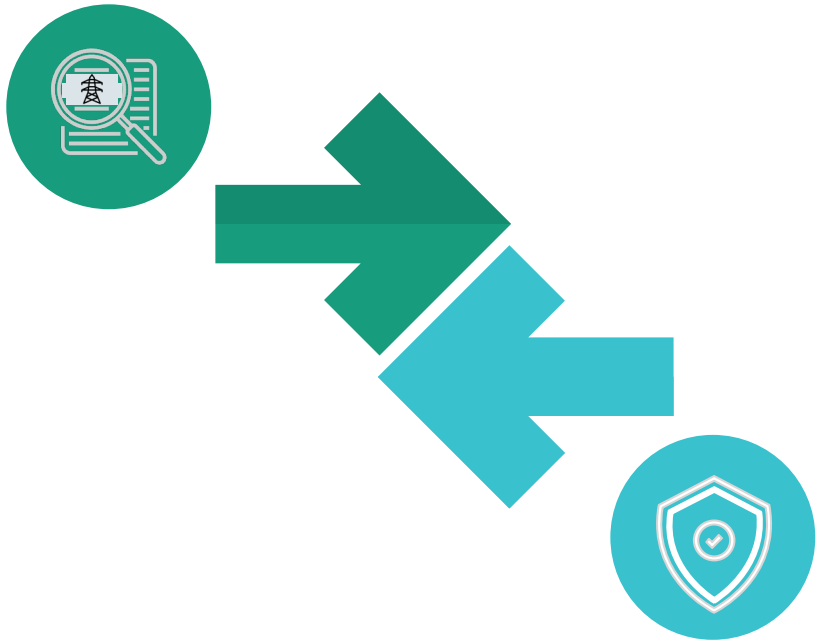
Data Verifiability

What?

Flexibility processes and the provision of flexibility must be **verifiable end-to-end**

Why?

Grid operators manage electricity grids which belong to **critical infrastructure**.
Grid stability needs to be secured at all time to ensure a well-functioning society.



Data Sovereignty

What?

The **protection of sensitive data** of the (private) stakeholders in flexibility processes must be ensured.

Why?

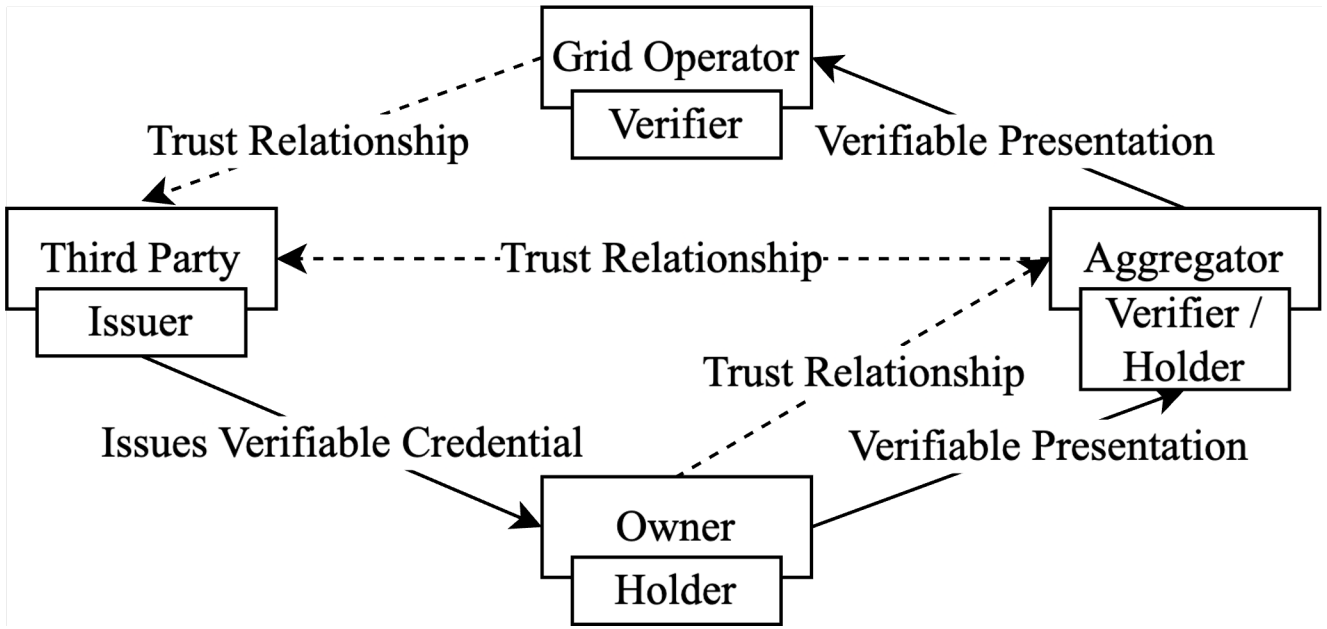
Private household/people related data must be protected due to privacy requirements.
Additionally, grid operators have an interest in **reducing** the **amount of data** they have to **manage, process, and protect**.

Brandt et al., 2022; Ross & Mathieu, 2020; Ferrag et al., 2018; Faquir et al., 2021; Hinterstocker et al., 2017; Parag & Sovacool, 2016; Döbelt et al., 2015

A digital spine as public infrastructure:

Addressing the tension between data verifiability and sovereignty

How Web3 technologies facilitate the trust diamond based on SSI‘s trust triangle concept



- **Wallet-based identity management:**
  Full access to and control over DER data empower households to utilize their assets across various use cases, independent of their OEMs.
- **Zero-knowledge proofs:**
  Ensures verifiability of data while upholding data minimization techniques like presenting qualified predicates in verifiable presentations between the owner and aggregator or the aggregator and the grid operator.
- **Distributed ledger:**
  Inter-sector verifiable data registry dynamically establishing trust anchors by certifying issuers. Maintains registries to prevent double marketing of assets.

Babel, M., Ehaus, M., Heess, P., Körner, M. F., Schick, L., & Strueker, J. (2025). Introducing the Trust Diamond for Energy Flexibility Provision: On the Tension of Data Verifiability and Privacy.

Conclusion & Call to Action

- Key Takeaways:
  - Digital Spine is necessary for unlocking DER flexibility (e. g. switching market roles)
  - Web3 technologies provide the tools for a secure, verifiable, and decentralized data infrastructure.
  - Coordination and cooperation is needed to address sovereignty, trust, and adoption challenges.

- Next Steps & Discussion:
  - How can stakeholders contribute to open DER data infrastructure?
  - What are the immediate implementation opportunities?

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