“Cloud-Edge Machine Learning in the Swiss Energy Prosumer Pilot: Enhancing Social Acceptability and Energy Flexibility”

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HES-SO HEPIA
Large-Scale Distributed Systems (LSDS) group

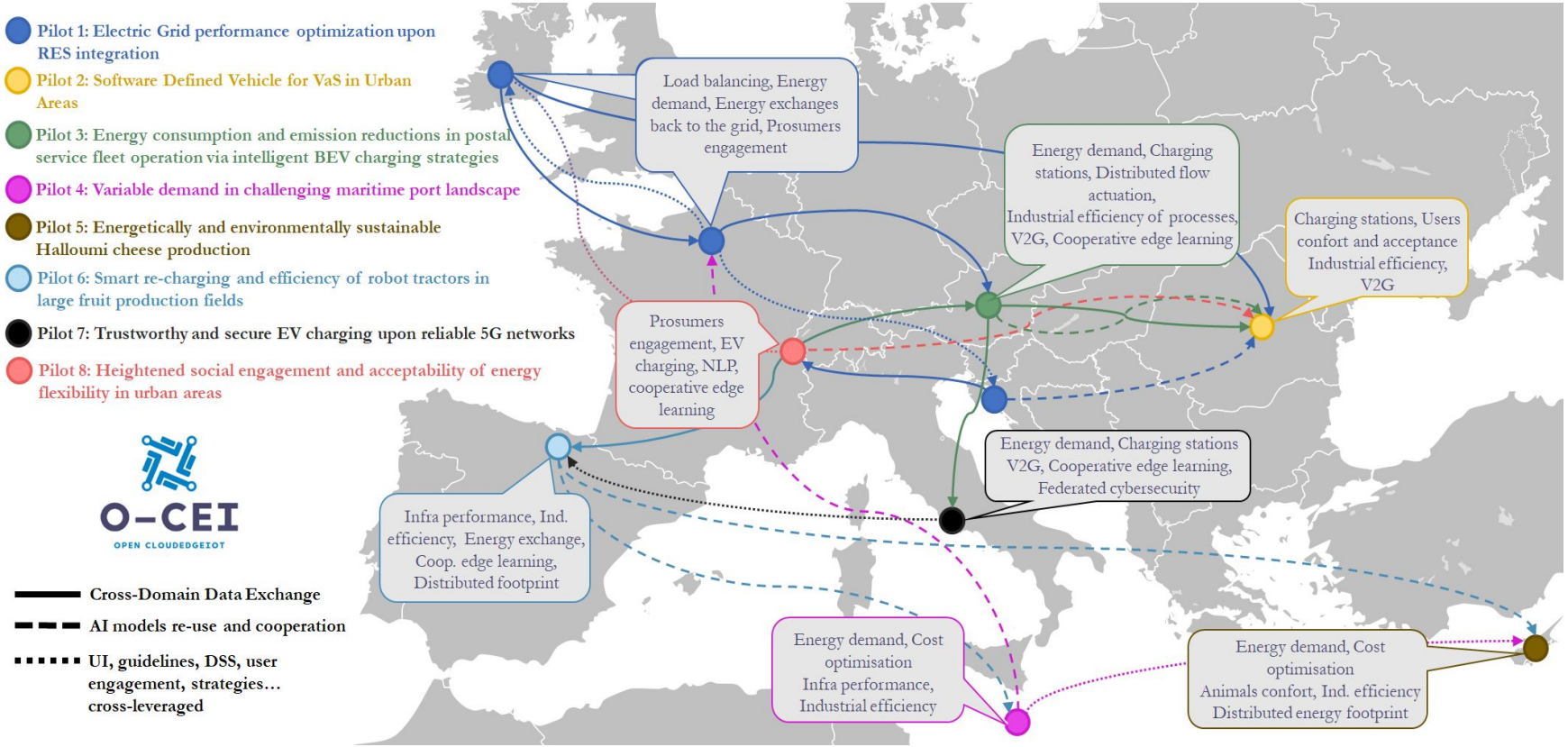
Open CloudEdgeIoT Project (O-CEI)

O-CEI

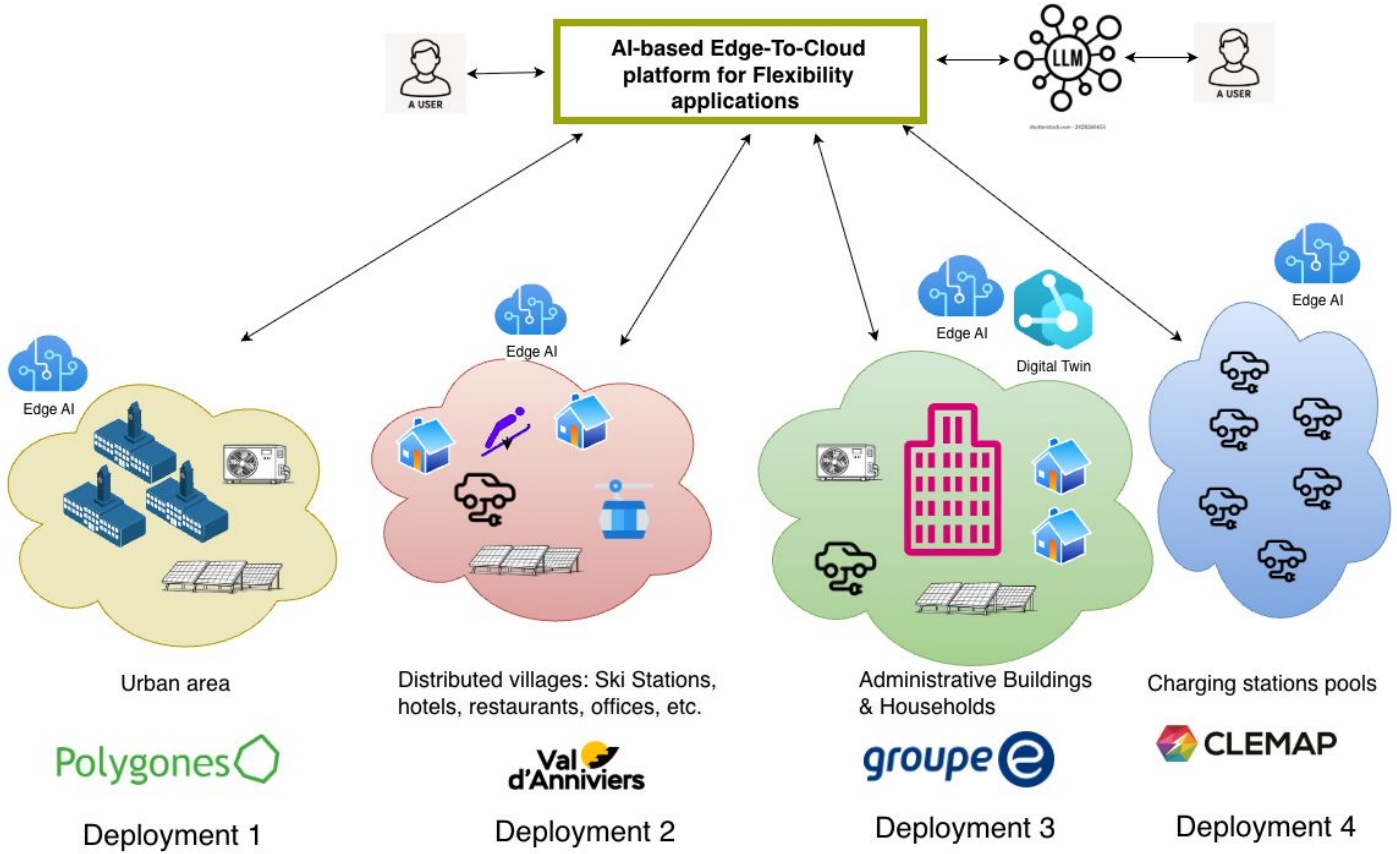
Integration and scaling project

https://o-cei.eu/

Open CloudEdgeIoT Project (O-CEI)



Swiss Pilot


A USER
AI-based Edge-To-Cloud platform for Flexibility applications
LLM
A USER
Edge AI
Edge AI
Edge AI
Digital Twin
Edge AI
Urban area
Distributed villages: Ski Stations, hotels, restaurants, offices, etc.
Administrative Buildings & Households
Charging stations pools
Polygones
Deployment 1
Val d'Anniviers
Deployment 2
groupe e
Deployment 3
CLEMAP
Deployment 4

Swiss Pilot


Basel
Zurich
St Gallen
Berne
Lucerne
Fribourg
groupe E
Davos
Lausanne
St Moritz
Sierre
Geneva
Val d'Anniviers
Polygones
Lugano

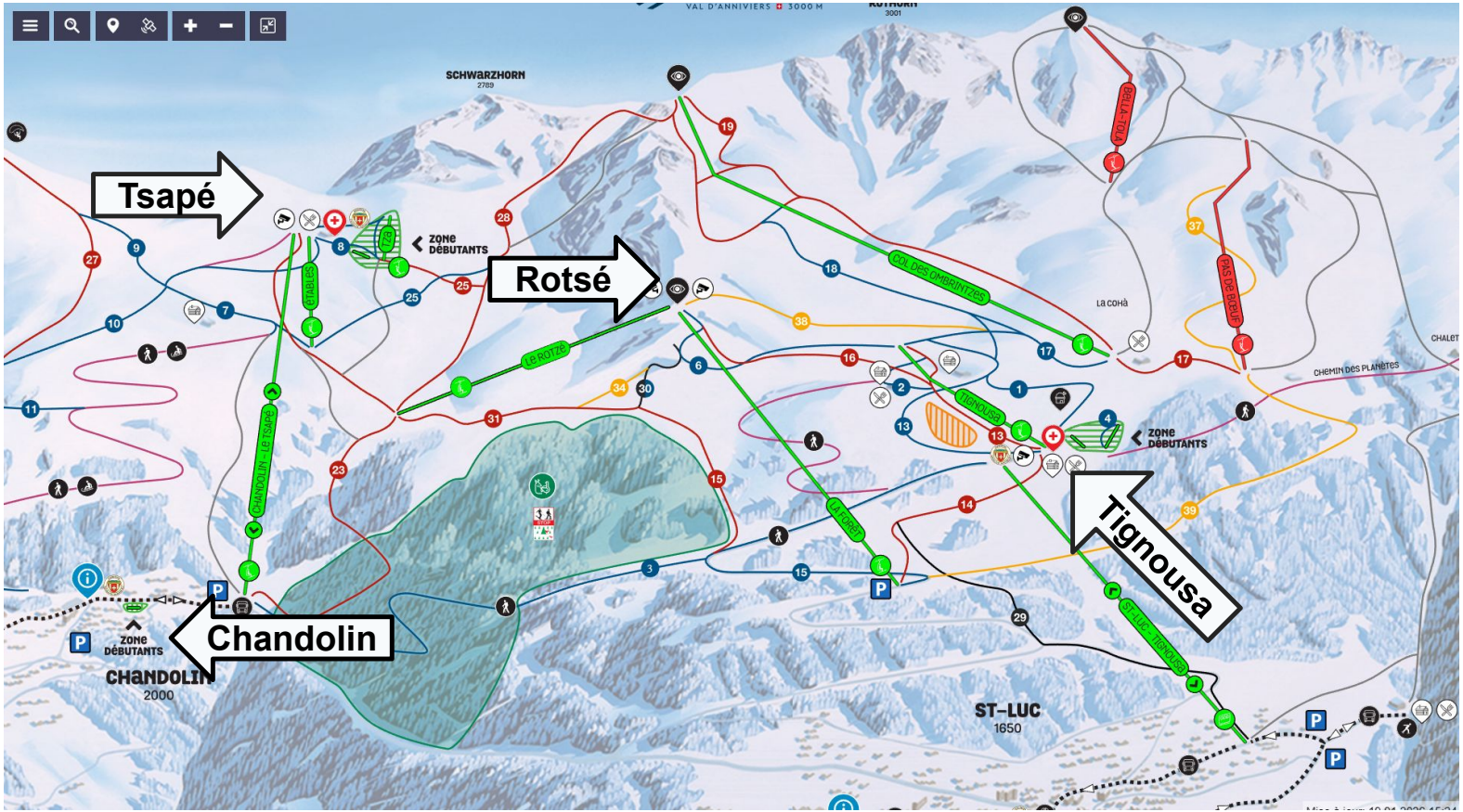
Swiss Pilot - Deployment

Les Vergers
Three buildings School (Gymnasium, Restaurant, classrooms): **7 Edge devices (since 2021)**

CODHA
20 buildings: **5 Edge devices (since 2023)**

POLYGONES
5-floor building with around 28 apartments: Large PV on roof. **8 Edge devices will be deployed by June 2026**

Swiss Pilot - Deployment



Swiss Pilot - Deployment

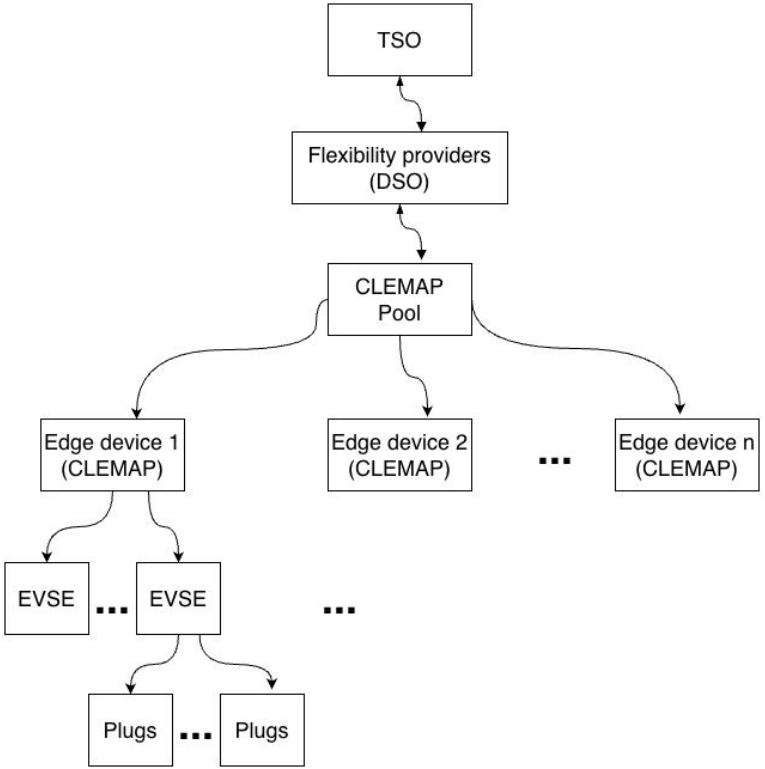
~22 buildings
EV: parking

~18 buildings
4 HP
3 EV

Deployment (15 devices) planned starting from Sept. 2026

~200 households
31 HP, 6 EV
48 PV installation

Swiss Pilot - Deployment



- 38 **CLEMAP Load Management**
- ~ 150 EVSEs
- ~200 plugs

Swiss Pilot - Technical

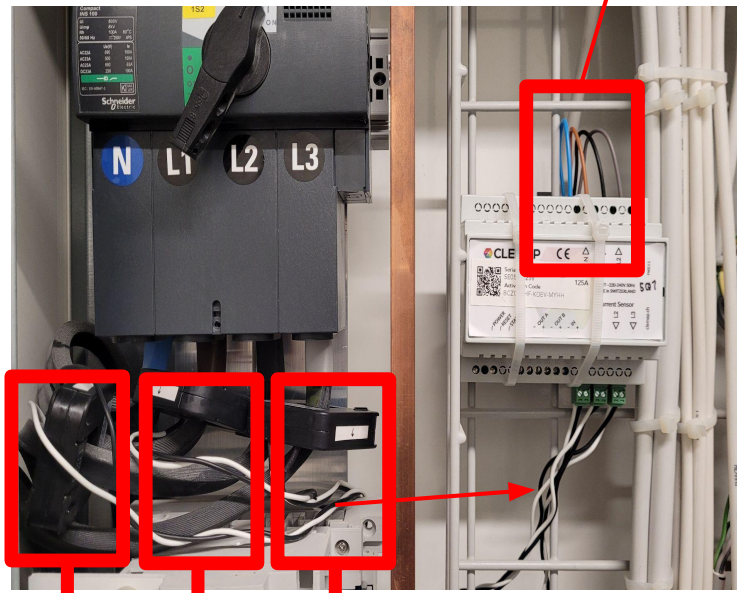
CLEMAP

CLEMAP Energy Monitor

- Onboard Raspberry Pi (Edge-IoT)
- Power (active, reactive), V, I, E
- Sampling rate up to 12 Hz

Current sensors

Voltage sensors



Swiss Pilot - Technical

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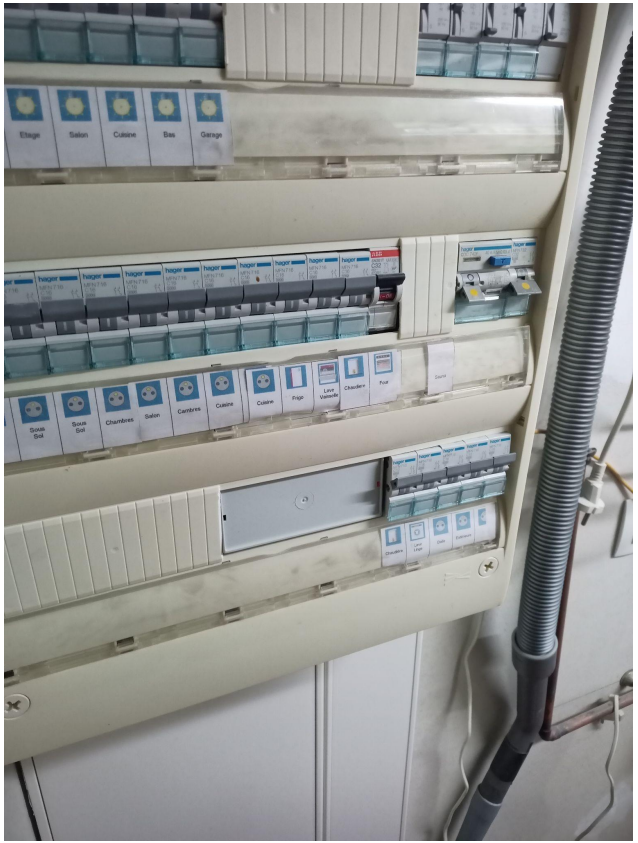

Swiss Pilot - Technical

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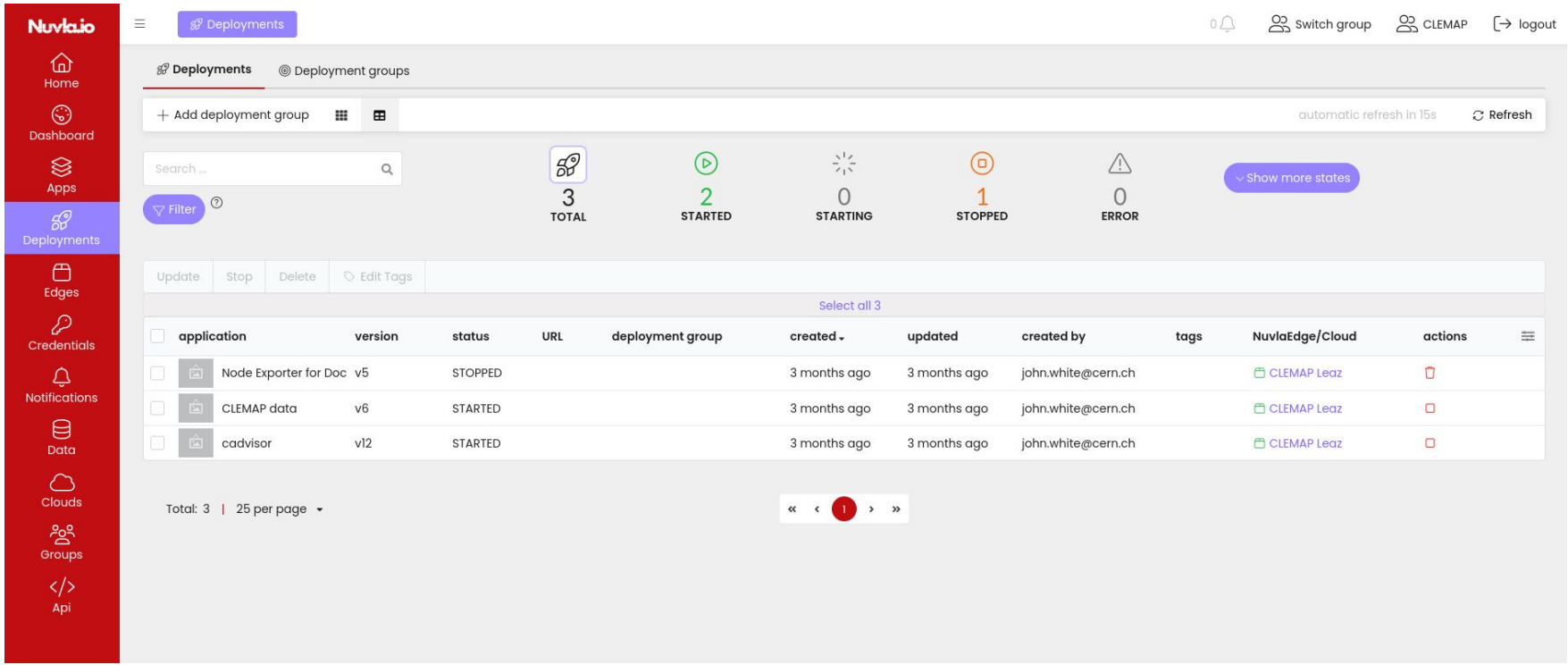
Swiss Pilot - Technical

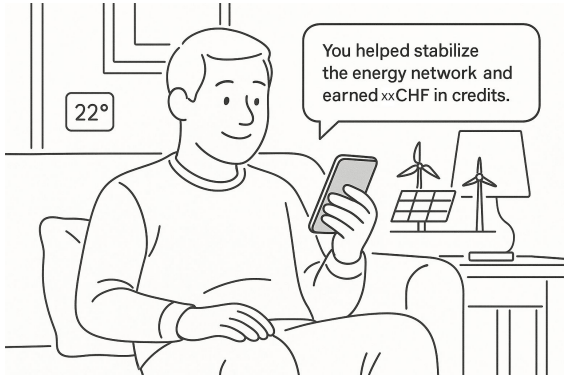


https://github.com/nuvla

Swiss Pilot - Scenarios

Bob receives a notification from his energy App

Bob adjusts his heat pump.



Bob receives a notification confirming his participation and showing his savings

- From collected data, **identify “Heat pump”**;
- Combine DSO-scheduled energy price;
- Arrive to a solution to save money/energy.
- Social acceptability. Awareness. Active pro-active participation.

Swiss Pilot - Scenarios

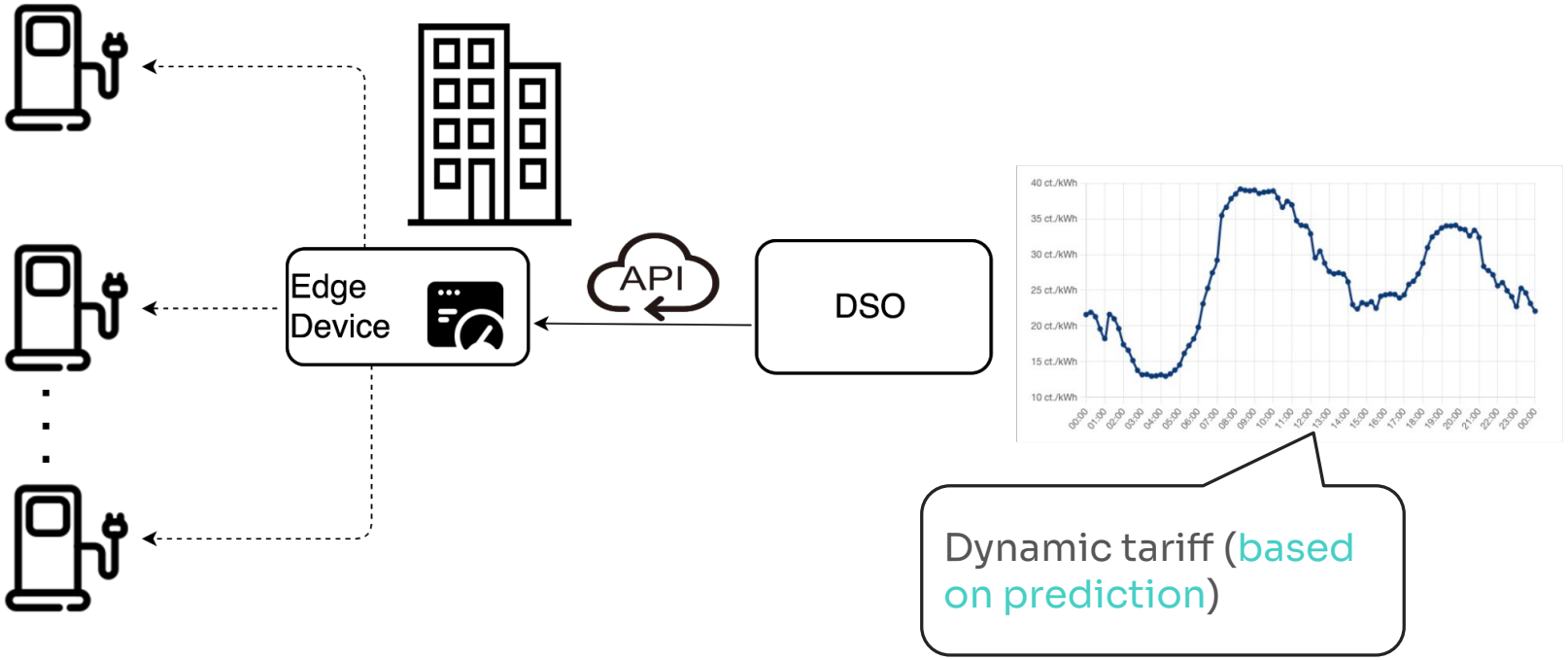
Emma opens her energy app to check the projected electricity prices for the next hours

Emma selects "***Smart Schedule***" and sets "***Car ready by 6:30 AM***."

Charging completed. You saved xx CHF and reduced your carbon footprint

- **Identify the EV charging patterns.**
- Social acceptability. How much data are you willing to give for efficiencies?

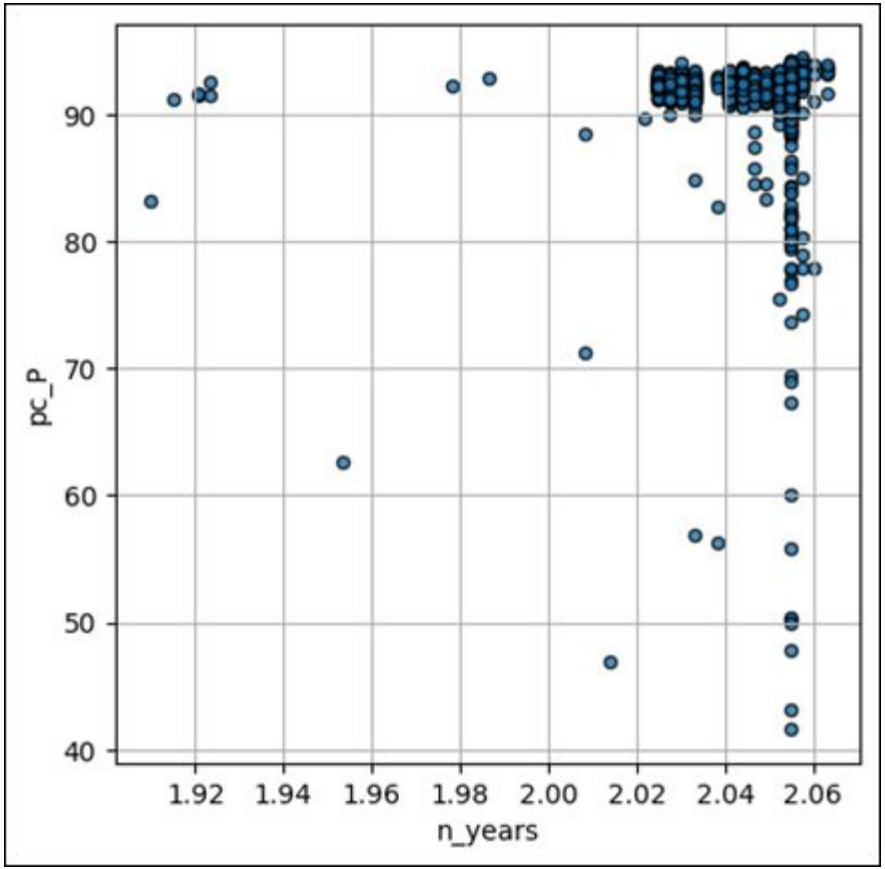
Swiss Pilot - Scenarios



- Sell energy flexibility to a DSO based on EV charging load predictions and dynamic tariff.
- **Identify EV charging patterns**

CLEMAP vs Smart Meter

CLEMAP	Smart meter
Up to 12Hz sampling	Typically 15m per sample.
V,I, P_active P_reactive, P_apparent, E	V, I*, P_s, P_total
Data coverage essentially perfect	Data coverage not perfect
Real-time data	Real-time data possible.



- Smart meter data from group-e

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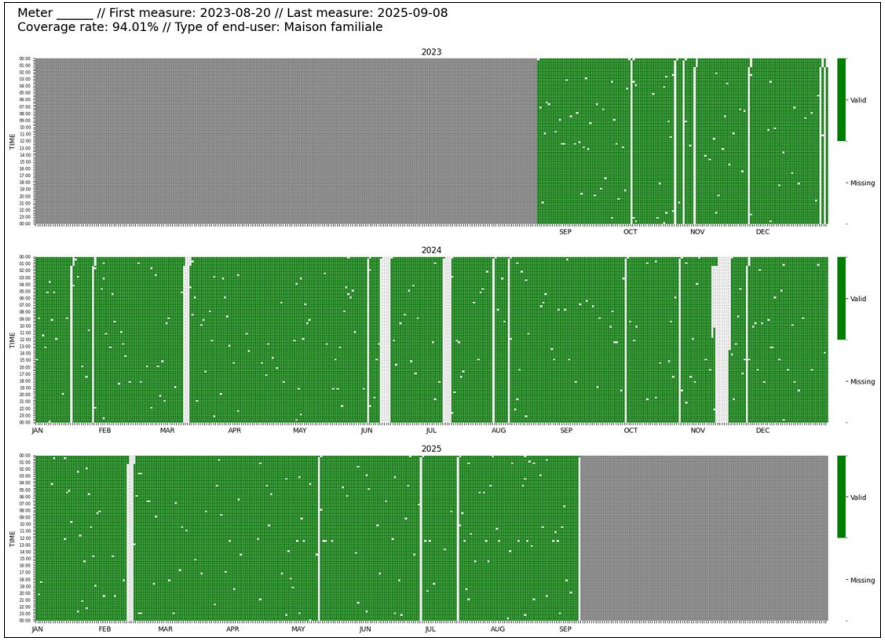

- Courtesy group-e

CLEMAP vs Smart Meter

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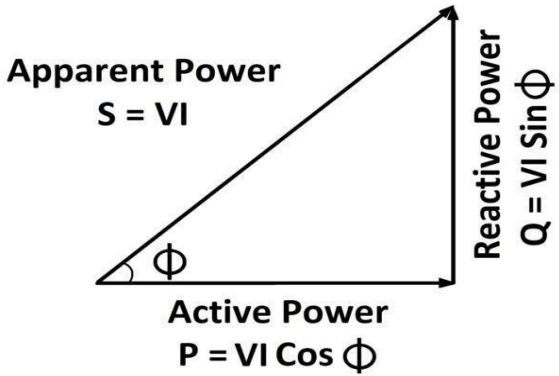


Active/Reactive power useful to discriminate loads…

Data

Grafana dashboard for Real time data

Data

Grafana dashboard for [Real time ML prediction]

Data Analysis: 24h

- 24h. Household. Periodic activity visible
- Quiet time… at night “background” visible.

Data Analysis: Morning

- Household: Morning activities.
- Appliances used… e.g. kettle.

Data Analysis: Mid-day

- Household: Morning activities.
- Appliances used… e.g. kettle.

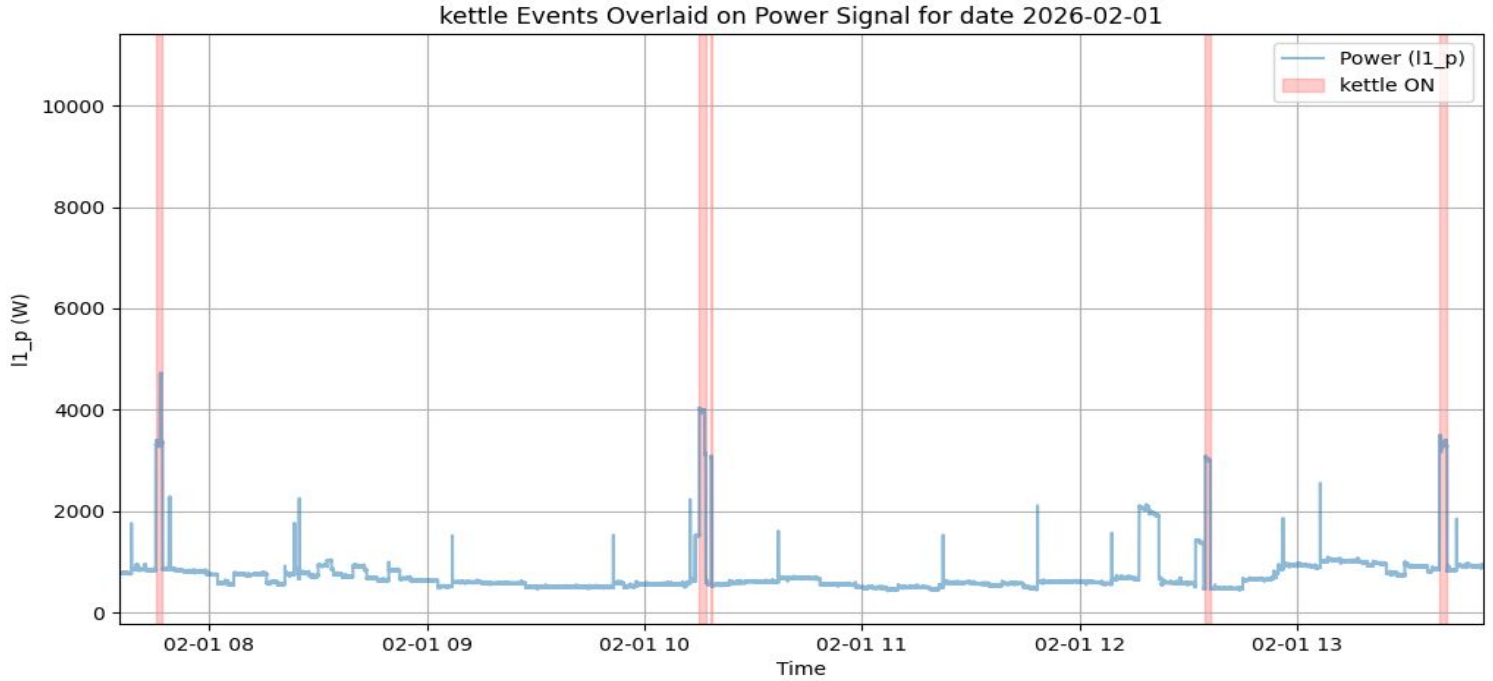
Data Analysis: Evening

- Household: Evening activities
- Appliances used… e.g. cooking.

Data Analysis: Procedure

- Split signal into training/test sets.
- Identify (appliance) load patterns in the training set.
- **Label training set (0,1), add features.**
- Train a classifier (window-feature + RandomForest) on labelled training set.
- Drop “unimportant” features.
- Re-train on labelled training set.
- Evaluate model on the labelled test set.
- Show results.

Data Analysis: Labelling



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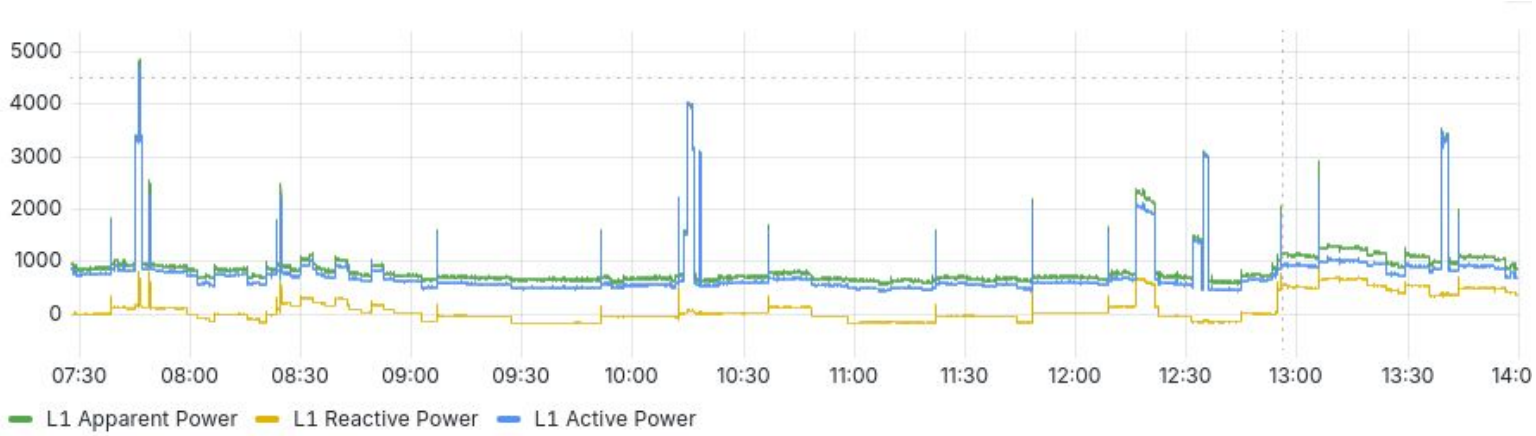

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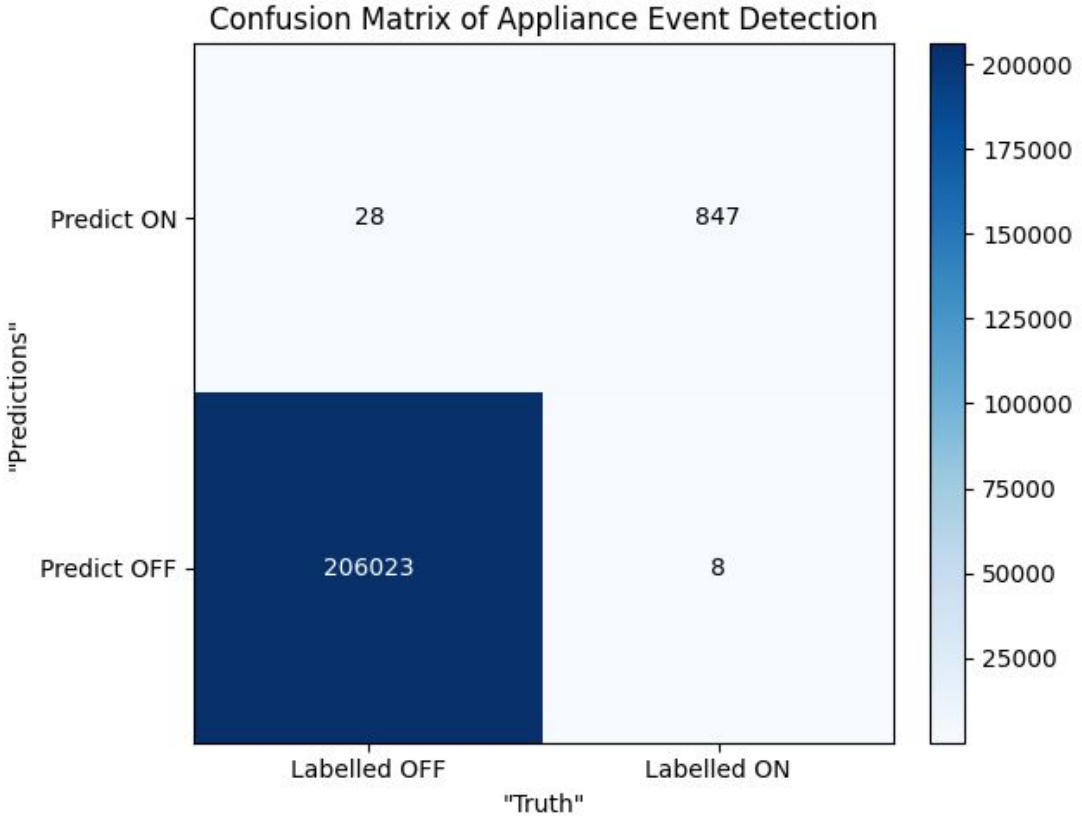
- Evaluate model on the labelled test set.
- **Show results.**

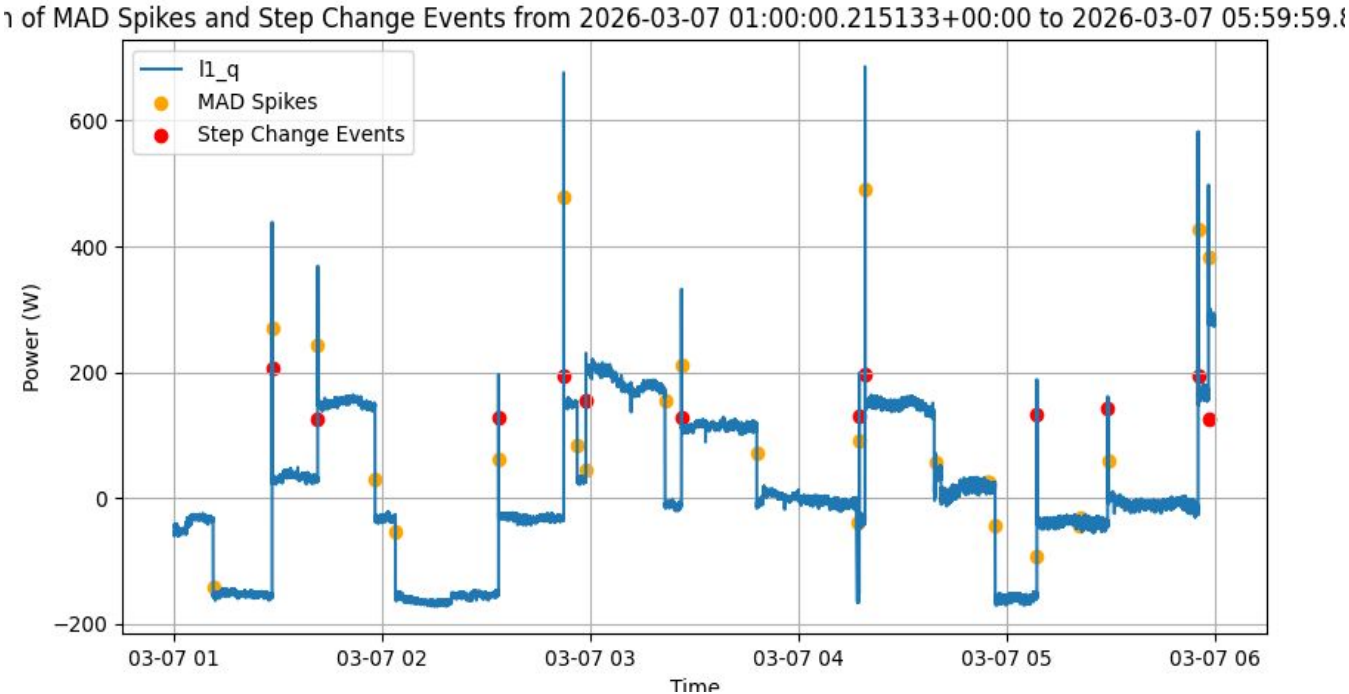
Data Analysis: Evaluation



Data Analysis: Night (Quiet) time

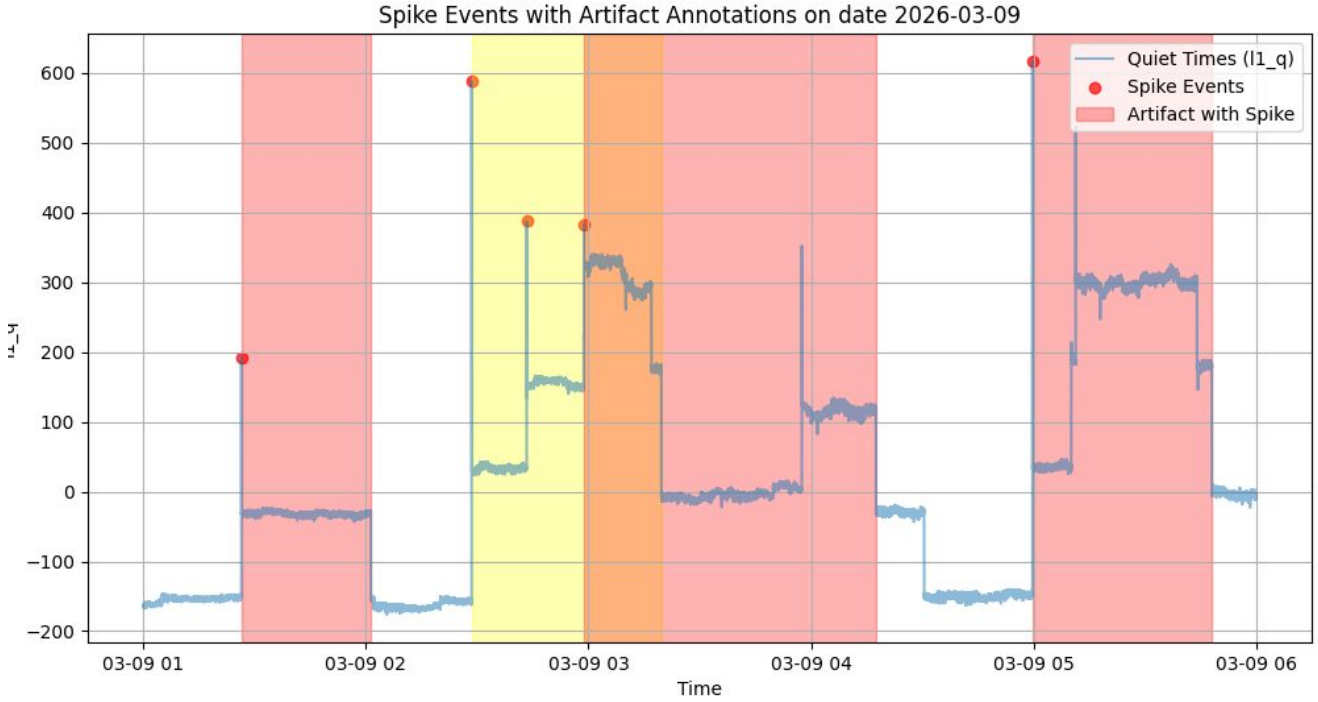
- 24h. Periodic activity visible
- Quiet time… at night “background” visible.

Data Analysis: Night (Quiet) time



- Detect power spikes and drops in reactive power series. Quiet times.
- Mean Absolute Deviation and power steps.

Data Analysis: Night (Quiet) time



- Identify the Spike and power step.
- Predict the duration of events in the test sample.

Data Analysis: Future

- Extend to identify “all appliances”.
- Need work to create a labelled validation set (!).
- Refine background studies to remove repeating signals.
- Predict appliance usage.
- Predict overall energy load.

Thank you

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