A Proposal for a Secure and Interoperable Data Framework for Energy Digitalization

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Abstract : The process of digitizing energy systems involves transforming traditional energy infrastructure into interconnected, data-driven systems that enhance efficiency, sustainability, and responsiveness. As smart grids become increasingly integral to the efficient distribution and management of electricity from both fossil and renewable energy sources, the energy industry faces strategic challenges associated with digitalization and interoperability — particularly in the context of modern energy business models, such as virtual power plants (VPPs). The critical challenge in modern smart grids is to seamlessly integrate diverse technologies and systems, including virtualization, grid computing and service-oriented architecture (SOA), across the entire energy ecosystem. Achieving this requires addressing issues like semantic interoperability, IT/OT convergence, and digital asset scalability, all while ensuring security and risk management. This paper proposes a four-layer digitalization framework to tackle these challenges, encompassing persistent data protection, trusted key management, secure messaging, and authentication of IoT resources. Data assets generated through this framework enable AI systems to derive insights for improving smart grid operations, security, and revenue generation. Furthermore, this paper also proposes a Trusted Energy Interoperability Alliance as a universal guiding standard in the development of this digitalization framework to support more dynamic and interoperable energy markets.