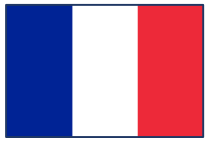


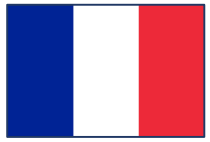
FRENCH PERSPECTIVES TOWARDS ENERGY FLEXIBLE BUILDINGS

JÉRÔME LE DRÉAU, MARIKA VELLEI
(LA ROCHELLE UNIVERSITY, LASIE UMR CNRS 7356)

JOHANN MEULEMANS
(SAINT-GOBAIN RESEARCH)

Public seminar Annex 67
Energy Flexible Buildings (04/04/2019)

OUTLINE



France, a specific country ?

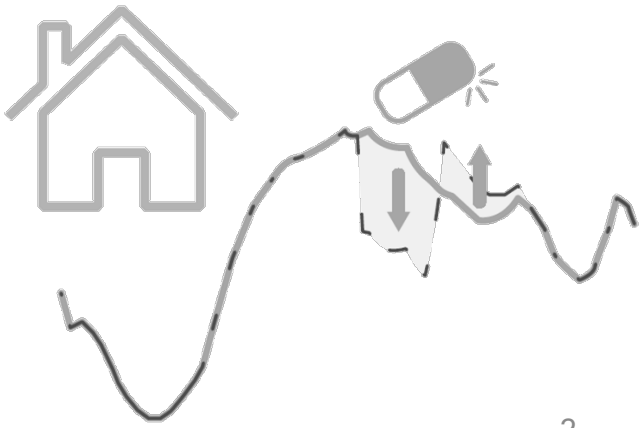
- Electrical production and consumption
- Perspective of development of flexibility in residential buildings

Flexibility from space heating

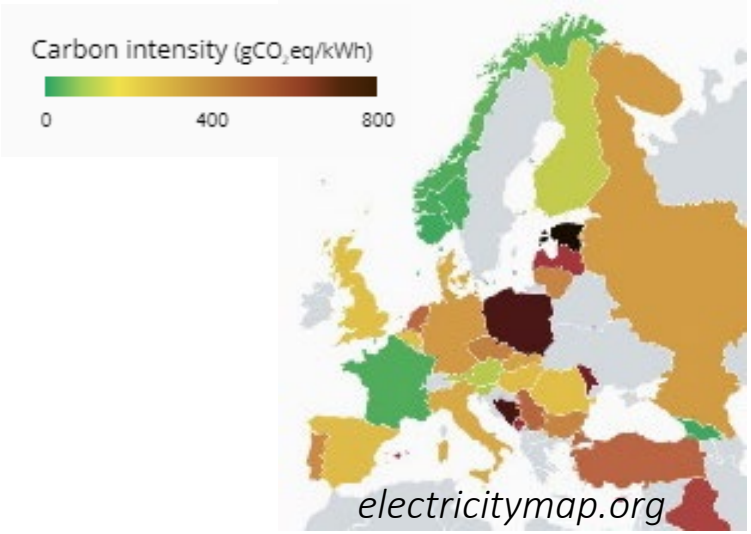
- Influence of the envelope properties & emitter types
- Thermal comfort under dynamic conditions

Flexibility from white-goods usage

Perspectives



FRENCH CONTEXT

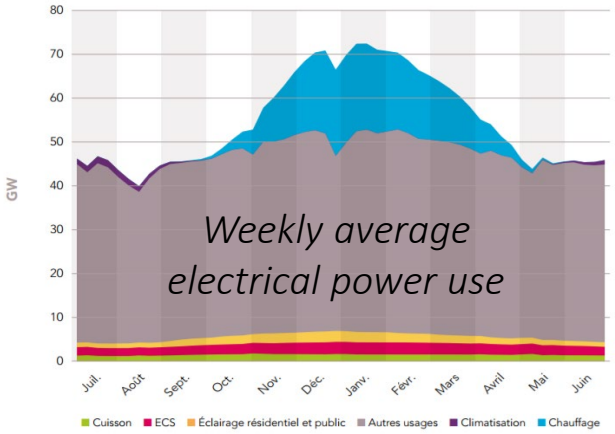


Electricity production :

- Large share of nuclear energy (**72%**)
- Little renewable (7% windmills+PV)
- Low CO_2 content (but nuclear wastes)

Electricity consumption :

- Large share of direct electrical heating (**45%** of space heating)
- Large usage of TOU (**41%** households with "heures pleines / heures creuses")
- **8 GW of flexibility** from dom. hot water



Demonstration projects (with on-site measurements) : Voltalis (2009), Modelec (2011), Smart-Electric Lyon (2012), GreenLys (2012), etc

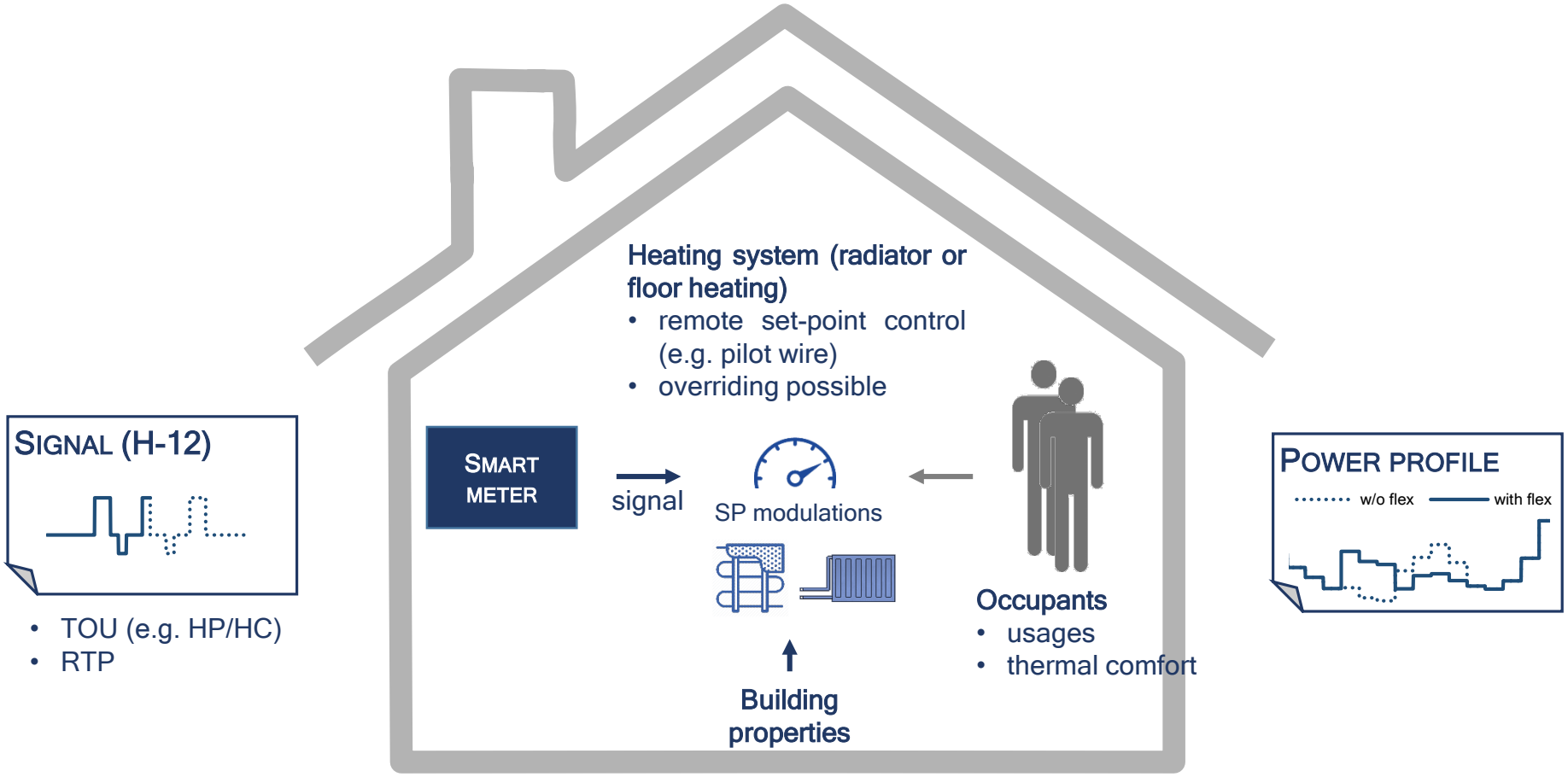
PERSPECTIVE OF DEVELOPMENT OF FLEXIBILITY

Results from techno-economic analyses at French level:

- comparison of different smart-grid solutions (flexibility from residential buildings or industry, batteries, PSPS, new generation)
- flexibility mainly from industry (& tertiary) ≈5 GW
- flexibility from residential sector
  - **RTP (dynamic) control ≈1 GW** (activated from 10 to 100 hrs per year)
  - **TOU control ≈18 GW** (for heating, DHW, white goods and electric vehicles)

	Share of flexible households (RTP + TOU)	
	Horizon 2030	Horizon 2060
Heating	8-25% *(9 GW)*	75%
Domestic Hot Water	50-60% *(5,4 GW)*	100%
White goods	-	56%
Electric vehicles	25-36% *(4,5 GW)*	80%

FLEXIBILITY FROM SPACE HEATING

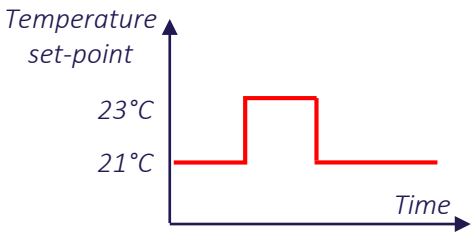


[SPACE HEATING] ENVELOPE & EMITTERS PROPERTIES

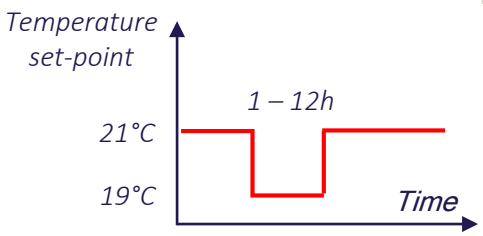
Type of demand response

Type of building

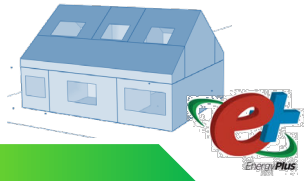
Type of emitter



Upward modulations
(for valley filling, anticipation)



Downward modulations
(for peak shedding, load shifting)



Heating need [kWh/m².year]

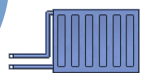
50's

BR 1982

BR 2005

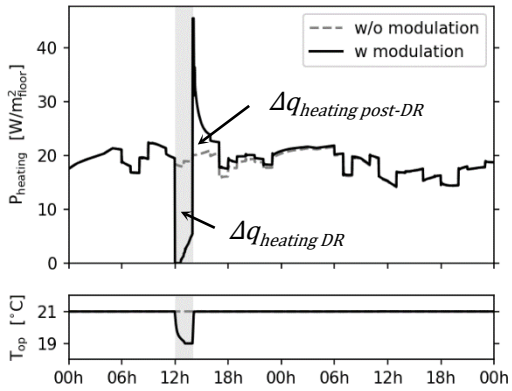
BR 2012

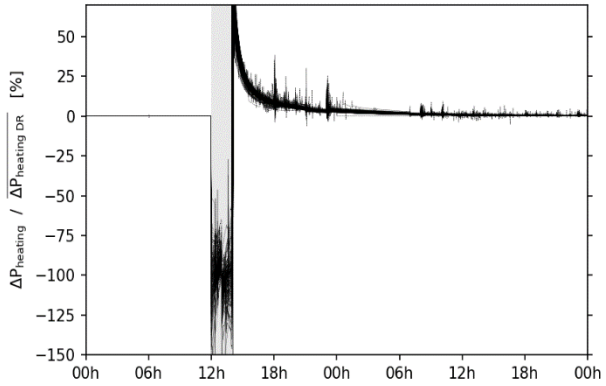
BR 2020



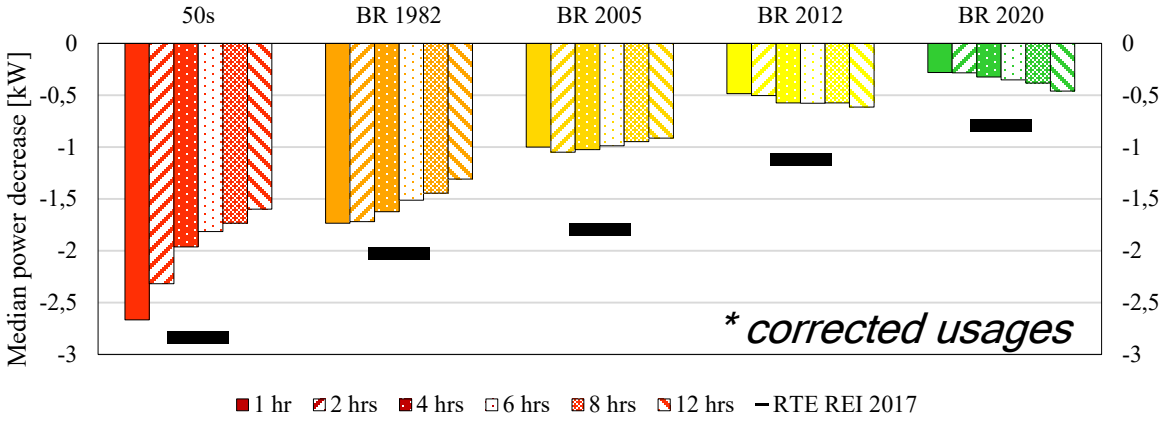
[SPACE HEATING] ENVELOPE & EMITTERS PROPERTIES

- Estimation of the energy shifted and power profiles (BES)





- Estimation of the mean power* change during the DR events



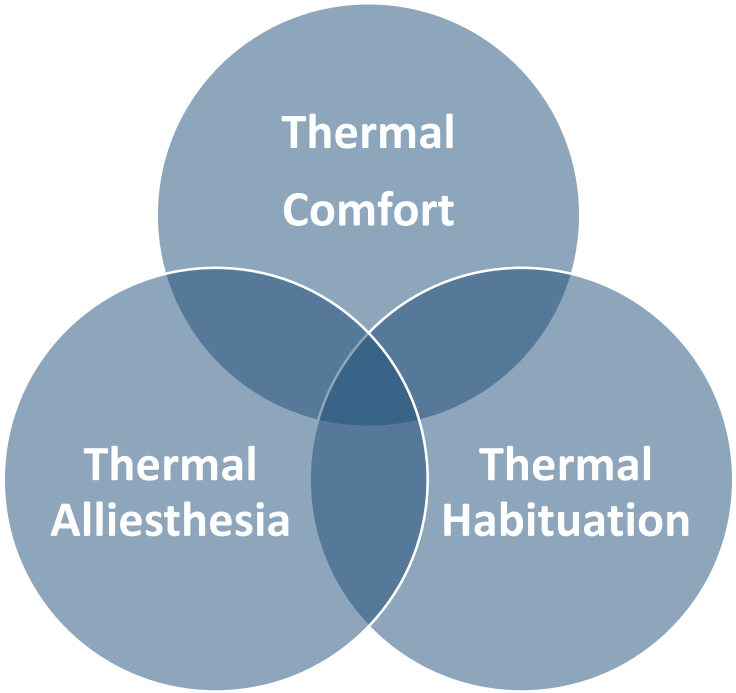
[SPACE HEATING] THERMAL COMFORT UNDER DYNAMIC ENVIRONMENT

- Fanger's PMV/PPD model (EN 15251) : derived from a steady-state heat balance equation and steady-state laboratory experiments

- Proposal for a new thermal comfort model based on PMV :

$$\frac{\partial PMV}{\partial t}$$

- ***negative alliesthesia*** *moving away from neutral*
- ***positive alliesthesia*** *moving towards neutral*

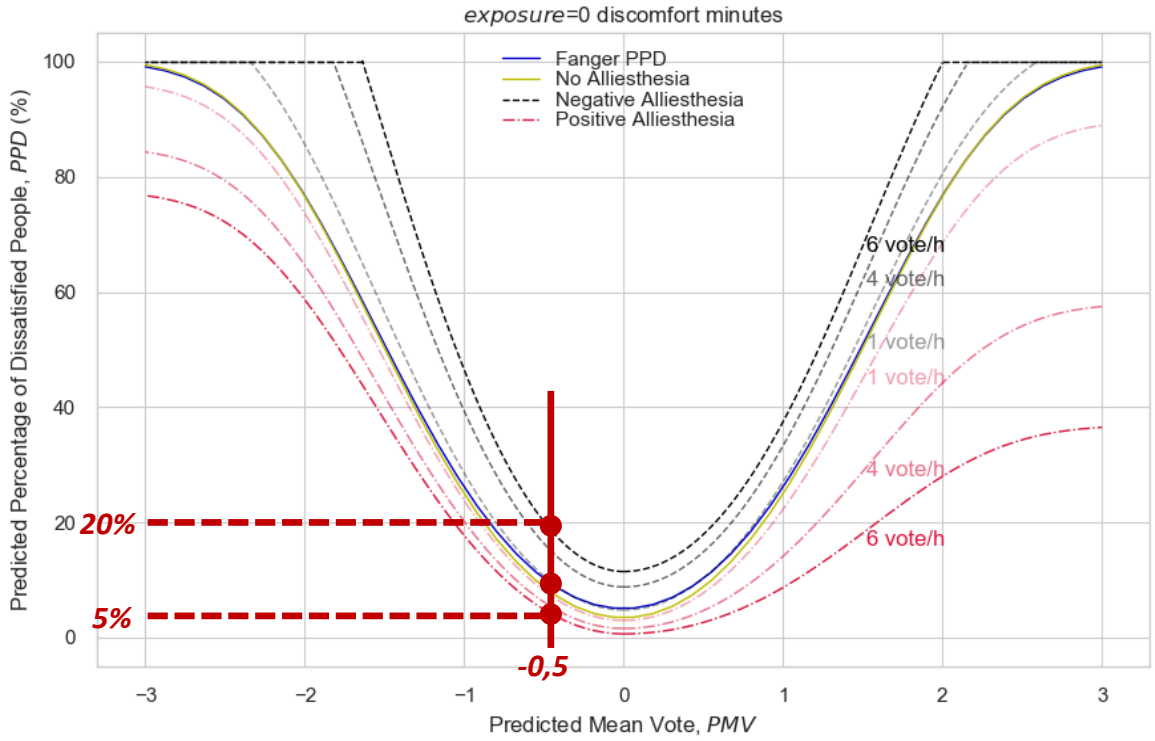


Repeated rises and falls *of the temperature have the potential to induce habituation, which leads to a reduction of the normal response or sensation*

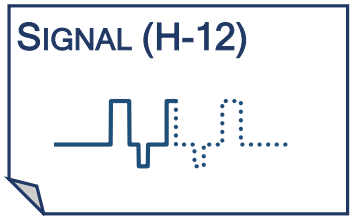
[SPACE HEATING] THERMAL COMFORT UNDER DYNAMIC ENVIRONMENT

Experimental data collected from IEQL (University of Sydney)

- 56 students in climatic chambers
- 6 different cyclical temperature variations (overall duration 2 hrs)
- highest rates of temperature change (up to 30°C/h)



FLEXIBILITY FROM WHITE-GOODS USAGE



- TOU (e.g. HP/HC)
- RTP

Washing machine / Dishwasher

- option smart-start or delay start

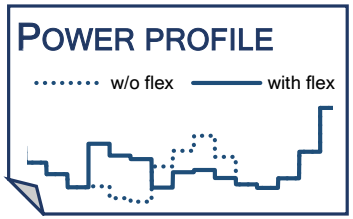
SMART METER

signal

start

Occupants

- usages (TUS)
- flexibility



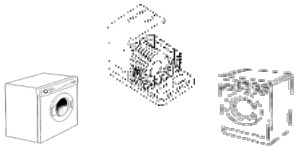
MODELLING WHITE-GOODS USAGE

INPUT (USER, DEFAULT)

Household
(nbr occupants, occupation)

Equipment usage
(mean nbr of cycles, monthly variation, waiting time)

Flexibility
(double tariff subscriptions, tariff structure)



Equipment
(energy class, capacity, program type)

CREATING TIME-SERIES OF ACTIVITIES
(clustering)

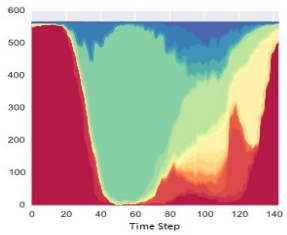
SELECTING STARTING TIME
(random picking, shifting)

APPLYING FLEXIBILITY
(agent-based dw & wm)

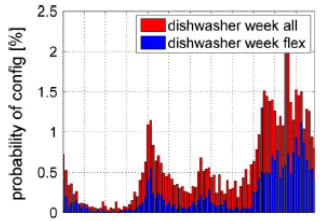
CALCULATING POWER DEMAND

DATABASE

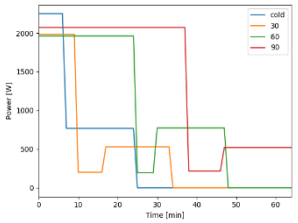
Time Use Survey
(INSEE 2009-2010, 12 000 foyers)



Proba. flex. configurations
(LINEAR 2009-2014, 186 foyers)



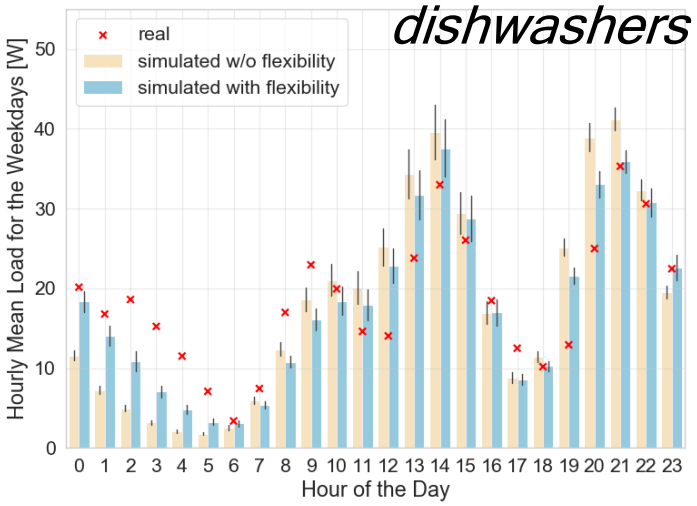
Unit load curves
(260 equipment, 1200 profiles)



VALIDATION OF THE FLEXIBILITY POTENTIAL

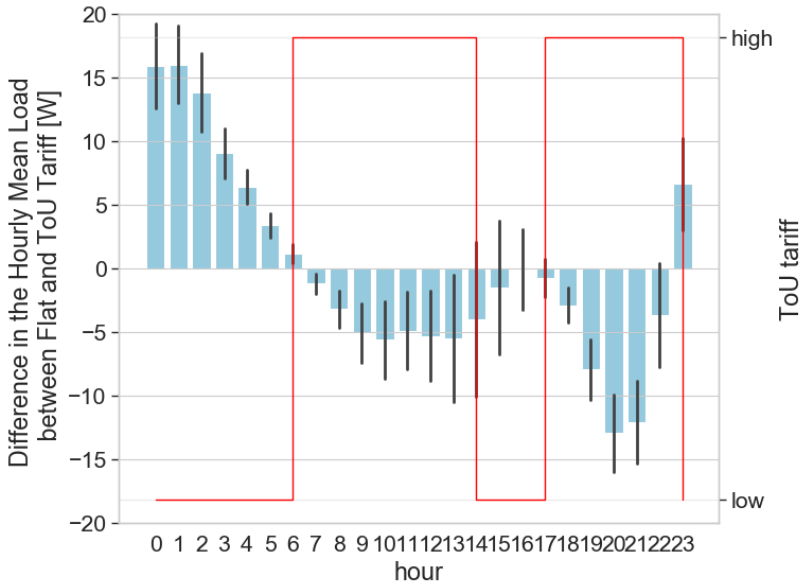
Measured data : 107 households (Froid Lavage, 2015), 41% TOU

- 60 dishwashers
- 100 washing machines
- 23 dryers

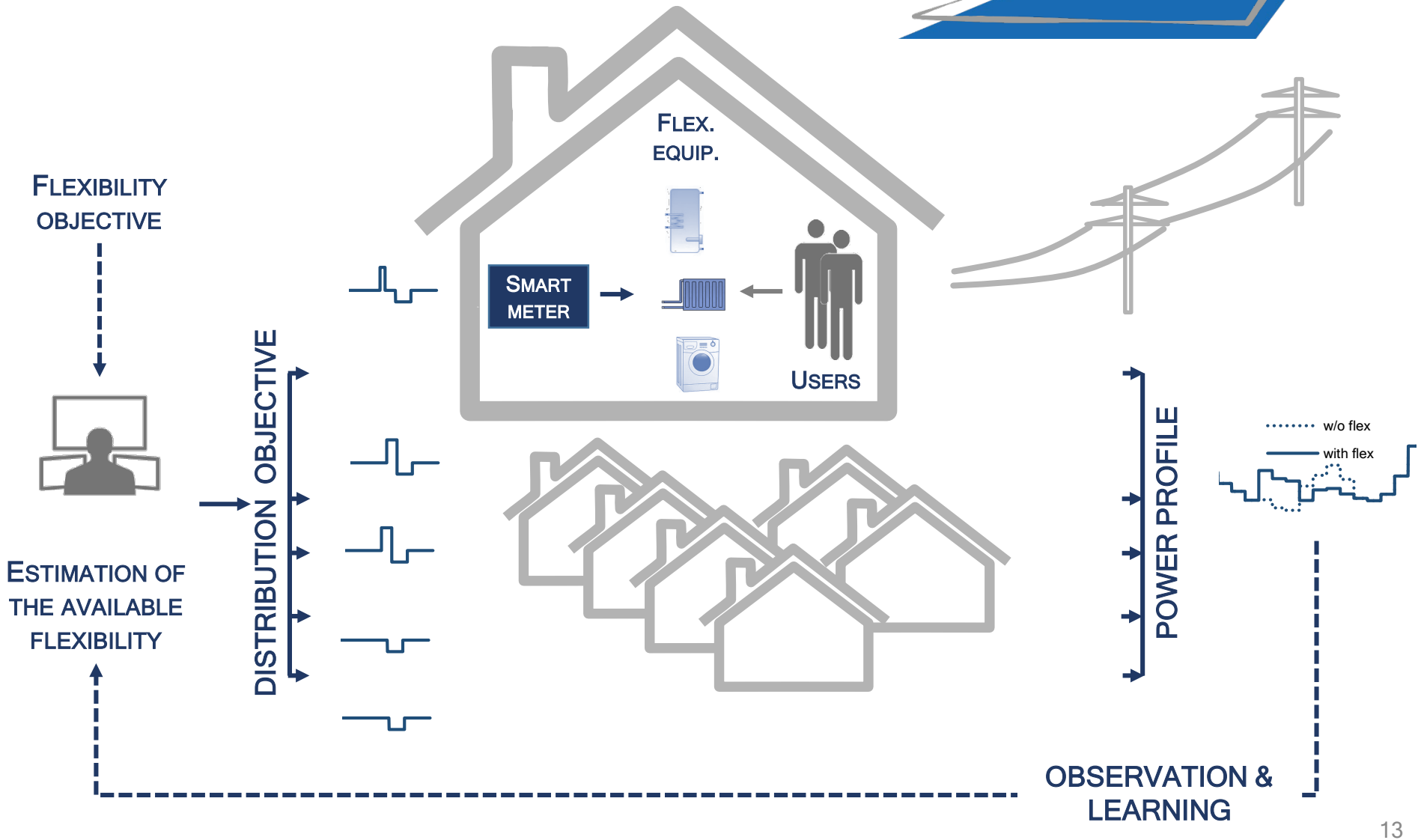


Night-share of the annual energy consumption :

	Flat tariff	TOU tariff
Dishwasher	15%	32%
Washing machine	6%	26%
Dryer	15%	16%



PERSPECTIVES



MERCI !

Related projects :

- ANR CLEF (2018-2021)
- Collaboration LaSIE/SGR (2017-2018)

Contacts :

- Jérôme LE DRÉAU (jledreau@univ-lr.fr)
- Marika VELLEI (mvellei@univ-lr.fr)
- Johann MEULEMANS (Johann.Meulemans@saint-gobain.com)

Websites :

- http://lasie.univ-larochelle.fr/2018-2021-CLEF-ANR
- https://gitlab.univ-lr.fr/jledreau

REFERENCES

Journal articles :

- M. Vellei and J. Le Dréau, “A novel model for evaluating dynamic thermal comfort under demand response events”, in Building & Environment (**under review**).

Conference articles :

- J. Le Dréau, M. Vellei and Y. Abdelouadoud, “A Bottom-Up Model to Evaluate the Flexibility of French Residential Wet Appliances”, in IBPSA 2019 (**under review**).
- M. Vellei and J. Le Dréau, “Evaluating Dynamic Thermal Comfort under Demand Response Events: a Novel Model Compared against Fanger's PPD Model”, in IBPSA 2019 (**under review**).
- J. Le Dréau and J. Meulemans, “Upscaling the flexibility potential of space heating in single-family houses”, in CISBAT (**under review**), 2019.
- J. Le Dréau and J. Meulemans, “Characterisation of the flexibility potential from space heating in French residential buildings,” in 7th International Building Physics Conference, IBPC 2018, 2018.

Other publications :

- J. Le Dréau and J. Meulemans, “Building stock characterisation of space heating flexibility from single-family houses “, in IEA EBC Annex 67 - Examples of Energy Flexibility in buildings, 2019.
- ADEME, Systèmes Electriques Intelligents Premiers résultats des démonstrateurs, 2016.
- ADEME & Artelys, Trajectoires d'évolution du mix électrique à horizon 2020-2060, 2018.
- OPECST, Note n°11 Le stockage de l’électricité, 2019.
- RTE, Réseaux électriques intelligents, 2017.