Unsupervised algorithm for disaggregating low-sampling-rate electricity consumption of households

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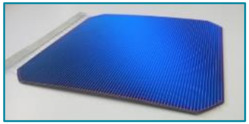
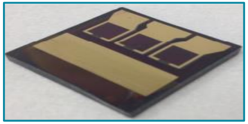
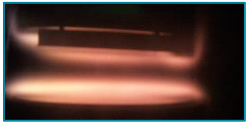


Si-HJT cells

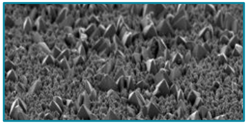
Si cells with passivated contacts



Perovskite cells

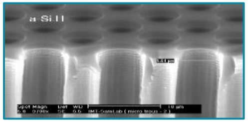


Advances coatings



Conductive oxides TCOs

Module design and reliability



Thin film electronics detectors

Building energy management

PV grid integration and local storage

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DEVICE USAGE ESTIMATION ALGORITHM

Residential NILM in unsupervised manner

Unsupervised

No training and time-consuming data collection

15 min data

Low-sampling rate of conventional smart meters

Efficient computing

Scales linearly with data growth

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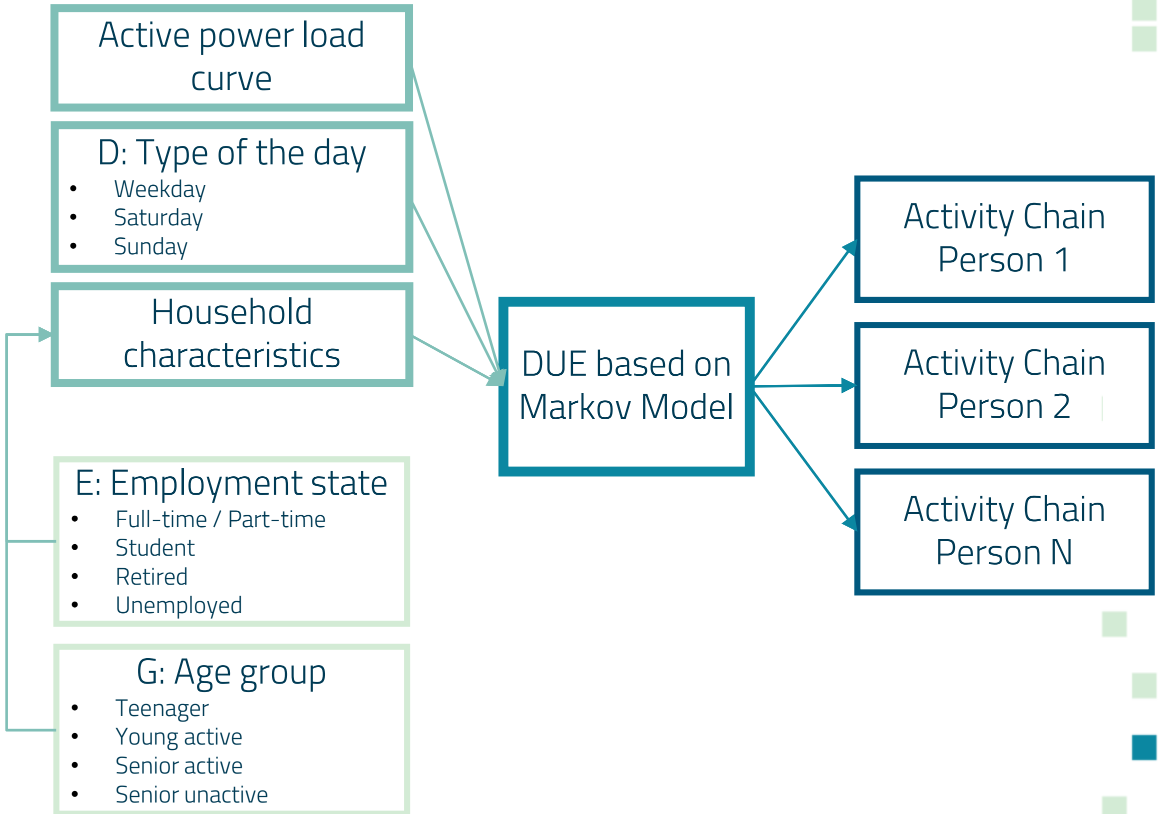
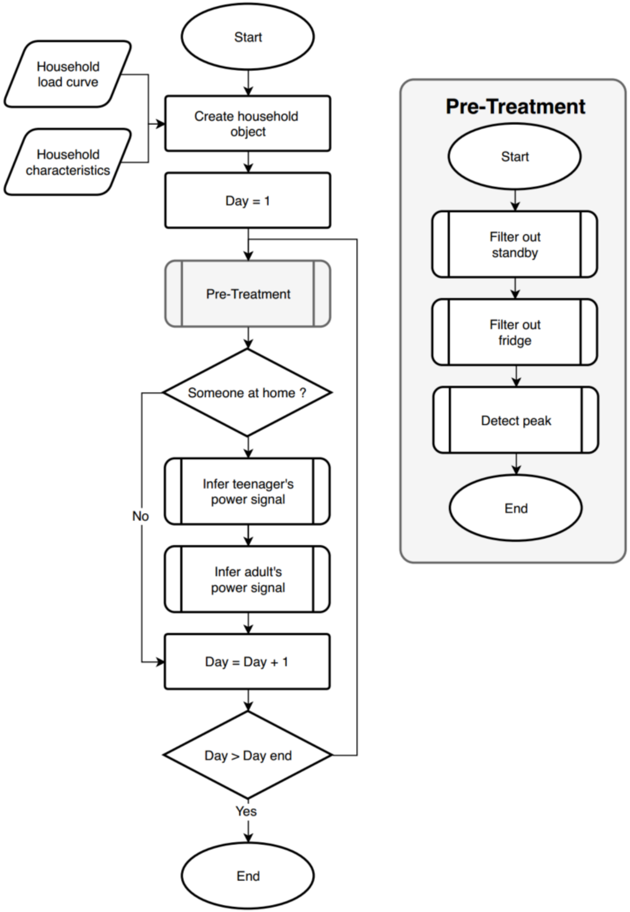
HOW IT WORKS?



Active power load curve
D: Type of the day
• Weekday
• Saturday
• Sunday
Household characteristics
E: Employment state
• Full-time / Part-time
• Student
• Retired
• Unemployed
G: Age group
• Teenager
• Young active
• Senior active
• Senior unactive
DUE based on Markov Model
Activity Chain Person 1
Activity Chain Person 2
Activity Chain Person N

ASSUMPTIONS

- Children < 10 years old - no energy needs
- Teenagers < 18 years old -random activity chain
- Adults – optimized activity chain
- No partial presence/absence at home



CATEGORIES, APPLIANCES & ACTIVITIES

Category	Appliances	Related activities
Cooking	Coffee maker, stove, oven, microwave, kettle	Cook, eat
ICT	Printer	Use computer, work, homework
Housekeeping	Washing machine, dishwasher, tumble dryer, vacuum cleaner	Clean, wash dishes, laundry
Entertainment	TV, stereo, PC, TV box, laptop, DVD, gaming console	All
Light	Lights	All
Fridge	Fridge, freezer	
Heating	Hairdryer, HP, boiler	Shower
Standby	Modem	

Recognized activities:

- Clean
- Use computer
- Cook
- Wash dishes
- Eat
- Homework
- Play game
- Laundry
- Music
- Watch TV
- Shower
- Work

No appliances used:

- Sleep
- Outdoor

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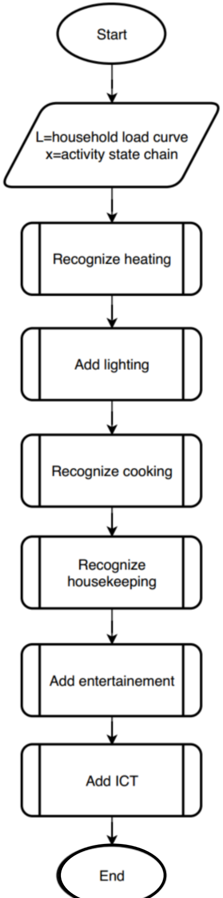
WORKFLOW



STEP 1: Pre-treatment

- Filter out standby and fridge
- Detect power peaks

STEP 2: Optimize activity chain

- Define list of possible activities and their probabilities based on D, E and G.
- Select activity based on occurrence and time duration probabilities
- Check compatibility with measured load curve

STEP 3: Recognize load profile

- Select time period where activities of this category occur
- For each existing appliance in household inventory check sufficiency of energy and time budget – set device as used – generate power signal

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BENCHMARKING

Performance compared to state-of-the-art

COMPARISON SETTING

Algorithms

- Combinatorial Optimization
- Factorial Hidden Markov Model
- Graph Signal Processing
- Discriminative disaggregation via sparse coding

Datasets

- ECO
- SMARTENERGY.KOM
- UK-DALE

Metrics

- Error on energy share

$$E_m = \frac{\sum_t \hat{P}_m^t}{\sum_t \sum_m \hat{P}_m^t} - \frac{\sum_t P_m^t}{\sum_t \sum_{m \in M} P_m^t}$$

- NMSE

$$\mathrm{NMSE}_m = \frac{\sum_t \left(\hat{P}_m^t - P_m^t\right)^2}{\sum_t \left(P_m^t\right)^2}$$

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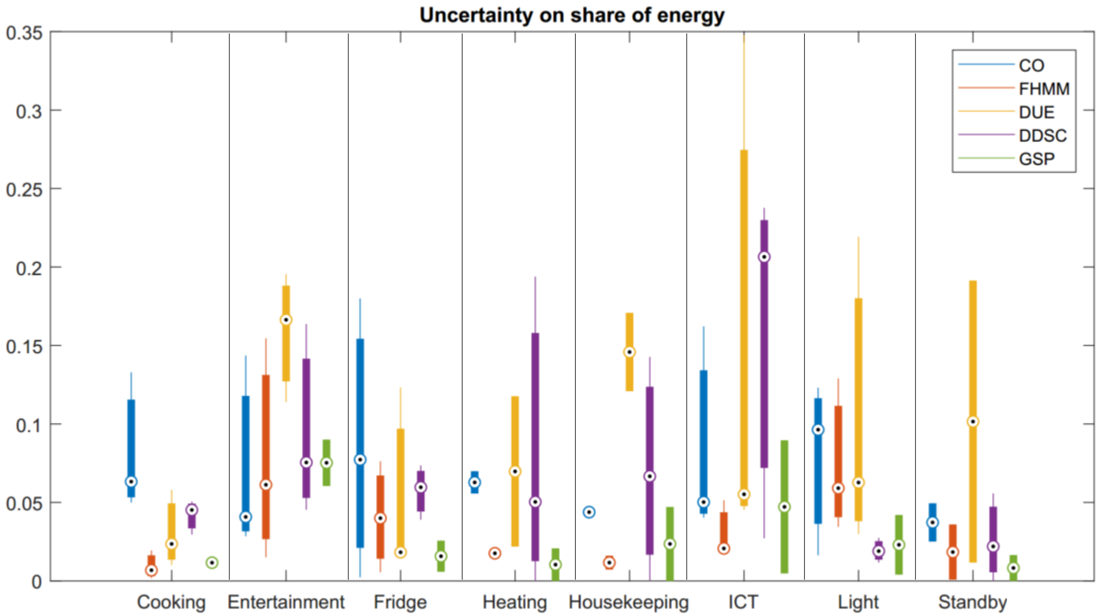
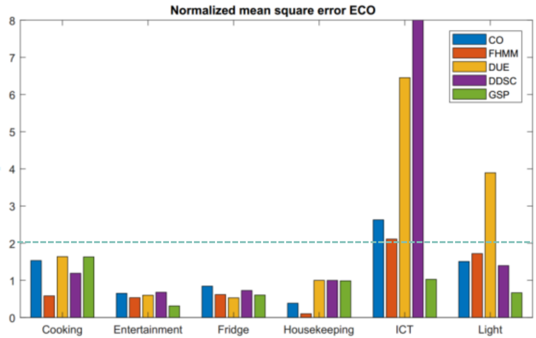
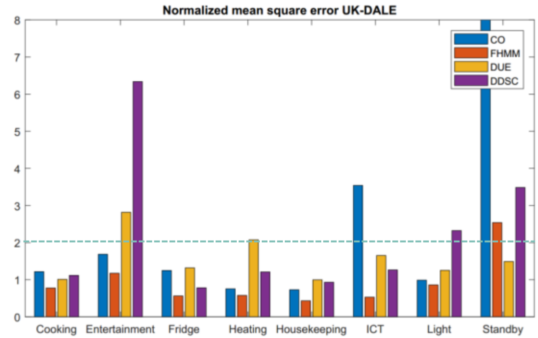
RESULTS – ENERGY SHARE

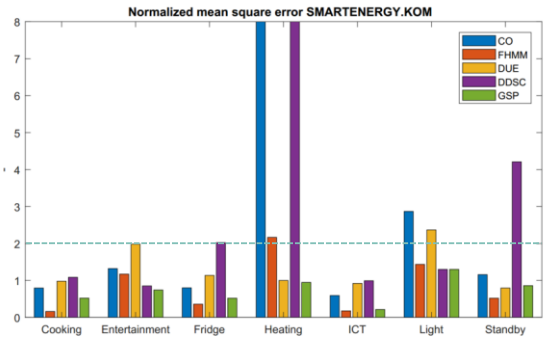


- Average uncertainty on energy share ~ 20%
- DUE is unsupervised, while other are supervised
- DUE is survey-based, always assumes presence of all categories

RESULTS – NMSE





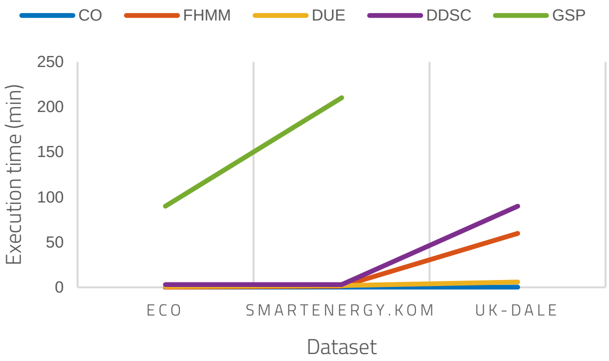


- Dataset dependent
- Acceptable deviation ≤2

CONCLUSION & OUTCOMES

DUE algorithm is…

- Unsupervised
- Based on 15-min data resolution
- Computationally efficient – scales linearly with dataset size



- Potential use:
  - For statistical applications
  - By utilities to provide new services at low cost
- To be published soon

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THANK YOU!

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SCCER - FURIES
Shaping the FUtuRe Swiss Electrical InfraStructure

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