Special Report
Your guide to the Session 6

CUSTOMERS, REGULATION, DSO BUSINESS AND RISK MANAGEMENT

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Introduction

Policy and regulation is changing the DSO business rapidly and development turns quickly into implementation. This greatly affects and challenge the DSO's and their business processes and risk management.

Society is also in a somewhat contradictory situation where sustainability, electrification and affordability have important ambitions and goals while the securities in the world are great due to war and politics.

CIRED Session 6 tries to structure this complex situation and provide guidance through submitted papers and round-tables. The papers has been split into 4 different blocks and within each of these blocks there are sub-blocks representing important key aspects for that block.

Short summaries of each block and sub-block

Block 1 covers policy, regulation, integrated energy systems and the DSO role. The sub-blocks within this first block are:

- **Innovation in regulation:** This section discusses various innovative approaches to regulation, including a novel method for classifying Finnish electricity distribution system operators using geographic spatial data and k-means clustering. It also outlines E-REDES' simulation-based approach to validating compliance with European Requirements for Generators for distributed energy resources in Portugal
- **Tariff evolution & market design:** This sub-block presents new electricity tariff models, such as a demand-based system for residential users in Buenos Aires, Sweden's regulatory framework for network tariff design, and voluntary time-of-use tariffs developed by Primeo Energie in Switzerland. It also discusses the SCOPE project in Belgium, which introduces a peer-to-peer local flexibility market, and a market-based demonstrator for reactive power compensation using wind turbines.
- **Smart meter and data management:** This section provides an overview of how smart meter data is used in the Netherlands for grid management while adhering to privacy regulations. It also presents an open-source, real-time energy monitoring system called xKy in France, and a graph-based algorithm developed by Enedis to infer the electrical phase connection of customers using Power Line Communication data from Linky smart meters.
- **Regulatory framework and developments in Grid Modernization and Planning:** This sub-block explores Finland's regulatory approach to steering electricity distribution network development amid growing decarbonization and capacity demands. It also introduces a method to translate Switzerland's national energy scenarios into localized, substation-level load profiles for distribution grid planning, and investigates the use of non-firm grid connections for small-scale PV systems as a flexible and cost-effective alternative to traditional firm connections.
- **Business case and sustainability evaluations:** This section evaluates the profitability of various energy storage technologies in France's Day-Ahead and Frequency Containment Reserve markets. It also presents the CONVEY project, which models a circular, cross-sectoral hydrogen ecosystem at the Port of Hirtshals, Denmark, and analyzes the carbon footprint from household electricity consumption in Bushehr, Khuzestan,

and Hormozgan provinces in Iran.

Block 2 aims at capturing the DSO business process and risks. The sub-blocks within the second block are:

- **Roadmaps and innovation:** This section identifies critical focus areas that will shape the future of the grid, based on research into European trends, literature reviews, and collaborative workshops with stakeholders and industry peers. It also provides recommendations on how electric utilities can improve their resource allocation in digital innovation.
- **Forecasts and modelling:** This sub-block presents various forecasting models and methodologies, including a statistical regression model for forecasting distribution electricity demand in South Africa, and a resilient, model-free framework for Home Energy Management Systems (HEMS) using distributed energy resources. It also highlights lessons learned from developing and using short-term congestion forecasts for active power in flexibility markets.
- **Asset & risk management including weather effects:** This section describes methods and processes for ensuring technical data accuracy for technical assets, and provides an overview of the current regulatory framework in Italy to stimulate the planning and development of a resilient distribution network. It also introduces a cost-benefit analysis framework tailored to the evolving needs of DSOs.
- **Customer and human resources:** This sub-block focuses on understanding high-voltage customer segmentation, and investigates the role of gender diversity in the behavior of outsourced electric distribution enterprises. It also provides a comprehensive analysis of energy theft in the UK.

The third block, **Block 3**, covers customer interaction, energy sharing, e-mobility and flexibility with the following sub-blocks:

- **Customer interaction:** This section discusses various aspects of customer engagement and communication strategies, including the creation of communication personas based on technical and socio-demographic information.
- **Energy sharing:** This topic explores the impact of Energy Communities on power grids and market structures, offering recommendations for sustainable growth and innovation.
- **E-mobility:** This section covers grid-aware EV charging, battery storage location optimization, and the integration of local peer-to-peer energy markets with secure grid congestion management.
- **Flexibility:** This topic addresses congestion management in low-voltage grids, the effectiveness of residential battery storage within a VPP framework, and the role of household flexibility in supporting microgrids.

Block 4 focuses on digitalization, AI, business processes and cyber-security and include the following sub-blocks:

- **Digitalization:** This section discusses various aspects of digital transformation in the electricity distribution sector. It includes the analysis of low voltage grid behavior in the Netherlands, the implementation of digital transformation in Egypt, and the development of open-source infrastructure for real-time monitoring in France. It also covers the role of smart meters in Portugal and the creation of an open data platform by Northern Powergrid.
- **Artificial Intelligence (AI):** This sub-block explores the use of AI in electricity distribution companies to tackle both technical and non-technical challenges. It includes methodologies for forecasting solar PV, solar thermal, and wind power generation in Spain, AI-driven approaches to demand-side management, and the use of AI for fault localization and detection in power systems .
- **Digitized business processes:** This section highlights the digitization of business processes to enhance operational efficiencies. It includes the control of non-technical losses in Argentina, the computation of missing information using graph theory in France, and the development of real-time consumption monitoring systems in Finland. It also discusses the implementation of modern AMR meters in Finland and the creation of a digital platform for collective self-consumption in Portugal.
- **Cyber security:** This sub-block addresses security issues in energy facilities, the development of incident handling processes for the OT domain in DSOs, and the implementation of security measures to protect communication interfaces. It includes an analysis of cybersecurity findings in over 100 energy systems and the use of cryptographic protection for communication in the Netherlands.

This special report is quite long in order to acknowledge all relevant and interesting papers. It is recommend to read further chapters based on block/sub-block interest.

Block 1: Policy, regulation, integrated energy systems and DSO roles

Innovations in Regulation

Paper 162 presents a novel method for classifying Finnish electricity distribution system operators (DSOs) using geographic spatial data and k-means clustering. By analyzing responsibility areas and urban-rural characteristics, the study identifies seven distinct DSO categories—more nuanced than the traditional three (urban, rural, mixed). The approach enhances regulatory insight and supports more targeted regulation by revealing internal variations in DSOs' operating environments. The method also demonstrates how spatial data can bridge datasets from various sources for improved regulatory and planning applications.

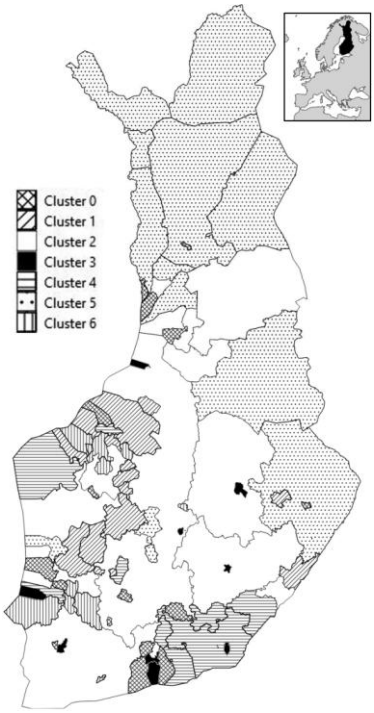

Figure 1: DSO's responsibility areas with their respective cluster indexes in Finland (Paper 162)

This paper (**paper 378**) outlines E-REDES' simulation-based approach to validating compliance with the European Requirements for Generators (RfG) for distributed energy resources in Portugal. It details the simulation requirements for generator owners, including fault-ride-through scenarios, reactive power injection, and model adequacy. A benchmarking study compared practices across European DSOs, identifying best practices and challenges, especially under low-power conditions. The study emphasizes the need for validated models and standardized simulation protocols to ensure grid stability and regulatory compliance.

Tariff Evolution & Market Design

Paper 10 proposes a new electricity tariff model for residential users in Buenos Aires that shifts from volumetric billing ($/MWh) to a demand-based system ($/kW), aiming for fairer cost allocation. It introduces charges based on both the user's own peak demand and their demand coinciding with the system's peak load, reflecting actual infrastructure usage more accurately. Two tariff structures are presented—one with fixed, own demand, and coincident peak components, and another with just the latter two. This approach also addresses cost imbalances caused by solar prosumers under net metering, promoting more equitable and efficient energy distribution.

Paper 257 outlines Sweden's regulatory framework for network tariff design aimed at promoting efficient grid utilization amid rising electricity demand and renewable integration. The Swedish Energy Markets Inspectorate (Ei) mandates that tariffs include four components: energy, power (forward-looking), customer-specific, and fixed fees. These components are designed to reflect actual grid usage costs and incentivize customers to adapt their consumption patterns. The regulation, effective from January 2027, balances economic efficiency with simplicity and transparency, and allows flexibility in implementation by system operators.

Primeo Energie, a Swiss DSO, developed voluntary time-of-use tariffs—"NetzAktiv" for demand and "SolarAktiv" for production—to encourage customer-side flexibility and reduce the need for costly grid expansion. These tariffs use seasonal and intraday pricing to incentivize load shifting and grid-friendly PV generation behavior. The approach balances regulatory compliance with customer engagement and aims to evolve into fully dynamic tariffs. Initial results described in **paper 318** show that combining both tariffs can effectively smooth grid peaks and offer financial benefits to customers with flexible consumption or generation.

The **paper 514** discusses the ecosystem, regulatory and algorithmic challenges, and pilot implementations on the ORES network in Belgium. The SCOPE project introduces a peer-to-peer local flexibility market designed to mitigate injection congestion in distribution networks without requiring DSOs to purchase flexibility directly. Instead, energy producers and flexibility providers (e.g., industrial loads or storage) trade services to absorb surplus renewable generation, reducing curtailment. This innovative model aims to enhance renewable integration, reduce CAPEX, and incentivize investment in flexible assets, with potential for broader European deployment.

This paper (**paper 519**) presents a market-based demonstrator by Belgian DSO ORES and wind producer

Luminus to provide reactive power compensation using wind turbines. The pilot aimed to reduce reactive energy penalties at substations by compensating for reactive power imbalances, especially during low wind periods. Over 10 months, the service halved the substation's reactive power costs, proving technically and economically viable. The study also outlines a simple market design and identifies future improvements, including dynamic setpoints and regulatory adaptations for broader deployment.

Paper 702 proposes a coordinated peer-to-peer (P2P) energy trading strategy across multiple distribution networks (DNs), where the Distribution System Operator (DSO) optimizes P2P prices to enhance system-wide economic benefits. To manage uncertainties in renewable generation and load demand, the authors apply a distributionally robust chance-constrained optimization (DRCCO) using a Wasserstein ambiguity set. Simulation results on IEEE 85-bus and 69-bus systems show that the proposed method improves revenue and maintains voltage constraints under uncertainty. The approach demonstrates the potential for scalable, resilient P2P energy markets in interconnected DNs.

This paper (**paper 710**) explores how electric vehicles (EVs) can help balance electricity spot market price peaks in Finland. It highlights that EV charging, especially when scheduled during low-price hours, offers significant cost savings for consumers and flexibility for the power system. The study finds that while EVs can influence daily electricity demand profiles, their overall impact on price volatility is limited compared to the effects of increasing wind power and industrial electricity use. The paper concludes that although EVs offer valuable flexibility, broader systemic changes will have a more substantial influence on electricity markets.

The GLocalFlex project introduces a novel flexibility marketplace that enables consumers and producers, especially at low voltage levels, to trade energy flexibility through automated, pay-as-bid auctions. The **paper 832** explores various business models based on different combinations of roles (e.g., Market Operator, Aggregator, Local Resource Operator) that can be assumed by actors in the marketplace. Five role configurations are analyzed, each with trade-offs in specialization, scalability, and operational complexity. The study aims to identify sustainable business models that can support widespread adoption of the GLocalFlex platform across Europe.

Paper 842 explores Brazil's use of regulatory "tariff sandboxes" to modernize its outdated electricity tariff structure, originally based on a 1968 decree. These sandboxes allow pilot projects to test innovative pricing models—such as time-of-use, fixed, and prepaid tariffs—within a controlled environment. The initiative, coordinated by ANEEL and involving 31 distribution companies, includes phases of planning, public consultation, national research, and monitoring. Early findings emphasize the importance of consumer education, transparent communication, and regulatory flexibility to ensure successful adoption and support Brazil's energy transition goals.

This study presents a UK-based randomized controlled trial (Beat The Peak+) testing the effectiveness of financial incentives and climate messaging in encouraging residential electricity load shifting. Participants received free energy on Sundays if they reduced weekday peak usage, while others received only normative messaging. The trial used econometric methods, qualitative interviews, and system-level simulations to assess behavioral and systemic impacts, though full results remain under embargo. Preliminary insights described in **paper 889** suggest that lifestyle factors, communication strategies, and incentive design significantly influence consumer engagement and flexibility outcomes.

This paper (**paper 1050**) reviews the current distribution tariff structure in Ireland, which has remained largely unchanged since 2000, and assesses its suitability in a decarbonised, decentralised, and digitalised energy future. With increasing adoption of behind-the-meter generation, electric vehicles, and heat pumps, the traditional one-way power flow model is becoming outdated. The authors highlight the need for tariff reform to ensure fair cost recovery and efficient network usage, especially as smart meters and flexible technologies become more prevalent. The Commission for the Regulation of Utilities (CRU) has initiated a review to align tariffs with evolving customer behaviors and climate goals.

The study described in **paper 1069** proposes a dynamic pricing model for electric vehicle (EV) charging stations that adjusts prices based on real-time network congestion to alleviate grid stress and improve load distribution. Using machine learning, particularly Bayesian Ridge Regression, the model predicts congestion and sets prices to incentivize off-peak charging or use of less congested stations. Simulations show a 15–20% reduction in congestion at peak locations and a 12% increase in revenue compared to flat pricing, while maintaining user fairness. The approach offers a scalable, practical solution for DSOs and policymakers to manage growing EV demand and support sustainable grid operations.

Paper 1168 from Brazil critically examines the role of subsidies in the global and Brazilian power sectors, highlighting how poorly designed subsidies can disproportionately benefit wealthier groups while burdening vulnerable populations. It reviews international subsidy practices aimed at promoting renewable energy and contrasts them with Brazil's current subsidy structure,

which heavily supports renewable generation and distributed generation (DG) at the expense of low-income consumers. The authors argue that Brazil's clean energy matrix no longer justifies continued subsidies for renewables and that resources should be redirected toward social tariffs and modernization. The paper calls for rational, time-bound, and impact-assessed subsidy policies to ensure social equity and economic efficiency in the energy transition.

This paper (**paper 1194**) presents a hybrid model combining Bidirectional Long Short-Term Memory (BiLSTM) neural networks with SHAP (Shapley Additive Explanations) to forecast and interpret day-ahead electricity market prices in the UK. The model achieves high prediction accuracy while offering explainability by identifying the time-dependent influence of features like demand and renewable generation. Case studies show how price sensitivity varies under different demand and renewable conditions, and a pixel-flipping validation confirms the reliability of SHAP explanations. The approach enhances transparency in machine learning-based forecasting, supporting better decision-making for market participants and system operators.

Paper 1180 explores the potential for service providers (SPs) to participate in both local and national flexibility markets, based on findings from the Uppflex project in Sweden. Through interviews, workshops, and financial assessments, the paper identifies strong motivation among SPs but also significant barriers, including administrative complexity, lack of standardization, and limited profitability in local markets. Technical and financial analyses show that while national markets offer more frequent opportunities, local markets can be more profitable during specific hours if value-stacking is enabled. The authors recommend coordinated market design, standardization, and tools to support SP participation across system levels to optimize grid efficiency and reduce system costs.

Smart Meter and Data Management Show Cases

Paper 46 provides an overview of how smart meter data is used in the Netherlands for grid management while strictly adhering to privacy regulations. Since the rollout of smart meters to 90% of households, ten approved use cases have been developed under a national Code of Conduct, covering areas such as voltage monitoring, outage detection, energy consumption validation, and PV system registration. These use cases are carefully vetted through a multi-step process involving DSOs, privacy officers, and independent data protection authorities. The paper highlights this collaborative framework as a model for balancing data utility and privacy, with future applications including the detection of EV chargers and home batteries.

Paper 193 presents an open-source, real-time energy monitoring system called xKy, designed to enhance collective self-consumption operations in France by leveraging Linky smart meter data. The system enables participants to monitor their energy usage and production in real time, improving self-consumption rates and user engagement. The study highlights the importance of user support and interface design, noting that active engagement is influenced by targeted communication strategies. Future work will focus on integrating alert systems and improving user trust and accessibility.

In the research described in **paper 356** Enedis, the French DSO, developed a graph-based algorithm to infer the electrical phase connection of customers using Power Line Communication (PLC) data from Linky smart meters. Since phase information is not recorded during installation, the method uses phase shift measurements between meters and concentrators to compute the most likely connection phase. The algorithm, implemented at the edge on concentrators, achieves about 97% accuracy and helps improve grid maintenance and phase balancing. Limitations include data sparsity and communication failures, which Enedis plans to address through delayed computation and enhanced monitoring.

In the work described in **Paper 416** Elenia, a Finnish DSO, developed a real-time consumption monitoring and alert system called AinaLab, leveraging next-generation smart meters. The system allows customers to view five-minute interval data and receive near real-time alerts for abnormal electricity usage, particularly useful for remote or seasonal properties. The backend Smart Grid Platform (SGP) processes massive time-series data efficiently, enabling flexible, user-defined consumption guard settings. This customer-centric innovation enhances energy awareness, supports risk prevention (e.g., heating failures), and lays the groundwork for future smart grid services.

This study by NGED investigates the accessibility and reliability of aggregated smart meter data across its UK network (**paper 424**). Due to privacy regulations, data must be aggregated, but many substations—especially rural ones—lack enough smart meters to meet the threshold, limiting data availability. Despite this, extrapolated smart meter data closely matches network monitoring data and outperforms Elexon Load Profiles in estimating substation demand. The findings support using aggregated smart meter data for network planning, while highlighting the need to address data gaps and privacy constraints.

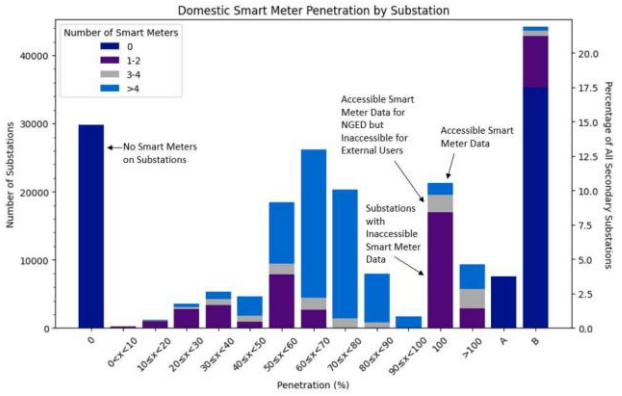

Figure 2: Smart meter penetration at substations. The "A" bar represents substations with no customers connected to them and the "B" bar represents substations with only commercial customers. The ">100" category highlights substations with more smart meters than customers (paper 424).

Paper 622 introduces DATAMITE, an open-source framework designed to facilitate secure and interoperable data sharing among energy stakeholders through Energy Data Spaces. It showcases use cases from Portuguese DSO E-REDES and Greek DSO HEDNO, demonstrating how DATAMITE supports open data sharing, system planning, and collaboration with energy service providers. The framework ensures data quality, governance, and sovereignty while enabling integration with platforms like Gaia-X and OMEGA-X. By enhancing data accessibility and standardization, DATAMITE supports smarter grid operations and the broader energy transition.

This paper (**paper 981**) summarizes the pilot projects and innovations developed under Norway's CINELDI research center, which aimed to support a flexible, intelligent, and robust electricity distribution grid. It describes 33 pilot projects and around 60 innovations, including dynamic line rating and fast frequency response systems, many of which involved collaboration between DSOs, researchers, and technology vendors. The paper introduces a checklist to help transition research into practical applications and discusses scalability and replicability challenges. Key takeaways include the importance of structured pilot planning, cross-stakeholder collaboration, and follow-up projects to ensure successful implementation and broader adoption.

Regulatory framework and developments in Grid Modernization and Planning

Paper 62 explores Finland's regulatory approach to steering electricity distribution network development amid growing decarbonization and capacity demands. It highlights the role of mandatory Network Development Plans (NDPs), which require DSOs to assess and report on network conditions, investment strategies, and future capacity needs every two years. Since their introduction, NDPs have led to significant improvements in network reliability, particularly through increased underground cabling, and have revealed a sharp rise in expected customer production capacity. The Finnish model demonstrates how structured regulatory planning can guide long-term infrastructure development without compromising DSOs' operational autonomy.

The **paper 172** introduces a method to translate Switzerland's national energy scenarios into localized, substation-level load profiles for distribution grid planning, demonstrated through Zurich's network. It integrates spatial, demographic, and technical data to model future electricity demand and generation, accounting for local variability and voltage levels. The model supports planners by providing granular, actionable insights and has already been applied in real-world studies. Future improvements could include probabilistic modeling and finer spatial resolution to enhance planning precision.

The study described in **paper 250** investigates the use of non-firm grid connections for small-scale PV systems as a flexible and cost-effective alternative to traditional firm connections. Modelling a real Spanish low-voltage grid, it shows that curtailing 8–16% of PV output can effectively mitigate overvoltage issues with minimal economic impact on households. The approach links curtailment levels to contracted power, promoting self-consumption while preserving grid stability. The findings support non-firm connections as a viable strategy for integrating distributed renewable energy in a fair and efficient manner.

Paper 638 presents ENOWA's approach to designing a fully Static Frequency Converter (SFC)-fed traction power system for NEOM's rail network, compatible with a 100% renewable grid. The study models various SFC configurations and introduces a meshed feeding concept to optimize power distribution, resilience, and scalability. Simulation results show that the meshed SFC system reduces load variance and improves efficiency compared to conventional configurations. The paper concludes that SFCs offer a technically and economically viable solution for resilient, future-proof railway electrification in high-renewable environments.

This paper (**paper 665**) describes a comprehensive framework to compare different implementations of Operating Envelopes (OEs), which define dynamic import/export limits for distributed energy resources (DERs) in distribution networks. The framework categorizes OE design by location, level, timing, and allocation methodology, and explores trade-offs between technical efficiency, fairness, and computational complexity. It highlights how different OE strategies affect customer equity, DER utilization, and integration with

flexibility markets. The work aims to guide utilities and policymakers in deploying scalable, fair, and explainable OE solutions to support DER integration.

This paper by SP Energy Networks (**paper 806**) outlines a strategic transformation toward a Whole System approach in Great Britain's electricity networks to support Net Zero goals. It emphasizes cross-sector and cross-vector coordination, integrating planning across electricity, gas, heat, and transport systems. The strategy is built on three pillars: system thinking, cultural transformation, and enablement, with practical examples of collaboration across stakeholders. The paper also highlights regulatory developments, such as the Whole Electricity System licence obligation and the launch of the National Energy System Operator (NESO), as key enablers of this transition.

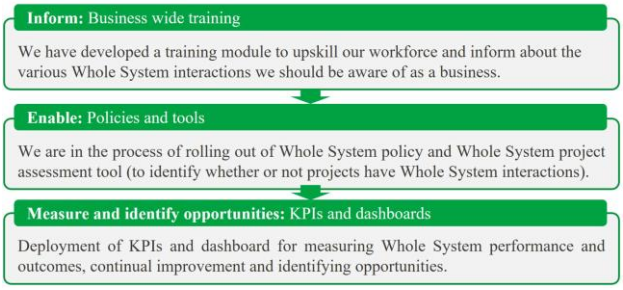

Figure 3: Whole System cultural implementation approach (paper 806)

Paper 834 presents a strategic roadmap developed by the CINELDI research center to guide Norway's transition to a flexible, intelligent, and secure power grid by 2040. It identifies three key pillars: digitalization and automation, flexibility in energy use and storage, and enhanced security of supply. The roadmap outlines short- and long-term measures, emphasizing collaboration among stakeholders and the integration of advanced technologies. The envisioned 2040 scenario includes widespread use of standardized data, automated flexibility trading, and risk-based grid management to support electrification and climate goals.

Paper 917 presents a practical 10-point plan developed by Lechwerke AG and Bayernwerk AG to accelerate Bavaria's energy transition. It emphasizes synchronizing renewable energy deployment with grid expansion, simplifying approval processes, and promoting innovative grid connection methods like the "feed-in connector." The plan also advocates for digitalization, flexible storage solutions, sector coupling, and decentralized power generation to ensure a secure, affordable, and sustainable energy supply. A key focus is fostering public acceptance and regulatory reform to support infrastructure development and climate neutrality goals.

This paper outlines strategies for deploying Innovative Grid Technologies (IGTs) such as advanced conductors, dynamic line rating, digital twins, modular power flow control, and advanced monitoring across European distribution networks. It highlights the benefits of IGTs in enhancing grid capacity, flexibility, and cost-efficiency, while addressing barriers like regulatory inertia and lack of technical familiarity. The authors of **paper 958** propose practical guidelines for identifying IGT opportunities, including scenario planning, cost-benefit analysis, and combined technology deployment. The paper also stresses the need for new assurance mechanisms in the absence of formal standards and emphasizes the urgency of adopting IGTs to meet Europe's energy transition goals.

This paper (**paper 1010**) compares the regulatory and technical frameworks for managing flexibility in low-voltage grids across Hungary, Germany, Sweden, and the EU. It highlights the growing need for intelligent control of flexible assets like EVs, heat pumps, and PV systems due to rising electrification. The study presents real-world data showing voltage challenges and explores decentralized and market-based solutions such as the neoflex algorithm, SWITCH platform, and Hungary's Flex.ON platform. It concludes that while national approaches vary, shared EU goals and tools can support a coordinated, flexible, and secure energy transition.

In **paper 1026** SP Energy Networks (SPEN) outlines its strategy for supporting local and regional decarbonization plans through targeted electricity network planning. The paper introduces the Local Authority Network Insight Tool (LANIT), which enables stakeholders to model low carbon technology (LCT) deployment and assess grid impacts in real time. By integrating LANIT outputs into SPEN's network planning and forecasting processes, the company ensures alignment with local Net Zero ambitions. The approach enhances collaboration with 40 Local Authorities and supports strategic infrastructure development to accommodate growing demand from EVs and heat pumps.

Business case and sustainability evaluations

The study described in **paper 566** evaluates the profitability of various energy storage technologies (e.g., Li-ion, PHES, SMES) in France's Day-Ahead (DA) and Frequency Containment Reserve (FCR) markets. Using a 1 MW storage model, it analyzes how efficiency, self-discharge, and energy capacity affect revenues across different market conditions from 2018 to 2021. Results show that PHES and Li-ion batteries are optimal for DA markets, while technologies like flywheels and SMES excel in FCR due to their high efficiency. Li-ion and lead-acid batteries are best suited for stacked services, offering

strong performance in both markets.

Paper 728 presents the CONVEY project, which models a circular, cross-sectoral hydrogen ecosystem at the Port of Hirtshals, Denmark. The system integrates wind-powered hydrogen production with distribution networks for hydrogen, oxygen, heat, and electricity, aiming to decarbonize port operations. Using the SpineOpt modeling framework, the study evaluates different scenarios involving electrolyzer technologies, storage options, and offtake demands. Initial results show economic and environmental benefits, including emissions reductions and increased resource efficiency, though challenges remain in balancing supply and demand for byproducts like heat and oxygen.

The study described in **paper 779** uses the STIRPAT model to analyze the carbon footprint from household electricity consumption in Bushehr, Khuzestan, and Hormozgan provinces in Iran. It finds that population growth and economic activity are major contributors to rising CO_2 emissions, with Bushehr having the highest carbon footprint. The paper evaluates various scenarios, including increased electricity use, improved energy efficiency, and reduced carbon intensity, showing that integrated strategies can significantly lower emissions. The findings support policy recommendations for energy efficiency, renewable energy adoption, and sustainable development planning.

Paper 902 reviews seven rooftop solar PV business models, categorized by ownership: customer, utility, third-party (including leasing, PPA, RaaS), and community models. It analyzes each model's structure, benefits, and drawbacks, particularly in the context of the UK's post-subsidy environment following the withdrawal of the Feed-in Tariff (FiT). The study highlights challenges such as financial viability and policy uncertainty, while identifying opportunities like integrating battery storage and emerging models like RaaS. It calls for policy support and further research to promote solar adoption and energy system resilience.

Paper 988 introduces the "Energy Wallet" metric, a comprehensive approach to evaluating energy affordability by including not only energy bills but also the capital and maintenance costs of home and transport electrification technologies. Using U.S. residential data and a 2050 Net-Zero scenario, the study analyzes 21 rural household profiles and tests the impact of electrification and time-of-use (TOU) tariffs. Results show that while electrification and efficiency upgrades can reduce long-term costs, TOU tariffs may increase expenses for some households, especially in colder climates. The study highlights the importance of equitable access to electrification technologies and the need for supportive policies to ensure a just energy transition.

Paper 1164 presents a methodology for estimating the Value of Lost Load (VoLL) in Croatia using publicly available data, addressing the absence of dedicated customer surveys. The authors analyze regional and seasonal variations in electricity consumption, GDP, and salaries to derive VoLL values, proposing a model that reflects temporal and geographic differences. Their findings suggest that the current VoLL used in Croatia underestimates the true cost of outages, with the proposed method yielding values over 1.6 times higher. The study supports more accurate and cost-effective network planning aligned with EU regulatory principles.

The **paper 1284** explores how subsidies can be integrated into energy optimization models for low voltage grid nodes. It presents an enhanced optimization algorithm that incorporates various types of subsidies—monetary, technical, regulatory, and market-based—into decision-making for energy-efficient upgrades and distributed energy resource (DER) installations. Using a reinforcement learning-based model, the study demonstrates that subsidies can significantly influence the selection and characteristics of optimized components, such as more efficient PV systems and heat pumps, leading to improved self-sufficiency and reduced grid dependency. The results show that incorporating subsidies extends the periods of energy autonomy and enhances long-term energy efficiency at the grid node level.

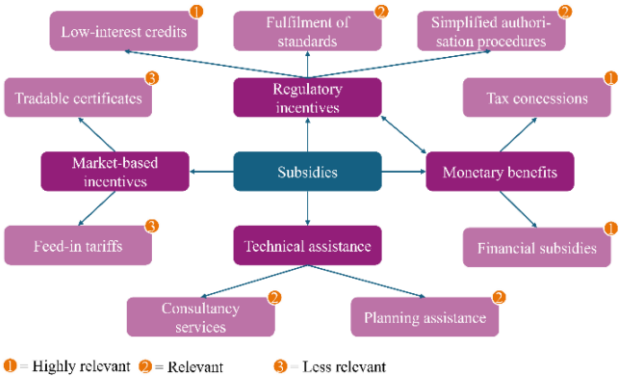

Figure 4: Treemap of the various subsidy types and low voltage grid nodes including a prioritisation of adaptation relevance

The following table gives an overview, where the papers are presented.

Table 1: Papers of Block 1 assigned to the Session

	Paper No. Title	MS a.m.	MS p.m.	RIF	PS
10	A tariff for power capacity coincident with the system's peak load in the metropolitan area of Buenos Aires, Argentina				X
62	Distribution Network Development Amid Policy Actions: Regulatory Plans as a Steering Strategy				X
162	Categorizing Finnish distribution system operators by combined geographic data and K-means clustering	X			
172	Data-Driven Regionalisation of Nation-Wide Energy Scenarios for Local Grid Planning: A Case Study of Zurich's Distribution Network				X
250	Small-scale curtailment of PV generation under non-firm connections				X
257	The Swedish regulation on designing network tariffs for an efficient utilization of the power grid	X			
318	Designing demand- and production-side tariffs to mitigate grid expansion costs within the Swiss regulation scheme	X			
378	E-REDES Requirements for simulation in meeting RfG Compliance on Portuguese Distribution Grid Connections				X
514	SCOPE project – An innovative market-based solution to deal with injection congestion				X
519	Reactive Power Services at DSO Level : A Market Approach on Belgian Network				X
566	Economic Assessment of Different Storage Technologies for the participation in Day-Ahead and Primary Reserve Markets				X
622	Sharing electricity distribution data through Energy Data Spaces using the DATAMITE Framework				X
638	Traction Power Sizing Optimization for the world's first 100% SFC Fed greenfield Electrification System.				X
665	A Parameterisation of the Dynamic Operating Envelope Design Space				X
702	Coordinated Peer-to-Peer Transactions in Multiple Distribution Networks with Distributionally Robust Chance-constrained Optimization				X
710	Electric vehicles as resource to balance the price peaks in electricity SPOT-markets – Case Finland, a threat or a possibility?				X
728	Cross-sectoral energy system model for hydrogen valley concept				X
779	Calculation of Carbon Footprint Caused by Electricity Consumption Based on Economic Growth and Population Increase in Southern Provinces of Iran with STIRPAT Model , is the title of my abstract				X
806	Whole System Approaches in GB				X
832	New business models supported by innovative interoperable solutions enabled by the GLocalFlex marketplace				X
834	ROADMAP FOR THE TRANSITION TO A FLEXIBLE AND INTELLIGENT POWER GRID IN NORWAY BY 2040				X
842	Tariff Sandboxes as a Tool for Modernizing the Tariff Structure of the Brazilian Power Sector				X
902	A Review of UK and International Roof-Rental Mechanisms for Optimising Solar Energy Adoption				X
917	Ten-point plan to accelerate the energy transition in Bavaria				X
958	Deployment strategy of Innovative Grid Technologies across European Distribution systems				X
981	Innovation and pilots as important steps for the transition of the electricity distribution grid				X

988	The Energy Wallet: A new metric for energy affordability assessment in the energy transition context	X			
1026	Supporting Local, Regional and National Energy Plans Through Targeted Electricity Network Planning Support				X
1050	REVIEWING ELECTRICITY DISTRIBUTION NETWORK TARIFFS FOR CUSTOMERS IN A DECARBONISED, DECENTRALISED AND DIGITALISED FUTURE				X
1069	Congestion-based Dynamic Pricing for Charging of EVs				X
1164	Regional and seasonal analysis of publicly available data for VoLL estimation when missing dedicated survey	X			
1168	Subsidies in the Power Sector: The Necessary Social and Economic Rationality				X
1180	A financial and technical study on service providers possibility to participate in local and national flexibility markets	X			
1194	Day-Ahead Electricity Market Price Forecasting and Analysis: An LSTM-SHAP Approach				X
1284	Influence of subsidies on future load time series and optimisation possibilities at low voltage grid nodes				X

Block 2: DSO business risk management

Roadmaps and innovation

Paper 171: This paper identifies six critical focus areas—or "bets"—that will shape the future of the grid. These insights are based on research into European trends, literature reviews, and collaborative workshops with internal stakeholders and industry peers

Paper 1286: The objective of this paper was first to identify how electric utilities currently steer digital innovation, which objectives they pursue, and which challenges they face, and then to provide recommendations on how they could improve their resource allocation in this area.

Forecasts and modelling

Paper 136: A statistical regression model is developed to forecast distribution electricity demand and tested for forecasting accuracy to assess the financial impacts of the Day-Ahead Energy purchasing penalties on South Africa's distribution sector.

Paper 256: The paper describes how replaced the fixed profiles with probability density functions of network usage to be used by both network planning and -operations therewith taking a step towards stochastic network development.

Paper 319: This paper examines five publicly available hosting capacity maps alongside relevant hosting capacity literature and identifies seven factors where different assumptions are applied to hosting capacity quantification.

Paper 383: This paper also addresses regulatory incentives and perceived technical barriers, identifying specific steps permitting DSOs to serially implement IGTs across DSO network.

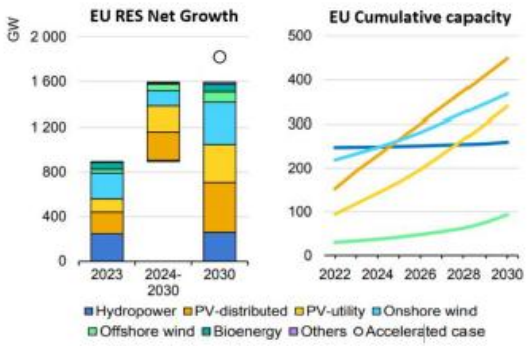

Figure 1: Europe renewable electricity diversity and forecast until 2030 (paper 383).

Paper 626: This study introduces a resilient, model-free framework for HEMS using distributed energy resources (DERs) such as electric vehicles (EVs), photovoltaic (PV) systems, and energy storage systems (ESS).

Paper 683: The objective of this paper is to develop a locational signaling methodology within the use of distribution system tariff that seeks to encourage the growth of micro and mini distributed generation (DG) towards the most technically favorable locations for DG along a feeder.

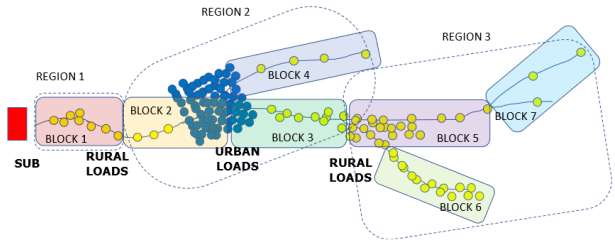

Figure 2: Alternative possibility of dividing the feeder into aggregate load blocks (paper 683).

Paper 1146: This paper highlights the lessons learned from developing and using short-term congestion forecasts for active power in the flexibility market CoordiNet, later Uppsala flexibility market, and sthlmflex during the winter seasons 19/20 to 23/24.

Paper 1258: This paper focuses on enhancing the reliability of distribution systems by considering customer preferences. It is demonstrated that taking into account customer choices in improving distribution reliability leads to competition.

Asset & risk management including weather effects

Paper 441: This paper describes the methods/processes being used and under development to ensure technical data accuracy for technical assets. The process needs to consider that each asset's type has a unique characterization, which means that the challenges will be distinct for each equipment.

Paper 462: The paper provides an overview of the current regulatory framework in Italy to stimulate the planning and development of a resilient distribution network with a detailed discussion on the parameters to be used in the cost-benefit assessment, which is the main tool for evaluating grid development interventions recognized at the regulatory level.

Paper 512: This paper introduces a cost-benefit analysis framework tailored to the evolving needs of DSOs, emphasizing the value of innovative grid technologies in managing uncertainty. The analysis highlights how faster deployment of innovative solutions can address short-term challenges while ensuring long-term grid resilience.

Paper 571: The implementation of an asset risk-based investment asset strategy at TAURON Dystrybucja, Poland's largest distribution system operator (DSO), is described in this paper.

Paper 650: The main goal of the work covered by this paper is to promote the implementation of differentiated intervention models in the fuel management strips, enhancing biodiversity values, generating value from ecosystems in rural areas, promoting integrated vegetation management as a green infrastructure strategy.

Paper 954: In this paper focus will be on calculating the CNAIM methodology's PoF (probability of failure) parameter for 10 kV (MV) PILC cables based on Danish failure statistic for PILC cables and their age distribution.

Paper 1111: Northern Powergrid (NPg) initiated the development of its in-house Investment Delivery Management System (IDMS) to replace outdated systems, manual processes, and fragmented databases. The goal was to create a unified solution for managing capital Investment Plans, Programmes, Projects, and Work Orders. The work is described in this paper

Paper 1124: The study employs machine learning to create climate risk maps for different scenarios (known as Representative Concentration Pathways – RCPs) and time intervals and assesses the potential impacts on the National Grid Distribution.

Paper 1261: This paper propose a new method for managing congestions caused by probabilistic load profile shifts by integrating Connected Electric Vehicles (CEVs) and load shedding within a market environment.

Customer and human resources

Paper 146: The purpose of this paper is understanding the high-voltage customer of CPFL Piratininga and CPFL Santa Cruz, segmentation of customers based on characteristics such as type of invoice and type of billing.

Paper 364: This investigation combines innovation resistance theory and gender diversity framework to verify whether functional-related barriers (usage, value, and risk) may affect firm-level decisions to adopt technologies in work routines while assessing if this relationship is moderated (supported or restrained) by firm's gender diversity.

Paper 1039: This paper provides a comprehensive analysis of energy theft in the UK, examining societal and industry-led efforts to combat it. Moreover, it highlights areas where the industry could improve to effectively identify and mitigate energy theft.

Potential scope of discussion

The range of challenges and possibilities in the area of DSO business risk management is large. Analyzing the papers from this year's conference it is clear that we move from visions and roadmaps towards more hand-on asset and risk management as well as the importance of forecasts and planning.

To elaborate on subjects where this year's conference lack papers then standardization (including ISO55000) and cross sector innovation is missing. It is also noted that papers around sustainability is low.

Table 2: Papers of Block 2 assigned to the Session

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
136 Developing Day-Ahead Demand Forecasts to Simulate a Dynamic Energy Purchasing Market in South Africa				X
146 High-voltage customer segmentation				X
171 The modern DSO - A vision about the challenges to overcome to meet the expectations of tomorrow.				X
256 Modeling dynamic network usage in Stedin's network and operations planning using Stedin Energy Transition Impact Assessment Model (SETIAM)	X			X
319 Overlooked factors in transparent hosting capacity calculations	X			X
364 An innovation resistance theory applied to firm-level perspective: Investigating the role of gender diversity in the behavior of outsourced electric distribution enterprises				X
383 Title: Fast Network Developments With Innovative Grid Technologies	X			X
441 E-REDES | A Pioneer & Automated Data Acquisition Process to Improve Asset Characterization				X
462 Climate Change Impact on Distribution Network: Regulatory tools for Resilience	X			X
512 Managing Uncertainty for DSOs				X
571 A Risk Based Approach to Efficient Investment Optimization for DSOs in the Energy Transition				X
626 A robust model-free framework for resilient home energy management system with V2G facility under extreme events				X
650 Integrated Vegetation Management approach for fuel management strips in E-REDES				X
683 Locational signal methodology for distributed energy resources				X
954 Using the CNAIM methology for 10-20 kV PILC cable systems				X
1039 A Comprehensive Analysis of Energy Theft in the UK				X
1111 Integrating the Investment Delivery Management System and Invest: Advancing Asset Management through Seamless Intervention Modelling and Tracking				X
1124 Framework for Risk Assessment of the Electrical Power Grid under Extreme Weather Conditions				X
1146 Lessons learned from developing and using short-term congestion forecasts for active power to procure local services on flexibility markets	X			X
1258 An Analysis of Game Theoretic Methodologies for Reliability Enhancement in Electrical Distribution Systems				X
1261 Risk-based Congestion Management in ADNs Using V2G operation of Connected Electric Vehicles				X
1286 How can electric utilities drive their investments in digital innovation?	X			X

Block 3: Customer interaction, energy sharing, e-mobility and flexibility

Block 3 covers wide range of interesting topics related to customer interaction, energy sharing, e-mobility and flexibility, and the presentations and discussions of this block will report on experiences from many countries – each highlighting specific issues.

Paper 0024 reports on grid-aware charging and its benefits for various levels of the distribution grid, as well as its role in the future-proof grid design for DSOs. Reducing firm

capacity and increasing non-firm capacity, is very important for enabling a better use of our grid at all levels - anticipating a 2.4% reduction of the peak power at primary substation level and a 160 kW peak reduction per LV grid in Liander's region.

Paper 0043: This paper evaluates the difference between a location of BESS scattered by users and a location optimized by the distributor, based on a model of typical network of the metropolitan area of Buenos Aires (Argentina).

Paper 0084 reports on how Energy Communities impact on powergrids and market structures, offering recommendations for sustainable growth and innovation.

Paper 0147 from Brazil reports on how technical and socio-demographic information on almost 9 million customers was used to create 8 communication protopersonas. The "protopersona" refers to the groups of customers with a similar profile identified by the clustering technique, prior to the application of a customer survey.

Paper 0182 explores congestion points and addresses them by calculating the potential of flexibility in the LV grids. This has been done by automated modelling and calculation of the networks, with multiple combinations of flexible DERs (solar photovoltaic (PV) installations, hybrid and all-electric heat pumps, home and public electric vehicle chargers, and home batteries).

Paper 0207 addresses the integration of local peer-to-peer (P2P) energy markets with secure grid congestion management to accelerate decarbonization at the community level. Simulations involving 250 prosumers and 362 nodes evaluate financial benefits, market liquidity, and the role of wind power in enhancing local energy trading, especially during winter when PV generation is low. Results indicate that wind power integration increases prosumer earnings in winter, reducing dependence on external suppliers.

Paper 0208 presents a field experiment from the Netherlands, that evaluates the effectiveness of residential battery storage within a VPP framework in achieving peak shaving and enhancing grid stability at the low voltage level, highlighting the potential of distributed battery storage, in supporting grid stability and enhancing renewable energy integration.

Paper 0215 from the Netherlands is based on an experiment conducted in 2015 in which the expected Dutch residential load for 2025 was created in practice by simultaneously charging electric vehicles and baking a lot of pizzas with a power outage as the result. This paper reflects on the findings of that experiment given the current state of the energy transition and put forward key recommendations for EV integration in the grid for the coming years. The main findings are that the risk for unbalance is mitigated, but that overloading risks due to load synchronization effects by day-ahead price incentives exist in the upcoming years.

Paper 0222 from Finland reports on a day-ahead electricity price analysis used to demonstrate that public charging can be relatively affordable compared to home charging and can improve both social and individual EV users' welfare. This requires the implementation of cost-reflective dynamic pricing that incentivises EV users to utilise public charging whenever cheap electricity, such as surplus renewable energy, is available.

Paper 0237 highlights critical regulatory, economic, and business factors enabling community-based DSOs. A multi-phase economic modelling approach underscores the value of "revenue stacking," where flexibility services and resilience enhance returns beyond traditional energy sharing models.

Paper 0332 elaborates on the role of household flexibility in supporting microgrids for stability and electricity supply during high demand or adverse conditions. Flexible resources like batteries and heating systems allow households to aid microgrid operations in island mode and enhance resilience. Advanced digital communication technologies facilitate real-time data integration for dynamic demand-side adjustments and efficient resource allocation, ensuring optimal energy management. The study examines technical and socio-economic aspects, assessing household readiness to adjust energy usage for grid balancing, providing insights for optimizing microgrid operations and fostering collaboration for sustainable energy systems.

Paper 0339 examines low voltage (LV) developments in the Netherlands, focusing on the shift to fossil-free energy with electric vehicles (EVs), rooftop solar panels (PVs), and heat pumps (HP), which increase peak grid demand. It emphasizes the need for alternative demand management strategies, highlighting flexibility as a key solution. A strategy for enabling LV flexibility through resident power limiting contracts by the Distribution System Operator (DSO) using Home Energy Management Systems (HEMS) is outlined, stressing the importance of market participation.

Paper 0345: Flexibility in electricity consumption is becoming crucial due to the rise of weather-dependent renewable energy sources. Implicit load flexibility significantly affects customer consumption profiles and distribution grid planning. Distribution system operators (DSOs) lack data on customer retail tariffs, hindering their ability to locate flexible customers. This paper examines how extreme electricity market events can help identify flexible customers with spot-market contracts and the

influence of network tariffs with power-based fees on flexibility. Findings indicate that 80-90% of customers identified through basic consumption data analysis had spot-price contracts during days of very low market prices.

Paper 0347: The study examines dynamic grid capacity management for integrating distributed energy resources (DER) in low-voltage (LV) grids, highlighting the limitations of traditional fixed planning. It compares dynamic management using operating envelopes (OEs) with static and conventional approaches. Advanced methods allow real-time adjustments, optimizing capacity utilization. A Vienna case study evaluates OEs in urban LV networks, modeling a subnetwork in the BIFROST environment to assess flexibility and key performance indicators (KPIs) like EV charging capacity. Results indicate that dynamic management improves grid efficiency and informs future planning for a resilient grid infrastructure.

Paper 0431: This study examines the energy profiles of Dutch wholesale market participants serving energy communities, industrial parks, and decentralized governments, utilizing 15-minute interval data from the ENTRNCE Trader platform in 2024. The case study shows that diverse consumption and production profiles can trade locally under real conditions. Additionally, it finds that local energy trading volume can increase with a Local Energy Market (LEM), indicating that LEMs could achieve sufficient liquidity when these profiles merge, facilitating time and financial investment in their development.

Paper 0460: This paper examines three smart charging algorithms for electric vehicles (EVs): peak demand reduction, dynamic pricing optimization, and a combined approach. A case study of a Flemish EV charging park with 40 AC and 3 DC chargers over three years of dynamic tariffs shows that peak demand reduction yields the highest savings, while dynamic pricing optimization further reduces costs, particularly with capacity-based tariffs. The study utilizes efficient rule-based algorithms, suitable for small and medium-sized enterprises (SMEs), assuming perfect knowledge of future sessions. A sensitivity analysis indicates that modest capacity-based tariffs incentivize peak shaving, emphasizing the role of regulatory structures in cost reductions. The findings highlight the benefits of combining these strategies for significant energy cost savings in EV charging for SMEs.

Paper 0464: This paper examines the use of Common Network Asset Indices Methodology (CNAIM) to assess risk during flexibility services demonstrations amid planned outages. A model analyzing health indices revealed that the probability of failure correlates with the circuit's overall health index. While the methodology is a useful estimation tool in data-limited situations, it has limitations. For Distribution Network Operators (DNOs), it justifies operational flexibility and addresses Customer Interruptions (CI) and Customer Minutes Lost (CML) penalties. The paper concludes that CNAIM can estimate financial risks from network outages, supporting the procurement of flexibility services.

Paper 0478: EREDES has created a machine learning tool to forecast call volumes for all telephone lines. Utilizing historical data and predictive algorithms, it improves forecast accuracy, enabling optimal sizing of contact center operations. This enhances adherence to SLAs and customer satisfaction, while automating the process and reducing management workload.

Paper 0502 from the Netherlands propose FlexFinder, a multi-agent system using Large Language Models for contract identification and negotiation. It interacts with customers to infer needs and suggest customized contracts, automating a traditionally expert-driven process – enabling efficient, scalable negotiations, optimizing grid use and promoting renewable energy adoption.

Paper 0531 utilizes a service design process to hypothesize user needs and solutions for testing. User interviews and segmentation yield four service concepts, ranging from limited to advanced assets, driven by analytics or alerts. Each concept includes user journeys, service blueprints, flow diagrams, and mock interfaces.

Paper 0536 analyses the integration of prosumers and electric vehicles (EVs) into an industrial zone's distribution grid, highlighting how EVs play a crucial role in addressing grid challenges like reverse power flows and energy losses, enhancing efficiency as prosumer systems are rapidly deployed.

Paper 0581: Electric Water Heaters (EWHs) are effective for energy management due to their storage capabilities. This study examines data from 4,500 smart EWHs in Norway, analyzing their performance and consumption patterns against hourly electricity prices. It compares smart EWHs with traditional ones and overall household consumption. Findings indicate that smart EWHs respond to price signals, reducing electricity costs and not increasing grid peak load by shifting usage to off-peak times. These insights are pertinent to the wider European context.

Paper 0649: This paper explores two streams: the first describes the pilot project and regulatory sandbox framework, emphasizing collaboration among stakeholders like regulators, energy authorities, and commercial partners to overcome implementation barriers. The second section addresses technical aspects and practical implementation, presenting examples of solutions and challenges faced by E-REDES during deployment.

Paper 0727: The black-box Mixed Integer Linear Programming model assesses flexibility potential in industries with variable production speeds, enabling production shifts to adjacent hours. Its simplicity aids initial evaluations where data is limited, focusing on consumption-production relationships. It manages equipment start-ups and shutdowns to prevent thermal fatigue. Evaluated in the ELEXIA project using data from the port of Sines' regasification plant, it achieved energy savings of up to 6.3% and economic savings of 8.86%.

Paper 0741: The paper discusses the STREAM EU project pilot in Finland, which prototypes mechanisms for incentive-driven flexible active power usage to stabilize and optimize the grid. It explores using a portion of heating load as a Frequency Containment Reserve, complementing existing SPOT price optimization. The research focuses on the feasibility of integrating household assets into FCR services, optimizing available flexibility, and maintaining customer service levels.

Paper 0775: Heat pumps are essential for decarbonisation, but their integration into energy systems presents challenges like voltage drops and overloading in low-voltage grids. Technologies such as the SG-Ready interface can enhance flexibility and control. This study analyzes the dynamic response of two heat pumps with 0.2s resolution, particularly during SG-Ready state changes. By sharing our dataset, we aim to advance grid-oriented control research. Findings show quick, predictable responses during blocking events, but notable variability during start-up, affecting grid operation simultaneity.

Paper 0780: This article introduces a simplified method for assessing energy flexibility in local energy communities, crucial for integrating intermittent renewable energy. The approach uses a basic indicator needing minimal data while aligning with advanced methods. Simulations from the REFIT database indicate that the method accurately identifies 80% of houses in the most flexible categories.

Paper 0823: This paper summarizes findings from the second EQUINOX heat pump flexibility trial, involving over 1,000 UK households. EQUINOX addresses demand increases on substations due to heat pump adoption for building decarbonization, which peaks at the same times as network demand. The trial showed that domestic heat pump flexibility can mitigate these challenges. During 36 two-hour events in winter 2023-4, 47% of participants provided turndown on request, achieving 0.61kW of demand response for a total of 6.5MWh. Analysis suggests that if similar demand response is maintained, it could cover 19% of forecasted capacity exceedance in constrained areas. Heat pumps can offer "baseload" advance dispatch flexibility, aiding in capacity constraint alleviation. The next trial in winter 2024-5 will explore simultaneous flexibility for both distribution and transmission networks.

Paper 0855: This paper evaluates three PV-battery integration strategies in decentralized energy communities using real data: (SI) one-to-one distributed systems, (SII) distributed PV sharing a central battery, and (SIII) community-scale shared PV with distributed batteries. Simulations assessed PV export reduction, peak load relief, transformer loading, battery utilization, net load, and self-consumption. Results show SII relieves grid congestion best but incurs higher system losses, supporting resilient grid and sustainable energy community design.

Paper 0918: Vehicle-to-Grid (V2G) technology enables bidirectional power flow between electric vehicles (EVs) and the grid. Charger architecture is key to V2G implementation and cost. This paper compares a 7 kW 220V single-phase AC charger and a 20 kW 380V 3-phase DC charger for V2G applications, assessing their power efficiency, charge-discharge transition time, harmonics, and cost-effectiveness, providing insights into their advantages and limitations for V2G planning and deployment.

Paper 0944 examines Vehicle-Grid Integration (VGI) at workplace charging. Two smart charging strategies were tested: "Minimum Power" to flatten consumption and "Optimal Power" to reduce costs and peak withdrawals. Both strategies effectively curtailed peak power and lowered grid energy use, especially with photovoltaic (PV) systems, reducing grid withdrawals by up to 40% and monthly peak loads by up to 70%. Optimizing EV charging timing and power levels alleviates grid impact and enhances economic benefits, with potential yearly savings of 33% to 70%. These results highlight the importance of smart charging for EV adoption and grid stability.

Paper 0970: This work analyzes scenarios of local energy communities for self-consumption, focusing on local energy markets with distributed generation (PVs) and comparing cases with local energy storage and demand-side management (DSM). It emphasizes the need for energy storage and DSM to enhance user benefits and reduce reliance on the external grid. The study does not focus on optimization or scheduling algorithms but examines various levels of energy storage and DSM in local energy communities of different sizes and seasons. Results indicate that without energy storage or DSM, the advantages of local energy communities are minimal due to low electricity trading volumes.

Paper 1015: Social engagement and data sharing are vital for sustainable energy systems. This paper, based on the ENPOWER and Crete Valley projects, focuses on the

Dingle Peninsula, utilizing smart meter data to analyze energy behavior and optimize renewable energy use. Two Data-Sharing Workshops with local stakeholders emphasized financial benefits, community independence, and local sustainability, while also raising concerns about data privacy. Additionally, historical data from 49 household smart meters from 2019 to 2022 was analyzed, categorizing households by their assets. Monte Carlo simulations modeled EV charging patterns, incorporating variability from local EV infrastructure.

Paper 1080: The rapid deployment of low carbon technologies (LCTs) challenges network companies in managing electricity networks. The Community Distribution System Operator (CDSO) concept addresses this by engaging customers and LCTs in small energy communities within the low voltage (LV) network. A CDSO aims to balance demand and generation for each cell, ensuring power flows remain within network capacity. Successful implementation requires coordination of customer electricity demands, flexibility, and LV network design. Energy communities should collaborate with DNO/DSO to optimize revenue, minimize costs, and reduce customer disruptions while keeping network assets within thermal and voltage limits. Properly managed cells can provide better outcomes for community members than direct customer-DNO relationships.

Paper 1089: This study presents a VPP operational methodology addressing DER status uncertainty. It estimates communication losses and failures using historical PV plant data and calculates failure ratios based on missing data periods. These ratios assess fault likelihood during real-time data loss. A case study on a VPP with an energy storage system and PV plant shows that the operator can adjust its schedule per DSO requirements. Various missing communication scenarios are simulated with Monte Carlo methods, revealing improved grid stability for the DSO and increased economic benefits for the VPP operator compared to conventional methods.

Paper 1116: This paper presents a method to reduce peak demand at fast charging stations by using surplus energy from interconnected solar-powered streetlights. Each streetlight, equipped with a solar panel and battery, often has unused energy during the day. By connecting these streetlights, their combined surplus can support EV chargers, lessening grid reliance during peak times. This research differs from previous studies by focusing on interconnected systems to meet fast charger energy needs. This scalable solution is particularly beneficial for EV infrastructure in the Global South, where solar streetlights are common.

Paper 1137: Flexibility is vital for grid planning and operation due to increased variable renewable generation and rising electrification demands. It offers significant opportunities from various load types, distributed energy storage, and local generation, collectively termed virtual power plants (VPPs). However, interoperability issues hinder their integration for grid services. This paper outlines key interoperability requirements and suggests solutions, drawing on insights from the Horizon Int:Net project.

Paper 1149: This paper explores multi-market optimization of PV-integrated hybrid energy storage systems (HESS) for frequency regulation and energy trading. A mixed-integer linear programming (MILP) model is created to maximize revenue by allocating power across fast frequency response (FFR), frequency containment reserve for normal operation (FCR-N), and day-ahead (DA) markets, considering technical constraints, market rules, and battery energy storage (BES) degradation. A case study using Finnish market data shows HESS can provide multiple services, with FFR and FCR-N being the most profitable.

Paper 1157: Active consumers gain from tailored incentives like client managers and the Unnati program, which rewards energy-saving efforts and enhances grid efficiency. Public platforms celebrate their contributions, boosting customer participation. For prosumers, TPDDL supports renewable energy integration via net metering, feed-in tariffs, and a dedicated cell for technical challenges, promoting investments in renewable energy and ensuring reliable grid access for surplus electricity. TPDDL's approach highlights the crucial role of active consumers and prosumers in creating a resilient, efficient, and sustainable energy network, emphasizing engagement in the future of energy distribution.

Paper 1163: In Portugal, energy sharing is managed by the DSO, utilizing smart meter data to facilitate transactions among market participants. Initially, only two schemes were available—fixed and proportional—prompting a need for innovative approaches to boost consumer benefits and self-consumption. Due to limited experience, a regulatory sandbox was established, allowing E-REDES to propose a pilot project to test dynamic and hierarchical schemes. Approved in late 2022, the project aims to develop and assess these methodologies, focusing on their potential to enhance consumer value and incentivize participation.

Paper 1167: The paper outlines Elenia's development of self-service calculators to help customers size photovoltaic (PV) systems and electric vehicle (EV) chargers for home use. During the energy crisis, sellers often suggested oversized PV systems, increasing network reinforcement costs for Elenia. To mitigate this, Elenia created a calculator that evaluates business cases for PV installations, using the EU PVGIS-tool for production

calculations and customer consumption data for accurate recommendations. It also checks for necessary network reinforcements before connection approval. Additionally, a similar calculator helps customers size home chargers based on their consumption history and charger specifications. Customer feedback has been positive, highlighting Elenia's neutral support for informed decision-making. The usage data offers insights for network development, showcasing how DSOs can improve customer engagement and planning with data-driven tools.

Paper 1170: CPFL Energia optimizes processes for a better customer experience through the First Contact Resolution (FCR) project. FCR measures service efficiency, identifies bottlenecks, and drives improvements by focusing on resolving requests in the first interaction. This enhances customer satisfaction and operational efficiency. Daily monitoring via dynamic dashboards allows for real-time evaluation of service performance and initiative effectiveness. FCR exemplifies CPFL Energia's strategic use of data to enhance customer relationships and service excellence.

Paper 1198: In recent years, more households are utilizing electricity from solar power plants and heat pumps alongside grid electricity. These integrated systems offer significant savings compared to conventional systems, which rely solely on grid electricity, gas, or pellets. This paper discusses the advantages and disadvantages of integrated systems and evaluates their economic feasibility by analyzing implementation and usage costs. A case study in Sombor, Serbia, examined a household with a heat pump and solar power plant, revealing that it nearly meets its electricity needs. Data collected over a year were compared to a classic system's performance during the same period, using energy prices from Serbia and the EU for estimates.

Paper 1202: Technologies like air storage and refrigeration offer flexibility akin to battery storage, enabling power use "time-shifting" from high to low price periods. Engaging in flexibility/ancillary markets can generate additional revenue for users and aid Distribution System Operators. A case study on a UK cement works shows that liquid air storage can leverage frequency, balancing, wholesale, and Piclo flexibility markets. Simulation indicates that a market portfolio approach can boost revenues by 10-200% compared to the Balancing Mechanism alone, and using ancillary markets can increase revenues by at least 8 times or more.

Paper 1236: This study presents a framework combining a Demand Response Readiness Factor (DRRF) tool with Natural Language Processing (NLP) to evaluate DR program implementability. NLP automates literature selection and insight extraction, enhancing model robustness and information scope. The DRRF uses a Variable Correlation Index (VCI) to identify success factors and a Country Similarity Index (CSI) for tailored recommendations. Initial findings suggest NLP integration improves DR scalability and adaptability, enhancing grid stability, consumer engagement, and renewable energy integration. Future phases will validate the tool through pilot studies for complex simulations and real-time adjustments.

Paper 1270: EU climate targets aim for climate neutrality by 2050, impacting power distribution development and operation. Distribution networks must enhance hosting capacity for distributed generation and new loads. Utilizing generation and consumption flexibility can defer or reduce necessary investments to address temporary technical limit violations. Sometimes, available resources for flexibility are outside the affected area, limiting their usefulness. This paper presents a methodology to determine the optimal flexibility area for Distributor Operators, considering various network configurations, particularly in emergencies. The methodology's application to realistic distribution networks is demonstrated.

Table 3: Papers of Block 3 assigned to the Session

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
0024 Grid-aware EV charging and future-proof grid design: Policy decision-making by a Dutch DSO				X
0043: A distribution model with batteries scattered among users vs a model with batteries concentrated by the distributor				x
0084 Roadmap for unleashing large-scale energy transition potential by fully viable and integrated Energy Communities				X
0147 Communication personas		X		X
0182 Flexibility for congestion management in low-voltage grids: An automated network modelling case study on multiple flex resources with outlook 2025-2050.				X

0207 Economic scalability of local energy and flexibility market under consideration of medium voltage nodes.				X
0208 Aggregating distributed plug & play battery storage units effects on local grid dynamics and efficiency		X		X
0210 Charging electric vehicles, eating pizzas, and safeguarding the grid in 2025		X		X
0222 Enhancing the attractiveness of public EV charging – from minor role into a real deal through dynamic pricing				X
0237 Community DCO: Enabling energy communities to balance renewable energy generation and demand to improve networks resilience				X
0332 Empowering Microgrids with Adaptive Household Energy Management				X
0339 Enhancing low voltage flexibility through home energy management: a co-creation approach with DSOs and market product development.				X
0345 Identification of price flexibility spot contracts customers from load data based on extreme events on electricity market				X
0347 Accelerating E-mobility charging integration with dynamic grid capacity management				X
0431 Complementarity of Residential, Industrial, and Municipal Participants in Local Energy Markets: a Real-Life Data Showcase				X
0460 Smart algorithms for EV charging in SMEs: A Flemish case study on balancing peak demand reduction and dynamic pricing				X
0464 Operational flexibility in distribution networks: Application of CNAIM to facilitate planned outages				X
0478 E-REDES implements machine learning based call volume forecasting in order to enhance contact center efficiency				X
0502 FLEXFINDER: Automatic medium voltage grid contracts with language models				X
0531 Developing new concepts for B2B2C energy flexibility service design approach				X
0536 Optimizing grid stability: how electric vehicle integrations can address challenges from rapid prosumer system development				X
0581 Implications of smart electric water heaters: A detailed analysis of load profiles and aggregated peak load		X		X
0649 E-REDES foster regulatory sandbox for flexible connection, allowing EV charging in collective buildings				X
0727 Blackbox MILP optimization model for industrial DSF potential asessment				X
0741 Prototyping innovative mechanisms for incentive-driven explicit flexibility in residential buildings				X
0775 Characterization of grid-oriented control of heat pumps via SG-Ready				X
0780 Quantifying residential demand flexibility: An accessible indicator approach				X
0823 EQUINOX: Learning from developing and trialing the capacity to procure flexibility from a portfolio of domestic heat pumps		X		X
0855 Integrated PV-battery design mapping strategies and control in decentralized energy communities for enhanced grid congestion relief				X
0918 Charge and discharge characteristics of ISO15118-20 based AC and DC V2G system				X
0944 EV smart charging strategies for reduced operating costs and grid impact: A case study on workplace charging infrastructure				X
0970 Bridging the gap between PV generation and demand: The role of energy storage and demand-side management in local energy systems				X
1015 Data access and effective social engagement: A pathway to resilient and consumer-activated communities				X

1080 Community DSO: coordinating community flexibility in the low voltage network considering uncertainty				X
1089 Improved aggregated distributed energy resource operation method for distribution network considering communication losses				X
1116 Reducing peak demand of EV fast charging stations using interconnected solar-powered streetlights				X
1137 The challenges of interoperability for VPPs addressing load flexibility				X
1149 Multi-Market Optimization of PV-Integrated Hybrid Energy Storage Systems for Frequency Regulation and Energy Trading				X
1157 Incentive Strategies for Active Consumers and Prosumers: Tata Power Delhi Distributions Approach				X
1163 Innovative energy sharing schemes in Portugal: A pilot project by E-REDES under a regulatory sandbox				X
1167 Self-service calculators for sizing PVs and EV charger for home use		X		X
1170 First Contact Resolution				X
1198 Analysis of the work of the prosumers with solar power plant and heat pump				X
1202 Using Novel Technologies to Provide Flexibility to Distribution Systems by Exploiting a Market Portfolio Approach				X
1236 Scaling demand response readiness frameworks through NLP integration				X
1270 Assessment of the DSO'S flexibility procurement area				X

Block 4: Digitalization, AI, business processes and cyber-security

Block 4 covers the broad field of digitalization in general including artificial intelligence (AI) and new digitized business processes as well as cyber security in the IT and OT systems within the DSO business.

Sub block 1: Digitalization

Paper 0046 demonstrates how analysis of low voltage grid behaviour requires individual data, governed by strict privacy laws in the Netherlands. The aim of the paper is to provide an overview of approved use cases in the Netherlands and their benefits for DSOs.

Paper 0111 presents a study for better understanding the factors that influence the successful implementation of digital transformation (DX) in the electric distribution utilities, using Egypt as an example case. In this paper, four contributions of DX as applied to the Egyptian electric distribution utilities are outlined.

Paper 0193 introduces a new open-source infrastructure for real-time monitoring based on Linky meter data, enabling participants to make informed decisions and take timely actions in France. It includes a description of the xKy device, applied to a collective self-consumption operation involving nine participants, supported by the Energy Transition Observatory (OTE). The project encompasses the implementation of gateways in participants' homes and the development and operation of real-time monitoring website, aimed at increasing participants' self-consumption rate.

Paper 0375 discusses how smart grids, and smart meters have played a key role in this new role of the DSO, as it's believed that the proliferation of smart meters in the low voltage grid will enable the DSO to collect data and operate in near real-time. The DSO in Portugal, E-REDES, has developed the Smart Metering Plus solution, which virtualises the HAN interface of the smart meter and allows the prosumer real-time access to the data measured by the smart meter and available on the HAN interface.

Paper 0805 explores how Northern Powergrid's open data function has worked with a wide range of stakeholders, both internal and external from a variety of origins to build an open data platform that seamlessly connects anyone with the data they are looking for. The papers outline the process they have developed to identify stakeholders' data requirements and how they use these to develop open data products. The paper also explores how they have created a

user journey on their Open Data Portal that can direct someone of any knowledge level or interest area to the data they are looking for.

Paper 0929 dive into the growing share of intermittent distributed energy resources, as the need for distribution network flexibility to contribute to network management is inevitable. The paper presents a systematic framework for classifying strategies to harness these resources based on their availability and management type.

Paper 0979 addresses semantic interoperability lessons learned based on a concrete use case within the field of access to metering and customer data. The paper leverages some results from Horizon Europe Energy Data Space projects, specifically OMEGA-X, EDDIE, Enershare, DataCellar and Int:Net.

Sub block 2: Artificial Intelligence (AI)

Paper 0190 investigates the use of artificial intelligence (AI) in electricity distribution companies, focusing on its ability to tackle both technical and non-technical challenges. Utilizing a qualitative case study approach, the research analyses practical AI applications through semi-structured interviews with key personnel from Iranian electricity distribution firms and secondary data from relevant reports.

Paper 0357 presents a methodology for hourly forecasting of solar PV, solar thermal, and wind power generation in the Spanish intraday market using advanced Machine Learning techniques.

Paper 0366 explores an innovative AI-driven approach to demand-side management that leverages data analytics techniques to analyse consumption patterns and detect anomalies, as well as load pattern forecasting. The methodology involves big data techniques, AI algorithms, and statistical methods to extract actionable insights from smart meter data.

Paper 0467 studies how artificial intelligence can help find and pinpoint faults in power systems and how AI systems use historical records plus real-time measurements to detect failures and pinpoint their exact locations.

Sub block 3: Digitized business processes

Paper 0087 gives and insight how Edenor (Empresa Distribuidora y Comercializadora Norte SA) carried out a plan of activities to tackle the control of non-technical losses implementing different courses of action contemplating different client profiles and their social environments.

Paper 0356 describes the methodology deployed by the France DSO, Enedis, in order to compute this missing information using graph theory over Power Line Communication (PLC) data. It also discusses the key challenges encountered regarding data collection, data quality and graph algorithm implementation.

Paper 0416 presents the work carried out by the Finnish DSO, Elenia, within the AinaLab to provide new features from meters directly to consumers. In AinaLab, customers can monitor the load distribution of their home's electricity system and view their own electricity consumption with a five-minute resolution, phase by phase, with no more than a 20-minute delay, and possibly even faster in the future. Real-time and accurate information about their consumption and production helps customers understand the usage of their home and electrical appliances.

Paper 0475 outlines the implementation of modern AMR meters and their role in bolstering the adaptability of the urban power grid. By harnessing over 20 million daily data points from smart meters, Helen DSO in Finland has developed sophisticated applications that augment network hosting capacity and improve customer service. Key contributions include real-time load forecasts for the local 110 kV grid to identify flexibility needs, assessment of demand response capabilities, and implementation of an online service for efficient electricity capacity management.

Paper 0543 presents and discusses the main features of a Digital Platform developed and maintained by E-REDES, the largest DSO in Portugal, to enhance the management of Collective and Self-consumption providers recently emerging in the Country's energy market.

Paper 0592 presents a methodology to leverage open data to build referential systems that can be used to accurately position clients. The idea behind the work is, that having an accurate view of the distribution network is essential. It serves as the basis for many analyses useful for its maintenance and development or predicting its load and capacity. It also helps technicians to quickly identify where they need to go when a physical intervention is needed.

Paper 0709 presents a dynamic profiling model implemented by Enedis in France, the data used (from smart meters), and the performance achieved. This data service is essential to operations of the market, as it enables electricity flows to be allocated by quarter-hour and by market player (Balance Responsible Party) for the purpose

of billing system balancing costs (balancing is essential to the stability of the grid).

Paper 0725 present the work the DSO in France, Enedis, have carried out to develop a secure solution that guarantees the confidentiality of its customers' consumption data while meeting the following objectives: actively contributing to the energy transition by providing meaningful data to states and local authorities; providing curves with enough information to be useful for the needs of the concerned public; and, complying with personal data protection laws, thus protecting their customers' privacy (GDPR).

Paper 0941 shows how advanced metering infrastructure is widely implemented in Jakarta's rural districts to handle payments on time as well as disconnection and reconnection of customers in a simple and cost-effective way.

Paper 0943 leverages information technology and scientific analysis to delve into the existing process for grid connection applications of new energy projects in China, identify bottlenecks, and propose solutions to expedite the new energy transition. By accurately assessing the impact of digital transformation the paper aims to provide theoretical support for
accelerating the development of the new energy industry and contributing to global energy transition.

Paper 0966 reports on the results from two case studies carried out by SINTEF in Norway concerning data integration for improving maintenance performance at a Distribution System Operator (DSO). The two case studies are: 1) earth fault work process and 2) inspection planning for secondary substations. In addition to reporting on experiences from the two case studies, the paper also discusses the potential gains and challenges for efficient data integration for DSOs in general. As the case studies exemplify, the potential for improving maintenance performance through efficient data integration is substantial.

Paper 1162 discusses the digitalization of business processes to enhance operational efficiencies and generate error-free billing at Tata Power Delhi in India. The paper outlines the six key steps involved in the customer lifecycle, from applying for a new connection to the payment of bills, and highlights the role of technologies such as smart meters, Customer Relationship Management (CRM) systems, and data-driven decision-making.

Sub block 4: Cyber security

Paper 0765 analyses security issues in over 100 global energy facilities, including substations, power plants, and control centres, using intrusion detection systems (IDS). It identifies the top five most common network security risks and highlights unsecure implementations in substations. It also details operational issues on the station and process bus, such as configuration errors, network failures, and IEC 61850 interoperability problems.

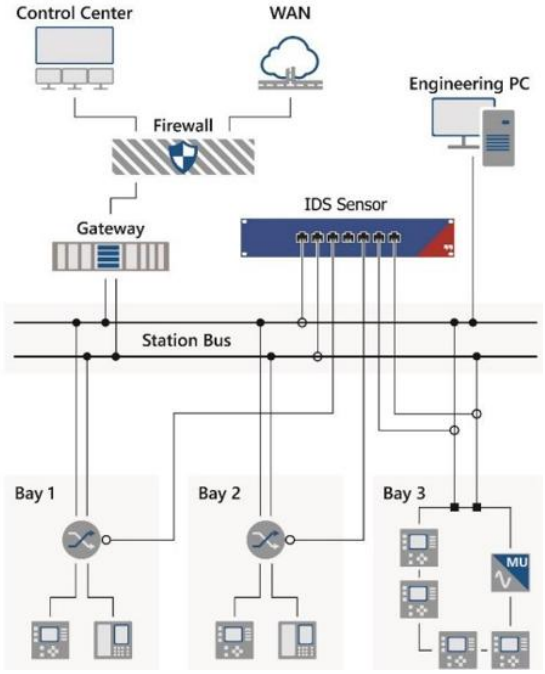

Figure 3: Connection of an IDS in PAC systems from paper 0765.

Paper 0969 focuses on developing a robust step by step Incident Handling process which can be followed by the OT domain in a DSO and shall recommend the use of advanced modern technologies in the various phases of the incident handling process.

Paper 0991 proposes security measures isolating real-time interfaces from outside threats enable the rollout to start quickly. To prevent the increase of risk with the installed capacity, cryptographic protection of communication has been added, by using IEC 61850 MMS with TLS as described in IEC 62351. The PoC demonstrated that some Vendors already supported these measures, while other Vendors quickly and effectively added support to their products, although there were constraints to certificate management.

Table 4: Papers of Block 4 assigned to the Session 6

Paper No. Title	MS a.m.	MS p.m.	RIF	PS
46 Overview of smart meter use cases in the Netherlands				X
87 Control of non-technical losses, sustainability and social inclusion				X
111 Study of digital transformation success in electricity distribution sector: The case of Egypt				X
190 Identifying the applications technical and non-technical of artificial intelligence in electricity distribution companies				X
193 Open source structure in a residential collective self-consumption: sub-minute data collection operation.				X
356 Connection phase computation using Linky metering system communication data				X
357 From 1 to 48 Hours: Preprocessing Strategies and Machine Learning Forecasting for Solar, Photovoltaic and Wind Power in the Spanish Intra-day Electricity Market				X
366 Advanced AI-Based Data Analytics for Effective Peak Load Management at Major University Campuses in Tehran				X
375 E-REDES SMART METERING PLUS SOLUTION FOR REAL-TIME ACCESS TO METER DATA VIA VIRTUAL HAN INTERFACE				X
416 Consumption alarms to customers using smart meters real-time measurement.		X		X
467 AI-driven fault localization and detection in electric distribution networks: enhancing reliability and operational efficiency				X
475 Modern AMR meters enabling an efficient and flexible urban power grid				X
543 "E-REDES" Portal for Collective Self-Consumption and Energy Communities				X
592 Developing a geocoded address reference system adapted to energy distribution networks		X		X
709 Dynamic load profiling for the market: an industrialized innovation by Enedis leveraging the widespread deployment of Linky smart meters				X
725 Realistic Individual Load Curves Generation for Personal Data Protection				X
765 Analysis of cybersecurity findings in over 100 energy systems		X		X
805 DNO Open Data - a case study		X		X
929 Smart metering capability for the energy transition: Gap assessment & disparity quantification				X
941 Leveraging Advanced Metering Infrastructure to Accelerate Cash-In				X
943 New Energy Cloud Digitalization Business Process Improves the Efficiency of China's Power Grid Services				X
966 Enabling the implementation of intelligent maintenance processes by efficient data integration		X		X
969 Advanced cyber incident handling techniques for OT in DSOs.				X
979 How to improve semantic interoperability ? a concrete use case based on EUMED Metering profile in the context of energy data space projects				X
991 Securing the Realtime DER Interface for The Netherlands: Key takeaways from protecting IEC 61850 MMS with IEC 62351				X
1162 Digitalization of business (including customer) processes to enhance operational efficiencies and generating error free billing.		X		X