4th Stakeholder Group Meeting
September 2025

Online (MS Teams), 15/09/2025

Alexandre Lucas, INESC TEC

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Agenda

- Overview of where we are in the project
- The latest versions of LPC/UI Config File tool
- Use Cases and the different architectures
- Lessons learnt
- Data Space Connector developments
- Open Mic session
- Closing

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Overview

Throughout the project we have output several open source tools with the guidance of the stakeholders group namely:

- 0 LPC IEEE2030.5 over NATS
- A client/server library for NATS communication
- Testing procedures
- A storage sizing Hybridization tool
- UI for the DS connector
- 4 DS Valorization cases

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Overview

In 2025 Disseminated of our work in different conferences, fairs including:

Type of Event	Event name	Nbr of events
Fairs	Hyvolution Paris 2025 – Hydrogen industry exhibition; Hannover Messe 2025 – Major industrial technology trade fair; ESS Europe – Exhibition for batteries and energy storage; The smarter E Europe – Integrated energy exhibition platform; EM-Power Europe – Exhibition focused on smart energy solutions; Battery Show Stuttgart 2025 – Trade fair for advanced battery technology; Lisbon Energy Summit and Exhibition 2025 – Exhibition & conference; Battery Recycling Expo 2025 – Exhibition dedicated to recycling technologies	8
Conferences*	ICSEE 2025 – International Conference on Sustainable Energy Engineering; World Sustainable Energy Days Battery Recycling Europe; FEV's Zero CO2 Mobility and Energy Conference; Wind Europe Annual Event (has exhibition elements too, but primarily a conference); Energy Tech Summit 2025; RE-BATTERY 2025 Raw Materials Summit;19th International Conference on Compatibility, Power Electronics, and Power Engineering (CPE-POWERENG 2025); ICSMARTGRID 2025 Conference; IEEE PowerTech 2025; SPE Conference (Society of Petroleum Engineers); AABC – Advanced Automotive Battery Conference; Energy Storage Global Conference	15
Policy related events	RTR Conference (organised by BEPA) – Research & innovation policy dialogue; EARPA Spring Meeting – Policy & automotive research associations; BRIDGE General Assembly – EU-funded projects and policy exchange; EUSEW 2025 (European Sustainable Energy Week) – EU institutional policy event	4
Others	All Electric Society –Vision-driven initiative, not a formal fair or conference (context needed, but likely falls under "conceptual event").	1

*More than a dozen publications

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InterSTORE overview & Implementation scope

❖ At this point we have the following updated version:

- Version 1.5 of the LPC,
- version 1.3.2 of the UI Data Space connector

❖ Since our last meeting, we have run the demos and concluded most of the works targeting 9 UC

- Monitoring
- Control
- LPC and native libraries
- Both EMS (platforms) and devices have deployed the tools
- Performance under lab conditions using RTDS

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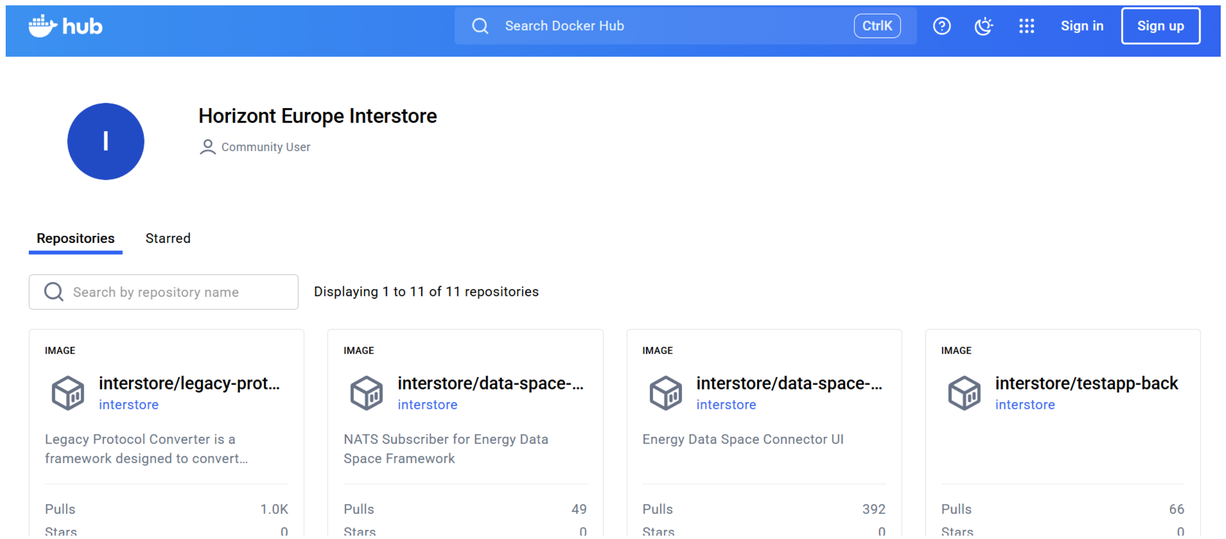
Engagement numbers

Only on Dockerhub:

- ❖LPC – >1100 downloads
- ❖DS connector UI – 400 downloads
- ❖Local API service . – 150
- ❖DS Fiware data app + Blockchain notarization – > 350 downloads



https://hub.docker.com/u/interstore

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InterSTORE main results

Main Performance indicators:

Indicator	Value reached
❖ IEEE2030.5 NATS Communication speed	under 100 ms
❖ Number of different DER devices successfully tested and demonstrated	32
❖ Number of assets monitored by the EMS solutions	37
❖ Number of different DER devices and EMS successfully tested with the IEEE2030.5 and demonstrated in real-life pilots	21
❖ Nbr. Of shared services/files subscribed and published	over 3000
❖ Integrated power of the HESS within the project demos	over 4MW

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InterSTORE highlights

- ❖ InterSTORE White paper available on our Webpage
- ❖ Policy reccomendation
- ❖ Comparison with other standards/protocols
- ❖ Towards adoption

Scan a QR code to download our White paper

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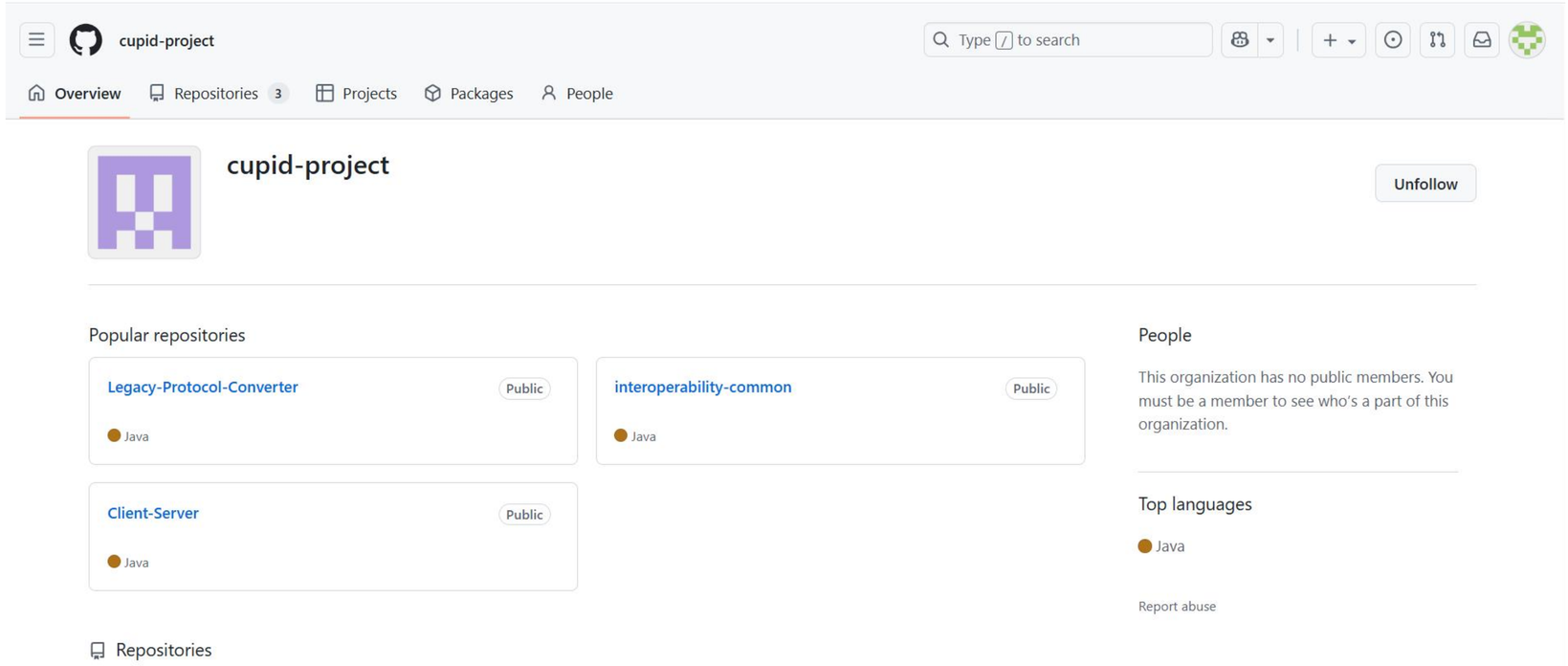
Overview and looking at the Future

- Linux Foundation for Energy under the name CUPID, to which I ask you to follow, engage and contribute, as this will be the future stage for the project developments.

https://github.com/cupid-project



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How can you as a Stakeholder contribute

We invite you to:

- Engage with the Cupid project. Further developments are welcome.
- Adopt in real life in your assets and infrastructure.
- Propose in other projects and implement in other use cases.
- Engage with InterSTORE partners for knowledge transfer.
- Share experience from your own projects and implementation.
- Work still needs to be done, but that’s why we need community engagement.

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Final Event

Date: 25 November 2025
Hybrid event: Double Tree by Hilton Brussels City, Rue Gineste 3, 1210 Brussels and online

For more information, go to our website:
InterSTORE Final event | interstore

And register for the event here:
InterSTORE Final event – EASE

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The latest versions of the LPC/UI Config File tool

Matjaz Juric, SUNESIS

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Legacy Systems Protocol Converter

Legacy Systems Protocol Converter (LPC)

- Provides simple and configurable transformation between legacy protocols and IEEE 2030.5

Supported protocols:

- ModBus (serial and TCP)
- MQTT
- RabbitMQ
- NATS (for IEEE 2030.5)

Supported IEEE 2030.5 formats

- XML
- JSON
- All 321 IEEE 2030.5 elements are supported

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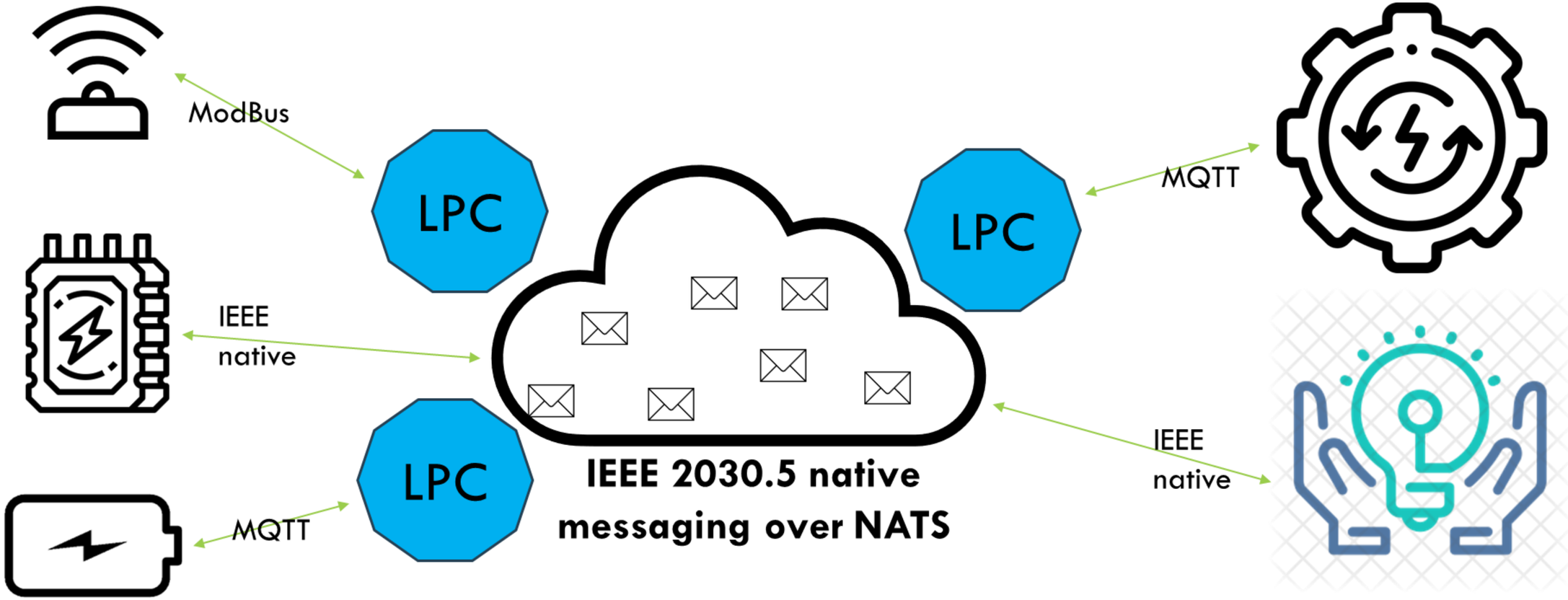

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Legacy Systems Protocol Converter

```json
{
  "datetime": "28-08-2023 12:00:35",
  "status": "active",
  "start": "28-08-2023",
  "duration": 900
}
```

```yaml
transformations:
  - name: JSON IncomingEvent to XML IEEE2030.5 Event
    description: Example showing transformation of messages from JSON to XML
    connections:
      incoming-connection:
        - MQTT-connection
      incoming-topic: topic1
      incoming-format: JSON
      outgoing-connection:
        - NATS-connection
      outgoing-topic: event/myevent
      outgoing-format: XML
    to-outgoing:
      '<Event>
        <creationTime>$timestamp</creationTime>
        <EventStatus>
          <currentStatus>
            <lpc:mapping>
              <path type="integer">/status</path>
              <values>["scheduled", "active", "cancelled", "cancelled_with_r", "superseded"]</values>
            </lpc:mapping>
          </currentStatus>
          <dateTime>
```

```xml
<Event>
    <creationTime>1702909917932</creationTime>
    <EventStatus>
        <currentStatus>1</currentStatus>
        <dateTime>1693216835000</dateTime>
        <potentiallySuperseded>false</potentiallySuperseded>
    </EventStatus>
    <interval>
        <duration>900</duration>
        <start>1693216835000</start>
    </interval>
</Event>
```

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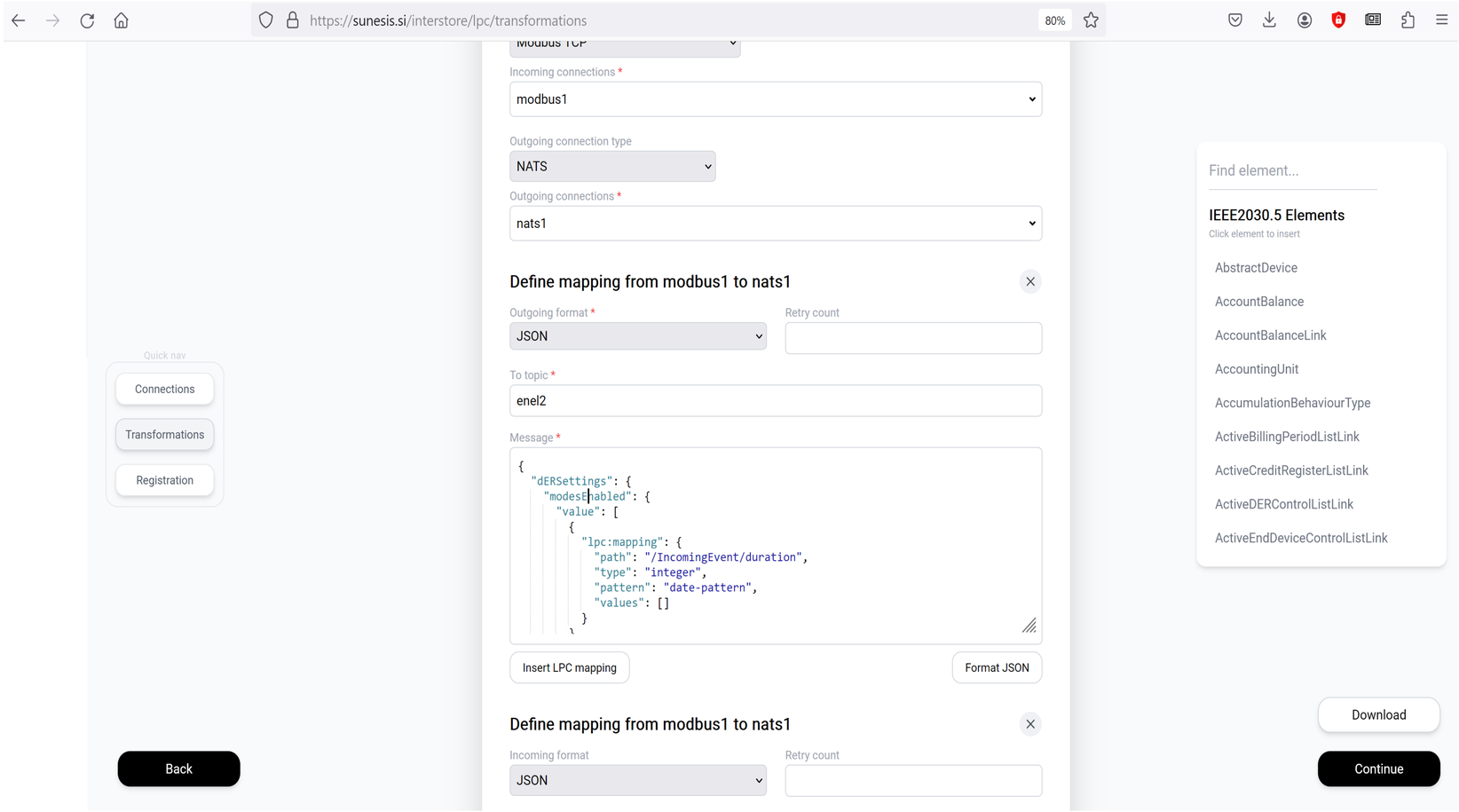
LPC UI for Simplifying Configuration

- https://sunesis.si/interstore/lpc/



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New Features in LPC

Latest version is Version 1.5 (Sep 12, 2025)

New features:

- RabbitMQ support with flexible queue/topic mappings
- Cron-based interval request scheduling
- Synchronization with NTP server supported for interval requests
- New validation flag for IEEE2030.5 messages
- Option to use the pymodbus library with Modbus TCP
- Support for unsigned and signed integers when using Modbus connections
- Configuration of logs inside the configuration of LPC
- Option of message validation for compliance with IEEE 2030.5 schema
- Several performance and scalability improvements

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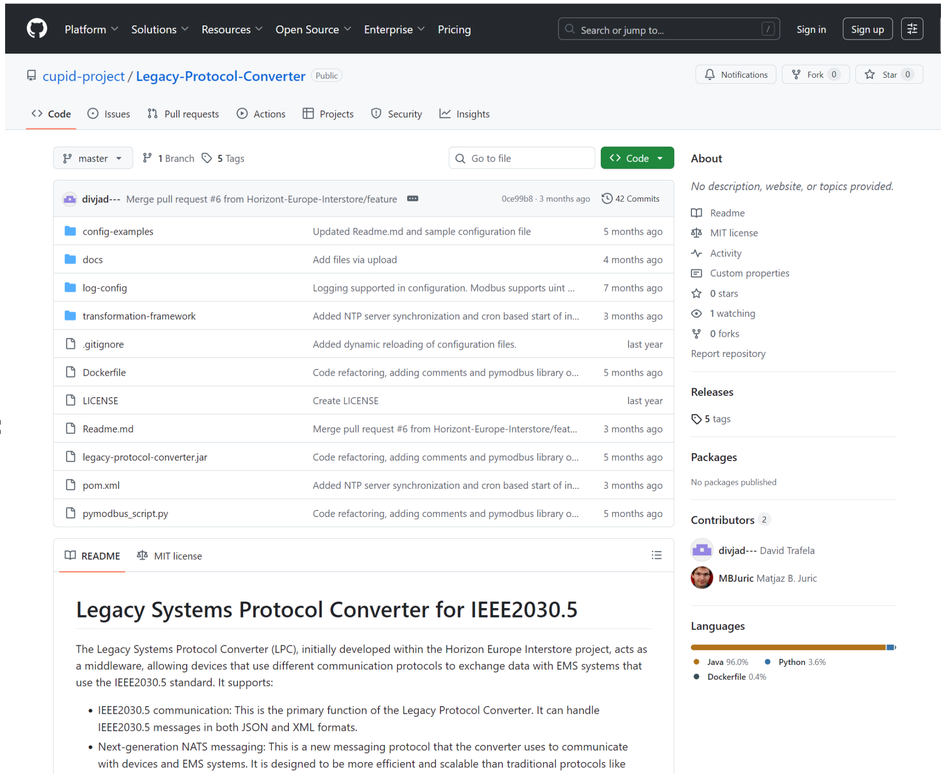
Linux Foundation Energy

LPC has been adopted by Linux Foundation for Energy.

LPC can now be found in Linux Foundation hosted repo on GitHub - CUPID:
https://github.com/cupid-project/Legacy-Protocol-Converter

CUPID code is currently mirrored with original Interstore repository
https://github.com/Horizont-Europe-Interstore/Legacy-Protocol-Converter

CUPID will move to the Linux Foundation Energy GitHub org by the end of the year.



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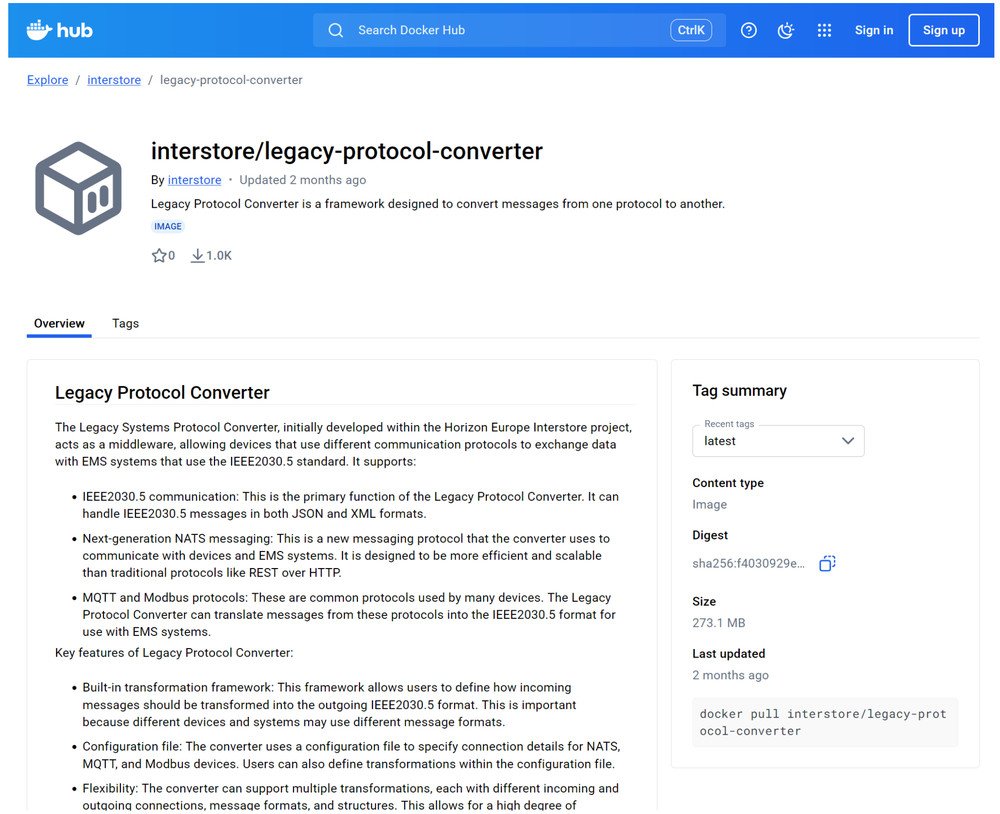
Docker Hub

LPC has pre-build images on Docker Hub:
https://hub.docker.com/u/interstore

Using Docker Hub images is the fastest way to start using LPC. It only requires one command:
docker pull interstore/legacy-protocol-converter

Note: You also need to define the mapping, as shown before.



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Use Cases and the different architectures

Daniele Carta, Forschungszentrum Jülich

JÜLICH
Forschungszentrum

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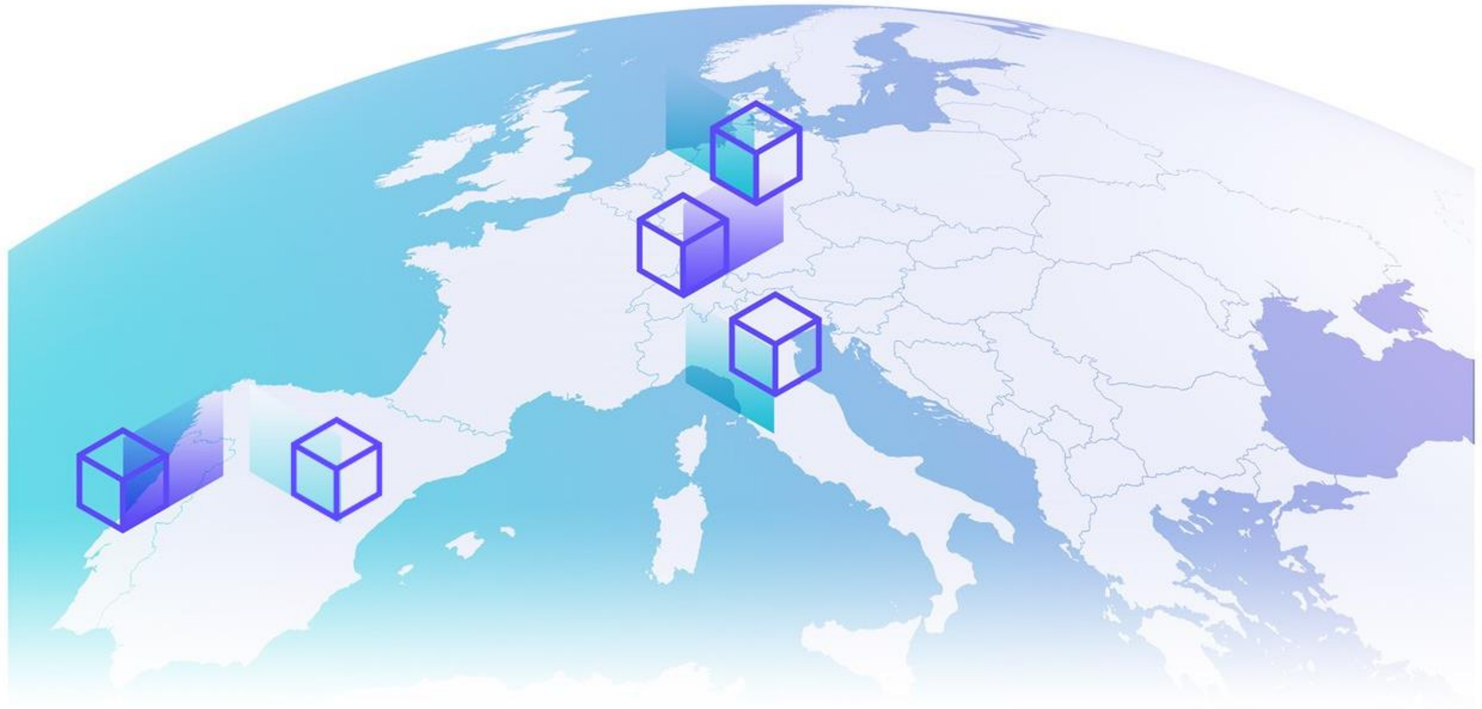
Pilot sites

Overview

- Austria – Residential flexibility pilot
- Italy – E-mobility flexibility pilot
- Germany – Commercial flexibility pilot
- Portugal – Industrial flexibility pilot
- Spain – Laboratory test bed



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Use cases

Overview

UC #	Use Case name	HESS performance	Monetisation	Connected Data Spaces	Flexibility/ Consumer engagement	IEEE2030.5	2nd Life Batteries	EV Battery support
1	DES Flexibility Market Monetisation	✓	✓	✓	✓	✓		
2	Energy community DES utilisation	✓	✓	✓	✓	✓		
3	Grid supporting BESS	✓		✓		✓		
4	Innovative Frequency services	✓				✓		
5	Hybrid floating storage flexibility monitoring	✓			✓	✓	✓	
6	Management of battery systems for Node capacity increase				✓			✓
7	Adaptive BESS management for autonomous grid operation	✓		✓	✓	✓		
8	Multiphysics flexibility Optimization for Home Management Systems and their global integration	✓		✓	✓	✓		
9	Management of EV charging clusters as HESS			✓		✓		✓

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Austrian pilot

Overview of the Energy community in Dietach

- UC1: DES Flexibility Market Monetisation

- UC2: Energy community DES utilisation

Key aspects:

- ✓ Local energy community
- ✓ Monitoring and control
- ✓ Inverters from various manufacturers
- ✓ Communication via cellular network

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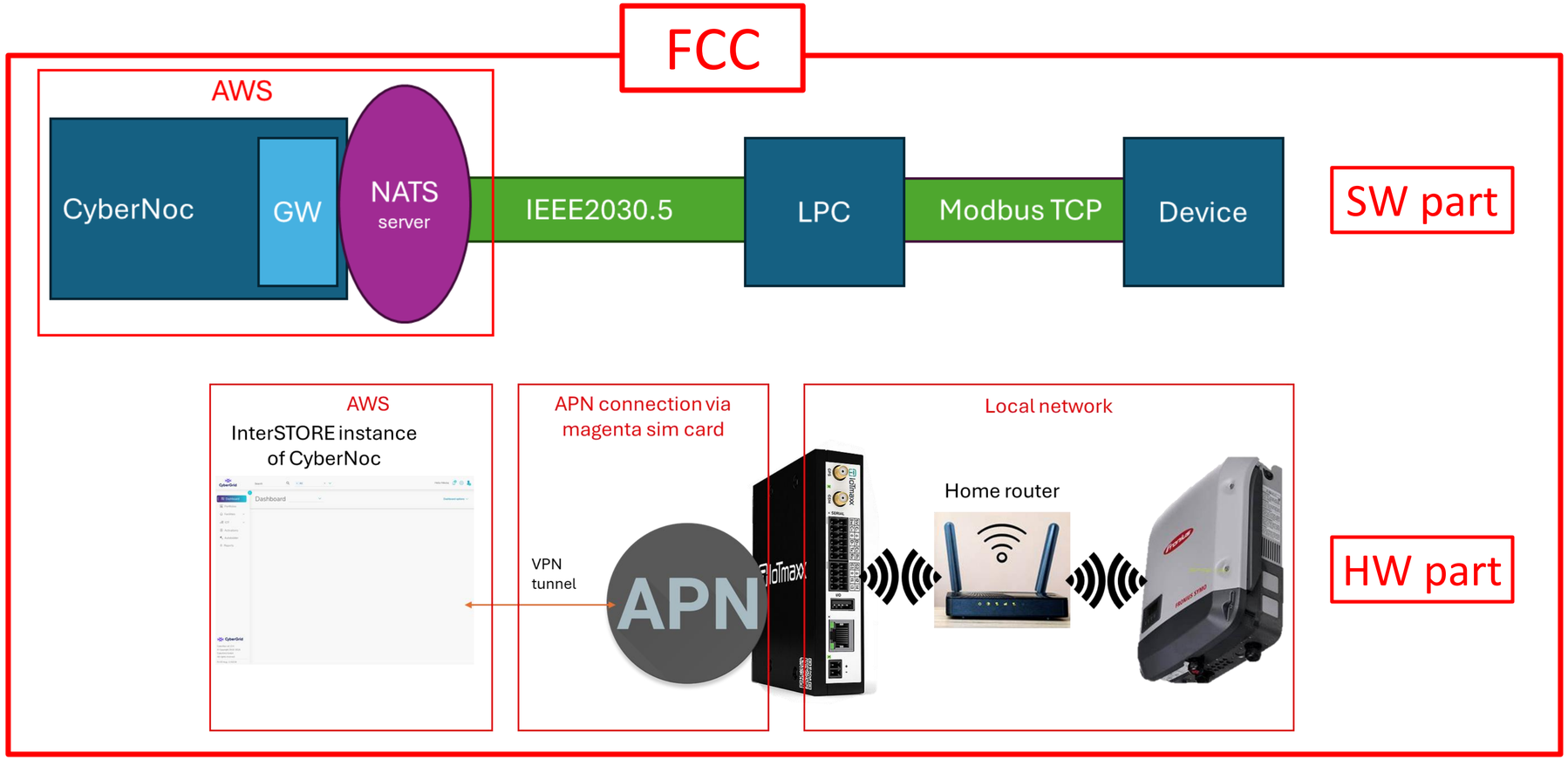
Austrian pilot

Overview of the architecture



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Austrian pilot

Overview of the inverters

Due to all the different scenarios in the community, the Austrian pilot target primally Fronius inverters (50% of cases) with a plan to expand to others.

Manufacturer	Type	Asset type
Fronius	Symo 10, Symo 8.2	PV
Fronius	Symo Gen24 Plus	PV
Fronius	SymoHybrid 5.0	BESS
Huawei	SUN2000, Solar Inverter	PV
SolarEdge	SE9K	PV
Solax	X3-HYBRID-15.0-D G4.2	PV
Huawei	LUNA2000	BESS
Varta	Pulse neo	BESS
BYD	HVM	BESS

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German Pilot

Use cases

- UC3: Grid supporting BESS

- UC8: Multiphysics flexibility optimization for Home Management Systems and their global integration

Key aspects:

- ✓ Multi-physics system
- ✓ Monitoring and control
- ✓ LPC Implementation on low-cost hardware
- ✓ Analysis of deployment times

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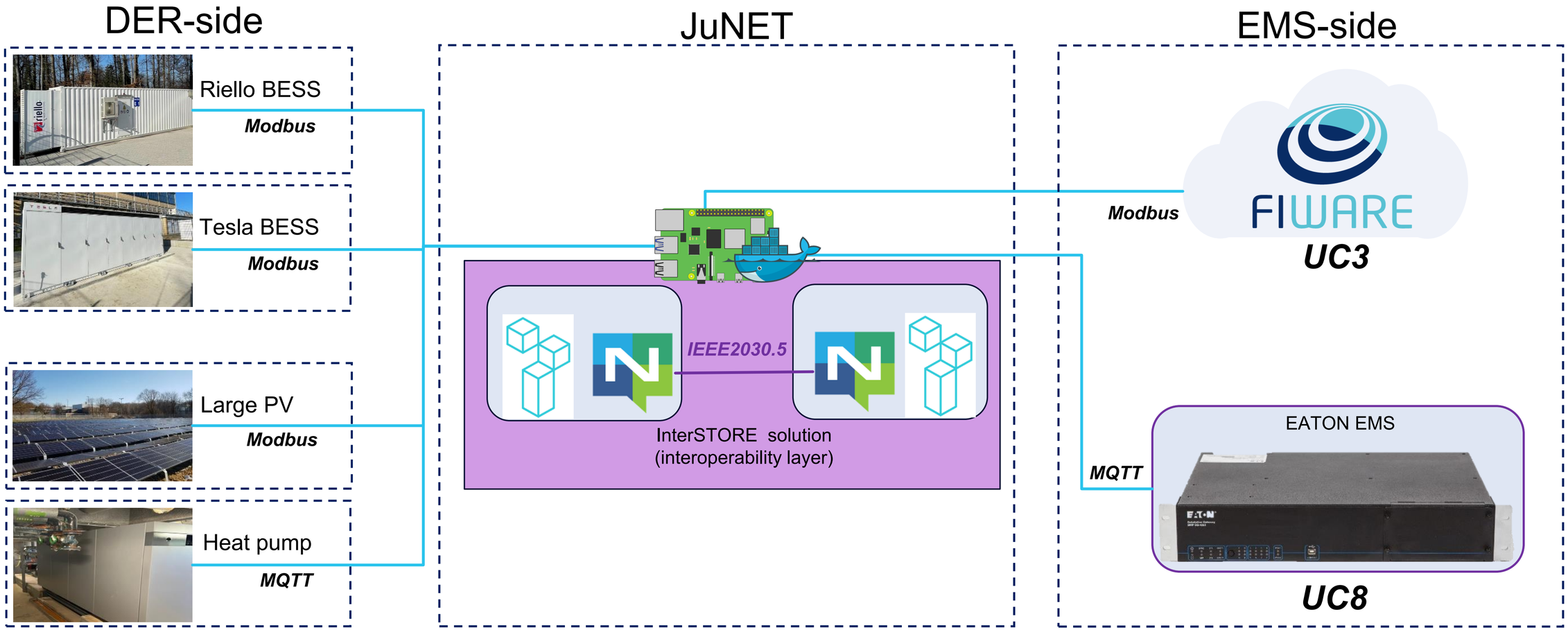
German Pilot

Overview of the architecture



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German Pilot – UC3: Grid supporting BESS

Overview of deployment time (KPI9)

Average time "LPC" = 86% faster

User ID	Time LPC integration [hours]				Time "traditional" integration [hours]			
	Riello	Tesla	PQI	Janitza	Riello	Tesla	PQI	Janitza
SD_1	5.37	4.56	4.50	4.05	46.25	37.00	30.83	27.75
SD_2	11.87	9.26	8.63	8.48	50.00	40.00	33.33	30.00
SD_3	5.49	4.41	4.52	4.52	40.00	32.00	26.67	24.00
SD_4	6.05	4.61	4.26	3.82	47.33	37.87	31.56	28.40
SD_5	7.57	6.22	5.68	5.25	43.67	34.93	29.11	26.20
PhD_1	3.85	3.61	3.50	3.17	50.00	50.00	28.33	25.50
PhD_2	3.10	2.84	2.58	2.48	50.00	50.00	28.24	25.41
PhD_3	10.97	8.62	7.50	6.75	50.00	50.00	31.23	28.11
PhD_4	4.47	3.67	3.33	3.22	50.00	50.00	32.75	29.48
Postdoc_1	8.03	7.27	6.58	6.17	50.00	50.00	33.30	29.97
Postdoc_2	2.76	2.49	2.33	2.26	50.00	50.00	30.23	27.20
Postdoc_3	1.72	1.66	1.50	1.37	50.00	50.00	30.67	27.60

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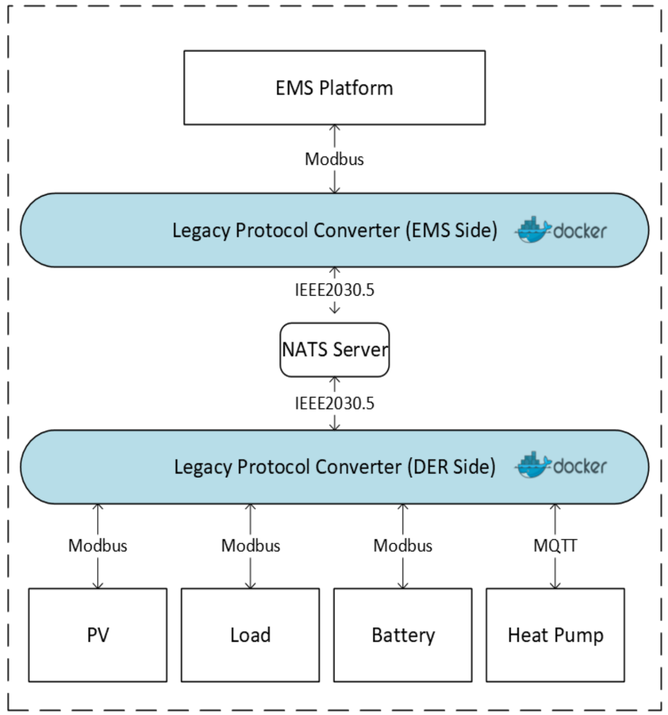
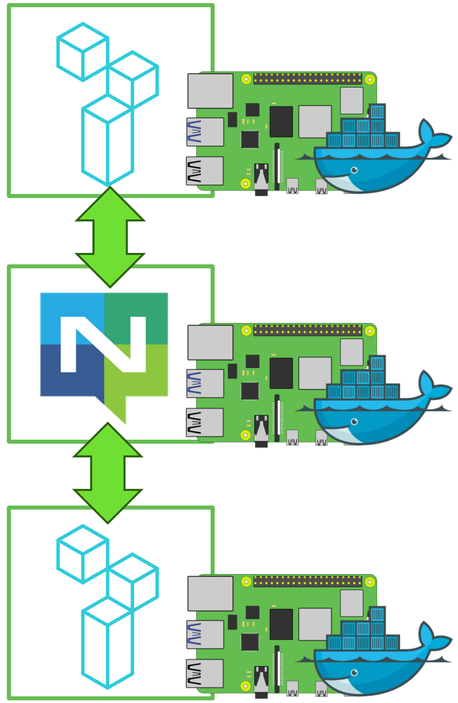
Avg total time demonstration = 21 days/user

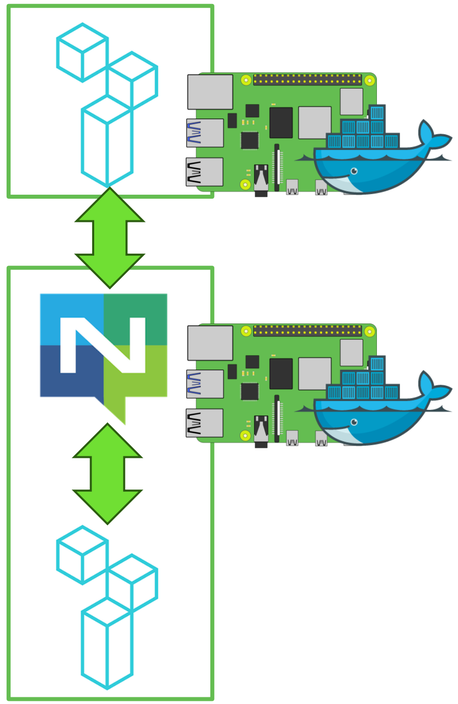
German Pilot – UC8: Multiphysics flexibility optimization for Home Management Systems and their global integration

Overview of activities and developments

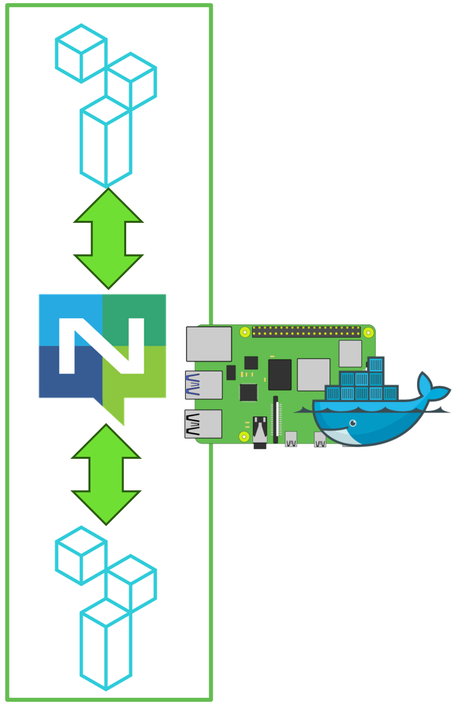




Solution 1



Solution 2



Solution 3
OUR
CHOICE

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German Pilot – UC8: Multiphysics flexibility optimization for Home Management Systems and their global integration

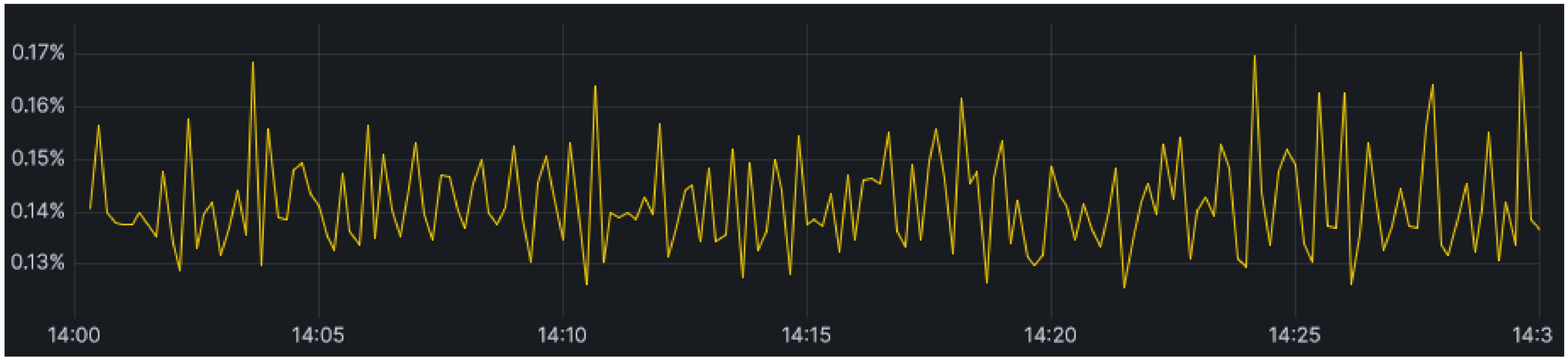
Overview of activities and developments – Resource usage

Resource usage LPC

<25%

Resource usage NATS

<0.2%



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Italian Pilot

Overview of activities and developments – MQTT broker and InfluxDB

- UC9: Management of EV charging clusters as HESS

Key aspects:

- ✓ Test of local ancillary services for DSO
- ✓ EV chargers, batteries, supercap, PV system
- ✓ Monitoring and control
- ✓ Native integration of IEEE2030.5

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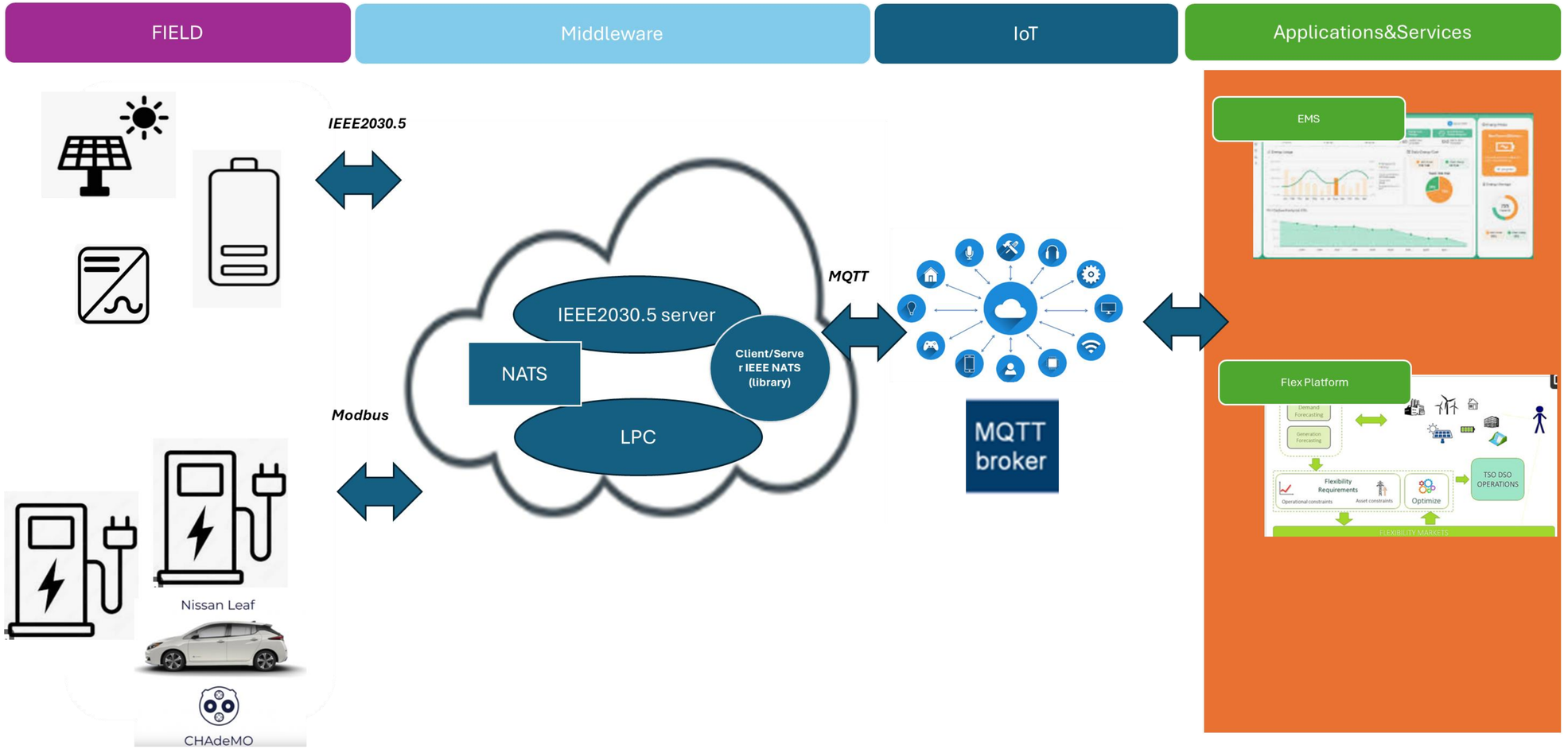
Italian Pilot – UC9: Management of EV charging clusters as HESS

Overview of the architecture



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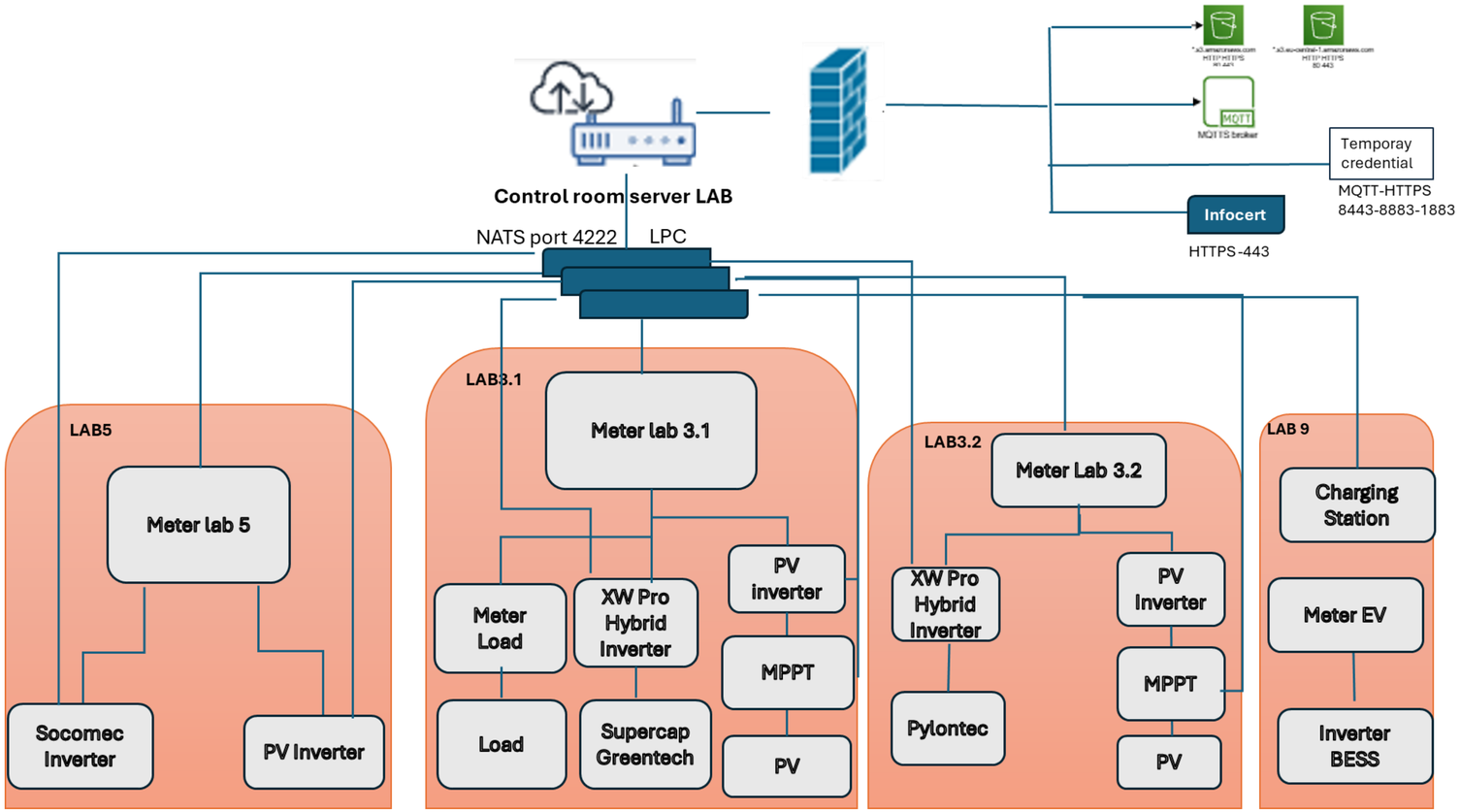
Italian Pilot – UC9: Management of EV charging clusters as HESS

Overview of network topology and integration XLAB – IT platforms



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Portuguese Pilot

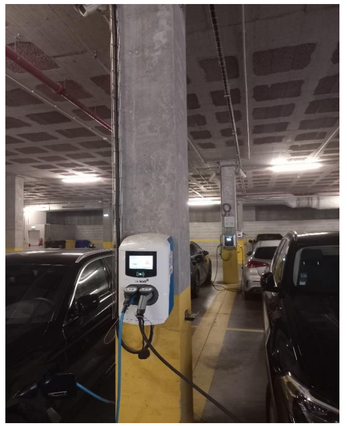
Use cases

- UC5: Hybrid storage higher performance and flexibility provision

- UC6: Management of battery system for Node capacity increase and user DR

Key aspects:

- ✓ EV driver engagement
- ✓ Hybrid battery systems
- ✓ Monitoring via LPC
- ✓ Control via LabVIEW



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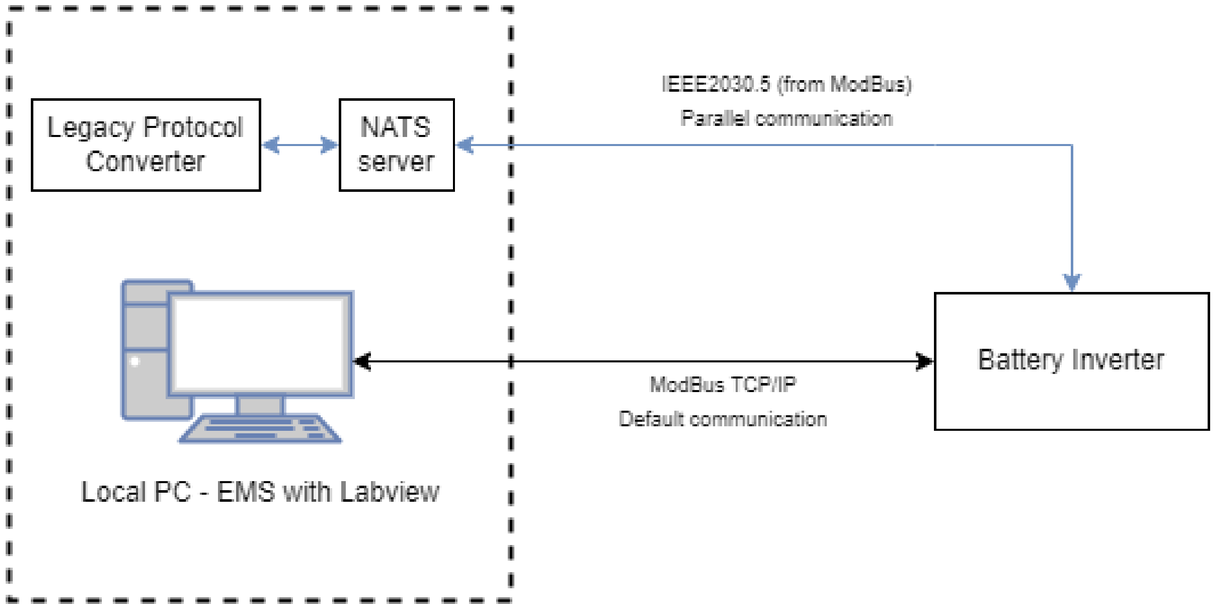
Portuguese Pilot – UC5: Hybrid storage higher performance and flexibility provision

Overview of architecture



- Vanadium redox flow, with 10kW and 40kWh
- Second-life lithium batteries with 100kW and 92 kWh

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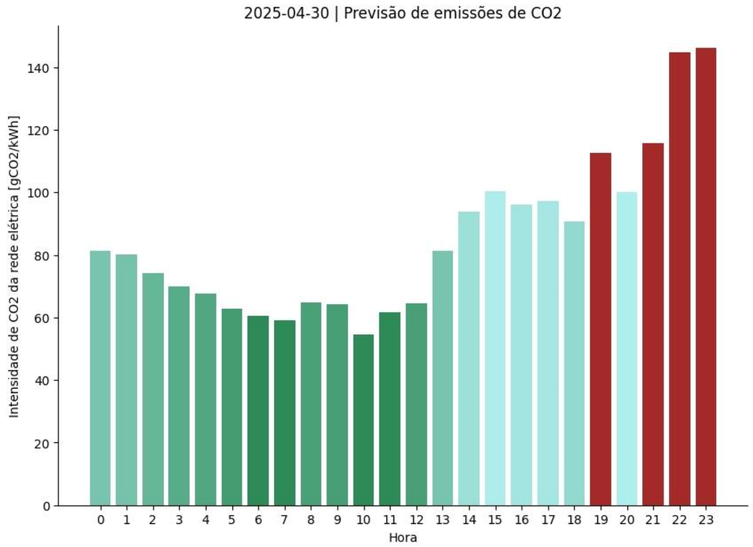
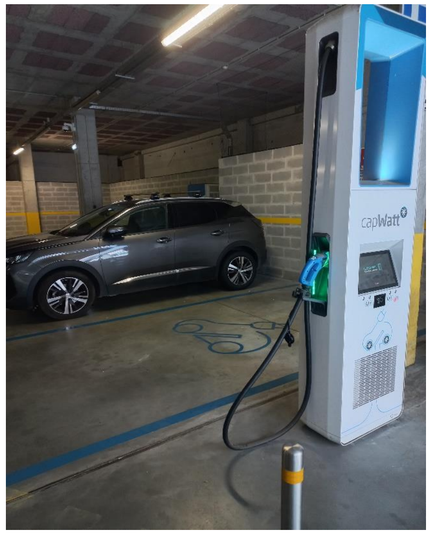
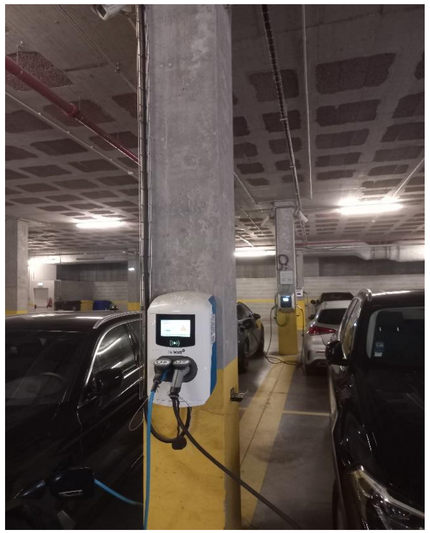
Portuguese Pilot – UC6: Management of battery system for Node capacity increase and user DR

Overview of activities and developments







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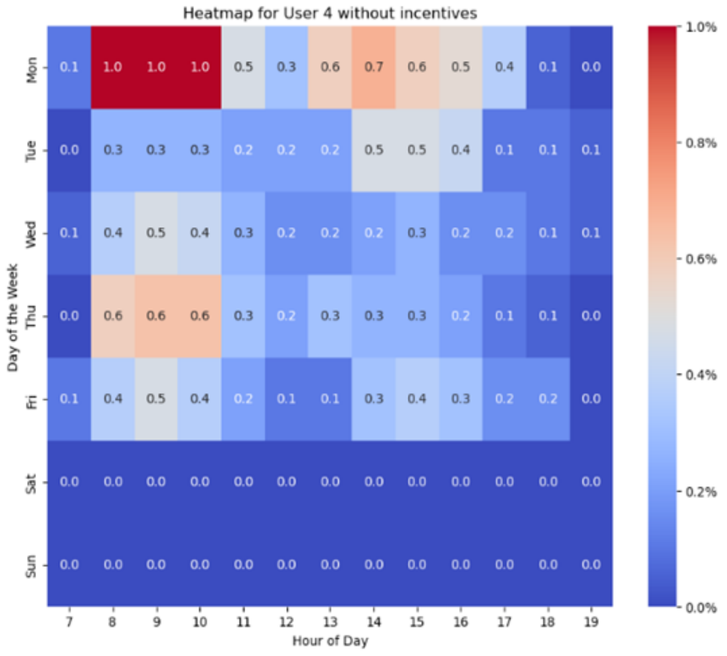
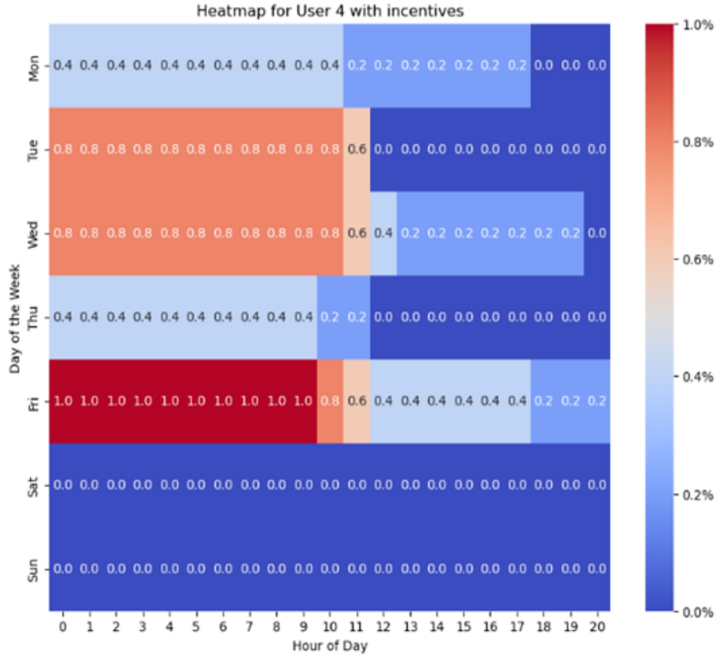
Portuguese Pilot – UC6: Management of battery system for Node capacity increase and user DR

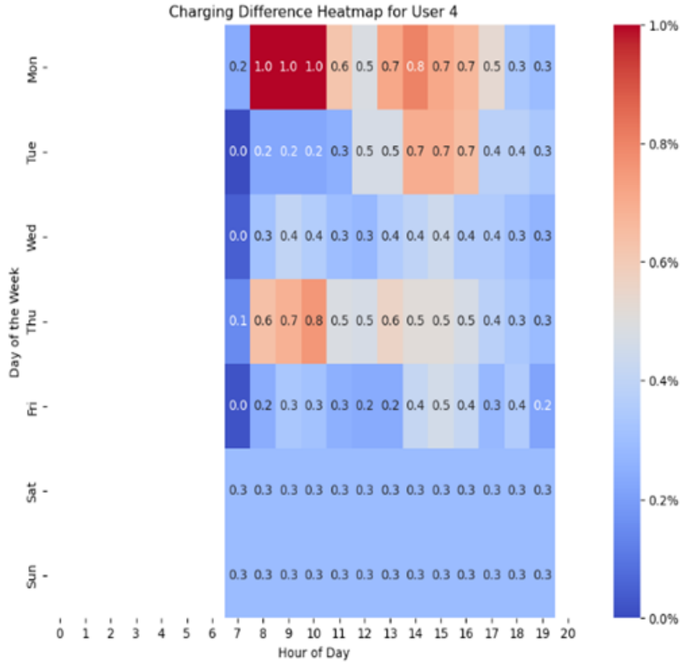
Changes in the user behavior



Without incentives



With incentives



Difference

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Spanish Lab

HESStec Lab facilities in Valencia

- UC4: Innovative Frequency services

- UC7: Adaptive BESS management for autonomous grid operation

Key aspects:

- ✓ Fast frequency services
- ✓ Autonomous grid operation
- ✓ Analysis of LPC response time
- ✓ Monitoring and control

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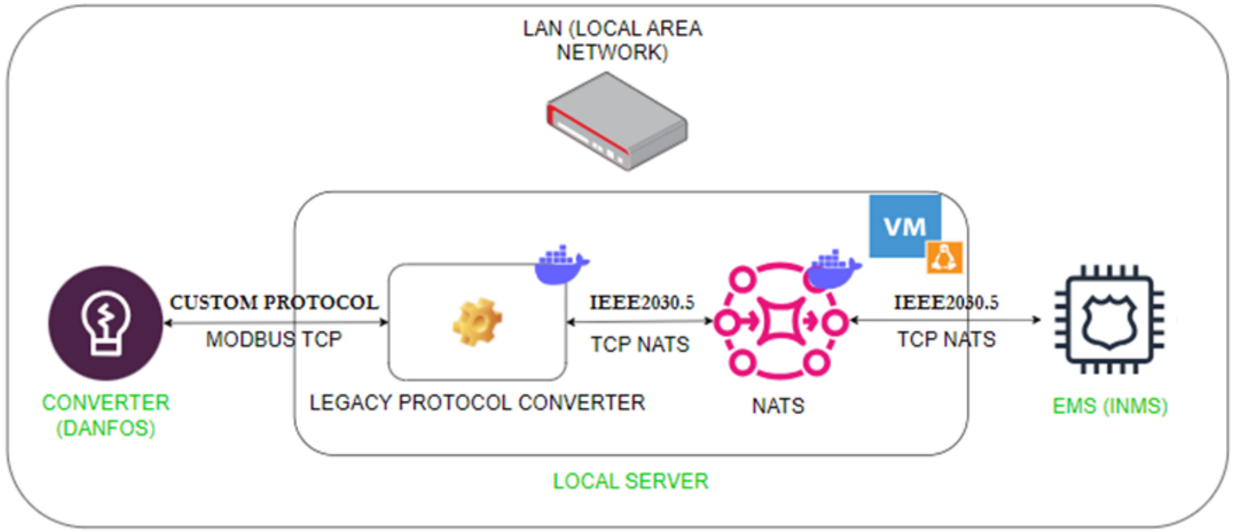
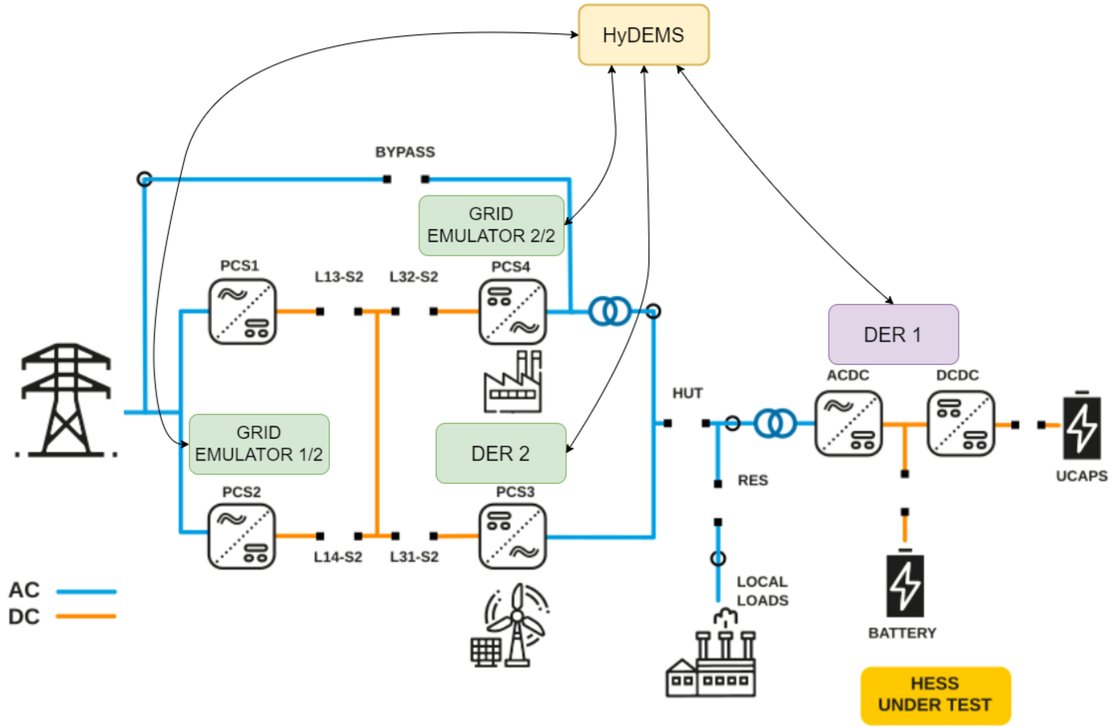
Spanish Lab

Overview of architecture





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Spanish Lab

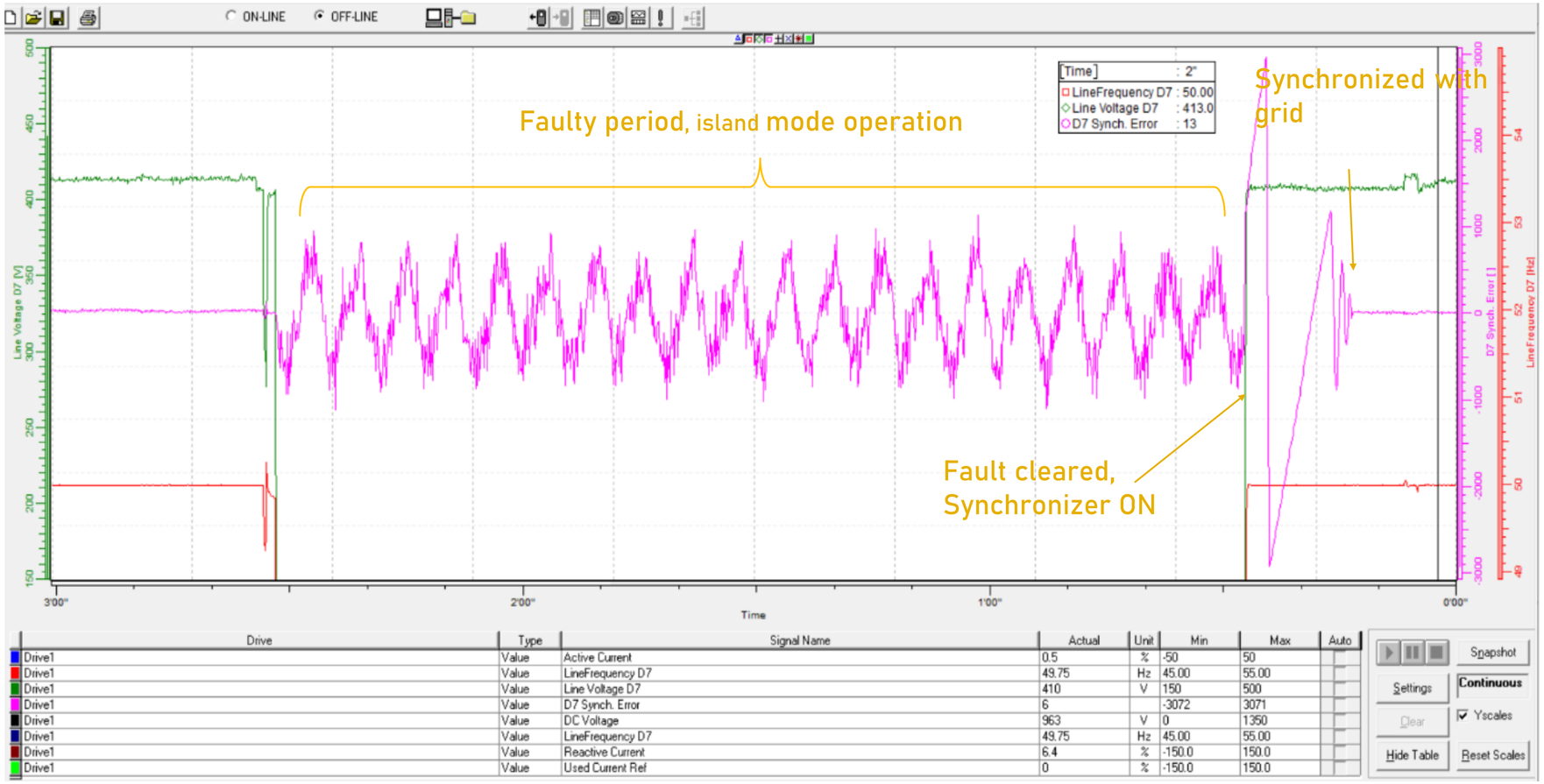
Example of voltage-dip tests

Phases:

a) island operation

b) synchronization after clearing the fault

c) grid connection



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Lessons Learnt

Daniele Carta, Forschungszentrum Jülich

JÜLICH
Forschungszentrum

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Lessons learned

LPC deployment

- Due to the low computational burden, LPC can be deployed on low-cost solutions such as SBC
  - Low resource usage even in the presence of a large number of integrations
- Depending on the logging level, and the data exchange, hard drives can be filled up quickly
  - It can be easily avoided using the proper logging settings
- Config files can be created quickly, reducing deployment times
  - The IEEE2030.5 scheme must be known in advance
- Config files can be updated/added while the LPC is running
  - Avoids downtimes from due to stop and re-start

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Lessons learned

Assets integration

- Full integration with Modbus and MQTT-based devices
  - Synchronization issues can be solved with NTP server (can be indicated in the config file)

- Suitable for monitoring and control
  - Certain assets can be controlled only with one specific library (can be selected in the config file)
  - 100 ms seems to be the best trade-off, between latency and performance, for Modbus polling interval

- Hybrid integration
  - Various types of batteries, charging stations, PV systems, and inverters from different manufacturers
  - Multi-physics integrations require adaptation of IEEE2030.5 model (e.g., for thermal storage)

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Lessons learned

User engagement

- Challenges during deployment within households -> need to inform and instruct owners
  - Need to investigate IP addresses
  - Limit discomfort for users (downtimes, technicians presence, and so on)
  - Concerns on status of private assets -> “Don’t destroy my battery”

- 1/3 of EV drivers reported user behavior
  - Limited number of charging stations with respect to EV drivers
  - 100% of users are willing to change their behavior, depending on the incentive
  - Need to find a suitable means of communication/tool to interact with users

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Data Space Connector

Marcantonio La Franca, Engineering

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OneNet Data space Framework

Agenda

- Development Timeline
- Latest Features
  - Push mechanism flow (external service integration)
  - NATS integration
- Live Demo (latest version)
- Data space Roadmap & Next Steps

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OneNet Data space Framework

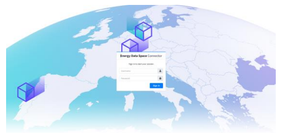
Development Timeline in the InterSTORE project (WP2 – T2.4)

Starting point 2023 (M1)

- General Purpose Data Space Connector
- Energy Domain Standardization
- Fiware Context Broker
- IDSA components

V1.0.5 March 24 (M15)

- Open Source GUI
- Blockchain Notarization



V1.1.2 October 24 (M22)

- Data exchange optimization

V1.2.0 December 24 (M24)

- Push Mechanisms
- External service integration

V1.3.2 March 25 (M27)

- IEEE2030.5 via NATS Integration

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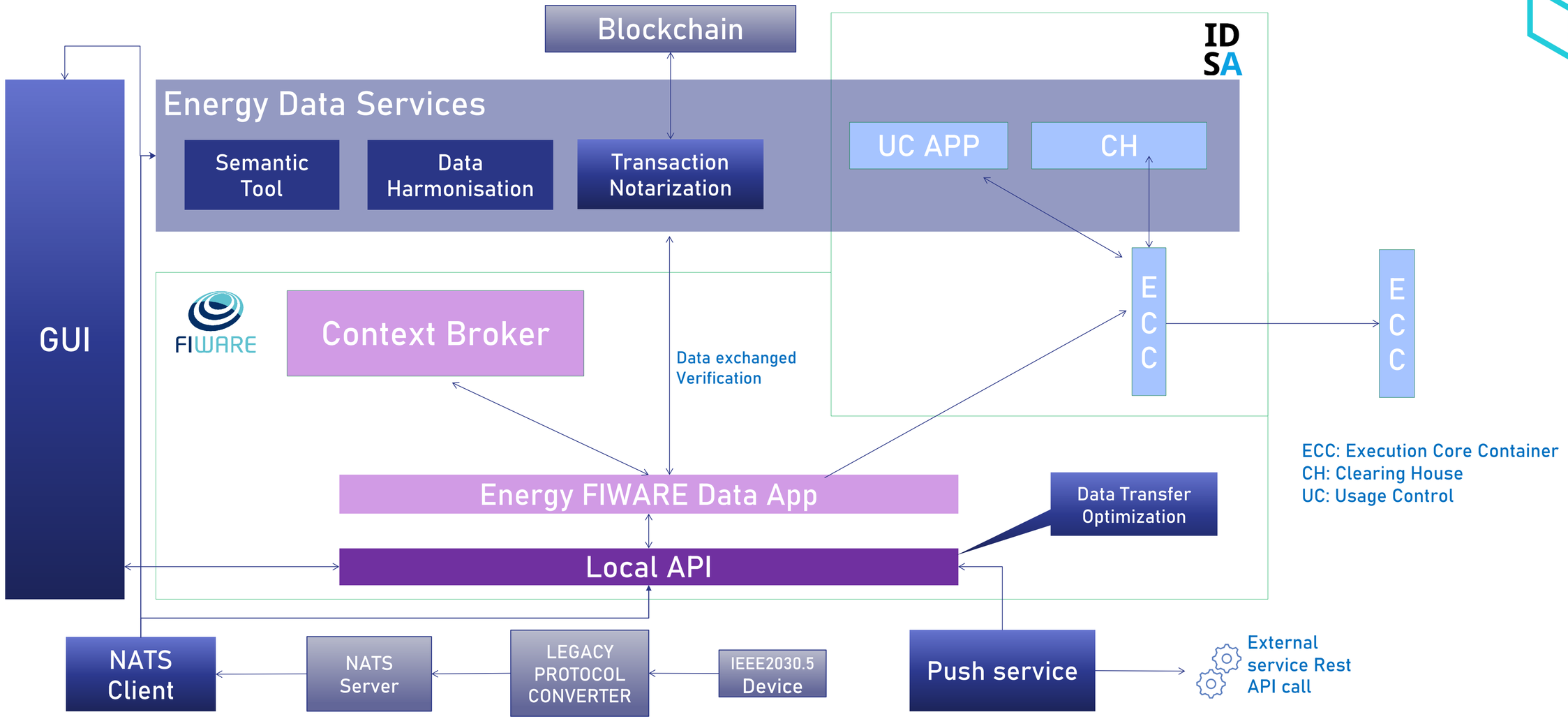
OneNet Data space Framework

Block diagram architecture – Latest Version



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OneNet Data space Framework

Why a push mechanism in energy data space?

The standard flow in a data space (consumer request data to provider), is effective for most energy scenarios, but it has reduced flexibility for use cases where data needs to be uploaded and sent efficiently and in real-time.
The push flow mechanism overcomes these limitations by offering:

- External service integration (Rest API)
- (near) Real-Time Data Delivery (instant access to data)
- Reduced Latency (vs pull mechanism)
- Efficient Resource Utilization (avoid constant polling)
- Support for Event-Driven Use Cases (immediate data actions)
- Proactive Stakeholder Actions (decisions based on the most current data)

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OneNet Data space Framework

Push mechanism overview

1 – Service creation and Configuration

Service Provider

Energy Dataspace Connector

2 – Subscription Flow and Pushing Data

Data Provider

3 – Web Service call to send data

4 – Get Response

2XX OK
5XX KO

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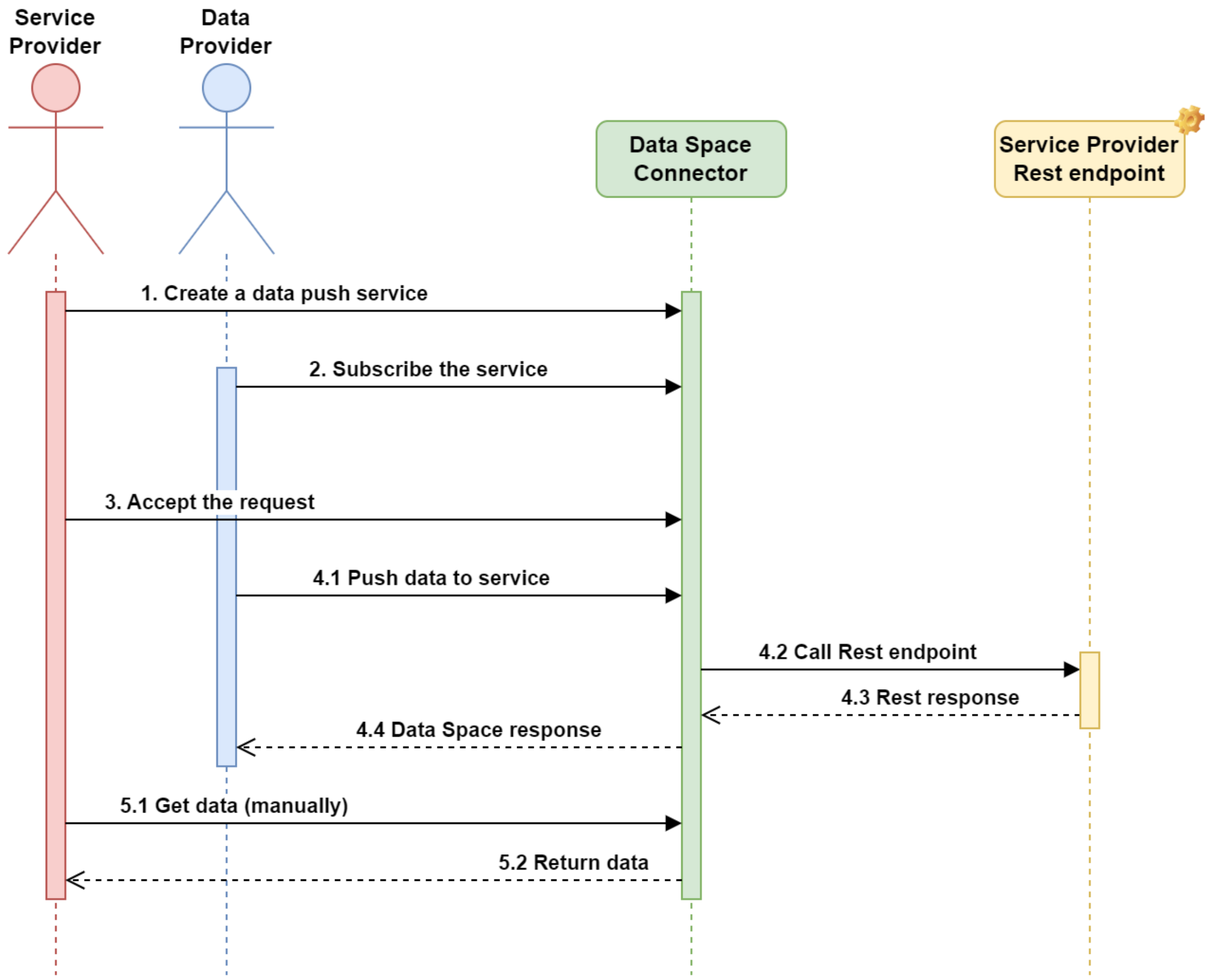
OneNet Data space Framework

Push mechanism Sequence Diagram



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OneNet Data space Framework

IEEE2030.5 integration via NATS opportunities

The integration of Data Space with NATS creates numerous opportunities to advance the digitalization of the energy sector and enhance the integration of Distributed Energy Resources (DERs).

Key Benefits

- Enhanced Interoperability
- DER Optimization
- Data-Driven Decision Making
- Privacy and Security Management
- Integration with Smart Cities and IoT
- Improved Customer Engagement and Energy Efficiency

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OneNet Data space Framework

IEEE2030.5 integration via NATS – use cases examples

- Microgrid Management
- Electric Vehicle (EV) Integration
- Dynamic Pricing and Demand Response

The integration opens up a world of possibilities for secure, interoperable, and intelligent energy management. By leveraging the benefits of both technologies, utilities, grid operators, and consumers can achieve higher efficiency, better grid stability, and a more sustainable energy future.

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OneNet Data space Framework

IEEE2030.5 via NATS integration overview

Integrating data space with an IEEE 2030.5 interface device is possible combining several key technologies

- **IEEE 2030.5** (the smart grid communication message standard)
- Legacy Protocol Converter (**LPC**)
- **NATS** (a high-performance messaging system)
- **InterSTORE Energy Data Space** Open Framework (for secure and scalable data sharing)

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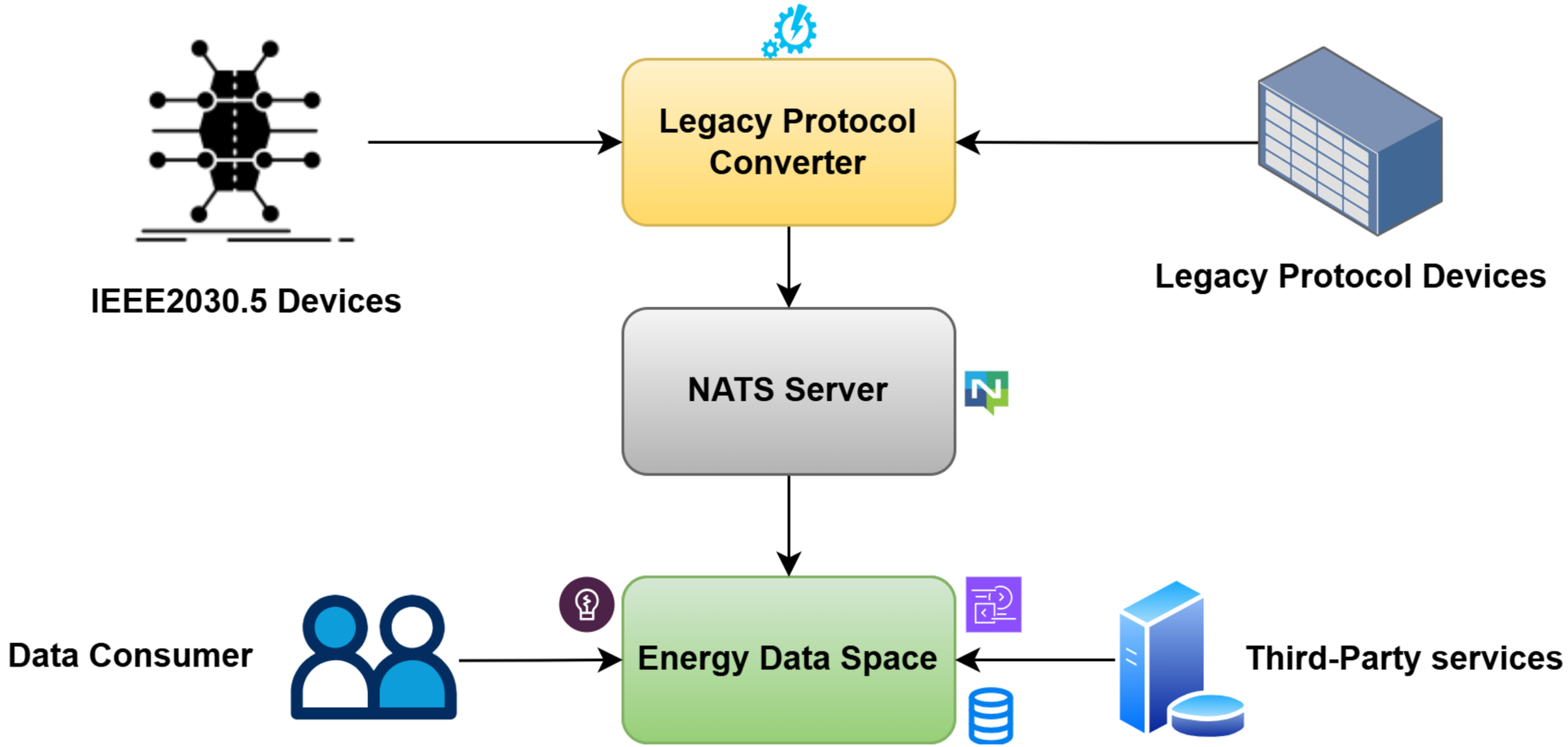
OneNet Data space Framework

IEEE2030.5 via NATS integration diagram



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OneNet Data space Framework

Roadmap & Next Steps

- Submission under LFE (ongoing)
  - Creation of a technical community for continuous development and maintenance
- Technical and Semantical Interoperability
  - Data Space Protocol implementation (ongoing)
  - Extensions of Vocubalaries and Standard Data Models
- Support for real-time communication
  - Additional Communication protocols and mechanisms
- Digital Twin Federation
  - Digital Twin Model exchange
  - Data Space for Digital Twin interoperability
- Common European Energy Data Space (CEEDS)
  - Integration and deployment with other DS Technologies (EDDIE, AIIDA, SIMPL…)

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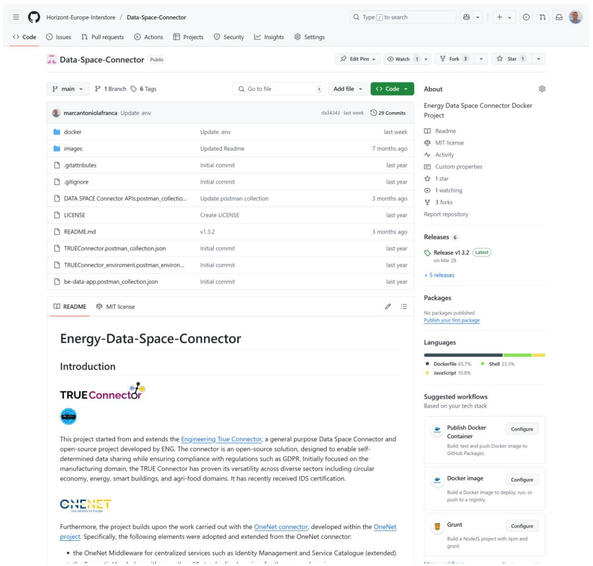
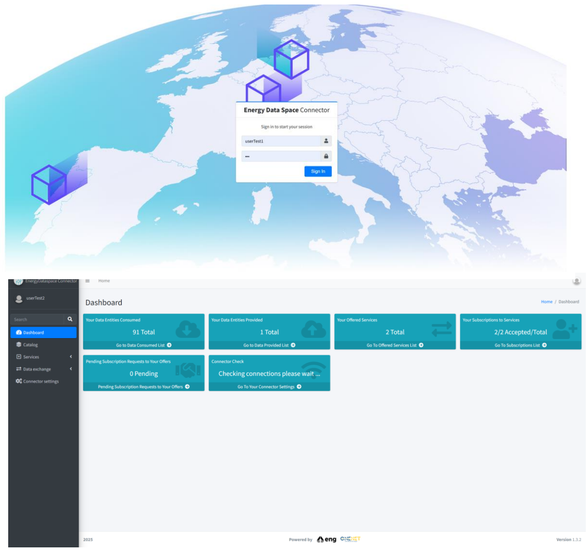
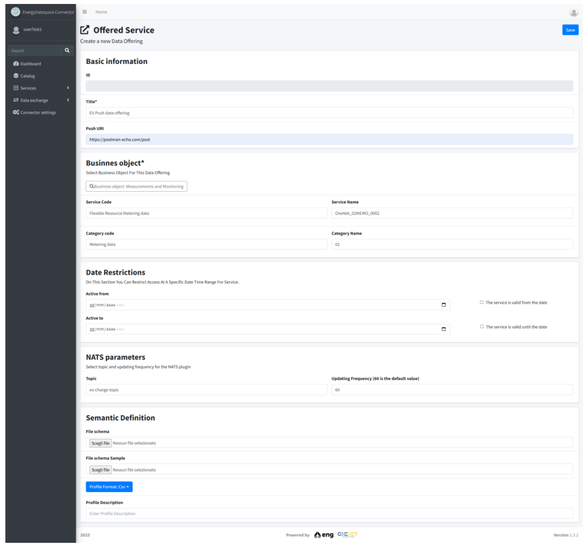
OneNet Data space Framework

Latest Version (v1.3.2) Live Demo

- Improvements to the GUI (e.g. the addition of the Service Catalog, detail fields, data table filtering)
- Push Flow Mechanism (external service integration)
- NATS protocol integration







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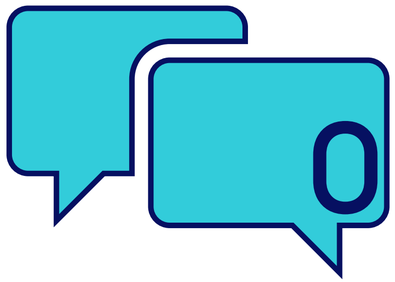

Open Mic Session

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Closing Remarks

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