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INTERNATIONAL SMART GRID ACTION NETWORK

Power Transmission & Distribution Systems

Exploring the interaction between power system stakeholders: Insights from Pilot Projects

Summary

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Summary

Motivation

The electricity system is undergoing a significant transformation driven by the increasing integration of renewable energy sources, widespread adoption of decentralized generation technologies, and advancements in digitalization and automation. Traditionally characterized by a unidirectional flow of electricity from centralized power plants to consumers, the grid is evolving into a dynamic, bidirectional system. Distributed energy resources (DERs), such as rooftop solar panels, wind turbines, electric vehicles, and battery storage, are playing an increasingly prominent role, generating electricity closer to consumption points and impacting grid operations. Simultaneously, decarbonization goals and the electrification of sectors like transportation and heating are reshaping energy demand patterns and introducing new peaks and variability. This shift requires enhanced coordination among stakeholders to ensure that the system remains reliable, flexible, and efficient, while also accommodating the complex interactions of local and large-scale energy resources.

Project Contents and Objectives

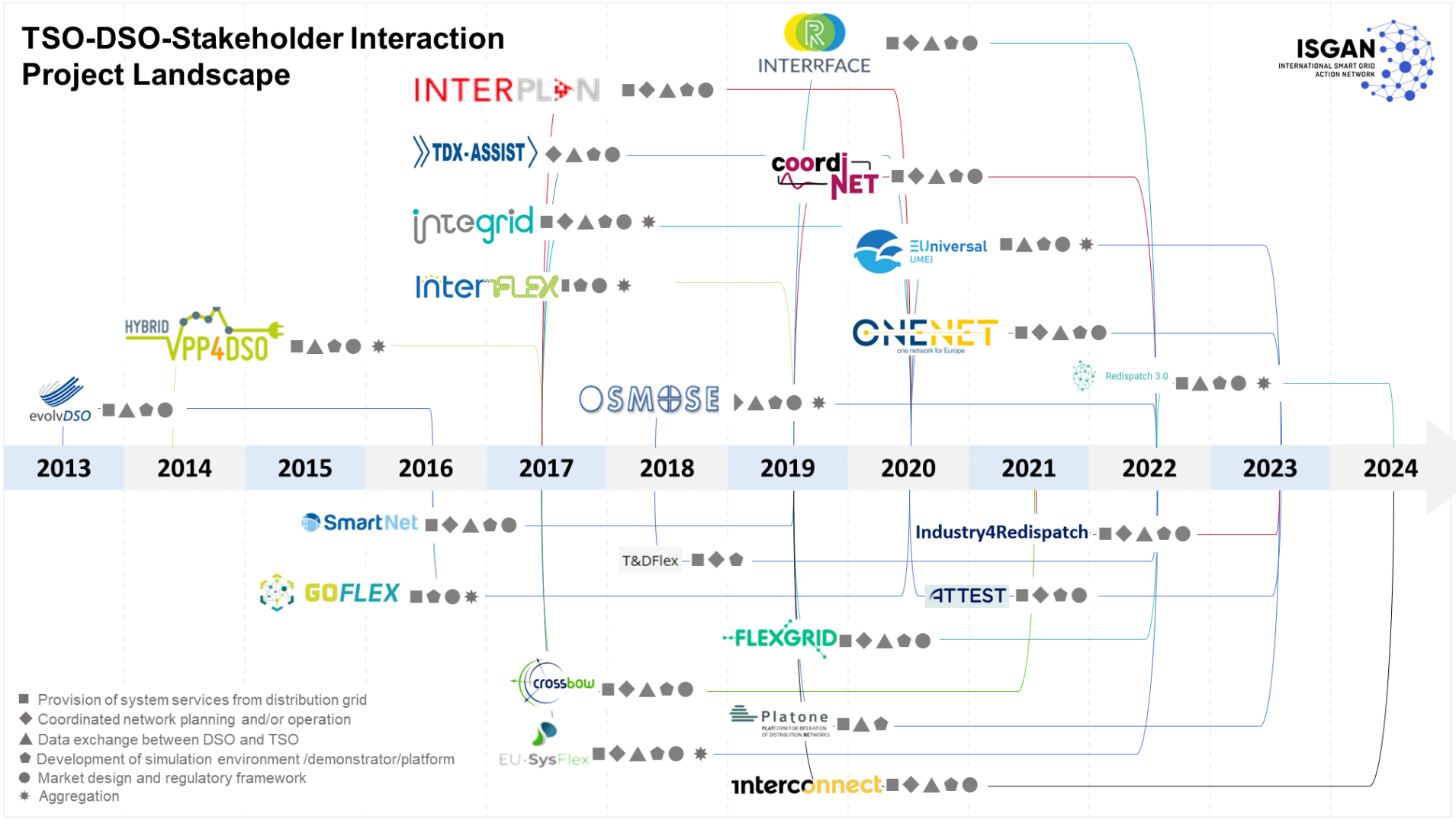
The purpose of this report is to provide a comprehensive overview related to the experience and insights gained from global pilot projects in the field of providing flexibility for coordinated capacity management by transmission and distribution system operators. The overall goal is to provide a holistic overview of the ongoing developments in the integration of flexibility, offering valuable insights into how these projects are shaping the future of transmission and distribution network operations. The report highlights the key lessons learned and identifies the primary challenges across several key areas, including, Technical, Information and Communication Technology (ICT), Economic and market-related, and Regulatory aspects.

Methodology

The methodology and approach to collect the information are based on a comprehensive project and literature review, complemented by insights gathered from stakeholder engagements, including a survey, international workshop, and expert interviews. The project and literature review serve as the foundation, providing an overview of the publicly available material (deliverables, scientific publications, presentations, etc.) from concluded projects. The survey aimed to gather data from stakeholders in the energy sector based on their recent experiences from pilot projects. It focused on the effectiveness, challenges, and benefits of flexibility solutions and stakeholder interaction across technical, economic, and regulatory aspects. Furthermore, the hosted workshop facilitated in-depth discussions among stakeholders, allowing for the exchange of ideas and identification of emerging trends. It aimed to foster dialogue on critical topics, share experiences from pilot projects, and highlight best practices. Key themes included technical challenges in flexibility modelling, the role of information and communication technologies, data exchange, and cybersecurity. Economic, market, standardization, interoperability, and regulatory aspects were also discussed, particularly concerning TSO-DSO interactions. The workshop concluded with an analysis of future work and strategic outlooks, offering valuable insights for the continued integration of flexibility in power systems. In addition, expert interviews were conducted to gather in-depth perspectives from leading experts in the field. The experts shared their experiences, challenges, and strategies, combining their theoretical knowledge with practical insights.

Results and Conclusions

Based on the evaluation of overview of the key insights and highlights drawn from pilot projects across the globe, the development of a TSO-DSO project landscapes highlights the multiple initiatives undertaken between 2013 and 2024. These projects focus on key aspects such as system services provision, coordinated network planning, data exchange, market design, simulation environments, and aggregation.


TSO-DSO-Stakeholder Interaction
Project Landscape
ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK
INTERRFACE
INTERPLAN
TDX-ASSIST
coordiNET
integrid
EUniversal
UMEI
interFLEX
HYBRID VPP4DSO
ONENET
one network for Europe
Redispatch 3.0
evolvDSO
OSMOSE
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
SmartNet
Industry4Redispatch
T&DFlex
GOFLEX
ATTEST
FLEXGRID
crossbow
Platone
PLATFORM FOR OPERATION OF DISTRIBUTION NETWORKS
EU-SysFlex
interconnect
Provision of system services from distribution grid
Coordinated network planning and/or operation
Data exchange between DSO and TSO
Development of simulation environment /demonstrator/platform
Market design and regulatory framework
Aggregation

The overall study highlights that improved TSO-DSO-stakeholder coordination significantly enhances grid stability and efficiency. Key findings from the assessment include:

1. **Enhanced TSO-DSO Coordination**
   - Strengthen cooperation among transmission system operators (TSOs), distribution system operators (DSOs), and other stakeholders to optimize grid efficiency, maximize flexibility resources, and enhance system resilience.

2. **Investment in Technology and Integration**
   - Prioritize investment in advanced grid technologies and seamless integration to enhance flexibility, digitalization, and efficiency. This includes the integration of advanced data analytics, real-time data exchange, and predictive modelling.
   - Ensure compliance with cybersecurity and data protection (GDPR) standards while enabling interoperability.

3. **Market Mechanisms for Flexibility**
   - Develop flexibility markets with dynamic pricing, bid stacking, and bid forwarding to allow TSOs and DSOs to efficiently procure ancillary services.
   - Introduce standardized pre-qualification and incentive structures to increase participation from decentralized energy resource (DER) providers, aggregators, and service providers.

4. **Regulatory and Policy Frameworks**
   - Establish clear and forward-looking regulatory frameworks that foster innovation and market stability.
   - Update network codes to reflect evolving TSO-DSO roles and deploy innovative coordination models.
   - Enable controlled testing environments through regulatory flexibility mechanisms such as regulatory sandboxes and experimental frameworks.

5. **Stakeholder and Consumer Engagement**
   - Increase participation in flexibility markets through awareness campaigns, incentives, and user-friendly interfaces.
   - Implement dynamic tariffs and transparent communication to enhance consumer engagement, energy literacy, and prosumer involvement.

6. **Continuous Learning and Knowledge Sharing**
   - Promote ongoing learning, industry collaboration, and knowledge exchange through workshops, surveys, and expert interviews.
   - Regularly assess international pilot projects to refine market models, operational strategies, and emerging technologies.

Outlook

The future energy transition demands enhanced flexibility markets to integrate high renewable energy penetration and widespread electrification. Research and industry efforts should focus on refining procurement methods, enabling real-time bidirectional coordination between grid operators, and advancing sector coupling for multi-energy system interoperability. Key enablers include AI-driven optimization, smart contracts, and real-time analytics to enhance efficiency and system balancing. Regulatory frameworks must evolve to support innovation while ensuring reliability, security, and market transparency. Policy harmonization across regions is essential to prevent inefficiencies, while pilot projects will validate and scale new solutions. Achieving a resilient, sustainable, and optimized energy system requires coordinated efforts from policymakers, regulators, TSOs, DSOs, aggregators, market participants, and consumers.