D6.6 - White goods pilot report

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List of abbreviations

Abbreviation	*Explanation*
WM	Washing machine
TD	Tumble dryer
B2B	Business-to-business
B2C	Business-to-customer
PPW	Pay-per-wash (WMs)
PPU	Pay-per-use (TDs)

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Executive summary

Gorenje as - all other producers of white-goods - is currently using a linear business rationale, which is not sustainable in the long-term. The COVID and Ukrainian crisis exposed the vulnerability of current linear business model, demonstrating that companies like Gorenje cannot run its business in a sustainable and profitable way due to increasing material supply uncertainty and material price volatility. The goal of Gorenje in ReCiPSS project was to demonstrate that is possible to achieve a win-win effect by transitioning/upgrading traditional manufacturing industry towards operating as a service provider. In this four and half years a lot of learnings were made. Out of them not all were positive, but at the end we clearly demonstrate that with careful cost of the costs and offered services it is possible to do this transition. Some of most important learnings for Gorenje are presented in this deliverable. This deliverable is related to tasks 6.6 and 6.7: Report on white goods pilot. The results of the tests will be used to further improve and optimize the business and technical requirements and functions.

During the project a roll-out of 182 washing machines (WMs) and 148 tumble dryers (TDs) has been carried out in Slovenia, The Netherlands, Denmark and Sweden to test different scenarios and validate a subscription-based offer in real life environment, and to evaluate the economic and environmental benefits for the OEM and customer.

New competences have been built and tested like data gathering capabilities, to identify user patterns in real-time in order to better understand behavioural aspects. These have been used to provide feedback in the form of user reports and allow for adjusting contracts based on gathered insights. These capabilities are crucial to increase success and adoption of this new business approach in the long-term.

The identified perceived customer benefits and acceptance of the subscription model seem to outweigh perceived disadvantages. While test users showed interest in new WM/TD features, knowledge and awareness need to be increased regarding the sustainability of this new subscription service. This will require new marketing approaches with new sustainability contents to increase attractiveness of the offering.

Economic benefits for Gorenje can be improved significantly compared to conventional sales scenario through increased earning and lower environmental burden over WM/TD lifetime. However, from a risk perspective the retention of customers i.e., the contract duration of the subscription offer has largest impact on the economic success of the tested approach. This in turn indicates the relevance of the newly tested applications like the ConnectLife app to identify customer preferences in shortest time and minimize the risk of contract cancellations.

After the formal project end, Gorenje will keep the demonstrators up and running with the objective to collect as much data as possible in order to prepare additional requirements for further pay-per-use business development. This is expected to result in refinements for different markets and target users and additional product categories. For the transformation from demo environment to the commercial setup Gorenje will develop additional functionalities which will enable expansion of pay-per-use service-based businesses. The industrial roll-out is currently planned to take place in spring 2024, prioritizing existing ReCiPSS demo markets. Afterwards Gorenje plans to gradually expand the business also to other markets where Gorenje/ASKO appliances are present.

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During the project execution and with the data and themes related to the white-goods demonstrator at least 9 PhD theses and 2 master theses have been delivered (some yet to be finalized). This confirms the complexity and the need for the future scientific research in this field. In addition, the knowledge gained in this project will spill over to the two additional Horizon Europe projects namely CircThread and DiCiM.

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1. Introduction

1.1. Objectives

This deliverable is reporting task 6.6 and 6.7. The report will evaluate the economic benefits for the Original equipment Manufacturer (OEM) Gorenje and their customers. This includes customer acceptance, customer behaviour and perceived customer benefits, as well as economic benefits for the OEM. The results of the tests will be used to further improve and optimize the business and technical requirements and functions.

1.2. About Gorenje

Gorenje is One of Leading European Manufacturers of Products domestic appliances with production in Slovenia, Serbia and Czech Republic. Gorenje's product portfolio ranges from cooking appliances, dishwashers, and advanced washing machines (WMs), Tumble dryers (TDs) and niche refrigerators. Gorenje has the ambition to become the global manufacturer of WMs and provider of laundry pay-per-wash offerings to ensure long-term sustainable competitiveness both in the business to customer (B2C) and business to business (B2B) segments. The B2C segments cater consumers who move often and are concerned about upfront costs (e.g., students), Environmental conscious people or People who would do their laundry as much as possible carefree. Whereas in B2B segments the consumers can be Laundrettes, Student dormitories; Other businesses (e.g., hotels, landlords).

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2. Gorenje demonstrator

The overarching purpose of the demonstrator is to learn about the opportunities and challenges of re-shaping Gorenje's business model by deploying 330 WMs and TDs as a pay-per-use offering in four markets.

2.1. Slovenia

In Slovenia a total of 51 appliances have been rolled out. Out of these, 15 appliances were tested with B2B test users (health care, a kindergarten, a school and small businesses) and 36 appliances with private B2C costumers. The types of tested products are 27 units of ASKO Professional WMs and 24 units of ASKO Professional TD (see Figure 1 for an exemplary installation).

Figure 1: Example of installed WMs and TDs on Slovenian market

The selected test users are predominantly in the close vicinity of the Gorenje production facility so that the average distance from customer to service point ranges between 10 km and 15 km. The pick-up and installation of the appliances has been organized by test users themselves in order to test the simplicity of installation (including placement of the appliances, power and Wi-Fi connection) by the test users.

The test users did not need to pay for using the WM/TD, but instead agreed on data exchange during the test period, and participation in surveys, interviews and workshops. Concerning data gathering the chosen washing/drying programs are logged, which enables the calculation of average water and energy consumption based on average consumption for these programs.

In the last period of testing, the new functionalities in the pay-per-use setting have been investigated. These include different payment schemes, such as monthly fee, pay-per-use and a combination of fixed price for limited amount of usage with increased fees for additional usage.

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2.2. Netherlands

In the Netherlands 80 appliances have been rolled out to engage B2B players (health care, kindergarten, schools and small businesses) and private B2C costumers, incl. ATAG/ASKO employees. Tested products are the Professional WM and Professional TD (see Figure 2 for an exemplary installation).

Customers are obligated to test new functionalities in the pay-per-use setting. Customers have been contacted for installation and delivery, incl. aftersales service agreement. The distance from customer to service point ranges between 25 km and 30 km. Furthermore, customer did not need to pay for using the WM/TD, but instead agree on data exchange during use, and participation in surveys, interviews and workshops.

When it comes to data gathering the chosen washing/drying programs could be logged, and water and energy consumption being calculated based on average consumption for these programs.

Figure 2: Example of installed WMs and TDs in the Netherlands

2.3. Denmark

In Denmark 183 appliances have been delivered to the market. The engaged customers consist of B2B players, such as laundry rooms, property and development companies, restaurants, farms or non-profit foundations providing services for people with special needs. Also B2C customers were engaged, including Gorenje Group Nordic employees. Two types of professional WMs (namely WMC6763PC.S/R and WMC8947PI.S/R) as well as TDs (TDC1771HC.S/R and TDC1485HC.S/R) have been distributed. Figure 3 shows an examplary installation.

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Figure 3: Example of installed WMs and TDs on the Danish market

After signing the contract, the delivery, installation and connection of the machines to the wifi was carried out by a logistics company. The distance from test users to service point ranges between 25 km and 50 km. The test users do not pay for using the appliances, but they are obligated to test the functionalities, agree with the machines collecting usage data and sending them to ASKO via wifi, to cooperate in collecting customer feedback, for instance, participate at surveys, interviews, etc., and accept that ASKO photographs the appliances installed in their homes/facilities.

2.4. Sweden

In Sweden, the total of 16 appliances (8 WMs and 8 TDs) have been distributed to 8 customers, out of which one is a B2B player from the apparel industry, and the rest of them are B2C customers. The products deployed at this market are a professional WM WMC6763PC.S/R and a professional TD TDC1771HC.S/R. The products were delivered and installed by a logistics company or sent directly to the test users. The distance from test users to service points ranges between 50 km and 450 km. Figure 4 shows exemplary installations.

The customers are using the appliances free of charge. However, they agreed to test the functionalities and cooperate in providing feedback (participate in surveys, interviews, workshops, etc.). Furthermore, the test users gave consent to the company to collect their usage data and send them to ASKO via Wi-Fi, photograph the installed appliances and used these photographs in an anonymized form.

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Figure 4: Example of installed WMs and TDs on the Swedish market

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2.5. Summary

Table 1 shows a summary of the roll-outs in the four markets Slovenia, The Netherlands, Denmark and Sweden.

	Slovenia	*Netherlands*	*Denmark*	*Sweden*
Volumes (number of WMS and TDs)	51	80	183	16
Customer types	B2B (health care, kindergarten, school, SMEs), B2C	B2B (health care, kindergarten, schools, SMEs), B2C	B2B (health care, kindergarten, schools, SMEs), B2C	B2C
WMs and TDs	Connected WMs and TDs	Connected WMs and TDs	Connected WMs and TDs	Connected WMs and TDs
Contractual condition during use	Obligatory functionality tests	Obligatory functionality tests	Obligatory functionality tests	Obligatory functionality tests
Type of subscription model	various	none	none	none
Payment scheme	No payment, data exchange, interviews, surveys	No payment, data exchange, interviews, surveys	No payment, data exchange, interviews, surveys	No payment, data exchange, interviews, surveys
Logistics setup	Customer-own installation	Subcontractor delivers and installs WM/TD	Subcontractor delivers and installs WM/TD	Subcontractor delivers and installs WM/TD
Average distance from inventory/service point	15 km	30 km	50 km	450 km
Average distance from customer to repair/service point	10 km	25 km	25 km	50 km
Collected data during use	Selected programs	Selected program, time stamp, number of cycles	Selected program, time stamp, number of cycles	Selected program, time stamp, number of cycles

Table 1: Summary of roll-out in four markets

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3. Customer perspective of pay-per-wash pilot

3.1. Customer obligations

The test users did not need to pay for using the WM or TD, but instead agreed on data exchange during the test period as well as participation in surveys, interviews and workshops. The test users are only allowed to wash if the WM is connected to the internet via Wi-Fi. They also have the possibility to use Gorenje's ConnectLife app with their appliances to manage their washing cycles (see Figure 5 for screenshots of the app).

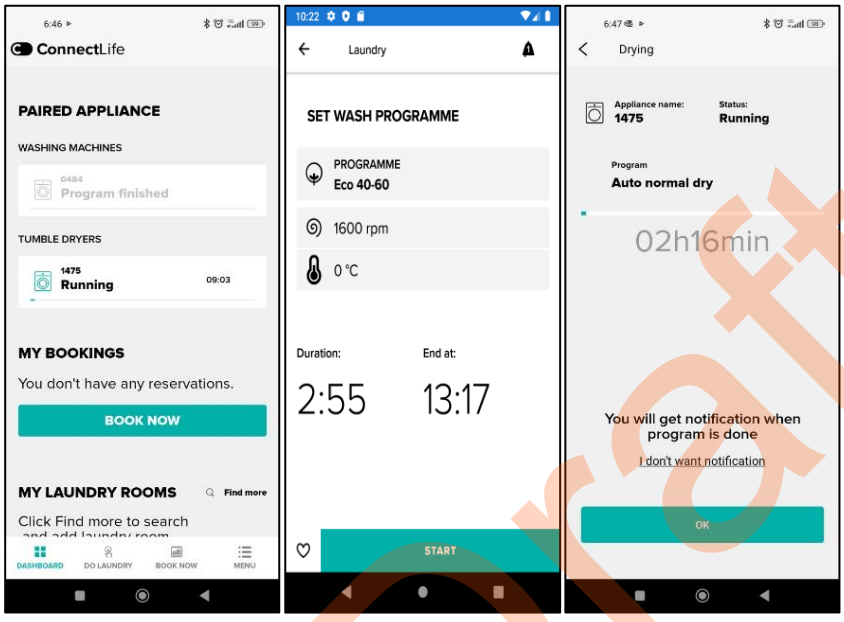

Figure 5: Screenshot of the ConnectLife app

When it comes to data gathering, data is logged during washing and drying programs, which allows for calculating average water and energy consumption based on average consumption for these programs. This data has been instrumental in creating individual user reports which are addressed in the following section 3.2.

In the last period of testing, additional new functionalities in the pay-per-use setting have been investigated. These include a booking system of a laundry room through ConnectLife app (see Figure 6 for screenshots) and different payment schemes (Figure 7). The tested payment schemes included monthly fee, pay-per-washing cycle and a combination of a fixed price for a limited amount of usage with additional fees for more cycles. For the pay-per-wash business model also e-wallet has been tested (Figure 7), which enables users to buy credits, which can later be used in a laundry room.

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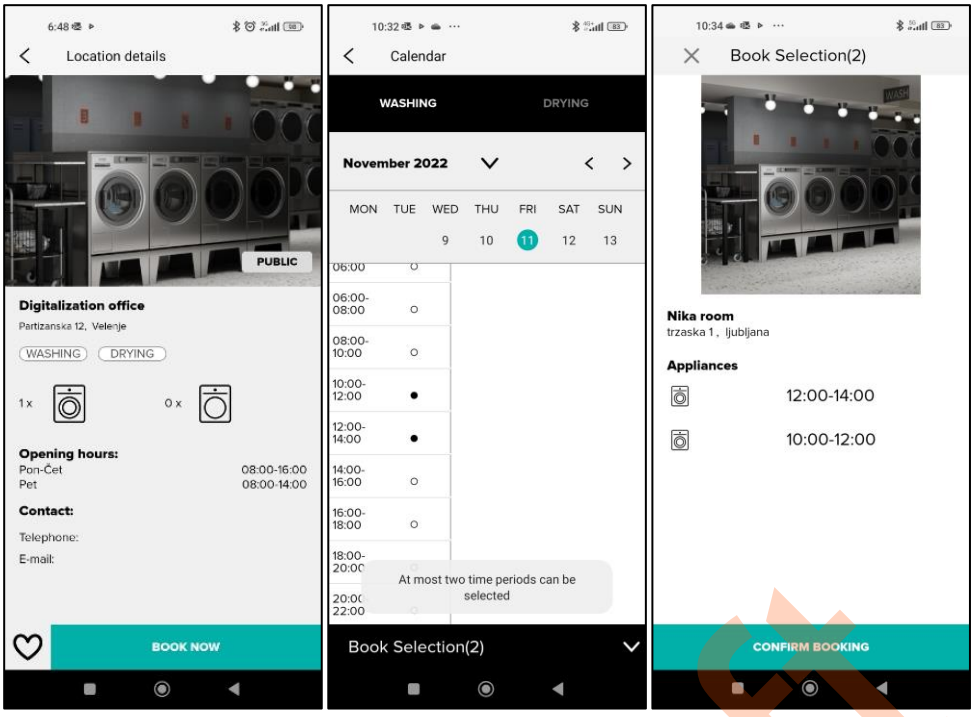

Figure 6: Example of booking a time slot in laundry room via ConnectLife app

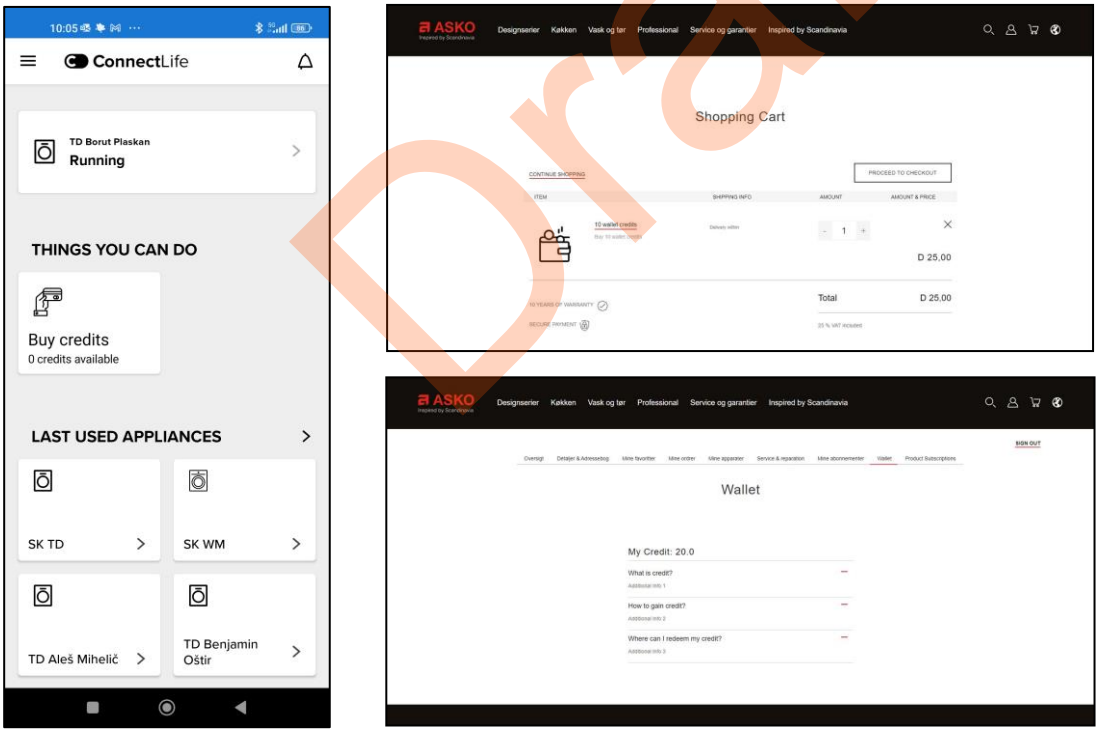

Figure 7: Example of buying credits

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3.2. Customer washing behaviour

During the pilot phase, usage and consumption data is generated during use of the appliance and sent to the ConnectLife app. The logged data consists of, among others, store time stamps, program choice, program duration, washing temperature and error codes, this provided a continuous stream of raw data. Figure 8 shows an overview of the ConnectLife application and collected raw data samples.

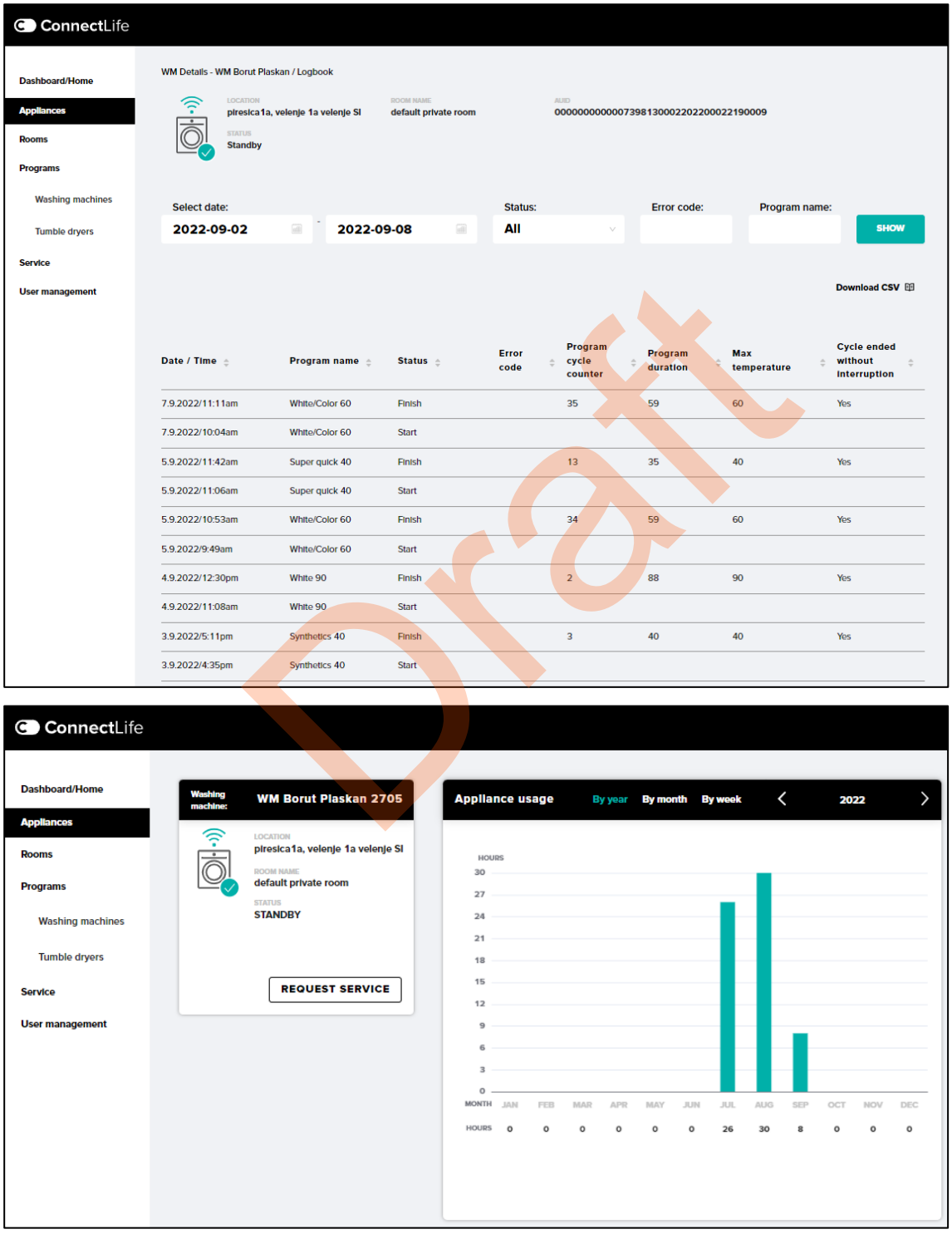

Figure 8: Screenshot from ConnectLife application with raw usage data

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Based on these new data gathering capabilities individual “user reports” can be generated identifying current washing pattern and providing opportunity to lower environmental burden for the test user. Initially the following criteria are quantified:

- Total number of washing cycles over time [#/day]
- Total power consumption [kWh]
- Total water consumption [litre]
- Number of washing cycles per washing program [#/program]
- Number of washing cycles with selected temperature [#/temperature choice]

As a result of these insights, individual user consumption data can be compared to average user consumption data of users (reference data). This allows for providing details feedback to users regarding their program choices and timing of conducting washing cycles. Figure 9 and Figure 10 show a visualization of the criteria listed above. In addition, average consumption values are included (in grey) in order to create a reference for evaluation and recommendation. The green and red smileys indicate if the test user is below or above the average value, resulting in a note on how to improve environmental burden.

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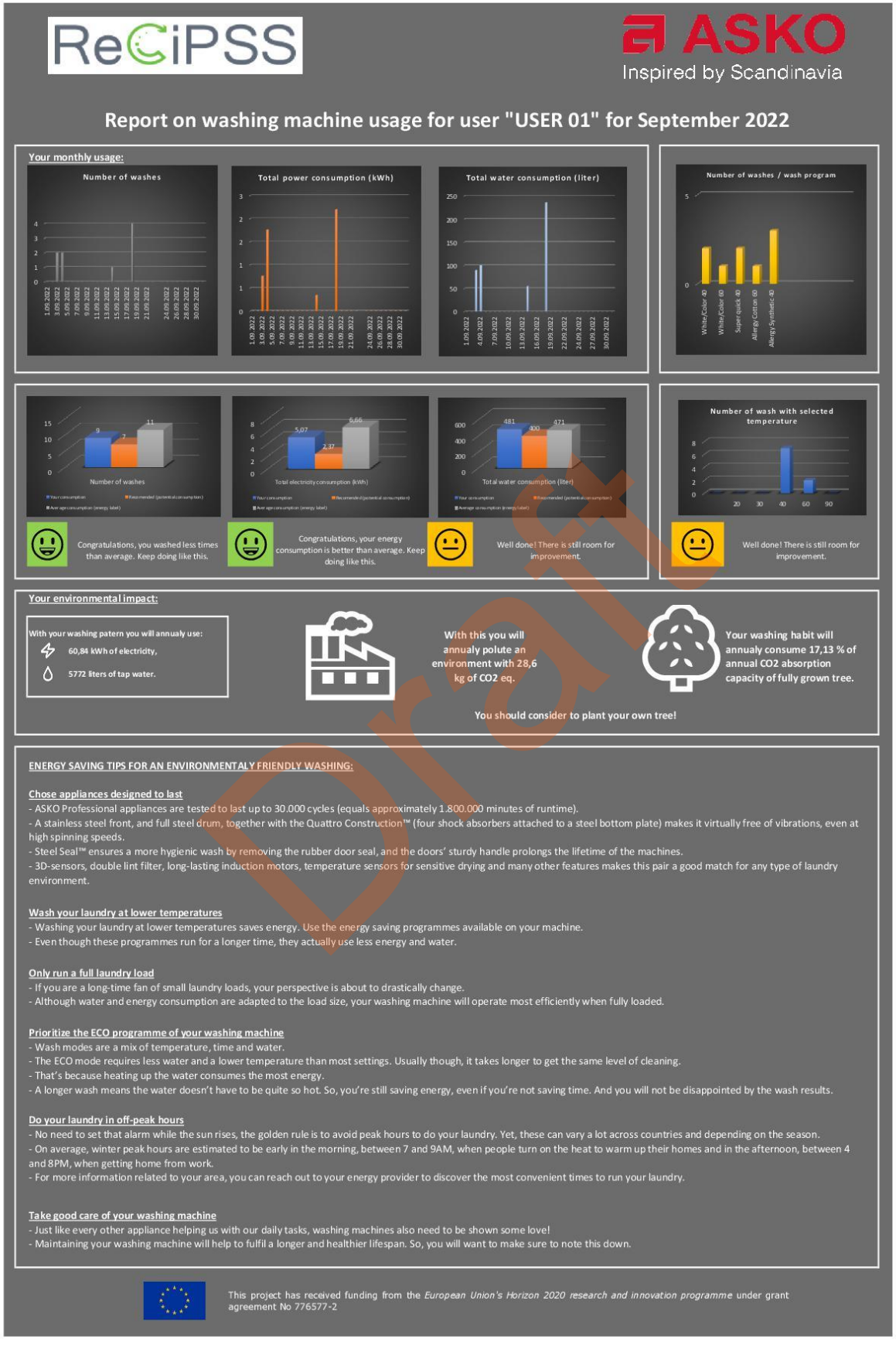

Figure 9: Exemplary test user report on WM usage (example 1)

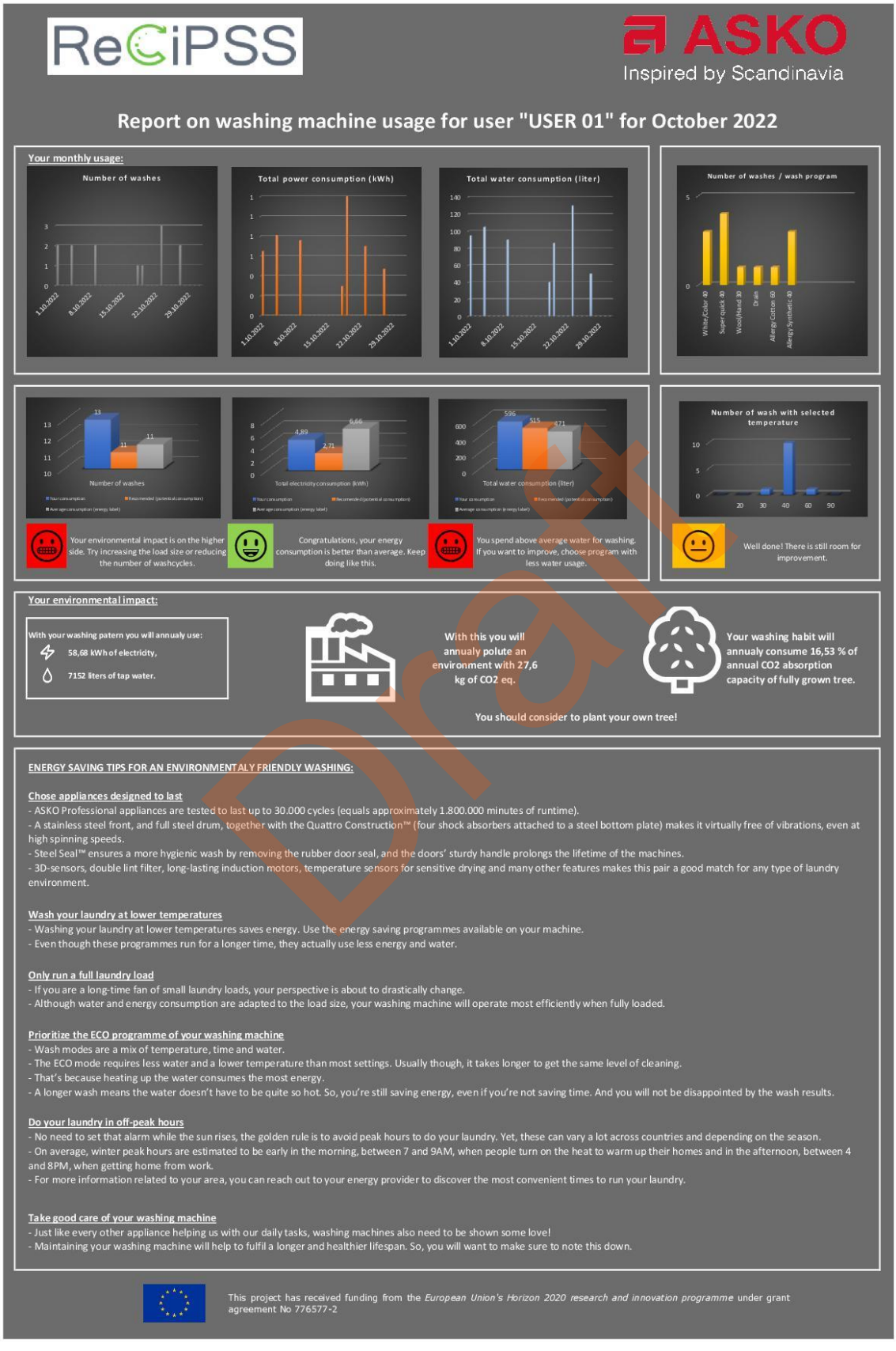

Figure 10: Exemplary test user report on WM usage (example 2)

Based on the collected usage data the estimated average cost has been calculated for each month for the test user for each of the proposed subscription model i.e., pay per wash (fixed price or price based on wash temperature), fixed monthly fee or mixture of monthly fee and pay per wash (see Table 2). The calculation was performed based on predefined pricing scenarios based on KTH simulation which methodology is described in chapter 5.

	Cost estimate for test users	
Subscription model for WMs	***9 washing cycles***	***13 washing cycles***
PPW fixed price cost calculation	23,40 €	33,80 €
Monthly fee + PPW	29,00 €	35,00 €
Monthly fee (unlimited washes)	35,00 €	35,00 €
PPW based on wash temperature	24,40 €	32,20 €

Table 2: Cost estimations per subscription model for WMs

Similarly, as for the WMs the newly established data gathering capabilities have been applied to TD operations to create individual "user reports". The aim is to identify current drying pattern and providing opportunity to lower environmental burden for the test users. Initially the following criteria are quantified (Figure 11 and Figure 12):

- Total number of washing cycles over time [#/day]
- Total power consumption [kWh]
- Number of drying cycles per drying program [#/program]

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Figure 11: Exemplary test user report on TD usage (example 1)

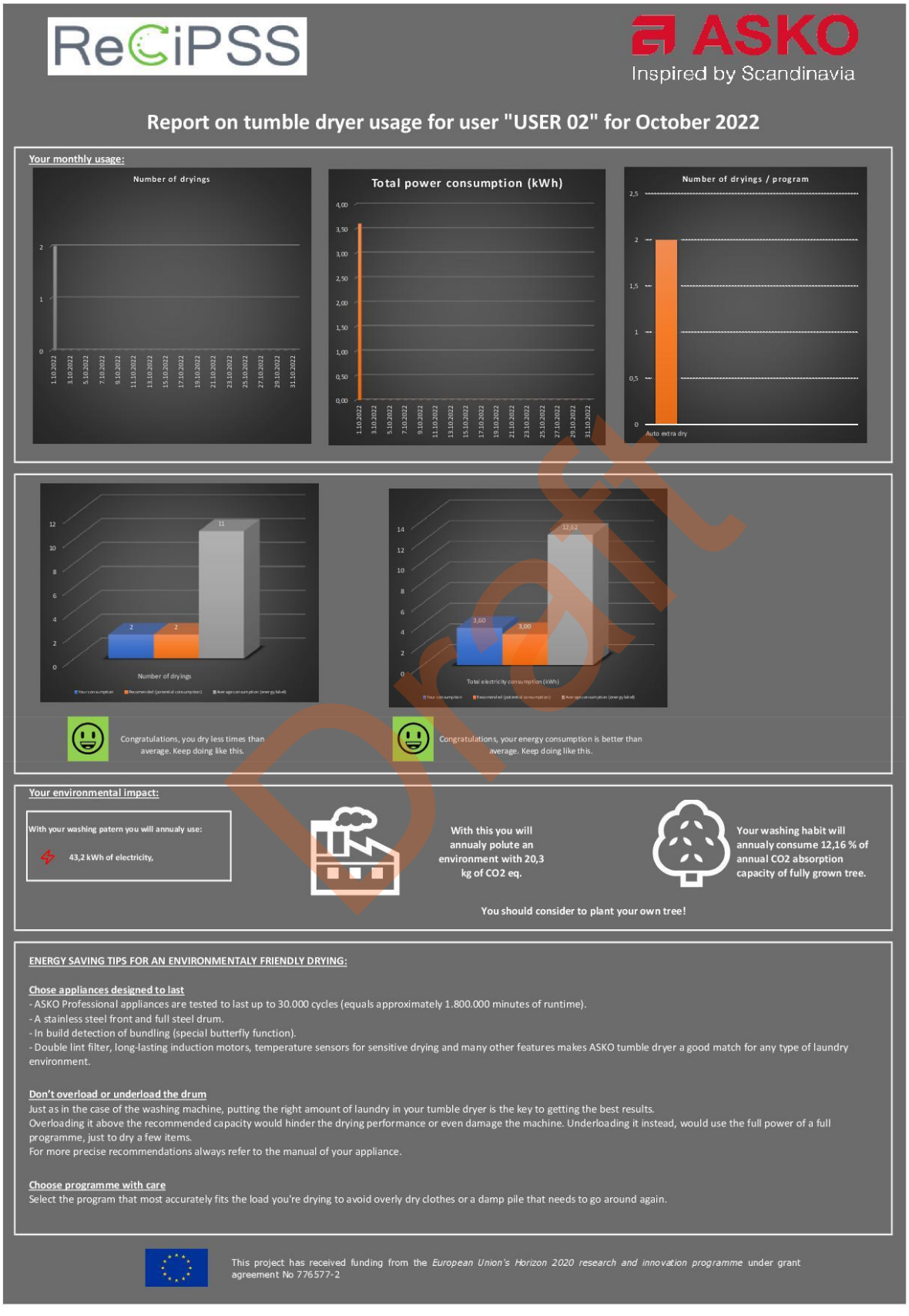

Figure 12: Exemplary test user report on TD usage (example 2)

Correspondingly as for the WM, the estimated average cost for the test user has been calculated per subscription model for TD use, as laid out in Table 3. The calculation was performed based on predefined pricing scenarios based on KTH simulation which methodology is described in chapter 5.

	Cost estimate for test users	
Subscription model for TDs	***2 drying cycles***	***17 drying cycles***
PPW fixed price cost calculation	4,00 €	34,00 €
Monthly fee + PPW	13,00 €	32,00 €
Monthly fee (unlimited cycles)	25,00 €	25,00 €
PPU based on drying program	5,60 €	42,40 €

Table 3: Cost estimations per subscription model for TDs

3.3. Customer perceived benefits and acceptance

3.3.1. Test user feedback

To gain insights into customers perspectives of the business model as well as their experience with appliances, test user feedback has been collected from 18 testers, out of which 16 are in the Slovenian market and 2 testers in the Dutch market. All of these testers are B2C customers employed at Gorenje or Atag. The data has been collected through the means of a questionnaire composed of both open-ended and closed-ended questions. The questionnaires have been filled out by an interviewer during a phone/video interview. This format was chosen because of a relatively high number of open-ended questions and the possibility to ask for more details where needed. The feedback was collected from 24/10/2022 to 02/11/2022. Most of the testers are testing both appliances i.e., a WM and a TD. There are only 4 testers in the sample that are only testing a WM and 1 that is only testing a TD.

In general, the testers expressed positive experience with the appliances, especially with the WM, which can also be seen in Figure 14 and Figure 15. The testers were asked to describe their positive experience with the appliances as well as what they think could be improved. Many of the testers appreciated the performance and efficiency of the appliances, however, in case of TDs, several participants complained about the laundry not being completely dry at the end of the cycle. The appliances were also praised for their ease of use, possibility to modify programs and settings or the design. One of the most important issues related to both appliances seemed to be the connectivity and the application. The experience described by the users of respectively the WMs and TDs is summarized in Table 4 and Table 5 below.

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Positive experiences	*Suggested improvements*
• Washing performance (washes the laundry well) • Speed – short programs • Reliability • Low noise level • Ease of use (clear instructions, simple and intuitive user interface) • Possibility to modify programs • Possibility to change settings • Possibility to erase programs from the display • Capacity • Design (robustness, appearance) • Absence of the rubber seal	• Some settings could be made accessible more easily • User manual could be simplified • Weight of the machine • Possibility to change some setting on pre-defined programs (on the machine, not via app) • Noise level • Delayed end rather than delayed start • Visible water drops sliding down the machine from the glass after opening the machine • Drum illumination • Stability of Wi-Fi connection • More functionalities in the app (user´s environment with the profile, invoices, tracking the usage, connecting with the organisation, changing programs, temperature, etc.) • Working panel at the top could be harder • A special program for down clothes

Table 4: Positive experience and suggested improvements from WM testers

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Positive experiences	*Suggested improvements*
• Drying performance (dries the laundry well) • Low noise level • Heat pump – lower temperature of the dried laundry • Low energy consumption • Stability (stable at the place where it is put) • Reliability • Possible customization of programs • Ease of use • Speed of drying • Design • Lower temperature – more friendly to the laundry • Additional features (possibility to lower the temperature, additional programs) • Possibility to change some things through the application • Possibility to connect the heat pump to the waste (no need to empty the water reservoir) • Special bedding program preventing bundling	• Shorter drying times – faster programs • Clothes are not dry at the end of the cycle • User manual could be simplified • Possibility to change some setting on pre-defined programs (on the machine, not via app) • Noise level (in general) • Buzzing metallic noise • Door fixation (the air blowing from the machine) • Condenser tank is in a strange position (it is hard to spill the water out) • Application • Connectivity

Table 5: Positive experience and suggested improvements from TD testers

Interviews have been performed with the test users to evaluate their user experience for 9 criteria presented in Figure 14 below. The scales for the evaluation, and the analysis tool from the User Experience Questionnaire[1] have been used as basis to collect data. Based on consultations with Gorenje, most the appropriate criteria have been selected from the original questionnaire. One criterion has been added (Usability: Complicated to use – easy to use). The respondents evaluated their experiences on a 7-points scales where the ends represent the opposite extremes (e.g., inefficient - efficient) as show in Figure 13.

Figure 13: Exemplary 7-point scale as part of the test user questionnaire for the criteria "efficiency"

In order to avoid bias, the side of the positive and the negative attributes has been exchanged as provided by the original questionnaire (i.e., positive and negative extremes alternate between the left and right side of the scale). The 1-7 scale has then been transformed to a scale ranging from -3 to +3

[1] https://www.ueq-online.org/

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(with 0 as neutral middle point). Negative numbers represent the negative side of the scale (e.g., more annoying), positive values represent the positive side of the scale (e.g., enjoyable).

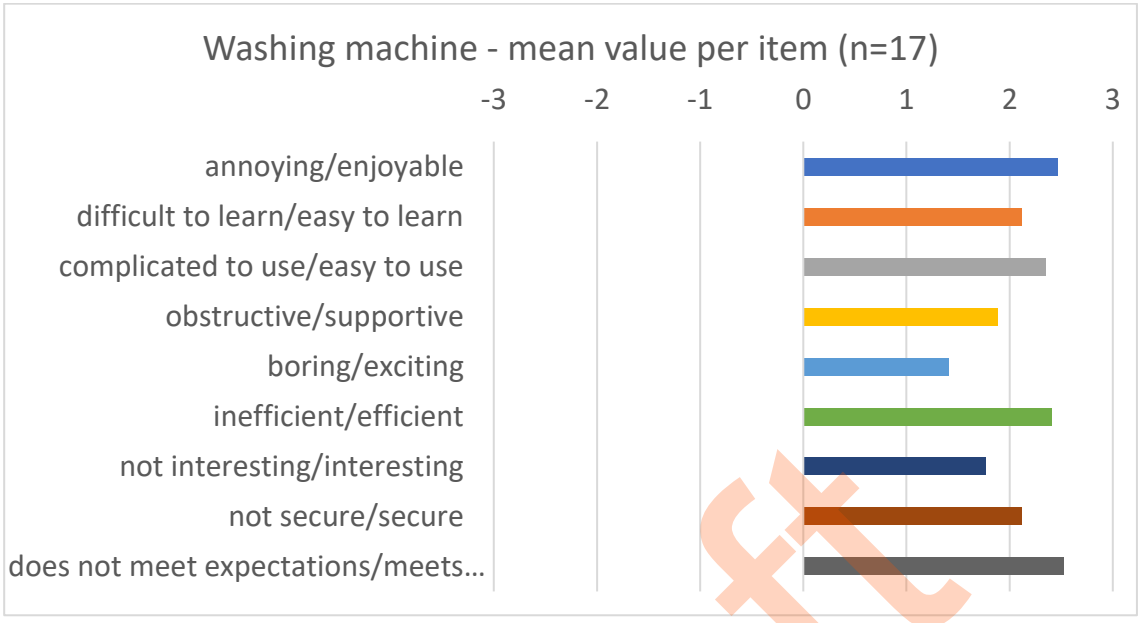

Figure 14: Average user experience rating for 17 WMs

It can be observed that the overall evaluation of the user experience is rather positive since all the means are on the right side of the scales. A relatively low score for boring/exciting can be explained by the fact that many participants commented they did not see how an appliance such as WM or TD can be exciting. Lower score for obstructive/supportive can be partly explained by the fact that two participants were not sure about the meaning (even after additional explanation) and therefore opted for the neutral middle point on the scale. Others explained they lowered the score because of the problems with connectivity for the WM or the fact that drying programs could be improved. Figure 15 shows similar results for TDs.

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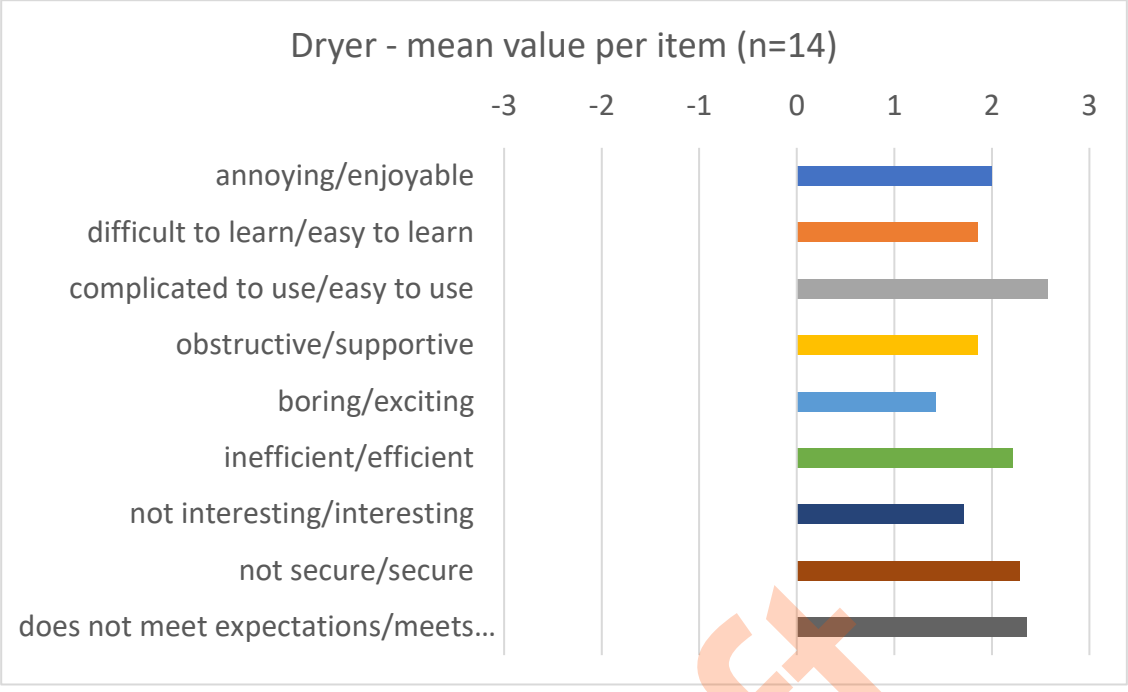

Figure 15: Average user experience rating for 14 TDs

With regards to additional features and functionalities, the possibility to program the start of the appliance on the exact time would be most appreciated by the testers. This is followed by paying by credit card and thirdly, paying by PayPal. Figure 16 shows an overview of all additional features as part of the interview and their respective scoring. The features were evaluated on a scale from 1 to 7 (1 = Not interested at all, 7 = Very much interested).

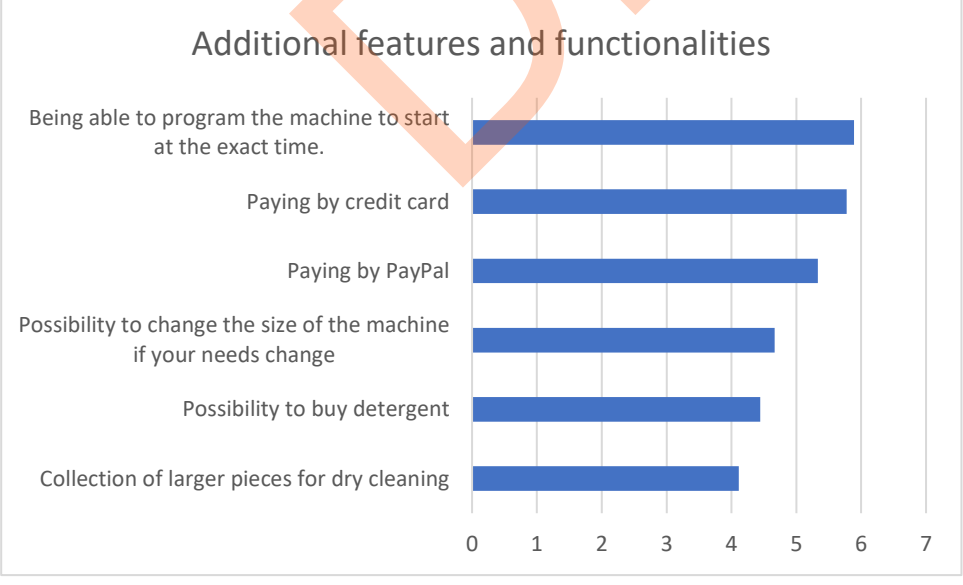

Figure 16: Overview of most demanded additional features

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Among other desirable features and functionalities, the test users mentioned autodose function (automatic detergent dosing), being able to program when the cycle should end, or to start when the energy is cheap, local payment systems and a possibility to select a wash program with the help of a wash wizard based on certain parameters such as material, dirtiness, etc.

The testers have also been asked whether they would be interested in maintenance services, i.e., the company cleaning their appliances. Around 60% claimed they would be interested in such a service. Out of those who would be interested, 63,6% would like to have the maintenance once a year, 36,4% of them opted for every two years[2].

The type of information which is most interesting to testers has also been investigated. Here the testers indicated that they are mainly interested in seeing information about electricity consumption, followed by optimal detergent usage and water consumption. These information types have been evaluated on the same scale as above (1 = Not interested at all, 7 = Very much interested). Other suggestions included the information when the machine should be cleaned (based on the state of the filters in the dryer) and gamified feedback. Figure 17 summarizes most interesting information types for testers.

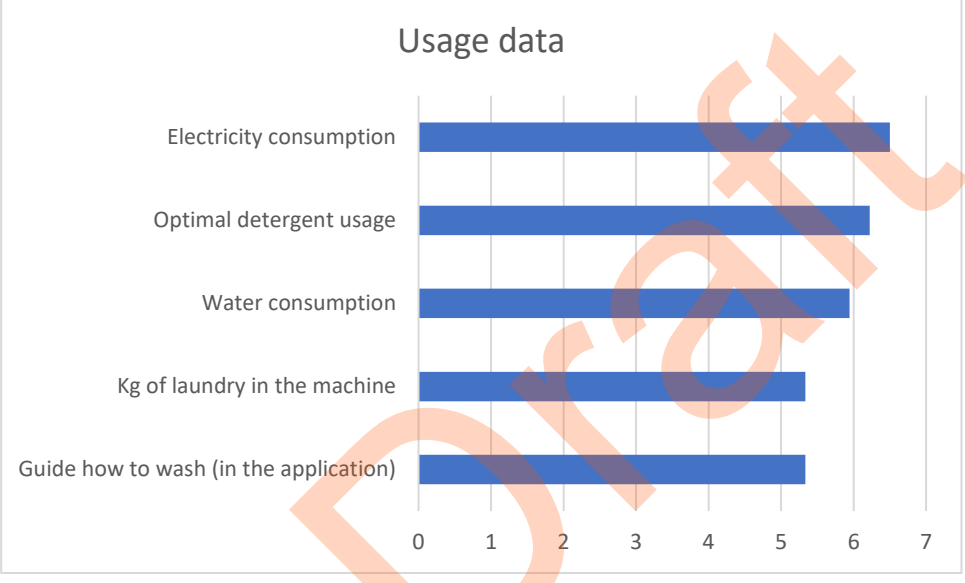

Figure 17: Most relevant information types for testers of WM and TDs

3.3.2. Consumer perceptions of the business model

Apart from the experience based on direct use of the appliances, the testers were also asked about their perception of the concept of service based concept of offering a professional appliance instead of owning one. Out of 18 testers, 10 would consider becoming customers of this service in a full commercial setting. Another 3 testers were not sure, claiming it would depend on the final prices, and 5 testers would not become rental customers, reasoning with higher costs, culture, or the fact that it would not be suitable for their current situation. However, even though they are opposed to renting, two of these testers would like to buy a professional machine.

[2] Answer options: Every 2 years/ every year/ every 6 months/ every 3 months/ every month/ other:….

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Benefits

One of the main benefits perceived by the respondents was the fact that test users do not have to worry about any problems related to the machines, as the company has full liability and needs to ensure functionality at all times. They also mentioned the benefit of having access to high quality appliances without investing big amounts of money in the beginning, a possibility to try a professional machine and see how it is different from a regular one. Several respondents appreciated the model for the possibility of upgrades after the rental period, therefore always providing them with access to the best appliances on the market. Flexibility has also been highlighted, as some of the testers considered this model as most suitable for the people who move often or live in rented flats. Among perceived benefits, saving resources (energy, water and money) was also mentioned, as well as the fact that pay-per-use makes the consumption visible and motivates the test user to think about improvement. To better illustrate the test users' perceptions of the new concept, several quotes of the testers are presented below, explaining what they perceive as benefits of renting a professional appliance instead of owning one:

„That is an interesting idea. Everybody has some problems with years, when the warranty ends, some troubles usually start, if it was possible to rent for 5 years and then rent another one, I would be interested in such solution. It would really be a win-win situation for the customer and the producer - the producer will rent a lot of them and a consumer will not have to think about everything - when the machine should be changed... "

„Much cheaper from the user perspective. These appliances all cost around 2000€, so it´s 4000€ altogether, you don´t have front investment, you can actually afford really high-quality product for a reasonable amount. "

Disadvantages

As for the disadvantages of this concept, some respondents expressed a preference for ownership. Several testers believed that in the long term, renting would be more expensive than buying the machines. Preference for ownership was also related to the fact that a rented appliance might have been used by someone else before and they might have treated it irresponsibly, or to the fact that customers would have to change machines more often – at the end of the lifecycle – which would entail delivery, installation, connection, etc. Another perceived disadvantage was related to the inability to wash or dry without wi-fi connection. Several comments from the testers regarding their perception of the disadvantages of renting professional appliances instead of owning regular ones:

„I want to be the owner of the machine. I´m not the person that wants to rent something for a long time. I have family and I know that I want a machine at the end, at home. But for someone who maybe just needs a machine for a month, renting is a very good option. If I took a machine, I want a new one that no one else used before me. Maybe it was rented before, maybe the people didn't use it in a very nice way...then you need service if something goes wrong."

„It´s not your own item - all the time, you need some information, you have to call a service..."

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Sustainability

The testers were also asked whether they feel that they behave sustainably when using this product/service. The majority of them agreed, reasoning with the fact that the appliances have longer lifetimes since they are made of more durable materials, spare parts are available for a longer time and when they break, they are repaired by the company and given a second life. In addition, the respondents mentioned energy efficiency, getting feedback which motivates to think about saving or the fact that less products are used if people do not buy them.

> *„Yes, in some way. If your own appliance broke down and you couldn't fix it, you would throw it away, in this case, they would take it and change just the critical components, not the whole appliance. Also, this is more durable, less raw materials is used."*

> *„Yes - because you can measure and get some feedback (although quite technical) about your washing, at least you start thinking about how to improve and reduce the number of washes, by seeing it, you already get the idea that you have to deal with it."*

> *„With the robustness of the concept of the machine, I get the impression that it will be longer lasting and if there is also maintenance, I will have the best use of energy and material that was put into this device, I will feel satisfaction that I´m doing something positive with this."*

A few testers expressed some doubts about the sustainability, mentioning the need to produce more packaging if the machines are changed more often or the fact that within this model, the users still have machines at home. One participant commented that the topic is completely new and he does not see the sustainability aspect at the moment, which indicates a need for educating potential customers in future.

The testers have been asked if they have received sufficient information about sustainability of this product service (see Figure 18). Those who claimed not having received sufficient information, or just having received it to some extent, expressed that they would like to receive more information about energy and water consumption. In addition, the testers would be interested to know how much they saved compared to the time they were using appliances in the previous setting. Also, personalized feedback on the washing behaviour is of interest and tips how to improve. Moreover, information about the recyclability of the appliances, the materials used, spare parts availability and how to repair the appliance have been mentioned as of interest. Finally, testers addressed also sustainability of the production as well as politics of the company in this regard, how an eco-program differs from a regular one and what benefits sustainability can bring them.

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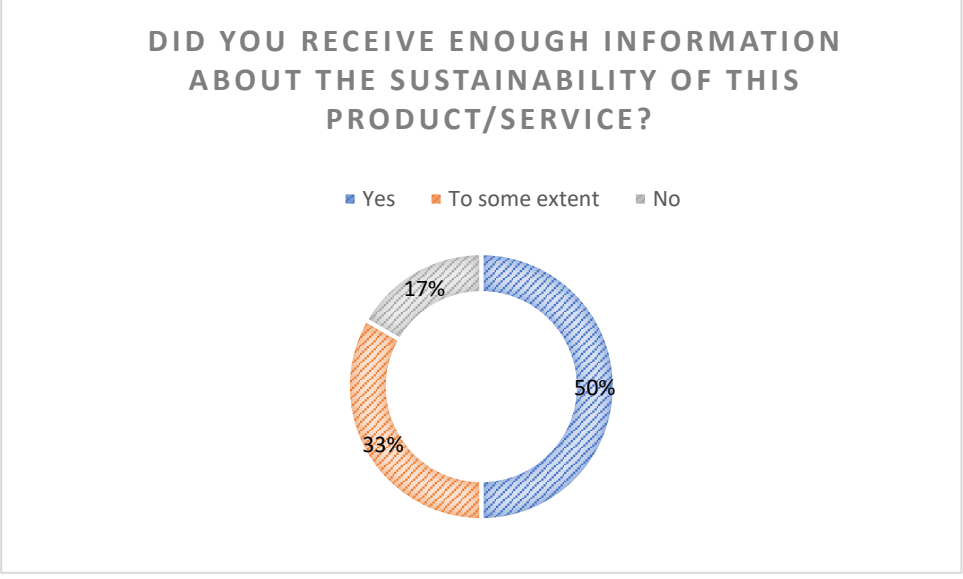

Figure 18: Overview of results if testers received sufficient information regarding the sustainability of the tested service

Connectivity and data collection

Regarding attitudes towards the fact that the appliances are connected to the Internet and collect usage data, most of the participants were not concerned sharing their user data. This goes with the understanding that the collected user data would be used in a beneficial manner for further development of the appliances or predictive maintenance. Some testers even considered it as an advantage if they could also access the data. Other testers admitted that they are not completely at ease with the collection of their user data, but added that today data is collected everywhere so one has to accept it. One of the test users claimed that he would probably mind it if was another company than Gorenje collecting the data. Exemplary quotes from testers:

> *„Well, few years ago, we would be really concerned about that but now, everything is on the Internet, we must not be afraid anymore, that is the life we are living right now, besides, we also have legislation - GDPR and so on...Also, we can´t avoid to share data. We have to accept it. However, we have some fuses to protect us (customers). “*

> *„No problem. So much data is collected so I don´t think that the data about wash cycles and frequencies will reveal something about me that they already don´t know. If you look at the stores - they´re collecting all the data with the loyalty cards, Google is tracing where you park, where you go...In this period, we are selling information about us for convenience. “*

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4. Multi-method simulation modelling

As part of Task 2.3 "*Planning the circular business implementation of the demonstrators"* of the ReCiPSS project simulation models combining agent-based, discrete-event, and system dynamics were developed to evaluate the economic, environmental, and technical performance of adopting white goods-as-a-service. In particular, the aim was to estimate revenue streams, cost streams, and profit margins over different time horizons of pay-per wash offerings. The stakeholders considered in the model included the manufacturer, service and business units (SBU), and customers. The manufacturer produces and delivers washing machines to the SBU which is responsible for the deployment and management of washing machines in a pay-per-wash scheme in the corresponding market. Therefore, installation, service and maintenance, deinstallation, recovery and redistribution activities are performed by the SBU. The model aims at simulating different customer choices in terms of service packages preferences (e.g., contract duration, service level, etc.) and different behaviours in terms of premature contract termination and subscription renewal. As a result, the journey of the washing machine is tracked throughout its lifecycle from production to recycling. The total number of use cycles and the duration of each use cycle the machine goes through, depends on customers' behaviour the machine was deployed during its lifecycle. The model considers a lifecycle costing approach accounting for all cost occurred during the lifecycle of a washing machine (i.e., value creation, delivery, use, recovery, and reuse) to determine the monthly price (i.e. subscription fee). As a result, lifecycle revenues, profits margins, and market shares are estimated over the course of time. Moreover, the environmental impact of manufacturing, servicing and refurbishing activities occurred during the lifecycle of a washing machine have been estimated.

The results presented in this section refer to 100 washing machines deployed in a subscription-based scheme. The subscription offers consider Gold, Silver, and Bronze packages depending on customer preferences in terms of washing machine type, contract duration, service readiness, and program package. The simulation runtime is set to 212 months, equivalent to the duration of the period that starts when the first washing machine is manufactured and ends when the last washing machine reaches its end of life. By tracing and tracking the journey of each washing machine, its technical, economic, and environmental performance are estimated.

4.1. Technical performance

The technical performance of the system refers to the quantity, quality and timing of product returns for value recovery and redistribution. Figure 199 shows the distribution of gold, silver, and bronze customers that 100 washing machines can serve during their multiple use cycles. It is assumed that gold customers are served with newly manufactured washing machines, silver customers with refurbished washing machines not older that ten years (refurbished WMs of type A), and bronze customers with refurbished washing machines older than ten years (refurbished WMs of type B). At simulation end, 100 washing machines served a total of 621 customers: the number of gold, silver, and bronze customers amounted to 100, 313, and 208 respectively. As a result, one washing machine served in average six different customers during its entire lifecycle (one gold, three silver, and two bronze customers). The duration of each use cycle varied from a minimum of three months (due to contract obligations) to a maximum of seven years as different user behaviours were simulated in terms of subscription termination or renewal.

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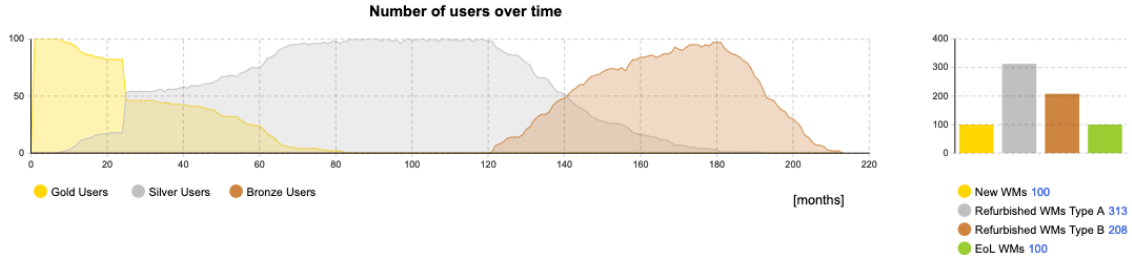

Figure 199: Number of users over time served by 100 washing machines deployed in a subscription-based model (Roci et al., 2022).

4.2. Economic performance

4.2.1. Lifecycle costs

By following the product journey from manufacturing to end of life, allows us to account for all the costs occurred during the entire lifecycle of the product. Figure 20 indicates the cost streams throughout the entire lifecycle of 100 washing machines. It can be observed that manufacturing cost represents the highest cost factor, followed by installation, refurbish, and deinstallation cost. The washing machine is designed for longevity and connectivity, hence, leading to high manufacturing cost. Designing for long lasting leads to less repair and maintenance during the use phase. The average number of use cycles a washing machine goes through its entire lifecycle is six, hence leading to high installation, deinstallation, and refurbishing costs. This has implications in terms of business model design. Short-terms contacts may be more attractive service offers for the end user; however, this flexibility leads to more transportation and recovery operations as the machines needs to be brought to as-new condition and certified every time it is deployed to a new customer.

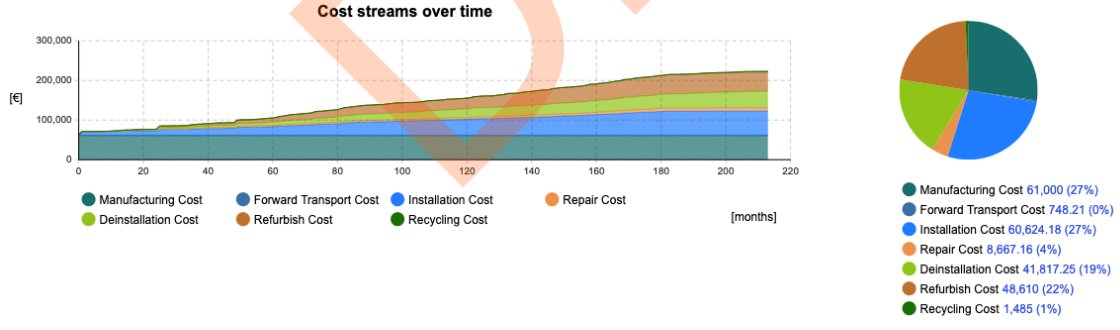

Figure 200: Lifecycle costs of 100 washing machines deployed in a subscription-based model (Roci et al., 2022).

4.2.2. Lifecycle revenues

The lifecycle costs obtained above are used to determine the monthly subscription fee (i.e., cost-based pricing). As a result, lifecycle revenues generated by each washing machine are estimated. Figure 211: Lifecycle revenues generated by 100 washing machines deployed in a subscription-based model (Roci et al., 2022).

indicates these revenue streams over different time horizons. It can be observed that 100 washing machines generated in total €469 299, meaning that in average one washing machine generates ca.

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€4 693 during its entire lifecycle. As mentioned in Section 4.1, a washing machine serves in average one gold, three silver, and two bronze customers, generating in this way ca. €1309, €2621, and €763 in each market segment respectively.

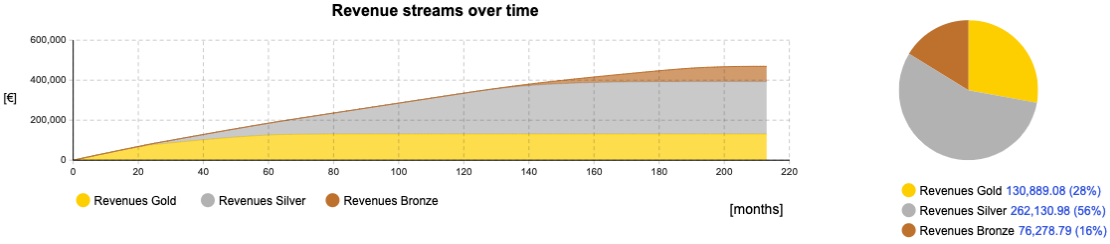

Figure 211: Lifecycle revenues generated by 100 washing machines deployed in a subscription-based model (Roci et al., 2022).

4.2.3. Break-even point

By analysing the economic performance of subscription-based offerings it can be observed that there is a time mismatch between revenues generated and cost streams. When looking at the profit over time shown in Figure 222: Profit over time generated by 100 washing machines deployed in a subscription-based model (Roci et al., 2022).

, the business becomes profitable around month 23 (i.e., it takes around 23 months for the company to break-even). The lowest value amounts to €-68 000 in month 1 due to the initial manufacturing and installation costs. When shifting from selling products to selling functionality, the revenue streams are postponed over time, resulting in longer payback times.

Figure 222: Profit over time generated by 100 washing machines deployed in a subscription-based model (Roci et al., 2022).

4.3. Environmental performance

While following the journey of each washing machine from the manufacturing phase to the end of life, their environmental impact is also estimated. As shown in Figure 233: Lifecycle environmental impacts generated by 100 washing machines deployed in a subscription-based model (Roci et al., 2022).

23, the use phase causes the highest environmental burden, which is usually the case for energy-using products. It can be noted that the manufacturing of the washing machine causes the second highest environmental burden, followed by refurbishing, installation and deinstallation. The high environmental

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impact of refurbishing, installation, and deinstallation is due to the multiple use cycles of the washing machine during its lifecycle.

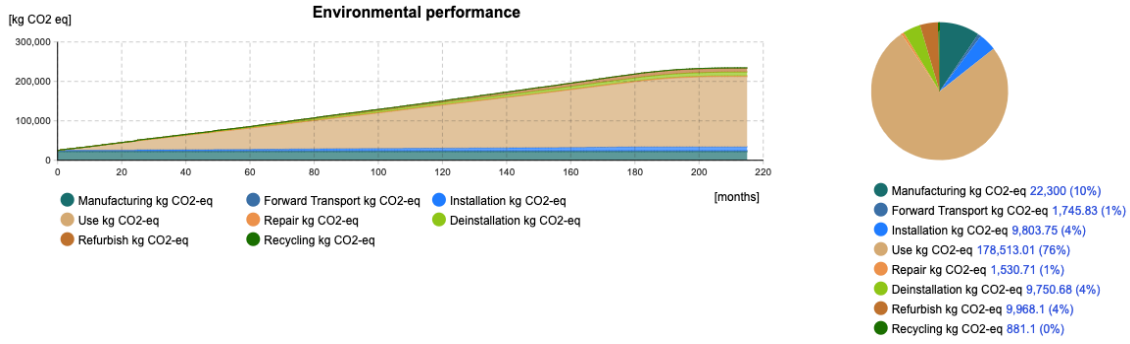

Figure 233: Lifecycle environmental impacts generated by 100 washing machines deployed in a subscription-based model (Roci et al., 2022).

5. Multifactor sensitivity analysis

The multifactor sensitivity analysis consists of a baseline scenario of three consecutive customer use cycles for one WM, with refurbishment activities in between. For this sensitivity analysis the four markets Slovenia, Denmark, The Netherlands and Sweden are considered at an aggregated level, since merely the transport distances vary while the remaining input of the model remain unchanged. The following activities were considered as basis for the multifactor sensitivity analysis in order to model revenue, cost and CO2kg-impact over time:

- Manufacturing (1x)
- Forward transport (1x)
- Installation (3x)
- Use cycle (3x)
- Deinstallation (3x)
- Reverse transport (3x)
- Refurbishing (2x)
- Recycling (1x)

As input data the actual pilot data was used where possible e.g., volumes of WMs piloted per market or their distance to service points in each pilot market. For the forthcoming use cycles financial estimates were used from ReCiPSS deliverable D2.2 and environmental impact estimates from previously carried out LCAs and master thesis by Gorenje.

There are three parameters that were varied in order to compare their outcome and analyse sensitivity:

- Installation and deinstallation cost (as a proxy for labour cost)
- Average distance between customer and service point
- Contract duration of use cycle

Each of these three inputs was varied with -50%, +50% and +100% respectively in order to compare their outcomes to the baseline scenario. The result is quantified in EBIT (€), emissions (CO2kg eq.) and material demand per year (tons/year). EBIT stands for Earnings Before Interest and Taxes and is calculated by subtracting direct product and operational cost from product/service revenues. Consideration of EBIT allows for profitability estimations while taking changes in both revenue and direct cost into consideration at the same time.

Figure 24 and Figure 25 summarize the results of the sensitivity analysis. As can be seen the duration of contract length had the most significant impact from an economic and environmental perspective. This can be explained through the underlying business model which assumes monthly subscription, which promotes extending and retaining contracts as long as possible to maximize income. On the other hand, an extended use phase increases the environmental impact through a higher number of washing cycles during the WM lifetime, through increased used of electricity, water and detergent.

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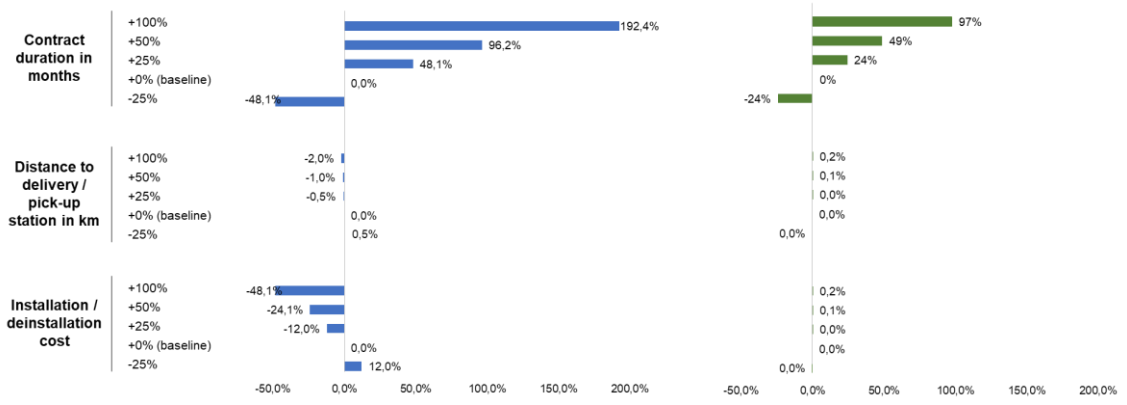

Figure 244: Impact on EBIT [€] and environment [CO2kg eq.] as a result of variations in contract duration, transport distance and de-/installation cost

As the delivery distance and pick-up transport for most of the WMs is relatively short i.e., between 10 and 30 km for roughly 80% of all WMs, the transport distance has relatively small impact on both cost and CO2-impact side.

(De)installation cost can be seen as proxy for labour cost. Variations in labour cost have high impact on profitability, but could be mitigated with extended contract duration. For each %-point of increased labour cost, the contract duration needs to be extended by 0,5 %-points to compensate for any EBIT losses.

As can be seen in Figure 25, the material demand per year is compared to the linear scenario. One outstanding finding is that even a reduction of 25% in contract duration has a lower material demand compared to a conventionally sold model with a lifetime of ten years.

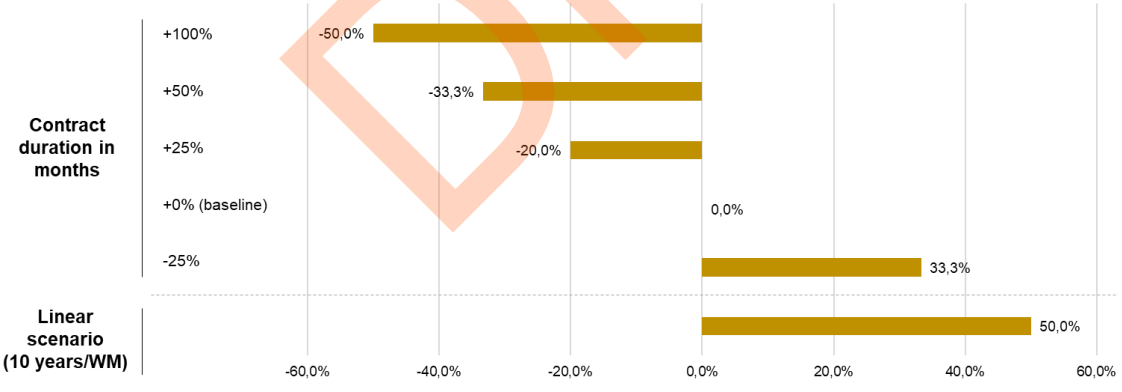

Figure 255: Impact on material demand [tons/year] as a result of variations in contract durations, and comparison to linear sales scenario

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6. Lessons learned

The most important advantage of the OEMs is to design the product in such a way that operational costs are minimized and that the quality of service for the test users is at a desired level. This is also one of the main advantages in comparison to "pure" service providers that cannot influence the product/design itself and therefore also cannot control costs as efficiently. Another learning is that customers demand complete washing solutions, i.e., not only WMs, as it was anticipated in the beginning of the project, but also TDs, resulting in including both in the package. This was an interesting learning that customer needs must always come first, while the majority of the company develops new services offerings and products based on technical expertise.

Based on these learnings Gorenje designed and developed long lasting smart appliances in ReCiPSS project, which are robust and durable and with the capability of real-time condition monitoring. The appliances are well-designed for reparability, refurbishment and recyclability i.e., built with natural materials such as metal and glass. These are first Gorenje appliances that are built similar to professional smart WMs and TDs, which are designed according to circular economy principles (ASKO Professional WM85/75.C and TD85/75.C). These appliances are designed to last 6-10 times longer in comparison to common household WM and TD. For these purposes a new inverter technology was developed, which enables WMs to run optimum loads depending on the actual load on the machine. Smart algorithms determine the optimal water level for highest energy efficiency and optimal detergent consumption resulting, for example, in 15 liters less water consumption per wash in comparison with the traditional system. Both WMs and TDs are designed for condition monitoring and usage tracking, which is the basis to provide user feedback and to analyze device information, defect prediction and AI functions for future B2C and B2B users. Based on the enabled Wi-Fi-connection, first functionalities have been implemented, such as remote status and operation monitoring and room booking. The appliances support external systems for B2B users like support for booking systems and external autodosing.

The developed IoT platform to support the implementation of the pay-per-use functionalities has been described in previous deliverables. It allows for connecting appliances, the manufacturer and service providers using Mobile/Web applications with backend ICT infrastructure and enables condition monitoring, contract signing, billing and installation as well as service interventions etc. During the development phase we learned that Gorenje has to extend its ERP system for the purpose of the pay-per-use business model to consider information protocols with banks, handling of payments, accounting systems etc. The existing web shops were configured only for one-time purchasing transactions, so the system had to be upgraded and tested with new functionalities specially developed for pay-per-use services. Since the regular business is running during the project, all these new developments have been implemented and tested in a test environment. The complexity of the needed change and the extend of the problem were surprising to the project team and dramatically surpassed anticipated work and width of the problem during the project implementation.

The greatest challenge that we have noticed during the design of the pay-per-use model is mainly related to the huge financial gap in the first two years until the breakeven point with slow uptake of the revenues (see Figure 266: Business model simulation

). As the top management, shareholders, or financiers are not inclined to support such a situation, the project team had the challenge to find a suitable solution but on the other side this could be a game stopper for small and medium size companies.

Referring to simulation study perform as part of Task 2.3 "Planning the circular business implementation of the demonstrators" and published in Roci, M., Salehi, N., Amir, S., Shoaib-ul-Hasan, S., Asif, F.M.A., Mihelič, A., Rashid, A., 2022. *Towards Circular Manufacturing Systems implementation: A Complex Adaptive Systems perspective using modelling and simulation as a quantitative analysis tool.* Journal of

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Sustainable Production and Consumption. https://doi.org/https://doi.org/10.1016/j.spc.2022.01.033 the following results were obtained.

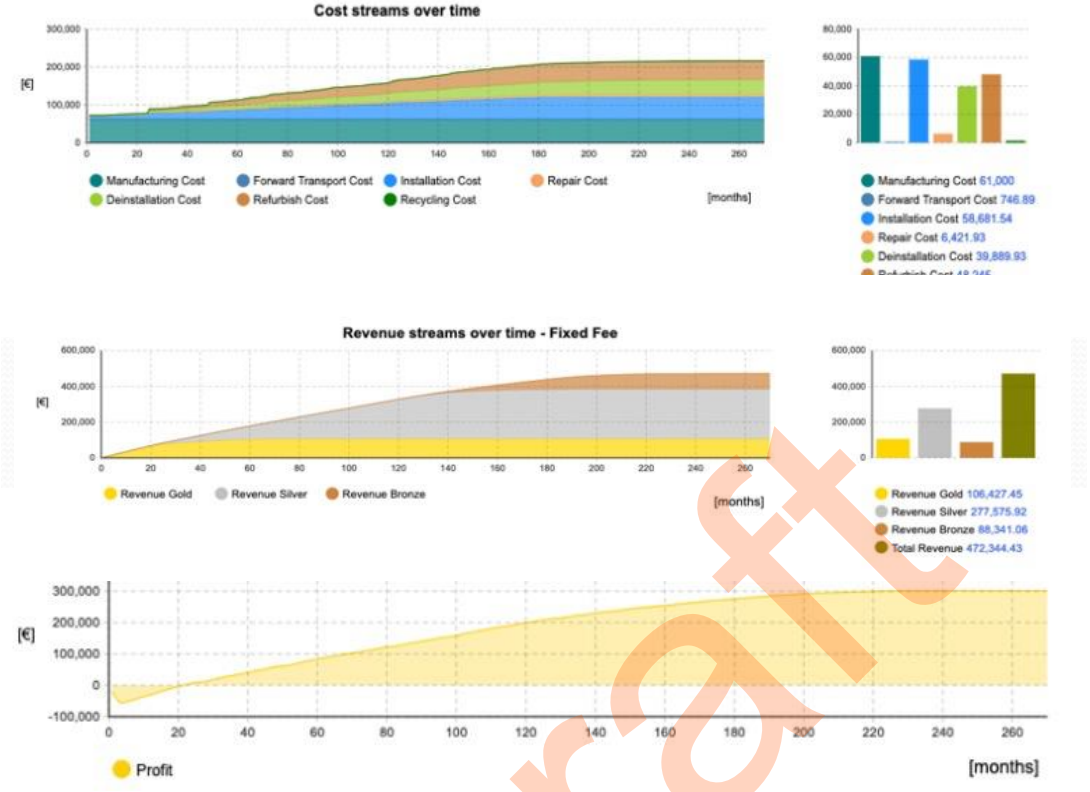

Figure 266: Business model simulation

During the project we have also learned that the co-creation and business model simulation brought very useful insights and in advance prevented possible failures and money loss. Initially in the project we also noticed internal conflicts as SBUs see pay-per-use as a threat to their current business.

Next challenge observed is also legal ambiguity or unclarity as there are missing legal frameworks for the pay-per-use model that include cross-border transfer of used appliances (today legally categorized as “waste export”). This issue is more elaborated in other deliverables.

Regarding the environmental impacts of the pay-per-use model, we have learned that besides the impact of WM and TD design and their production, also user behavior has crucial influence to lower environmental burden. Based on analyses done in the project (LCA study performed as part of Task 3.2 Co-creating the circular business models in order to ensure user acceptance by a master thesis student at TUD) we have demonstrated with the proper set up of the pay-per-use business model additional 20-40 % environmental impact reduction for different user types, as shown in Figure 27.

A full attributional LCA, from cradle-to-grave, as defined in ISO14040 standards (ISO, 2006) was performed with the aim to compare a traditionally sold Gorenje washing machine with the Gorenje pay-per-wash (PPW) circular business model, to investigate whether the pay-per-wash model fulfils the expectation of reducing environmental impacts. The study was performed by Kirsten Steunenberg as her Master thesis project for the Master Industrial Ecology (joint degree Leiden University and Delft University of Technology), supervised by Prof. Conny Bakker (TU Delft) and Dr. Jeroen Guinée (University of Leiden).

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Figure 277: Environmental savings for different types of testers of WM and TDs

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7. Conclusion

A roll-out of 330 WMs and TDs has been carried out in Slovenia, The Netherlands, Denmark and Sweden. With the attempt to test a new subscription-based business model to facilitate the implementation of circular practices, Gorenje has expanded its traditional scope of manufacturing to include customers as integral part of their business rationale. New competences have been built, such as data gathering capabilities, to identify user patterns in real-time in order to better understand behavioural aspects, provide feedback in the form of user reports, and allow for adjusting business conditions. These capabilities are crucial to increase success and adoption of this new business approach in the long-term.

To the largest extent, perceived customer benefits and acceptance seem to outweigh perceived disadvantages. As there will always be customers preferring ownership over subscription, this new approach allows for entering a new business and addressing new customer segments, thus contributing to the long-term success of the company. While test users showed interest in new WM/TD features, knowledge and awareness need to be increased regarding the sustainability of the new subscription service. This will require new marketing approaches with new sustainability contents.

While there seem great economic benefits for Gorenje to increase earning and lower environmental burden over WM/TD lifetime, the contract duration i.e., retention of customers, is most vital for business success. This in turn indicates the relevance of new applications like the ConnectLife app to identify customer preferences in shortest time and minimize the risk of contract cancellations.

After the formal project end, we will keep demonstrators up and running with objective to collect as much as possible data in order to prepare additional requirements for further pay-per-use business development and refinement for different markets and target users and additional product categories. For the transformation from demo environment to a real-life setting, we will develop additional functionalities which will enable expansion of pay-per-use service-based businesses. The industrial roll-out is currently planned to take place in spring 2024, prioritizing existing ReCiPSS demo markets. After this we plan to gradually expand the business also to other markets where Gorenje/ASKO appliances are present.

During the project execution and with the data and themes related to the white-goods demonstrator at least 8 PhD theses and 2 master theses have been successfully defended or are close to being defended. This confirms the complexity and the need for the future scientific research in this field. Beside this the knowledge gained in this project will be spilled over to the two additional Horizon Europe projects namely CircThread and DiCiM.

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Appendix A Questionnaire for testers (home users)

1. **What are your POSITIVE experiences with this washing machine, dryer and the service?**
   Washing machine.....
   dryer.....
   service.....

2. **What would you like to IMPROVE when using this washing machine and the service?**
   Washing machine.....
   dryer.....
   service.....

3. **What do you perceive as BENEFITS of this concept (renting professional machines) as compared to owning a regular washing machine (and dryer)?**
   .....
   .....

4. **What do you perceive as DISATVANTAGES of this concept as compared to owning a regular washing machine?**
   .....
   .....
   .....

5. **Would you consider becoming a customer of this service (in a real setting, not just as a tester)? Why/Why not?**
   .....
   .....

6. **Do you feel that you behave sustainably when using this product and service? Please explain.**
   .....
   .....

7. **Is it important to you?**
   .....

8. **Did you receive enough information about the sustainability of this product/service?**
   Yes/to some extent/no

9. **If no – which information would you like to receive?**
   .....

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10. **How do you feel about having a machine that is not in your ownership?**

.....

.....

11. **How do you feel about the fact that the machine is connected to the internet and collects your usage data?**

.....

12. **Please tick the point on the scale that best matches your experience with the washing machine.**

Annoying o o o o o o o **Enjoyable**

Space for additional comments.....

Easy to learn o o o o o o o **Difficult to learn**

Space for additional comments.....

Complicated to use o o o o o o o **Easy to use**

Space for additional comments.....

Obstructive o o o o o o o **Supportive**

Space for additional comments.....

Boring o o o o o o o **Exciting**

Space for additional comments.....

Inefficient o o o o o o o **Efficient**

Space for additional comments.....

Not interesting o o o o o o o **Interesting**

Space for additional comments.....

Secure o o o o o o o **Not secure**

Space for additional comments.....

Meets expectations o o o o o o o **Does not meet expectations**

Space for additional comments.....

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13. **Please tick the point on the scale that best matches your experience with the dryer.**

Annoying o o o o o o o **Enjoyable**

Space for additional comments.....

Easy to learn o o o o o o o **Difficult to learn**

Space for additional comments.....

Complicated to use o o o o o o o **Easy to use**

Space for additional comments.....

Obstructive o o o o o o o **Supportive**

Space for additional comments.....

Boring o o o o o o o **Exciting**

Space for additional comments.....

Inefficient o o o o o o o **Efficient**

Space for additional comments.....

Not interesting o o o o o o o **Interesting**

Space for additional comments.....

Secure o o o o o o o **Not secure**

Space for additional comments.....

Meets expectations o o o o o o o **Does not meet expectations**

Space for additional comments.....

14. **Which additional functinalities of the service you would be interested in?**

.....

15. **Payment method: (matica s možnosťami)**

Credit card: **Not interested at all** o o o o o o o **Very much interested**

PayPal: **Not interested at all** o o o o o o o **Very much interested**

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16. Which additional features and functinalities would you be interested in?

Possibility to buy detergent	**Not interested at all** o o o o o o o **Very much interested**
Collection of larger pieces for dry cleaning	**Not interested at all** o o o o o o o **Very much interested**
Possibility to program the machine to start at the exact time.	**Not interested at all** o o o o o o o **Very much interested**
Possibility to change the size of the machine if your needs change	**Not interested at all** o o o o o o o **Very much interested**
Paying by credit card	**Not interested at all** o o o o o o o **Very much interested**
Paying by PayPal	**Not interested at all** o o o o o o o **Very much interested**
Other suggestions	**.....**

17. What kind of usage data would you like to see?

Water consumption	**Not interested at all** o o o o o o o **Very much interested**
Electricity consumption	**Not interested at all** o o o o o o o **Very much interested**
Optimal detergent usage	**Not interested at all** o o o o o o o **Very much interested**
Kg of laundry in the machine	**Not interested at all** o o o o o o o **Very much interested**
Guide how to wash (in the application)	**Not interested at all** o o o o o o o **Very much interested**
Other suggestions	**.....**

18. What degree of control over the washing machine would you prefer?

Fully automatic machine o o o o o o o **All done by myself**

Please explain.....

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19. Would you be interested in maintenance services (cleaning the machines)?
Yes/No

20. If yes, how often?

- ○ Every 2 years
- ○ Every year
- ○ Every 6 months
- ○ Every 3 months
- ○ Every month
- ○ Other...

21. **How much would you be willing to pay for these maintenance services? (per** year).....

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