Deliverable D3.6 – Report on Smappee results and recommendations

Contents

1. Introduction

Tenants have a large influence on their energy consumption, especially regarding electricity consumption for their appliances. They can reduce their energy consumption through behavior change, which is addressed by the Energy Ambassador program of TRIME. But they can also purchase energy efficient appliances to reduce their energy consumption.

Since many appliances are required to have an energy label, it has become clearer how energy efficient the different appliances are. But in general, appliances with a good energy label (i.e. label A+++) are more expensive than appliances with a worse energy label (i.e. label A or worse). Depending on the use pattern, energy efficient appliances can 'earn back' their higher price with their reduced energy consumption.

In TRIME, to identify the key parameters that can induce a change in purchasing behavior, the energy consumption of the individual appliances was monitored in 10 households in 6 Social Housing Organisations (SHOs).It was originally intended that the monitoring would take place in 14 households, but this was not possible because of difficulties with commitment of the tenants and with the planning of the installation. Based on the results, advice for tenants on purchasing new appliances has been composed. The focus is on fridges, freezers and washing machines, because these appliances are common in most households, consume a considerable share of the total electricity consumption in a dwelling, and appliances with a broad range of energy labels are available on the market.

In Chapter 2, the use of Smappee in TRIME is explained. In Chapter 3, the results of the monitoring of the electricity consumption using Smappee is given. In Chapter 4, general data about the energy consumption of the appliances are given. In Chapter 5, the results are discussed and conclusions are drawn.

We have provided a summary of information that can be used by the SHOs with the tenants in Appendix 1.

2. Methodology

In this chapter, the concept of Smappee and the use of the device in TRIME is explained.

2.1. Smappee

Smappee is a device that monitors the energy consumption of the different appliances in a dwelling. The device is installed in the dwelling's switchboard, and detects when an appliance is switched on or off. Based on the electricity power needed, the change in power (e.g. when a pump is switched on, it briefly uses more power to get started) and some other parameters, it can label appliances based on their electricity consumption pattern. The data is stored on the server of Smappee and can be viewed using the website or using an app for the smartphone.

Smappee offers a range of monitoring equipment for electricity, photovoltaic panels, gas and water.

2.2. Smappee in TRIME

Every SHO in TRIME was required to buy 2 Smappee devices and install them in two of their dwellings for a period of at least two months. After two months, the tenants were given the login details, so that they could view their data as well. TUDelft recorded the Smappee results on a regular interval, but the event data are not always complete because of the relatively low number of data points retained.

3. Total energy consumption measured with Smappee

In this chapter, the results of the monitoring of the energy consumption using Smappee are described. First, the installation and experience of use of the Smappee devices are given. Then the total electricity consumption as measured using Smappee is presented. Finally, the electricity consumption per appliance as measured with Smappee is discussed.

3.1. Smappee installation

Smappee was installed in 10 households in 6 SHOs. Each Smappee was given a reference code, which is used in the analysis and the presentation of the results. Table 1 gives the installation and running dates of the installed Smappee devices.

Table 1: Smappee devices installed in TRIME and installation dates

Smappee Reference	SHO	Date of Installation	Date of removal
Cir1	Circle	6 December 2015	Running
EH1	Eigen Haard	2 February 2016	Running
EH2	Eigen Haard	30 May 2016	Running
Log1	Logirep	21 February 2016	28 June 2016
SB1	Sestao Berri	13 January 2016	Running
SB2	Sestao Berri	22 March 2016	Running
Vil1	Vilogia	23 February 2016	26 May 2016
Vil2	Vilogia	22 March 2016	21 June 2016
ZK1	Zonnige Kempen	9 December 2015	Running
ZK2	Zonnige Kempen	9 December 2015	Running

In this analysis, the Smappee data from 1 January 2016 until 30 September 2016, as far as available, are used.

3.2. Total energy consumption

In Figure 1, the average daily energy consumption per household is given per month. The average daily energy consumption varies between 2 and 17 kWh per day. For comparison, the average daily electricity consumption per household in the Netherlands is 9.0 kWh (Nibud, 2016). The households EH1, EH2, SB2 and Vil2 show a decreasing trend, probably as an effect of the energy saving measures they took in the Energy Ambassador program. The other households do not show any trend.

The average energy consumption of household EH1 is very low: 2.8 to 4.3 kWh/day. According to the questionnaire, the tenants have an A++ fridge and an A+++ washing machine used 3 times per week, and no drier. This indicates that energy efficient appliances possibly lead to a low energy consumption.

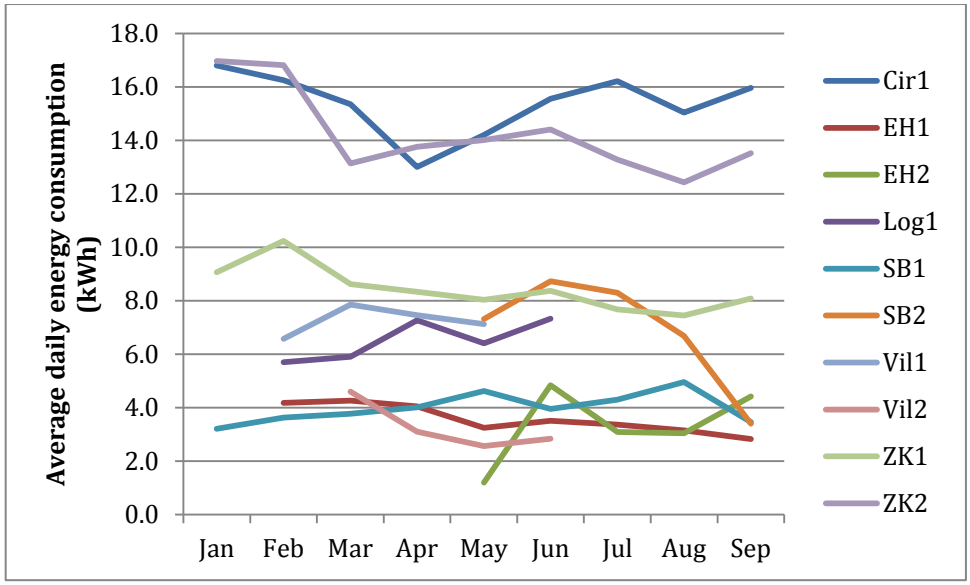

Figure 1: Average daily energy consumption per household

Figure 2 gives the average share of the 'always on' energy consumption in the total energy consumption. The 'always on' energy consumption is the energy consumptions of appliances that Smappee interprets as being always on, e.g. appliances that are standby or are being used constantly. The share of 'always on' energy consumption ranges from 8 % to 50 %. One could expect that when the usage of appliances decreases, the share of 'always on' appliances would increase. However, there are no trends visible in the data that would lead to such conclusion.

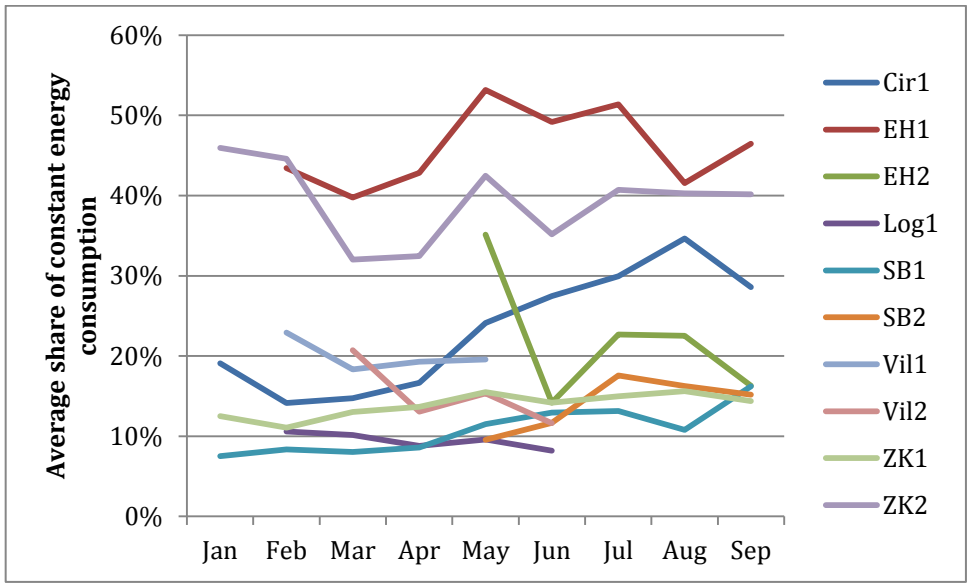

Figure 2: Average share of 'always on' energy consumption

3.3. Energy consumption per appliance

Smappee learns to recognize different appliances when in use for a longer period. However, the identification of the recognized appliance in Smappee is difficult.

Smappee offers a training mode, in which all appliances in the dwelling should be turned off, and one appliance at a time should be then turned on and off a few times. The SHOs found that this process is bothersome to the tenant, and that the success rate is very low. Most of the Smappee devices were therefore not trained, and the appliances were only identifiable with a number. Appliances that use different amounts of power during operation, such as washing machines (heating the water, turning the vessel, pumping off the water) are often recognized as multiple appliances, thus obfuscating the identification of the appliances. This made monitoring difficult.

The events show that in several dwellings, some appliances were switched on for a very short period, often a few seconds, and/or very often (serval times per 10 minutes). This raises doubts about the reliability of the Smappee data, because few appliances are used that shortly or frequently.

Monthly consumption data of the individual appliances was not available in the Smappee app, only extrapolated yearly consumption was available. This also hampered the analysis of the individual energy consumption of the appliances, as no consumption history was directly available.

Smappee is better suited in situations where the tenant can identify the appliances themselves over a longer period of time. For future remote monitoring projects for electricity consumption of appliances, other sensors that are connected directly to the appliances, such as Plugwise or similar systems, are probably a better solution. The TRIME project did thoroughly review the use of other systems; the findings are in Appendix 2. It was agreed that Smappee seemed the best solution at the time, because it would measure all appliances in a dwelling instead of only a limited number with e.g. Plugwise, it has a lower price than most alternatives, and it was presumed that the installation and use was less complicated and intrusive than with Plugwise or similar systems.

4. General data about energy consumption of appliances

For the tenants in TRIME, it is important to get insight in the possibilities to save energy with their washing machines, fridges and freezers. It is also helpful for them to get advice on the energy consumption of these appliances when they purchase a new or secondhand one. This chapter provides some general information about the energy consumption of these appliances and the possibilities to save energy.

Electricity costs and savings were calculated using an electricity price of € 0.20 per kWh. This is close to the € 0.206/kWh average for all European countries (Eurostat 2016). Electricity prices in Europe range from 10 cent/kWh (Bulgaria) to 31 cent/kWh (Denmark).

4.1. Fridges and freezers

Currently, fridges, freezers are available on the market with an energy label of up to A+++. Although these appliances with energy labels A and B are still available, these are not considered energy efficient any more. Fridges and freezers with energy label A+++ use 50% less electricity than those with energy label A+. Although the label A+++ appliances are often more expensive than label A+ appliances, the difference in price is generally earned back by a lower electricity bill in a few years.

Tables 2 and 3 give the average yearly energy consumption for different appliances with different energy labels or ages (MilieuCentraal, 2016a)

Table 2: Energy consumption of new fridges and freezers

Appliance	Average yearly energy consumption (kWh)			Electricity costs per year (€)		
	A+	A++	A+++	A+	A++	A+++
Combi fridge/freezer	300	220	150	60	44	30
Fridge table model	150	110	75	30	22	15
Fridge high model	180	140	90	36	28	18
Freezer chest model	240	180	120	48	36	24
Freezer cupboard model	250	190	120	50	38	24

Table 3: Energy consumption of older fridges and freezers

Appliance	Age				
	7-8	10	15	20	25
Combi fridge/freezer [a]	350	380	450	500	600
Fridge table model [b]	175		220		300
[a] Milieucentraal, 2016a [b] Nuon, 2016					

Cooling down food outside the fridge before putting it in the fridge or freezer will save electricity. Also having frozen food thaw in the fridge will save energy by

using the cold of the frozen food. If a freezer or the freezing compartment of a fridge is covered with ice, then the cooling capacity will decrease and the energy consumption will rise drastically. Defrosting the freezer or fridge regularly will prevent ice accumulation in the freezing compartment. No-frost freezers do not need to be defrosted.

If the door of a fridge or freezer does not close completely, then warm air can enter the fridge or freezer, raising the temperature and increasing ice accumulation. Make sure that the door closes snugly and clean the rubbers of the door for a longer lifetime.

The backside of a fridge or freezer is used to dissipate the heat extracted from the inner compartment. If this heat cannot dissipate easily, then the compressor needs to work harder and the energy consumption increases. Keeping the backside clean and free of obstacles clean ensures good heat dissipation. Do not put the fridge or freezer next to a warm appliance such as an oven or dishwasher.

If you are away from home for a longer period, empty the fridge and/or freezer, shut it down, clean it and keep the door open to prevent bad smell.

4.2. Washing machines

Although there are still washing machines available on the market with energy labels A, B and C, the washing machines with energy labels A+, A++ and A+++ use significantly less electricity and are therefore often a cheaper choice for the long-term. Washing machines with energy label A+++ use 20% less electricity than those with energy label A+. For example, a front-loading washing machine with a capacity of 6 kg has an average yearly electricity consumption of 125 kWh for a label A+ machine, but a label A+++ machine uses on average 100 kWh per year (MilieuCentraal, 2016b).

The temperature for washing in a washing machine is an important factor for the energy consumption of a washing machine. Table 4 shows the costs for electricity when washing 5 kg of clothing in an average label A washing machine (Electricity price 2016 for the Netherlands is 0.20 euro per kWh) (MilieuCentraal, 2016b)

Table 4: Costs of washing 6 kg of clothes in a label A washing machine at different temperatures

Temperature	Costs
15 °C	€ 0.02
30 °C	€ 0.07
40 °C	€ 0.10
60 °C	€ 0.18
90 °C	€ 0.29

When hot water from an efficient gas boiler is available, a hot fill washing machine can lead to an 80% reduction of the electricity consumption of a washing machine (MilieuCentraal, 2016b).

Washing a full load of clothing is more energy efficient than washing a half load. Centrifuging with the highest speed available is recommended when using a

tumble dryer. When the wash is dried to the air, a lower spinning speed will lead to a further reduction in electricity consumption.

5. Discussion and conclusion

In the TRIME project, a Smappee was installed in 10 dwellings in 6 social housing organisations. The energy consumption was recorded in a period varying from three to nine months. The average electricity consumption varied between 2 and 17 kWh per day. A decreasing trend in the electricity consumption was found in four households, which could be attributed to energy saving measures they took in the Energy Ambassador program.

It was difficult to link the electricity consumption to specific appliances, because the training of the Smappee devices to recognize and identify the individual appliances is time-consuming. For remote monitoring, it is nearly impossible to identify the individual appliances without information about the use pattern of the appliances. In some cases, the frequent switching of a few appliances raised doubts about the reliability of the Smappee data. Smappee is better suited in situations where the tenant can identify the appliances themselves over a longer period of time. For future remote monitoring projects for electricity consumption of appliances, it is recommended to use sensors that are connected directly to the appliances, such as Plugwise or similar systems.

In Chapter 4, general advice about the energy consumption of a few types of appliance is given. In summary:

- In general, A+++ label **fridges** use 50% less electricity than A+ label fridges, resulting in average 15-30 euro savings per year
- In general, A+++ label **freezers** use 50% less electricity than A+ label freezers, resulting in average 24-26 euro savings per year
- In general, A+++ label **washing machines** use 20% less electricity than A+ label washing machines, resulting in average 5 euro savings per year.
- The savings compared to older appliances with worse energy labels are even larger than described above.

References

Eurostat, 2016. http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics (accessed 24 November 2016)

MilieuCentraal, 2016a. https://www.milieucentraal.nl/energie-besparen/apparaten-en-verlichting/huishoudelijke-apparaten/koelkasten-en-vriezers/ (in Dutch, accessed 3 October 2016)

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Nibud, 2016. https://www.nibud.nl/consumenten/energie-en-water/ (in Dutch, accessed 3 October 2016)

Nuon, 2016. https://www.nuon.nl/energie-besparen/apparaten/hoeveel-verbruikt-uw-koelkast.jsp (in Dutch, accessed 3 October 2016)

Appendix 1: Summary for tenants

Fridges and freezers

- A new fridge or freezer with energy label A+++ can save on average 40 to 90 euro per year on electricity costs, compared with an average 8 to 25 years old fridge or freezer.
- The yearly electricity consumption of a new A+++ label fridge or freezer can be 15 to 30 euro lower on average than that of an energy label A+ fridge or freezer.
- The savings compared to older fridges and freezers with worse energy labels are even larger than described above.
- Additional electricity can be saved by:
    - Cool down food outside the fridge before putting it in the fridge.
    - Let frozen products thaw in the fridge.
    - Defrost your freezer regularly.
    - Check whether the door closes correctly, and clean the rubber of the door regularly.
    - Keep the backside of your fridge or freezer open and clean.
    - Do not put the fridge or freezer next to a warm appliance such as an oven or dishwasher.
    - Shut down you fridge or freezer and open the door when it is empty for a longer period (e.g. on holiday).

Washing machine

- A new washing machine with energy label A+++ can save on average 25 kWh per year, compared with energy label A+ washing machines. The difference with older washing machines is even larger.
- The yearly electricity consumption of a new A+++ label washing machine can be 5 euro lower on average than that of an energy label A+ washing machine.
- Additional electricity can be saved by:
    - Wash your clothing at the lowest temperature possible (depending on the washing powder) can save up to 27 cent per run.
    - Using the washing machine with a full load of clothing is more efficient than using it with only a half load.
    - When you use a tumble dryer, have the washing machine centrifuge the clothing at full speed. If you dry the clothing to the air, use the lowest centrifuging speed.
    - A hot fill washing machine uses less electricity, especially if the hot water is heated using an efficient gas boiler.

All prices calculated using the electricity price in the Netherlands in 2016 (20 cent per kWh).

Appendix 2: Review of Smappee and Plugwise

Before purchasing the monitoring equipment for the electrical appliances in the dwellings. The TRIME team made a thorough review of possible measurement systems. In a first screening, Smappee and Plugwise were considered as the most feasible options. The properties, advantages and disadvantages of both systems are summarized in Table 5.

Table 5: Properties, advantages and disadvantages of Smappee and Plugwise

	Smappee	**Plugwise**
System description	The Smappee monitor is a device that measures the energy consumption of your electrical appliances with one sensor close to the fuse box. The sensor is clamped to the main cable and records the energy use. The various devices are recognized by their energy signature or the electrical traces they leave. If you have solar panels, you can also use the Smappee monitor to measure the energy generated. The Smappee monitor is installed close to the fuse box. It then starts measuring your energy consumption and the yield of your solar panels as well as communicating with your smartphone or tablet. The Smappee app gives you direct insight in your energy consumption, energy costs and the yield of your solar panels. To save on energy costs and contribute to a greener environment, you can take on energy guzzlers and standby power. This manual describes the installation of the Smappee monitor.	With the Home Basic package, that contains 9 Circles, a USB stick and a Plugwise Source license you get a complete package with the goal to control and reduce your energy consumption. The USB stick is the gateway in the Plugwise system that you stick into your pc or laptop. The Plugwise Source software works on your laptop or pc and offers far more possibilities to view your energy usage.
Costs of equipment per dwelling	€ 199.-	€ 319.95
Additional costs	Electrician to install the Smappee (costs unknown, dependent on type of fuse box), smartphone or tablet	Extra features: csv export (€ 24.75) and 5 minute interval storage (€ 49.55), minicomputer for remote

	(owned by occupant or newly purchased)	control and access (€ 250.-)
Total costs per dwelling	€ 199.-	€ 644.25
Measurement data	Total electricity consumption and consumption per appliance. About 70% can be linked to appliances.	Electricity consumption per smart plug. The considered system contains 9 smart plugs which can measure 9 appliances
Reliability measurement data	Measurements of total electricity consumption are reliable with an accuracy of 1%. Accuracy of measurement data per appliance is strongly dependent on characteristics of the household. A household that uses many appliances in the same time produces more "noise" in the measurements and thus the measurements will be less accurate.	Measurements of Plugwise are reliable because each plug measures one appliance.
Additional requirements	- Enough space in the fuse box for the clamps. Especially older fuse boxes have limited space to fit the clamp. - An (empty) outlet near the fuse box. - The fuse box must be within reach of the wifi network. - A smartphone of tablet with iOS or Android devices. It is possible to use Smappee in Windows with an Android emulator, but not all functions might then work correctly.	- Internet access. Plugwise also works without internet: the data is then saved on the minicomputer and can be collected at the end of the measurement period. - Some dwellings have a special outlet for the furnace that is not compatible with the smart plugs - A power strip (with multiple outlets) to measure the total energy consumption of a media set with multiple components.
Advantages	- System is usable after the TRIME project - Real time energy consumption - System saves data during internet disruptions for one	- System is usable after the TRIME project (also without the extra features) - Real time energy consumption - Csv export function

	week - Relatively cheap - Data total energy consumption is reliable - Smappee is probably more user friendly after the TRIME period	(separate option) - System works without internet - Data is reliable and accurate - More often used for monitoring projects - Directly recognizes different appliances
Disadvantages	- Data per appliance is not really reliable or accurate - The fuse box must be within reach of the wifi network - 50%-80% of the appliances can be measured - Appliance recognition is not always working correctly - Takes a while before appliances get recognized, and some will not be recognized at all - Webportal does not show real time data. Information in the csv output is not energy consumption per appliance, but switching time, power consumption per appliance and total energy consumption	- For the TRIME project extra features and mini computers are necessary - Only 9 appliances can be monitored - More expensive than Smappee - The plug has to be plugged in a wall outlet, which is not always easy to reach - Lightbulbs without a wall outlet cannot be measured

TRIME

THE PARTNERS

The TRIME project team includes the following organisations:

Circle Housing
Enhancing Life Chances

ZONNIGE KEMPEN

intent TECHNOLOGIES

TU Delft Delft University of Technology

Vilogia
Bien dans ma ville

LogiRep
Groupe PolyLogis

EIGEN HAARD

u-sentric
design, with people

HAVENSTEDER

sestaoBERRI

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TRIME is a Pan-European project helping social housing customers reduce their energy use; enabling them to save money and live a healthier lifestyle.