D3.9 – PRACTICES THAT CHANGED AND THE EXTENT OF CHANGE

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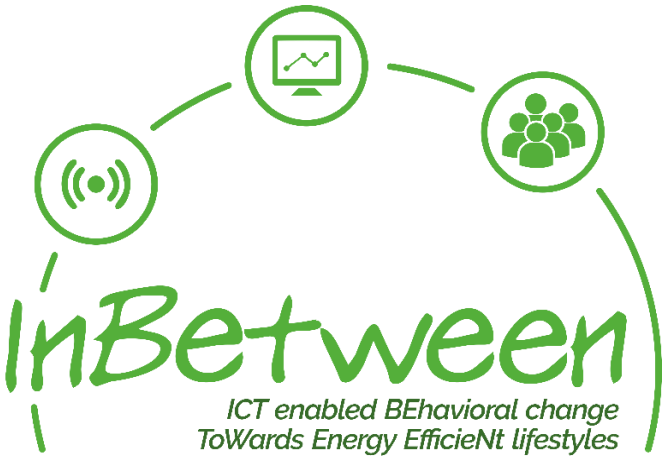

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DISCLAIMER

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EXECUTIVE SUMMARY

This report focuses on the contribution of the platform toward the adoption of low(er) energy daily practices without compromising user comfort. We present the data collected and the methodology we apply to correlate between the use of the app and changes in energy consumption. We aim to explain the methodology we use and the rationale behind it and present the KPIs we applied. As the project progresses, in the forthcoming D3.10 we will present a full and more detailed analysis.

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1 INTRODUCTION

The InBetween project applies a user-centric approach for bringing about energy savings from behavioral change. This report focuses on the contribution of the platform toward the adoption of low(er) energy daily practices without compromising user comfort.

The project has two demo-sites: Vilogia, in France (hereafter, VIL) with **25** residential users, and Sonnenplatz, in Austria (hereafter SON), with **8** residential and **6** non-residential users. For more details on the demo-sites and the characteristics of the residential and non-residential users, see **D1.1.**

Figure 1 presents an overview of the platform evaluation approaches and criteria we apply.

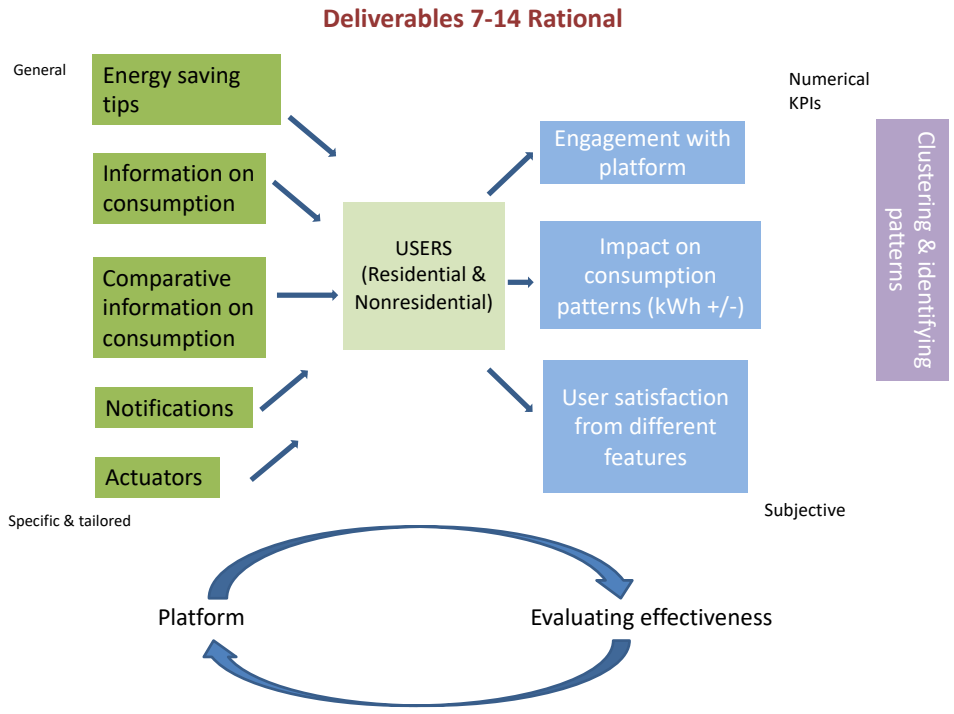

Figure 1: An overview of the user-centric approach

Daily obligations, family constraint as well as habit and inertia are barriers for energy behavior change (elaborated in D3.4). Interventions that do not consider obligations and constraints could be perceived by users as negatively impacting their comfort. InBetween applies a user-centric approach and allows users to manage their energy use and schedule the operation of appliances according to their own needs. In addition, users have the option to select the notification they want to receive and disable the ones which they find irrelevant or unhelpful. The platform provides different types of energy management options, notifications and advice, not all of them are related to energy savings (e.g., security, health).

In this report we present the methodology we apply to correlate between the use of the app and changes in energy consumption. To evaluate the practices that changed and the extent of change, at least two conditions need to be fulfilled: (1) the app / web interface to be used for some time, at least 2 months, and (2) we need a valid baseline for comparison. Due to a delay in the baselining period[1] and hence a very short time of user experience with the app[2], at the time of writing this report there is no reliable data on changes in user behaviour available.

Thus, in this report we focus on the methodology we developed and used and the rationale behind it and present the KPIs we applied. While we would have liked to use the limited data gathered so far from the few interviews held and the various KPIs in order to try to point at some possible connections between the changes in energy consumption (and other non-energy performances), given the limited data, at this point in time, this is not possible. As the project progresses, in the forthcoming D3.10 we will present a full and more detailed analysis.

2 METHODOLOGY FOR IDENTIFYING BEHAVIOR AND PRACTICES THAT CHANGED

2.1 RATIONALE

To identify practices and behaviour that might change due to the app/platform usage, we need to be able to correlate and associate between the usage of the app and changes in demand.

Overall, we divided the above mentioned behaviours and practices into the following categories:

- Thermal comfort related (e.g., space heating, water heating)
- Appliance operation (e.g., washing machine)
- Non-energy routines (e.g., health and security)

As there are many factors that could lead to changes in energy consumption behavior (as well as other types of behavior), associating between the app and these changes is not trivial. Obviously, we are aware of the fact that we are unable to capture all the factors. Being aware of these inherent limitations, we developed the following methodology to link between usage of the app and changes in consumption (Figure 2 describes the methodology):

(1) We developed a set of numerical KPIs related to the use of the platform to identify which features were used the most and in what ways. These will allow us to measure the intensity of app/platform usage, including breakdown to different screen and services.
(2) We developed a set of numerical KPIs related to energy consumption and other measurements. These will allow us to monitor changes in energy consumption, with a breakdown to different energy practices (such as heating, use of appliances, manage energy), as well as non-energy ones (such as security and health).

[1] For VILOGIA, the delay was also caused by the change of internet provider for VIL's participants. The main reason is that a faster internet solution has been deployed on the 3 buildings right after the sensors installation, and even though tenants were told to inform the demosite responsible (i.e. VILOGIA) when such a change occured, they didn't. In June '19, while the VHT installation was processed, the only action VIL managed was to unplug/replug the GW, which didn't change anything in the 14 households concerned. A more detailed methodology was applied after, from beginning of September '19: the sensors supplier (i.e. DEVELCO) provided VIL another solution to connect locally the GW to an internet network, so they have been able to upgrade the offline GWs. The visits took place from September '19 to Feb '20.

[2] The app was deployed already in May 2019, but without the functionality, as we still were baselining.

(3) We developed a questionnaire in which users are asked to estimate the contribution of the app to their energy consumption. The answers will allow us to learn how users themselves estimate the contribution of the app to the energy use.

(4) Once we have collected reliable and detailed data on energy consumption, as well as other practices (health, security) we will draw the connections by associating the app usage and energy consumption (e.g., correlation, regression model, clustering).

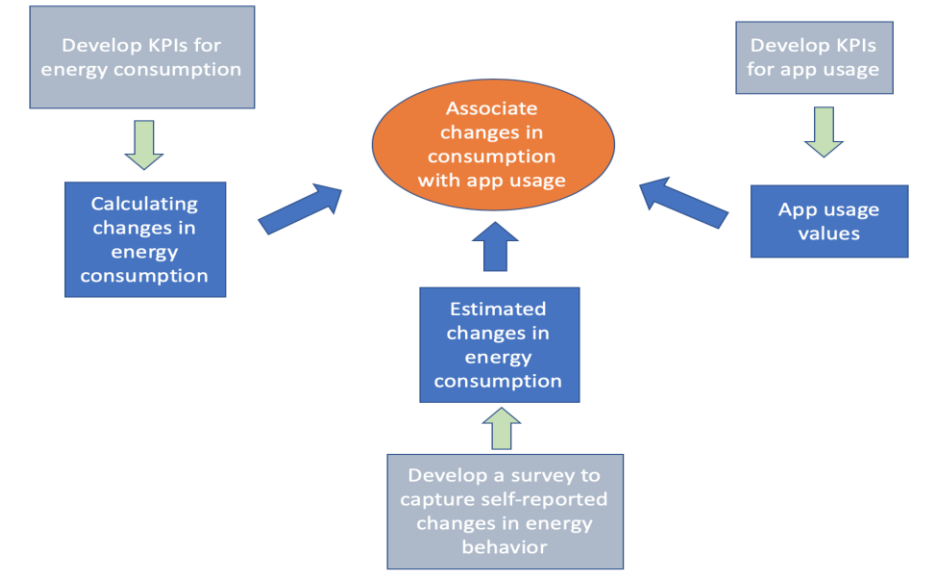

Figure 2: Methodology rationale

2.2 ENGAGEMENT WITH THE PLATFORM

The platform (in the form of app or web interface) is the tool we use to engage users. Engagement with the platform refers to the ways and time users use different features of the app, i.e., opening it, go to specific screens and options. While we cannot infer from this data if the information on the different screens is useful or meaningful to users, it provides an indication of the app usage. We use the Google analytics tool to gather information on the use of energy management options (actuators), optimization services, notifications sent and energy use.

We use Google analytics to collect information from five activities:

- Main Activity
- Monitoring Activity
- Login Activity
- About us Activity
- Privacy Policy Activity

For each activity (screen), we collect:

- Views: *The number of app screens or web pages users saw. Repeated views of a single screen or page are counted*.
- Users: *The total number of active users.*

- New users: *The number of users who interacted with the site or launched the app for the first time.*
- Screen views per user
- Engagement time: *The average length of time that the app was in the foreground, or the web site had focus in the browser*
- Event count: *The number of times users triggered an event.*

2.3 IDENTIFY PRACTICE/BEHAVIOUR THAT CHANGED (SELF REPORTING)

To learn about the behaviors that changed due to the use of the app we developed a questionnaire and interviewed users. The following questions aim to capture aspects of practices that were influenced by the platform (the full questionnaire is presented in D3.7).

1. Which aspect of the tool you use the most? Can you rank each one (on a scale of 1-10)?
    a. Energy
    b. Weather
    c. Security
    d. Health
    e. Benchmarking

2. Which behaviours and practices (if any) have you changed recently:
    a. thermal comfort related
        i. which ones and in what way?
        ii. has the tool contributed to this change (if yes – elaborate, is it related to notifications, to general information, etc.)
    b. energy management (schedule)
        i. which ones and in what way?
        ii. has the tool contributed to this change (if yes - elaborate, is it related to notifications, to general information, etc.)
    c. energy management (remote control via actuators)
        i. which ones and in what way?
        ii. has the tool contributed to this change (if yes - elaborate, is it related to notifications, to general information, etc.)
    d. daily routine related
        i. which ones and in what ways?
        ii. has the tool contributed to this change (if yes - elaborate, is it related to notifications, to general information, etc.)

2.4 ENERGY AND NON-ENERGY RELATED KPIS

We defined 26 KPIs that the platform can calculate in order to evaluate energy savings, comfort characteristics, environmental impact and the use of services offered by the app. Some of these were used to calculate changes in energy consumption, as well as changes in other non-energy measured components (e.g., air quality).

1. Energy consumption - total
2. Energy consumption by person - total
3. Energy consumption by floor area - total
4. Energy consumption - heating
5. Energy consumption by person - heating
6. Energy consumption by person - cooling

7. Energy consumption by person - ventilation
8. Energy consumption by person - lighting
9. Energy use by person - hot water
10. Energy use by person - hot water
11. Energy consumption by person - other
12. Source energy consumption
13. CO_2 emissions
14. Energy savings
15. CO_2 emission savings
16. Energy cost savings
17. Energy use % of ideal demand
18. Peak load indicator
19. Load match index
20. Temperature discomfort indicator
21. % uncomfortable hours
22. Thermal discomfort indicator
23. % hours with bad air quality
24. Stale air indicator
25. Volatile organic compound levels
26. Benchmark score

Detailed information on the KPIs, how they are calculated and the demo site in which they are applied are presented in table 1 below.

Note that not all the KPIs are applicable for both demo-sites, as the demo-sites differ in many characteristics, as detailed in D1.1. For example, lighting and cooling KPIs are either not relevant or cannot be calculated in the demo sites, while the hot water consumption per person is out of the project scope for some buildings in SON.

However, even if not implemented in the InBetween project, the platform has the capability to provide them in other settings.

* marks KPIs that are not implemented in the demo sites. This could be either due to lack of relevant data or because we did not decide yet on a methodology.

All KPI starting with 01 refer to energy consumption, while 02 refer to comfort and health.

Table 1: KPIs calculation and implementation

	ID	Short name		Implemented in VIL implementation	Implemented in SON
gen	00_00	Benchmark score		Benchmarker score from MySQL DB/service output [decimal number between 0 and 1]	
	01_01t	Energy consumption - total		Integral of demand value reported by devices of device type 'external_meter_interface' [kWh]	
energy use	01_01	Energy consumption by person - total		Integral of demand value reported by devices of device type 'external_meter_interface' divided by the number of registered inhabitants [kWh/person]	

	01_02	Energy consumption by floor area - total		Integral of demand value reported by devices of device type 'external_meter_interface' divided by the heated area [kWh/m^2]	
	01_03t	Energy consumption - heating		Total integral of demand from appliances with 'radiateur' in their location_in_space column in MySQL DB [kWh]	Integral of demand reported by devices of device_type 'heat_meter' [kW]
	01_03	Energy consumption by person - heating		Total integral of demand from appliances with 'radiateur' in their location_in_space column in MySQL DB divided by the number of registered inhabitants [kWh/person]	Integral of demand reported by devices of device_type 'heat_meter' divided by the number of registered inhabitants [kWh/person]
	01_04	Energy consumption by person - cooling		*Was not implemented in the demo sites due to not being able to measure cooling, ventilation and lighting consumption	
	01_05	Energy consumption by person - ventilation			
	01_06	Energy consumption by person - lighting			
	01_07t	Energy use by person - hot water - total		Total integral of demand from appliances with 'cumulus' in their location_in_space column in MySQL DB [kWh/person]	*Was not implemented due to DHW appliances not being labeled
	01_07	Energy use by person - hot water		Total integral of demand from appliances with 'cumulus' in their location_in_space column in MySQL DB divided by the number of registered inhabitants [kWh/person]	*Was not implemented due to DHW appliances not being labeled
	01_08	Energy consumption by person - other		*Was not inplemented due to not being able to measure cooling, ventilation and lighting consumption in the demo sites.	
	01_09	Source energy consumption		*Removed due to not having secondary/primary split energy measurements in demo sites	
	01_10	CO2 emissions		Estimated equivalent CO2 emission based on total energy consumption [kgCO2] (=**0.0687 kgCO2/kWh** * 01_01t for VIL and (=**0.0314 kgCO2/kWh** * 01_01t + 0.041kgCO2/kWh * pv_production for SON)	
	01_11	Energy savings		*Was not implemented as methodology for determining the baseline is yet to be defined.	
	01_12	CO2 emission savings			
	01_13	Energy cost savings			
	01_14	Energy use % of ideal demand			
	01_15	Peak load indicator		Maximum instantaneous demand value [kW]	

	01_16	Load match index		0 since no RES is present	integral of (min(1,on-site generation/load)).100 over given time span
Comfort an health	02_01	Temperature discomfort indicator		Area under the temperature(time) curve when not(**18 degC** <= temperature < **24 degC**) and occupancy > 0 divided by the time not(**18 degC** <= temperature < **24 degC**) and occupancy > 0 [degC]	
	02_02	% uncomfortable hours		Ratio between time when not(**18 degC** <= temperature < **24 degC**) and occupancy > 0 and time when occupancy > 0 [decimal number between 0 and 1]	
	02_03	Thermal discomfort indicator		*Was not implemented as used commonly for crowded spaces, not homes	*Not implemented as PMV/PPD parameters need to be defined
	02_04	% hours with bad air quality		Ratio between time when not(VOC < **1000 ppb**) and occupancy > 0 and time when occupancy > 0 [decimal number between 0 and 1]	
	02_05	Stale air indicator		Area under the VOC(time) curve when not(VOC < **1000 ppb**) and occupancy > 0 divided by the time not(VOC < **1000 ppb**) and occupancy > 0 [ppb]	
	02_06	Volatile organic compound levels		Average VOC value [ppb]	

2.5 BASELINE AND BENCHMARKS FOR COMPARISON

We used three different baselines for comparison:

(1) Data gathered in the corresponding week /month of the previous year, during the baseline period of the project (baseline period is the time in which data was gathered but no intervention took place). This data is relevant to examine practices related to thermal comfort. That is because thermal comfort is associated with seasons.

(2) Data from a recent previous period (due to limited data at the time of writing this report, for practical reasons, here we present data from the previous two weeks). This data allows us to examine practices that are not tightly linked to thermal comfort and seasons (e.g. use of washing machine, changes in water heater settings, use of actuators).

(3) Changes in the ranking compared to previous period (e.g., two weeks) and in comparison to other users. This data allows us to see if users changed their energy performances compared to themselves and given their own specific constraints. But it also provides an idea about the progress compared to others in the same demo site.

We also collected data from user themselves about the behaviour that they changed. While this information is not numerical, thus cannot serve as a benchmark, we are using it to learn about the usefulness of the app as perceived by its users.

3 RESULTS

3.1 APP USAGE

The following tables contain aggregated information about the app usage, in the two demo sites, for the period 20.12.2019-20.1.2020 (i.e., one month).
In particular, the Table 2 contains overview of app usage for all users. Table 3 and Table 4 depict the same information for VIL and SON, respectively.

The app usage is represented by the:

- number of "views" for each of the application screens (activity[3]), representing total access to this particular screen by users
- number of "users", representing a number of individual users accessing particular screen
- "screen views per user", representing the corresponding ratio
- "engagement time", representing the average time spent in a particular screen of the app.

Table 2 All users

Screen name	Views	Users	Screen views per user	Engagement time (sec.)
Main	649	25	25.96	478.76
Monitoring	301	21	14.33333	663.3333
Login	92	11	8.363636	223.0909
Benchmark	66	19	3.473684	59.21053
Device Schedule	48	14	3.428571	89.07143
Energy Management	45	15	3	88.8
Tips	25	16	1.5625	53.125
User Profile	20	10	2	23.9
About us	7	5	1.4	6.6
Image Picker	4	4	1	25.5
Optimized Device Schedule	3	1	3	20
Privacy Policy	2	2	1	2.5

Table 3 Users from Vilogia (France)

Screen name	Views	Users	Screen views per user	Engagement time (sec.)
Main	197	7	28.14286	288
Monitoring	112	7	16	592.8571
Login	5	3	1.666667	104.6667
Benchmark	16	5	3.2	52.6
Device Schedule	11	5	2.2	145.2
Energy Management	10	4	2.5	74.5
Tips	7	5	1.4	58

[3] In Android application's terminology, each screen in the application is called "activity".

User Profile	5	4	1.25	17.75
About us	2	2	1	3
Image Picker	1	1	1	27
Optimized Device Schedule	3	1	3	20
Privacy Policy	1	1	1	3

Table 4 Users from Sonnenplatz (Austria)

Screen name	Views	Users	Screen views per user	Engagement time (second)
Main	371	13	28.53846	384.6154
Monitoring	154	10	15.4	865.1
Login	31	6	5.166667	243.8333
Benchmark	35	10	3.5	69
Device Schedule	26	7	3.714286	39
Energy Management	29	9	3.222222	42.66667
Tips	12	8	1.5	64.25
User Profile	14	5	2.8	30.8
About us	5	3	1.666667	9
Image Picker	3	3	1	25
Optimized Device Schedule	0	0	0	0
Privacy Policy	1	1	1	2

The following graphs depict information about app usage in the two demo sites, during the period 20.12.2019-20.1.2020 (i.e., one month).

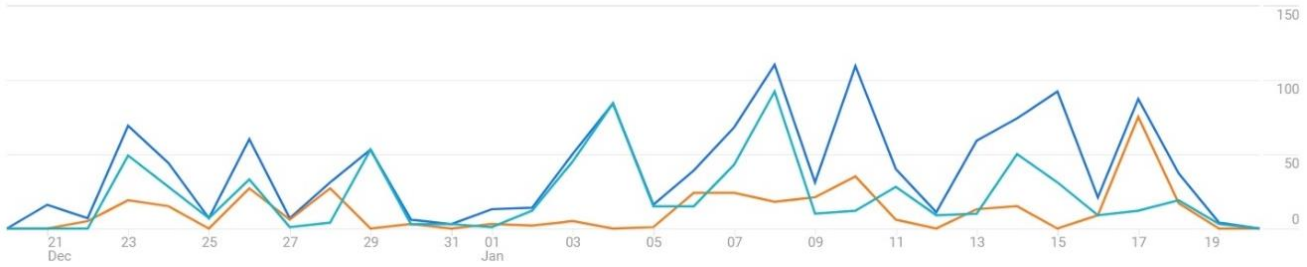

Figure 3. Total app screen views over time: for all users (blue), only users from France (brown), only users from Austria (green)

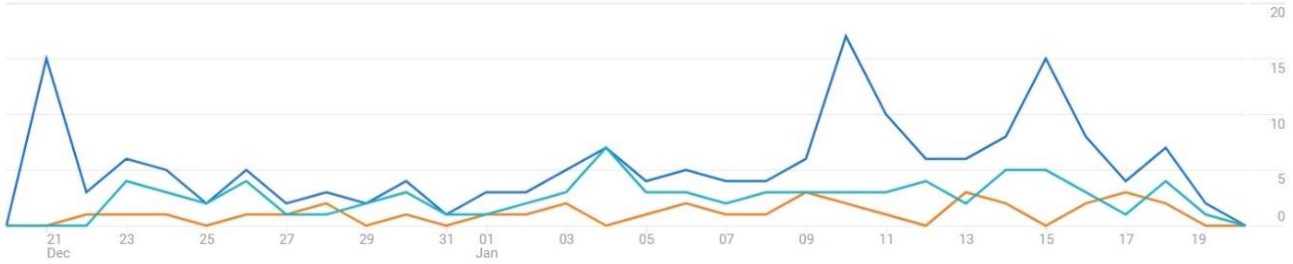

Figure 4. Active users over time: for all users (blue), only users from France (brown), only users from Austria (green)

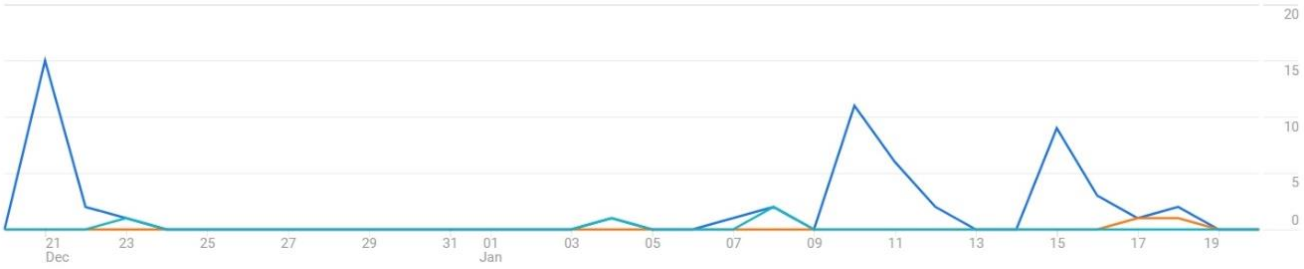

Figure 5. Number of new users over time: for all users (blue), only users from France (brown), only users from Austria (green)

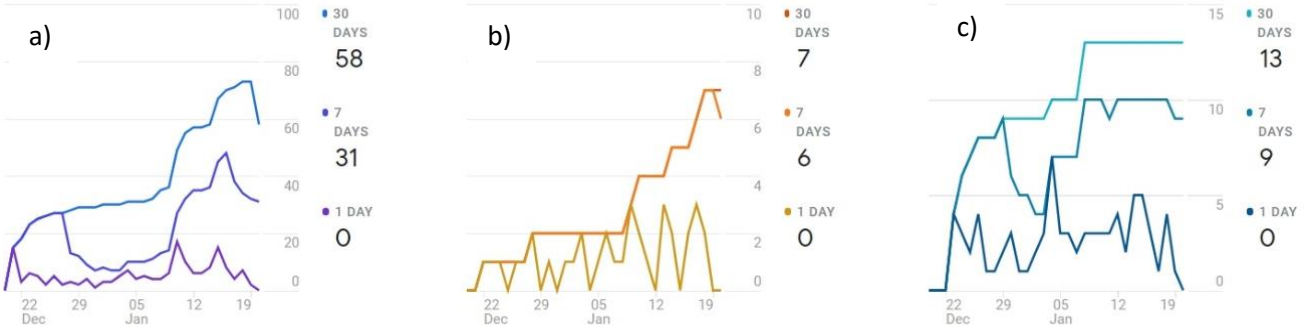

Figure 6: User activity over time with a varying sliding window (1 day, 7 days and 30 days) for: a) All users b) Users from France and c) Users from Austria

The tables and graphs above indicate that:

(a) until January 2020, the app was not intensively used by users, and

(b) the screens that were watched the most are the main activity, monitoring activity and benchmark activity.

As stated above, due to the delay in the sensors' installation, which in turn led to a delay in the baselining period, the current user experience time with the app is very short, and therefore limiting our ability to provide a valid analysis of the extent of behavior changes in relation to app usage.

3.2 MAIN INSIGHT FROM THE INTERVIEWS

As described in D3.7, we held six interviews in total in both demo sites: four in SON and two in VIL. We are aware that the interviews are probably somewhat biased. This bias is due to a variety of reasons, including the short period of time in which the app was used before the interviews took place, the small number of users that were interviewed in both demo sites, and the fact that these people are likely to be more interested in new technology than the average person. Considering the above, we cautiously infer that the heating related practice and behaviors were influenced the most by the use of the app and the services it offers. Users reported turning off the heating when the room is empty or if a window is open, as well as reducing the temperature setting in specific rooms if the app advised them of higher temperature. This is in line with the information about the screens that are most viewed, provided by Google analytics (presented above).

This finding is not surprising, given the time of year in which the interviews took place (winter) and given the fact the heating is a significant electricity consumer in the total household load in VIL.

The full analysis of the interviews is presented in D3.7.

3.3 CHANGES IN ENERGY USE (AND OTHER INDICATORS)

In the following sections, we present data gathered over the last three months, from the 29th November 2019 until the 21st of February 2020, in which the App was actively used by tenants in the demo sites. These three months are divided into six periods of two weeks. In total we present different KPIs in six points of time and show the changes in measurements in comparison to two benchmarks: same month in previous year (2019, the baseline period), and in comparison to the previous recent period (e.g. measurement taken two weeks before). This enables us to observe changes over the long term (a year ago) and short term (two weeks ago). We focus on the changes in values ('Delta') rather than on absolute values.

Each table below presents six chronological and consecutive bi-weekly periods, without overlapping, in which consumption / measurement is indicated. For example 'p1_C' refers to the value (e.g., of consumption) in the first period (out of the six periods reported in this table), and 'p2_C' refers to the value in period two. The table also provides comparison to the same measurement in the same period of time of the previous year and to the same measurement reported two weeks before. To illustrate, 'p1_1A', refers to the same measurement in the same period of previous year, 'p1-2W' refers to the same measurement measured 2 weeks before (p1_2W, p2_2W etc.).

The tables present selected changes ('delta') in various KPIs only for the users who participated in the interviews, for the period of three months. The sample includes two residential users in VIL (vil 527, vil 552), two residential users in SON (son ba, son be), and two non-residential users in SON (son b6, son b9).

Note that in some cases there is no data or the value can not be calculated (e.g., dividing with zero). These are marked with NaN (not a number).

3.3.1 Change in performances (benchmarking rank)

The benchmark score uses unique performance evaluation methodology that takes into account a weighted combination of four distinct factors to calculate the efficiency rating of each individual energy consumer/household (see details in D3.5 section 5).

The user benchmarking methodology is based on four different elements where each one of them covers a different aspect of energy efficiency. Those elements are:

- **Data envelopment analysis** (DEA)
- IOT data-driven **machine learning** consumption prediction **algorithm** (MLA)
- **Correlation** measurement between energy consumption and renewable sources' production (CORR)
- **Responsiveness** to user-tailored **energy** conservation (**saving**) and optimization notifications (RES)

If each of these elements is considered to produce a ranking r_k between -100% and 100% (or 0% and 100% in the case of DEA) and each of these rankings is assigned a corresponding weight w_k, the final unscaled score (rating) can be obtained as a linear combination of these factors

$$R_{\text{unscaled}} = \sum_{k=1}^{4} w_k r_k = w_1 r_{DEA} + w_2 r_{MLA} + w_3 r_{CORR} + w_4 r_{RES},$$

with the most basic implementation assuming that that the sum of the weights equals one.

Table 5 presents the differences over time (i.e., changes) in the benchmark score only for users who were interviewed. The values in the columns p1_C, p2_C…p6_C present the benchmark values calculated for each users in the reported six periods. The value 'NaN' in columns 1A and 2W indicates that we do not have benchmark values for these periods.

Results, presented as the values in the cells p1_C, p2_C through p6_C indicate that no changes in the value of the benchmark were registered over the last three months. However, as reported in the interviews, most users did not receive notification during that time, and did not used the app extensively. This is likely to change in the following months.

For the simplicity of presentation, the remaining tables are presented in Annex 1.

Table 5: Benchmark - changes in performance score

	1st bi-weekly period			2nd bi-weekly period			3rd bi-weekly period			4th bi-weekly period			5th bi-weekly period			6th bi-weekly period		
	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago
	p1_C	**p1_1A**	**p1_2W**	**p2_C**	**p2_1A**	**p2_2W**	**p3_C**	**p3_1A**	**p3_2W**	**p4_C**	**p4_1A**	**p4_2W**	**p5_C**	**p5_1A**	**p5_2W**	**p6_C**	**p6_1A**	**p6_2W**
vil-527	0.6	NaN	0	0.61	NaN	0.01	0.61	NaN	0	0.61	NaN	0	0.61	NaN	0	0.61	NaN	0
vil-552	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-ba	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-be	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-b6	0.57	NaN	0	0.57	NaN	0	0.57	NaN	0	0.57	NaN	0	0.57	NaN	0	0.57	NaN	0
son-b9	0.75	NaN	0	0.75	NaN	0	0.75	NaN	0	0.75	NaN	0	0.75	NaN	0	0.75	NaN	0

Legend:
C – Benchmark calculated value
1A – Difference (delta) between the benchmark value reported in the period of time (p1, p2, etc.), and the benchmark value calculated in same period of previous year (one year ago).
2W – Difference (delta) between the benchmark value reported in the period of time (p1, p2, etc.), and the benchmark value calculated 2 weeks before.
NaN - Not a Number –no data or value can not be calculated.

3.3.2 Changes in KPIs over time

The data gathered during the baseline period is relevant to examine practices related to thermal comfort associated with seasons. The data gathered during a recent period (previous two weeks) is relevant to examine practices that are not tightly linked to thermal comfort and/or seasons (e.g. use of washing machine, changes in water heater settings, use of actuators).

For the simplicity of presentation, all tables are presented in Annex 1.
We divided the three months into two week periods and compared each periodic KPI to the same period in the previous year, and in the two previous weeks. This enables us to observe changes over the long and short term. Each table presents six periods of two weeks each, in which current consumption or measurement is indicated (p1_C, p2_C, etc.), and compared to the same measurement in the previous year (p1_1A, p2_1A, etc.), and to the previous 2 weeks (p1_2W, p2_2W etc.).

Notes:

1. Not all KPIs are applicable for both demo sites (see details in table 1).
2. Some calculations are based on the information provided by users themselves (e.g., appliances registered as 'radiators' or 'DWH').
3. Per-capita calculations are based on information gathered in the initial survey and by information provided by demo site owners.
4. Some values are '0' due to lack of valid /available data.

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4 CONCLUSIONS

The platform provides various opportunities to present users useful, meaningful and actionable information beyond merely advising them on consumption and performances. This is evident in the list of KPIs the platform can present. However, due to the and the small numbers of users who experienced the platform and were interviewed, at this point of time, it is impossible to generalize any insights about the practices and extend of change.

Many cells in tables 6 through 14 show the value '0', meaning that no change was registered or that data is missing, and while the interviewees indicated that some thermal comfort practices might have changed and this might be very cautiously supported by tables 7&8 in Annex 1, we are well aware that the small and self-selected sample of users we interviewed is biased.

This report presented the approach and the KPIs we applied to capture changes in consumption and practices as well as to evaluate the extent of change. At this stage of the project, given the limited time of platform usage and the availability of data (i.e., number of points for which we have no data) it is impossible to indicate from the analysis the behavioral changes and the extent of change and to connect these to the app usage.

In the forthcoming D3.10, we will have more available data and therefore expect to see clearer trends, which will allow us to draw some more robust conclusions.

ANNEX 1: CHANGES IN KPIS

Below are presented selected changes ('delta') in various KPIs for the users who participated in the interviews, for the period of three months. The sample includes two residential users in VIL (vil 527, vil 552), two residential users in SON (son ba, son be), and two non-residential users in SON (son b6, son b9).
We divided the three months into two week periods and compared each periodic KPI to the same period in the previous year, and in the two previous weeks. This enables us to observe changes over the long and short term. Each table presents six periods of two weeks each, in which current consumption or measurement is indicated (p1_C, p2_C, etc.), and compared to the same measurement in the previous year (p1_1A, p2_1A, etc.), and to the previous 2 weeks (p1_2W, p2_2W etc.).

Notes:

1. Not all KPIs are applicable for both demo sites (see details in table 1).
2. Some calculations are based on the information provided by users (e.g., appliances registered as 'radiators' or 'DWH').
3. Per-capita calculations are based on information gathered in the initial survey and by information provided by demo-site owners.
4. Some values are '0' either due to lack of valid /available data. Since this analysis has an extended period from 24h previously to two weeks, the criteria for KPI validity become a lot stricter and therefore, many values are undefined (None/Nan) because of the missing data. In addition, some KPIs for the previous year are not avilable, as the measurement of these KPIs started later in the project.
5. The heat energy for SON is calculated based on heat_meter devices and the demand that they report.

Legend for all tables:
Legend:
C – C consumption/measurement (KPI) in the measured units. See details in annex 1 and under each table.
1A – Difference (delta) between the value of the KPI in the reported period and the same KPI in the same period of previous year (one year ago). I.e. this year value minus previous year value.
2W – Difference (delta) between the value of the KPI in the reported period and the same KPI value measured in the previous 2 weeks. I.e., this week value minus the value reported two weeks ago.
NaN - Not a Number –no data or value can not be calculated.

Table 6: Changes in total consumption (kWh)

	1st bi-weekly period			2nd bi-weekly period			3rd bi-weekly period			4th bi-weekly period			5th bi-weekly period			6th bi-weekly period		
	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago
	p1_C	**p1_1A**	**p1_2W**	**p2_C**	**p2_1A**	**p2_2W**	**p3_C**	**p3_1A**	**p3_2W**	**p4_C**	**p4_1A**	**p4_2W**	**p5_C**	**p5_1A**	**p5_2W**	**p6_C**	**p6_1A**	**p6_2W**
vil-527	493	NaN	64	502	NaN	9	578	NaN	76	422	NaN	-156	483	NaN	61	795	389	312
vil-552	54	NaN	NaN	125	NaN	71	96	-21	-29	98	-93	2	100	-138	2	60	-108	-40
son-ba	1465	NaN	-1103	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	2725	NaN	NaN	713	-494	-2012
son-be	NaN	NaN	NaN	NaN	NaN	NaN	101	NaN	NaN	775	NaN	673	741	NaN	-34	1545	NaN	804
son-b6	102	NaN	3	95	NaN	-7	112	NaN	17	93	NaN	-19	87	NaN	-6	86	NaN	-1
son-b9	NaN	NaN	NaN	24	NaN	NaN	27	NaN	4	23	-5	-4	24	-6	1	22	-9	-2

Table 7: Changes in energy consumption per capita (kWh/registered person)

	1st bi-weekly period			2nd bi-weekly period			3rd bi-weekly period			4th bi-weekly period			5th bi-weekly period			6th bi-weekly period		
	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2Weeks ago	Current	1 Year ago	2Weeks ago	Current	1 Year ago	2 eeks ago	Current	1 Year ago	2 weeks ago	Current	1 Year ago	2Weeks ago
	p1_C	**p1_1A**	**p1_2W**	**p2_C**	**p2_1A**	**p2_2W**	**p3_C**	**p3_1A**	**p3_2W**	**p4_C**	**p4_1A**	**p4_2W**	**p5_C**	**p5_1A**	**p5_2W**	**p6_C**	**p6_1A**	**p6_2W**
vil-527	493	NaN	64	502	NaN	9	578	NaN	76	422	NaN	-156	483	NaN	61	795	389	312
vil-552	54	NaN	NaN	125	NaN	71	96	-21	-29	98	-93	2	100	-138	2	60	-108	-40
son-ba	488	NaN	-368	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	908	NaN	NaN	238	-165	-671
son-be	NaN	NaN	NaN	NaN	NaN	NaN	1	NaN	NaN	9	NaN	8	9	NaN	0	19	NaN	10
son-b6	34	NaN	1	32	NaN	-2	37	NaN	6	31	NaN	-6	29	NaN	-2	29	NaN	0
son-b9	NaN	NaN	NaN	5	NaN	NaN	5	NaN	1	5	-1	-1	5	-1	0	4	-2	0

*The heat energy for SON is calculated based on heat meter devices and the demand that they report

Table 8: Changes in energy consumption per heated area (kWh/ m2)*

	1st bi-weekly period			2nd bi-weekly period			3rd bi-weekly period			4th bi-weekly period			5th bi-weekly period			6th bi-weekly period		
	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 eeks ago	Current	1 Year ago	Veeks ago
	p1_C	**p1_1A**	**p1_2 W**	**p2_C**	**p2_1A**	**p2_2 W**	**p3_C**	**p3_1A**	**p3_2 W**	**p4_C**	**p4_1A**	**p4_2 W**	**p5_C**	**p5_1A**	**p5_2 W**	**p6_C**	**p6_1A**	**p6_ 2W**
vil-527	7	NaN	1	7	NaN	0	8	NaN	1	6	NaN	-2	7	NaN	1	12	6	5
vil-552	1	NaN	NaN	3	NaN	2	2	0	-1	2	-2	0	2	-3	0	1	-2	-1
son-ba	3	NaN	-2	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	5	NaN	NaN	1	-1	-4
son-be	NaN	NaN	NaN	NaN	NaN	NaN	0	NaN	NaN	1	NaN	1	1	NaN	0	2	NaN	1
son-b6	1	NaN	0	1	NaN	0	1	NaN	0	1	NaN	0	0	NaN	0	0	NaN	0
son-b9	NaN	NaN	NaN	0	NaN	NaN	0	NaN	0	0	0	0	0	0	0	0	0	0

*The heat energy for SON is calculated based on heat meter devices and the demand that they report.

Table 9: Changes in total energy for heating (kWh measured for appliances registered as 'radiator' on the platform)

	1st bi-weekly period			2nd bi-weekly period			3rd bi-weekly period			4th bi-weekly period			5th bi-weekly period			6th bi-weekly period		
	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago
	p1_C	**p1_1A**	**p1_2W**	**p2_C**	**p2_1A**	**p2_2W**	**p3_C**	**p3_1A**	**p3_2W**	**p4_C**	**p4_1A**	**p4_2W**	**p5_C**	**p5_1A**	**p5_2W**	**p6_C**	**p6_1A**	**p6_2W**
vil-527	378	NaN	77	355	NaN	-23	400	NaN	45	312	NaN	-88	372	NaN	60	709	417	336
vil-552	189	NaN	67	57	NaN	-132	42	-109	-16	48	-124	7	50	-248	2	21	-120	-29
son-ba	3272	NaN	709	2832	NaN	-440	3292	NaN	460	3336	NaN	45	3148	NaN	-189	2848	NaN	-300
son-be	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-b6	619	NaN	194	563	NaN	-56	605	NaN	42	640	NaN	36	553	NaN	-87	525	NaN	-28
son-b9	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 10: Changes in total energy consumed for water heating (kWh measured for appliances registered as 'DWH' on the platform)

	1st bi-weekly period			2nd bi-weekly period			3rd bi-weekly period			4th bi-weekly period			5th bi-weekly period			6th bi-weekly period		
	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago
	p1_C	**p1_1A**	**p1_2W**	**p2_C**	**p2_1A**	**p2_2W**	**p3_C**	**p3_1A**	**p3_2W**	**p4_C**	**p4_1A**	**p4_2W**	**p5_C**	**p5_1A**	**p5_2W**	**p6_C**	**p6_1A**	**p6_2W**
vil-527	67	NaN	6	83	NaN	15	93	NaN	10	57	NaN	-36	51	NaN	-6	21	-383	-29
vil-552	64	NaN	24	37	NaN	-28	91	73	54	86	56	-5	124	-88	38	48	25	-76
son-ba	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-be	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-b6	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-b9	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 11: Changes in total calculated CO2 footprint (kg)*

	1st bi-weekly period			2nd bi-weekly period			3rd bi-weekly period			4th bi-weekly period			5th bi-weekly period			6th bi-weekly period		
	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago
	p1_C	**p1_1A**	**p1_2W**	**p2_C**	**p2_1A**	**p2_2W**	**p3_C**	**p3_1A**	**p3_2W**	**p4_C**	**p4_1A**	**p4_2W**	**p5_C**	**p5_1A**	**p5_2W**	**p6_C**	**p6_1A**	**p6_2W**
vil-527	34	NaN	4	34	NaN	1	40	NaN	5	29	NaN	-11	33	NaN	4	55	27	21
vil-552	4	NaN	NaN	9	NaN	5	7	-1	-2	7	-6	0	7	-9	0	4	-7	-3
son-ba	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-be	NaN	NaN	NaN	NaN	NaN	NaN	3	NaN	NaN	24	NaN	21	23	NaN	-1	49	NaN	25
son-b6	3	NaN	0	3	NaN	0	4	NaN	1	3	NaN	-1	3	NaN	0	3	NaN	0
son-b9	NaN	NaN	NaN	1	NaN	NaN	1	NaN	0	1	0	0	1	0	0	1	0	0

*Estimated equivalent CO_2 emission based on total energy consumption [kgCO2] (=0.0687 kgCO2/kWh * 01_01t for VIL and (=0.0314 kgCO2/kWh * 01_01t for SON)

Table 12: Changes in thermal discomfort ration (% of hours in which temperature is lower than 18°C and higher than 24°C)

	1st bi-weekly period			2nd bi-weekly period			3rd bi-weekly period			4th bi-weekly period			5th bi-weekly period			6th bi-weekly period		
	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago
	p1_C	**p1_1A**	**p1_2W**	**p2_C**	**p2_1A**	**p2_2W**	**p3_C**	**p3_1A**	**p3_2W**	**p4_C**	**p4_1A**	**p4_2W**	**p5_C**	**p5_1A**	**p5_2W**	**p6_C**	**p6_1A**	**p6_2W**
vil-527	0.38	NaN	-0.07	0.13	NaN	-0.25	0.31	NaN	0.18	0.70	NaN	0.39	0.44	NaN	-0.26	0.14	-0.42	-0.30
vil-552	0.83	NaN	0.37	0.53	NaN	-0.30	0.35	-0.29	-0.18	0.56	0.17	0.21	0.49	-0.49	-0.07	0.23	-0.07	-0.25
son-ba	0.89	-0.11	0.00	0.88	-0.08	0.00	0.91	-0.09	0.02	0.88	-0.12	-0.03	0.97	-0.03	0.09	1.00	0.08	0.03
son-be	0.00	NaN	0.00	0.00	NaN	0.00	0.00	NaN	0.00	0.00	NaN	0.00	0.00	0.00	0.00	0.00	0.00	0.00
son-b6	0.00	NaN	0.00	0.00	NaN	0.00	0.00	NaN	0.00	0.00	NaN	0.00	0.00	NaN	0.00	0.00	NaN	0.00
son-b9	0.75	NaN	-0.10	0.76	NaN	0.01	0.66	NaN	-0.10	0.85	0.23	0.20	0.96	0.47	0.11	0.99	0.21	0.03

Table 13: Changes in air quality related to VOC average (ppb)

	1st bi-weekly period			2nd bi-weekly period			3rd bi-weekly period			4th bi-weekly period			5th bi-weekly period			6th bi-weekly period		
	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago	Current	1 Year ago	2 Weeks ago
	p1_C	**p1_1A**	**p1_2W**	**p2_C**	**p2_1A**	**p2_2W**	**p3_C**	**p3_1A**	**p3_2W**	**p4_C**	**p4_1A**	**p4_2W**	**p5_C**	**p5_1A**	**p5_2W**	**p6_C**	**p6_1A**	**p6_2W**
vil-527	98	NaN	-10	105	NaN	7	97	NaN	-8	71	NaN	-26	124	NaN	53	101	NaN	-23
vil-552	122	NaN	-15	86	NaN	-36	108	NaN	22	100	NaN	-7	100	NaN	0	77	NaN	-23
son-ba	126	NaN	-34	153	NaN	26	84	NaN	-68	99	NaN	15	106	NaN	6	96	NaN	-10
son-be	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-b6	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
son-b9	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN