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# Evaluating the impact of advice and appliances replacements on power demand and energy consumption: feedback from a field study on the Réunion Island

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## ABSTRACT

The context of the French overseas territories is special. Those territories are off the main grid. This implies relying on an expensive and $CO_2$ rich energy mix for electricity generation. Nevertheless, according to the tariff equalization, the price per kWh is the same as the one on mainland France. The losses are financed by a tax paid by all the French customers.

In such a special context, reducing the electricity consumption is even more critical. But if we do not want to miss the target, we need to design actions and policies which consider local knowledge.

USER (Usages Spécifiques de l'Electricité à la Réunion) is a three-year project (2019-2022) funded by the French environmental Agency ADEME. USER aims at improving the knowledge about the households' use of electricity for their appliances on the Réunion island. A deep understanding of the Island households is the path to success for relevant actions that will be accepted and preserve as much as possible the wellbeing and the local ways of life.

In this paper, we will present and discuss the main results of the monitoring campaign conducted on a sample of more than fifty Réunion Island households. Their cold appliances were targeted in the first place because they remain a major source of electricity consumption. The active power at a short time step was recorded at the appliances level. A first period of monitoring helped to evaluate the initial situation for each participant thanks to some data processing: normal consumption and power demand, over consumption due to inappropriate behaviours, over consumption due to appliance failure. Then, a range of actions was introduced for each household: from advice to appliance replacement. Finally, a second monitoring round was conducted followed by an assessment.

The main lessons learned were that for TVs and rice cookers, we did not observe significative changes in the intensity of use. Equipment replacements for the cold appliances are very efficient. And finally, households were responsive regarding their washing-machines.

The goal is to help the local decision makers (ADEME and EDF Réunion) to fine tune their strategies when it comes to building energy efficiency actions.

## Introduction

When it comes to designing programs to improve energy efficiency or sufficiency regarding the households' electricity consumptions for their appliances, one of the first questions is: will it be successful?

The advice, end-use by end-use, have now been repeated for years. Nevertheless, we always wonder which are the best end-uses to target if we really want to make a significant step towards reducing energy use.

With the USER project on the Reunion island, we tried to address those questions.

In this paper, we will present the results we obtained from the field for 5 different end-uses: the rice cookers, the TVs, the washing-machines, the freezers, and the refrigerators. We will analyse the outcomes of the monitoring campaign. This will give an overview of what worked and what did not or at least did not bring the expected improvements in terms of reducing electricity consumption.

This may give some hints on what to focus on for other upcoming programs.

## The USER project

The USER project is a three-year research project backed by the French Agency for Ecological Transition (ADEME). USER stands for Usages Spécifiques de l'Electricité à la Réunion (Specific Electricity End-uses on the Reunion island). This project was selected in 2019 by the ADEME following its call entitled: "Vers des bâtiments responsables à l'horizon 2020". Led by EDF R&D, USER is a joint proposal from EDF R&D, EDF Reunion and the local association SPL-Horizon Reunion.

The USER project aims at improving the knowledge of the specific end-uses on the Reunion island where, for most households, those end-uses still represent the largest part of their electricity consumptions even if air conditioning is growing fast. Improving the knowledge means acquiring data on the appliances' stock (ownership rates, efficiency, technologies…). It also implies getting a better understanding on how the households use their appliances, and how their purchase behaviour given the choices they really have on the retail's shelves. Finally, the goal was to assess what can be expected from efficiency campaigns including advice and in some cases appliances replacements.

To address those questions, the USER project is divided into three phases:

1. A quantitative survey to get an overview of the residential appliances stock on the Reunion island. This survey is completed by a report on the market of the main appliances (fridges, freezers, washers…)
2. A monitoring campaign that targets some key appliances: cold appliances, washing appliances, rice cookers, TV…
3. A sociological study to better understand how households buy their appliances, make their choices and how they apprehend their electricity consumptions.

The first phase showed that on the Reunion Island, for the main appliances, the ownership rates are close to those in France mainland. Some differences exist; for example, the rice cookers are owed by 83 % of the households on the Island vs 8 % for France.

The results of the quantitative survey and the methodology are described in detail in (Binet 2022). In this paper, the results of the second part of the project- the monitoring campaign – are presented.

## The monitoring campaign

### The principles of the monitoring campaign

The monitoring campaign of the USER project is divided into two phases:

- <u>Phase one:</u> a selection of households is monitored during at least a month. Then, the data are processed and analysed. This provides insights on their electricity consumptions for the targeted appliances, to identify the malfunctioning and / or the over-consuming ones. Then, for each household, we set-up a report, a ranking, and a comparison with households alike for each appliance monitored in terms of electricity consumption
- <u>Phase two:</u> the reports are discussed with the households. They are completed with some energy efficiency advice for each appliance monitored. In some cases, for the cold appliances when they were identified as malfunctioning, they are replaced. Then, a second monitoring campaign was launched (same households, same appliances, at least a month later) to assess the depth of the energy savings and to identify where they came from.

Due to the wet and tropical climate of the Reunion island[1], we tried as much as possible to match the timeframes of the two phases. It's important for the cold appliances. Nevertheless, we also had to compose with the COVID 19 constraints.

## Households' selection, data recording, data processing, households' coaching

### Finding the "right" households

SPL-Horizon Reunion, our local partner, managed to recruit a sample of 63 households with enough diversity on key criteria (Binet 2022):

- Housing types
- Households' size (people over 15)
- Financial status.

Once the selection was done, for each household, 5 appliances were targeted. The priority was given to the most owned and used ones: cold appliances (fridges and freezers), washing-machines, TV, rice cookers.

### The monitoring system

The monitoring system used has been designed by EDF R&D. It consists of plug-in sockets (figure 1, left) that record every 6 seconds the instantaneous active power of each appliance plugged (figure 1 right). The continuous load curves are locally stored on an SD card (figure 1, left). This system has been used in the field for several monitoring campaigns for our own needs or for others (Binet 2021). For the USER project, SPL-Horizon Reunion oversaw the installing the monitoring systems on the field.

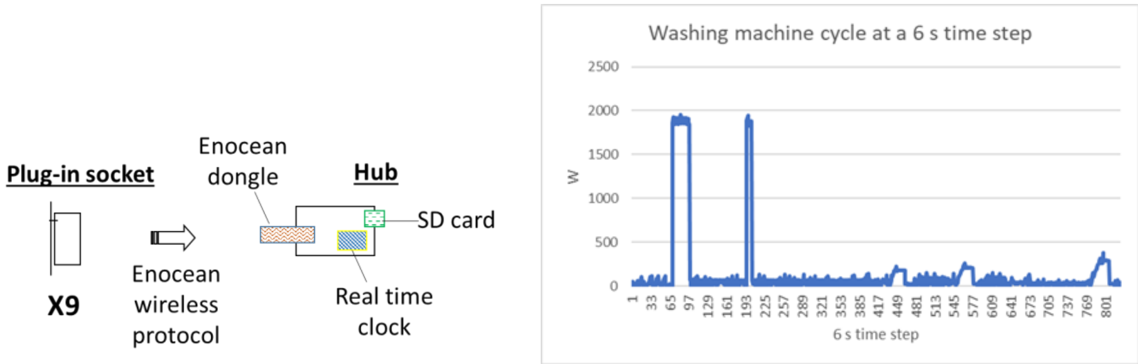



Figure 1. Diagram of the monitoring system (left), a 6 second load curve of a washing-machine (right)

### Data processing and reports generation after the first phase of the monitoring campaign

As with any data and particularly wireless data, the raw records need to be vetted: gaps are filled, anormal pikes are smoothed for example. After this first step, data from 45 households among the 63 were eligible for further processing, because some households finally refused to be monitored, others had not enough days recorded and in some rare cases, the monitoring system had recording problems.

The data processing consists in the computation of some key indicators: number of cycles per day, duration of the cycles, energy consumption, three-hour average load curves, daily cumulated energy… (Binet 2022). Those indicators allow to determine the malfunctioning and the overconsumptions for each appliance. This leads to a report generated for each household. Those reports include two rankings:

- The ranking of the appliances monitored by consumption within each household
- The ranking of the appliances monitored by consumption between households alike (according to the selection criteria).

[1] http://www.meteofrance.re/climat/reunion

Malfunctioning fridges and freezers[2] (15 % of those monitored) were replaced whenever it was possible. The new appliances were carefully chosen; same type, same volume, efficient, tropicalised[3].

**Households' coaching**

With the reports generated from the data, EDF Reunion edited, for each household, a more pedagogical document. The purpose of this document is to explain to the households their electricity consumptions for the appliances monitored and to make them understand how they can achieve energy sufficiency with the help of simple and basic measures.

Those documents were sent to the households, commented over the phone by SPL-Horizon Reunion and explained again in situ when the monitoring system was put back in place for the second monitoring campaign (figure 2).

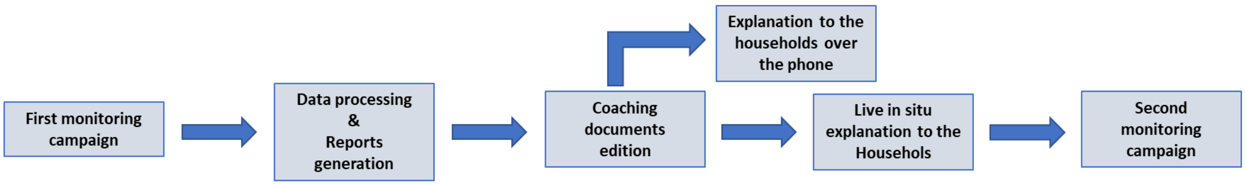



Figure 2. Chronological steps from the first monitoring campaign to the second monitoring campaign

## The ex-post results

In the following parts, we are going to present the ex-post results for 5 of the most important appliances: rice cookers, TVs, washing-machines, fridges, and freezers.

Those appliances:

- Are most **widespread**: they are owned by a vast majority of households and therefore, the populations monitored are the most significant in terms of number
- Cover **different end-uses**: cooking, entertainment, hygiene, food preservation
- Represent a **large share of the specific electricity consumptions** for the households: cold appliances stand for at least 25 % on average for example (Dupret 2021 – France mainland and a minimum for Reunion island households).

For each appliance, the guidelines are the same. We will present:

- The appliance and its specificities
- The number of households monitored
- The advice given
- The results obtained in terms of energy savings and their explanation. Whenever it may be relevant, we will add elements about power demand.

It must be underlined that after the second monitoring campaign, the number of households decreased slightly since some of them refused to be re-monitored.

[2] For a cold appliance, malfunctioning means no cycling (always ON, always OFF) or frequent irregularities when cycling
[3] Tropicalised for a cold appliance means that the machine is designed to work at best under a tropical weather

## The rice cookers

### Rice cookers' specificities

Rice cookers are very common on the Reunion island since rice is at the base of the local cuisine. Our ownership rates study showed that 83 % of the households own a rice cooker (Binet 2022). This makes it the most widespread cooking appliance on the island.

Like any other cooking device, it drains a significant power from the grid to heat the water and to convert it into steam. The efficiency of a rice cooker cannot really be improved since it relies on a resistor to make heat. Nevertheless, a better use of the rice cookers can lead to significant electricity savings if the right quantities at the right time are cooked. This means that the "keep it warm" function needs to be avoided as much as possible. On figure 3, it represents about half of the cycle's consumption.

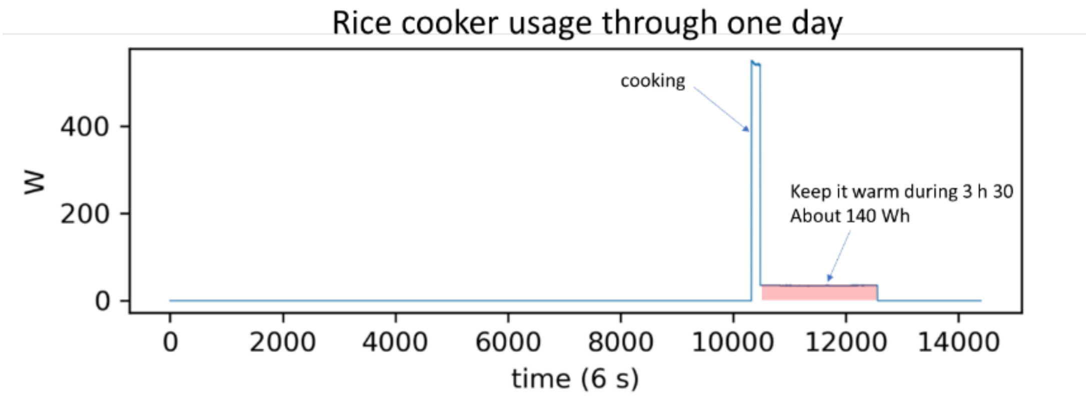



Figure 3. Typical load curve of a rice cooker

For our monitoring campaign, we managed to follow 11 households through phase 1 and phase 2.

### Results for the rice cookers

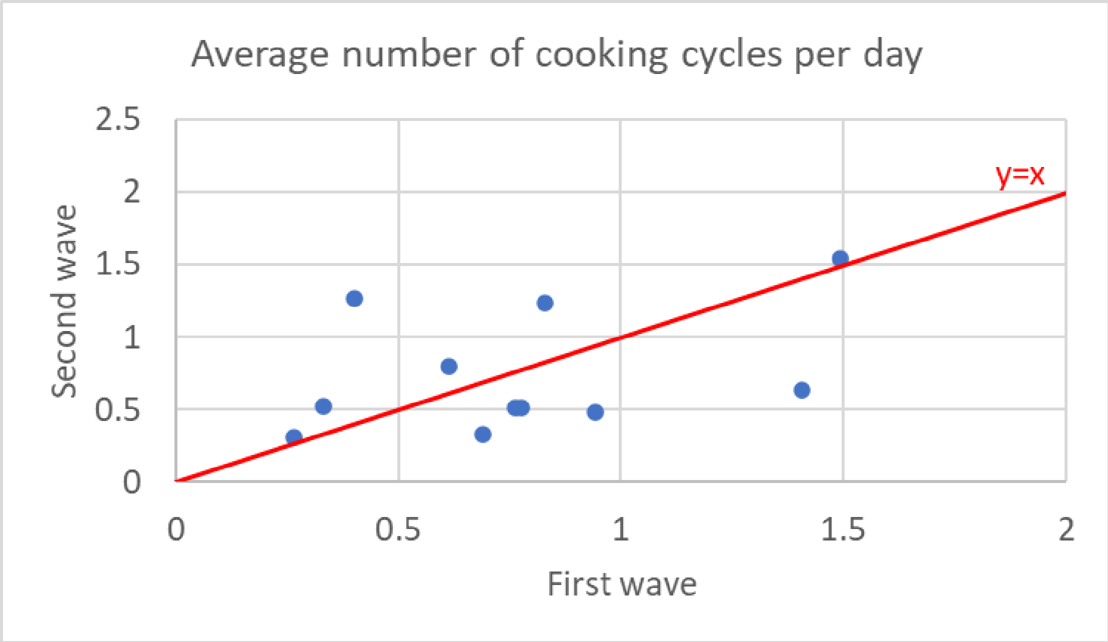
If we break down the usage of the rice cookers to analyse the behaviours that lead to the electricity consumptions recorded, the components are:

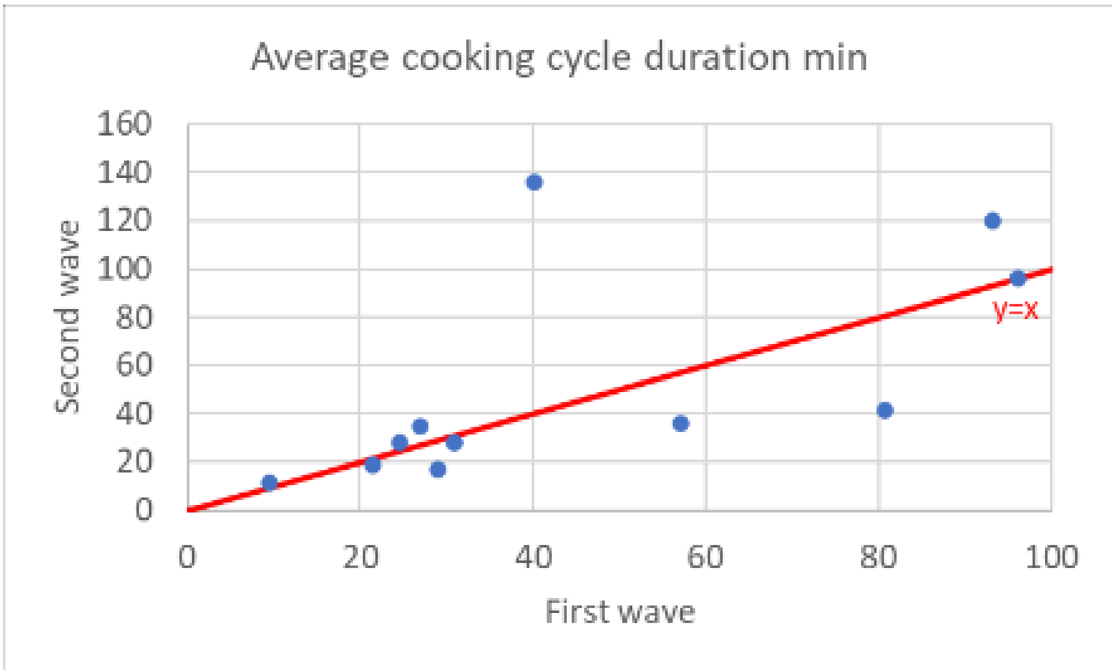
- Average number of cycles per day
- Average duration of one cycle
- Average electricity consumption per cycle.

Our analysis uses graphs that compare those components for the first versus the second wave. We use the first bisector to achieve this: the closer a household (represented by a dot on the graphs) is to the straight-line y = x, the more unchanged its usage is.

Regarding the average number of cycles per day (figure 4 top), it is an ex-aequo match: 5 households managed to reduce their number of cycles against 5 that increase their usage. Two stayed the same.

For the average duration (figure 4 middle), half of the households kept their habits. One third of the households managed to reduce significatively both their average number of cycles per day and their average duration per cycle (figure 4 bottom).


Average number of cooking cycles per day
Second wave
First wave
y=x
0
0.5
1
1.5
2
2.5
0
0.5
1
1.5
2


Average cooking cycle duration min
Second wave
First wave
y=x
0
20
40
60
80
100
120
140
160
0
20
40
60
80
100

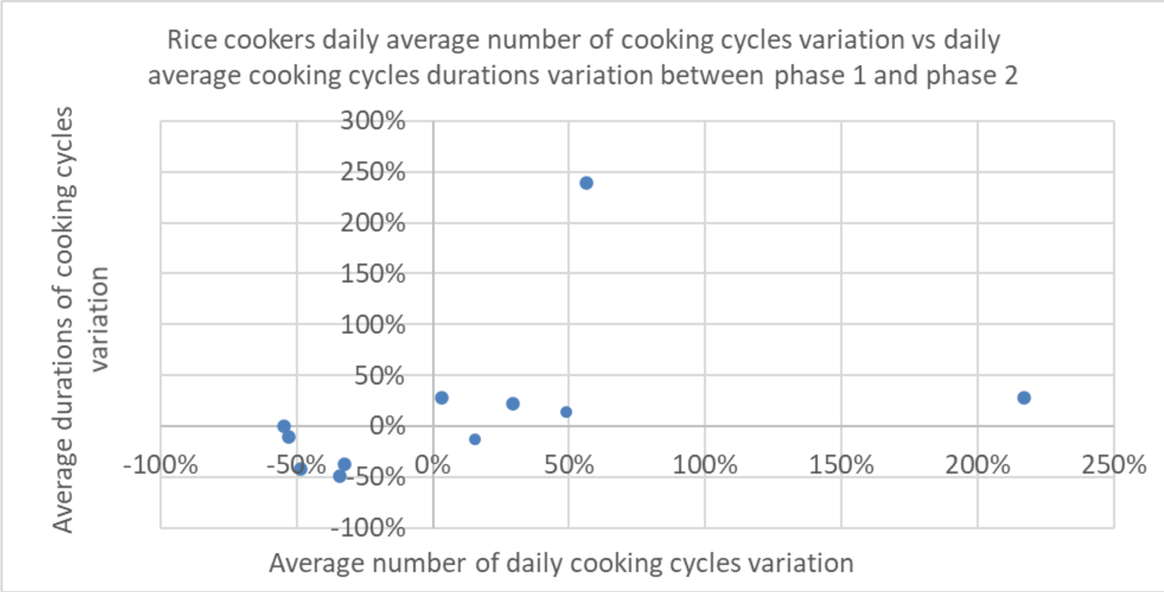
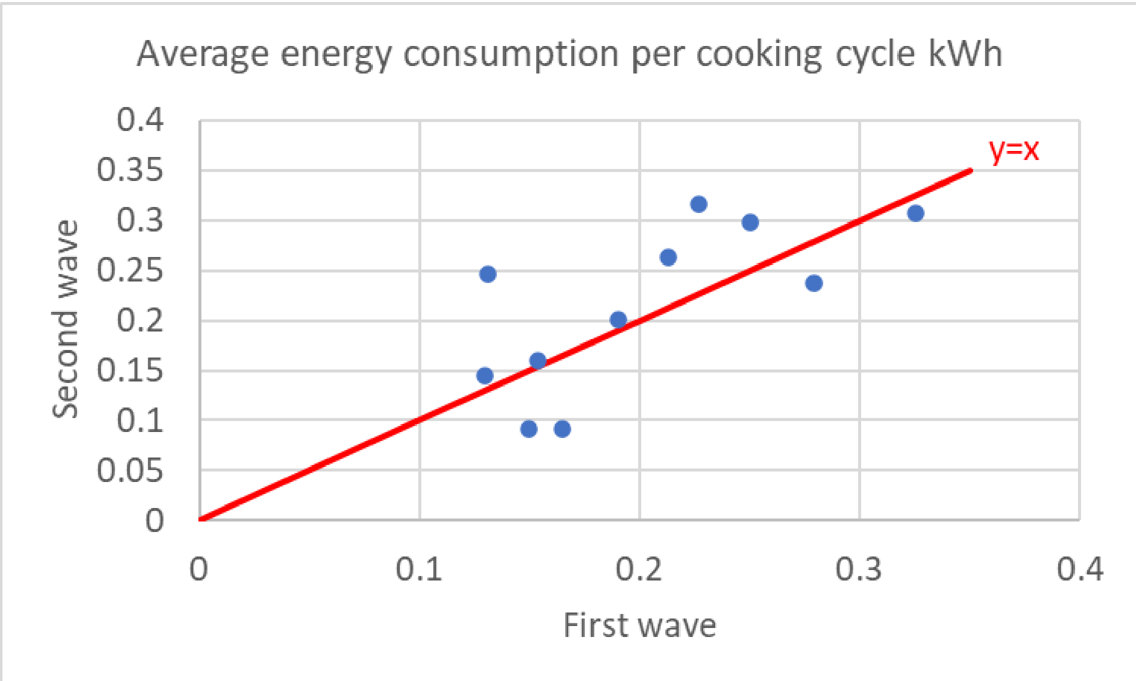



Figure 4. Average number of cooking cycles per day (top), average cooking cycles' durations (middle), variations (bottom)

For the average energy consumption per cycle (figure 5 top), we have a perfect split: one third of the households did not change their habits, one third managed to lower their consumptions (3 more significantly) and one third increased their usage intensity.

Finally, the combination of those components gives us the annual electricity consumptions (figure 5 bottom). Two households are near the bisector: this means almost no changes. 4 lowered their consumptions and 5 increased it.



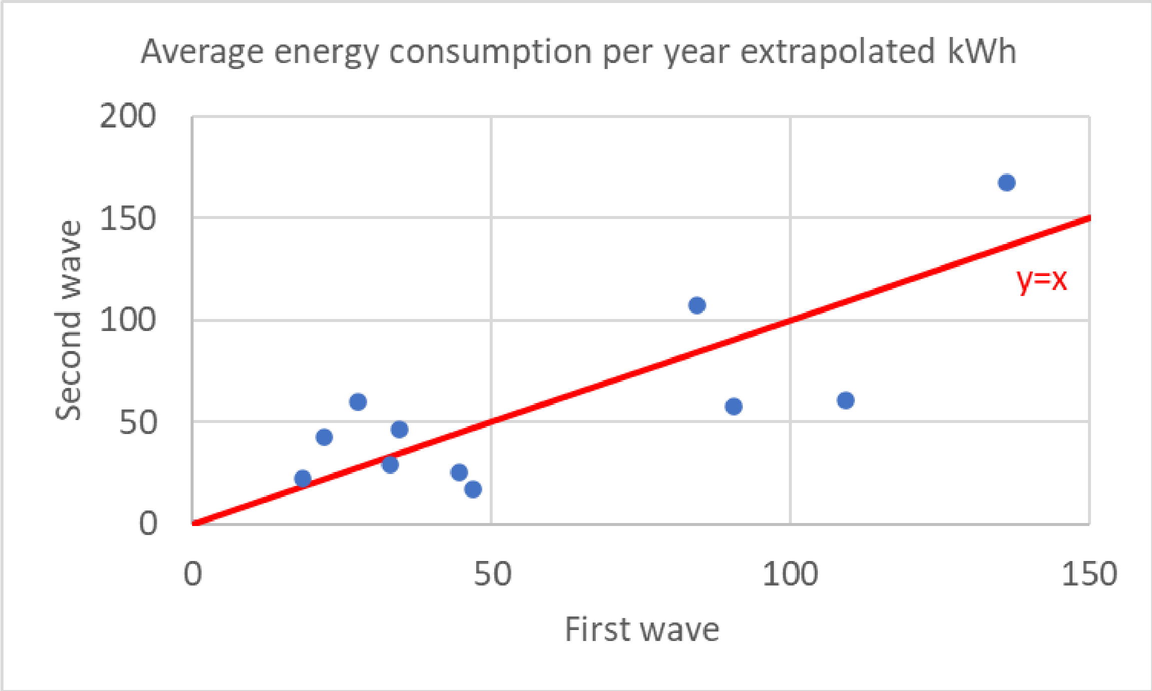



Figure 5. Average energy consumption per cooking cycle (top), average energy consumption per year extrapolated (bottom)

To complete our overview of the usages of the appliances, we introduced the quadrant graph (figure 6). The quadrant graph divides the plane in for equal parts. Each part corresponds to a possibility (from upper left and clockwise):

- Households with less cycles and longer cycles
- Households with more cycles and longer cycles (worst case)
- Households with more cycles and shorter cycles
- Households with less cycles and shorter cycles (best case).

It is important to note that this graph **does not indicate the magnitude** of the reduction (or increase) of the cycles' durations, of the number of cycles or of the consumption per cycle.

In each quadrant, we have the first bisector for the annual energy consumption:

- **in the lower left quadrant**, the dots should be under the first bisector (the households lowered their energy consumption for the usage)
- **in the upper right quadrant**, the dots should be above the first bisector (the households increased their energy consumption for the usage).

If not, this means that the appliance was replaced and / or that the usage mode is different (higher temperature for a washing-machine for example).

For the other two quadrants, there is no rule regarding the position around the first bisector.

**The quadrant graph is designed to give a quick overview of the situation before and after the coaching.**

In the case of the rice cookers (figure 6), we see that half the households managed to lower their energy consumptions but only 4 did it significatively. The reduction of consumptions mainly came from a diminution of the number of cycles (left quadrants).

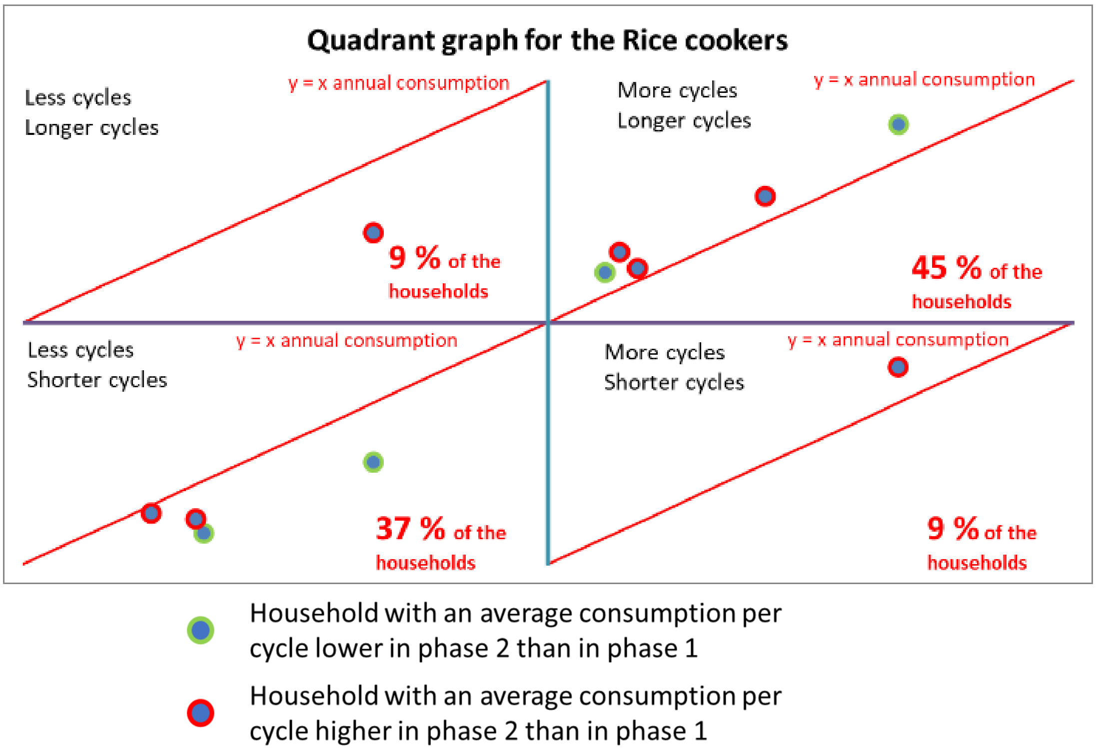
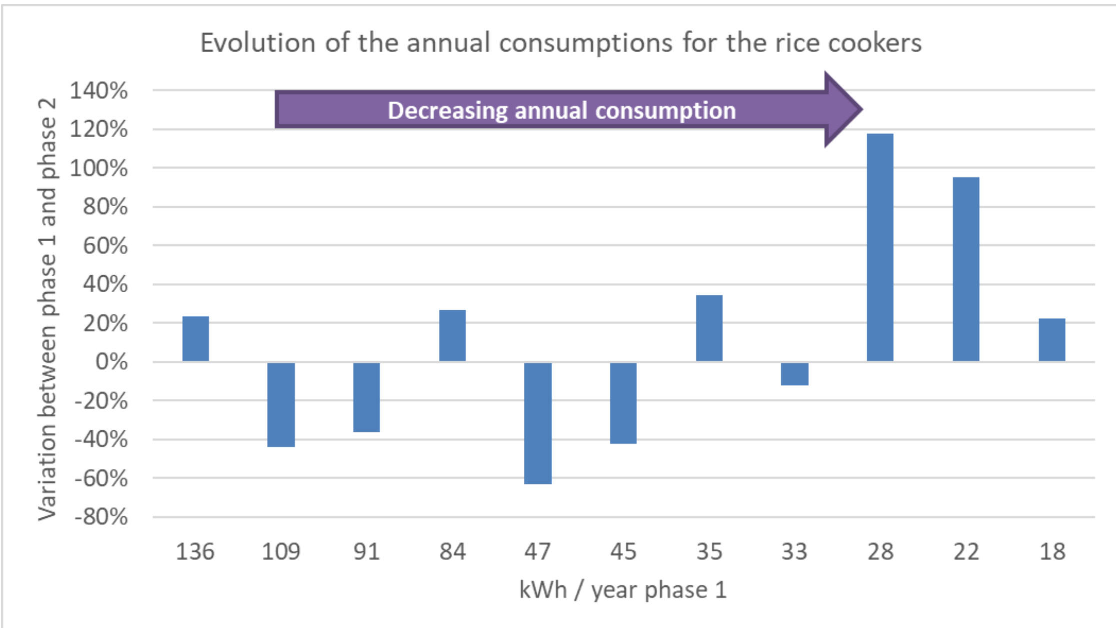



Figure 6. Quadrant graph for the rice cookers

If we draw the variations of the annual extrapolated electricity consumptions between phase 1 and phase 2 (figure 7 top), we note that two out of three lowest consumptions in phase 1 are the ones that increased the most in phase 2. And two third of the 50 % of the households with the highest energy consumptions in phase 1 reduced their consumptions significatively in phase 2.

The distribution of the extrapolated electricity consumptions for the rice cookers confirms that the match is quite even between the first and second phase of the monitoring campaign (figure 7 bottom). Nevertheless, the sum of the annual consumptions is slightly lower (2 %) for the second campaign and the average decrease for those who managed to do it reaches more than 39 %.



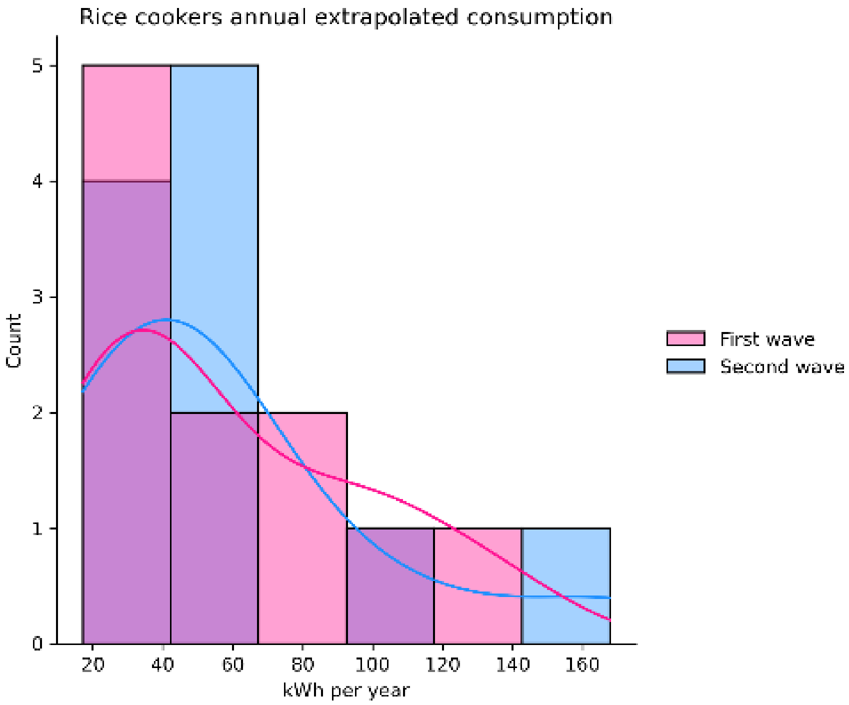



Figure 7. Evolution of the annual extrapolated consumptions for the rice cookers (top), distribution of the annual extrapolated electricity consumptions for the rice cookers (bottom)

It seems like cooking is quite difficult to change. We have the confirmation here even if the consumptions are a little bit lower…but it is very shy and it is hard to draw conclusions.

## The TVs

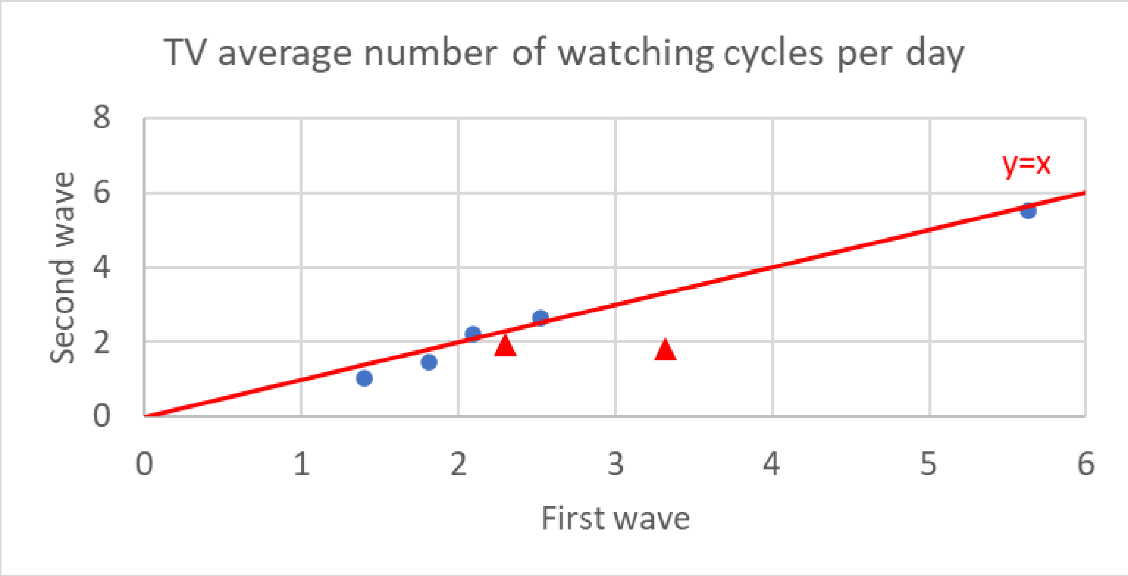
### TVs' specificities

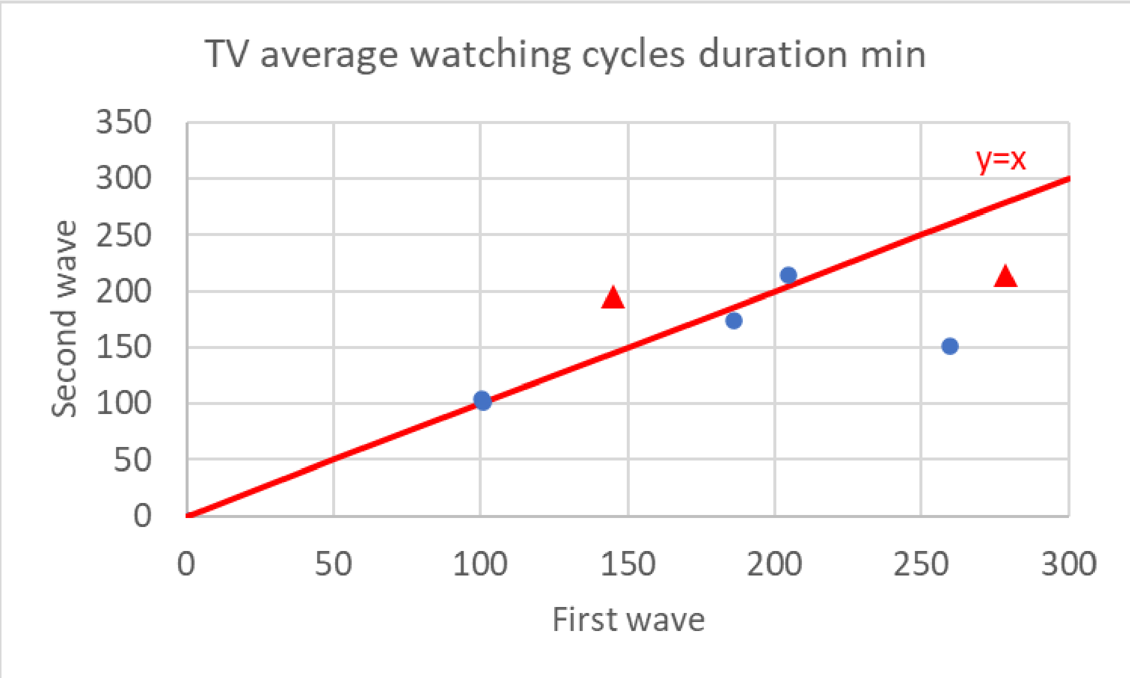
As in France mainland, TVs are owned by almost every household: the ownership rate is 97 % according to our survey. We managed to follow 7 TVs. The acceptance rate for monitoring this appliance is quite low and the opportunities to offer efficiency advice are limited. Indeed, thanks to the Ecodesign regulation, the standby modes are now very low. The most relevant advice would be to watch TVs less. Which is understandably quite hard to achieve.

### Results for the TVs

Only one household managed to really lower its average number of watching cycles per day (figure 8 top). Regarding the durations (figure 8 middle), 57 % of the households did not change their average habits (4 dots on the first bisector). Overall, only two household really managed to both reduce their average number of watching cycles and the average duration by watching cycle (figure 8 bottom).

▲ TV replaced by the household


TV average number of watching cycles per day
Second wave
First wave
y=x
0
2
4
6
8
0
1
2
3
4
5
6


TV average watching cycles duration min
Second wave
First wave
y=x
0
50
100
150
200
250
300
350
0
50
100
150
200
250
300

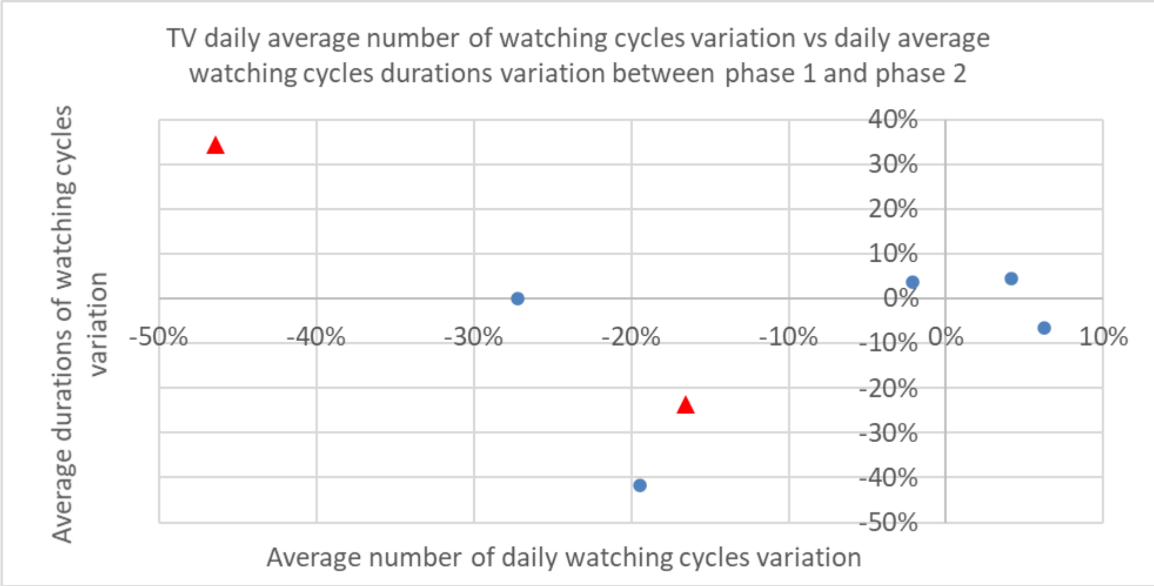
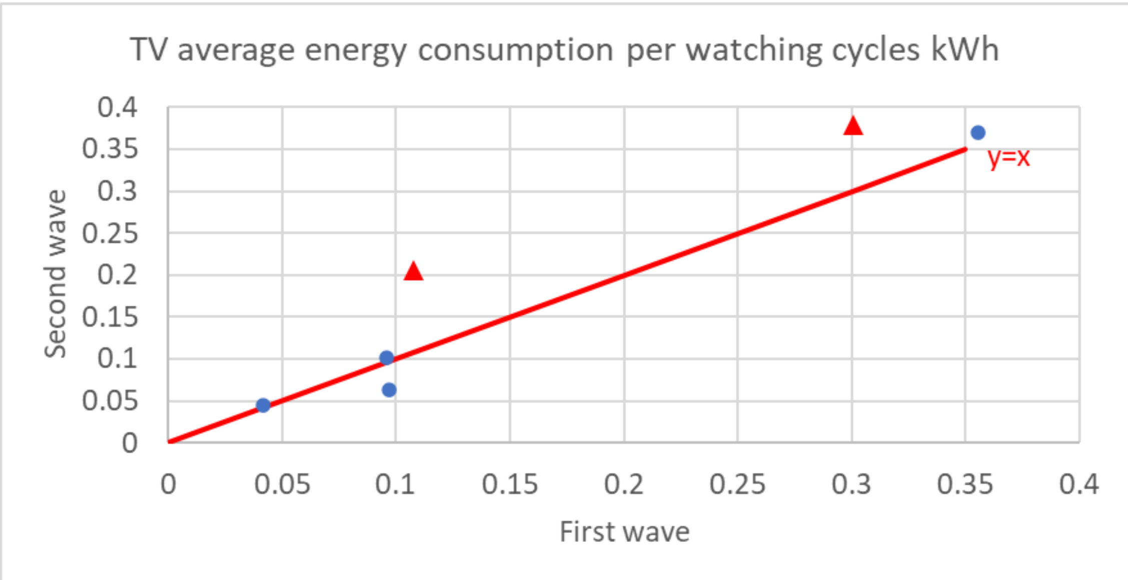



Figure 8. Average number of watching cycles per day (top), average watching cycles' durations (middle), variations (bottom)

Regarding the electricity consumptions per watching cycle (figure 9 top), it is interesting to note that the two households that replaced their appliances are above the first bisector. Both households switched to more power intense TV sets. For the household that lowered its average watching duration per watching cycle, it even annihilates its efforts on this point (figure 10 shows its load curves for phase one and phase 2).

Finally, for all the households, the annual extrapolated consumptions that combine all the effects previously cited are quite even (figure 9 bottom). Only two households significatively reduced its electricity consumptions (by 23 % and 47 %).

▲ TV replaced by the household



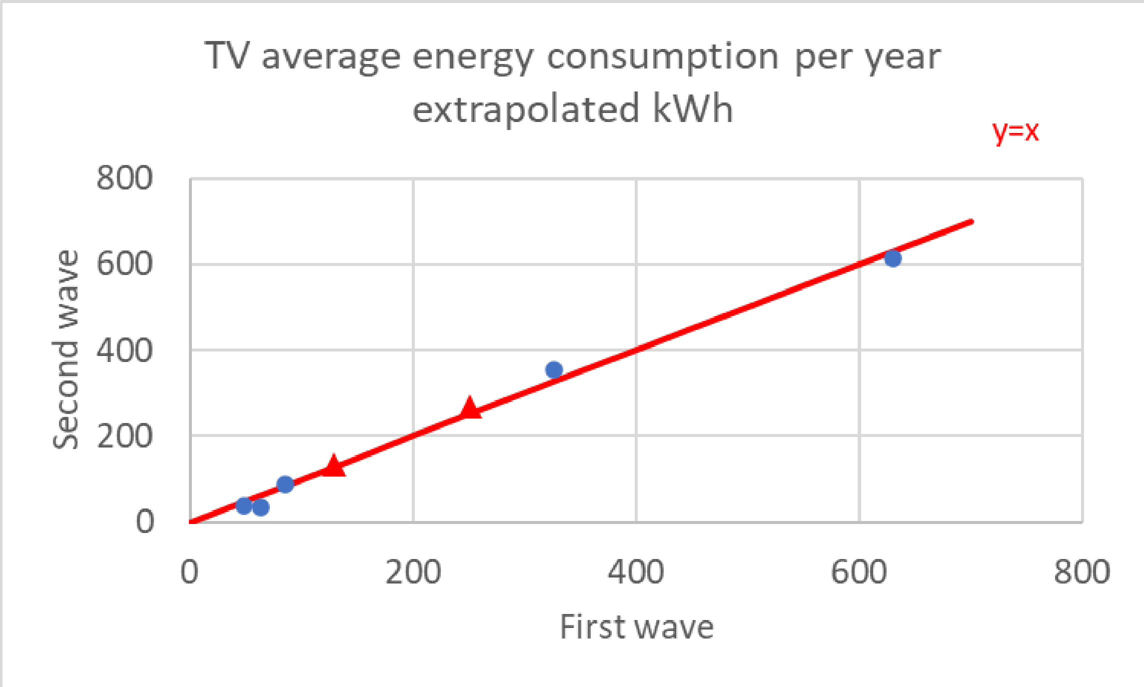



Figure 9. Average energy consumption per watching cycle (top), average energy consumption per year extrapolated (bottom)

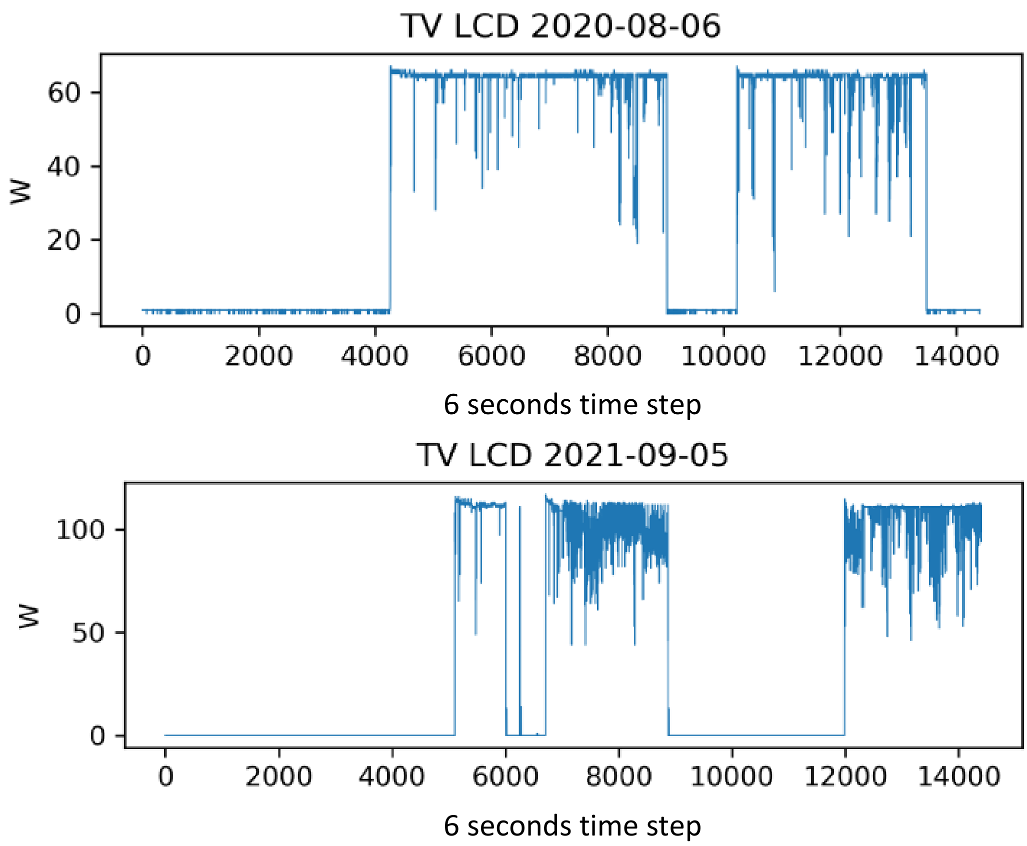



Figure 10. First phase of the monitoring campaign, one day (top), second phase of the monitoring campaign, the TV has been replaced (bottom)

The quadrant graph (figure 11) confirms the detailed analyse of the components but with the possibility to have all the information for each household (but the magnitude).

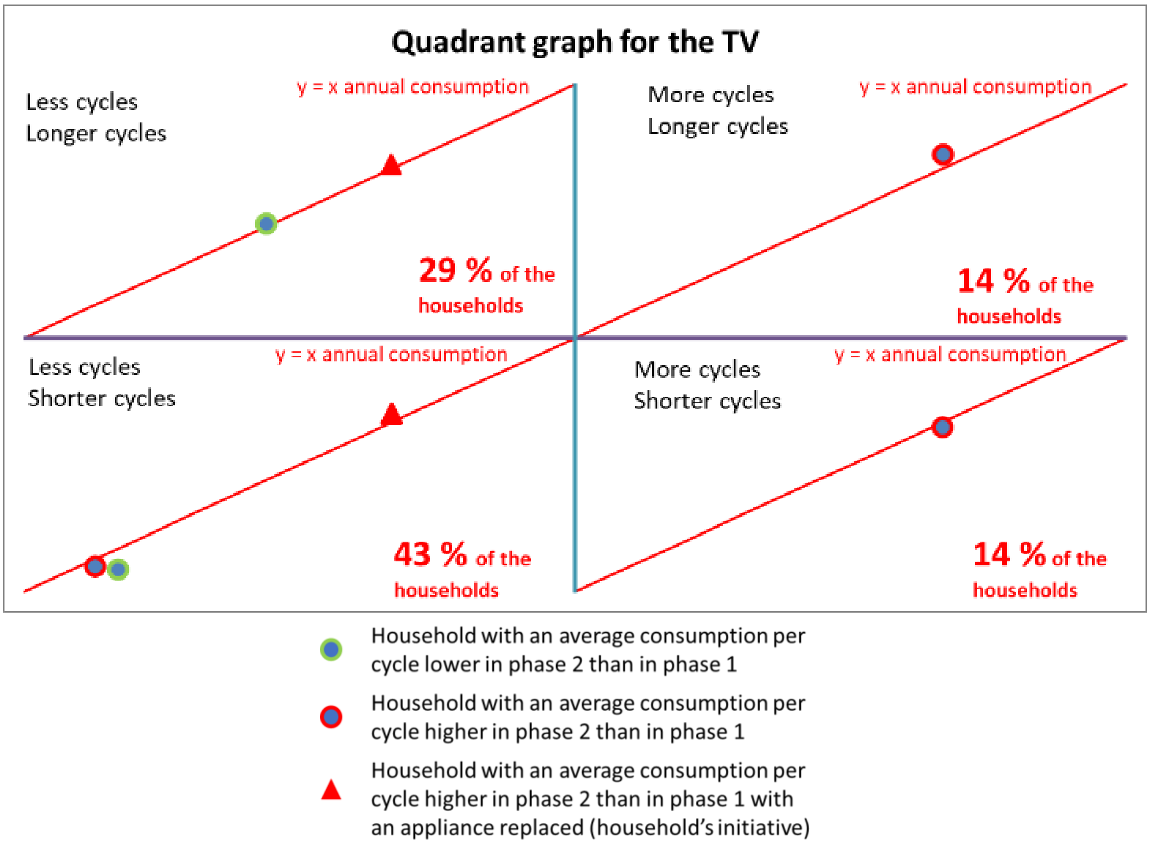
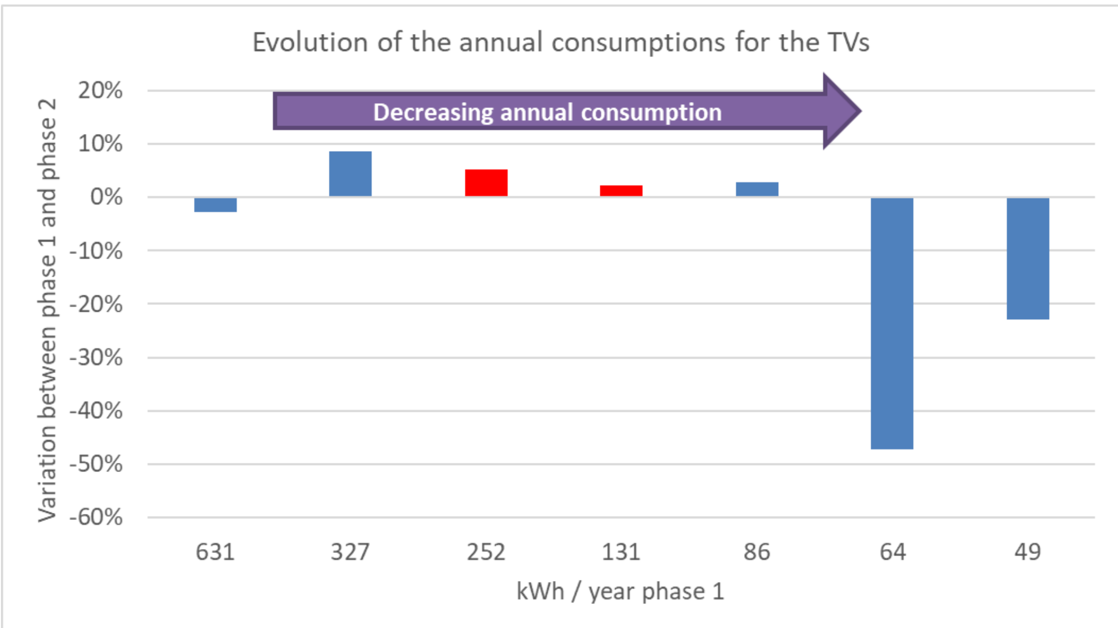



Figure 11. Quadrant graph for the TVs

If we consider the evolutions of the extrapolated annual consumptions between phase 1 and phase 2 (figure 12 top), it is interesting to note that the two households that managed to lower the most their usage of their TVs were those who already consumed less.

The distributions of the extrapolated annual consumptions are identical (figure 12 bottom). The households which reduced their consumptions did it by a mean of 24 %. The sum of the annual consumptions extrapolated has decreased of less than 1 %.



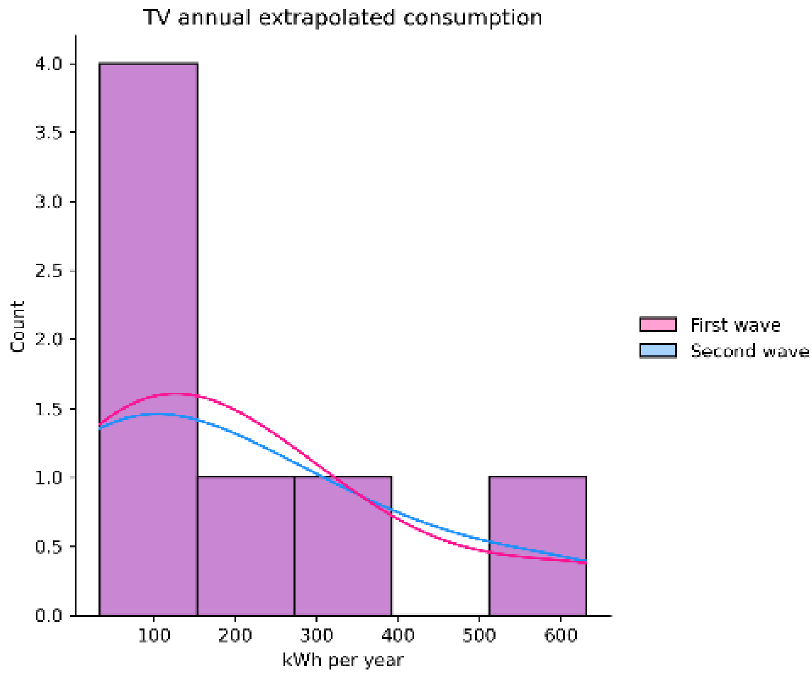



Figure 12. Evolution of the annual extrapolated consumptions for the TVs (top), distribution of the annual extrapolated electricity consumptions for the TVs (bottom)

To conclude, even if our sample is small, the hardlines regarding the TVs are present. The habits are strong: only three households (43 %) succeeded in changing their behaviours. Nevertheless, one of those three ruined its efforts because it replaced its TV set by an appliance that needs more power.

## The washing-machines

### Washing-machines' specificities

On the Reunion island, about 91 % of the households own a washing-machine. We managed to monitor 28 appliances.

The advice given to the households were:

- lower as much as possible the washing temperature
- If your appliance has an eco mode, use it
- Fill-up your washing-machine to lower the number of washing cycles you do.

Four households among the 24 changed their appliances between phase 1 and phase 2.

### Results for the washing-machines

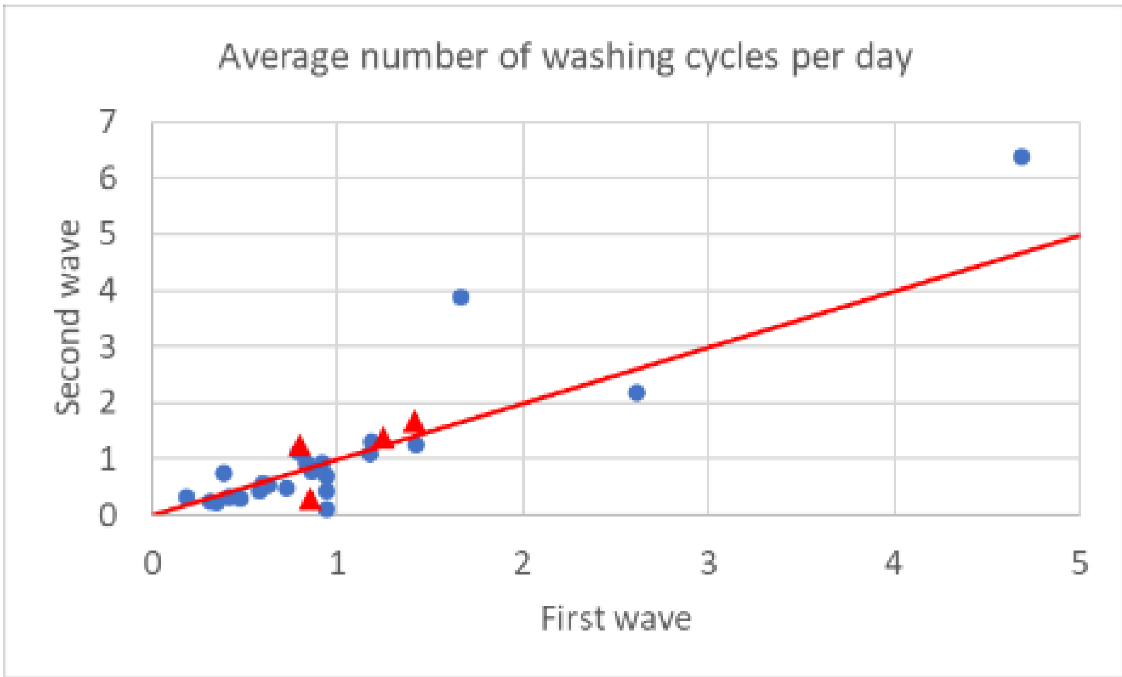
For the washing-machine, we do not consider the cycles' duration. Durations can be tricky for the washing-machines since it does not reflect well the intensity of use. The average consumption per washing cycle gives us a good proxy of the cycles' temperatures.

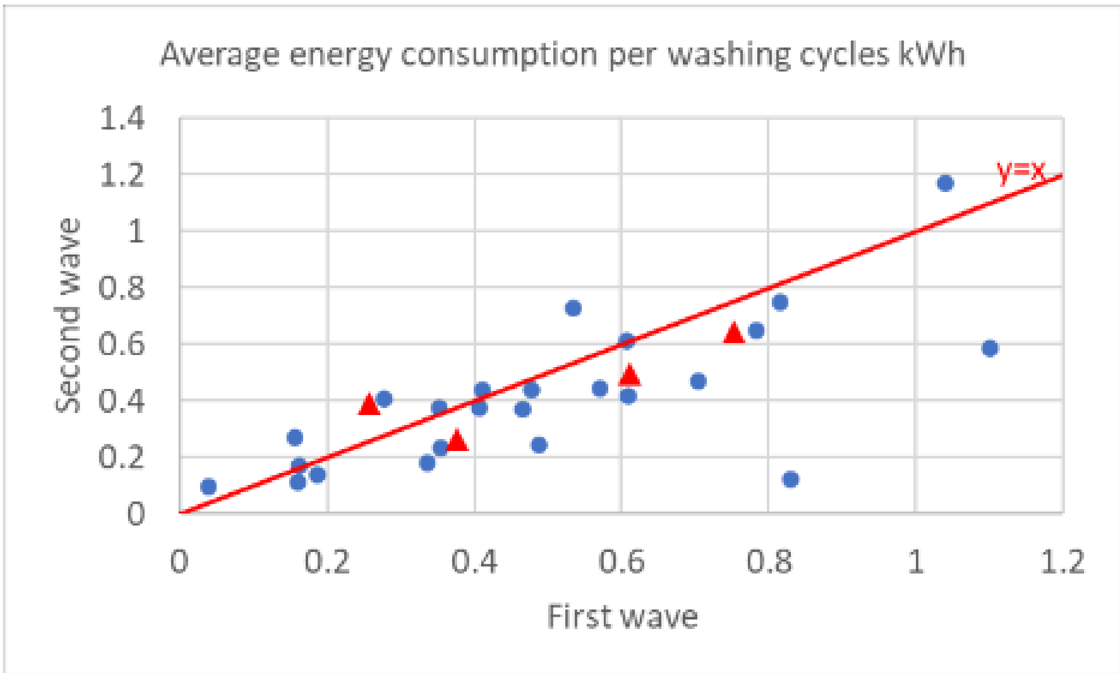
32 % of the households managed to lower both their average numbers of cycles and their cycles' temperatures which is noteworthy (figure 13).

29 % only lowered their number of cycles and 32 % only their cycles' temperatures.

**This means that almost every household was able, at some point, to improve its efficiency on at least one component of its washing-machine's use.**

▲ Washing-machine replaced by the household


Average number of washing cycles per day
Second wave
First wave
0
1
2
3
4
5
6
7
0
1
2
3
4
5


Average energy consumption per washing cycles kWh
Second wave
First wave
y=x
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
0.2
0.4
0.6
0.8
1
1.2

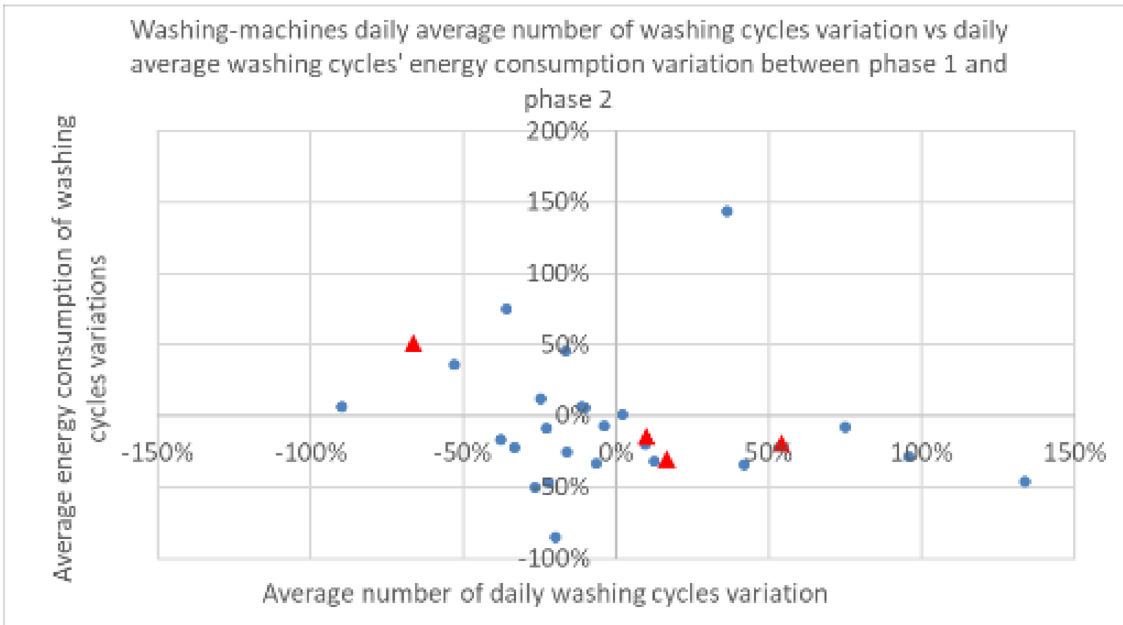
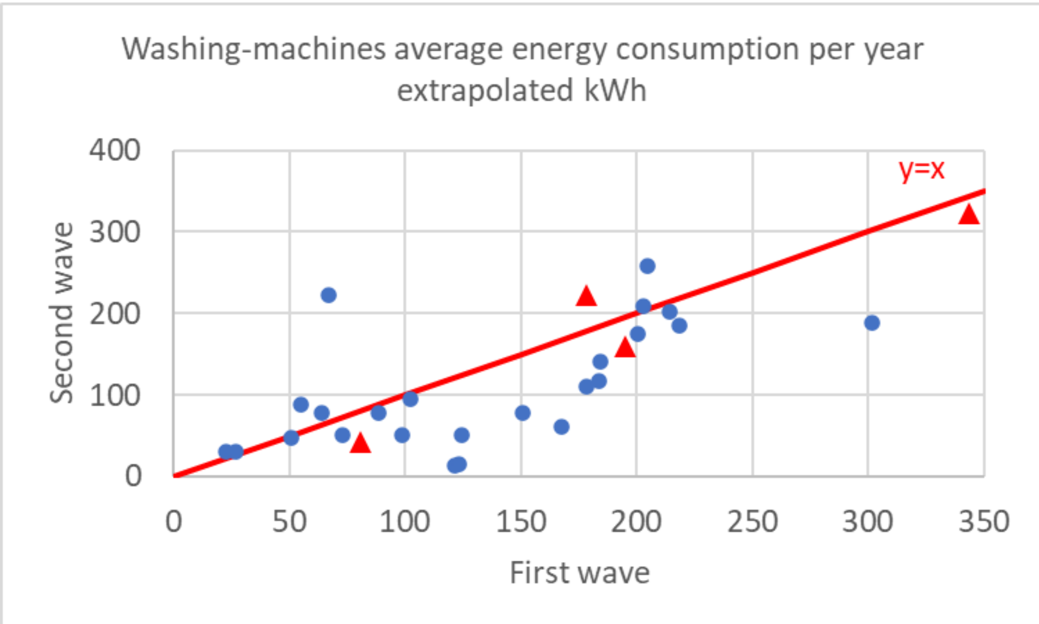



Figure 13. Average number of washing cycles per day (top), average energy consumption per washing cycle(middle), variations (bottom)

The evolution of the extrapolated electricity consumptions benefits from those efforts since 71 % of the households managed to lower them (figure 14 top) and the quadrant graph (figure 14 bottom) gives the overview.

▲ Washing-machine replaced by the household



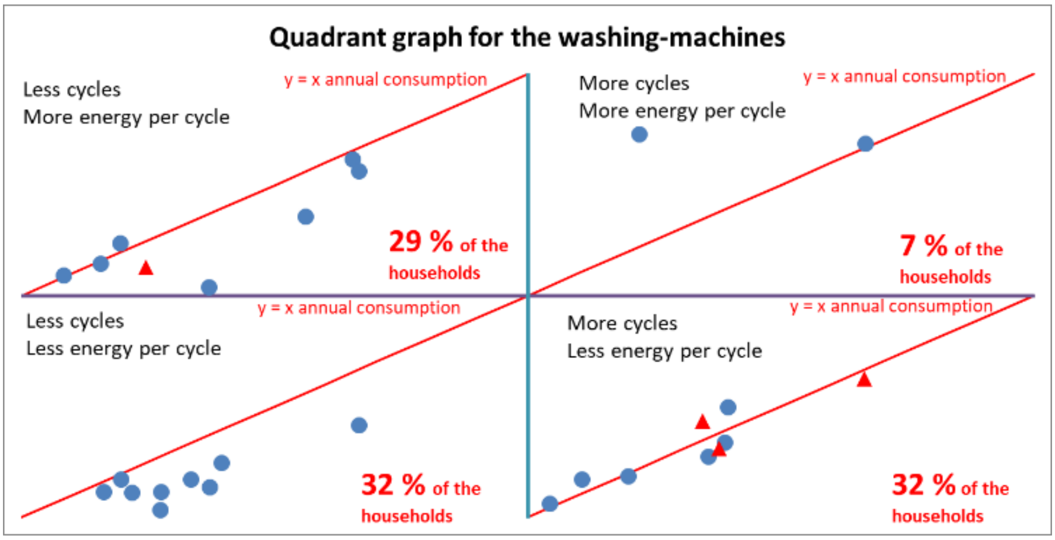


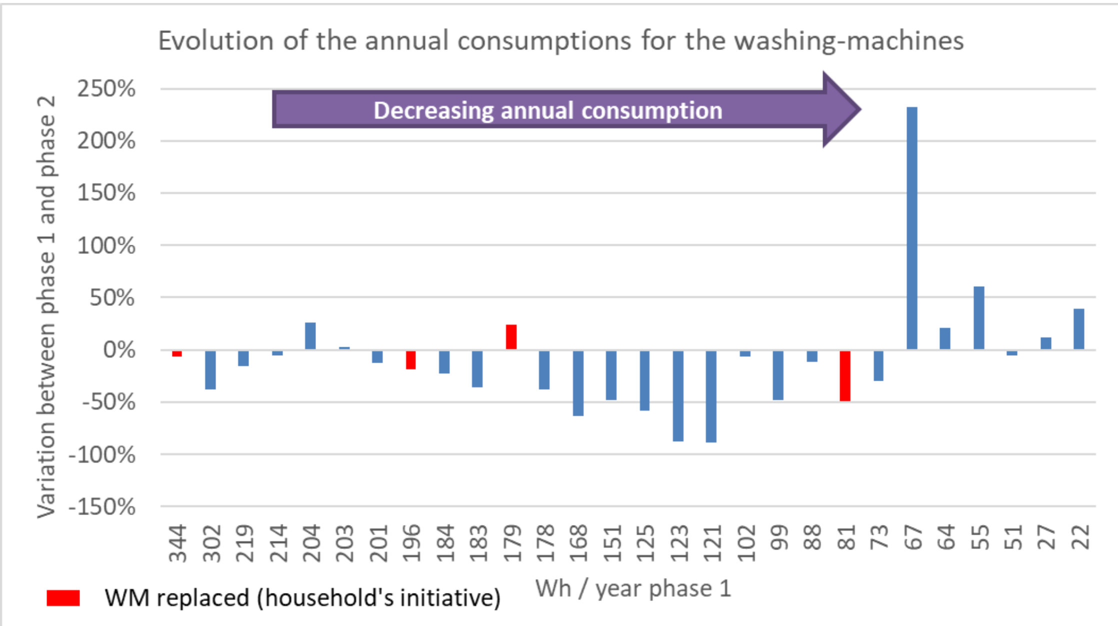

Figure 14. Average energy consumption per year extrapolated for the washing-machines (top), quadrant graph (bottom)

The evolution of the annual extrapolated electricity consumptions (figure 15 top) shows two interesting things:

- The washing-machines replaced by some households did not bring a breakthrough in terms of efficiency at first sight. It did lower the average energy consumption per cycle but 3 out of 4 households launched more cycles. Nevertheless, it's in the same magnitude than other households that did not changed their appliance.
- The household whose consumption increased by more than 200 % washed cold in phase 1 and introduced warm cycles in phase 2. Its washing-machine may be malfunctioning.

The distribution of the annual extrapolated consumptions confirms the increase of the sufficiency (figure 15 bottom).

**Overall, the consumptions of the washing-machines have decreased by 17 %.**



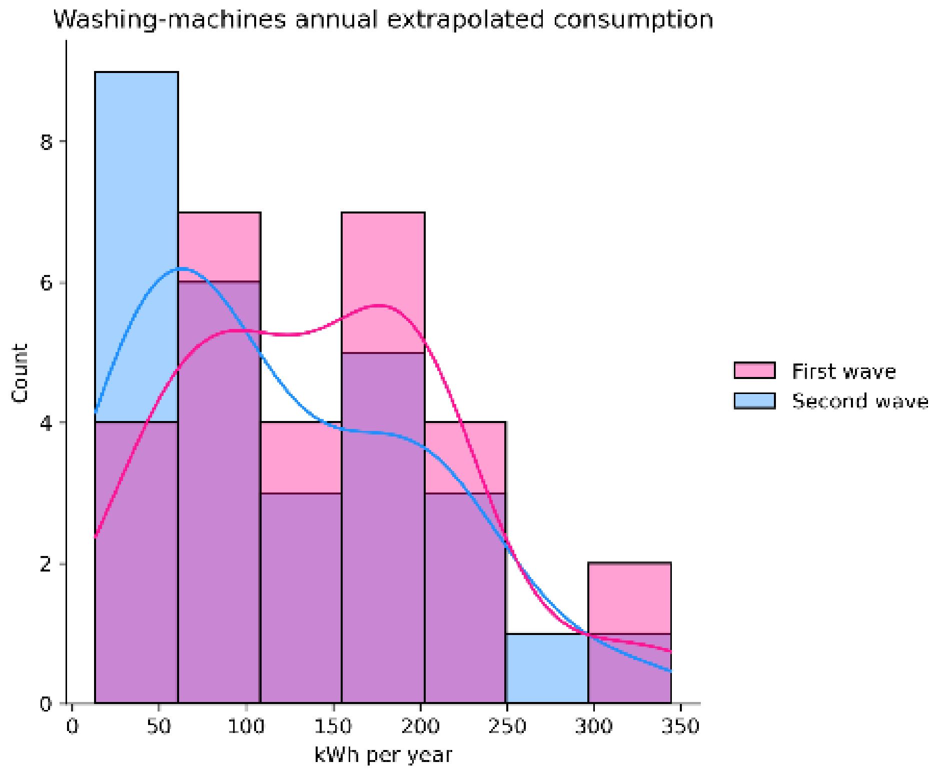
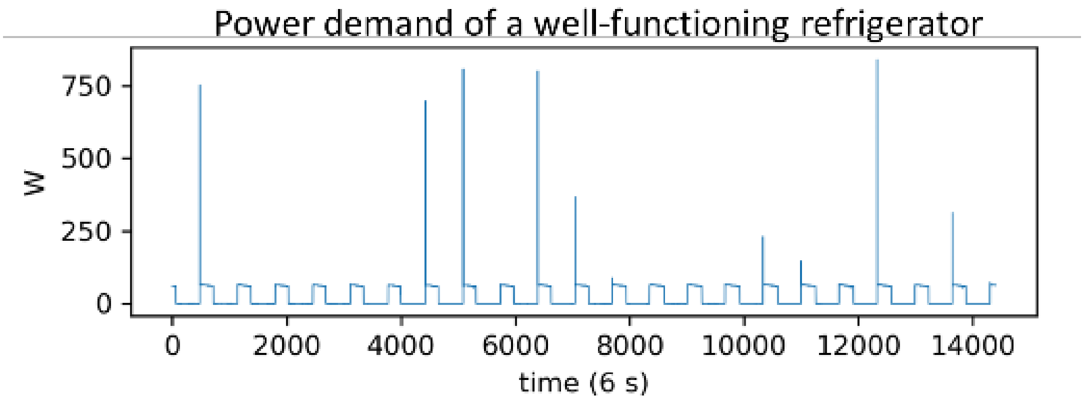
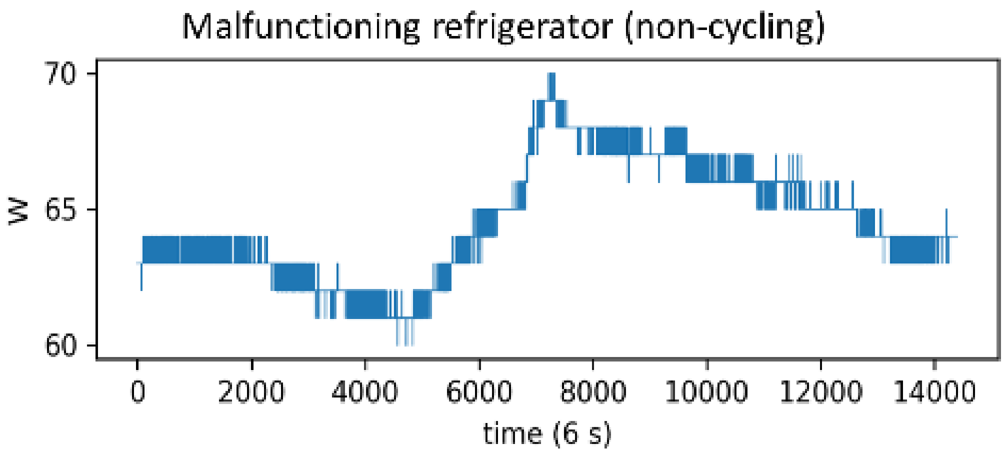



Figure 15. Evolution of the annual extrapolated consumptions for the washing-machines (top), distribution of the annual extrapolated electricity consumptions for the washing-machines (bottom)

## Cold appliances' specificities

Cold appliances include the freezers and the refrigerators (all kinds). A cold appliance which works well cycles regularly. Each cycle has almost the same shape in height and length (figure 16 top). On the contrary, a malfunctioning cold appliance cycles irregularly or does not cycle at all (figure 16 middle). During the day, the cycles are longer and / or more frequent than at night and, generally, the longest cycles happened at lunch and dinner time (figure 16 bottom). Based on those criteria, we found that 10 % of the refrigerators and 20 % of the freezers were malfunctioning and justified a replacement.





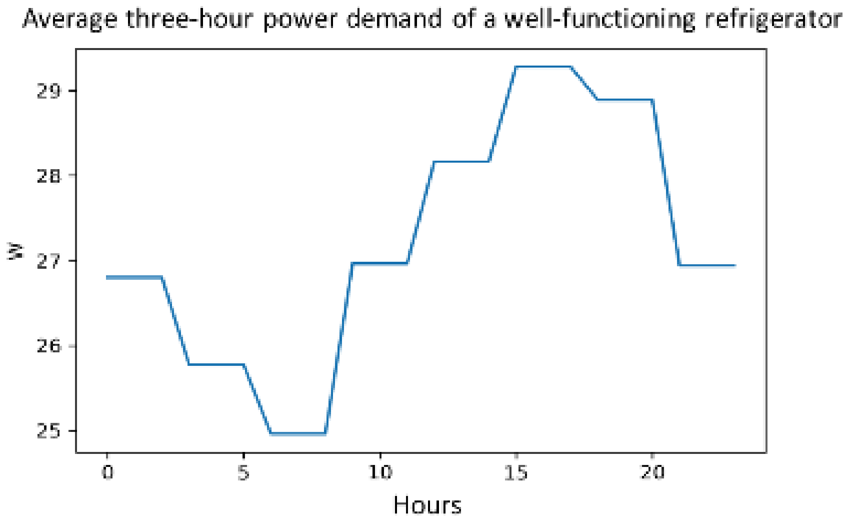




Figure 16. Load curve of a well-functioning refrigerator (top), load curve of a non-cycling refrigerator (middle), average three-hour power demand of a well-functioning refrigerator (bottom)

One of the main pitfalls encountered when monitoring cold appliances is the ambient temperature since it has a direct impact on the energy consumption. This parameter is very difficult to control. We tried to manage it at best: phase 1 and phase 2 of the monitoring campaign were conducted as much as possible during the same season.

The advice given to the households were:

- Clean and defrost regularly
- Avoid useless openings
- Avoid storing too much food an air flow is needed
- Cool down food before storing it
- The temperature set point should be of + 4 °C for the refrigerators and of – 18 °C for the freezers
- The appliances should be in a cool room or at least away from the direct sunlight or from a heat source.

The appliances chosen by the USER project are high-end efficient and tropicalised.

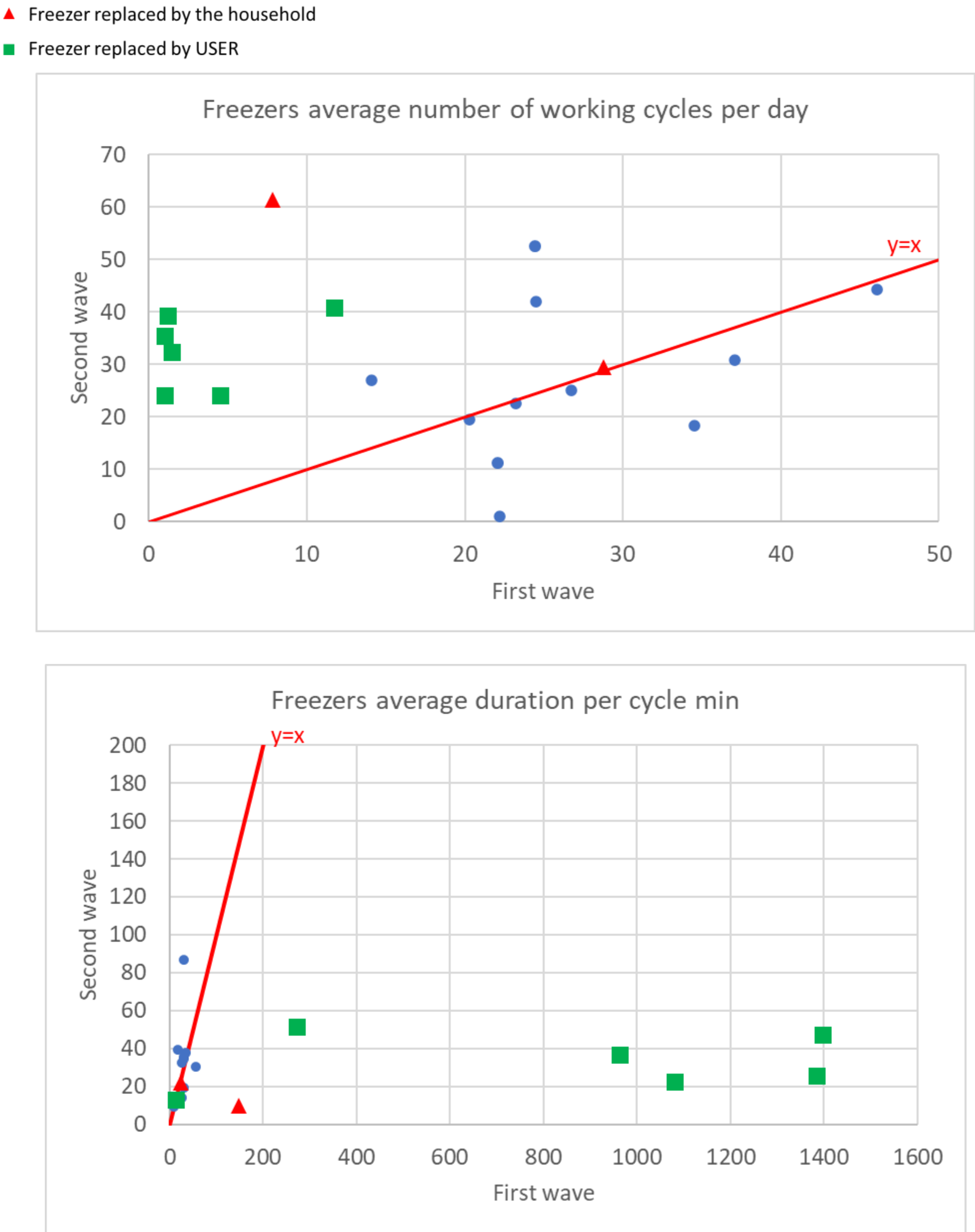
## The freezers

### Freezers' specificities

On the Reunion island, 59 % of the households own at least one freezer. We managed to monitor 19 appliances among which 8 were replaced: 6 by the USER project and 2 by the households themselves.

### Results for the freezers

Since one of the criteria to identify a malfunctioning appliance is the non-cycling status, the average number of working cycling per day increased greatly for the replaced freezers. On the contrary and logically, the average duration per cycle decreased (figure 17).



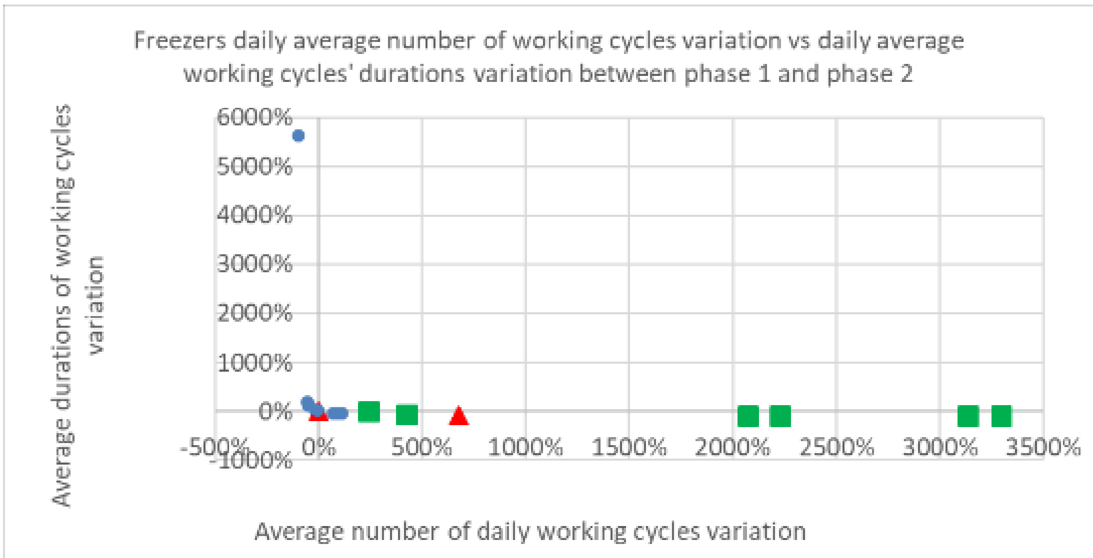
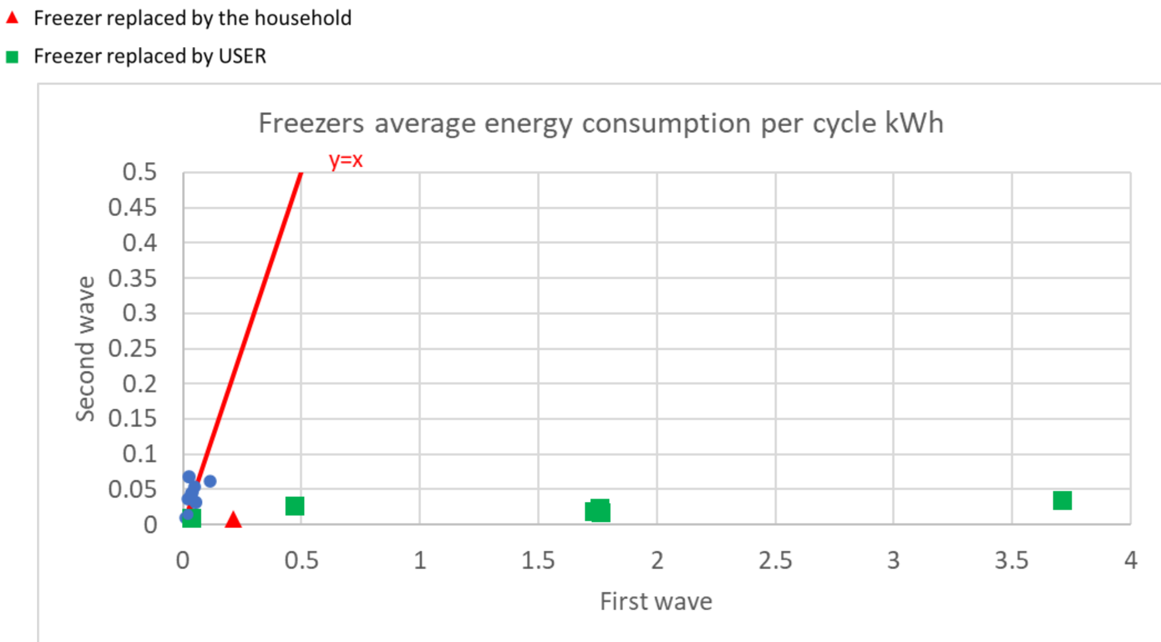



Figure 17. Average number of working cycles per day (top), average working cycles' durations (middle), variations (bottom)

Consequently, for the households in which appliances were replaced, the average annual extrapolated consumptions were lowered significatively and are now among the lowest (figure 18).
The appliances which have not been replaced are close to the first bisector and all slightly above except for two households (figure 18 bottom). This means that their consumptions did not really evolve, this cannot be caused due to higher ambient temperatures as these were of the same magnitude between phase 1 and phase 2. So why did the households did not manage to lower their consumptions?

For the two households whose consumptions increased (figure 18 bottom), one freezer was malfunctioning in phase 2 the other is suspected to have changed its appliance without notifying it. Indeed, the load curves seem to come from two different freezers.



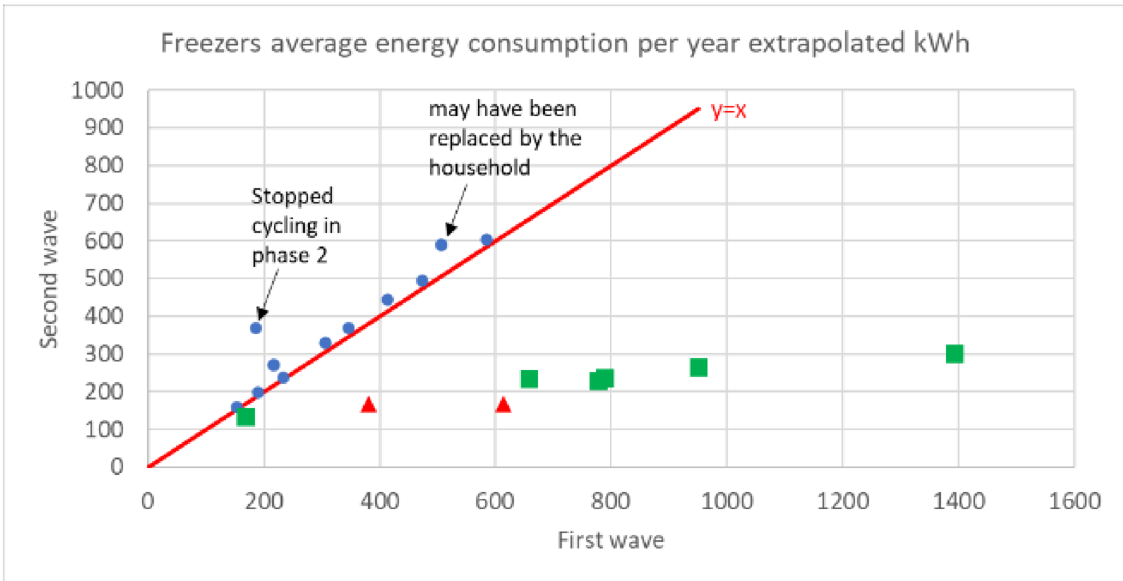
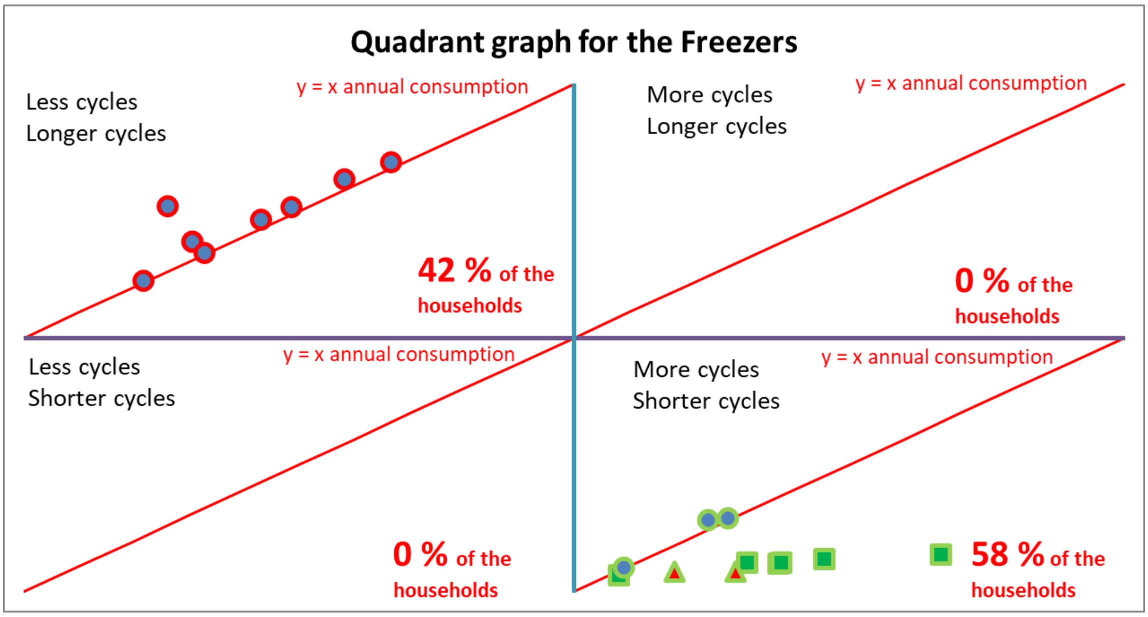



Figure 18. Average energy consumption per working cycle (top), average energy consumption per year extrapolated (bottom)

The quadrant graph (figure 19) gives the global overview and confirms that the population of freezers is divided in two:

- Those with less but longer cycles. They saw a slight increase of their annual extrapolated consumptions
- Those with more but shorter cycles which predominately saw their annual extrapolated consumptions decrease. All the replaced appliances belong to this category.



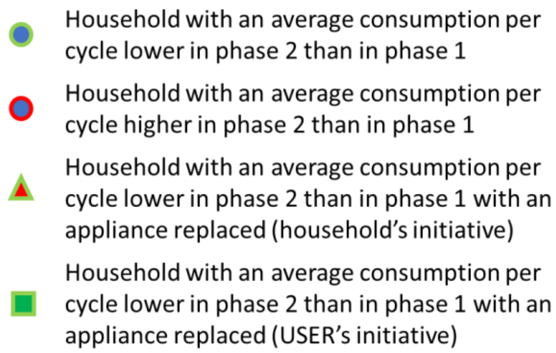
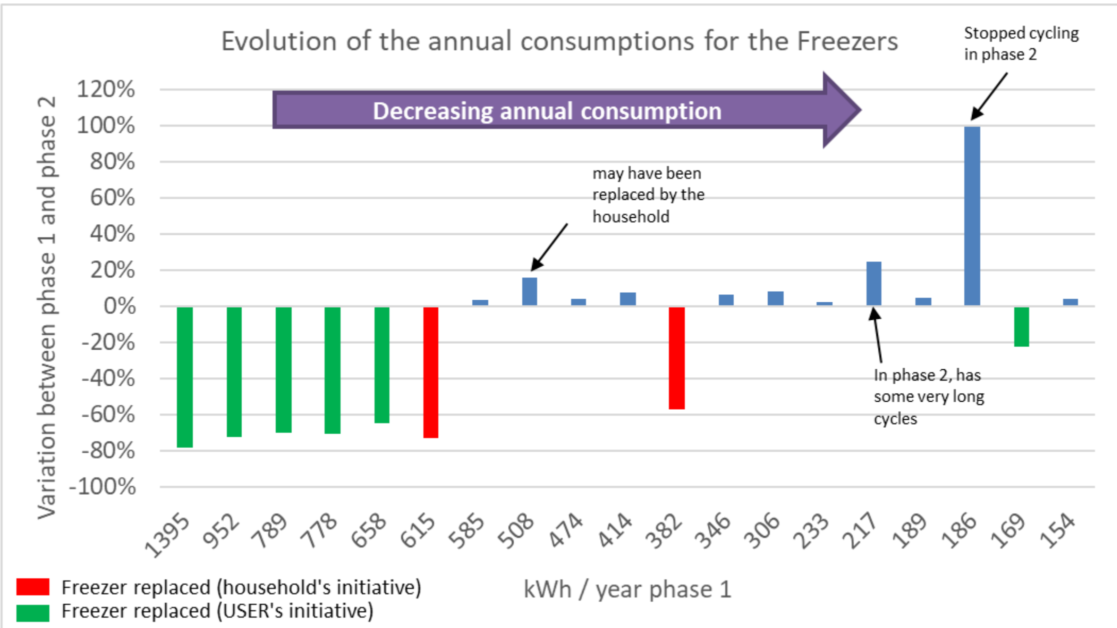



Figure 19. Quadrant graph for the washing-machines

The evolution of the average annual extrapolated consumptions (figure 20 top) confirms that the replaced freezers brought major energy gains: -70 % on average. For the non-replaced appliances, the energy consumption increased by 8 % (the malfunctioning freezer is not considered). The distribution of the annual extrapolated consumptions moves leftward (figure 20 bottom).



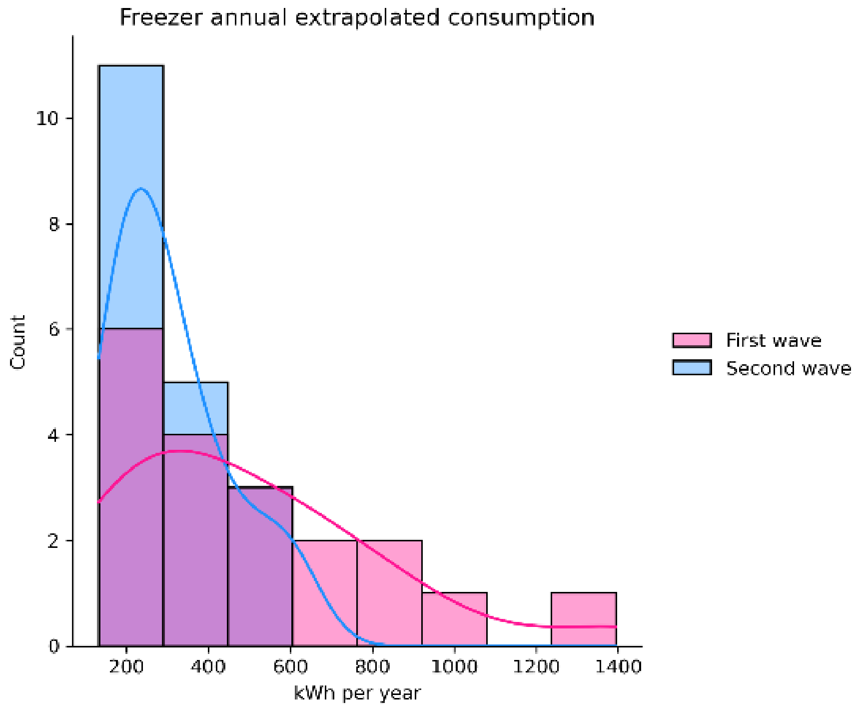



Figure 20. Evolution of the annual extrapolated consumptions for the freezers (top), distribution of the annual extrapolated electricity consumptions for the freezers (bottom)

In our population monitored, we found that 20% of the freezers were with very high electricity consumptions. A replacement is required to achieve electricity savings. Regarding the rest of the appliances, we did not note any efficiency improvements.

## The refrigerators

### Refrigerators' specificities

For the refrigerators, the ownership rate is 100 %. We managed to monitor 24 appliances among which 8 were replaced: 5 by the USER project or an EDF coupon and 3 by the households themselves. Among those 3, one is the ex-main appliance of the household. This main refrigerator has been replaced by the USER project.

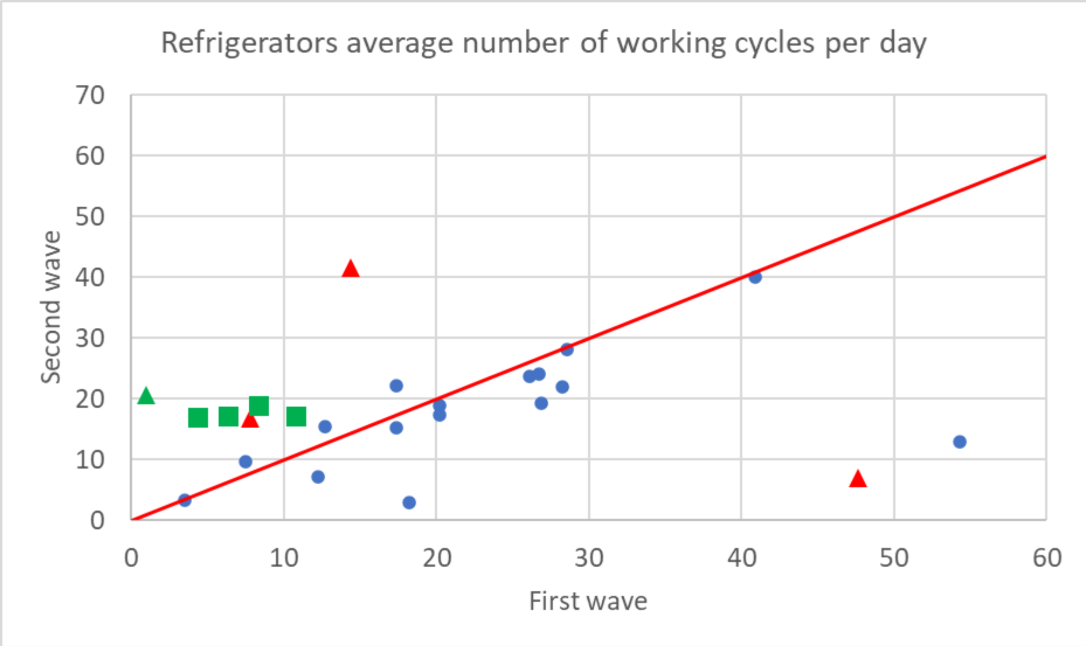
### Results for the refrigerators

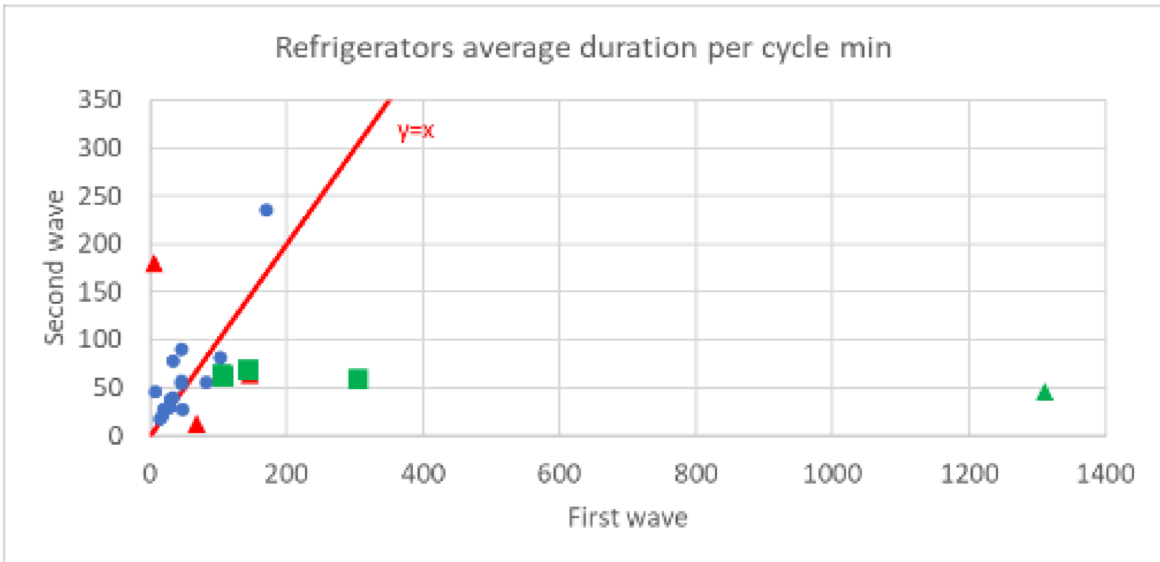
The findings are quite like those of the freezers: for the replaced appliances, the average number of cycles per day has increased but the average duration has decreased (figure 21). The others are distributed around the first bisector.

▲ Refrigerator replaced by the household

■ Refrigerator replaced by USER

▲ Refrigerator replaced by the household with an EDF coupon


Refrigerators average number of working cycles per day
Second wave
First wave
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60


Refrigerators average duration per cycle min
y=x
Second wave
First wave
350
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
1400

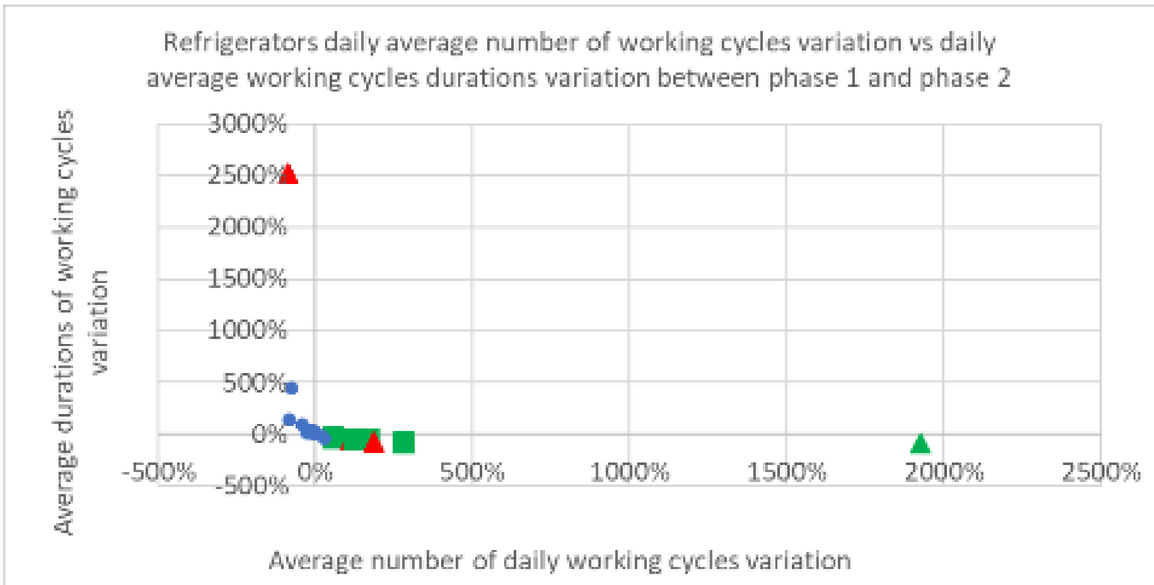

Refrigerators daily average number of working cycles variation vs daily average working cycles durations variation between phase 1 and phase 2
Average durations of working cycles variation
Average number of daily working cycles variation
3000%
2500%
2000%
1500%
1000%
500%
0%
-500%
-500%
0%
500%
1000%
1500%
2000%
2500%

Figure 21. Average number of working cycles per day (top), average working cycles' durations (middle), variations (bottom)

All the household with a replaced refrigerator has lowered the energy consumptions for this end-use but one (figure 22). This appliance was replaced by the household and the increase is due to a category switch: a combined fridge freezer replaced a smaller two-door refrigerator.

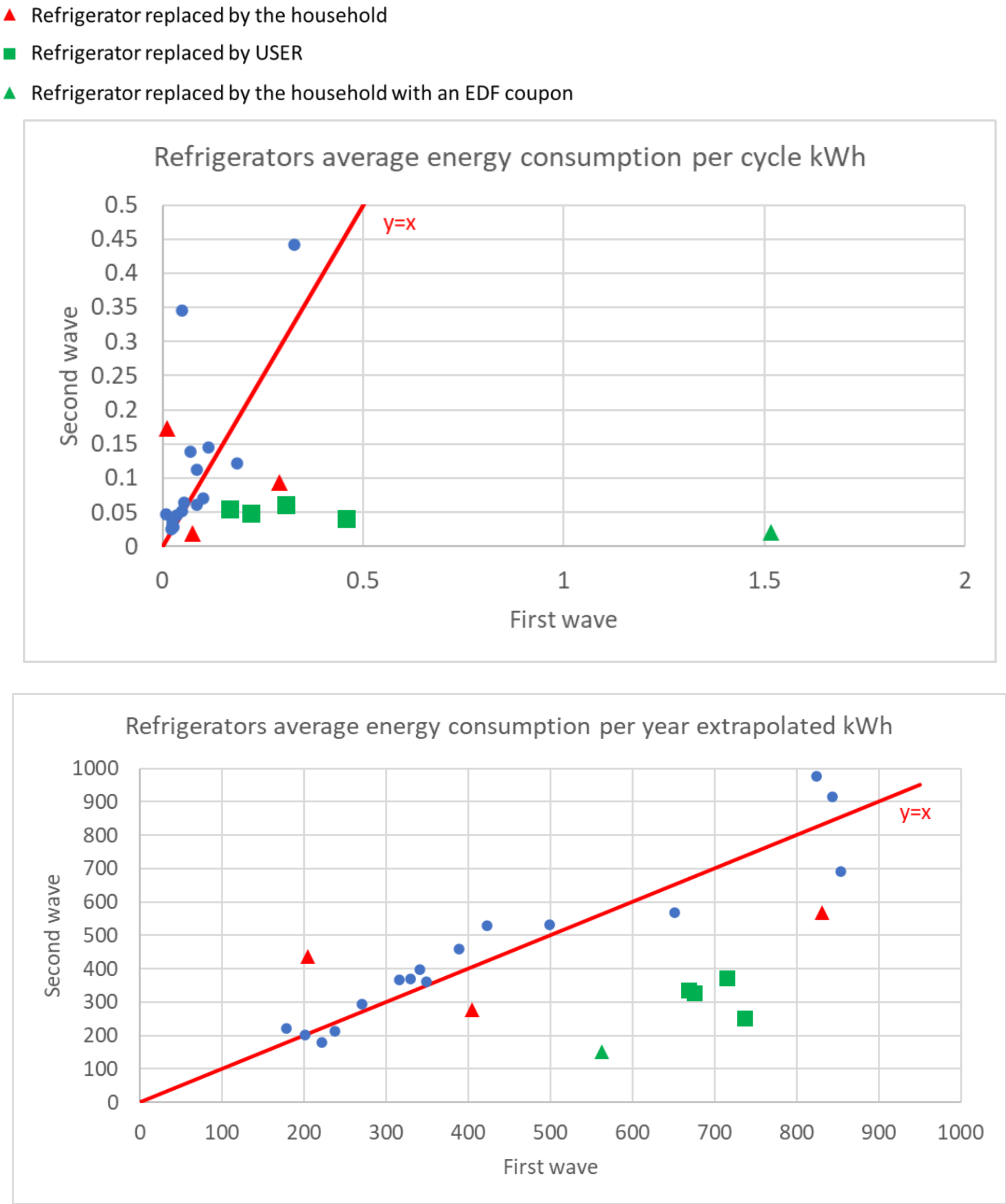



Figure 22. Average energy consumption per working cycle (top), average energy consumption per year extrapolated (bottom)

As in the case of the freezers, the population divides itself into the 2 same quadrants (figure 23). The "upgraded" appliance (full red triangle) stands out.

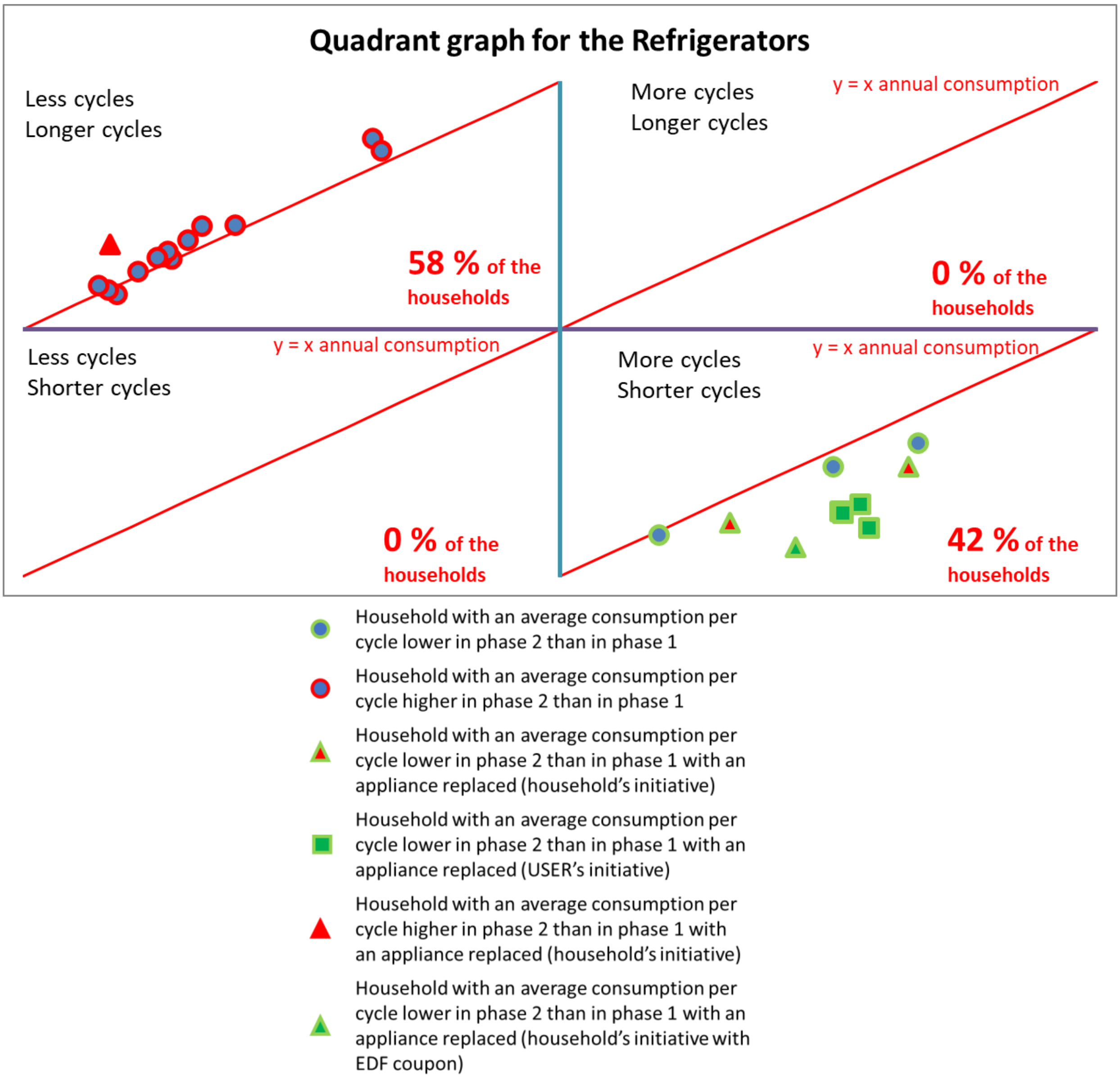
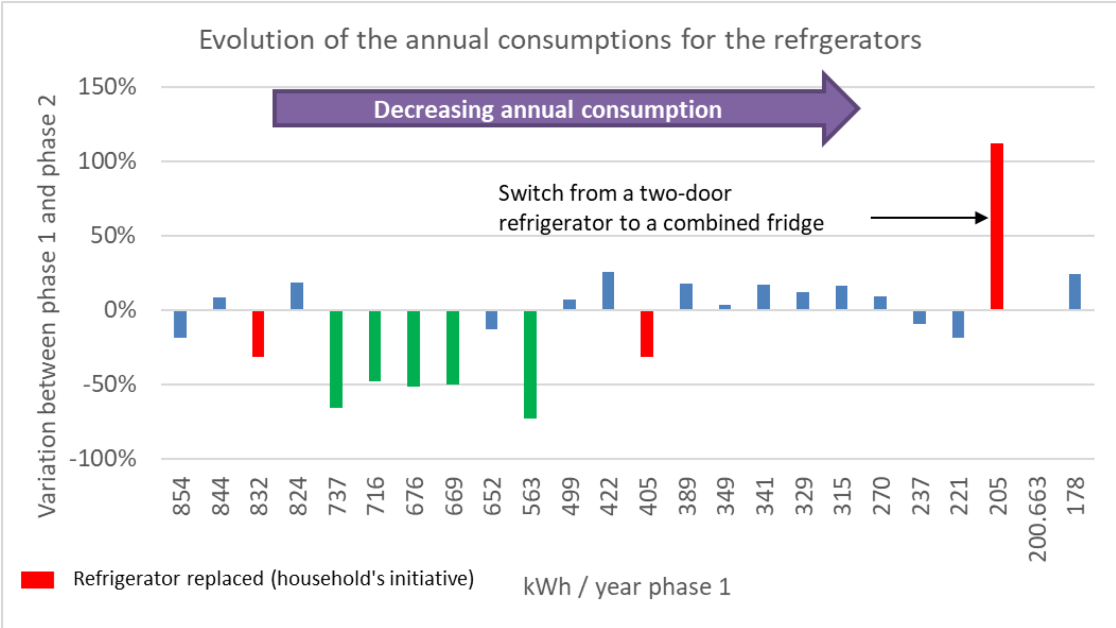



Figure 23. Quadrant graph for the refrigerators

If we do not consider the refrigerator which changed of category (figure 24 top), the replaced appliances led to lower the average electricity consumption by 50 %. For the unchanged refrigerators, about one third managed to decrease their consumptions by 14 % (calculated on the sum). The rest increased it by 14 %. This globally correspond to an increase of 5 % for the non-replaced refrigerators.

The distribution moves leftward (figure 24 bottom). The overall decreased being of – 15 %.



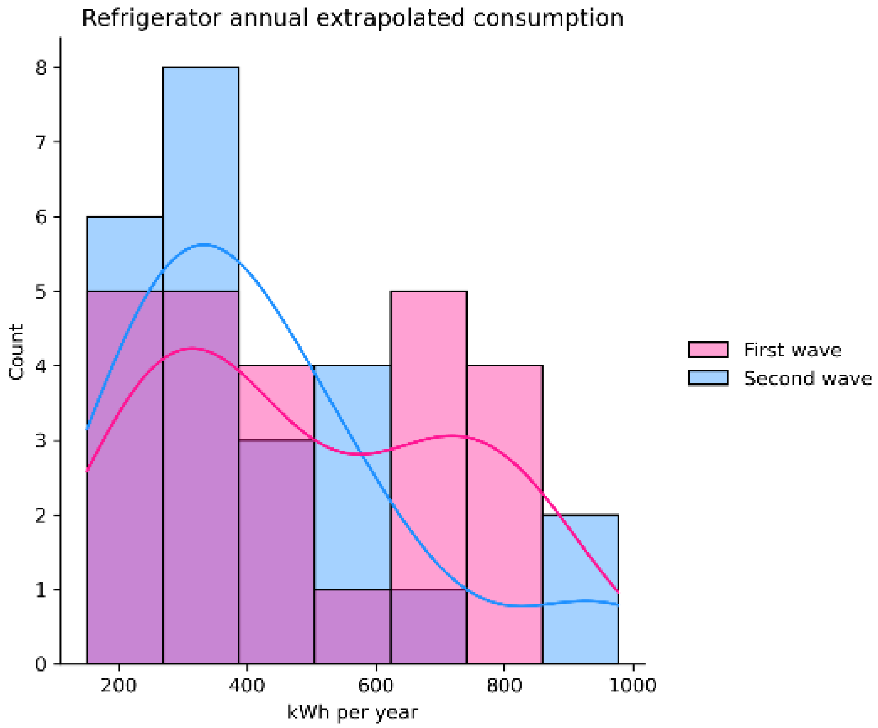




Figure 24. Evolution of the annual extrapolated consumptions for the refrigerators (top), distribution of the annual extrapolated electricity consumptions for the refrigerators (bottom)

The conclusions for the refrigerators are like those for the freezers: replacing malfunctioning or over-consuming appliances is very efficient to lower the electricity consumptions. For the unchanged refrigerators, the effects of the advice given are more uncertain. Nevertheless, contrary to the freezers, some of them did manage to lower their electricity consumptions. But it is fragile.

## Conclusions and discussion

In our paper we focused on 5 appliances that belong to 4 of households' basic needs: cooking, entertainment, hygiene, and food preservation.

Even if our samples are limited in size especially for the TVs, we can draw some conclusions on expected impacts in case of an up-scaled efficiency program was to be designed.

Results show that habits regarding cooking and entertainment seem to be hard to change. On the contrary, reducing the number of washing cycles and lowering the water temperature found a significant response from the households with a reduction of 17 % of the consumption dedicated to this end-use.
For the cold appliances, since the ambient temperature could not be rigorously controlled, conclusions are not easy to draw regarding the impact of the households' adoption of the advice. Nevertheless, we found that a significant number of appliances in the stock are malfunctioning and were therefore replaced within the program which resulted in major gains in terms of energy savings for the involved households.

In conclusion, we can establish our merit order according to what we noticed through the USER project:

- If no replacement is possible, the appliances for which the household has "full control", understands the direct impact of its actions (number of cycles, temperature) should be targeted first. Those changes do not need changes in deep habits. In our case, this was the washing-machines
- If replacements are possible, then the malfunctioning cold appliances should be sought after. In doing so, the gains are significant in terms of direct electricity consumed
- For end-uses with strong habits like cooking and entertainment, advice can be given but positive results seem harder to reach even if cooking leaves room for hope.

For future research on this topic, we would mainly recommend:

- To find a way to manage larger samples of households to draw more robust conclusions
- To investigate and understand better why cooking and TV watching seem hard to change

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