



Time Series Analytics for Electricity Consumption Data

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Adrien PETRALIA^{1,2}

Supervised by: Philippe CHARPENTIER², Themis PALPANAS¹

¹Université Paris Cité, Paris, France

²EDF R&D, Palaiseau, France



Background: Efficient Energy Management

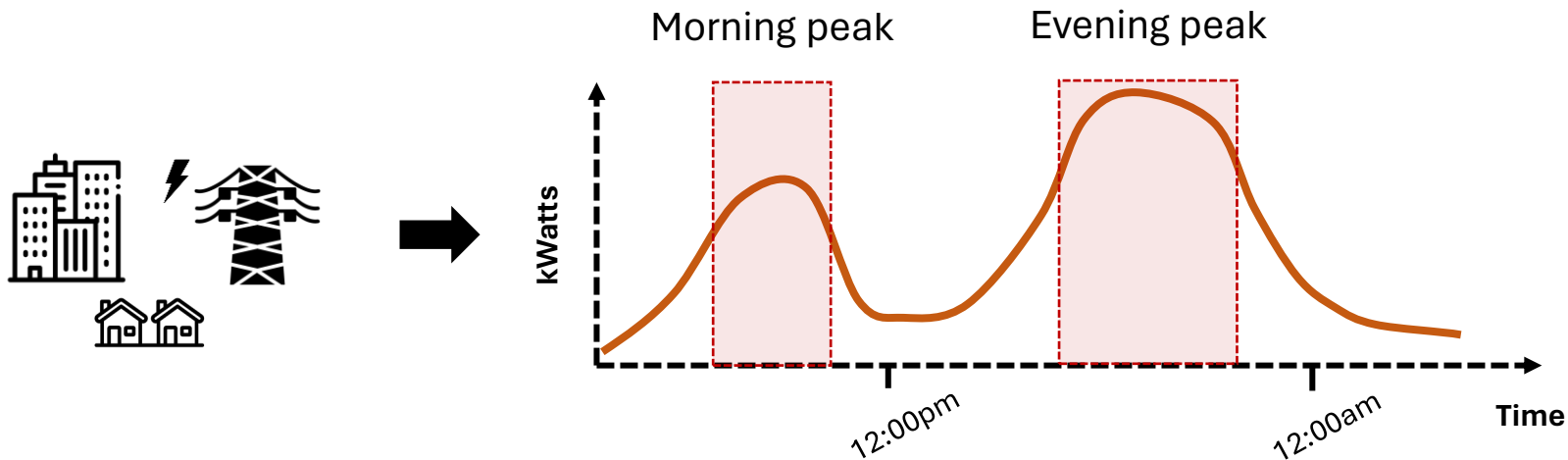
Energy savings is crucial to fight against climate change



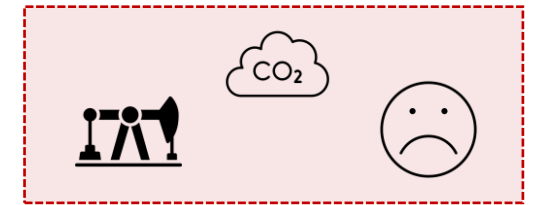
In the European Union (EU), **individual households** represented **26%** of final **energy consumption**



Electricity accounted for a **quarter of total households energy consumption**



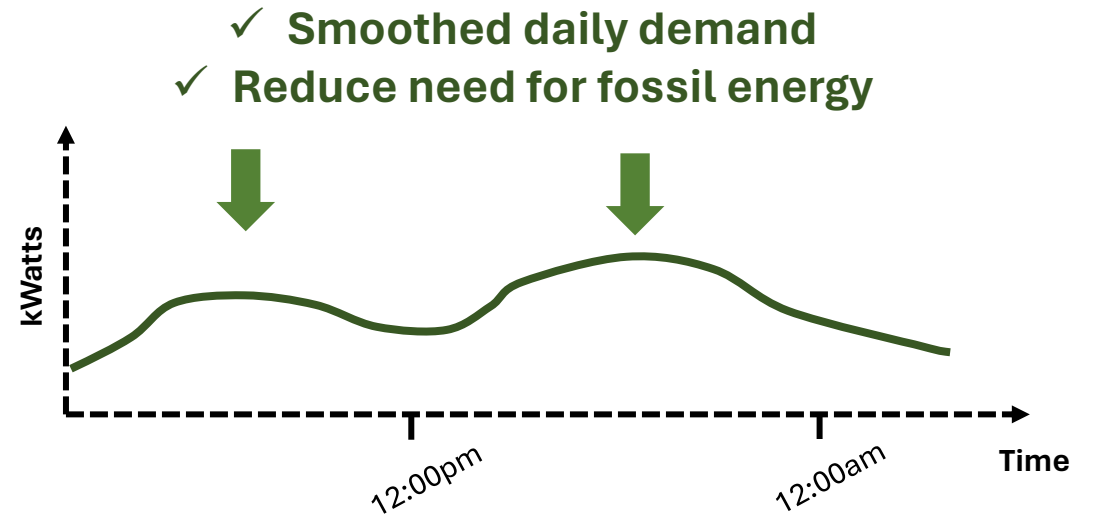
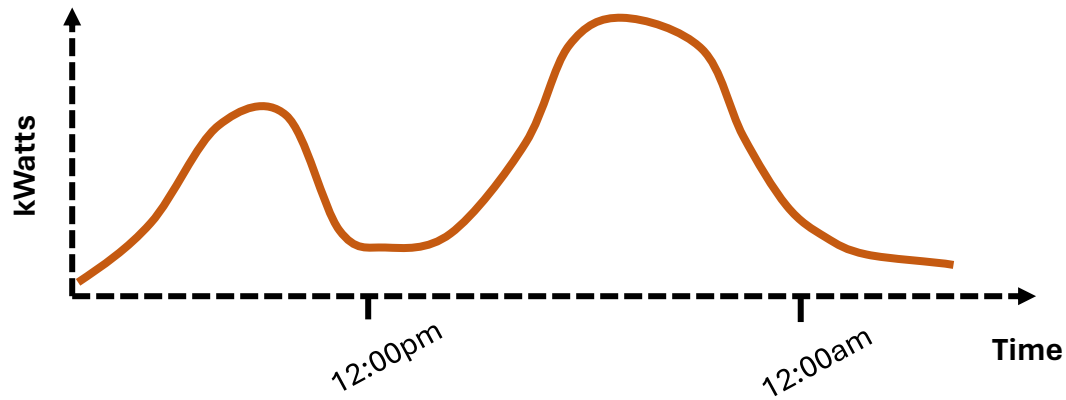
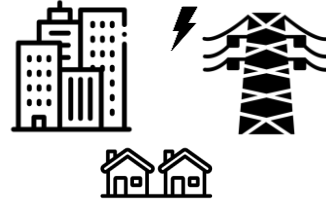
Typical **daily electricity grid demand** (load curve)



Use of **fossil energy** (oil, coal) to produce electricity to **absorb the peaks in demand**

Background: Efficient Energy Management

Reducing peak demand

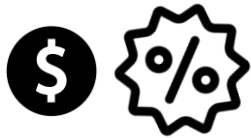


Electricity suppliers need to play an **active role in this process**

Background: Efficient Energy Management

How to convince clients to **change their consumption behavior** ?

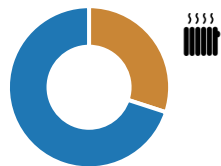
By offering personalized contracts



- 50% discount to charge your **electric vehicle** by night
- 50% discount to reduce your **heater usage** during peak hours



By providing detailed feedback about their consumption



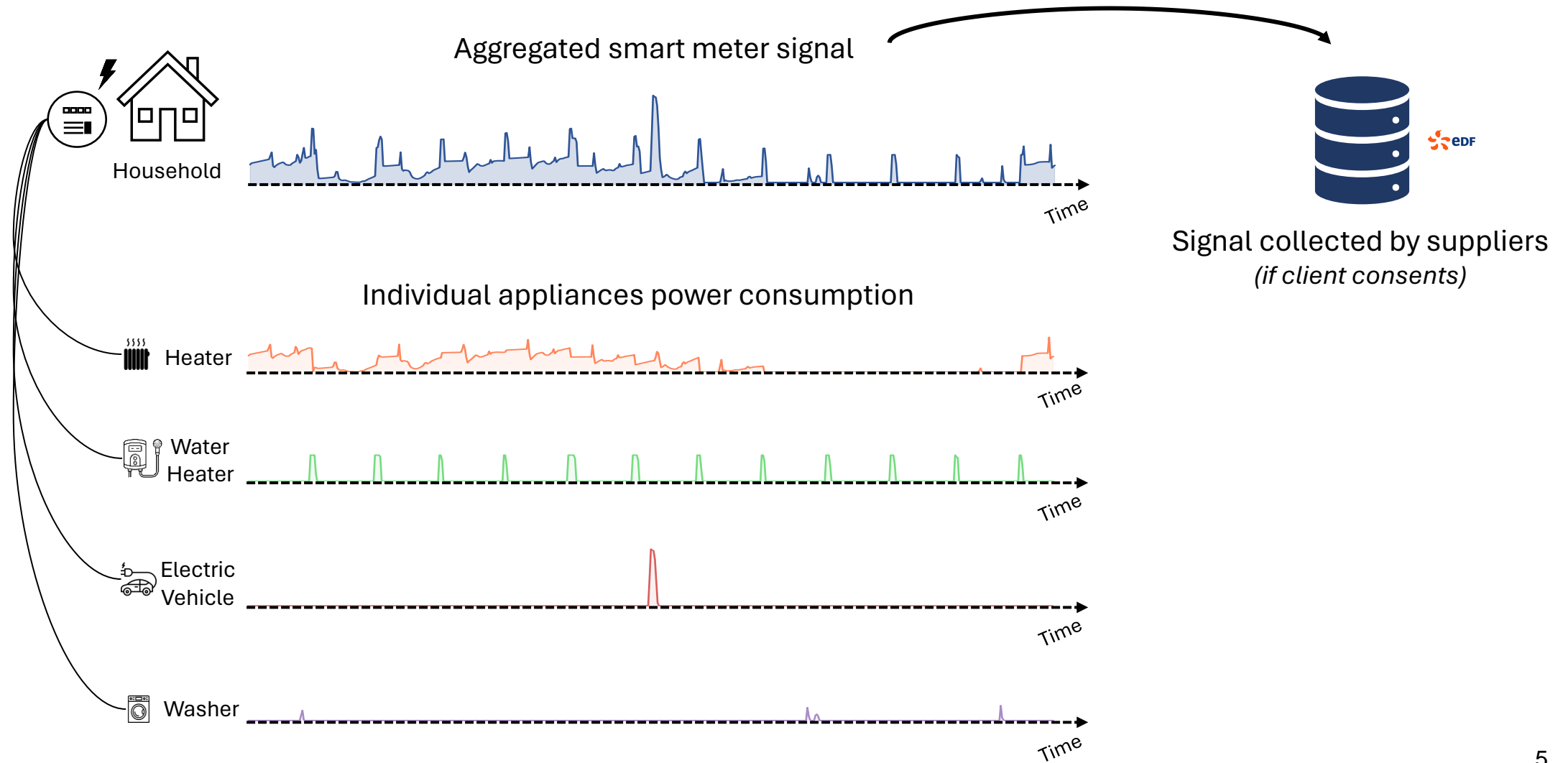
Household
electricity consumption

How much does your heater **cost you** per month?

Solutions/advice based on customers' characteristics

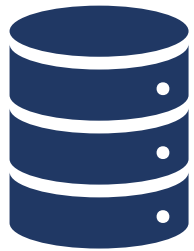
Background: Smart Meters Deployment

Millions of Smart Meters deployed in **individual households**

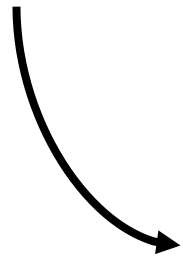


Challenges

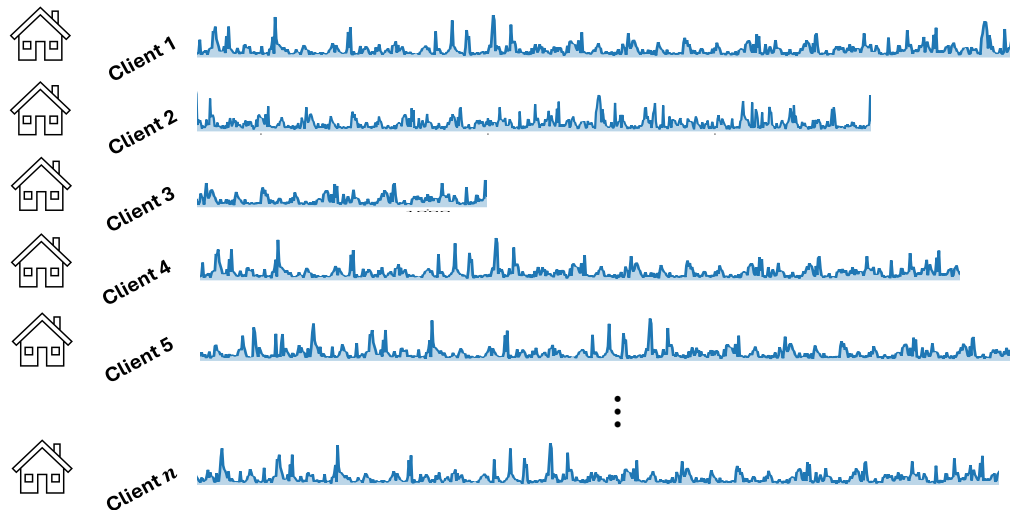
These data are store in large **electricity consumption databases**



**Electricity
consumption database
(Millions of clients)**



Recorded smart meter consumption



Characteristics

*Which appliances are present
in the house?*

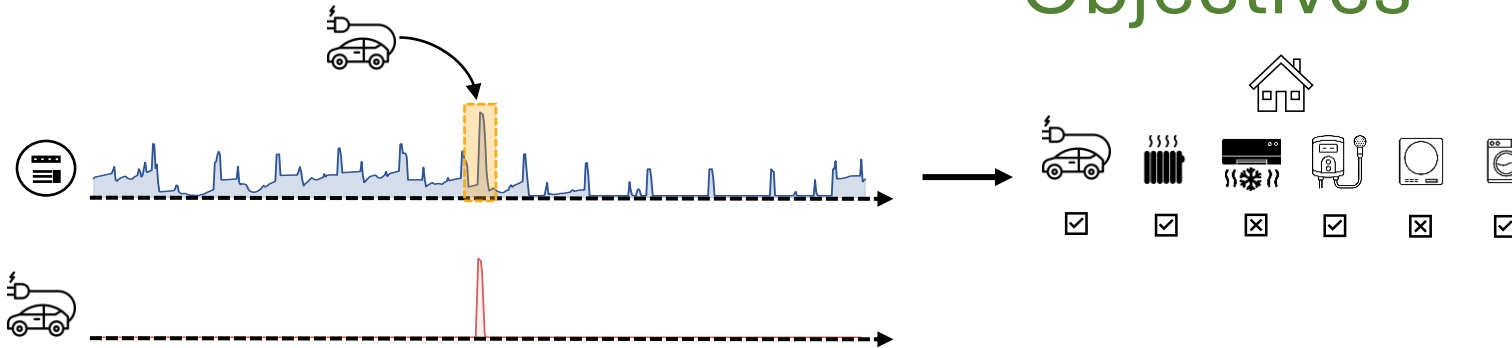
How the client use them?

*What proportion of
consumption does each
appliance account for?*

Challenges

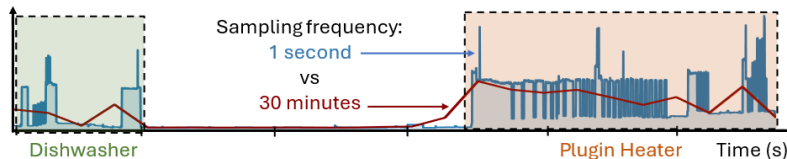
Can we propose *targeted* and *scalable approaches* for *electricity consumption time series analytics*?

Objectives



1. **Detect** appliances present in the house
2. **Localize** appliance's activation time
3. **Estimate** appliance's consumption

Challenges



Smoothed signal due to smart meter
very low frequency



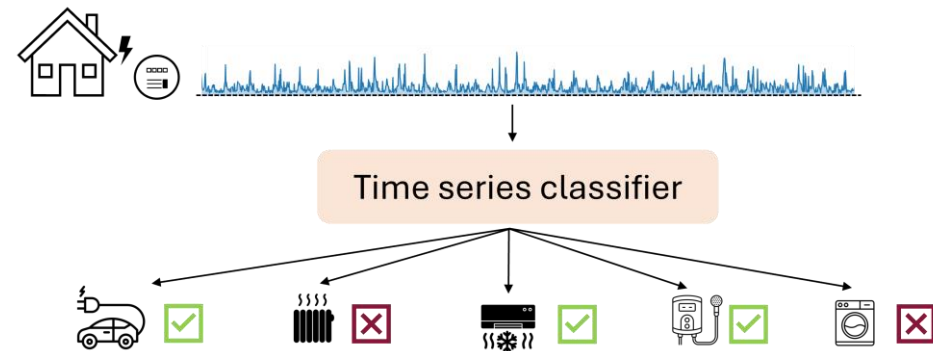
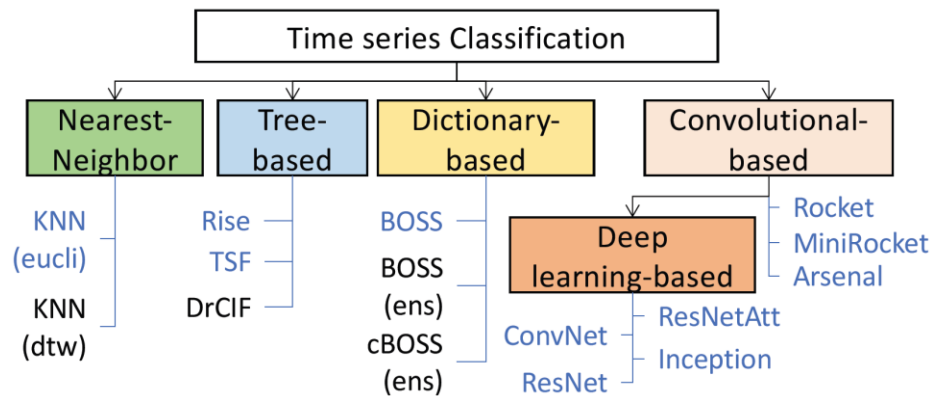
Few labeled data
available



Large electricity
consumption
database

Proposed solution: Appliance Detection as TSC

Appliance detection as a binary Time Series Classification (TSC) problem

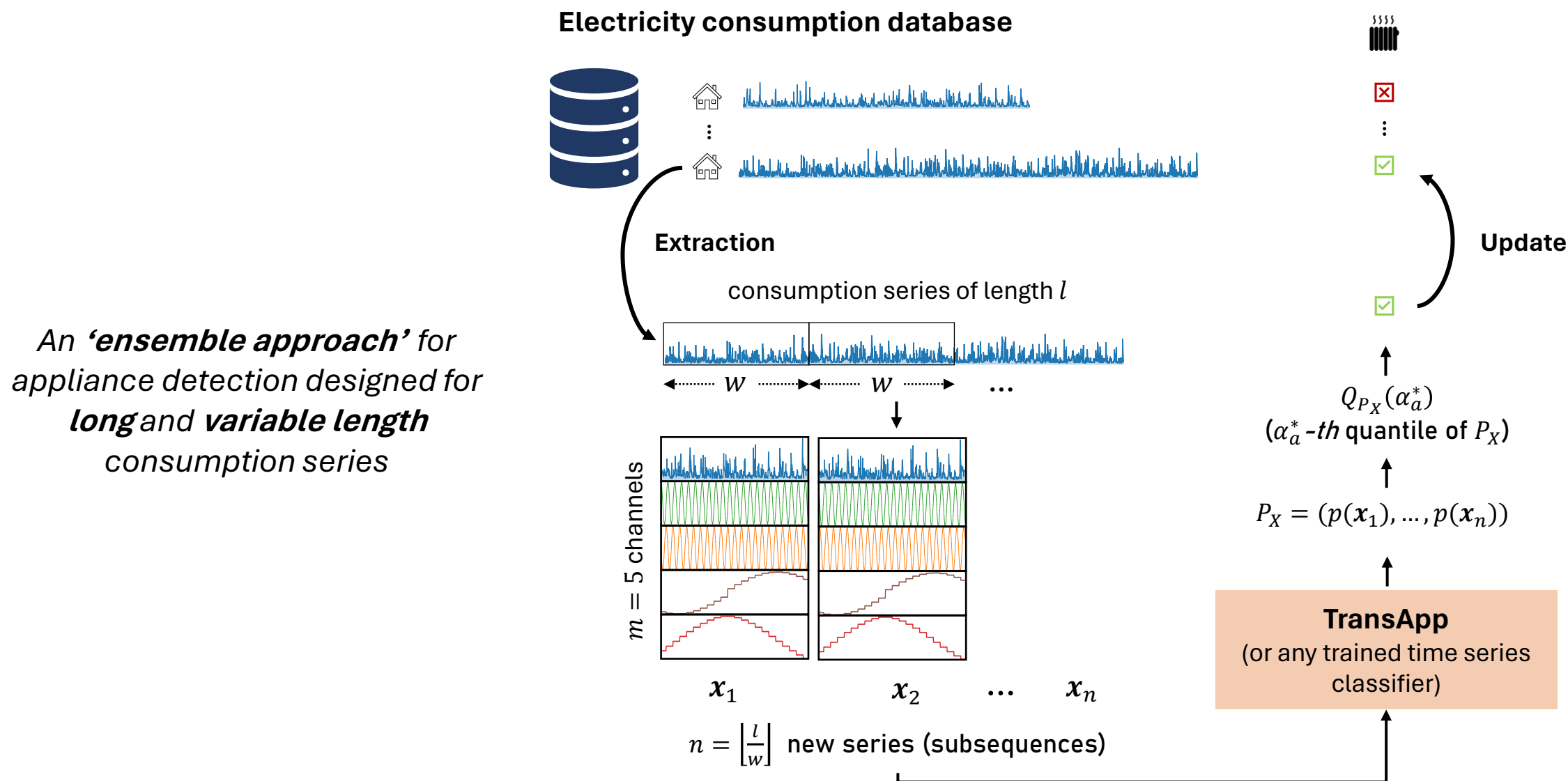


Deep learning-based approaches are the **most accurate** and **scalable** to **large dataset** of **long-time series** (i.e. Convolutional-based as Arsenal, ResNet, InceptionTime) [Petràlia et al. 2023]

However, reported **accuracies** are still **rather low** for real-world applications...

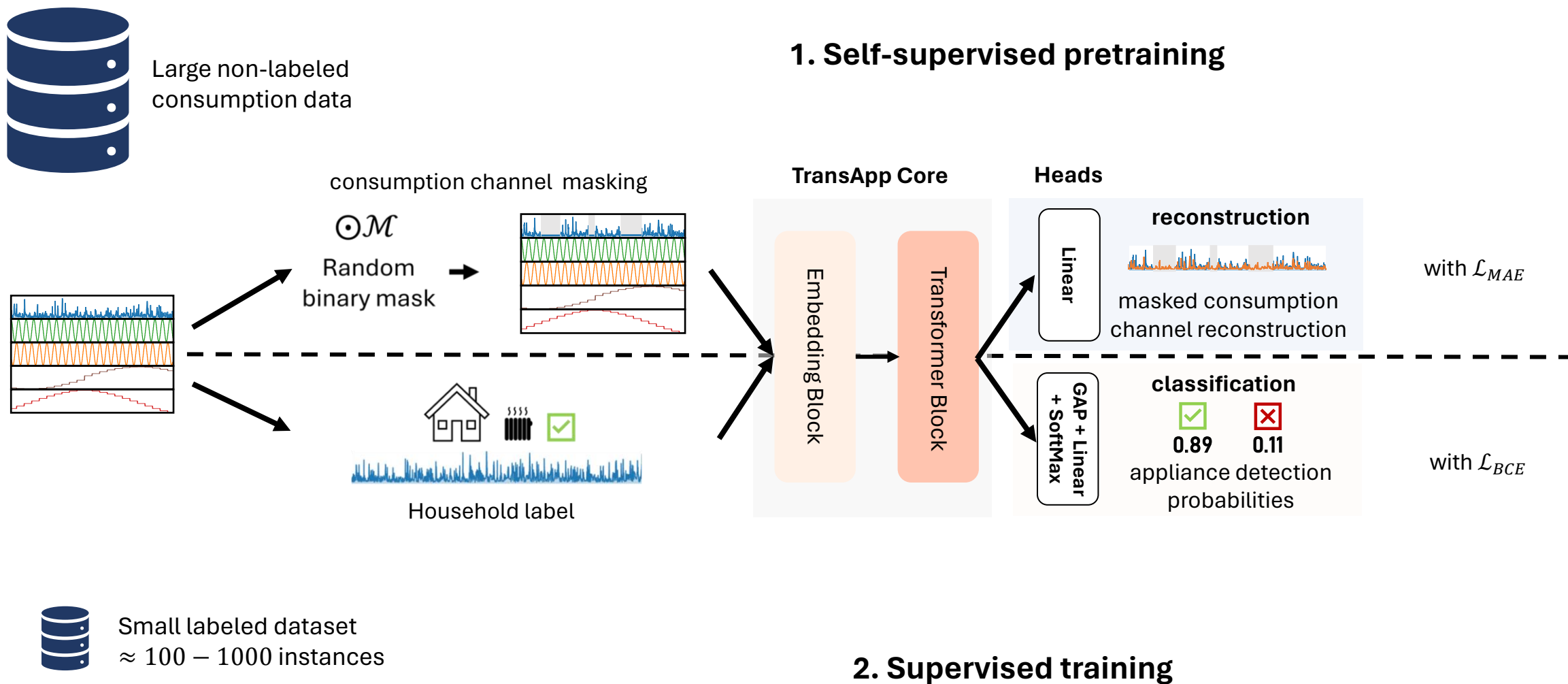
Proposed solution: ADF&TransApp

The Appliance Detection Framework: enhances classifiers' performance on appliance detection tasks



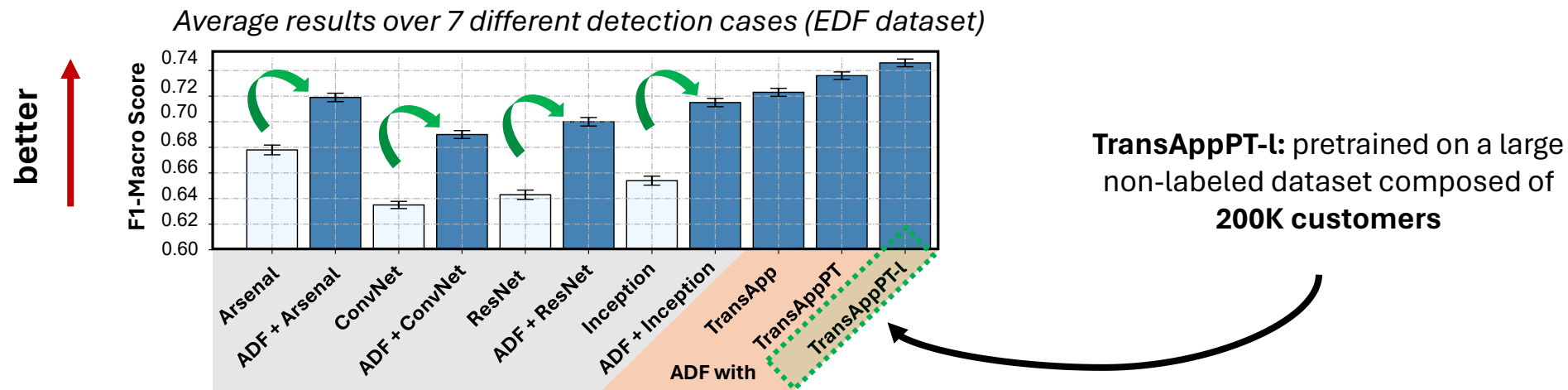
Proposed solution: ADF&TransApp

TransApp: a pre-train deep-learning time series classifier

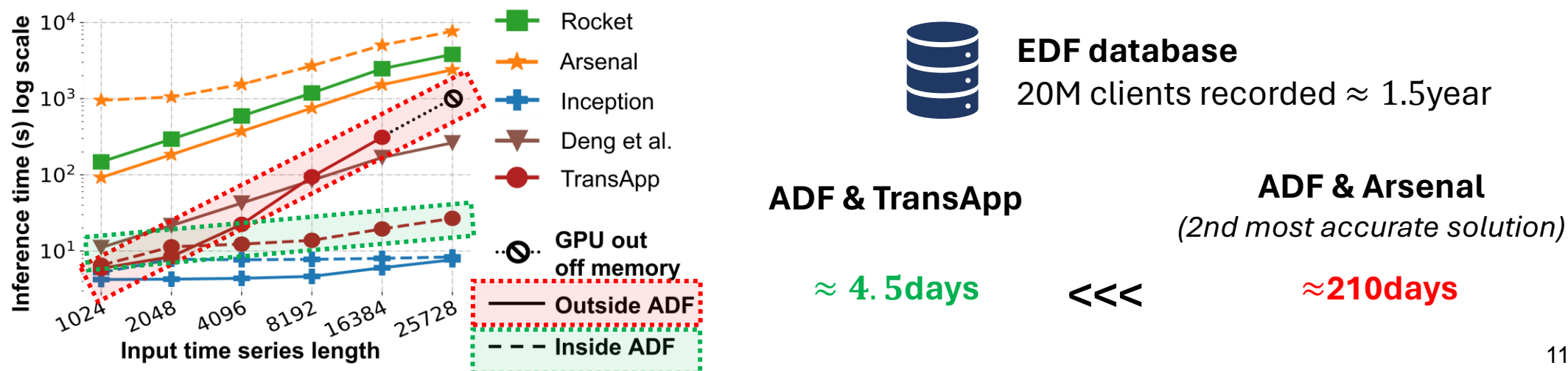


Proposed solution: ADF&TransApp - results

Appliance detection accuracy results

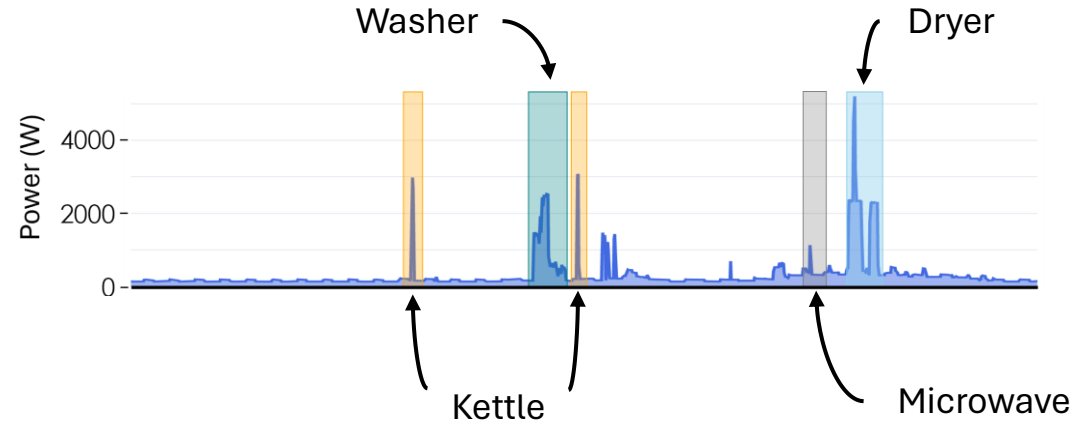


ADF makes TransApp scalable to large electricity databases of long consumption series

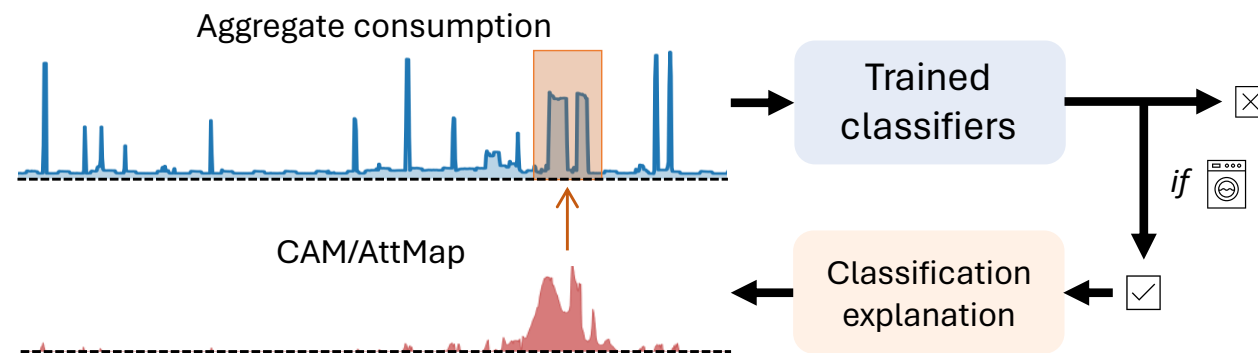


Ongoing work: DeviceScope

ADF&TransApp can accurately detect the appliance presence, but...
can we **localize** the appliance activation time?



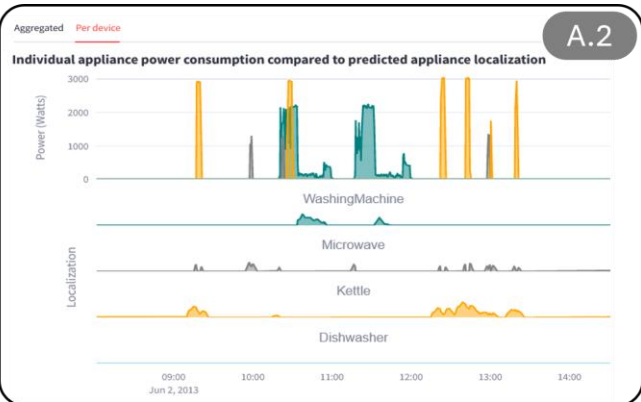
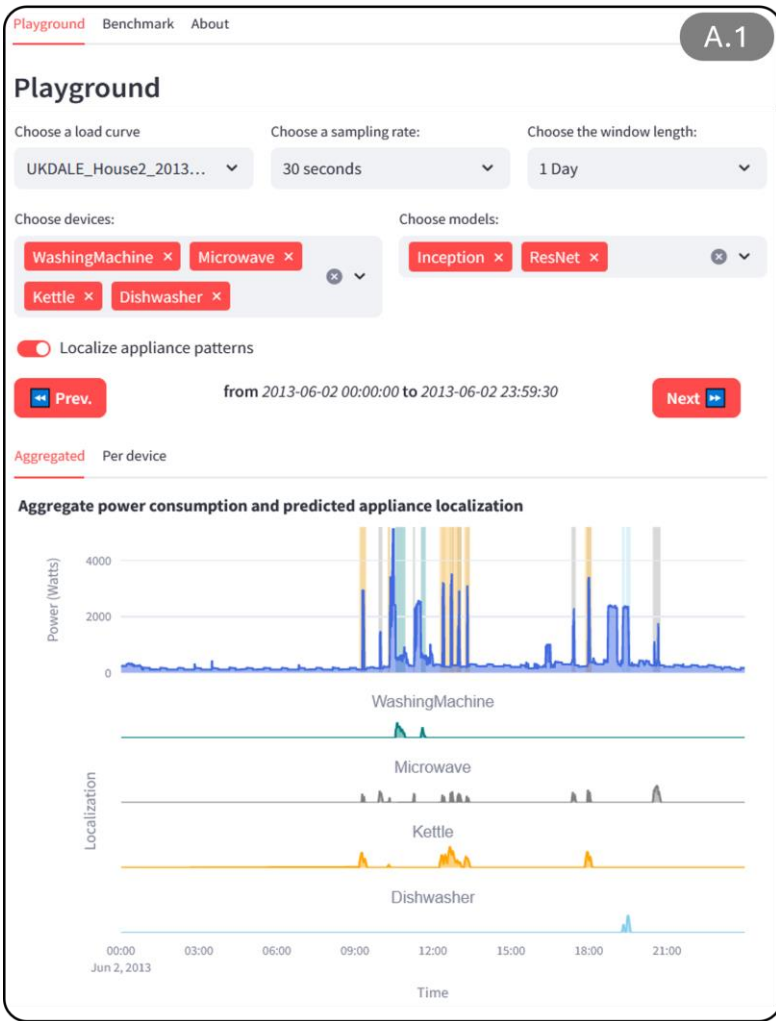
TSC combined with **explainable AI**



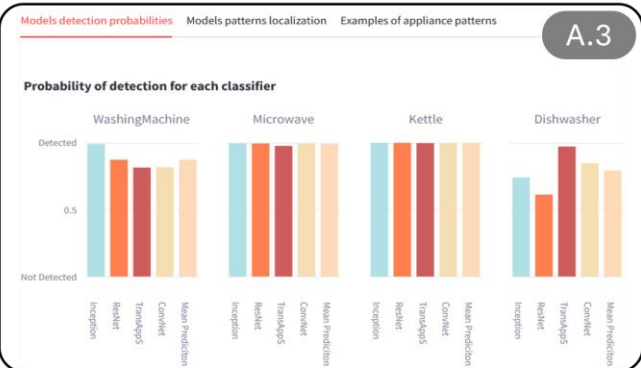
Ongoing work: DeviceScope

DeviceScope: An interactive system to browse, detect, and localize appliance patterns in electricity consumption time series

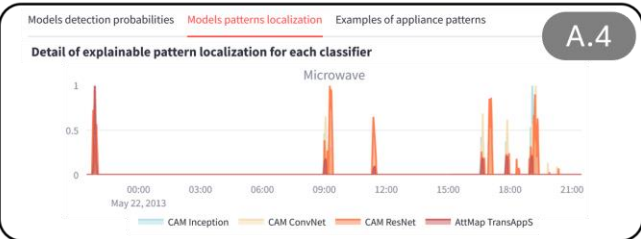
Consumer's
consumption
series
visualisation



Appliance activation
time **localization**



Appliance probabilities
detection

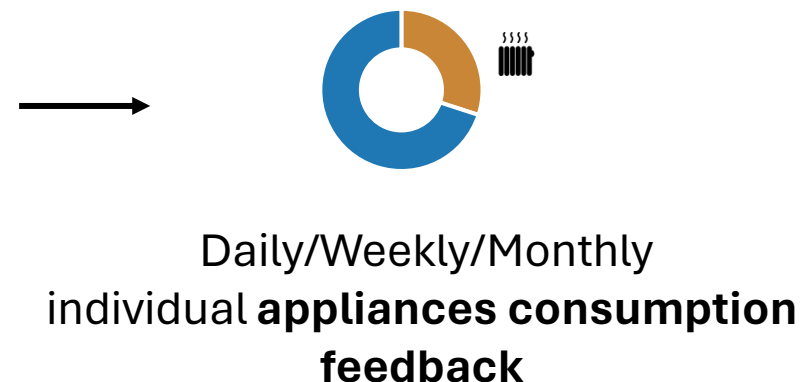
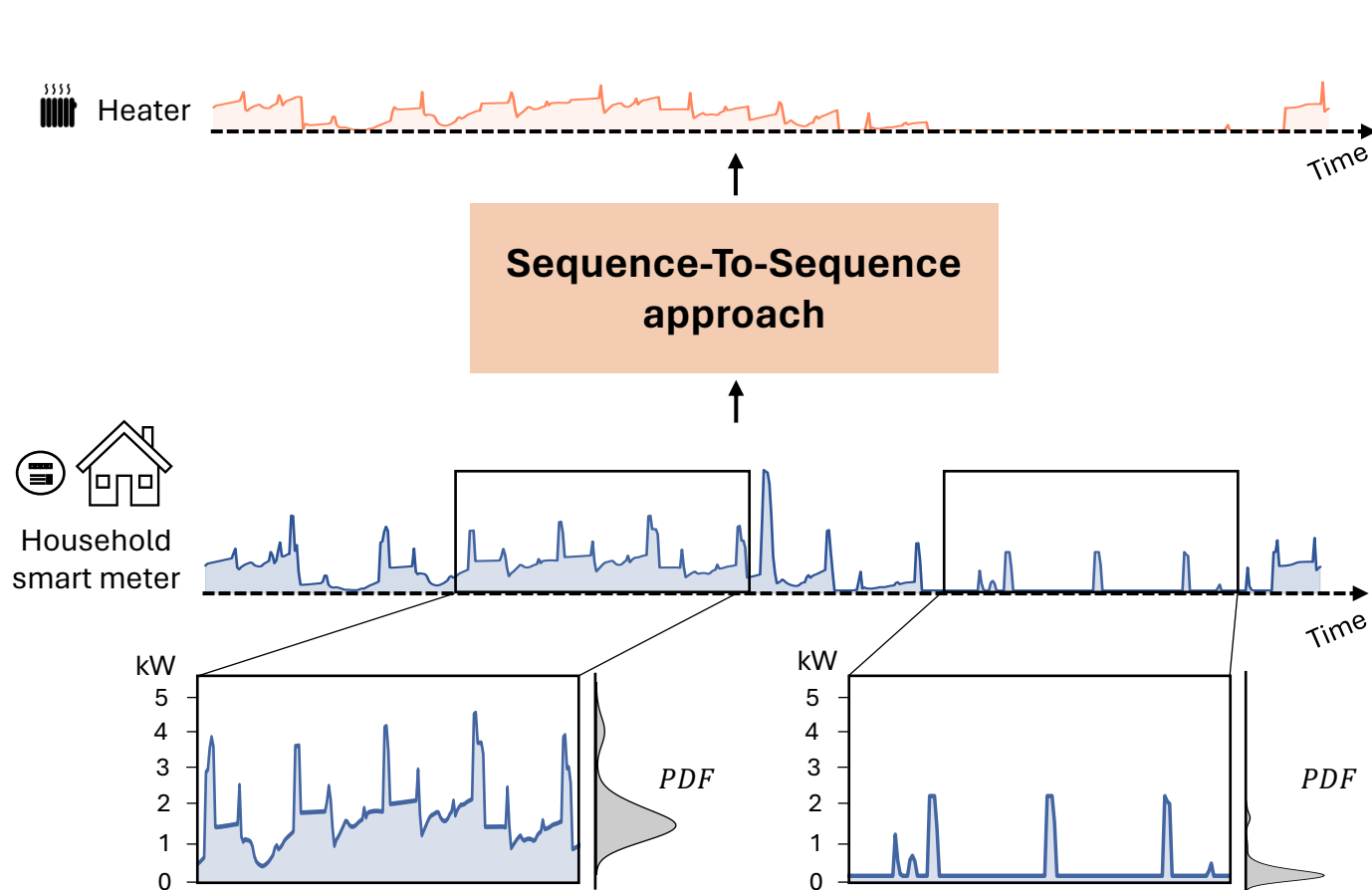


<https://devicescope.streamlit.app/>

DeviceScope application overview

Ongoing work: Energy disaggregation

Estimate appliances individual power consumption



The current proposed solutions operate on **small subsequences of an entire consumption series**

It induces a **data drift** that impacts model performance

We recently proposed a **novel deep-learning architecture** for **energy disaggregation** that takes into account **the non-stationarity nature of electricity consumption data**

To wrap up

- The **large amount of electricity consumption data** and **the lack of labels** make it challenging to train accurate solutions
- This PhD work proposes **new scalable solutions** for **electricity time series analytics**
 1. **Appliance detection** can be cast as a **TSC problem**
 2. Our **ADF&TransApp** is **an accurate and scalable solution** to detect appliances in electricity consumption series
 3. Our **DeviceScope** effectively **localizes appliance use**
- **Future research direction:** large electricity time series model

Thank you!

Contact: adrien.petralia@gmail.com



*Want to learn more about
this PhD work?*



*and feel free to join the
ADF&TransApp paper presentation
tomorrow 😊*