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A Digital Infrastructure for Integrating Decentralized Assets into Redispatch

Decentralized Redispatch (DEER): Interfaces for providing flexibility

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DEER

DEZENTRALER REDISPATCH

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Disclaimer

The opinions expressed in this White Paper solely represent those of the authors and do not necessarily reflect the views of the entire consortium, nor do they represent the views and opinions of the authors' respective companies and institutions.

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Executive Summary

English:

In response to the challenges posed by an increasingly decentralized energy system characterized by a high penetration of renewable energy sources, grid operators are experiencing heightened pressure to effectively manage grid congestion. Concurrently, both the European Union as well as the German government's ambitious climate targets are fostering the proliferation of small-scale systems like heat pumps, photovoltaic systems with battery storages, and electric cars, thereby enhancing the flexibility potential for redispatch operations. The project "Decentralized Redispatch (DEER): Interfaces for providing flexibility" aims to explore the integration of decentral flexibility into congestion management practices. This White Paper provides an overview on the project's first outcomes and the necessary background technologies and methods. The project's primary focus lies in designing an architecture in the context of a multi-agent-system that facilities secure and sovereign communication among all stakeholders in such a decentralized redispatch, ensuring data security, data privacy, and verifiability. The DEER project sets out to analyze the potential of leveraging self-sovereign identity management methods, combined with technologies such as zero-knowledge proofs and distributed ledgers, as a robust framework for achieving these objectives.

Deutsch:

Mit den Herausforderungen, die durch ein zunehmend dezentrales Energiesystem mit einem hohen Anteil erneuerbarer Energieanlagen entstehen, verändern sich auch die Anforderungen an das (zukünftige) Netzengpassmanagement. Gleichzeitig treiben sowohl die Europäische Union als auch die Bundesregierung für die Erreichung der Klimaschutzziele die Verbreitung von elektrifizierten Kleinstanlagen wie Wärmepumpen, Photovoltaik-Anlagen mit Heimspeichern und Elektroautos voran. Damit erhöht sich zeitgleich ein (bisher) ungenutztes Potenzial dieser Anlagen für den Redispatch. Das Projekt „Dezentraler Redispatch (DEER): Schnittstellen zur Flexibilitätsbereitstellung" zielt darauf ab, die Integration von Kleinstflexibilitäten in das Netzengpassmanagement zu erforschen. Dieses White Paper gibt ein Überblick über die ersten Projektergebnisse sowie die notwendigen Technologien und Methoden. Das Projekt konzentriert sich dabei hauptsächlich darauf, eine Architektur im Kontext eines Multi-Agenten-Systems zu entwerfen, die eine sichere und datensouveräne Kommunikation zwischen allen Stakeholdern im dezentralen Redispatch ermöglicht und damit sowohl Datenschutz als auch Verifizierbarkeit gewährleistet. Dabei zielt das DEER-Projekt darauf ab, das Potenzial von digitalen, selbstbestimmten Identitäten (SSI) in Kombination mit Zero-Knowledge-Proofs und verteilten Ledger-Technologien als geeigneten Rahmen zur Erreichung dieser Ziele zu analysieren.

Preamble

The ongoing (r)evolution and transformation of the energy sector in recent decades have instigated profound changes. The increased integration of renewable energy sources, the digitalization of the grid, and a rising sustainability agenda have changed how electricity is generated and distributed. Moreover, it has raised society's awareness of environmental issues and energy efficiency. These developments have far-reaching implications for consumer behavior, policymaking, and the socio-economic landscape. Amidst these developments and the heightened integration of renewable energy sources, the costs of Redispatch measures for congestion management have increased while new decentralized and electrified assets have not been integrated yet into the Redispatch measures.

Redispatch measures aim to ensure grid stability as they resolve transmission grid bottlenecks by dynamically re-allocating electricity generation and consumption. In the past, grid operators in Germany used flexibility mainly provided by conventional power plants to secure reliable congestion management ("Redispatch 1.0"). In the course of the current regime "Redispatch 2.0", also smaller assets >100 kW have to participate in cost-based Redispatch. As redispatch costs in Germany have risen over the last years and the number of decentralized, small-scale electricity generation and consumption units are rising, a hybrid, market based Redispatch mechanism for these assets <100 kW is currently being discussed under the term "Redispatch 3.0". These assets in turn offer great potential to (1) increase available capacity for redispatch, (2) decrease redispatch costs, and (3) reduce the ecological impact of Redispatch measures.

Aware of this fact, this transformation has aroused Transmission System Operators' (TSOs) and Distributed System Operators' (DSOs) interest in new solutions for seamlessly integrating decentralized electricity generation and consumption into the electricity grid and in particular for Redispatch. In this regard, the flexibility of small-scale assets promises to heavily support the electricity grid once they have been coordinated with each other and simultaneously have been actively integrated into the system. At this juncture, integrating small-scale assets (for Redispatch) means actively identifying them and their flexibility potential within the system following the purpose of offering that flexibility potential afterwards via an aggregator. However, scaling up the integration of small-scale assets might require decentralized solution architectures as this cannot be enabled by current centralized legacy systems due to the amount of data flow. Such an architecture requires verifiable information flows between relevant actors of the Redispatch system. By integrating additional relationships of trust between the participants, verifiable chains of custody are ensured and thus the reliability of the system is reinforced. This implies that TSOs, for example, need the capability to validate the legitimacy of offered flexibility quantities before deploying the provided flexibility. Apart from open issues regarding regulation and market design, the decentralized Redispatch still requires technological solutions to determine the flexibility provided by small-scale asset and to enable asset-specific verification of provided flexibility.

The following Figure 1 illustrates the "double trust triangle" for the validation procedure: First, the original equipment manufacturer (OEM) and the TSO are introduced as issuers of verifiable credentials (i.e., pieces of information that can be verified). Then, the owner of the flexible device (FD owner) in the role as holder of verifiable credentials and issuer of verifiable presentations (i.e., claims that can be verified using the verifiable credentials associated to them) towards the aggregator of flexible devices is shown. Moreover, the aggregator is illustrated to present verifiable presentations towards the TSO. This architecture allows for a trusted data flow with the sources of trust being the OEM and the TSO (i.e. not the FD owner and the aggregator).

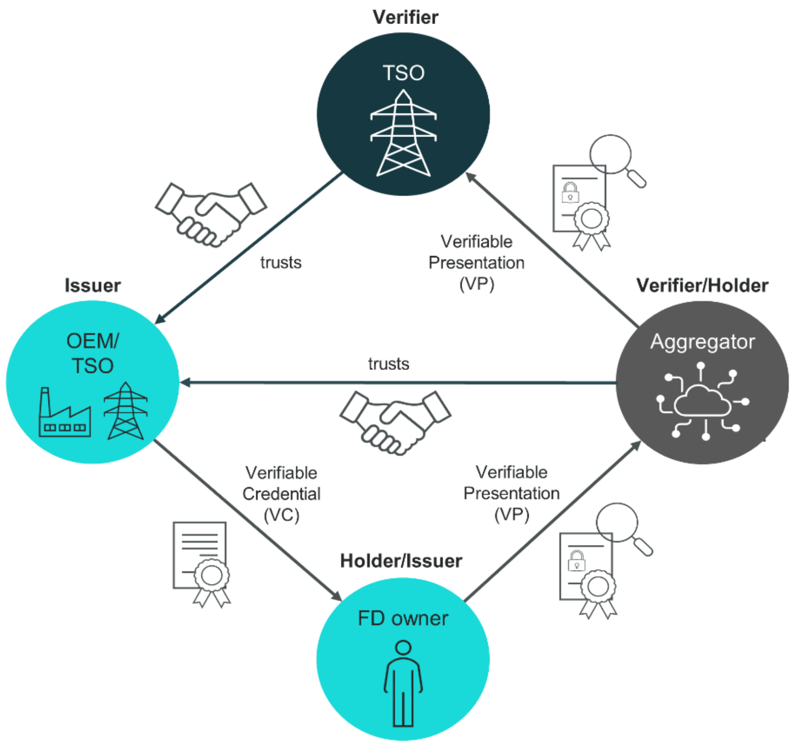

Figure 1: Overview on Double Trust Triangle.

Preamble

In the project "Decentralized Redispatch (DEER): Interfaces for Flexibility Provision" the consortium elaborates on exactly those solutions for actively integrating small-scale and decentralized assets into the overarching Redispatch process to reduce overall costs and carbon emissions, i.e., to actively integrate decentralized, small-scale assets. The project aims at controlling and managing the aggregated flexibility potential of these assets on-the-edge through a Multi-Agent-System (MAS). Moreover, the project involves developing a concept that utilizes technological concepts such as Self-Sovereign Identities (SSI) and Zero-Knowledge-Proofs (ZKPs) enabling verifiable flexibility provision and information exchange between relevant Redispatch participants.

In this context, the utilization of SSI ensures that participants have control over their identities and their personal data, considering privacy demands. Moreover, blockchain technology may be leveraged to create a secure and immutable ledger as an essential part of a trust infrastructure, e.g., in the sense of a verifiable trust registry. Additionally, ZKPs are used to present offers without disclosing sensible device owner data such as operation time or energy consumption. The combination of these technologies and concepts will facilitate the accurate and verifiable exchange of information, ensuring that each transaction is conducted securely and privacy-preserving.

This White Paper provides an overview of the evolution of Redispatch, explains how digital solutions such as SSI and ZKP facilitate decentralized Redispatch, and presents next steps for future realization. The paper is structured as follows. First, we present an overview of current developments in the energy system including cross-sector electrification and Redispatch regimes for congestion management in Germany. Secondly, we discuss how decentralized technologies and concepts such as blockchain, SSI and ZKPs can enable the integration of small-scale assets. In the third section, we detail an initial architecture that is intended to enable decentralized Redispatch through the use of technological concepts which ensure optimal flexibility provision and verifiable information exchange between the participants. Finally, we give an outlook of the goals pursued within the DEER project.

Transitioning to Decentralized Redispatch: Mapping the Path to Grid Control

Status Quo: Redispatch in Times of Energy System Transformation

In the realm of climate change mitigation and environmental action, one fundamental decarbonization measure is cross-sectoral electrification (Fridgen et al., 2020). This involves electrifying sectors traditionally dependent on carbon-intensive fossil fuels such as transport or residential heating. The implementation of electrified solutions including heat pumps or electric vehicles enables the decarbonization of these sectors if they are powered by renewable electricity (Michaelis et al., 2024). Figure 2 illustrates, according to various forecasts, that the number of electric heat pumps in Germany will significantly increase from

> The ongoing electrification calls for a new Redispatch regime which accounts for the potential of decentralized small-scale assets.

today's low levels to meet ambitious targets on the electrification of household heating. A similar picture emerges for the development of electric vehicles. The German government's electrification ambitions for the mobility sector envisage growth up to 15 million batteries that are added to the grid by 2030.

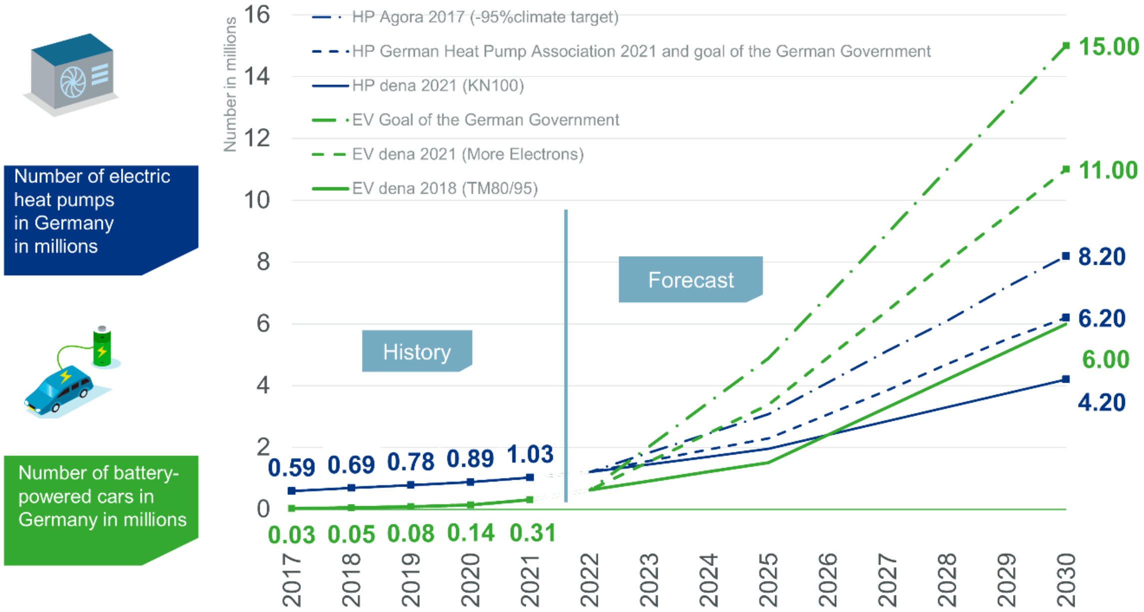

Figure 2: Projected number of electric cars and heat pumps until 2030. (Source: Kockel et al., 2022).

These efforts to promote cross-sectoral electrification, however, will lead to a doubled electricity consumption, increasing from around 550 TWh/a at present to 1,100 TWh/a by 2037 to 1,300 TWh/a by 2045 (Bundesnetzagentur, 2022). Additionally, the integration of small-scale assets such as heat pumps or electric vehicles represents an increase in the amount of decentralized electricity consumption units. At the same time, electricity generation is also becoming increasingly decentralized through the expansion of small-scale PV systems and wind power generators which are required to decarbonize the aforementioned sectors by providing green electricity in the first place.

Yet, these developments in the energy system pose challenges since existing electrical grids are not designed to accommodate such a significant increase in electricity demand as well as decentralization of consumption and generation.

In particular, TSOs bear the responsibility of guaranteeing grid stability, which includes proactively mitigating grid bottlenecks. When the grid is at risk of congestion, TSOs intervene with specifically presumed Redispatch measures: Power plants on the surplus side of the bottleneck are instructed to reduce their feed-in, while plants on the deficit side must increase their feed-in. Participating power plants are reimbursed for the provision of this flexibility. The interplay of (1) increasing redispatch volumes and (2) rising electricity prices has led to skyrocketing Redispatch costs of €2.7 bn in 2022 in Germany (BDEW, 2023). Additionally, these Redispatch measures can contribute to an increase in carbon emissions. In some scenarios renewable electricity generation must be ramped down and fossil-based electricity generation is ramped up to solve congestion within the grid.

In the past, only power plants with a generation capacity higher than 10 MW were asked to participate in Redispatch processes and could profit from the reimbursement for providing flexibility. This regime is known as "Redispatch 1.0". As a reaction to the transformation of the energy system, "Redispatch 2.0" was introduced in 2021 enabling power plants with a capacity over 100 kW to participate in congestion management. This change meant that renewable energy sources, which typically have lower generation capacities than conventional power plants, can now also participate in Redispatch. While the measures of Redispatch 1.0 and 2.0 were aimed at the generation side, there is an increasing focus on approaches to include the consumer side in congestion management. Such ideas are particularly interesting against the background of a growing number of small-scale assets at a household level and simultaneous decentralization on the generation side.

Future Perspectives of Small-Scale Assets in Redispatch

As mentioned before, the current and future developments of the energy system also require further adaptation of congestion management to fully exploit the potential that comes along with the changes in the energy system (i.e., an increasing number of decentralized small-scale assets). To reduce Redispatch costs, the proposed regime "Redispatch 3.0" aims to incorporate decentralized, small-scale assets that are already installed – and will be installed in the near future – into the Redispatch – as outlined, for example, in a study by TenneT TSO GmbH und TransnetBW GmbH on "Redispatch 3.0" (Ocker et al., 2022). This integration may involve aggregating the flexibility potential of numerous small-scale assets through a multi-agent system and subsequently matching them with the Redispatch demand. In this process, it is essential to reliably verify that offered and requested flexibility is correctly carried out. At the same time, this verification process should be data-minimizing to comply with privacy regulations and protect the data of participating asset owners. However, achieving this still requires substantial challenges to be solved – ranging from grid infrastructure to regulatory adoptions to a real-time data exchange between assets and grid operators. This is where the DEER project comes in, developing solutions for a decentralized Redispatch.

DEER project objectives

Digital technologies enable the integration of small-scale assets into Redispatch. To meet privacy requirements, approaches such as SSI, ZKP and DLT come into play.

The DEER project primarily focuses on the effective integration of decentralized, small-scale assets into Redispatch. A MAS is intended to serve as a system comprising many agents that can interact and communicate, in order to cooperatively aggregate the flexibility potential of their small-scale assets for decentralized Redispatch. To address the challenge of the apparent contradiction between reliable verification and data-protection, the project leverages digital technologies, specifically SSI and ZKPs, to enable verifiable and secure handling of processes related to offering, requesting, tracking, and billing of flexibility from decentralized assets. The goal of DEER is to enhance the contributions of these decentralized assets to the electricity grid, signifying the evolution of the Redispatch regime towards Redispatch 3.0. The project involves the conceptualization, development, and comprehensive field testing of a prototype that enables the aforementioned capabilities of integrating small-scale assets into the Redispatch process and ensuring verifiable information exchange. The project consortium includes research institutions and industry partners with expertise in decentralized technologies, grid operations, energy services, and standardization.

Blockchain

The foundational concept of blockchains, initially introduced by the pseudonym Satoshi Nakamoto – often better known as the underlying technology of Bitcoin –, was to enable secure financial transactions with low fees between mutually untrusting parties.

A blockchain functions as a distributed database where transactions are organized into chronological blocks. These blocks are cryptographically linked using hashes, creating an immutable and tamper-resistant ledger. Each node within a blockchain processes every transaction on the ledger as shown in Figure 3 resulting in a distributed ledger (DLT). Digital signatures and consensus mechanisms guarantee the authenticity of transactions and maintain the integrity of each block (Nakamoto, 2008; Schlatt et al., 2016). A blockchain based on these mechanics is therefore working without the need for trust between the network nodes as transactions are transparent, immutable, and agreed based on a consensus mechanism. The blockchain technology is used within the context of DEER as an immutable register, enabling the end-to-end verification of flexibility offers and their fulfilment. However, the immutability of the blockchain enabled through the distributed ledger also leads to privacy issues (Babel et al., 2023). Once data has been stored on the blockchain, it can no longer be deleted. The DEER project is therefore exploring the combination of different digital approaches in order to utilize the advantages of the blockchain without creating data protection problems.

Blockchains vary in public/private nature and usage restrictions, impacting access and validation rights. Public blockchains are open, while private ones restrict access (Schlatt et al., 2016). While being more centralized, permissioned blockchains tend to be more scalable and come with cheaper and faster transaction costs. Especially the transaction speed and their costs are vital in the context of DEER as the number of participants and their transactions in the decentralized Redispatch will be considerable.

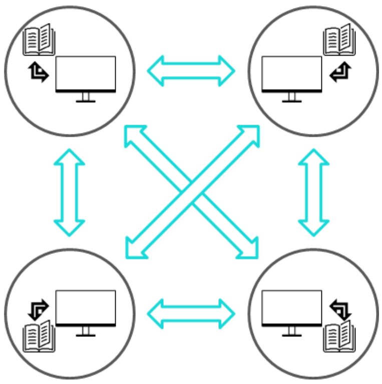

Figure 3: Peer-to-Peer distributed ledger - Blockchain

Self-Sovereign Identities

Self-Sovereign Identity (SSI) is an emerging model and paradigm for digital identity management comprising specific characteristics. As depicted in the following table these characteristics can be summarized into three main requirements: Security, Controllability, and Portability (Preukschat and Reed, 2021).

Security	Controllability	Portability
Protection	Existence	Interoperability
Persistence	Control	Transparency
Minimization	Consent	Access

Table 1: Characteristics of self-sovereign identities

SSI is a user-centered concept where the user controls the information shared with any third party (Preukschat and Reed, 2021). The core components of an SSI solution include Verifiable Credentials, Roles (Issuer, Holder, Verifier), Identifiers and Digital Wallets. SSI relies on digital certificates (Credentials), which can contain self-asserted or third party verified identity attributes (see Figure 4). Verifiable Credentials are essential for proving identity attributes between holder and verifier. Digital Wallets store Verifiable Credentials, keys and create Verifiable Presentations that consist of data derived from one or more verifiable credentials. These elements constitute the fundamental architecture of a SSI solution (Guggenberger et al., 2023; Mühle et al., 2018).

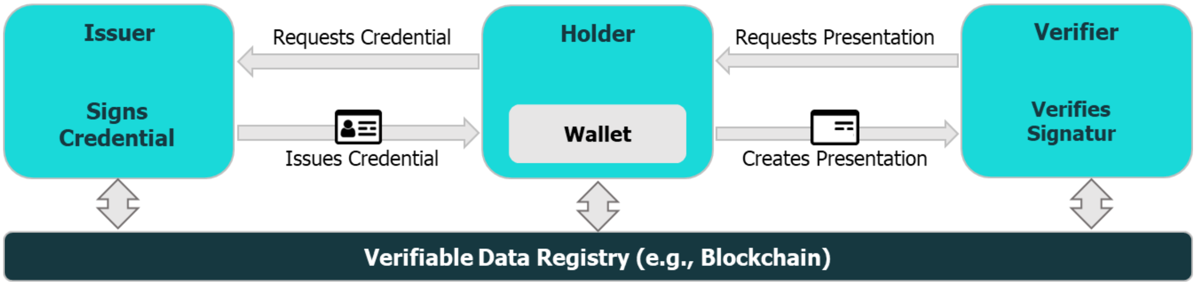

Figure 4: SSI-Workflow

In the context of DEER, SSI plays a significant role ensuring a fine granular identity and access management. With SSI, participants of the decentralized Redispatch can identify themselves to others and decide for themselves which data they share with whom (Gramlich et al., 2023). In addition, the small-scale assets are also given corresponding digital identities to ensure their reliability and suitability for flexibility provision. By doing so, the system becomes interoperable which is a key feature to create lean, cost-efficient verification processes and design an economic redispatch architecture.

Excursus

Zero-Knowledge Proofs

Through the cryptographic concept of zero knowledge proof (ZKP), a prover can convince a verifier about the correctness of a statement, without revealing any specific information beyond the validity of the statement itself. The mathematical foundations and the conceptual development of this proof mechanism was first elaborated in a seminal paper by Goldwasser et al. (1985). Even so their work was groundbreaking for the development of more sophisticated algorithms and concepts, that led to first non-interactive proof protocols (Fiat and Shamir, 2006), the technology did not, however, enjoy widespread acceptance in research and application.

Since the cryptographic boom, triggered by the introduction of blockchain technology (Nakamoto, 2008), researchers have increasingly focused on finding approaches that are decentral, scalable, and secure. ZKPs, as a collective term for various technologies are a promising concept to solve the blockchain trilemma, which describes the aforementioned tension field between scalability, decentralization and security in DLT systems. Thus, research around ZKPs is gaining traction in Information Systems in the recent years (Principato et al., 2023). Among the various ZKP concepts, "Succinct Non-interactive Arguments of Knowledge" (zk-SNARKs) in particular are cornerstones for today's improvements in processing time of applications using ZKPs. Succinctness refers to the generation of short, compressed proofs that can be efficiently verified, leading to a high-speed proof system.

In DLTs, these efficient types of ZKPs may be implemented to improve scalability of the systems without compromising on security. There exist approaches for DLTs that rely on SNARKs to prove the entire history of the blockchain without needing to include all the transaction data in each new block. This proof is then validated by network nodes without them having to store all the data. Compressing the blockchain in such a way enables faster syncing times, lower storage requirements and greater accessibility for network participants with limited resources (Bonneau et al., 2020).

Eberhardt and Tai (2018) propose to only post a proof of transactions on chain and compute verification off-chain. This idea has been further developed to a concept called rollups, which employ computational integrity proofs on Merkle Trees via ZKPs (Ozdemir et al., 2020). These so called layer two solutions (L2) minimize the computational overhead (Jeong and Ahn, 2021) and offer a high degree of data security without major drawbacks in decentralization. L2 solutions might play a key role in the future enhancement of the Ethereum blockchain by enabling it to increase the scalability of Ethereum in line with the proof-of-stake consensus protocol.

Within the SSI domain, ZKPs are an essential building block to ensure holder's data self-sovereignty by presenting predicates of identity information without revealing the information itself. In this way, holders present the information, required for the specific use case, without having to share sensitive personal data (Camenisch and Lysyanskaya, 2001). This allows, for instance, a person to prove that they have reached a certain age without having to reveal their date of birth. The application of zk-SNARKs in SSI Frameworks not only improves the scalability of revocation but also facilitates new design options for digital identity infrastructures. Especially current approaches for digital machine identities promise to facilitate more features such as geolocation proofs (Babel and Sedlmeir, 2023).

In a decentralized redispatch, the aforementioned progress made in succinctness of ZKPs play a vital role for ensuring verifiable information while providing privacy. Specifically, in the data exchange processes between flexibility providers and flexibility consumer, ZKPs provide a promising approach. It allows the flexibility provider to refrain from sharing any private information pertaining to the specific baseline. Instead, the flex provider can use a ZKP to demonstrate to the verifier that the flexibility promised in the offer has been delivered. Thus, the flexibility consumer can effectively validate the aggregated flexibility offer as stated, without divulging any details concerning the baseline of the small-scale facilities, the supplied flexibility, or the overall demand. This implementation of ZKPs ensures both the confidentiality of sensitive data as well as the transparency necessary for the accurate billing and validation of flexibility provision. In view of the expected regulatory steps towards carbon tracing by the European Union, a ZKP-based architecture may also lay the foundations for verifiable digital emissions certificates (Babel et al., 2022).

Multi-Agent Systems

A Multi-Agent System (MAS) comprises a group of multiple autonomous agents in a defined environment to achieve a predefined, common task. The completion of this task can be achieved by cooperating or competing, disclosing or concealing information within the system (Balaji and Srinivasan, 2010). With these properties, MAS are suited to solve complex problems in a dynamically changing environment (Dorri et al., 2018).

The integration of small-scale distributed power resources into the broader redispatch process in the distribution grid is such a complex problem. The underlying optimization problem is highly complex due to the numerous involved systems. Addressing this complexity requires intelligent control systems that operate in a distributed manner, mirroring the structure of the distributed systems. For scalability and data protection reasons, employing a MAS is a suitable approach. In the DEER project, each agent represents an individual system or a group of systems behind a common grid connection point. Using sensors, they can capture the current state of the systems and control them through actuators (Tiemann et al., 2022).

In this scenario, one of the main tasks of the software agents is to manage the flexibility of the distributed systems. A generic flexibility model is used, allowing for the immediate consideration of various system types and their individual constraints and primary applications. This model also efficiently calculates costs for utilizing flexibility in subsequent marketing.

To make the flexibility potential usable for the redispatch process and for marketing purposes, the individual flexibilities of the systems must be aggregated and, when needed, disaggregated. This process is implemented through a hierarchical organization of the agent system, breaking down flexibility aggregation and disaggregation into interrelated sub-problems. This not only allows for an efficient solution to the optimization problem but also enhances scalability and increases system reliability. In the event of disruptions in the communication infrastructure, dynamic adjustment of the system structure is possible.

Proposing a Decentralized Solution

DEER Architecture

> The DEER project proposes an architecture combining decentralized technologies for the Redispatch use case.

While the research project DEER is still ongoing, we have already developed an architecture, which we present in the following. The architecture aims to enable the integration of decentralized flexible small-scale assets into the Redispatch process to create a more resilient, flexible, and sustainable electricity grid. The proposed solution is based upon previously mentioned technical concepts and was developed jointly by the project consortium to achieve both self-sovereignty of data as well as verifiability and confidentiality of critical information.

Figure 6 illustrates the DEER architecture: Each household owning one or more small-scale assets is equipped with an intelligent agent system. The agent software runs on proprietary hardware and can utilize the secure interfaces of a Smart Meter Gateway (SMGW), if available. An agent performs (on-the-edge) predictions using machine learning, based on which it determines the Redispatch flexibility of its assets. After negotiations with other agents within the MAS the agent then offers this flexibility to an aggregator. The aggregator optimizes the aggregated flexibility potential of all agents that make their flexibility potential available to it, and then offers this potential on a Crowd Balancing Platform (CBP), where it is matched with the Redispatch demand determined by the grid operators. Subsequently, the Redispatch requests are distributed back to the individual assets (=disaggregation) in reverse to the offer processes.

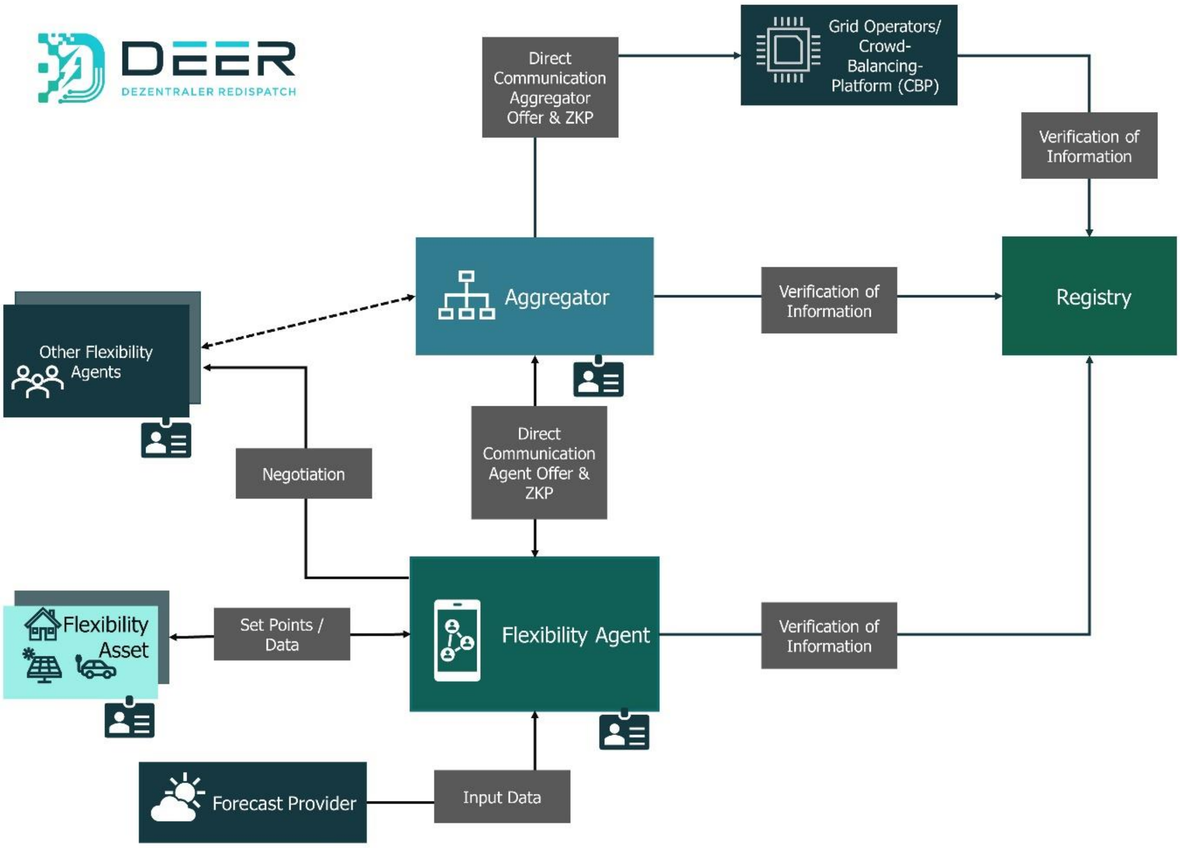

Figure 6: Proposed architecture for a decentralized Redispatch

As a relevant part of the project, in addition to direct communication between participants, the architecture also includes verifiable data exchange using SSI and blockchain technology. Digital certificates, which prove the identity of actors and the reliability of devices, ensure the communication of valid offers and orders between agents, aggregators, and grid operators. In order to track offers and orders effectively, it is necessary to know the flexibility providers' baseline accurately. The baseline of an agent corresponds to the electricity consumption or generation in the case without supplying flexibility. It is used to enable the retrospective check whether the requested flexibility has actually been delivered. However, the findings derived from the baseline also allow conclusions to be drawn about the flexibility providers' behavior, which requires strict data protection measures. This leads to a conflict between privacy requirements for individuals and the verification of their flexibility offers. To actively address this concern, the DEER consortium studies the possibility of using ZKPs to prove the correct execution of flexibility in a data-minimally secure manner, i.e., without disclosing private household information.

A field trial will test the concepts presented here for their applicability and usefulness.

As this study demonstrates, the DEER approach aims to utilize the flexibility potential of small-scale assets for congestion management. This may also enable a decrease in current Redispatch costs. In addition, the integration of these assets may reduce greenhouse gas emissions, as fewer fossil-fueled power plants must be ramped up for Redispatch. The proposed solution in the DEER project offers relevant features for this integration: digital identities enable the certification of both, devices and Redispatch participants, thus ensuring reliable offer and order processes. Cryptographic approaches, allow for the immutable but hidden storage of critical information, thus enabling robust but privacy-protecting verifiability.

What's next to come?

In the DEER project, some preliminary work has already been done to enable decentralized Redispatch. Building on the concepts developed so far and the proposed architecture, the project works on the following objectives within the next months:

1. Demonstration of the viability and pertinence of digital identities and ZKPs in the context of Redispatch. A prototype and a field-test of the presented concept will serve as evaluation of the projects' outcomes.
2. Development of a standard in collaboration with German standardization bodies based on the results of the project in order to promote the dissemination and general validity of decentralized Redispatch.
3. Publication of the scientific findings from the DEER project to promote research in the field of energy and information systems and to demonstrate the digital potential for decarbonization and cost reduction in the energy market.

The upcoming work in DEER will make an important contribution to the digitalization of the energy transition and promote new business areas in the energy market as well as cheaper and greener Redispatch.

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