



# Time Series Analytics for Electricity Consumption Data

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# Background: Efficient Energy Management

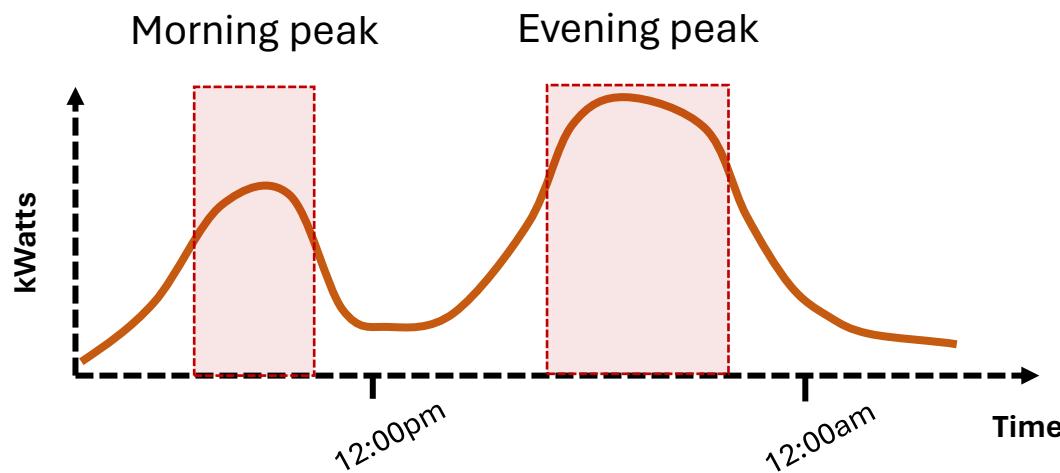
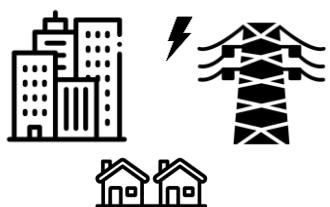
## Energy savings is crucial to fight against climate change



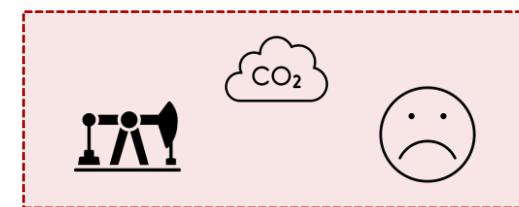
In the European Union (EU), **individual households** represented **26%** of final **energy consumption**



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



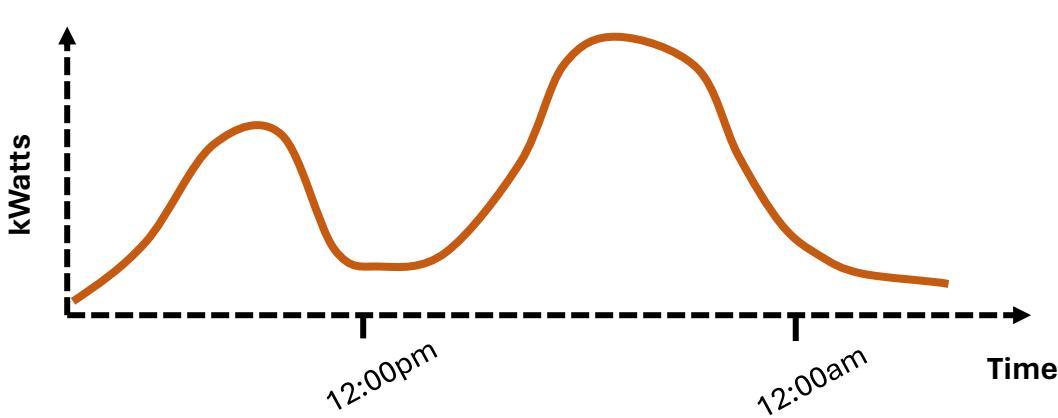
Typical **daily electricity grid demand** (load curve)



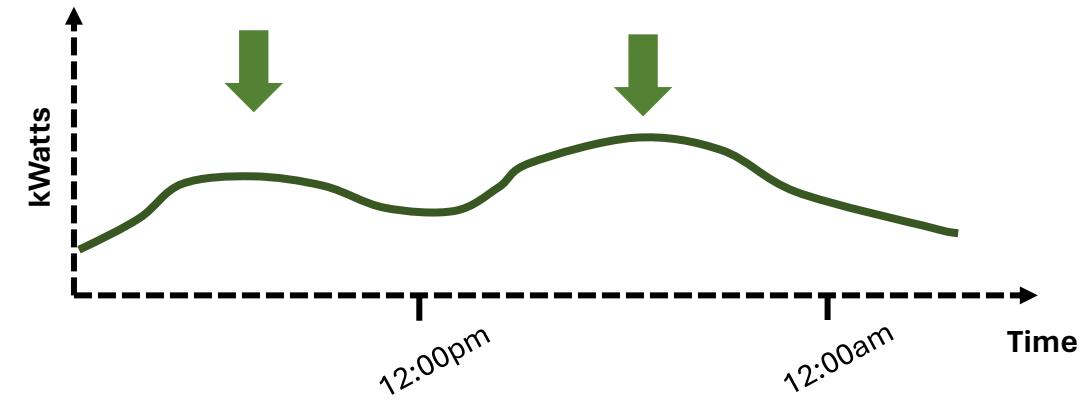
Use of **fossil energy** (oil, coal) to produce electricity to **absorb the peaks in demand**

# Background: Efficient Energy Management

## Reducing peak demand



- ✓ Smoothed daily demand
- ✓ Reduce need for fossil energy



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

# Background: Efficient Energy Management

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

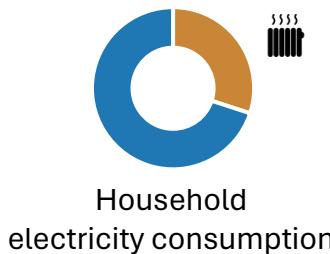
**By offering personalized contracts**



- **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**

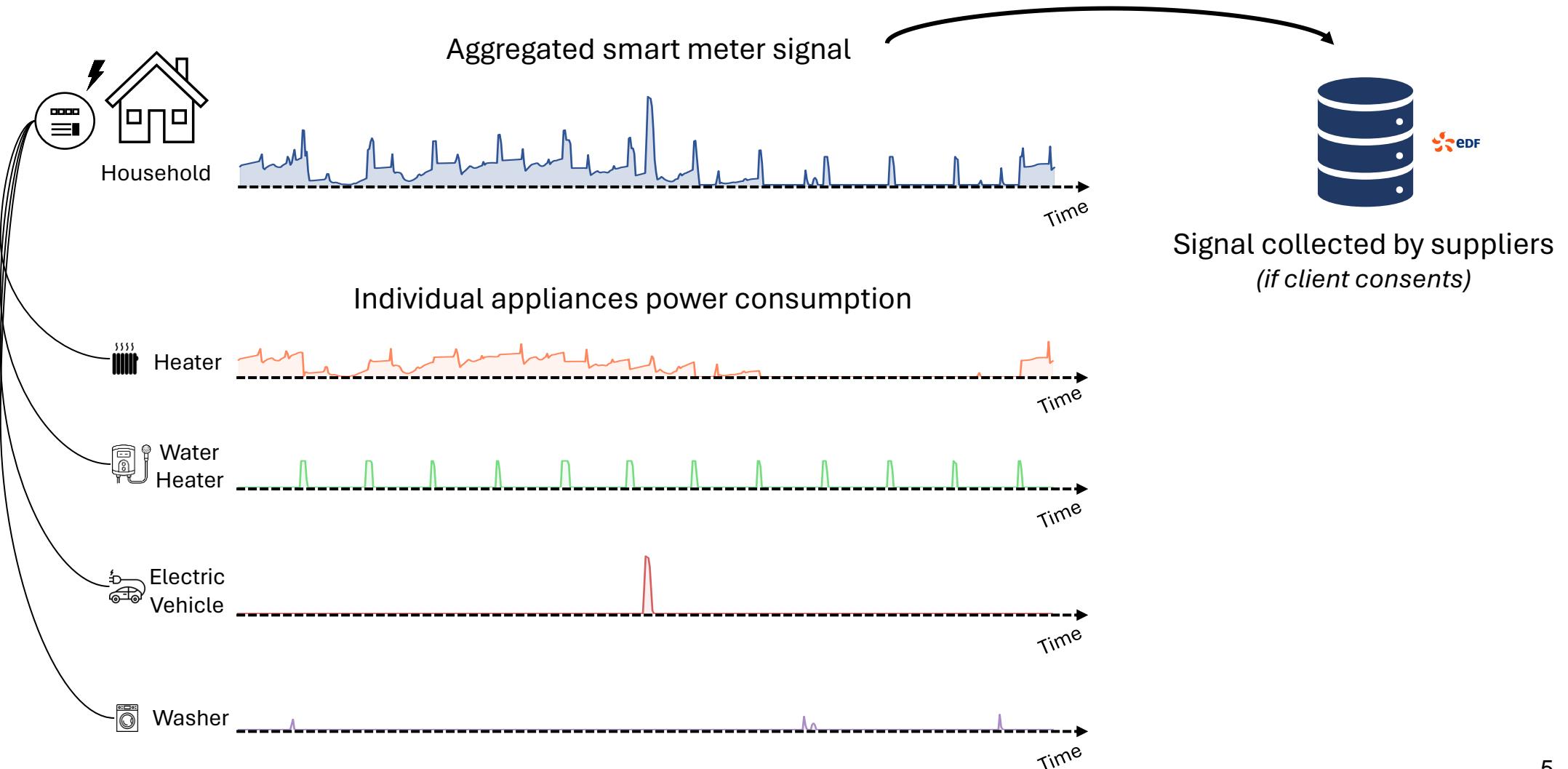


**How much does your heater cost you per month?**

**Solutions/advises based on customers' characteristic**

# Background: Smart Meters Deployment

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

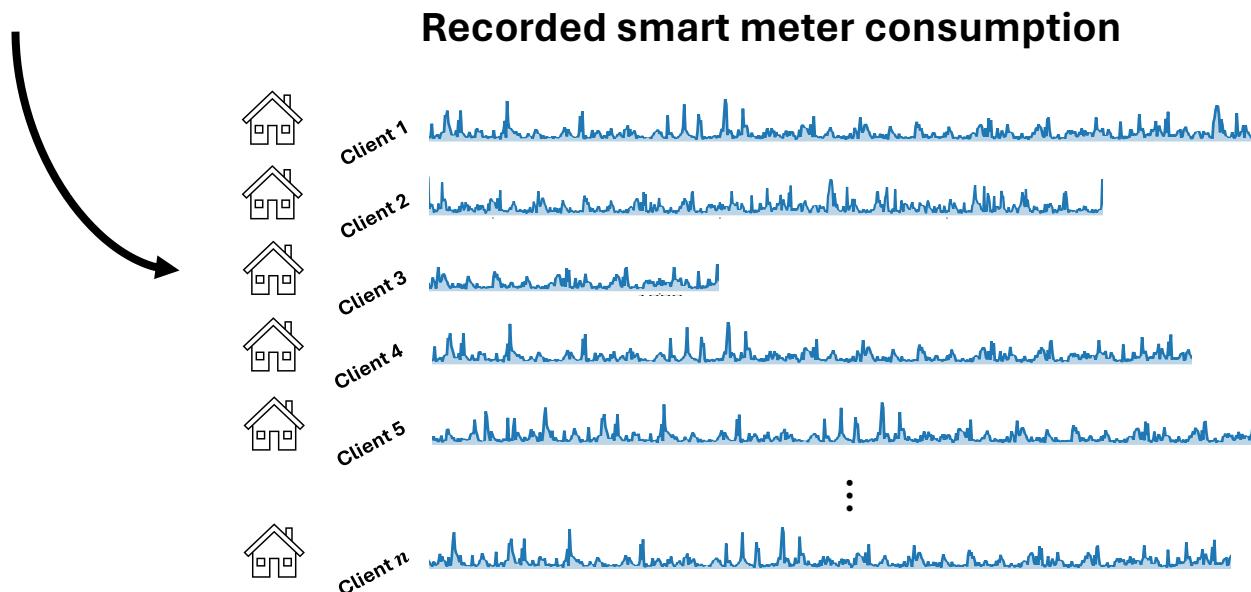


# Challenges

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



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



## Characteristics

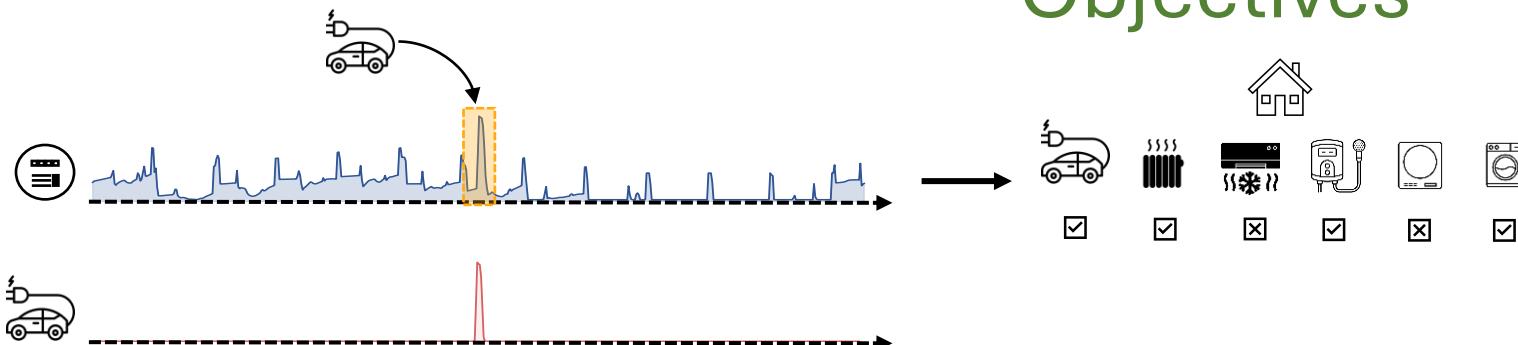
*Which appliances are present  
in the house?*

*How the client uses them?*

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

# Challenges

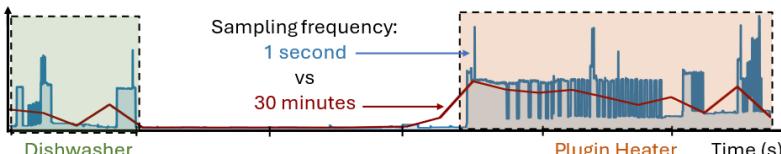
Can we propose **targeted** and **scalable approaches** for **electricity consumption time series analytics**?



## 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**



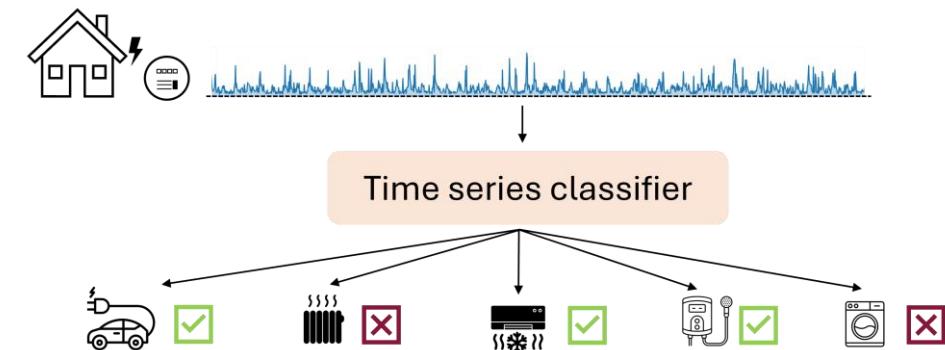
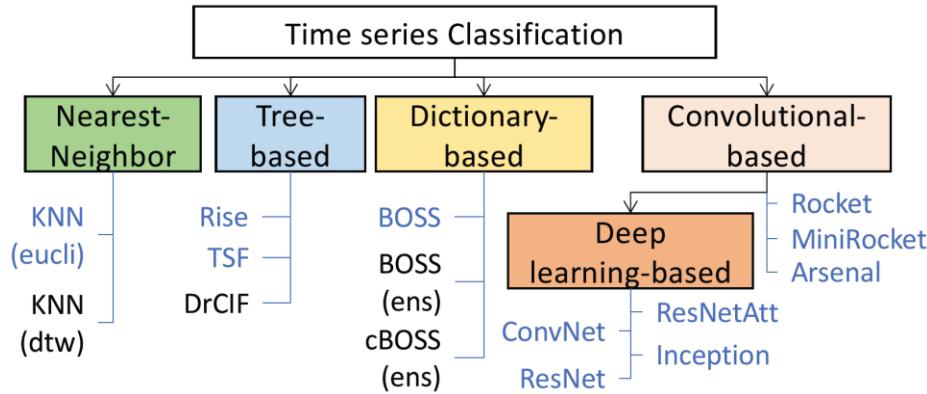
Few labeled data available



Large electricity  
consumption  
database

# Proposed solution: Appliance Detection as TSC

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

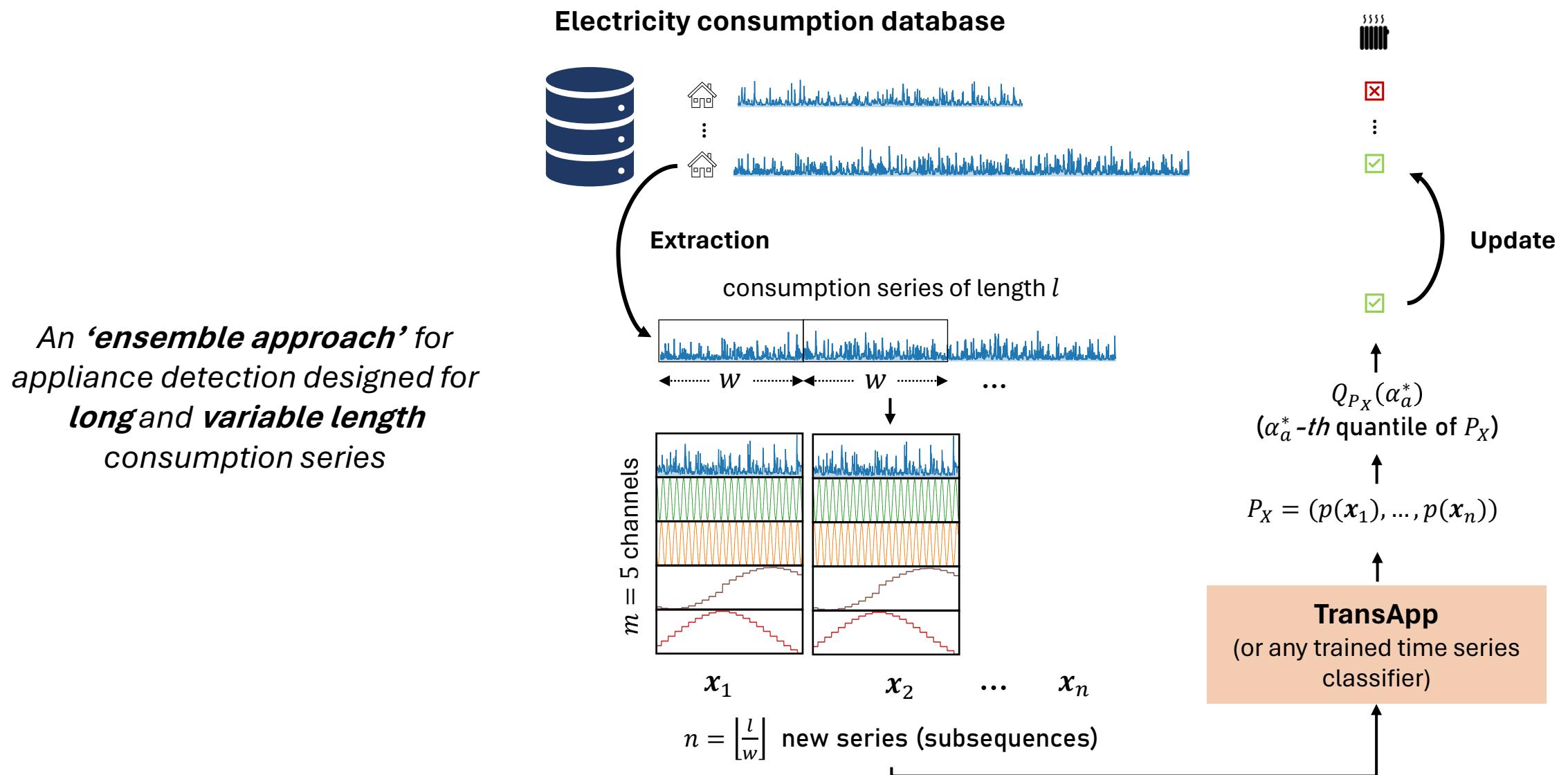


Deep learning-based approaches are the **most accurate** and **scalable** to large dataset of long-time series  
(i.e. Convolutional-based as Arsenal, ResNet, InceptionTime) [Petralia et al. 2023]

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

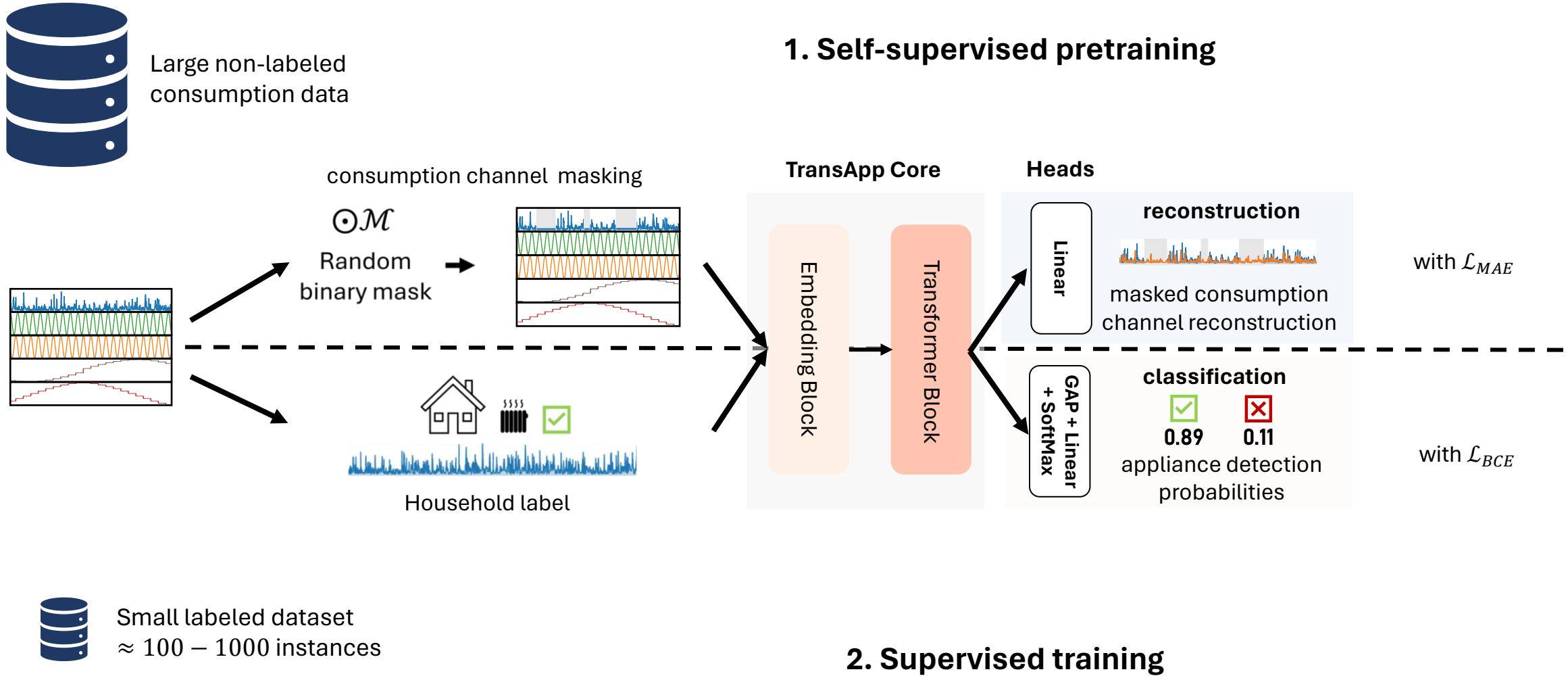
# Proposed solution: ADF&TransApp

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



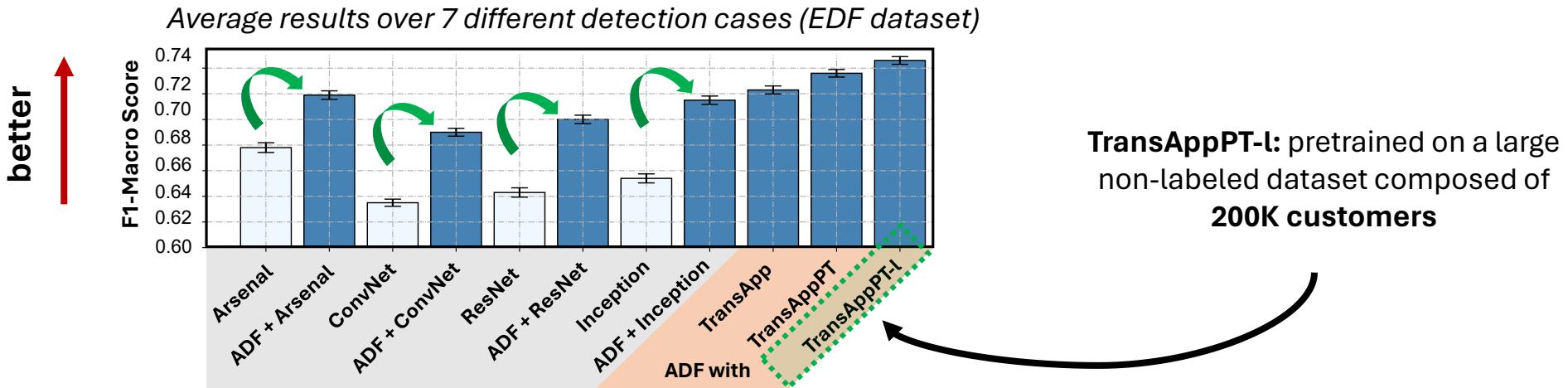
# Proposed solution: ADF&TransApp

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

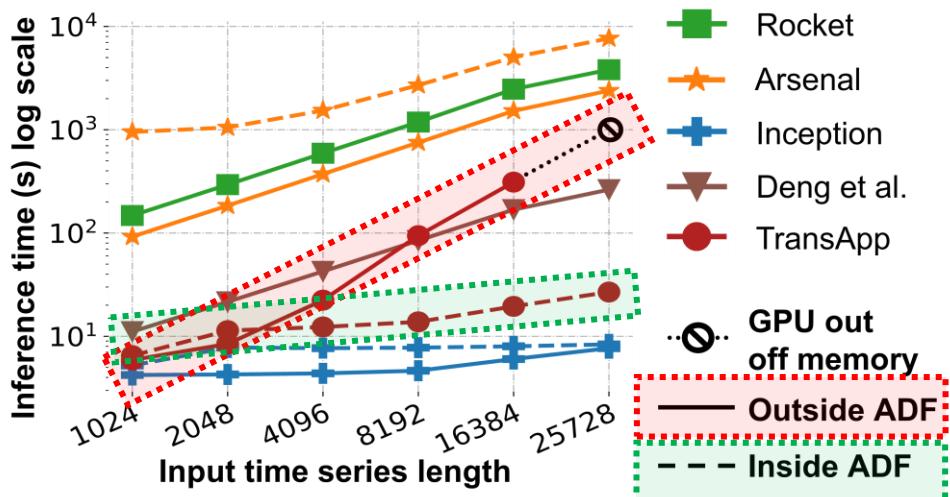


# Proposed solution: ADF&TransApp - results

## Appliance detection accuracy results



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



**EDF database**

20M clients recorded  $\approx$  1.5year

**ADF & TransApp**

$\approx$  4.5days

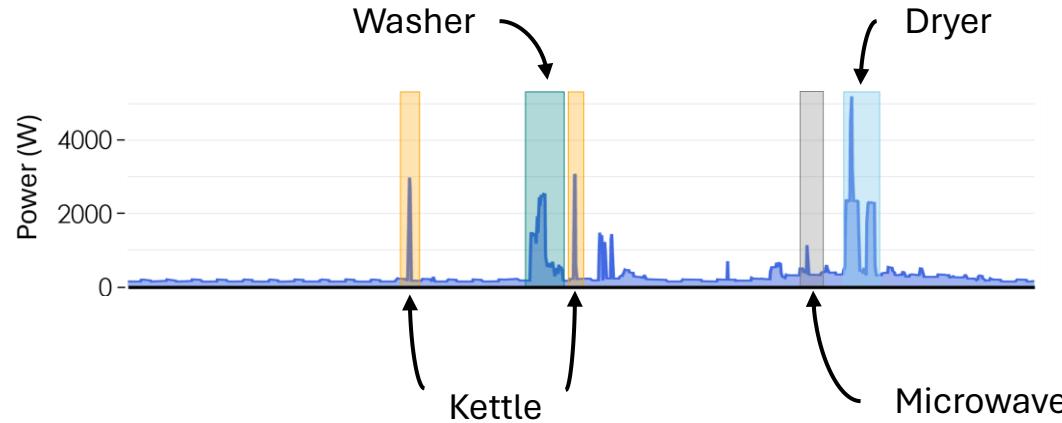
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**ADF & Arsenal**  
(2nd most accurate solution)

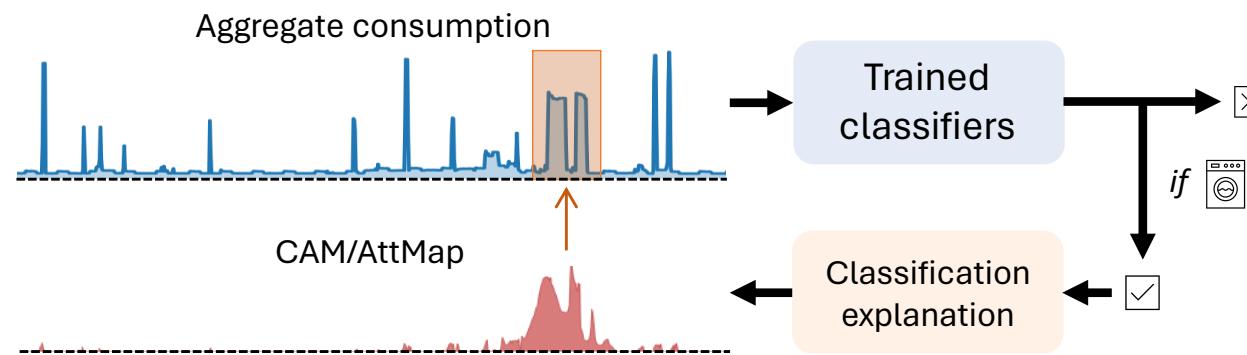
$\approx$  210days

# Ongoing work: DeviceScope

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



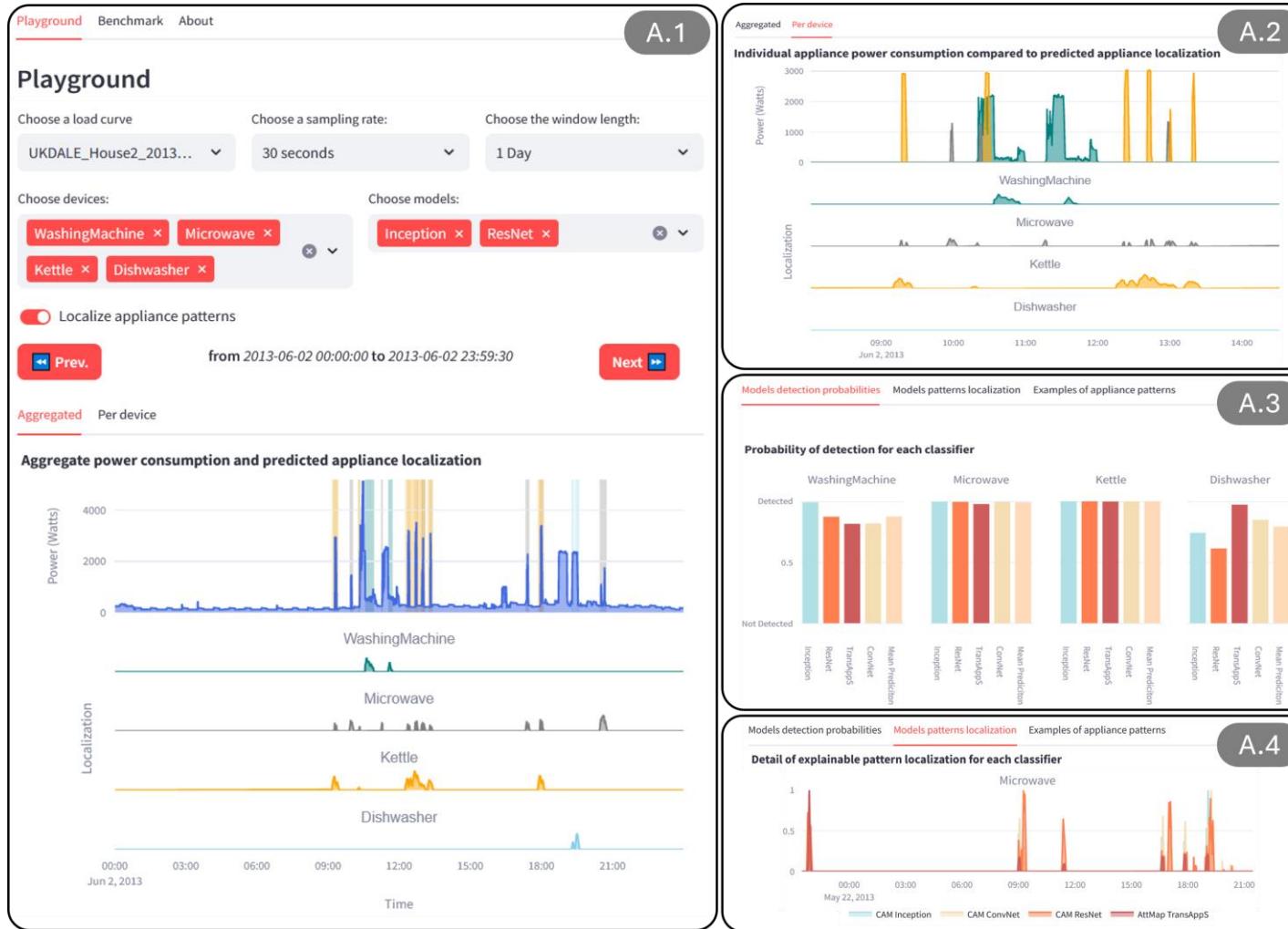
## TSC combined with **explainable AI**



# Ongoing work: DeviceScope

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

Consumer's  
consumption  
series  
visualisation



DeviceScope application overview

Appliance activation  
time **localization**

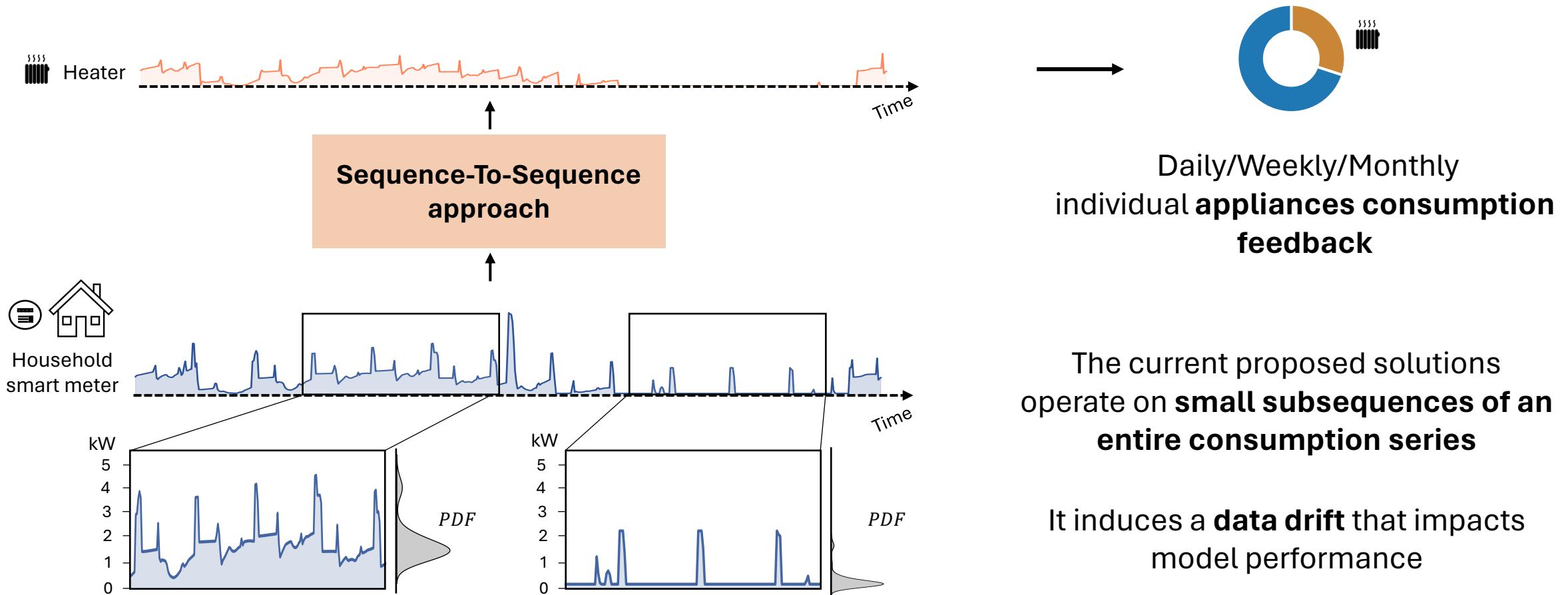
Appliance probabilities  
**detection**



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

# 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**

# Conclusion

## 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



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Paris Cité



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this PhD work?*



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**ADF&TransApp** paper presentation  
tomorrow ☺*