SAREF4ENER tutorial

Hedge-IoT WP4 Semantic Interoperability

8 April 2025

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TNO innovation for life

Outline

- Introduction to SAREF4ENER
  - What is the history
  - Which standards are being reused
  - Use cases
- Main concepts
- Diagrams and example devices
- References and further reading

What is SAREF4ENER?

Smart Applications REFerence ontology: extension for the ENERgy domain

An extension of SAREF focused on energy flexibility to optimize energy consumption and production based on device characteristics, grid signals and customer configurations

An **open standard** developed, maintained and evolved by ETSI (European Telecommunications Standards Institute) at https://saref.etsi.org/

Why SAREF4ENER

1

Interoperability: Enhances effective communication of energy management systems and smart devices, facilitating integration across various protocols and standards

2

Energy Flexibility: Enables higher efficiency of energy consumption and production, maximizing the use of locally produced energy, reducing load on the grid

3

Sustainability: Creates awareness of energy usage, promotes sustainable energy practices

4

Standardization: Embedded in a standardized framework and adopted as basis for EU Code of Conduct for Energy Smart Appliances manufacturers

Development of SAREF4ENER

- Based on CENELEC standards:
  - EN 50631 (also called “SPINE”)
  - EN 50491-12-2 (also called “S2”)
- Developed in collaboration with:
  - EEBUS (http://www.eebus.org/)
  - Energy@Home
  - S2 Consortium (https://s2standard.org/)
  - KNX (https://www.knx.org/)
  - H2020 Interconnect project (https://interconnectproject.eu/)

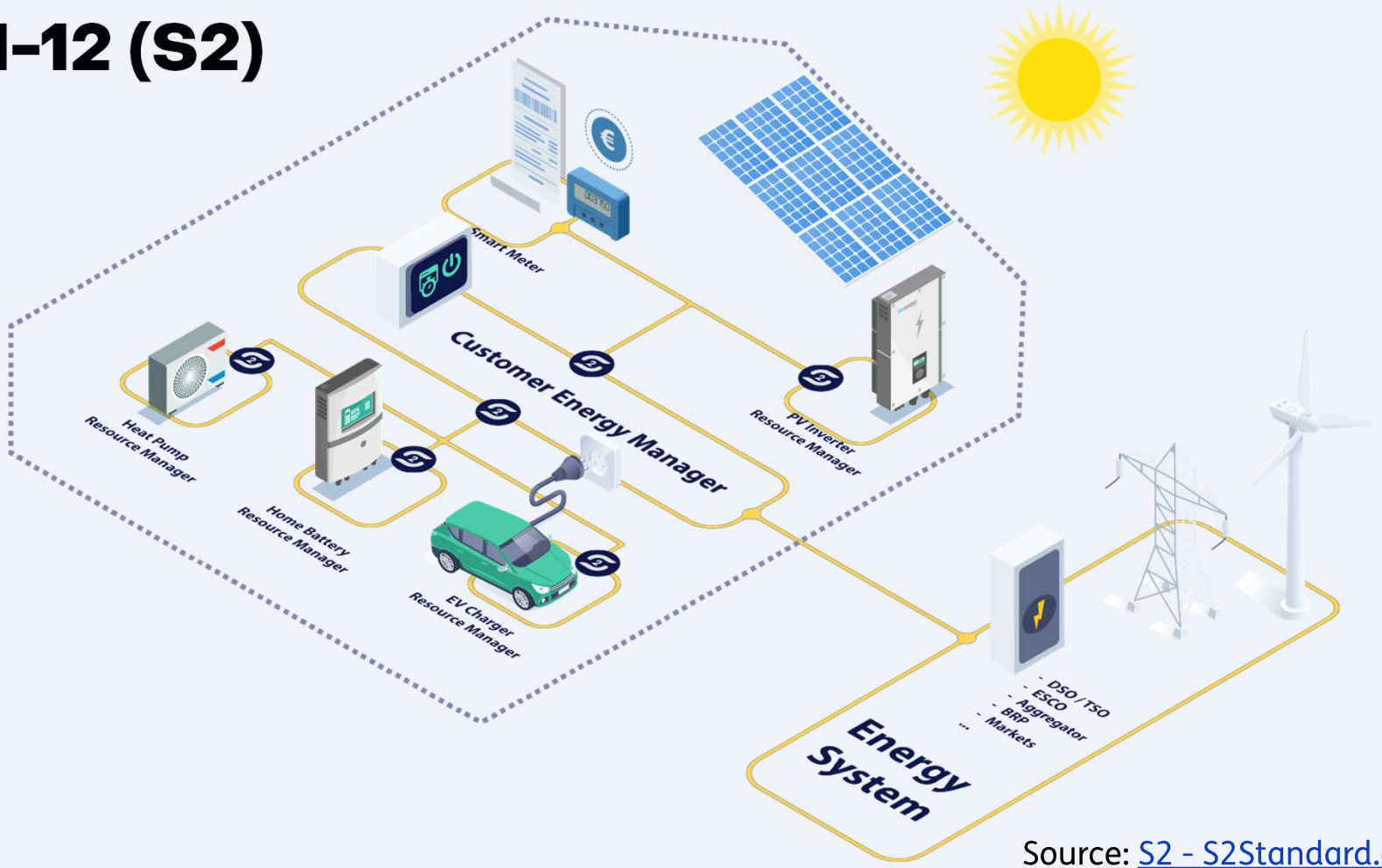
EN 50631 (SPINE)

- EN 50631 “Household Appliances Network and Grid Connectivity”
- Developed by CLC/TC 59X on "Performance of household and similar electrical appliances“
- Defines the information exchange between smart appliances and management systems in homes and buildings including energy management
- Based on mappings to the SPINE language and protocol (therefore often referred to directly as “SPINE”)
- The SPINE specification used in EN 50631 is available free of charge at https://www.eebus.org/media-downloads/

EN 50491-12-2 (S2)

- EN 50491-12-2 “General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) - Part 12-2: Smart grid – Application specification - Interface and framework for customer - Interface between the Home/Building CEM and Resource manager(s) - Data model and messaging”
- Developed by CLC/TC 205 on “Home and Building Electronic Systems (HBES)”
- Defines the information exchange of energy flexibility between energy management systems (EMS) and energy equipment in buildings
- Specifies the S2 interface as defined in the European Smart Grid Architecture developed in Mandate 490 of the EC(therefore often referred to directly as “S2”)
- Additional information is available a https://s2standard.org/, including a white paper and an S2 implementation in JSON

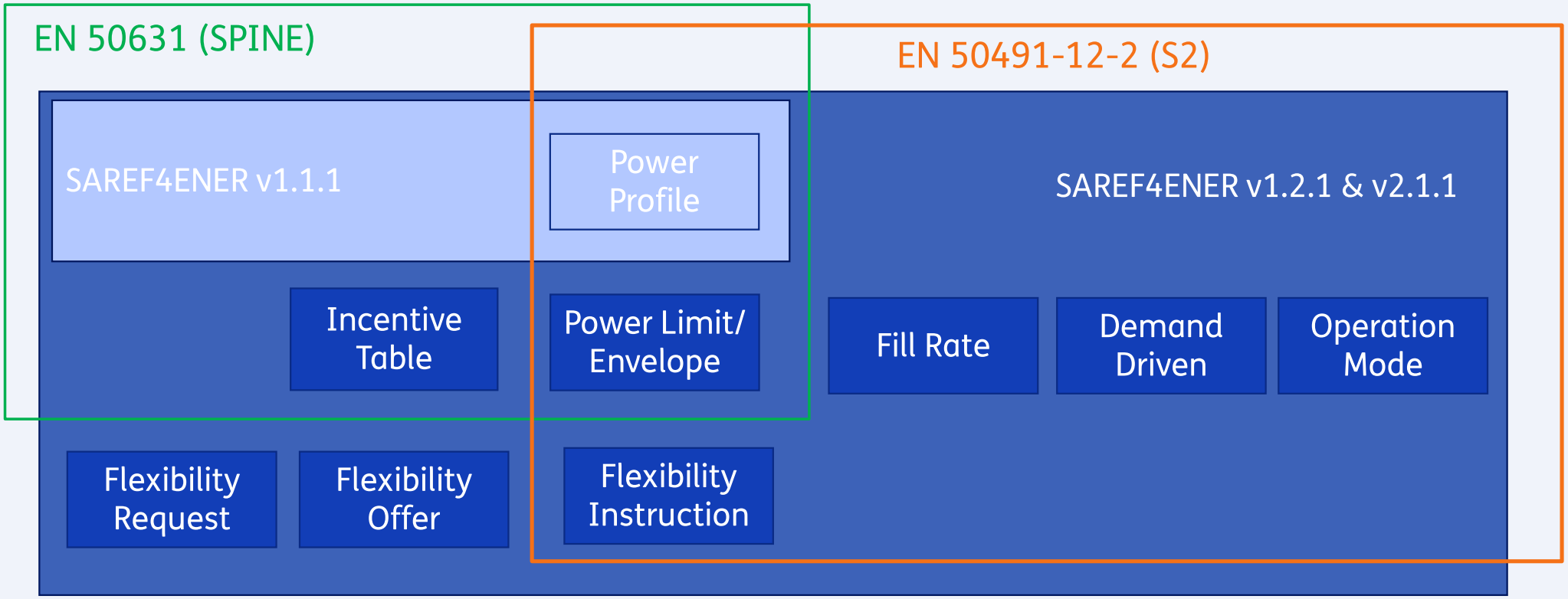
EN 50491-12 (S2)



Source: S2 - S2Standard.org

SAREF4ENER versions

Current version: SAREF4ENER v2.1.1 (October 2024) is based on SAREF core V4.1.1
https://www.etsi.org/deliver/etsi_ts/103400_103499/10341001/02.01.01_60/ts_10341001v020101p.pdf



SAREF4ENER

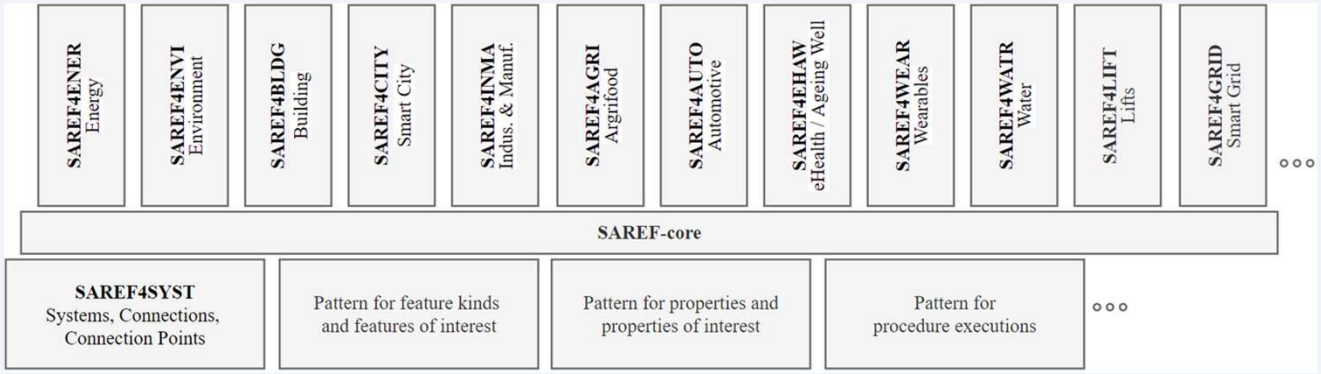
Use cases

Which use cases do you recognise for your pilot?

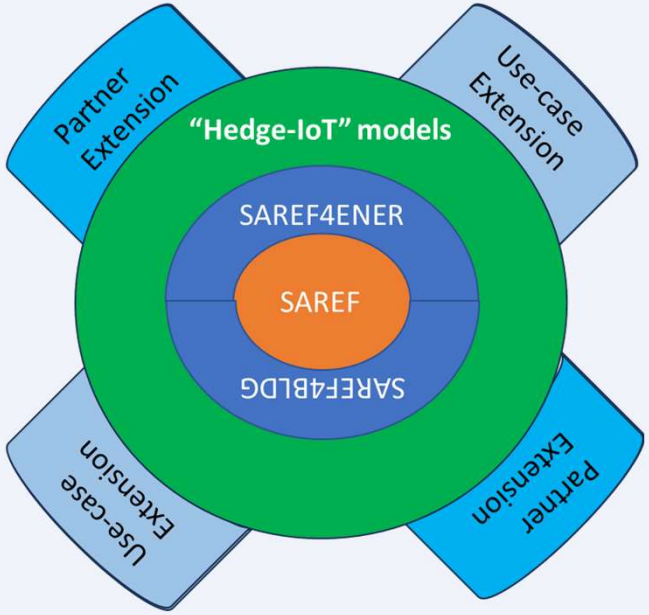
- **Flexible Start of Smart Appliances**
  - Reschedule appliances to optimize energy efficiency and accommodate user preferences. Users select preferred intervals; energy managers compute optimal start times.
- **Monitoring and Control**
  - Track start, status, and power consumption of all appliances, including non-smart devices.
- **Reaction to Smart Grid Requests**
  - Respond to incentives for adjusting energy use based on availability or emergency situations.
- **Limitation of Power Consumption**
  - Implement power limits set by energy managers, manufacturers (fail-safe), and contractual agreements
- **Incentives**
  - Negotiate energy usage incentives between consumers and energy management systems
- **Energy Flexibility Capabilities**
  - Describe energy flexibility of devices (e.g., PV systems, EV chargers, batteries, heat pumps) to optimize energy use without impacting user comfort
  - Network flexibility that can be used by network operators (DSO) to manage the electricity grids more efficiently to provide additional revenue stream to the consumers

SAREF framework

- Modular framework that comprises a generic **core ontology** for IoT and 12 **domain-specific extensions**, including SAREF for Energy



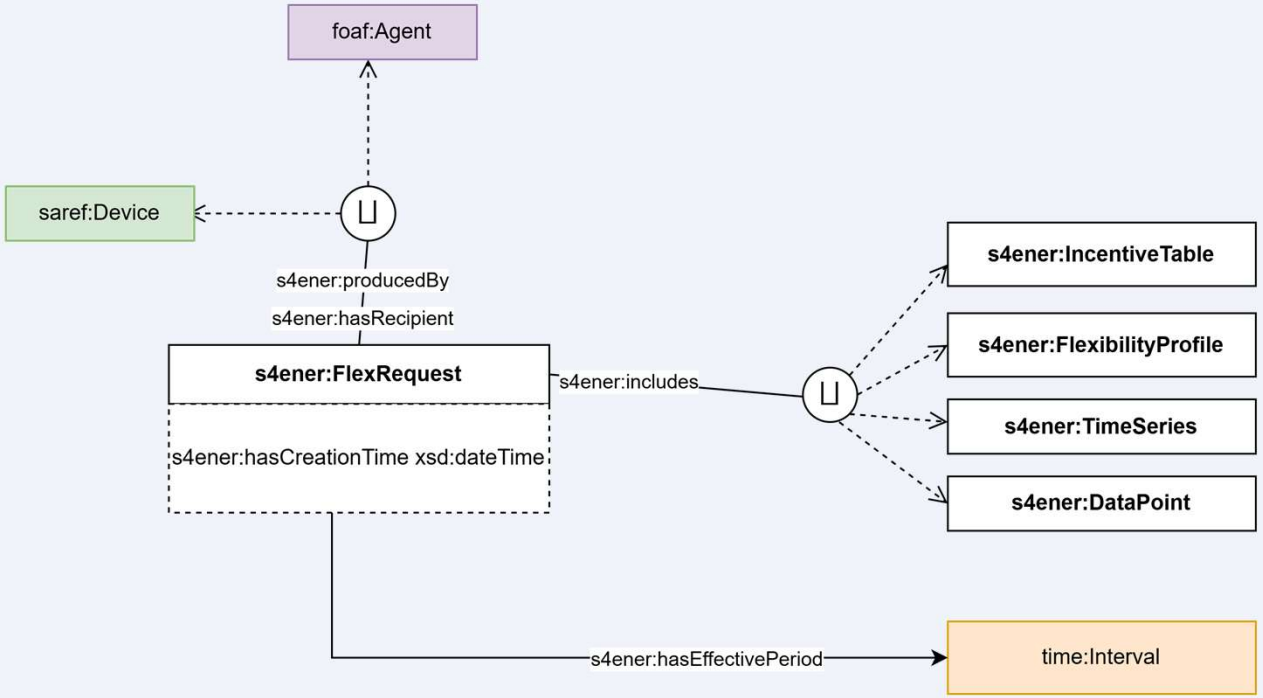
- Extensible framework to accommodate requirements from new use cases and changes in various domains.
  - Different governance and standardization decisions can be made per extension and on the Hedge-IoT models.



SAREF4ENER

Flexibility Communication

Flexibility Request | Flexibility Offer | Flexibility Instruction



SAREF4ENER

Flexibility Communication

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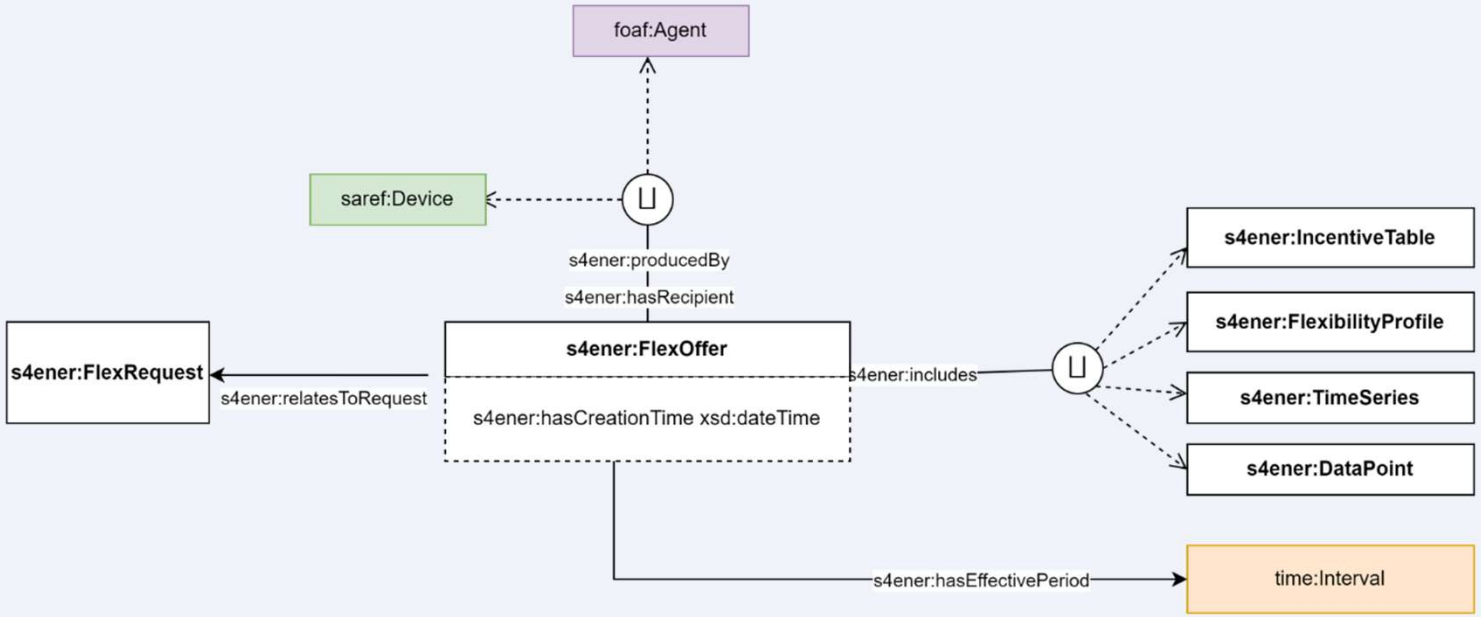

SAREF4ENER

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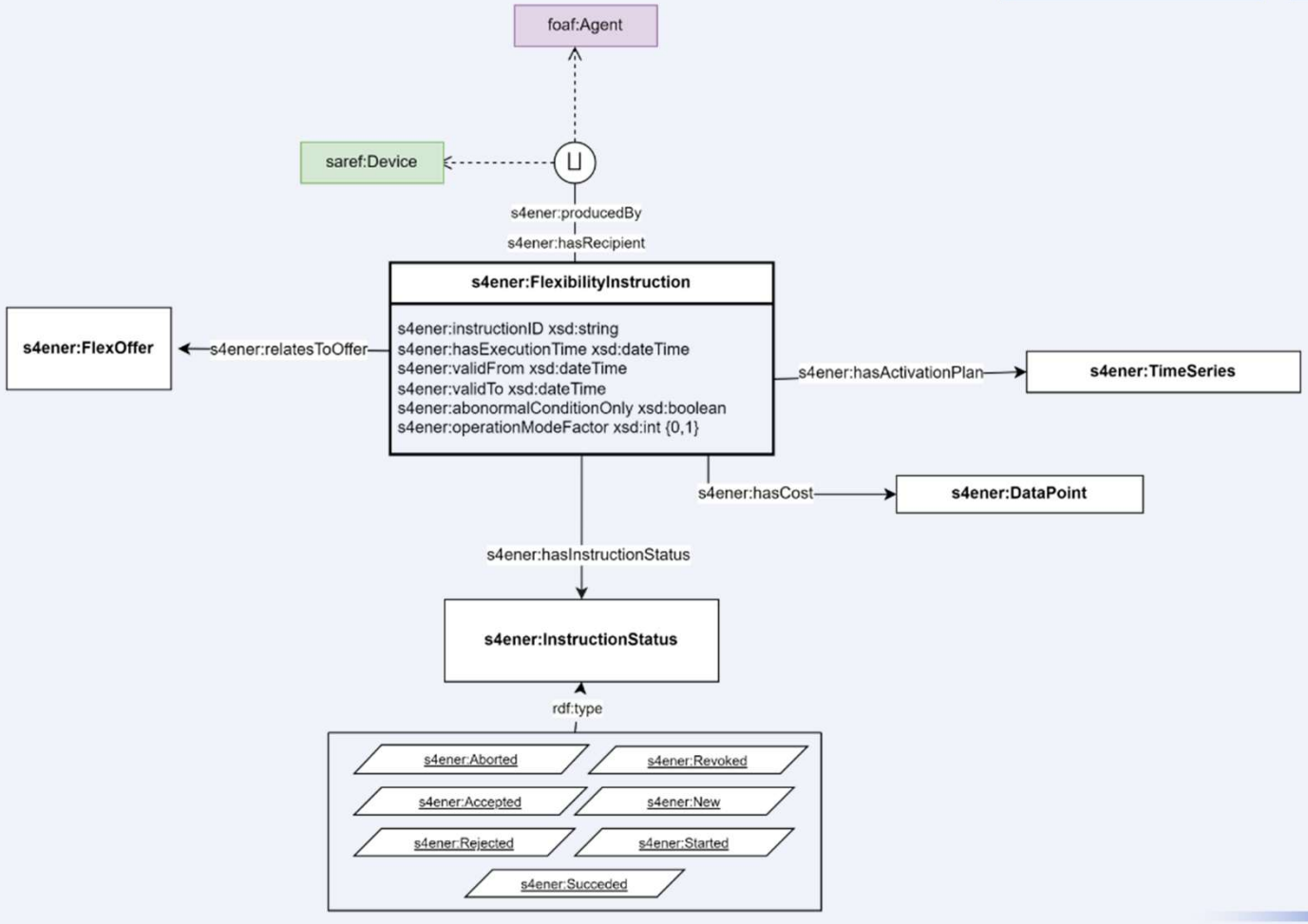
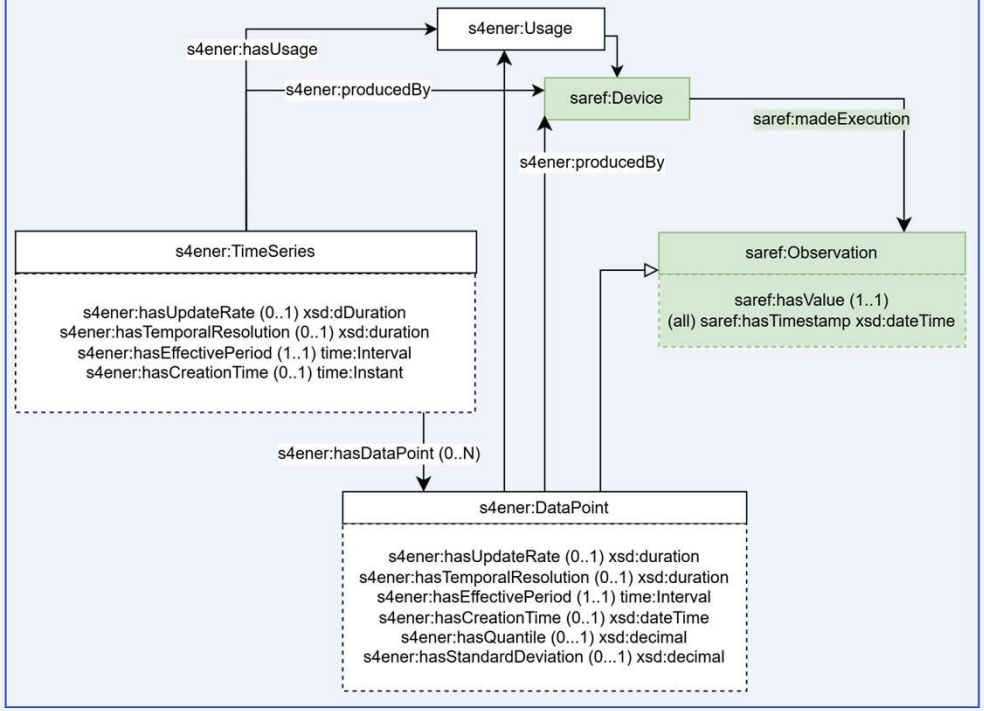
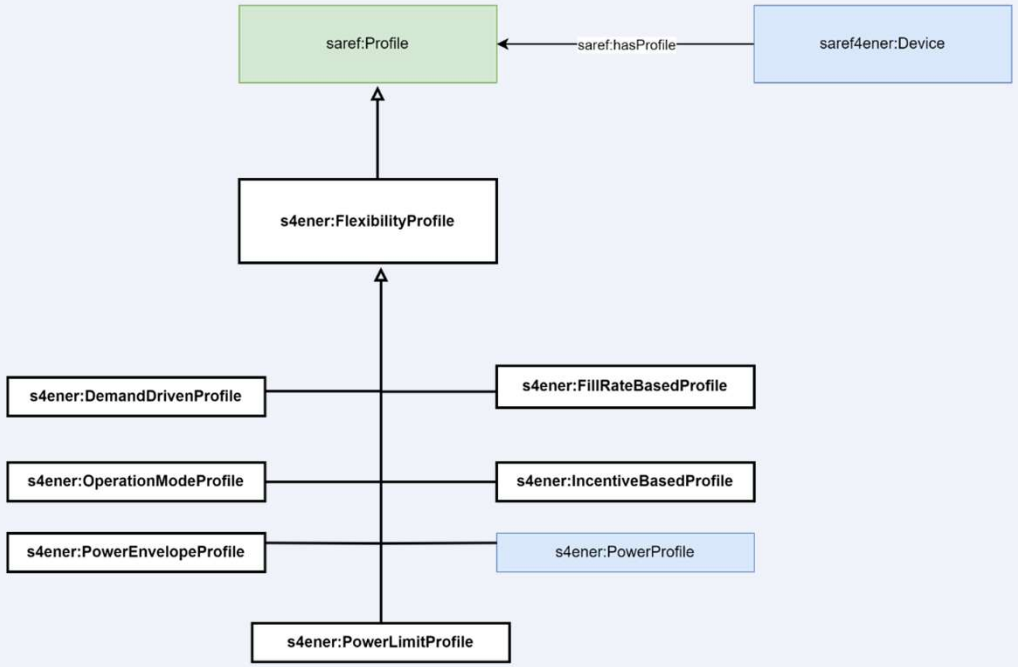


SAREF4ENER main concepts

- Time Series



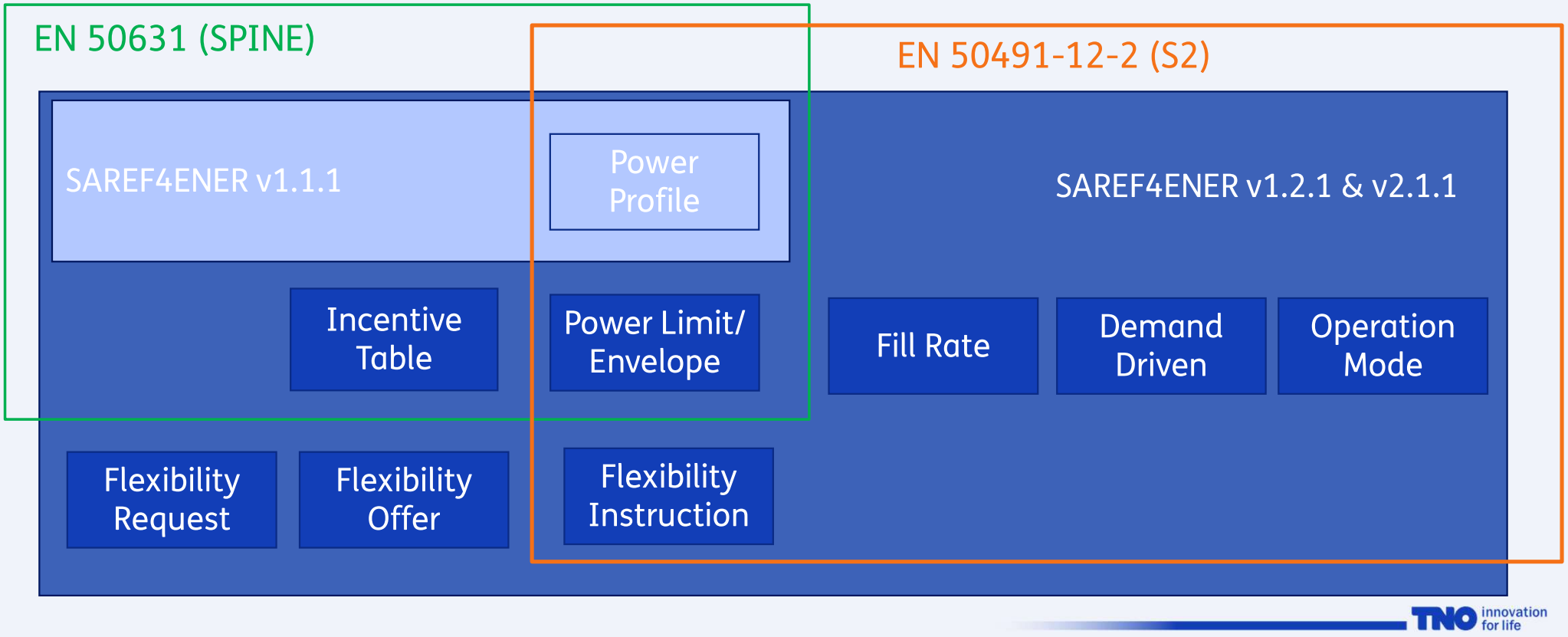
- Flexibility profiles



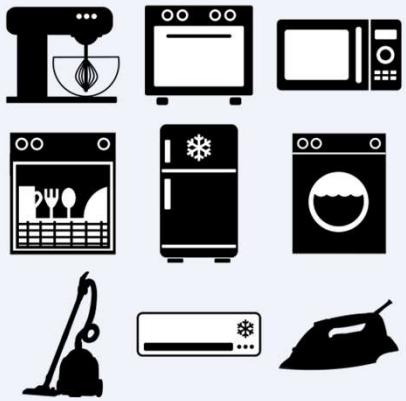
SAREF4ENER versions

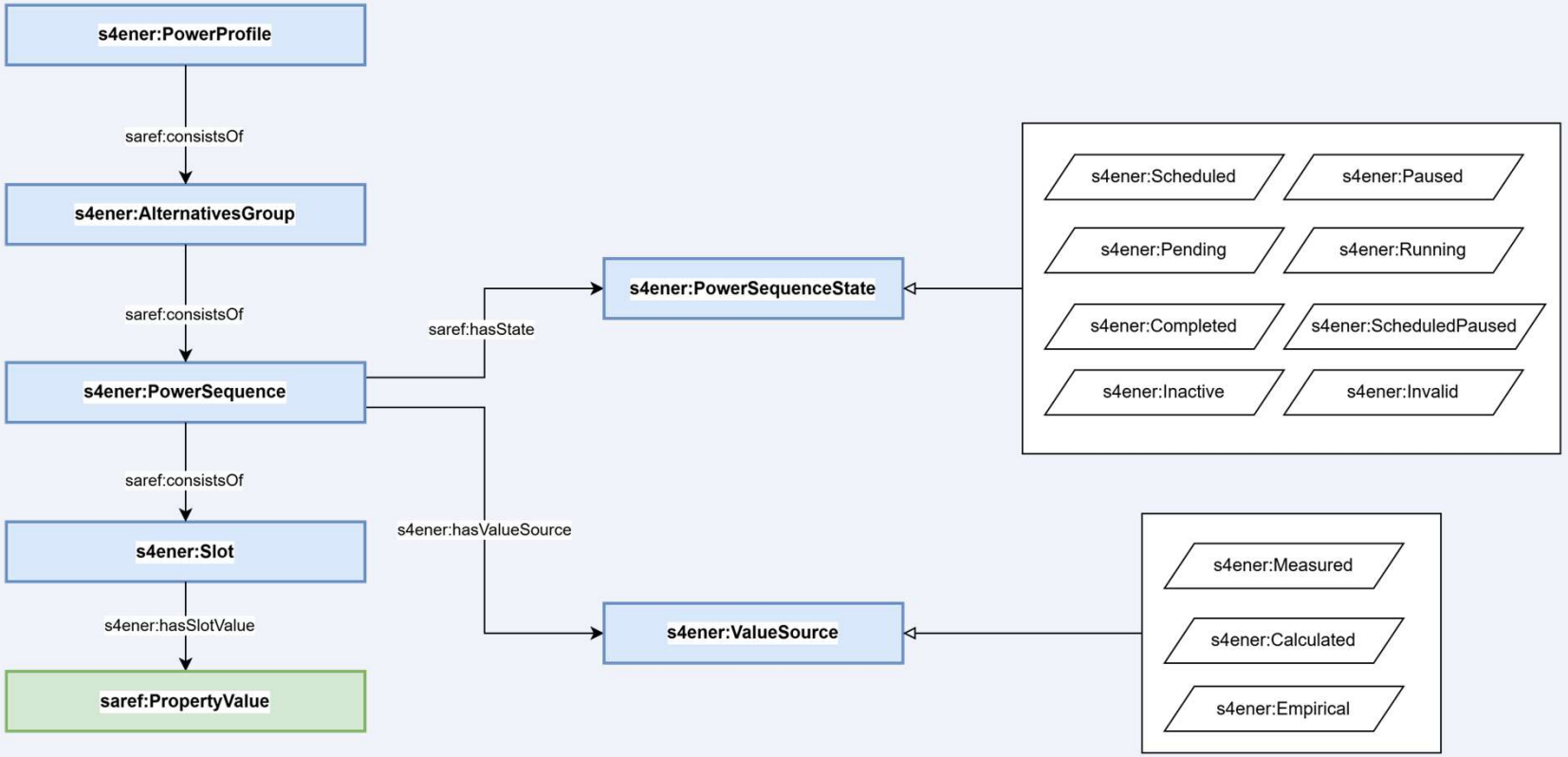
Which types of flexibility could your network, devices, or systems provide?

Current version: SAREF4ENER v2.1.1 (October 2024) is based on SA[illegible]e V4.1.1
https://www.etsi.org/deliver/etsi_ts/103400_103499/10341001/[illegible].01_60/ts_10341001v020101p.pdf



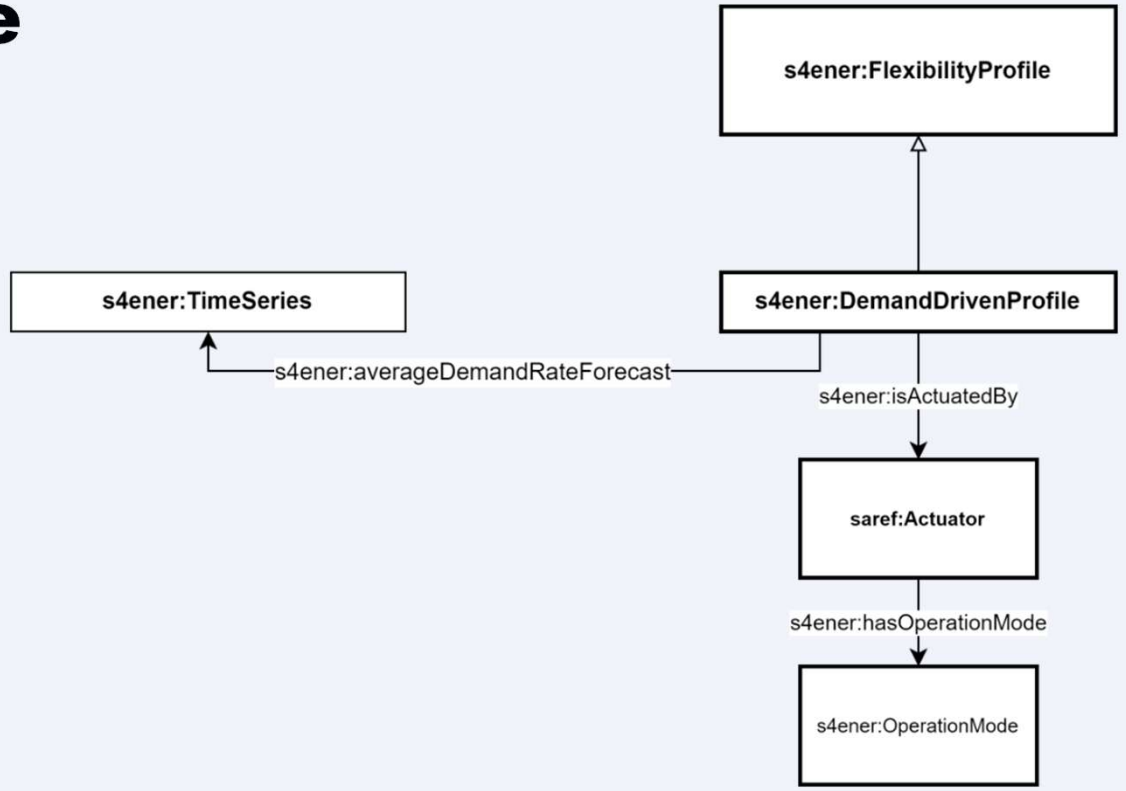
PowerProfile





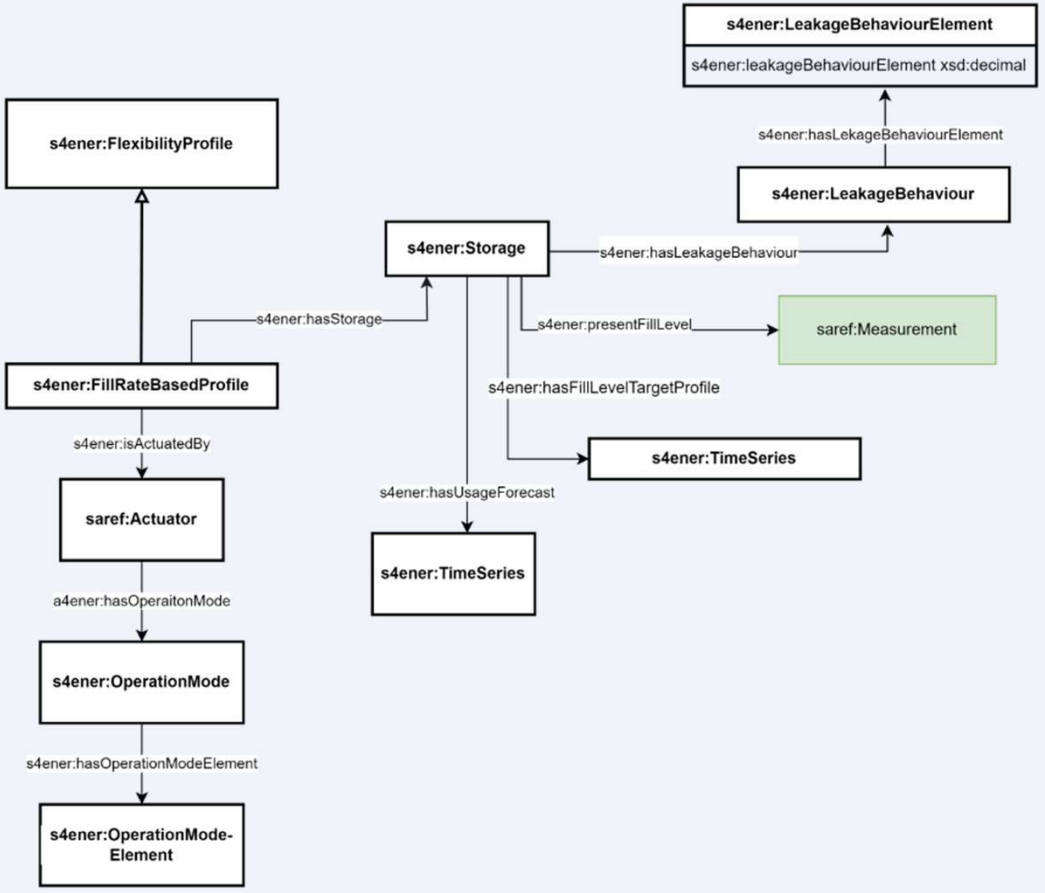
Example triples:
[examples/powerProfileExample.ttl · develop-v2.1.1 · SAREF / saref4ener · GitLab]

Demand Driven Profile



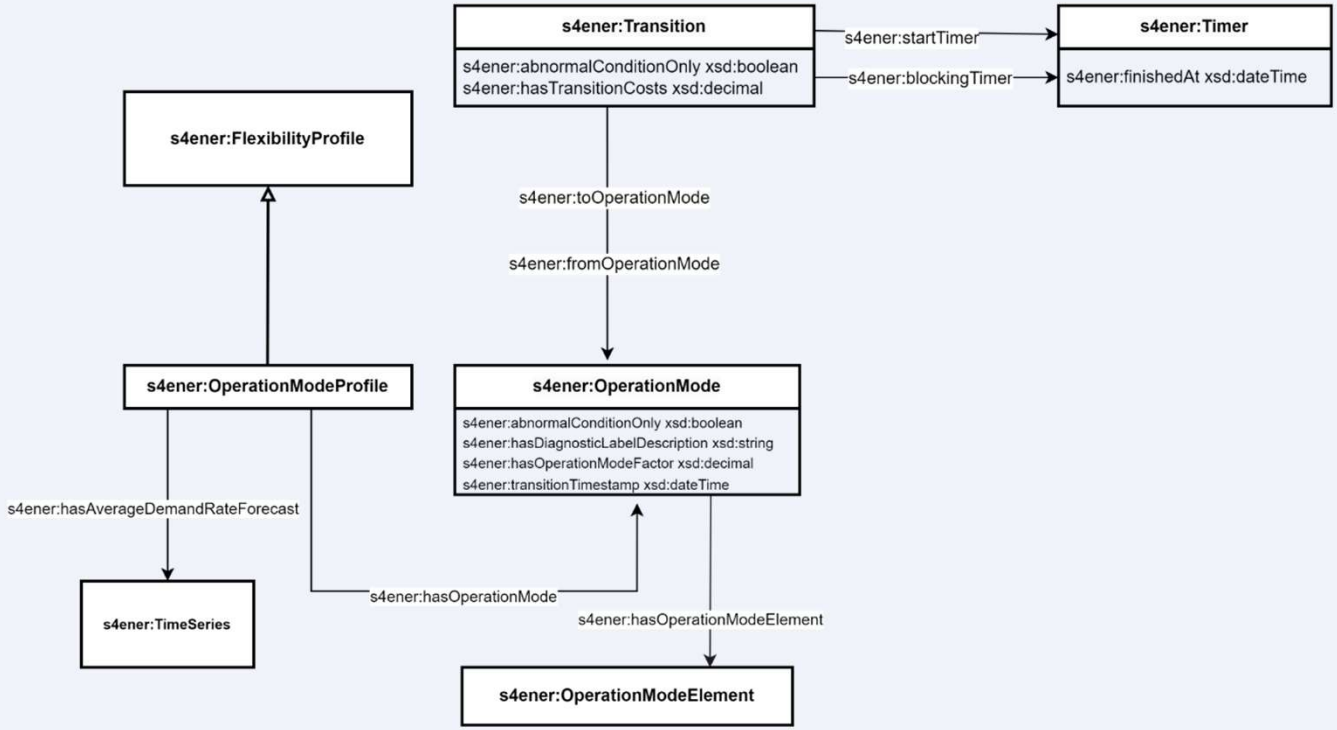
Example triples:
[examples/demandDrivenProfile.ttl · develop-v1.2.1 · SAREF / saref4ener · GitLab (etsi.org)]

Fill Rate Based Profile



Example triples:
[examples/fillRateProfile.ttl · develop-v1.2.1 · SAREF / saref4ener · GitLab (etsi.org)]

Operation Mode Profile

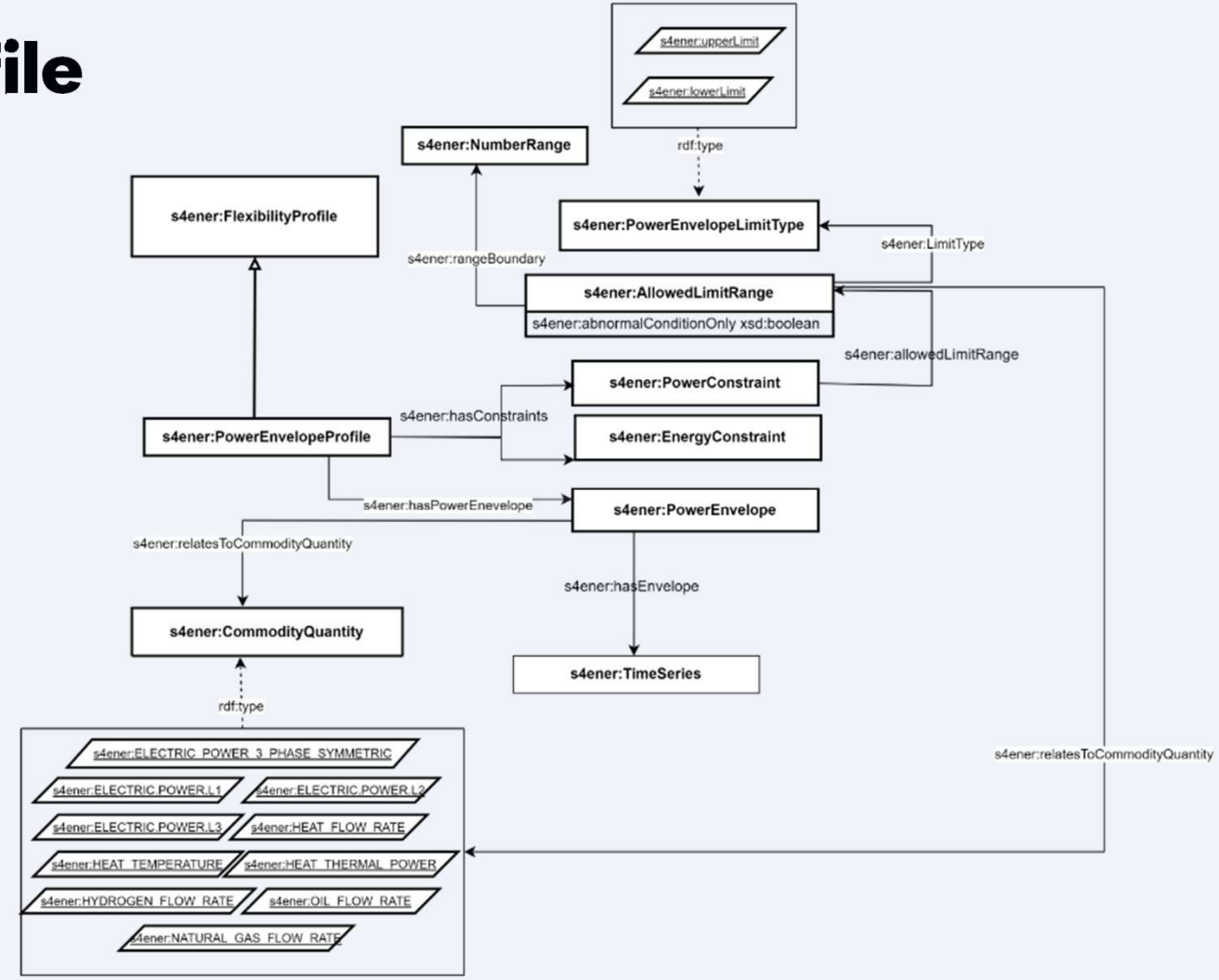


Example triples:
[examples/operationModeProfile.ttl · develop-v1.2.1 · SAREF / saref4ener · GitLab (etsi.org)]

SAREF4ENER

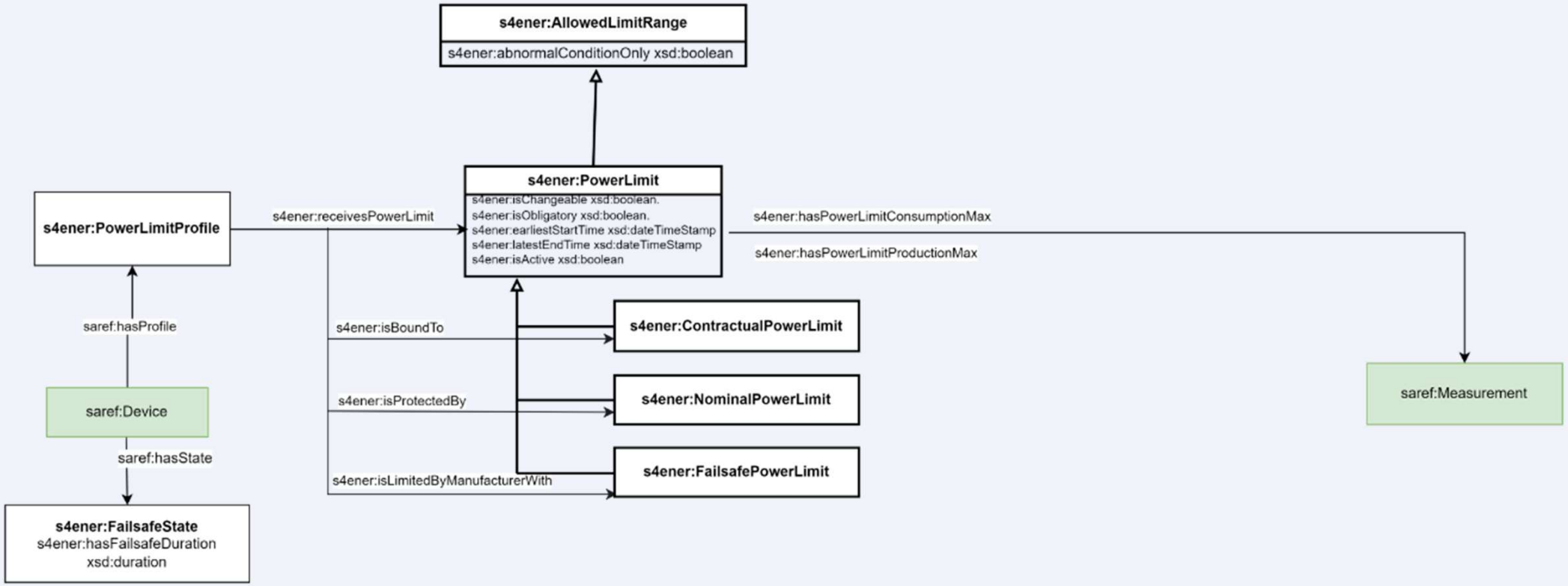
Power Envelope Profile

Example triples:
[examples/powerEnvelopeProfile.ttl · develop-v1.2.1 · SAREF / saref4ener · GitLab (etsi.org)]

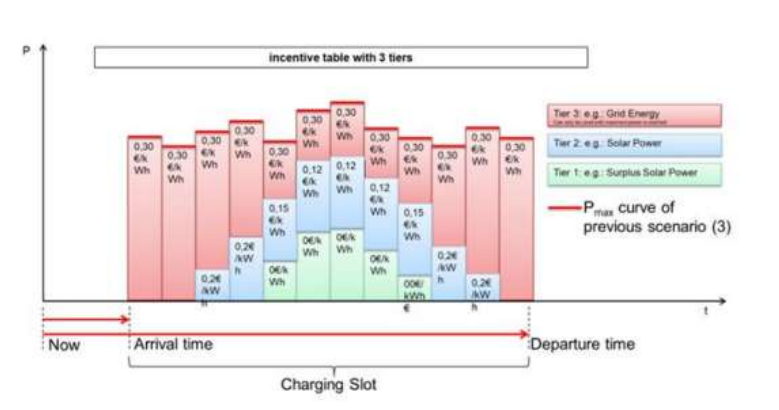


SAREF4ENER

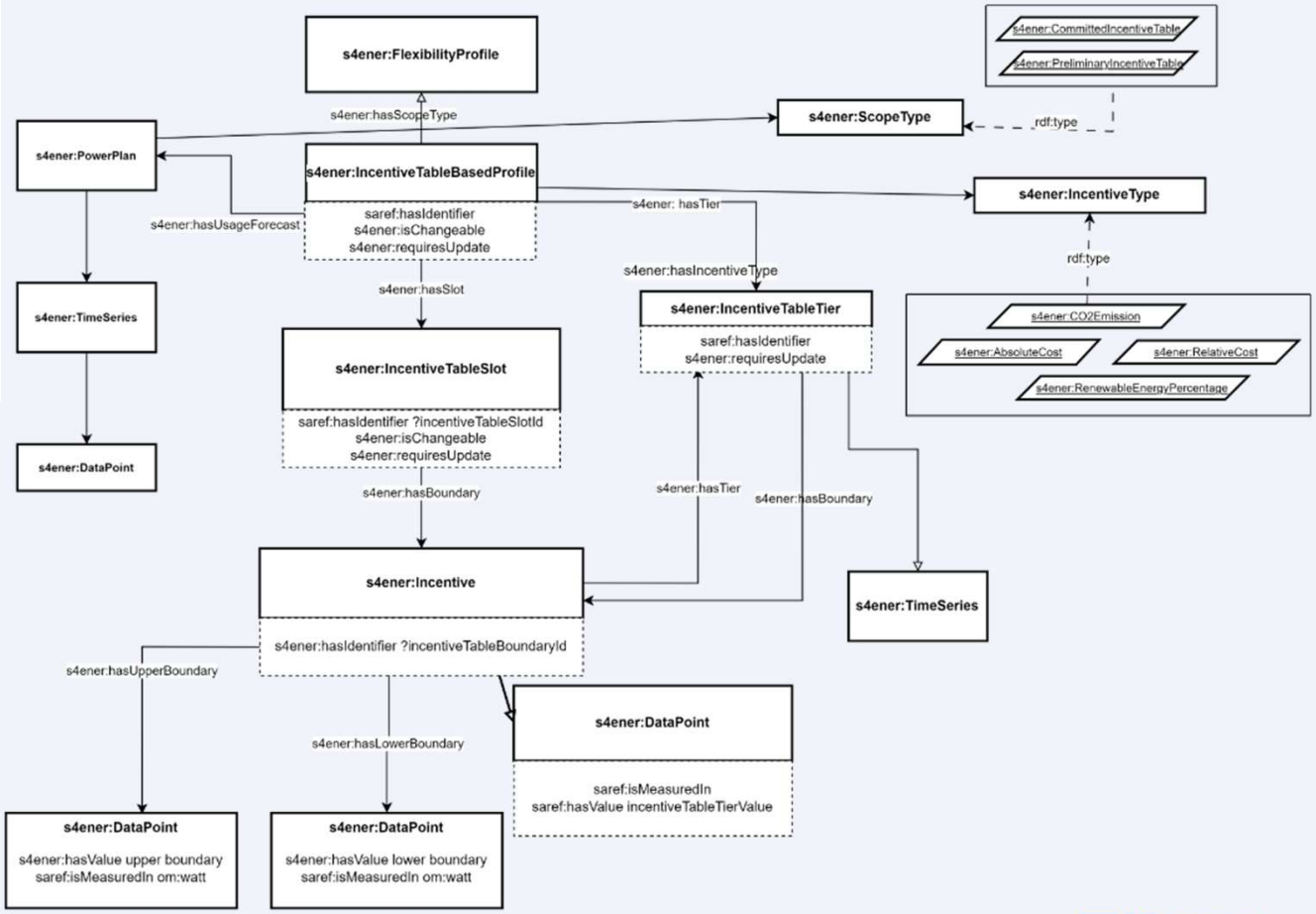
Power Limit Profile



Incentive Table Based Profile



Source: EEBUS Overview Use Cases (see slide 25)

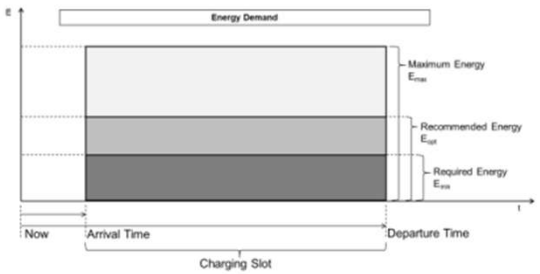


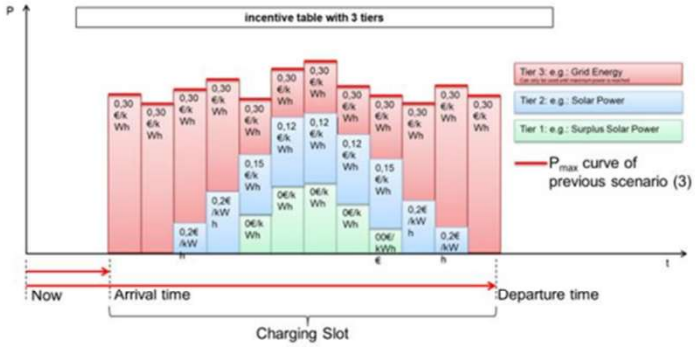
Example triples:
examples/incentiveTable.ttl · develop-v1.2.1 · SAREF / saref4ener · GitLab (etsi.org)

E-MOBILITY USE CASES (2)

Details Coordinated EV Charging

EV sends departure time, minimum/ target/maximum energy demand



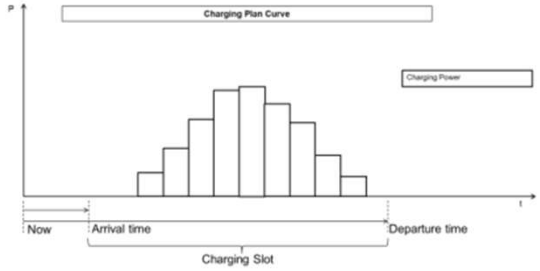


EMS sends incentive table / maximum power curve

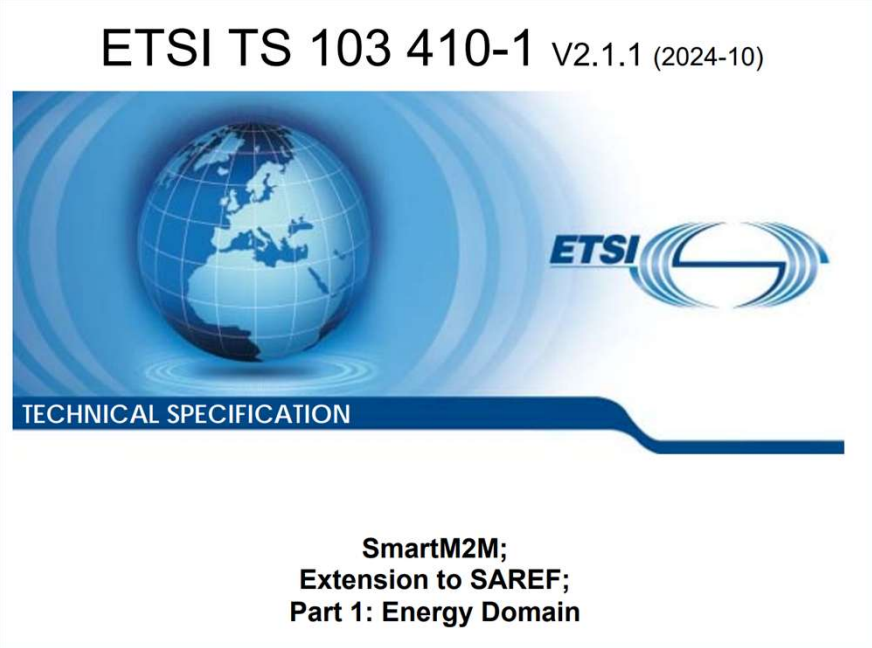
EMS

0-12 ct

EV provides charging plan



SAREF4ENER

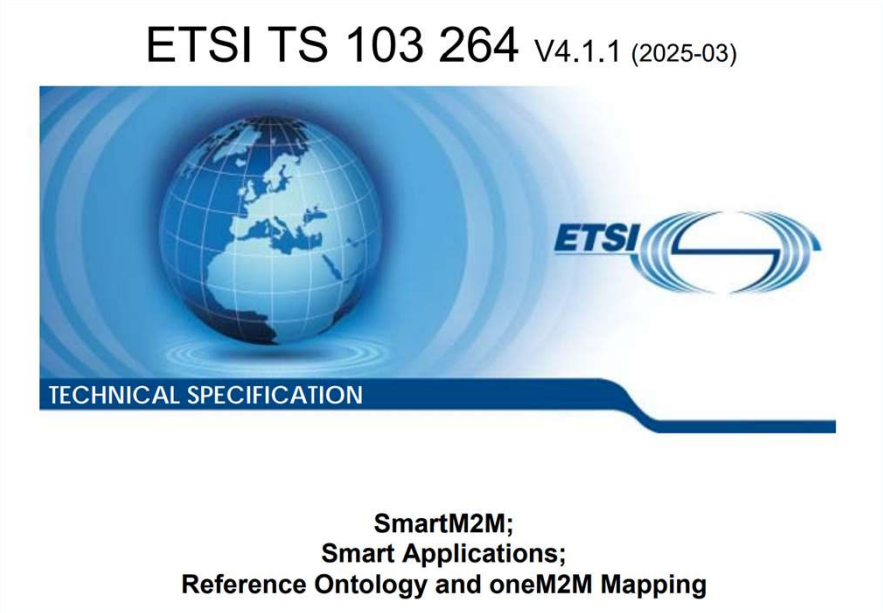


- **Technical Specification**
- ETSI TS 103 410 series
- Part 1: Energy Domain

- Disclaimer: https://saref.etsi.org/saref4ener/ still shows v1.2.1, but will be updated.

https://www.etsi.org/deliver/etsi_ts/103400_103499/10341001/02.01.01_60/ts_10341001v020101p.pdf

Normative Reference: SAREF core

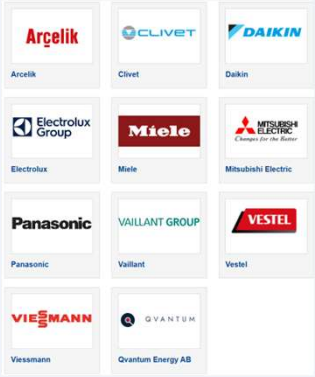


- **Technical Specification**
- ETSI TS 103 264
- Smart Applications Reference Ontology

https://www.etsi.org/deliver/etsi_ts/103200_103299/103264/04.01.01_60/ts_103264v040101p.pdf

Further reading

- **EU Code of Conduct for Energy Smart Appliances**
- A voluntary initiative aimed at ensuring interoperability of energy smart appliances
- Developed by Joint Research Centre (JRC) and DG ENER (Directorate-General for Energy)
- Examples: Washing machines, dishwashers, heat pumps, electric vehicle chargers



4. Commitment

Signatories of this Code of Conduct agree to make all reasonable efforts to:

a) Ensure that at least one model[2] of ESA available in the Union market implements the applicable use cases for the specific ESA according to Annex 1 and Annex 2 as of one year after the official launch of the first version of the Code of Conduct.

b) Ensure the implementation of interoperability profiles based on standardised open Application Programming Interface / open communication protocol to enable the information exchange for the applicable use cases (see point a).

c) Apply state of the art and open security mechanisms for the open communication protocol used (see point b) to: (1) secure the communication, (2) support the installation, administration and configuration (including the assignment of the system roles), (3) ensure proper authorisation for accessing the ESA, and (4) provide the control over the usage of private data, in accordance with the relevant EU legislation in force.

d) Ensure that all relevant information elements used in the implemented use cases (see point a) as well as in the open protocol (see point b) have a corresponding SAREF representation, fully compliant with the SAREF framework of ontologies according to the technical specification ETSI TS 103 264 (SAREF core) and ETSI TS 103 410 series (SAREF extensions) (see Annex 2).

e) Provide end-users with information on the use cases, including the conditions needed to use them, how to activate them and the benefits.

f) Cooperate with the European Commission and Member States authorities in an annual review of the Code of Conduct.

g) Indicate the compliance with the Code of Conduct when registering new ESA models in the EPREL database.

The implementation of the capabilities of Energy Smart Appliances can be realized in one of the following ways:

a. Physically in the ESA;

b. Represented as digital twin in the manufacturer cloud;

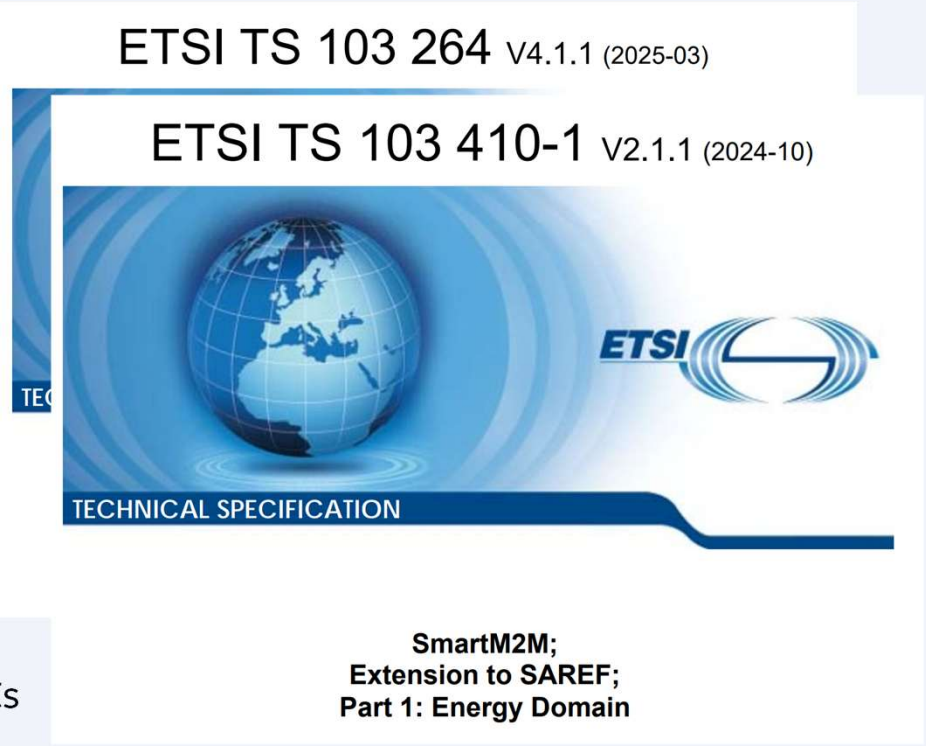
c. Represented as digital twin in a dongle/adapter, connected to the ESA.

The signatories commit to make their best efforts to indicate any of the above ways and the implemented use cases of the ESA in voluntary section of EPREL by selecting the corresponding option, (e.g. tick box, or similar).

https://ses.jrc.ec.europa.eu/development-of-policy-proposals-for-energy-smart-appliances

Wrapping up & Summary

- SAREF4ENER Main concepts:
  - Flexibility profiles
  - Timeseries and data points
  - Flexibility communication
- Use cases
  - Monitoring and control
  - Reacting to flexibility instructions
- Continuation:
  - Identify coverage of SAREF(4ENER) use cases with pilot SUCs
  - Apply and extend where applicable



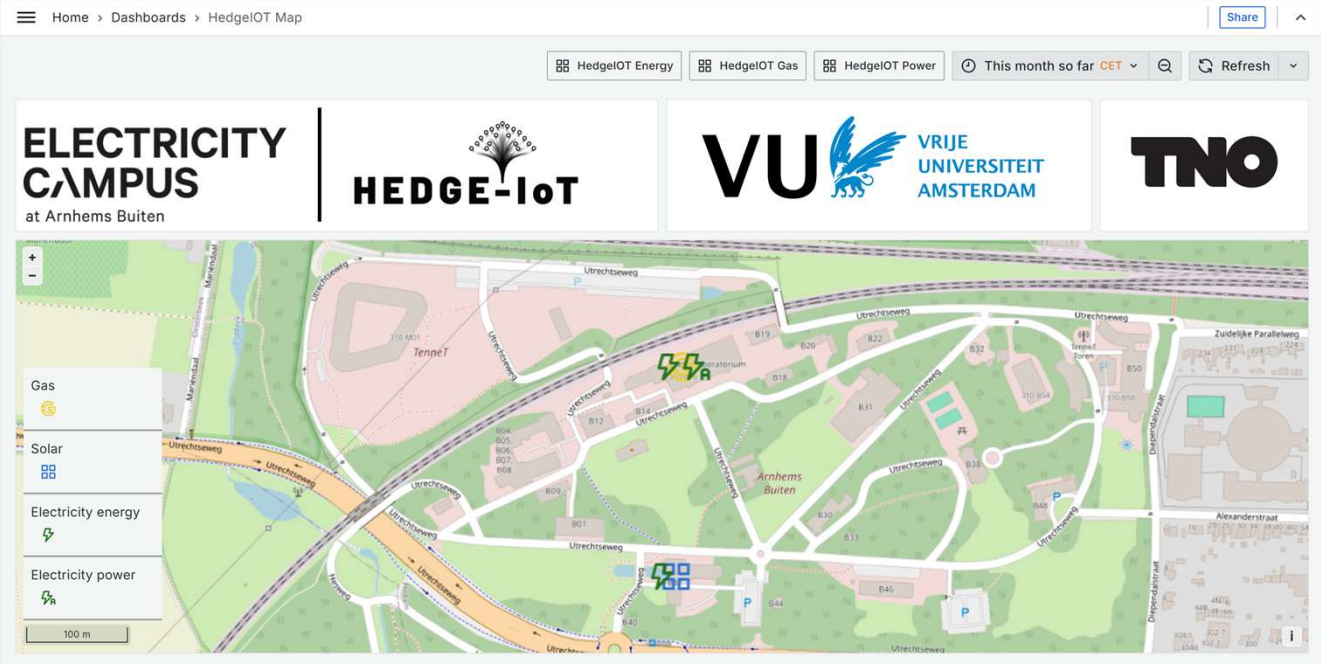
FAQ / Discussion points for SAREF & SAREF4ENER

- What if I don't have all information about a device? Can I still use it?
  - A little interoperability goes a long way, so you can reuse the properties for which you have data available. Reusing more properties is recommended.
- When is something a saref:Property, and when does it become a saref:PropertyOfInterest?
  - The difference between Property and PropertyOfInterest is exactly the type-token distinction SAREF supports in its modelling. Let's take temperature as the example property. A saref:Property refers to the Platonic concept of temperature as a type. A saref:PropertyOfInterest would refer to a token instantiation of the temperature type in, for example, a room in a building. The choice between saref:Property and saref:PropertyOfInterest depends on the granularity your modelling requires.
- What is the minimal number of triples I can use, with it still "counting" as SAREF?
  - Reusing a single concept from the SAREF namespace already counts as using SAREF, but the benefits of interoperability increase the more concepts of SAREF and its extensions you reuse.
- Is there a SAREF editor?
  - SAREF is based on RDF technology for which several editors are available. The commonly used free ontology editor is Protégé. Additionally, there are several commercial ontology development studio's available. Related technologies are available for translating your source data to RDF, for example RML, RDFlib, or Semantic Treehouse.
- Where can I find taxonomies, or should I always make my own?
  - It's a best practice to reuse taxonomies that are developed by experts in a particular field. This is usually preferred over developing a custom one. These can be found in various locations, so feel free to reach out for a specific taxonomy you may be looking for. For example, the common topic of units of measurements is covered in QUDT and in the Ontology of Measurement.
- Can I combine SAREF with other IoT ontologies, such as SSN/SOSA or WoT? Or would they "clash" together?
  - Ontologies, such as SAREF, are based on the principles of reusability and modularity, so the combination of standards always is recommended. SAREF, especially, is based on SSN/SOSA, so those models are closely aligned already. Combining with the Web of Things (WoT) Thing description is considered an enrichment instead of a clash.

SAREF

Hedge-IoT dashboard: Map of the Arnhems Buiten Electricity Campus with various energy assets

Example application of SAREF and SAREF4ENER



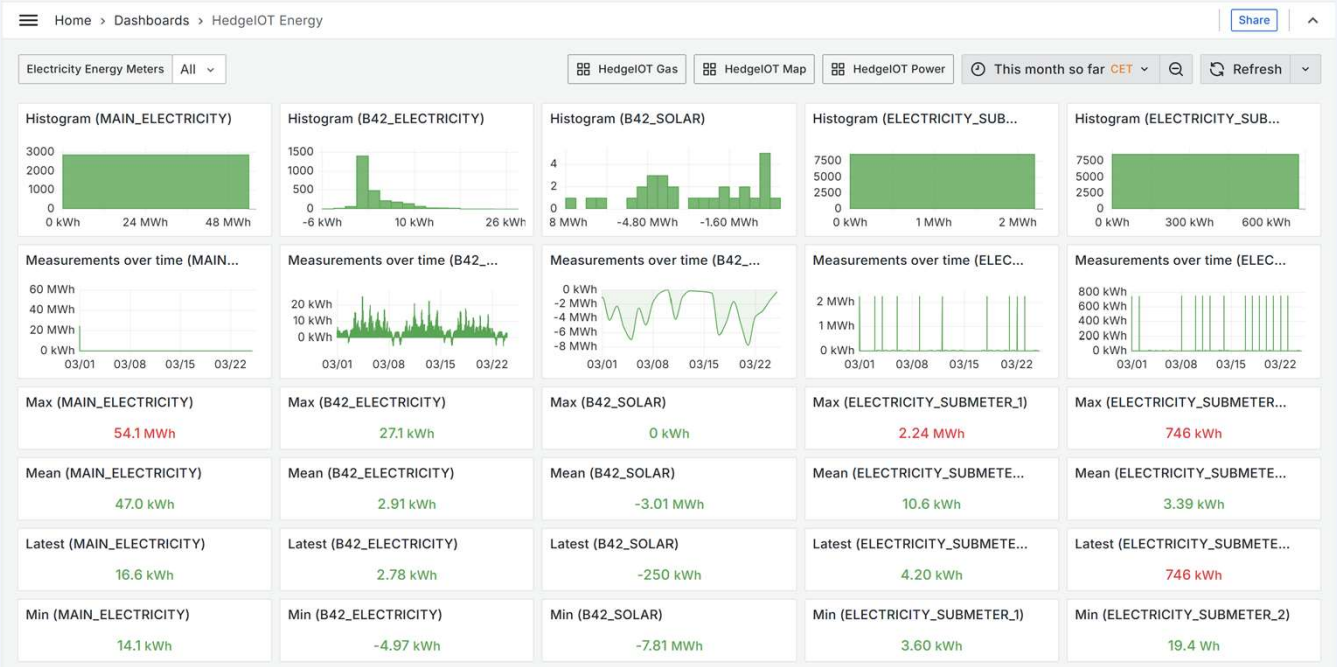
https://www.hedge-iot.labs.vu.nl/grafana/

- **Domains:** Smart homes, buildings and grids
- **Project:** Hedge-IoT (https://hedgeiot.eu)
- **Location:** Arnhems Buiten, Netherlands
- **Partners:** Arnhems Buiten, TNO, VU Amsterdam

SAREF

Hedge-IoT dashboard: Energy histograms and measurements at the Arnhems Buiten Electricity Campus

Example application of SAREF



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