D4.2 FIRST USER BEHAVIOR MODELER AND RECOMMENDER

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EXECUTIVE SUMMARY

The present deliverable is defined in the Grant Agreement document as:

"First user behavior modeler and recommender: initial prototype, with documentation, of the models and algorithms for establishing the users' status and determining the most suitable actions to recommend."

The initial prototype is delivered in the form of a **demonstrator application**. Link and usage guide for this app can be found in <Section 3 of this documentation. The demonstrator app exhibits the input and the output of the first version of the recommendation engine. It can be seen that given recommendable messages, data about user profiles and energy consumption, the engine is able to select the most suitable actions to recommend and also to select the best time to send the messages to the users. The construction of user models and the recommender algorithm are described in detail.

Multiple features of the final version of the recommender highlighted in the Grant Agreement are already present in the demonstrator. Time-series analysis is used on the energy usage data. Context information is taken into account by the recommender and user behaviour (presence in the house) is forecasted to optimize the time of notification.

This document accompanies the dD4.2 deliverable, which is a demonstrator.

Section 3 of this document explains how to use the online version of the demonstrator.

The demonstrator can be reached at http://212.32.240.74:5000/index

with basic http authentication.

username: encompass

password: demo

1 DESCRIPTION OF THE DEMONSTRATOR

This chapter describes the functionalities of the demonstrator app and also introduces the user model and recommendation logic. As promised in the Grant Agreement the demonstrator app uses the first prototype of the recommendation engine. The demonstrator app offers to possibility to select different inputs (different users, and dates) and shows the output of the recommendation: the most suitable messages to send to the user in the selected period and also the time of the notification. The demonstrator also reveals the status of the user model at the selected date on which the message selection is based on.

1.1 FUNCTIONALITIES

1.1.1 Household selection by user profile information

Energy consumption data from 68 households in Switzerland were collected in the previous year. All the participating households can be find in the demonstrator app. User profile information about all the households coming from self reporting questionnaires are shown in the app. For more detail see chapter 1.2.1:

Any household can be selected to simulate the recommendations it would get.

1.1.2 Simulating recommendation

The demo app simulates the recommendation process. The simulated period consists of 8 consecutive weeks. Recommendations can be seen for each week separately or for the whole period. For each week, the recommendations of previous weeks are taken into account.

1.1.3 Presenting the result of the recommendation and the user model

For each generation date, messages that would be sent to the user on the following week are shown. For each message the date when it starts to show on the user's tab and the hour when the notification about the message would be sent on that day are presented as well.

Variables from the user model are also shown. These are calculated during the recommendation process but only presented for the demo. During the real recommendation period, these will be only used by the algorithms, but won't be shown anywhere. Five features from the user model are presented (for detailed description of the user model see chapter 1.2.2):

- Hour when user usually arrives home on a weekday:
  an hour of the day is shown that is calculated from the motion sensor data.

- Hours when user is usually at home during the weekend:
  multiple hours of the day are shown as calculated from the motion sensor data. If the user behavior was not consistent in the preceding period, then no value is assigned to this feature in the user model.

- Difference in base energy consumption from the median of similar households (%):
  based on consumption data and information from the user profiles, the base consumption of the household is compared to households with the same number of rooms. The value

shows the percentage of the median by which the current household's consumption differs from the median of the group.

- Difference in base energy consumption when nobody is home from the median of similar households (%):
  based on consumption data and information from the user profiles, the base consumption of the household when nobody is home is compared to households with the same number of rooms. The value shows the percentage of the median by which the current household's consumption differs from the median of the group.

- Difference in active energy consumption (as estimated from the energy consumption time-series data) from the median of similar households (%):
  based on consumption data and information from the user profiles, the active consumption of the household is compared to households with the same number of people in them. The value shows the percentage of the median by which the current household's consumption differs from the median of the group.

1.2 RECOMMENDER ALGORITHM

1.2.1 Data

The expected data model of the final recommendation engine can be seen on Figure 1. The input includes user profile information from questionnaires, energy consumption measured from a smart meter device, luminance, temperature and motion data from a smart meter device and recommendable messages written by field experts.

For the development first prototype data from the baseline period could be used. During this period energy consumption data and user profile information from 68 households in Switzerland were collected. This means that many parts of the data model was still missing so couldn't be incorporated into the demonstrator. These parts - highlighted by red on Figure 1- are sensory data coming from the smart meter, the disaggregation of energy consumption data and the feedback from the users.

For making a more complex prototype in spite of the missing inputs, motion data was generated by us based on energy consumption data. Data generation was designed to give realistic estimation of sensory data.

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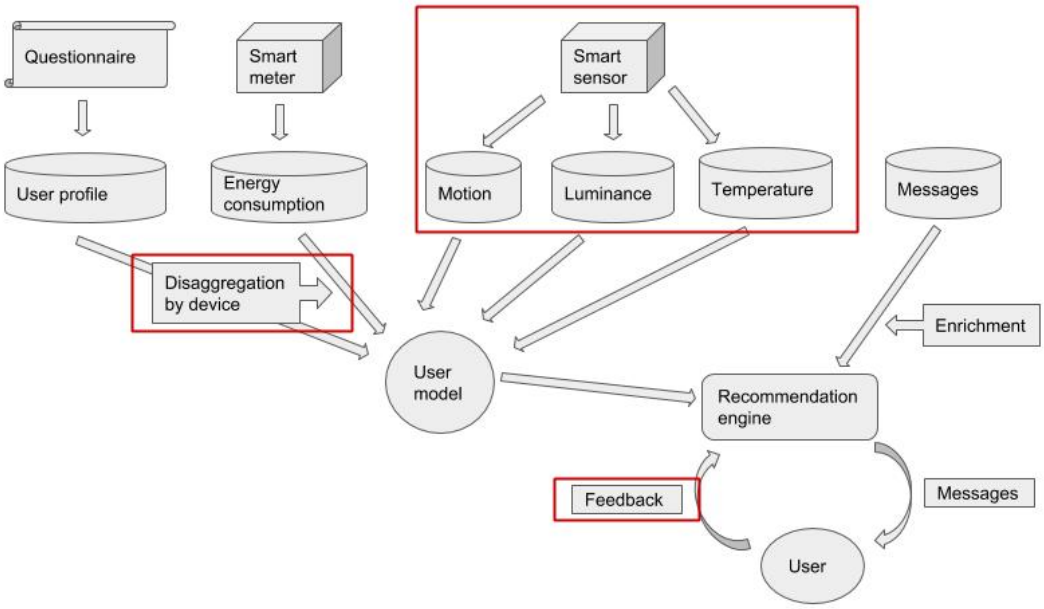


Figure 1 Data model of the final recommendation engine

1.2.1.1 User profile

Information present in user profile:

- information about residents: number of adults, kids and pets.
- features of the house: number of rooms, type of dwelling (e.g. single family house, apartment) and heating (electricity, oil, gas, wood).
- information about devices in the household: for each device type presence or absence is indicated.

1.2.1.2 Energy consumption

Summed energy consumption of each household in every 15 minutes is provided in kW. For the prototype data from 2017-05-08 to 2017-07-02 was used.

1.2.1.3 Messages

Each message has a title, a description and image or video. Each message was enriched by additional properties that can be connected to user profile information or behavioral patterns. The additional properties and examples can be seen in Table 1.

Property name	Levels	Description	Example message
energy_consumption	base	directed at decreasing the autonomous consumption	Vacuum or brushing the refrigerator coils makes the fridge cool down more efficiently.
	base_not_home	directed at decreasing energy consumption when residents are not present in the household	When being absent for a longer time, set heating down or turn it completely off.
	activity_based	directed at decreasing energy consumption when residents are not present in the household	Avoid raclette/table grill & deep fryer. They consume a lot energy, compared to frying and grilling a pan.
device	name of devices	the device the message is about	E.g. fridge - Keep fridge rubber seals clean and replace old ones.
family_type	small	directed to smaller households	Use a smaller fridge. Smaller households often don't need a big fridge. Every 100 l of fridge volume consumes another 10% more energy. For a two-people household, 100-160 l are more than enough.
	children	advices about how to involve children	Use fun, colourful stickers in prominent places to remind kids to turn things off.
season	heating	advices about heating	Use a thermofoil in the niche behind the radiator avoid heating loss.
	cooling	advices about cooling	Reduce energy of/Timing A/C by increasing setpoint up to (e.g.) 28°C during unoccupied periods.
activity_type	name of activities	type of activity the message advices to change	E.g. cooking - Turn off the oven 5 minutes before the meal has finished cooking to use the residual heat of the oven to finish

			it off.
scale_of_change	small	implementation of advice requires small effort	Use an electric kettle to heat water. Do not boil water in a pot.
	medium	implementation of advice requires medium effort	Slice food into smaller pieces before cooking. It makes cooking time quicker.
	big	implementation of advice requires big effort	Use bright light colours for your rooms. Also use bright or no lampshades, to increase the light intensity.
time_of_notification	weekday when arriving home	time period when the probability of realizing the advise is the highest	Leave the fridge open as short as possible. Decide first what to put in or take from the fridge. For example, sort shopping first while unpacking, then put in all cooled groceries in one go.
	weekend when usually home	time period when the probability of realizing the advise is the highest	Vacuum or brushing the refrigerator coils makes the fridge cool down more efficiently.
	morning	time period when the probability of realizing the advise is the highest	Don’t always use the oven. To warm a roll, mostly toaster is just fine.
	evening	time period when the probability of realizing the advise is the highest	Fully load the dishwasher. Do not waste energy on unnecessary further washing periods.

Table 1.

1.2.2 User model

The detailed user model can be seen below (Figure 2). As before, parts that are not included in the first prototype due to missing data are highlighted with red. Those parts are planned to be included later in a more comprehensive version of the user model.

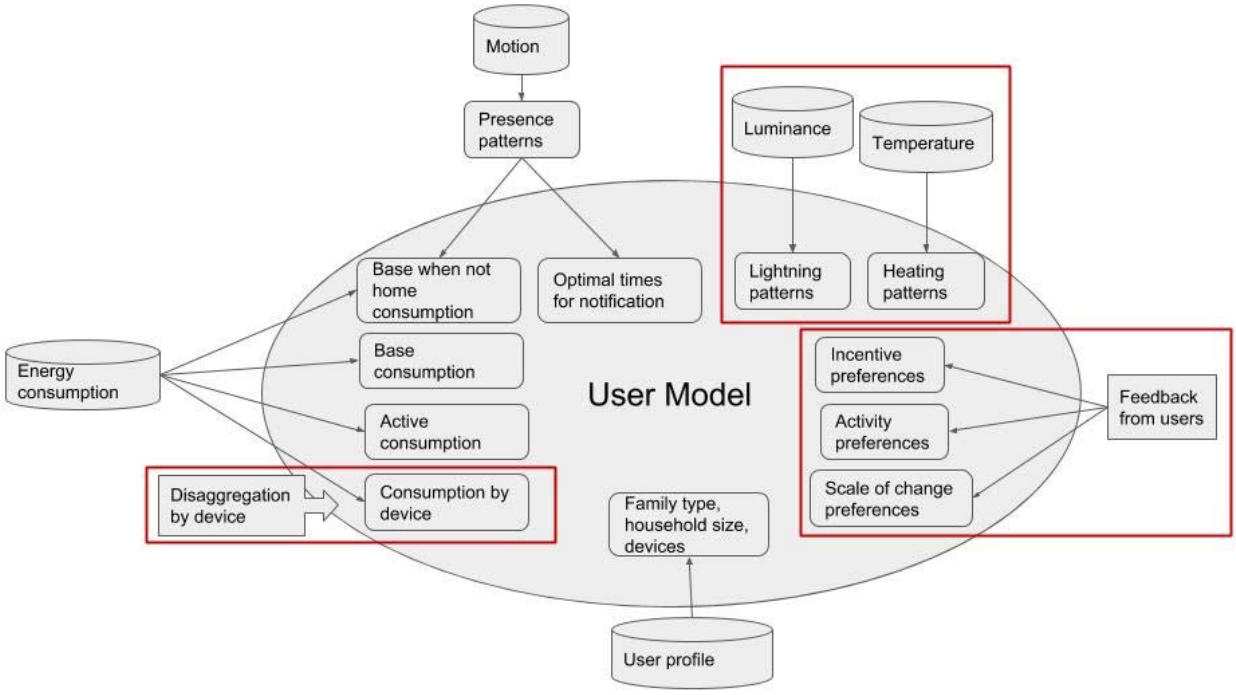


Figure 2: User Model of the recommender engine

The current version of user model is based on three input sources: energy consumption data, user profile and the motion data generated for the sake of the demonstrator.

From the user profile all information is taken that can be connected to the enriched message pool. Family type and household size is calculated from the number of adults, children and rooms. The list of devices present in the household is also indicated.

From motion information patterns about when residents are present in the household are recognised. This is used to personalize the time of sending notifications.

- Time periods are calculated when usually somebody is home at weekends. Each hour between 9AM and 10PM is included when at least 60% of the time the motion sensor showed activity in the household.
- The hour is estimated for each household when residents usually arrive home on weekdays. Each hour between 9AM and 10PM is selected when at least 60% of the time the motion sensor showed activity in the household. From these hours the latest one is selected after which the presence is continuous.

  E.g. If hours when usually home on weekdays are 9,10,13,19,20,21,22, then 7PM is selected as the hour when residents arrive home.

Motion information also takes part in determining periods when nobody is present in the households. This result is combined with data about energy consumption to calculate base consumption when nobody is

home. For each household, the 85th quintile is taken from all the hours when nobody is home. Households with the same amount of rooms are compared against each others. The ones that have a higher than median value within their group are considered as high consumers for this type of energy consumption.

Two other type of energy consumption is differentiated. Base consumption is calculated from the measured consumption values at 03:00, 03:15, 03:30, 03:45 AM during the previous week. Households with the same amount of rooms are compared against each other. The ones that have a higher than median base consumption within their group are considered as high consumers for this type of energy consumption.

Active consumption indicates the energy consumption arising from actively using devices in the household. For this prototype, behavior of the residents can only be estimated. For later versions, consumption data will be disaggregated by device usage, so behavior patterns will be more reliable. Households with the same amount of residents are compared against each others. The ones that have a higher than median value within their group are considered as high consumers for this type of energy consumption.

1.2.3 Recommendation logic

The recommendation logic has three steps. First, messages are filtered based on user profile, user model and contextual properties. In the second step a score is given to each message based on user history and the property of the messages. In the third step messages with the highest scores are selected and personalized notification time is calculated. The full process with the used inputs is shown on Figure 3. Detailed description of the calculation can be seen below.

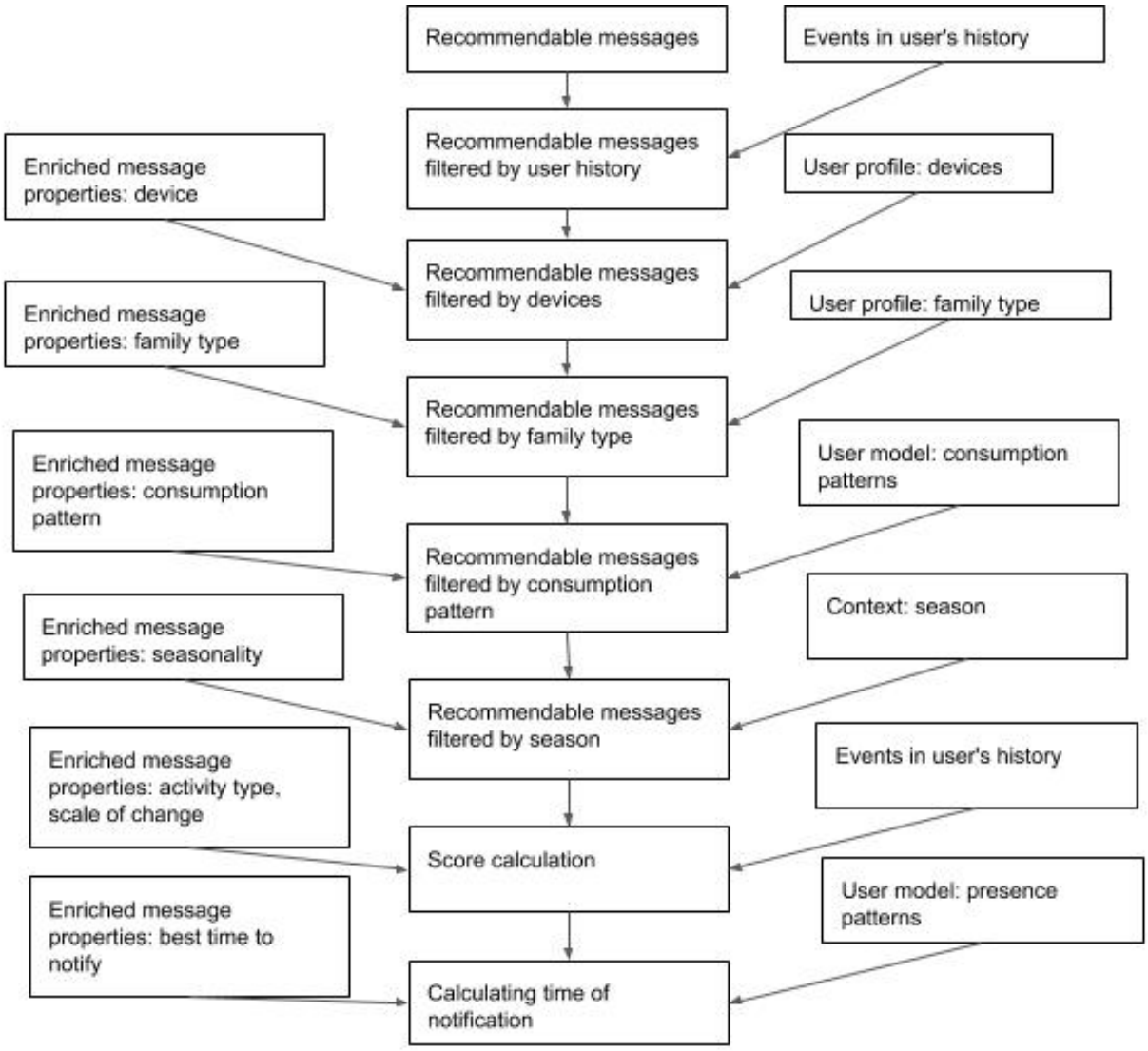


Figure 3: Logic of the recommender system

Excluding messages

For users (i is in the range of 1-68 for the demonstrator) and for all items (j is in the range of 1 - N (N=106 for the demonstrator) the recommender calculates the score p_{ij} which has a starting value of 1.

$$p^1_{ij} = 1 \quad (1)$$

For messages that have been already recommended to the user, the score is set to 0.

$$\begin{cases} \text{item in user's history } p^2_{ij} = 0 \\ \text{item not in user's history } p^2_{ij} = p^1_{ij} \end{cases} \quad (2)$$

Messages about unowned devices, not corresponding family type or off season are filtered.

$$\begin{cases} \text{unowned device } p^3_{ij} = 0 \\ \text{owned device or not connected to device } p^3_{ij} = p^2_{ij} \end{cases} \quad (3)$$

$$\begin{cases} \text{not corresponding family type } p^4_{ij} = 0 \\ \text{corresponding family type or not connected to family type } p^4_{ij} = p^3_{ij} \end{cases} \quad (4)$$

$$\begin{cases} \text{off season } p^5_{ij} = 0 \\ \text{on season or not connected to season } p^5_{ij} = p^4_{ij} \end{cases} \quad (5)$$

Messages that are directed to decrease a type of energy consumption that is already low are also filtered.

$$\begin{cases} \text{low consumption type } p^6_{ij} = 0 \\ \text{high consumption type } p^6_{ij} = p^5_{ij} \end{cases} \quad (6)$$

Calculating scores

Based on item properties in the user's history each score is revised. a_{ij} is the number of times an item with the same activity type feature as item j was recommended to user i. s_{ij} is the number of times an item with the same scale of change feature as item j was recommended to user i.

$$p^7_{ij} = p^6_{ij} - a_{ij}\,0.1 - s_{ij}0.001 \quad (7)$$

For making the recommendations less deterministic and to select from items with the same score, a random noise r_{ij} from a uniform distribution between 0.001 and 0.009 is added to each item.

$$r_{ij} \sim U(0.001, 0.009)$$

$$p^8_{ij} = p^7_{ij} + r_{ij} \quad (8)$$

Selecting messages and calculating time of notification

For every week k (k=3 for the demonstrator) messages m with the highest scores are selected for each user. Let j be the index of messages ordered by their score for each user.

$$p_{ij} : p_{ij} \geq p_{ij-1}$$

$$m_{ik} \in \{p_{i1}, p_{i2} \dots p_{ik}\} \quad (9)$$

For calculating the time of notification for each selected message 4 time categories were defined. For each message a time category t_j was chosen.

$$T = \{\text{'morning','evening','weekday\_arrive\_home','weekend\_usually\_home'}\}$$

$$t_j \in T \quad (10)$$

For messages where the time category feature is weekday_arrive_home a weekday is randomly chosen from the next 7 days. Where the time category feature is weekend_usually_home a weekend is randomly chosen from the next 7 days. Otherwise any other day is chosen from the next 7 days. The message shows in the user's page from midnight on the chosen day.

Next the hour when the notification would be sent is calculated. For each user and for each time category a time interval I_{it} was calculated and stored in the user model.

$$H = \{9,10,11,12,13,14,15,16,17,18,19,20,21,22\}$$

$$I_{it} \subseteq H \quad (11)$$

For each message an hour h_{ij} was chosen randomly from the time interval for the given time category for the given user.

$$h_{ij} \in I_{it} \quad (12)$$

2 EXAMPLE RESULTS AND LIMITATIONS

2.1 SIMULATIONS

For each household a simulation of message recommendation was run for an 8 week period. All simulations are based on the baseline data from this period. From this simulation three use cases are described below, each one representing a different feature of the recommendation engine.

2.1.1 Use Case 1 - High active energy consumption

As described above, the active energy consumption level of each household for each week is calculated. For households having a higher consumption than the median consumption of similar households, messages directed to reduce this type of energy usage are recommended.

An example household showing elevated active energy consumption was chosen. For each week the difference from the median consumption of other similar households and the selected messages that are targeted to reduce this value are shown. The same data can be seen in the demo app (http://212.32.240.74:5000/index?generation_date=2017-05-08&user=2000100532)

Date of simulation	Difference in active energy consumption	Title of message	Message
2017-05-08	31%	Enjoy the silence!	Buy as less electric toys for your kids as possible, also for relatives and birthday presents.
		Use headphones instead of speakers	Home amplifiers have become more energy demanding recently. Due to loudspeakers, special effects, time display or alarm function, it often needs more than 20 watts. Headphones need way less energy.
2017-05-15	10%	Keep it bright and clean	Clean lights, reflectors etc. on a regular basis. They work better, longer and save energy.
2017-05-22	67%	Iron reflectively	Use a heat reflective ironing-board to conserve energy.
		Let the sun be your servant	Avoid clothes dryer. Dry wet clothes outside or on a laundry rack.
		Conserved food & conserved energy	Consume less frozen products. Tins have been boiled once and are not constantly cooled/frozen.
2017-05-29	27%	Let the air be your servant	Dish washers have a drying program, using a lot energy. Let the clean dishes dry on open

			door.
		Is there still space?	Fully load the dish washer. Do not waste energy on unnecessary further washing periods.
2017-06-05	49%	Takes less energy, tastes the same	Avoid raclette/table grill & deep fryer. They consume a lot energy, compared to frying and grilling a pan.
		Slice and dice	Slice food into smaller pieces before cooking. It makes cooking time quicker.
		Cook time- and space-efficiently	Think ahead and make the most of your oven by cooking 2 meals at one go. It is usually big enough.
2017-06-12	37%	Toaster instead of oven	Don't always use the oven. To warm a roll, mostly toaster is just fine.
		Fresh & healthy	Consume less frozen products. Cooking fresh is not only energy saving, but healthy as well.
2017-06-19	13%	Everything in it?	Always completely fill up the washing drum. Don't do unneeded washing cycles.
		Don't speed up the laundry to high	To dry clothes on the outside or on a laundry rack, 1.000 rpm are enough. Use 1.200 rpm for tumble drying only.
		No high temperature washing program	Washing at 30-40°C is generally sufficient.

2.1.2 Use Case 2 - Time of notification: weekend usually home

The time of notification is set based on the properties of the message and features in the user model. For messages that advices improvements that takes longer time to implement, the time of notification is set for a weekend when residents are usually home.

An example household was chosen to whom multiple messages of this type was recommended. For each week, hours when residents are usually home on weekends, the selected messages that are scheduled to these hours and the hour of the notification is shown. The same data can be seen in the demo app (http://212.32.240.74:5000/index?generation_date=2017-05-08&user=2000100921)

Date of simulation	Hours when user is usually at home during the weekend	Date and time of notification	Title of message	Message
2017-05-15	9,10,11,12,14,15,16,17,18,19	2017-05-20 11:00	Cook time- and space-efficiently	Think ahead and make the most of your oven by cooking 2 meals at one go. It is usually big enough.
		2017-05-21 11:00	Let the sun be your servant	Avoid clothes dryer. Dry wet clothes outside or on a laundry rack.
2017-05-22	9,10,11,12,14,15,16,17,18,19	2017-05-28 11:00	Fight the ice!	Defrost freezer (e.g. before vacation) to melt ice layer.
2017-05-29	9,10,11,12,14,15,16,17,18,19	2017-06-03 17:00	Iron reflectively	Use a heat reflective ironing-board to conserve energy.
2017-06-05	10,11,12,14,15,16,17,18,19	2017-06-10 15:00	Nothing is for eternity	Keep fridge rubber seals clean and replace old ones.
2017-06-19	9,10,11,12,14,15,16,17,18,19	2017-06-25 18:00	Use the residual heat	Turn off the oven 5 minutes before the meal has finished cooking to use the residual heat of the oven to finish it off.
		2017-06-25 18:00	Why heating up empty space?	No pre-heating in baking oven. Put food directly into oven, when heating up.
2017-06-26	9,10,11,14,15,16,17,18,19	2017-07-01 11:00	Chalky kettles need more energy	Descale the kettle by using citric acid or vinegar. It will heat up more quickly.
		2017-07-01 11:00	Also clean behind the fridge	Vacuum or brushing the refrigerator coils makes the fridge cool down more efficiently.

2.1.3 Use Case 3 - Filtering messages for appropriate devices

Several message are textual advices about the proper usage of a device. Messages about devices that are not present in a given household are filtered.

An example household was chosen where some devices are present but some of them are absent from the ones connected to messages. The chosen household owns fridge, gaming set, electric oven and electric kettle. In the meantime there are no AC, dishwasher, electric hot plates, microwave or washing machine present. All the messages are shown from the simulation that can be connected to a specific device. Notice, that only messages are recommended that is connected to devices that are present in the household. The same data can be seen in the demo app (http://212.32.240.74:5000/index?user=2000100704)

Title of message	**Message**	**device connected to message**
Game over	Stop standby energy loss of gaming consoles.	gaming set
Nothing is for eternity	Keep fridge rubber seals clean and replace old ones.	fridge
Leave the fridge in peace	Leave the fridge open as short as possible. Decide first what to put in or take from the fridge. For example, sort shopping first while unpacking, then put in all cooled groceries in one go.	
Also clean behind the fridge	Vacuum or brushing the refrigerator coils makes the fridge cool down more efficiently.	
Fight the ice!	Defrost freezer (e.g. before vacation) to melt ice layer.	
Electric kettle is the best	Use an electric kettle to heat water. Do not boil water in a pot.	electric kettle
Chalky kettles need more energy	Descale the kettle by using citric acid or vinegar. It will heat up more quickly.	
Everything clear?	Keep the window of the oven clean so that you don't need to open the door to check the progress of your meal.	electric oven

2.2 CURRENT LIMITATIONS AND NEXT STEPS

2.2.1 Current limitations

As showed in chapter 1.2.1 not all input data was available for developing the current prototype. No luminance, temperature and motion data was provided for the households used in the demonstrator app. Although motion data imitating real data was generated and used in the prototype, the absence of real sensory data limited the complexity of the user model and the recommendation logic.

The other important input that was not available yet is the user feedback. As highlighted in chapter 1.2.2., feedback from users is planned to be involved in the user model. Without this data, no collaborative methods can be used.

Message selection is combining the enriched features of the messages with the user model as much as possible but in several cases the messages don't refer to any measurable data. These messages describe the optimal usage of a device, but that kind of behavior cannot be measured by the data used. E.g. "Periodically clean the fluff filter of the tumble dryer."

2.2.2 Next steps

The next step will be to finalize the recommender as outlined in the Grant Agreement:

Final user behavior modeler and recommender: validated prototype, with documentation, of the models and algorithms for determining the current status of the users and the most suitable actions to recommend based on the adaptive context detection, validated in the pilot experiments.

For achieving this goal, the current prototype will be improved based on data collected during pilot experiments.

The main improvement will be based on collecting feedback from the users about the recommendations. As shown on Figure 2, feedback information will be included in the user model. The recommendation logic, summarized in on Figure 3 will be also expanded. Depending on the quantity and quality of the input data, more complex algorithms might be implemented, such as collaborative filtering. With collaborative filtering, messages that users similar to the current user rated useful can be given a higher score.

As mentioned before, at this point devices measuring temperature, motion and luminance have not been installed yet. Once we receive this data new formulas for message selection can be applied. From temperature data the usage of heating and cooling devices can be inferred. Combining luminance data with motion activity, patterns of lamp usage can be detected. These observations will be included in the message selection algorithm and contribute to the adaptive context detection.

Each message will have different versions, using different incentives. The highlighted consequence of the same suggested action can be saving money or saving the environment for example. Selecting an incentive type for each message will be included in the recommender. Preferences for incentive types will be included in the user model and updated based on the received feedback from the user.

Disaggregation by device of the energy consumption will be provided for us as well. Using this data, device usage habits can be inferred and included in the user model as shown in Figure 2. Based on this, device specific messages can be excluded or selected with higher precision for each household and predicting the optimal time of notification can be improved as well.

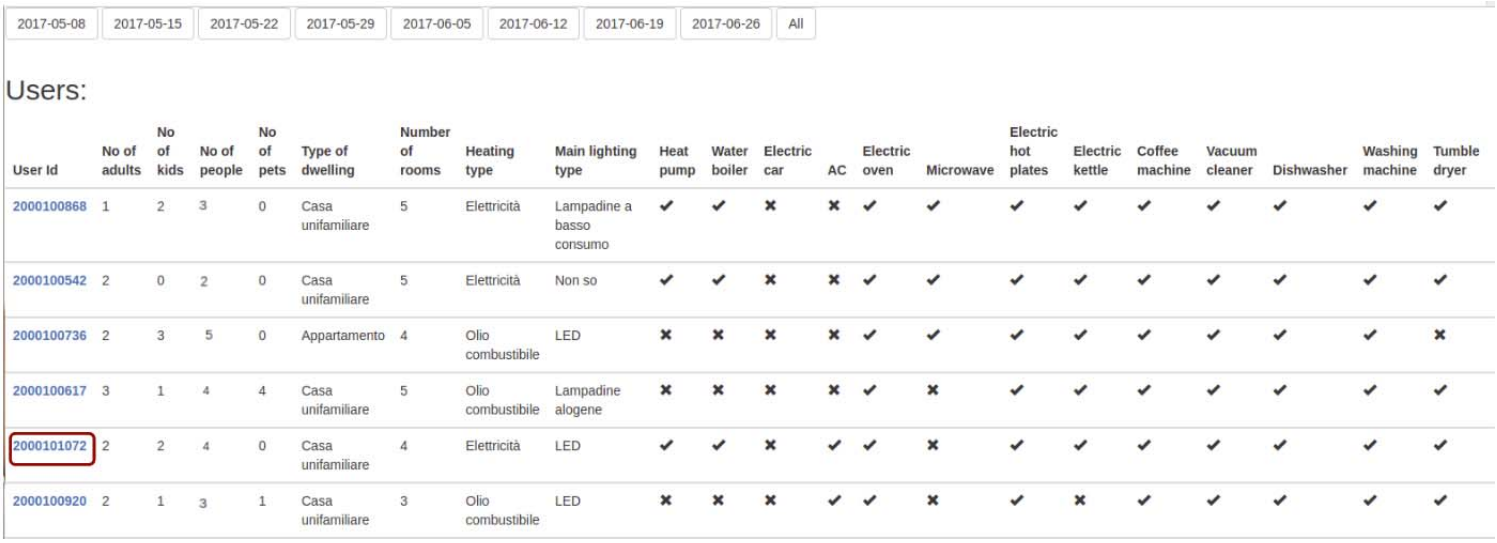
3 HOW TO USE THE DEMONSTRATOR

3.1 USER GUIDE

The demonstrator can be reached at http://212.32.240.74:5000/index with basic http authentication.

username: encompass
password: demo

Upon opening the demonstrator, the households and their user profile are shown. Any household can be selected by clicking the User Id (Figure 4).



User Id	No of adults	No of kids	No of people	No of pets	Type of dwelling	Number of rooms	Heating type	Main lighting type	Heat pump	Water boiler	Electric car	AC	Electric oven	Microwave	Electric hot plates	Electric kettle	Coffee machine	Vacuum cleaner	Dishwasher	Washing machine	Tumble dryer
2000100868	1	2	3	0	Casa unifamiliare	5	Elettricità	Lampadine a basso consumo	✔	✔	✖	✖	✔	✔	✔	✔	✔	✔	✔	✔	✔
2000100542	2	0	2	0	Casa unifamiliare	5	Elettricità	Non so	✔	✔	✖	✖	✔	✔	✔	✔	✔	✔	✔	✔	✔
2000100736	2	3	5	0	Appartamento	4	Olio combustibile	LED	✖	✖	✖	✖	✔	✔	✔	✔	✔	✔	✔	✔	✖
2000100617	3	1	4	4	Casa unifamiliare	5	Olio combustibile	Lampadine alogene	✖	✖	✖	✖	✔	✖	✔	✔	✔	✔	✔	✔	✔
2000101072	2	2	4	0	Casa unifamiliare	4	Elettricità	LED	✔	✔	✖	✔	✔	✖	✔	✔	✔	✔	✔	✔	✔
2000100920	2	1	3	1	Casa unifamiliare	3	Olio combustibile	LED	✖	✖	✖	✔	✔	✖	✔	✖	✔	✔	✔	✔	✔

Figure 4: initial interface for selecting a household

After selecting the household, new data appears on top of the list of households. The first part describes features in the user model for the first date of simulation (2017-05-08). Below that all selected messages are shown with the date when they appear in the user's page and with the hour when notification would be sent on that day (Figure 5).

2017-05-08 | 2017-05-15 | 2017-05-22 | 2017-05-29 | 2017-06-05 | 2017-06-12 | 2017-06-19 | 2017-06-26 | All

User model (for 2000101072 on 2017-05-08):

User feature	Calculated value
Hour when user usually arrives home on a weekday	20
Hours when user is usually at home during the weekend	12,13,17,20,21,22
Difference in base energy consumption from the median of similar households (%)	8
Difference in base energy consumption when nobody is home from the median of similar households (%)	8
Difference in active energy consumption from the median of similar households (%)	-10

Recommendations to show (for 2000101072):

Title	Description	Start showing on	Send notification at (hour of day)
Slice and dice	Slice food into smaller pieces before cooking. It makes cooking time quicker.	2017-05-08	21
Change power supplier	Eco-power for heat pump (e.g. by the power utility "Elektrizitätswerke Schönau").	2017-05-10	11
Check yourself	Energy calculators like "EngyCal" can measure losses and help to install a pre-/post-alarm-system.	2017-05-13	12
Nothing is for eternity	Keep fridge rubber seals clean and replace old ones.	2017-05-20	20
Use eco washing function	It lasts longer, but consumes less energy.	2017-05-20	20
Everything in it?	Always completely fill up the washing drum. Don't do unneeded washing cycles.	2017-05-21	20
Iron reflectively	Use a heat reflective ironing-board to conserve energy.	2017-05-22	17
Leave the fridge in peace	Leave the fridge open as short as possible. Decide first what to put in or take from the fridge. For example, sort shopping first while unpacking, then put in all cooled groceries in one go.	2017-05-25	20
Plate not empty yet?	Scrape off food pieces before washing the plates. Rinse them later so you do not need to consume more water than necessary.	2017-05-28	19
Toaster instead of oven	Don't always use the oven. To warm a roll, mostly toaster is just fine.	2017-05-31	10

Figure 5: preview of the hour when notification would be sent on the day

For selecting an individual week from the simulation, the appropriate button on the top of the page can be clicked (Figure 6).

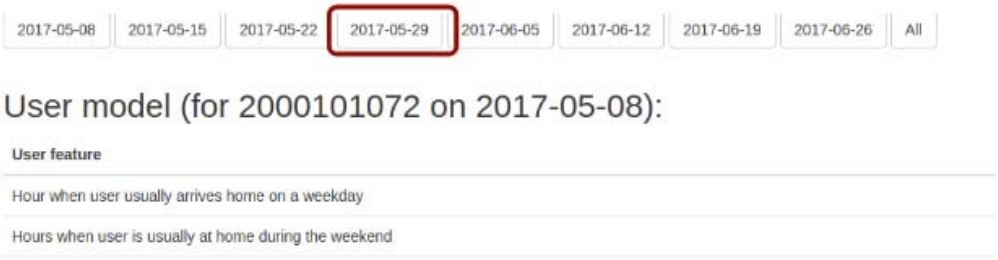


Figure 6: selecting an individual week from the simulation

This makes the user model for the given date and messages that would be sent out the following week appear (Figure 7). Weeks can be changed multiple times, it won't affect the result of the simulation, only controls what is shown on the demonstrator page. For looking at all recommendations the 'All' button can be used next to the dates.

Any time simulation for another household can be selected by clicking on another User Id under the Users heading.

2017-05-08 | 2017-05-15 | 2017-05-22 | 2017-05-29 | 2017-06-05 | 2017-06-12 | 2017-06-19 | 2017-06-26 | All

User model (for 2000101072 on 2017-05-29):

User feature	Calculated value
Hour when user usually arrives home on a weekday	20
Hours when user is usually at home during the weekend	12,13,17,20,21,22
Difference in base energy consumption from the median of similar households (%)	91
Difference in base energy consumption when nobody is home from the median of similar households (%)	91
Difference in active energy consumption from the median of similar households (%)	68

Recommendations to show (for 2000101072 on 2017-05-29):

Title	Description	Start showing on	Send notification at (hour of day)
Toaster instead of oven	Don't always use the oven. To warm a roll, mostly toaster is just fine.	2017-05-31	10
Electric kettle is the best	Use an electric kettle to heat water. Do not boil water in a pot.	2017-05-31	17
Game over	Stop standby energy loss of gaming consoles.	2017-06-03	18

Users:

User Id	No of adults	No of kids	No of people	No of pets	Type of dwelling	Number of rooms	Heating type	Main lighting type	Heat pump	Water boiler	Electric car	AC	Electric oven	Microwave	Electric hot plates	Electric kettle	Coffee machine	Vacuum cleaner	Dishwasher	Washing machine	Tumble dryer	Dehu
2000100868	1	2	3	0	Casa unifamiliare	5	Elettricità	Lampadine a basso consumo	✔	✔	✖	✖	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
2000100542	2	0	2	0	Casa unifamiliare	5	Elettricità	Non so	✔	✔	✖	✖	✔	✔	✔	✔	✔	✔	✔	✔	✔	✖
2000100736	2	3	5	0	Appartamento	4	Olio combustibile	LED	✖	✖	✖	✖	✔	✔	✔	✔	✔	✔	✔	✔	✖	✔

Figure 7: user model for the given date and messages that would be sent out the following week