Load and Demand Side Flexibility Forecasting

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Responsible for analysis of electric load data for residential, commercial and educational buildings. Current tasks include the exploration of data using supervised and unsupervised techniques as well as the development of disaggregation algorithms and predictive models for load profiles.

Education

PhD MINES ParisTech
Thesis topic: The optimization of planning and operations of the distribution grid in the context of high renewable energy penetration.

M.S., Loughborough University
Specialization: Hybrid systems (Kassel, Germany)

B.S. Engineering, Smith College, MA, USA
Specialization: Alternative energy systems

Eco CO2
Key facts

Founded in 2009, Eco CO2 is an environmentally oriented company contributing to innovative projects as well as social and solidary programs

The company's activities are focused on **accelerating the ecological transition through behavioural adaptation**

Our objectives

- ✓ Eco CO2 deploys **awareness raising programs for individuals and organisations** to encourage a sustainable **reduction in their environmental impact**.
- ✓ An **assistance program** provides the necessary tools to **better understand** the environmental consequences of ones actions, **suggestions** leading to a reduced environmental impact are provided and behavioural changes are evaluated through **data driven studies**.
- ✓ Contributes to social programs that work towards creating a more **sustainable society**.

Primary activities of Eco CO2

Awareness raising Programs

Eco CO2 creates and deploys **awareness raising programs** in the following categories :

- assist individuals to **better understand** their impact on the environment
- encourage sustainable behavioral changes
- sustain **positive communication**

The programs are :

- adapted to a varying **client base**
- achieved through collaborations with **local actors**
- **approved as serving the general public by authority members**

Consulting and analysis

Eco CO2 performs **studies** that contribute to :

- better understanding an **environmentally sustainable behavior** for a targeted group of the population
- evaluate the **evolution of key metrics** in relation to the ecological transition
- monitoring the impact of programs with variable magnitudes

Eco CO2 oversees the creation **:**

- and deployment of new programs in the ecological transition sector
- and business plan definition especially in relation to the French energy efficiency certificates (CEE)

Technology developement

Eco CO2 develops **new technology solutions :**

- **to mesure and display** energy consumption data simultaneously with environmental indicators (dashboards, data collection platform, etc.)
- **optimized control** of targeted appliances

ENVIRONNEMENT

ENERGIE

MOBILITÉ DURABLE

Context

Energy Transition

- Decentralized generators increasing in market shares that have a high variability and low predictability
- Electric load is growing
- Europe has ambitious goals to reduce electric consumption of the building sector
- Building energy use is highly variable based on end user habits

Awareness raising programs for energy efficiency

- Eco CO2 has developed tools to collect data and accompany end-users to reduce their energy use and optimize their consumption.
- Most effective advice to change end-user behavior is time and appliance specific
- Each household has a different capacity to reduce their energy use

Methodology

Existing algorithms

Proposed innovation

Electric load forecasting:

- Recurrent neural network (RNN) Long short-term model (LSTM)
- 2 hidden layers (200 and 100 neurons)
- 24-hour horizon prediction
- 400 epochs
- N/25 batch size
- ReLU rectifier

Non-intrusive load profile analysis

- Clustering to determine active and passive loads
- Temperature correlated loads are isolated
- National statistics are used to further decompose the 4 categories (active, passive and temperature correlated parts)

Evaluation of household flexibility

- Disaggregated load profiles using a questionnaire to identify possible appliances used regularly in the household
- Evaluate flexibility of household based on the presence and use of identified appliances

Prediction of household flexibility

- Prediction of disaggregated load profiles
- Coaching to reduce or postpone target appliance usages

Summary

- 3 households analyzed for case study
- 1 year of 1 hour resolution load data used for training and predictions

Case Study

- Data source: Eco CO2 collects data through multiple devices allowing the collection of data varying from 30 second resolution to 10 minute resolution. For this study a 1 hour resolution is used to develop a methodology that is compatible with the low resolution data available through the Linky data collection system massively deployed in France.

	Household 1	*Household 2*	*Household 3*
Surface (m^2)	100	110	160
Heating type	Natural gas	Natural gas	Natural gas
DHW	electric	electric	electric
VMC	yes	no	yes
Cooking	electric	electric	electric
Refrigeration	2	3	3 + freezer
Washing	3	3	3
Multimedia	6	6	7
Annual consumption (kWh)	5786	10193	4172

Load [kWh]

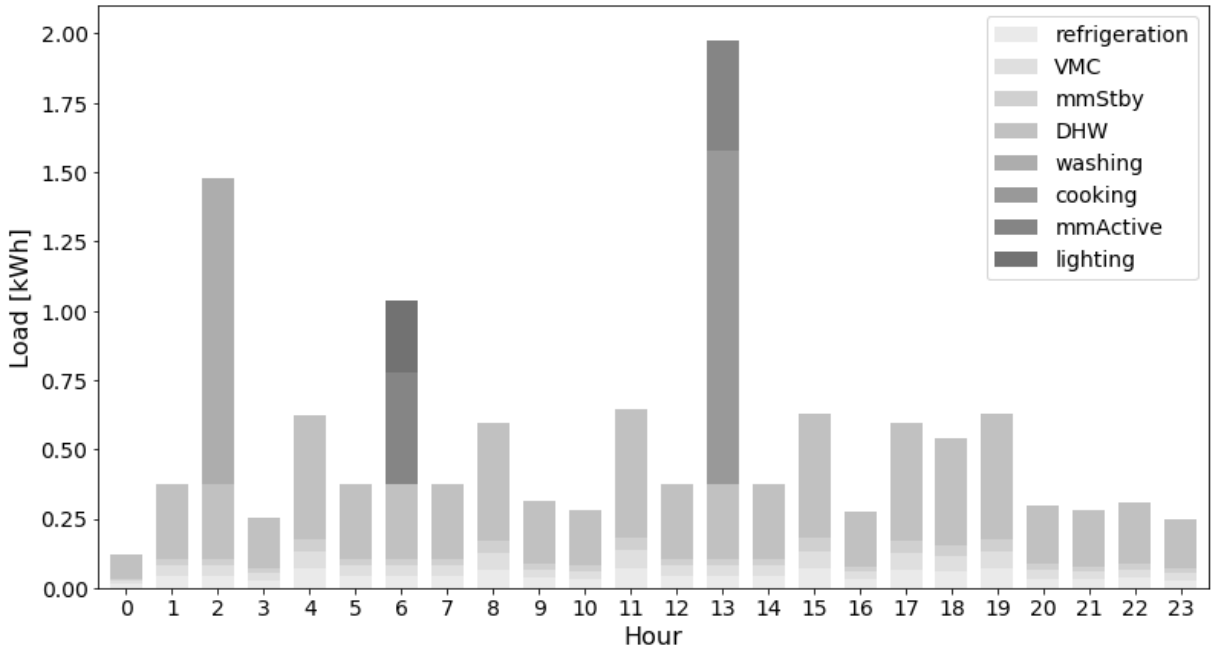
LSTM load forecasting model accuracy

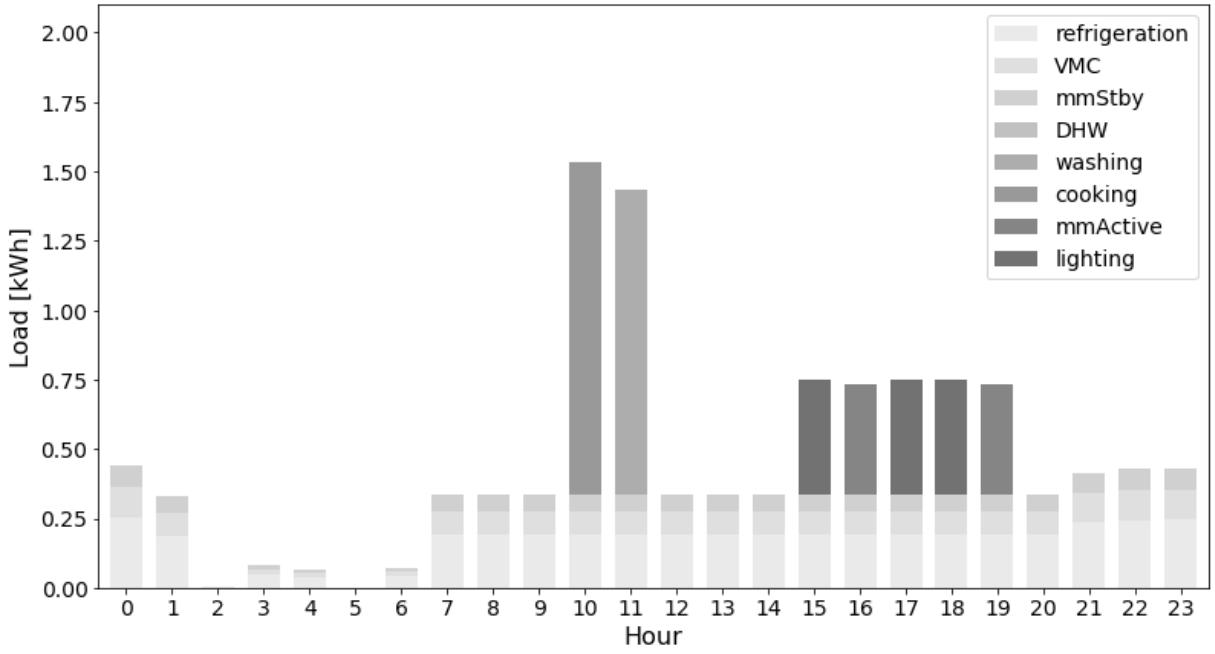
Household ID	R^2	*RMSE*	*MAE*
1	0.692	0.432	0.334
2	0.625	0.464	0.402
3	0.496	0.157	0.125

Results

Conclusions

- Majority of load classified as inactive (60% and up to 78%)
- Inactive load primarily DHW and refrigeration
- Active load primarily multi-media and lighting with small portion of cooking and washing

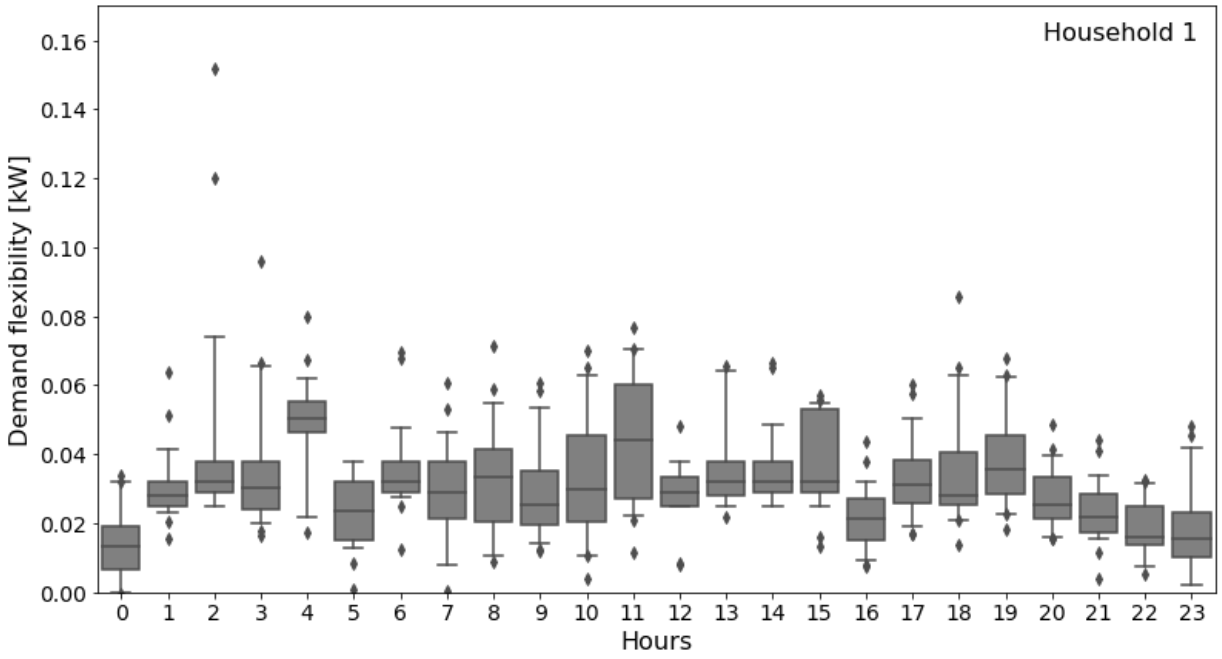


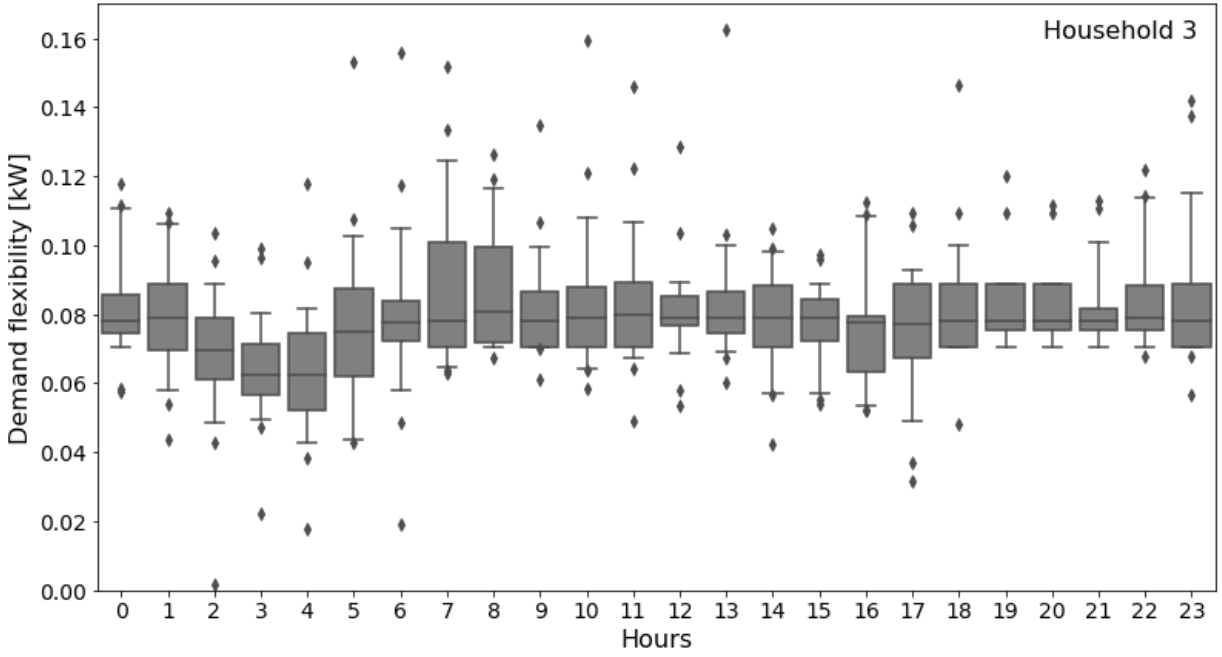


Résultats

Conclusions

- Highest load flexibility is associated with setpoints of refrigeration loads and domestic hot water heaters
- These high flexibility loads consume energy constantly during the day, therefore, flexibility for most households is relatively constant for all time periods
- Load flexibility of individual houses is relatively low, therefore load flexibility is more effective when applied across a large panel of users and not for individual households





Conclusions

Conclusions/Discussion

- An effective multi-step technique to forecast the average hourly demand flexibility of a household was developed
- This model is widely applicable and is also compatible with the type and resolution of data available through the massive deployment of smart meters.
- This solution allows for end-users to learn about their energy use and receive behavior adjustment suggestions for future possible use to encourage energy efficient behavior in advance.
- Overall, the individual demand flexibility of each user is
- limited, between 15W and 80W every hour, but the aggregate
- demand flexibility is interesting to exploit in a massive deployment program.

Future work

- With increasing decentralized electric generation technologies such as photovoltaic or wind energy, demand side flexibility will play an important role in the optimization of the future electric system.
- The quantification/adaptation of a large-scale deployment program focusing on user awareness raising should be conducted

CONTACT INFORMATION

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