



The Backbone of Digital Energy: Inside the ECLIPSE CERF Architecture

Standardizing Interoperability and Security for a Sovereign European Energy Space

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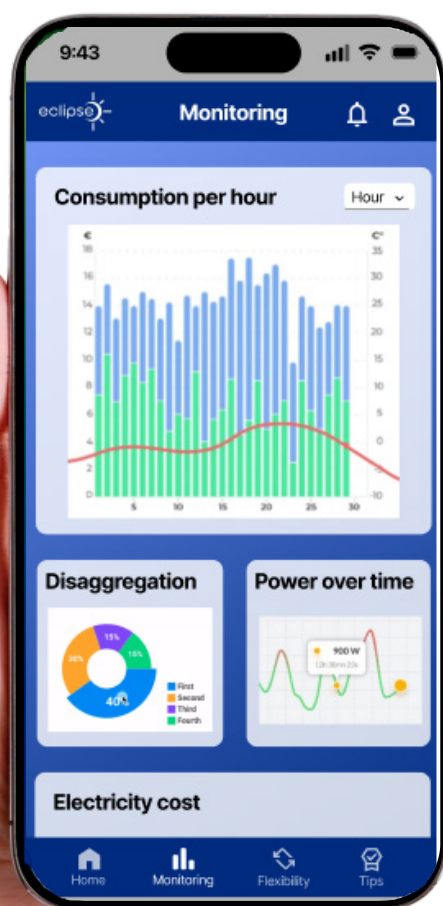
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A Functional Blueprint for One Europe.

Following the identification of consumer requirements and use cases, ECLIPSE DIGITAL Project's WP3 has delivered the technical foundations of the project. We have moved from vision to specification by defining a functional and replicable blueprint for the Common European Reference Framework (CERF). This isn't just a design; it is a roadmap that facilitates the implementation of future energy-saving applications while ensuring they are perfectly synchronized with their environment.

The CERF acts as the "connective tissue" of the European energy market. By consolidating architecture, data exchanges, and standards, we are building a framework that allows diverse systems, from smart meters in Poland to flexibility markets in Portugal, to communicate seamlessly.



The WP3 Mission

While WP2 defined what the users need, WP3 defines how the technology delivers it. Our goal is to provide a standardized digital environment where data flows securely, ensuring that no citizen or technology provider is locked into a proprietary silo



*"ECLIPSE DIGITAL Project doesn't just exchange data; it establishes a trusted fabric for the European energy market. By supporting accountability, certification, and automated trust within a federated environment, we are laying the **foundation for a resilient energy transition where every citizen can participate with total confidence**".*



Structured for Success: The Multi-Layered Architecture.

To manage the inherent complexity of Europe's power grids, ECLIPSE DIGITAL Project does not rely on a single technical solution but on a sophisticated, **multi-dimensional architectural framework**. The Common European Reference Framework (CERF) is structured using the Smart Energy Grid Architecture Model (SGAM), which allows us to map every interaction across five distinct interoperability layers: Business, Function, Information, Communication, and Component.

This methodology ensures that our digital solutions are not only technically sound but also **aligned with European economic policies and regulatory requirements**.

The Hourglass Model: Stability Amidst Innovation

The Hourglass Model [1] is a conceptual framework for interoperability that structures digital ecosystems around a narrow waist of common, standardized interfaces and data models. In the model, the CERF ecosystem is distributed in a top, bottom and a "narrow waist" of shared interfaces and data models. The narrow waist links applications (upper layers) to heterogeneous infrastructures such IoT devices (lower layers) and providing an integrated architectural approach aligned with stakeholder concerns.

The CERF identified components in the "narrow waist" of this hourglass, highlights where the core set of standardized interfaces and data models should remain stable.

This design ensures that as technologies or apps change, the central framework continues to facilitate seamless cross-domain communication without requiring expensive system overhauls.



Did you know?

The ECLIPSE DIGITAL Project's architecture is "*future-proofed*" through the Data Exchange Reference Architecture (DERA). This mapping ensures the project aligns with the emerging Common European Energy Data Space, supporting data sovereignty and transparency across the entire EU.

[1] <https://ceisphere.eu/hourglass-model>

The Same Language: Interoperability & Connectors

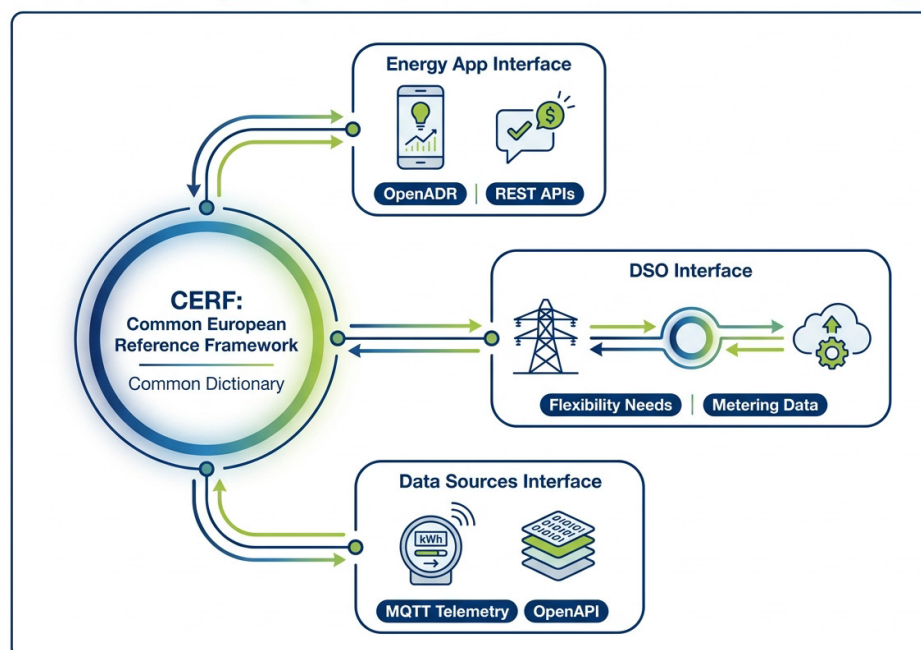
Interoperability, the ability of diverse digital systems to communicate and exchange data without friction, is the fundamental cornerstone of the Common European Reference Framework (CERF) architecture.

To bridge the gap between heterogeneous energy actors, WP3 has established specific Interoperability Profiles for three critical connection points.

These profiles act as a common dictionary, defining the transport, syntactic, and semantic rules that ensure interoperable communications across the entire European energy value chain:

- **The Energy App Interface:** This profile delivers personalized saving recommendations and market signals directly to the citizen. By combining OpenADR for standardized demand-response signaling with REST-style APIs, we ensure that energy apps can be easily integrated into modern mobile and web environments. This allows for the secure exchange of user profiles, consent tokens, and real-time alerts.
- **The DSO Interface:** Acting as a central hub, this interface links grid operators with flexibility aggregators and market actors. It facilitates the exchange of flexibility needs, grid constraints, and validated metering data through standardized protocols like OpenADR and REST APIs, ensuring that grid stability services respect established regulatory policies
- **The Data Sources Interface:** To provide a "ground truth" for billing and analytics, this interface harmonizes measurements from smart meters and historical data hubs. It utilizes lightweight technologies like MQTT for scalable, near-real-time telemetry and OpenAPI/REST for structured data access, ensuring that information flows efficiently from home appliances to high-level platforms.

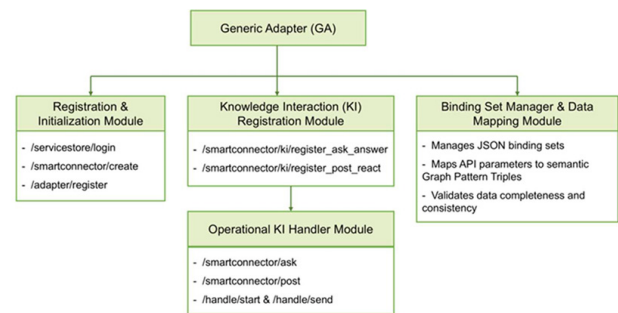
European Energy Project Architecture



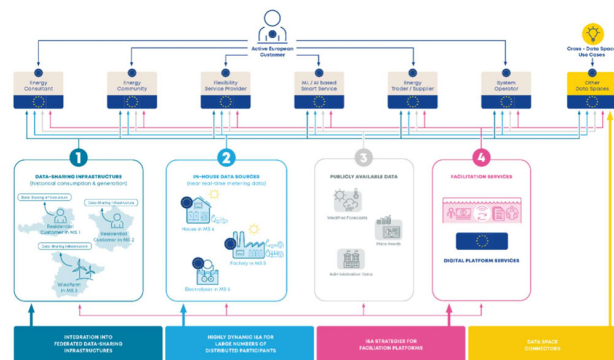
The ECLIPSE DIGITAL Reusable Connectors

To accelerate the deployment of these services, ECLIPSE DIGITAL identifies and adopts three powerful open-source software foundations that serve as reusable "connectors," allowing existing systems to integrate into the CERF with minimal cost.

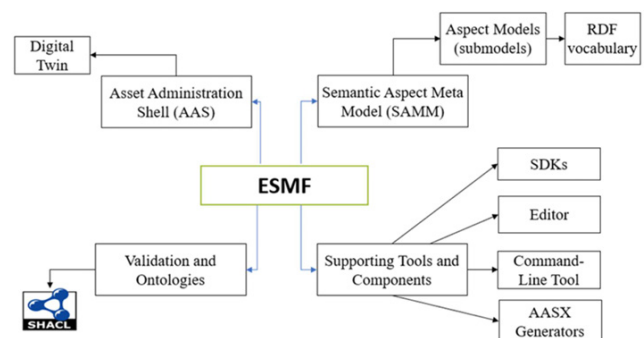
1.Generic Adapter (GA): Developed in the InterConnect project [2], the GA acts as a bridge for legacy devices and APIs that do not natively support semantic interoperability. It uses Service-Specific Adapters (SSAs) and "Knowledge Interactions" to transform traditional data calls into structured graph pattern triples that can be queried using SPARQL.



2.EDDIE Connector: Originating from the OneNet [3] and EDDIE [4] projects, this connector standardizes large-scale energy data flows by aligning them with the Common Information Model (CIM). It includes the AIIDA interface, which provides secure, consent-based access to in-house data from IoT devices and submeters for real-time flexibility services.



3.Semantic Modelling Framework (ESMF): Provided by the Eclipse Foundation [5], the ESMF specializes in the creation of Digital Twins. By using the Semantic Aspect Meta Model (SAMM), it creates virtual representations of physical energy assets, automating the generation of APIs and documentation so developers can build interoperable apps more rapidly.



The Power of Standards

ECLIPSE DIGITAL Project leverages mature global standards to ensure that the digital energy transition is truly borderless. By utilizing CIM (Common Information Model) for grid assets and utility data, and the ETSI SAREF ontology for smart appliances and energy IoT, the project ensures that a flexibility request generated in one country is interpreted identically by a smart device in another. This strategic alignment eliminates proprietary silos and fosters a unified, resilient, and consumer-centric European energy space.

[2] <https://interconnectproject.eu/>

[3] <https://onenet-project.eu/>

[4] <https://eddie.energy/>

[5] <https://www.eclipse.org/>

A Fabric of Trust: Cybersecurity & Data Protection.

In a decentralized digital energy ecosystem, trust is the most valuable currency. As we move toward real-time grid interaction, ensuring that data is both accurate and protected is paramount. To address this, Work Package 3 has established a rigorous Specific Data Protection Analysis (D3.2), implementing the Cross-cutting Characteristic Plan (X-CCP). This framework provides a deep understanding of security and privacy principles, ensuring that the CERF ecosystem is resistant against modern digital threats while remaining fully compliant with European regulations like GDPR and the Data Governance Act.



ECLIPSE PROJECT: SECURE EUROPEAN ENERGY INFRASTRUCTURE

Proactive Cybersecurity & Risk Mitigation

ECLIPSE DIGITAL adopts a proactive stance toward cybersecurity by conducting exhaustive threat analyses across all project use cases. Our framework is specifically designed to reduce critical risks, such as the propagation of falsified meter readings that could lead to incorrect grid predictions, or the injection of tampered market prices that might result in biased advice for consumers. By identifying these vulnerabilities early through the X-CCP, we implement mitigation strategies that prevent adverse grid effects and protect the financial interests of every participant.

Privacy-by-Design & Data Sovereignty

Privacy is not an afterthought in ECLIPSE DIGITAL; it is embedded into the system's architecture from its inception. We follow a Privacy-by-Design approach that prioritizes data minimization, ensuring that only the essential information required for grid stability and billing is collected. Through configurable techniques such as anonymization and pseudonymization, the CERF ensures that sensitive household consumption patterns are never exposed to unauthorized parties. Central to this pillar is the concept of data sovereignty, where users are actively involved in the authorization process, maintaining the absolute right to grant, revoke, or terminate data permissions at any time.

Building a Secure Infrastructure

The technical backbone of the CERF relies on a "defense-in-depth" strategy to protect data integrity and confidentiality. ECLIPSE DIGITAL utilizes the latest industry-standard encryption protocols, such as TLS 1.3, to secure every communication channel within the network. To manage access, we implement scoped access management via OAuth 2.0, ensuring that both users and service providers can only interact with the specific data sets they are entitled to. This secure infrastructure prevents unauthorized access and shields the system against Distributed Denial of Service (DDoS) attacks, creating a stable environment for the next generation of energy services.



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