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Load monitoring at a short time step to set up actions: a feedback from the USER project on the Reunion Island

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Summary

1. The context of the Reunion Island and the USER project

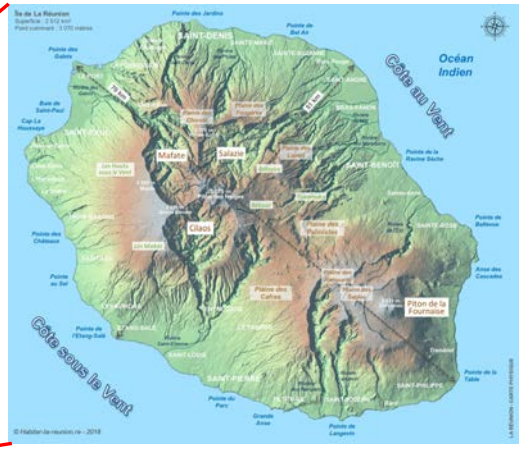
2. Results from the survey and methodology for the monitoring campaign

3. Feedback, conclusion and perspectives

1

The context of the Reunion Island and the USER project

The Reunion Island



- French overseas department
- 2512 sq.km
- 861 210 inhabitants
- Electricity generation in 2019 : 3 046.9 GWh (renewables 31.2 %) – source: OER Horizon Reunion

The Specificities of the overseas territories regarding electricity

- Electricity generation mainly relies on CO_2 rich solutions (69 % with fossil fuels)
- The tariff equalization mechanism keeps the price of the kWh on the island exactly the same as the one paid on France mainland

Answers:

- Switching to a larger share of renewables
- **Improving energy efficiency and reducing consumptions (in particular for the residential sector)**

The USER project

For most households on the Reunion Island, specific end-uses are their sole electricity consumptions (no heating, no hot water)

USER (specific end-uses of electricity on the Reunion Island) is a three-year project launched in 2019 and backed by the French Agency for Ecological Transition (ADEME)

Goals: Increase the knowledge about the specific end-uses on the Reunion Island: appliances ownership rates and characteristics, energy consumptions, impact of the energy efficiency advice, households behaviours regarding electricity and their choices

USER's answers:

1. A quantitative survey to get an overlook on the appliances' stock on the island
2. A two-part qualitative monitoring campaign
3. A qualitative sociological study

We will focus on point 1 and point 2

2

Results from the survey and methodology for the monitoring campaign

A quantitative survey to get an accurate overview of the specific end-uses: a precious requirement for the monitoring campaign

- The quantitative survey was conducted over the phone on a 1000 households sample selected to be representative of the Island's population
- Ownership, characteristics (size, technology, efficiency) and usage patterns were investigated
- Appliances were distributed in seven categories based on their purpose:

1. Cooling
2. Cold appliances
3. Cooking
4. Hygiene
5. Audio and video
6. ICT
7. Lighting, outdoor, mobility, and others

Myth: overseas territories have lower ownership rates than France mainland

On the most common appliances, it was proven to be globally **wrong** on the Reunion Island!

		Ownership rates	
Category	Appliance	Reunion Island	France mainland (EDF R&D)
Cooling	fixed	30%	15%
	mobile	2%	7%
Cold appliances	Refrigerators all types	100%	99%
	Refrigerators number per owning household	1.1	1.2
	Simple refrigerator (main appliance)	12%	24%
	Two-door refrigerator (freezer above - main appliance)	51%	30%
	Two-door refrigerator (freezer below - main appliance)	25%	41%
	American refrigerator (main appliance)	12%	5%
	Freezers	59%	54%
Hygiene	Washing-machine	93%	83%
	Dishwasher	24%	50%
	Tumble dryer	10%	25%
Cooking	Rice cooker	83%	8%
	Microwave oven	77%	70%
	Electric oven or mini-oven	67%	65%
	Coffee maker with filter	50%	50%
	Coffee maker other types	41%	38%
Audio and video	TV	97%	87%
	Number of TV per owning household	1.3	1.4
ICT	PC laptop (at least one)	63%	69%
	PC desktop (at least one)	21%	44%
	Smartphone (at least one)	82%	82%

Some key figures 1: characteristics, intensity of use, efficiency

Air conditionning

- ✓ **86%** of the AC systems are located in the **bedroom(s)**
- ✓ Used:
  - ✓ **4.8 months per year**
  - ✓ **6.3 hours per day**
- ✓ Turned ON when needed

Lighting bulbs

- ✓ **86%** of the households own at least one **LED**
  37% at least one **CFL**
  25% at least one **incandescent**
- ✓ **1.6** bulb types per household
- ✓ **19%** of the households acknowledge to sometimes enter in an empty room with the light on

Cooking

- ✓ **4,6 appliances on average.** 2 of them used at least once a day
  Most used on an everyday basis (when owned): coffee maker (without filter), cooktop, micro-wave
- ✓ **4 cooktops out of 10** are **induction** cooktops
- ✓ **Rice cookers: 29 min on average,** 43% at noon

Refrigerators

- ✓ **7.4 years**
- ✓ **36% of the households own an A+ or better** (but 43% don't know)
- ✓ **68%** of the households own a large appliance (> 1.50 m).

Freezers

- ✓ **8 years**
- ✓ **23% of the households own an A+ or better** (but 54% don't know)

Some key figures 2: characteristics, intensity of use, efficiency

Washing-machines, dishwashers, tumble dryers

- ✓ Dishwashers
  - **4.9 years**
  - **42%** are at least A+ (40% don't know)
  - **85%** are of 12 sets size
  - **2.9** cycles per week
  - **85%** are launched when full or close
  - **48%** of the cycles are low temperature cycles
- ✓ Washing-machines
  - **4.4 years**
  - **44%** are at least A+ (35% don't know)
  - **53%** are 6 to 9 kg
  - **2.9** cycles per week
  - **71%** are launched when full or close
  - **56%** of the cycles are low temperature cycles
- ✓ Tumble dryers
  - **4.5 years**
  - **38%** are at least A+ (35% don't know)
  - **60%** are 6 to 9 kg
  - **23%** of the equiped households use it everytime

TV and electronics

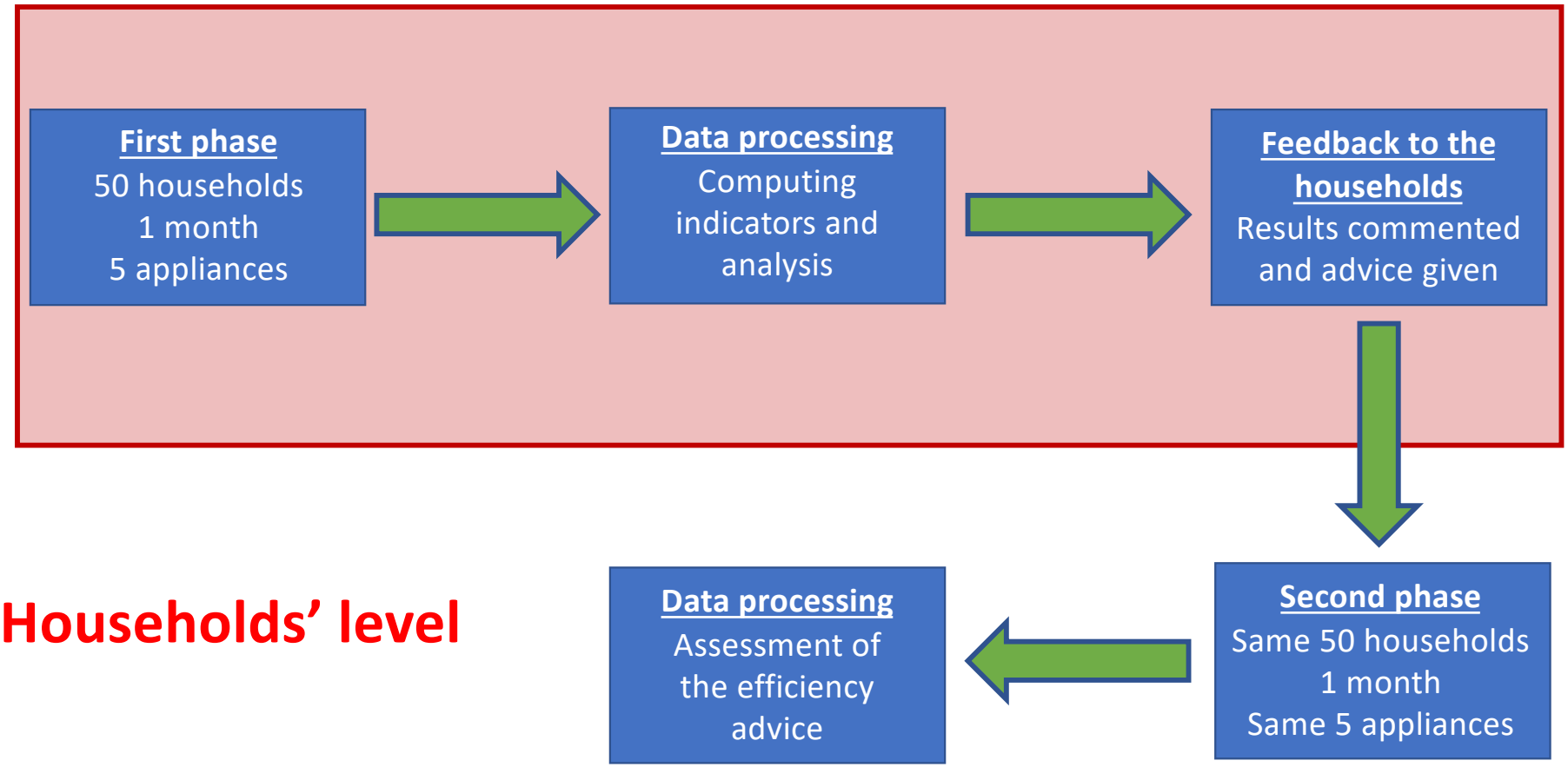
- ✓ 3.4 appliances per household
- ✓ Average diagonal: 94.7 cm
- ✓ **TV ON 5h23 per day** on average. 4 household out of 10 never use the standby mode

Very similar to France mainland (except for the efficiencies of white products: less efficient)!

PC and peripherals

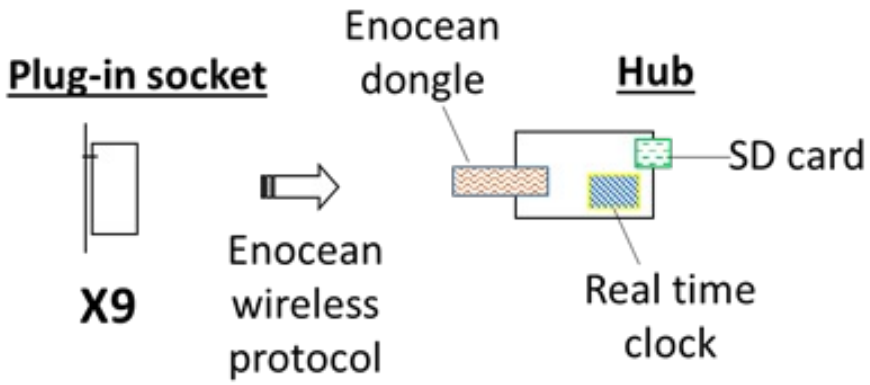
- ✓ 3.3 appliance on average
- ✓ **81%** own an high speed modem
- ✓ 1.3 laptop per equiped household
- ✓ Desktops used **4h a day on average**
- ✓ **43 %** of the equiped households charge their laptops once a day

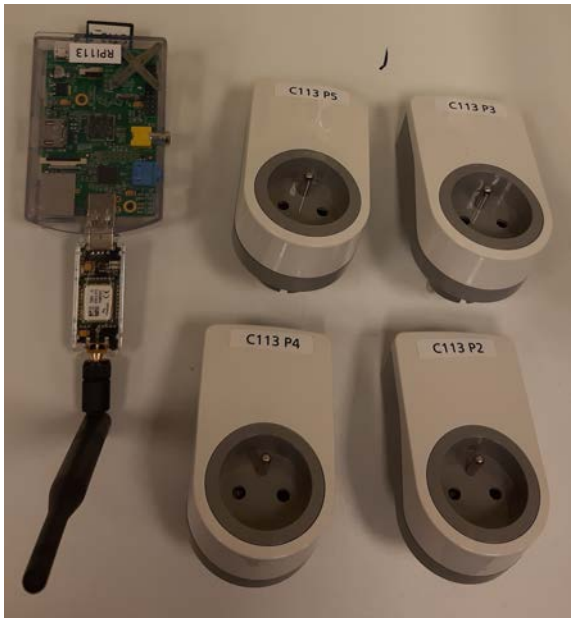
The two-phase monitoring campaign to assess the impact of efficiency advice



Households' level

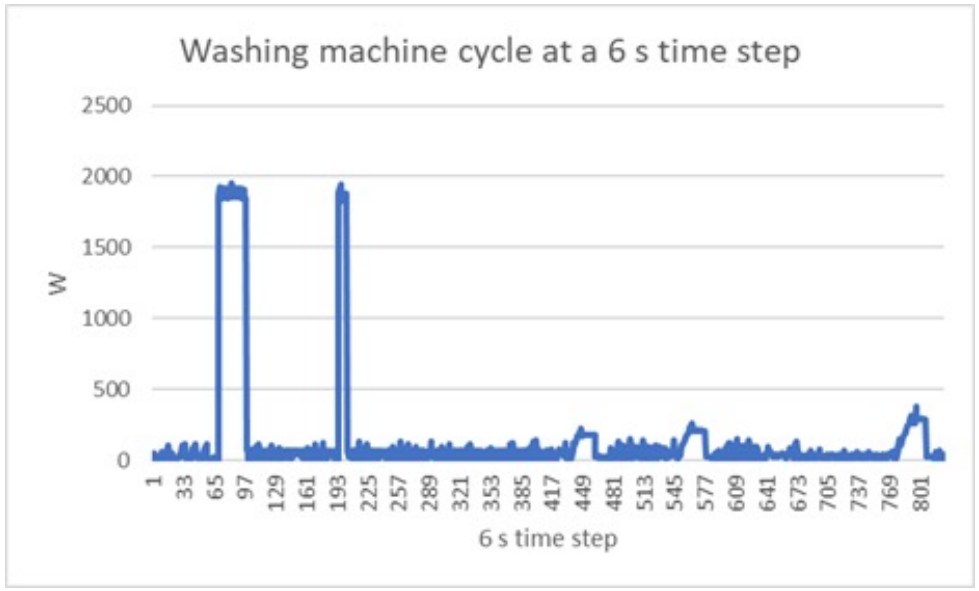
What is recorded?

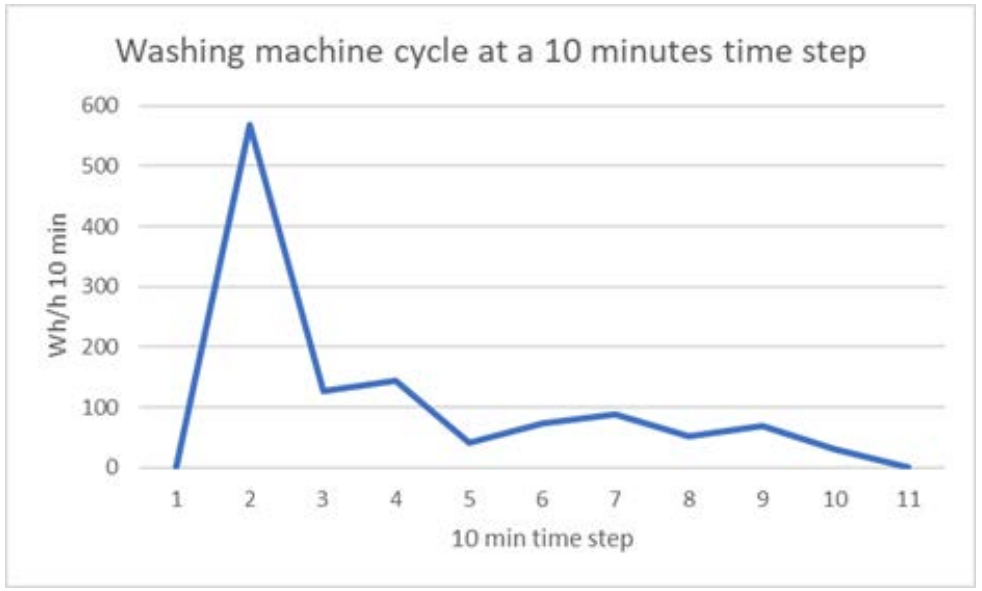




- Instantaneous active power
- 6 seconds time step
- 5 appliances
- Plug and play but in the USER context, installed on site by SPL-Horizon Reunion

The advantages of a « short » time step





- Real and accurate image of the appliances' functionning and power demand
- Allows to compute a large range of indicators

Building a balanced sample

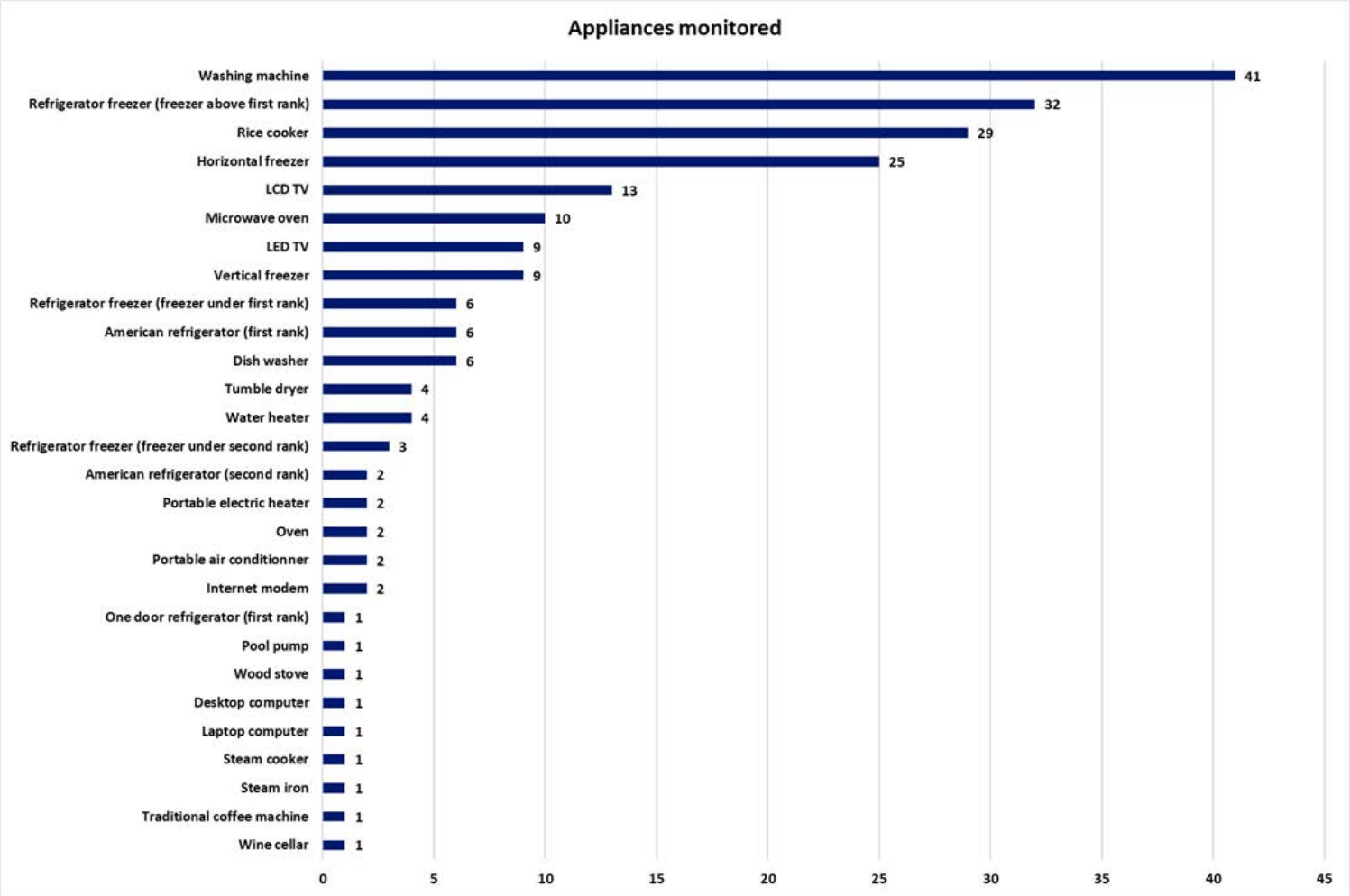
Two main guidelines:

- Capture enough diversity
- Follow as much as possible the same quotas than those used for the quantitative survey

Housing type	Household size (people over 15)	Financial status	Target	Number recruited	Percentage
House	≤ 2	Financial insecurity	11%	11	17%
House	≤ 2	No financial insecurity	26%	21	33%
House	> 2	Financial insecurity	9%	8	13%
House	> 2	No financial insecurity	21%	10	16%
Flat	≤ 2	Financial insecurity	6%	5	8%
Flat	≤ 2	No financial insecurity	12%	1	2%
Flat	> 2	Financial insecurity	5%	4	6%
Flat	> 2	No financial insecurity	10%	3	5%

Phase one: appliances recorded

- 28 different types of appliances recorded
- Focus on the cold appliances (refrigerators and freezers)
- Washing machines, TVs and rice cookers well represented
- Miscellaneous (acceptance sometimes hard)



Phase one: indicators (fitted for cold appliances)

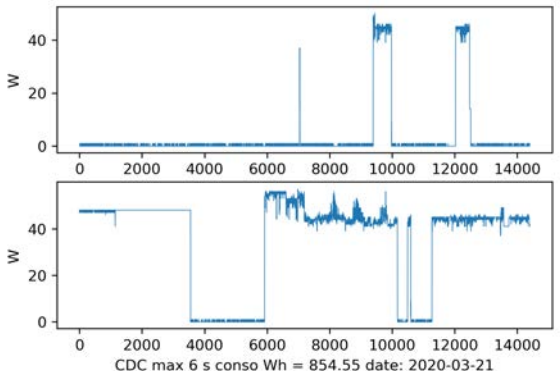
- Why focusing on the cold appliances?
  - First share of electricity consumption for the households
  - Hot and wet climate => increases the electricity consumption
  - Prone to malfunctionning
- Indicators are computed for each appliance but most relevant for cold appliances
- <u>Goals:</u>
  - To characterise the appliances and their intensity of use
  - To identify the malfunctionning appliances

Indicator / Value name	Definition
Theorical annual consumption	Computed thanks to equations tuned by EDF R&D. Input data are appliance type, efficiency, and total volume
Extrapolated annual consumption	Computed from the month recorded
Consumption ratio	Ratio between Extrapolated and theorical consumption
Minimal theorical annual consumption	Minimal annual consumption computed from the minimal three-hour power demand over the whole days
Maximal gain	Gain between the extrapolated annual consumption and the minimal theorical annual consumption
Daily average number of cycles	Total number of cycles divided by the total number of days
Average cycle duration	In minutes, computed on all the days
Average ON ratio	Mean of the ratio between cycle duration and length of the day
Three-hour average power demand ratio	Computed from the three-hour power curve. It is the ratio between the maximal and the minimal values

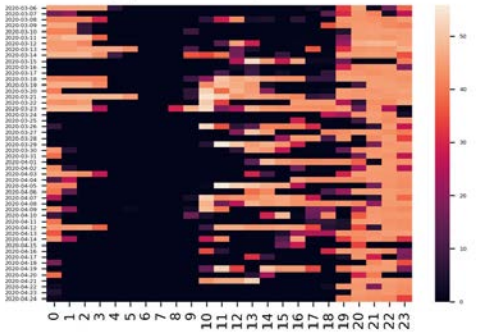
Phase one: graphs (fitted for cold appliances)

TV

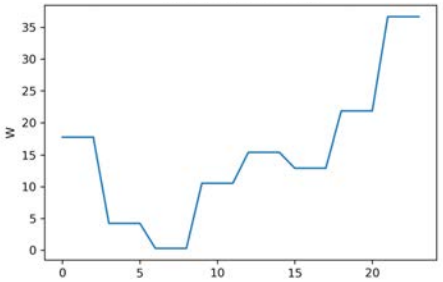
Days with min and max consumptions



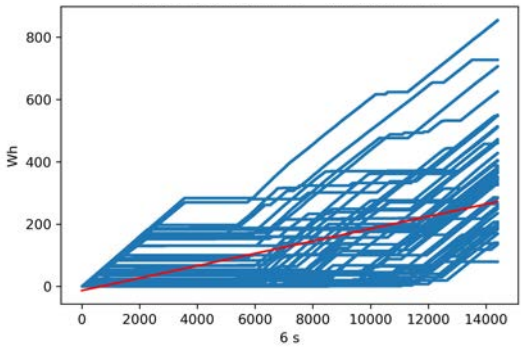
Hourly power heatmap LCD TV in W



Three-hour average load curve

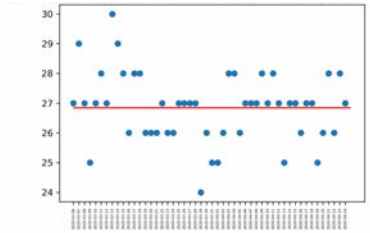


Daily cumulated energy

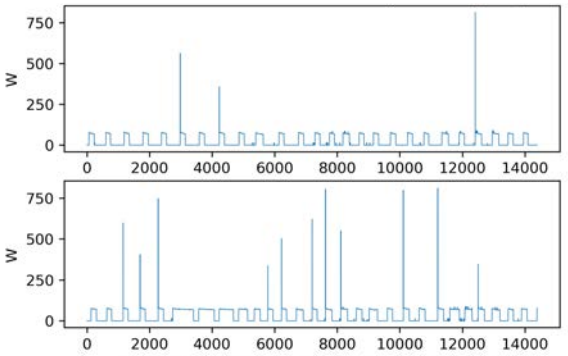


Refrigerator

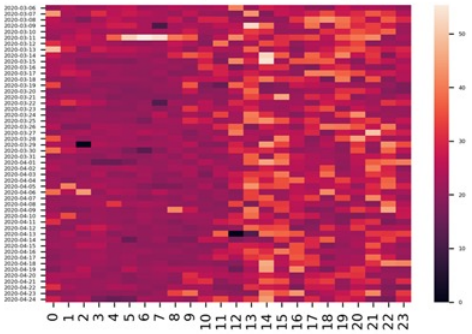
Number of cycles per day



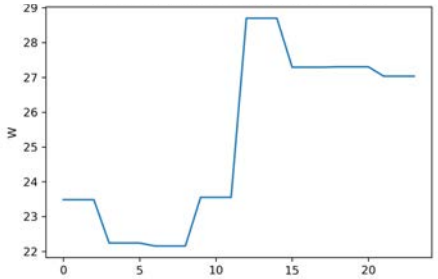
Days with min and max consumptions



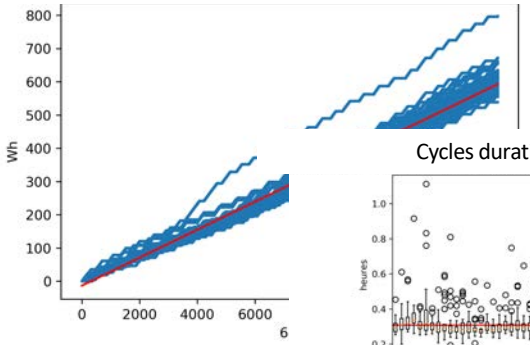
Hourly power heatmap two-door refrigerator in W



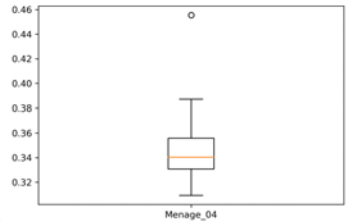
Three-hour average load curve



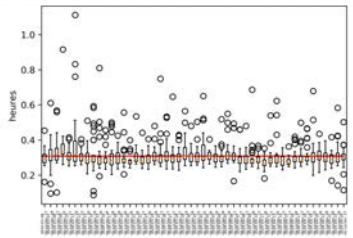
Daily cumulated energy



ON / OFF ratio distribution

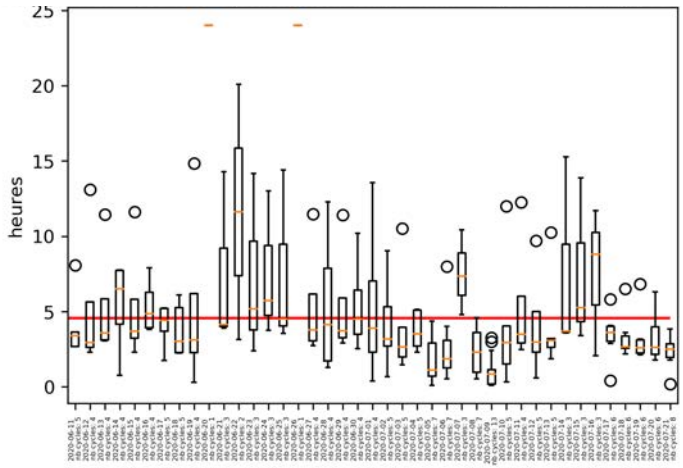


Cycles duration distributions

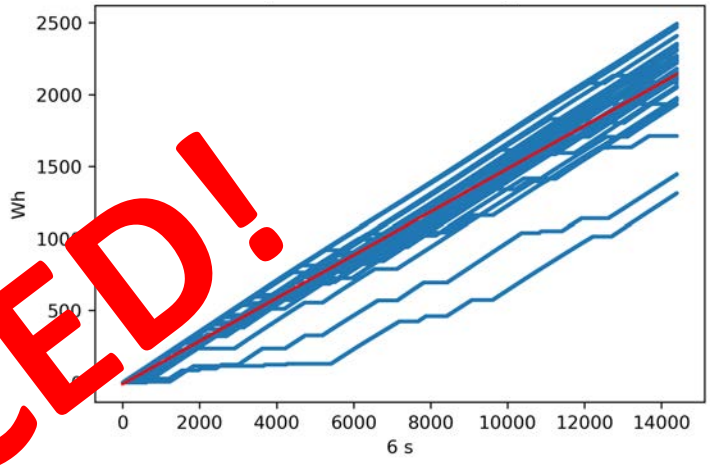


Phase one graphs: example of a malfunctionning freezer

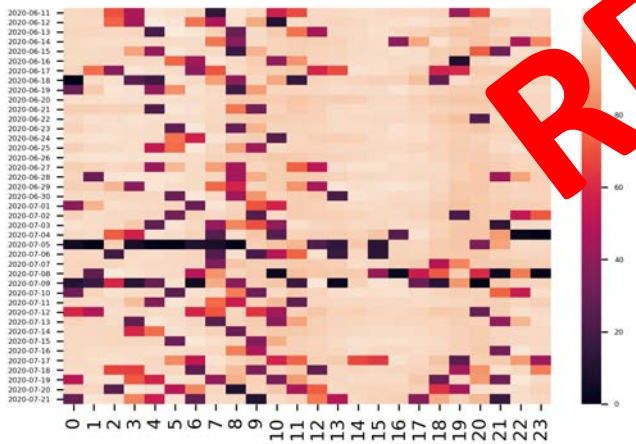
Cycles' length distribution



Daily cumulated energy



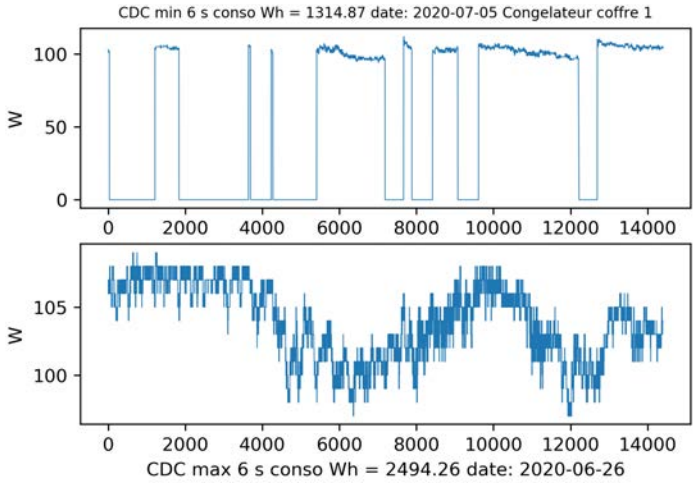
Heatmap W



REPLACED!

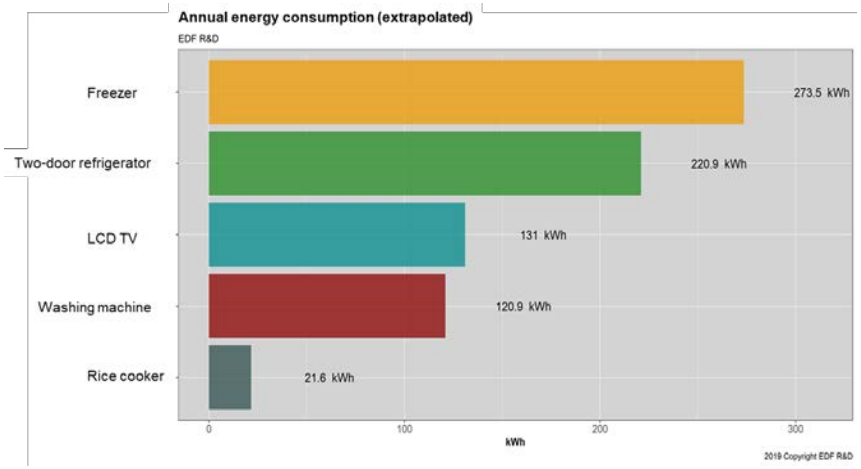
15 % of the cold appliances were found to be malfunctioning

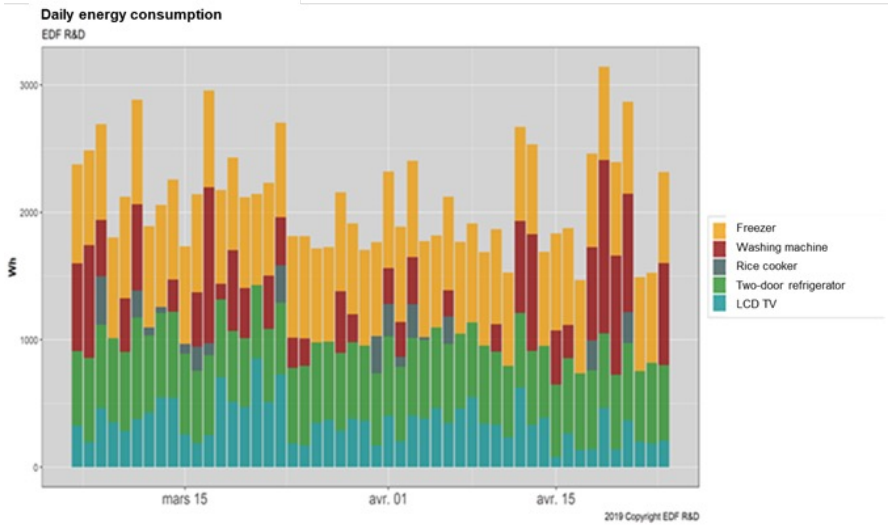
Days with min and max consumptions

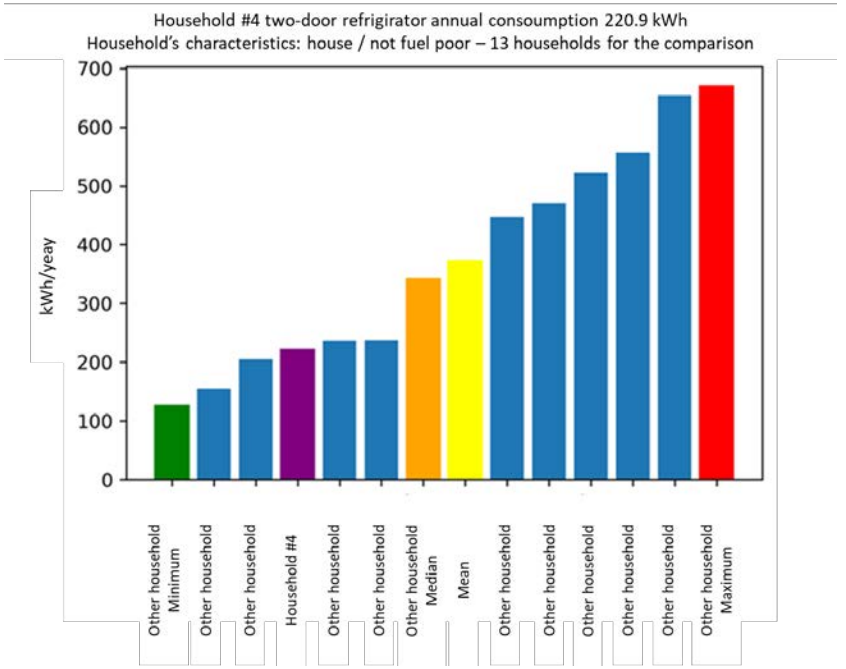


Phase one: reports given to the households

- For each household, focus on energy consumptions and their rankings within the appliances monitored (power not really relevant for the households)
- Comparison with other households alike (as much as possible)
- Relevant efficiency advice given appliance by appliance







3

Feedback, conclusion and perspectives

Feedback for the monitoring campaign

- Setting up a monitoring campaign is **complex!** Always expect the unexpected
  - ✓ A **quantitative survey** prior to the field study is a real plus: it does help to know and to understand the reality of the situation, it is also useful when designing the sample (appliances to focus on, getting the right diversity…)
  - ✓ For some households, following basic rules can be challenging. **Accompagnying the households is essential**
- When the level targeted is the households' appliances, **short time step power demand is relevant**
  - ✓ To undestand what's really going on (intensity of use, malfunctionning appliances…)
  - ✓ To compute indicators beyond the sole electricity consumptions
  - ✓ To address as much as possible tuned advice

Conclusion and perspectives

- At the end of the phase one of the monitoring campaign we were able to deliver **45 detailed and pesonalised reports** to the households involved
- Our focus on the cold appliances showed that **15 %** of them were malfunctionning. This is significant and raises the question of the **scaling-up** of this result to the whole stock
- The main concern was the household level but there is still **a lot to dig**: assessments of the consumptions at the stock level, comparisons with France mainland…
- **Results of phase two are coming**: which end-uses will benefit the most of the advice given?

Hint: it's not the TV!

ADEME

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