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Sustainable and Green Electronics for Circular Economy

Deliverable 1.2

Processes Specifications and initial testing plan

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Table of Contents

1. Introduction

1.1. Purpose of the document

This document contains a description of each of the 9 Pilots predicted as outputs for the Sustronics project and provides a preliminary list of Requirements and Specifications regarding the processes that these devices will make use of. Due to the broad range technical areas, as well as the several stages of technological maturity that these devices possess, these Reqs & Specs will also be presented in several degrees of specificity. Since the main key outputs of this project involve increasing sustainability of electronic devices, in the case of this document regarding processes, the usage of lower waste producing, more energy/resource efficient and biomaterial compatible solutions is prioritized. This cutting-edge approach comes with increased levels of uncertainty, so the goal of this document is to have a starting point and preliminary guide for a more detailed definition of Reqs & Specs for each Pilot. Therefore, low levels of specificity are to be expected at this point until further developments are achieved.
In an efficient system architecture approach the needs will first be determined from the pilot systems.
The pilot systems to be developed for Sustronics are in different application fields ranging from consumer products, (professional) health care, domestic appliances including automotive, medical and lighting. Not only the functional performance of the systems and cost targets but also an in depth consideration of the End of Life scenario, waste streams and options for recycling, reuse, regeneration etc. are determining the needs of systems with consequences for the needs of components, devices, materials and technology.
Therefore the setup is chosen to start with the System requirements and specification of the pilots in WP3 (Del 3.1). Based on this information the requirements and specifications for the components and devices (Del 2.1) and materials (Del 1.1) and processes (Del 1.2) can be collected and elaborated to drive the innovation in Sustronics.

A general view on relationship between needs, requirements and specification as shared at the start of the Sustronics project is depicted in Figure 1.

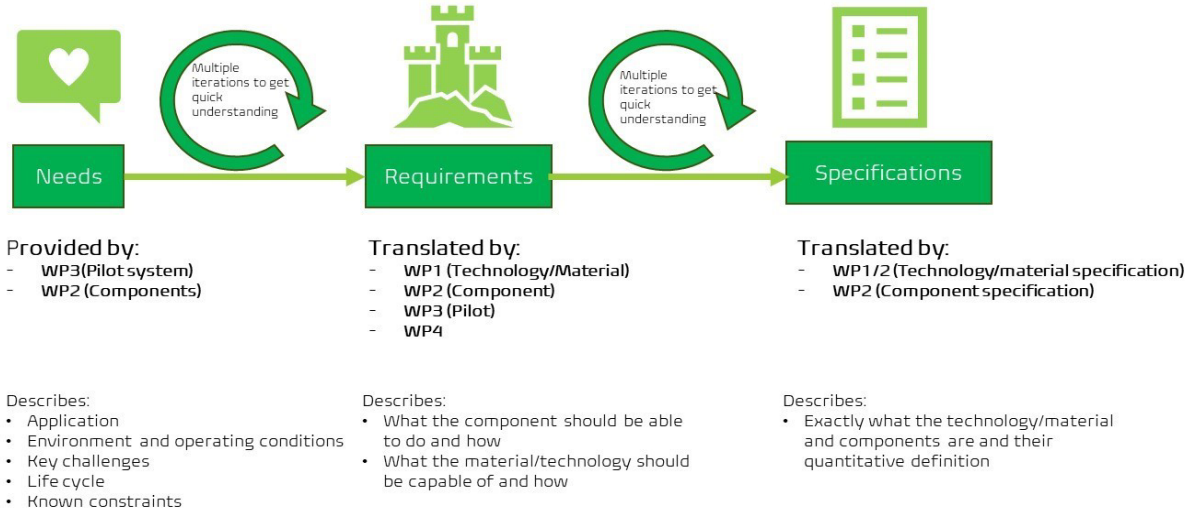

Figure 1: Relationships between needs, requirements and specifications in Sustronics project

The pilot systems that will be created will be based on needs and requirements for manufacturing technology and material and components selection originating from Sustronics project. The specifications will be validated at the end of the creation of the pilot systems.

Along the process of realisation of the pilots the analysis and improvement of the sustainability aspects in detail are in focus. The knowledge generated during the project on sustainable manufacturing and product development will allow methodology of ecodesign and sustainable business models. The project will allow to assess the whole life cycle and concepts for end-of-life management in more details because of these pilots. These activities are collected in WP 4. This workpackage will be active in all phases of pilot systems. The iterative approach of the pilots allows to update the needs, requirements and specifications for sustainability, costs and performance. The pilots will have three phases each starting with an innovated pilot after M15 and month 27 to result in the final prototype by the end of the project in M36.

As the pilots are different in their starting point of Technology Readiness Level (TRL) the level of details of the components and devices will also be varying.

The three use cases in Sustronics are as follows:

1 ‘circular electronic devices’,
2 ‘sustainable manufacturing for electronics’, and
3 ‘environmentally compatible single-use electronics’.

The three use cases, subdivided in nine pilots, are demanding different system requirements for materials, components, devices and system architecture. The Life Cycle Analysis and methods to generate a circular ecodesign will be important inputs for these requirements. Some pilots will be suited for reuse after refurbishment like medical equipment, others are to be designed for repair of devices (lighting products, consumer products). If end-of-life destiny is the waste stream then efficient regain of valuable materials can be supported by a design of the product that allows separation in early stage to increase the content of valuable material leading to cost effective recycling of materials.
The development of bio-based, renewable materials that are sufficiently available will be studied in Sustronics. To steer that development listing of requirements from the pilots is indispensable to guide the development.
Technology as will be developed for assembly will be based on system requirements for reliable products but also on the opportunity for disassembly, waste-stream management and could ask for a selection of material to be incinerated, dissolved or intelligently separable by designed processes like mechanical, temperature, photonic treatment.

The listing of user requirements and system specifications therefore is a key step in the development of Sustronics. It started with the pilot descriptions laid down in Deliverable 3.1.
For the project nine pilots have been collected with between brackets the pilot owners in abbreviation:

1.1 Green and circular image guided therapy systems (PMS)
1.2 Sustainable system integration and product design of personal health devices (PCL)
1.3 Sustainable luminaire (SIG)

2.1 Embedded electronic for EEG monitoring (PLUX)
2.2 Wearable health monitoring (SCR)
2.3 Sustainable dashboard for automotive (FAU)

3.1 Single-use diagnostic platform (IFAT)
3.2 Smart Hygiene (ESS)
3.3 Smart wound dressing (IFAG)

These pilots are different in application field (medical, consumer & lifestyle, automotive), End-of-Life destiny, potential for recovery via closed loop producer – collector, lifetime, price level etc and technology readiness level. Table 1 summarises the differences in pilots.

Table 1 Differentiation of pilots in character and challenges

Pilot #	Description	Application field	TRL	Sustainability challenge	Lifetime	End of Life*
1.1	Image-guided therapy system	Medical	9	Refurbish Low-energy components, remanufacturing, eco-design requirements for components (recycling, disassembly, energy use)	10-14 years per cycle	Return to producer
1.2	Personal health device	Consumer	9	Manufacturing and design for recycling and extended use phase	3 years	e-waste
1.3	Luminaire	Consumer and business	9	Manufacturing	10 years	e-waste
2.1	EEG monitoring	Consumer / medical		Design for recycling		?
2.2	ECG monitoring	Consumer/medical	7	Sustainable material choice (inks and substrate)		?
2.3	Automotive dashboard	Automotive	9	Design for recycling and disassembly	15 years	?
3.1	Diagnostic tool	Consumer/medical	2	Sustainable material choice		
3.2	Smart hygiene : urine diagnostic	Consumer/medical	2	Sustainable material choice	1 time use	Household
3.3	Smart wound dressing	Consumer/medical	2	Realisationrealization	Max 14 days	Medical waste and household

End of life is the current main (> 50 %) end of life destiny

The system requirements for the pilot are laid down in Deliverable 3.1 Initial system specification and design for pilots, including circularity aspects. These system specifications will be updated along the project after the three generations of prototypes (M15, M27 and M36). The requirements for devices and systems might be adjusted accordingly following these adjustments. The sustainability gains can be expected to be in different phases of the Lifecycle including an adjusted product design and marketing to allow for refurbishment.

1.2. Related documents

Del 1.1 will describe the needs, requirements and specifications of the pilot systems for materials.

Del 2.1 will describe the needs, requirements and specification for the components and devices.

The deliverable 3.1 is a reference to the pilot description and for more details reader is referred to these deliverables.

1.3. Additional notes

For every Pilot, a table with each specification has been made available with the following structure:

1. “**Nr**” column – In this column, all Specifications must have a number sequentially assigned to it. This was done to organize Specifications into subgroups;
2. “**Description**” column – Description of Specification;
3. “**Leading Partner**” column – Designation of the partner(s) mainly responsible(s) for the fulfilment of the Specification;
4. “**Priority Level**” column – In this column, a priority level is assigned in accordance with the Specification’s importance for the project’s objectives. If a **level 1** is assigned, this means it must be executed fully. If a **level 2** is assigned, this means that it is a “nice to have”, i.e., if dropping this item partially or fully in favour of prioritizing the ones with level 1 assigned to them, it should then be done;
5. “**Comments**” column – This field must be used to provide additional information on said item to aid in its execution.

2. Requirements and Specifications

2.1. Use case #1

Circularity for electronic devices can be achieved through different circular economy strategies. This use case will design electronic devices to be compatible with these different strategies while benefiting also from additive manufacturing technologies and bio-based materials. The three pilots will, thus, redesign existing products in line with circularity and sustainability requirements. Use Case 1 includes the following pilots:

- Pilot#1.1 Green and circular image guided therapy systems (PMS),
- Pilot#1.2 Sustainable system integration and product design of personal health products (PCL), and
- Pilot#1.3 Sustainable luminaire (SIG).

2.1.1. Pilot #1.1 Green and circular image guided therapy systems

Pilot description:

Philips Azurion is an interventional X-ray system used for minimally invasive treatment, such as percutaneous coronary interventions (PCI), peripheral vascular treatments and stroke treatment. From earlier full LCAs it is known that energy consumption is one of the largest contributors to the environmental footprint of these systems, calculated over a lifetime of 10 years. Another aspect to improve is the recoverability of systems from the field (currently at 66% for Allura, the previous generation of systems).

Figure 2: Philips Azurion system targeted in Pilot#1.1.

This pilot will design an Azurion with reduced environmental footprint, to be underpinned by LCAs. Specifically, the aim is to reduce the energy consumption by 30%, lower the LCA score by 10%, reuse 25% of material in remanufactured systems and increase the percentage of systems that are recovered from the field for repurposing from 66% to 80%.

Considering the contribution of improved components and devices, this pilot will focus on increasing material reuse in new designs and exploring energy-saving features. Certification of the components to be reused is indispensable and is part of the innovation design work of Sustronics.

For materials efficiency the increase of the value of materials in recycling is to be researched with e-waste processing company like Mirec. Findings will be used as input for eco-friendlier redesigns of Azurion components.

For the energy saving features devices with lower power consumption or intelligence in switch off mode. Especially the x-ray tubes and large display solution (including infrastructure) could save a lot of energy in lower power mode. Prerequisite for this introduction into the product is to not affect the outcome of treatment for the patient to be affected by part of the system functionality being unavailable at critical moments.

The specifications regarding Processes for Pilot#1.1 are in Table 2:

Table 2 - Process specifications for Pilot#1.1

Material and Process SPECIFICATIONS				
Nr	**Description**	**Leading Partner**	**Priority Level**	**Comments**
Process				
S2.1	Raw materials reprocessing cycles must be tracked in order to guarantee that materials properties are such as to maintain resulting parts' performance.	PMS/MIR /PEN	2	For tracking how many times component was recycled for example, use a serial number to know many times it was subjected to reprocessing, how long it was used, or where (under what conditions) it was used(also usable for Pilot 1.2
Safety aspects				
S3.1	Lifetime of metal parts after remanufacturing guaranteed for a total of 24 years (including first cycle).	PMS/MIR /PEN	1	Any remanufacturing processes applied on metal parts must be such that doesn't affect lifetime objective.
Sustainability				
S4.1	Lower LCA score by 10%	PMS/PE N/TAU	1	Use a combination of several sustainability requirements in order to achieve this, which includes processing and reprocessing
S4.2	Reuse of 25% of material in remanufactured systems	PMS/PE N/TAU	1	•Assess what components may be have a material swap, for a more recyclable and sustainable; •Remanufacturing processes of these materials must have an assessment of their impact on the LCA score;
S4.3	Increase the percentage of systems that are recovered from the field for repurposing from 66% to 80%	PMS/PE N/TAU	1	Recovery process must be taken into account for assessing its impact on LCA score;
S4.4	Data model for the sustainability data, which connects to the existing tooling in R&D	PMS/PE N/TAU	1	With the support of Windchill PLM already in use
S4.5	Sustainability data for all components in the system, to be obtained from suppliers via a standardized process	PMS/PE N/TAU	1	This process must be defined. With the support of Windchill PLM already in use
S4.6	Possibility to select configurations from full bill of materials in order to better determine their impact on LCA	PMS/PE N/TAU	1	With the support of Windchill PLM already in use
S4.7	Tooling to make LCA calculations based on the data, accompanied by a good definition of the methodology to perform the LCA	PMS/PE N/TAU	1	With the support of Windchill PLM already in use

2.1.2. Pilot #1.2 Sustainable system integration and product design of personal health products

Pilot description:

The goal of Pilot #1.2 is to design a circular PCBA, integrated into a Philips battery operated appliance, that can be processed and reconstituted into a new PCBA. This solution will be achieved in two phases: Phase A. Sustainable PCBA Innovation - the development of a practically implementable solution in 3 – 5 years' time and Phase B. Circular PCBA Product Demonstrator Model - an experimental solution with an implementation timeframe of 5 – 10 years. Particular attention will be paid on hazardous substances, following current and expected future EU restrictions, such as PFAS content and a BPA limit of @ 10 ppm.

Figure 3: Philips battery operated appliance.

This pilot should result in making a step forward a) decreasing resource usage by ≥ 20%, increasing recycled product weight ≥ 20% and having a share of bio-based materials up to 50% and b) supporting the Grooming and Beauty business on its journey to become more sustainable by increasing its circular revenues (25% by 2025), developing Eco-Hero products, and embracing eco-design principles (100% of the new product introductions eco-designed by 2025).

The specifications regarding Processes for Pilot#1.2 are in Table 3:

Table 3 - Process specifications for Pilot#1.2

Material and Process SPECIFICATIONS				
Nr	**Description**	**Leading Partner**	**Priority Level**	**Comments**
Process				
S2.1	Flexible PCBA: Additive Manufacturing	TNO	1	
S2.2	Flexible PCBA: Roll-to-roll technology	TNO	1	
S2.3	Modular aspect	PCL	2	Nr of maximum components to be assemble to be defined as more developments arise
Safety aspects				
S3.1	Compliance with BOMCheck	PCL	1	
S3.2	Comply with standard industry safety requirements	PCL	1	Specific norms to be defined as new developments arise regarding processes

S3.3	Limit substances of concern	PCL	2	During manufacture and assembly processes
Sustainability				
S4.1	Comply Philips Eco-Design guidelines - BOMCheck, sustainable alternatives	PCL	1	
S4.2	Decrease in resource usage by at least 20%	PCL	1	
S4.3	Increase in recycled product weight at least 20%	PCL	2	
S4.4	Inclusion of bio-based materials up to 50%	PCL	2	

2.1.3. Pilot #1.3 Sustainable luminaire

Pilot description:

The sustainable lighting demonstrator will be a lowest possible LCA luminaire. The conventional printed circuit board of the light source will be replaced by a more sustainable LED light source manufactured by the printed electronics technology. These LED light sources should provide good homogenous direct light which enables new opportunities for more sustainable luminaires. This luminaire will contain less materials. Next to the expected material reduction, the luminaire casing material should be more sustainable than the current reference.

A luminaire is a complete lighting unit and exists out of the main components light source, optics, housing, and a rim. Depending on the application area where the luminaire is used the specifications of the product can differ.

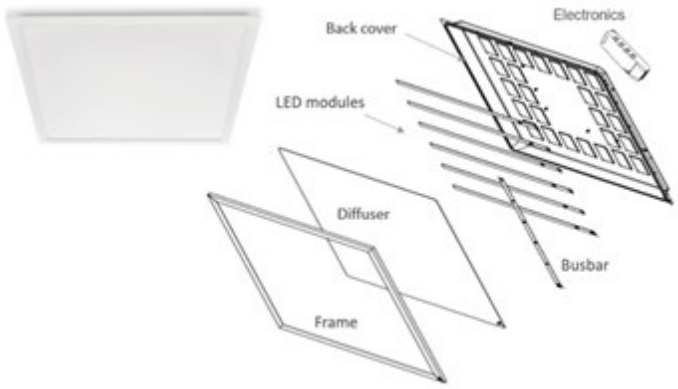

Figure 4: Schematic drawing of a luminaire.

The specifications regarding Processes for Pilot#1.3 are in Table 4

Table 4 - Process specifications for Pilot#1.3

Material and Process SPECIFICATIONS				
Nr	**Description**	**Leading Partner**	**Priority Level**	**Comments**
Process				
S2.1	Modularity: maximum of 5 parts for integration	SIG	1	
S2.2	Use of lower energy processes eg low pressure moulding	SIG	2	
Sustainability				
S4.1	End of Life: 80% of recovery of materials	SIG	1	The process of recovery must be taken into account regarding the overall reduction of LCA.

S4.2	Reduction in 10% energy for soldering processes	SIG	2	
S4.3	Overall reduction of LCA of 10%	SIG	1	Take processes

2.2. Use case #2

This use case will develop different approaches for decreasing environmental footprint as well as specifying new end-of-life management routes. The pilots are transforming existing electronic products (wearables, automotive) into environmentally friendly alternatives while maintaining the device functionality, specifically focusing on utilization of bio-based materials together with sustainable manufacturing concepts. Use Case #2 includes the following pilots:

- Pilot#2.1 Embedded electronics for EEG monitoring (PLUX),
- Pilot#2.2 Wearable health monitoring (SCR), and
- Pilot#2.3 Sustainable dashboard for automotive (CEA).

2.2.1. Pilot #2.1 Embedded electronics for EEG monitoring

Pilot description:

Pilot #2.1 goal is to design sustainable variants of conventional low-channel Electroencephalography (EEG) monitoring systems for potential applications in consumer (e.g., sleep monitoring at home) and clinical applications (e.g., minimum setup sleep monitoring solutions).

Figure 5: Dual-Channel EEG acquisition for pre-Frontal (Fp) readings at the forehead. FP1 and FP2 measurement locations highlighted in green.

This pilot aims to explore and propose sustainable interface and electronics design solutions that compensate for potential disadvantages over clinically accepted and disposable interfaces to ensure high-quality medical data acquisition.

The specifications regarding Processes for Pilot#2.1 are in Table 5:

Table 5 - Process specifications for Pilot#2.1

Material and Process SPECIFICATIONS				
Nr	**Description**	**Leading Partner**	**Priority Level**	**Comments**
Process				
S2.1	Maximum of 4 different sections expected: electrode, connector, wires, dataLogger	PLUX	2	Nr of modular components and respective processes to be defined as more developments arise
S2.2	Use LDS technology on the dataLogger casing for inclusion of conductive tracks and SMD's directly on it.	PIEP	1	As a substitute of the usage of PCB's for miniaturization of the device.
Safety aspects				
S3.1	Compatible with norm ANSI/AAMI ST67:2019	PLUX	1	
S3.2	Hydrogel or skin contact adhesive needs to pass ISO10993 cytotoxicity	PLUX	1	
S3.3	Pass all IEEE/IEC applicable norms	PLUX	1	
Sustainability				
S4.1	Electrodes: minimum shelf-life 12 months; minimum 10 uses	PLUX	2	
S4.2	Acquisition system: 2 years	PLUX	2	
Other Aspects				
S5.1	Operating temperature: 10°C to 30°C	PLUX	1	For operating conditions, however this must be taken into account during manufacturing and assembly processes if these affect normal operation negatively.
S5.2	Atmospheric pressure between 500hPa and 1060hPa	PLUX	1	For operating conditions, however this must be taken into account during manufacturing and assembly processes if these affect normal operation negatively.

2.2.2. Pilot #2.2 Wearable health monitoring

Pilot description:

Screentec's current disposable single-use ECG electrode will work as reference on this pilot. Current electrode is manufactured using fossil-based materials like PET, conductive traces are manufactured using silver paste and pouch where the final products are packed is made of PET/Al foil.

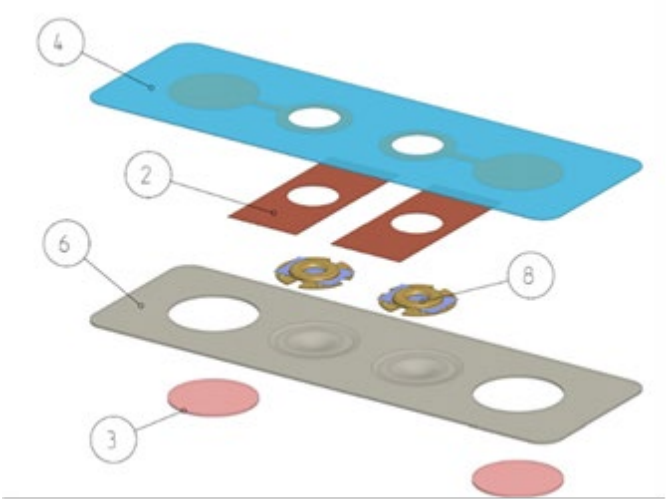

Figure 6: ECG electrode structure to be used in Pilot #2.2 Wearable Healthcare monitoring.

In this pilot the aim is to replace as many of the current product materials as possible with more sustainable alternative. As a second approach also a solution with multi-use electrode instead of single-use will be studied. LCA for used materials will be made to compare their sustainability and functional tests as well as shelf lifetime will be made to find out how the changed materials work in comparison to the reference.

The specifications regarding Processes for Pilot#2.2 are in Table 2:

Table 6 - Process specifications for Pilot#2.2

Material and Process SPECIFICATIONS				
Nr	**Description**	**Leading Partner**	**Priority Level**	**Comments**
Process				
S2.1	Flat-bed screen printing process will be used for samples and possible larger quantities. Curing made in batch oven, oven with conveyor belt or R2R oven.	SCR	1	
S2.2	Resistivity/square resistance, layer thicknesses, surface roughness, microsopic pictures of printed structures to be taken.	VTT	1	
S2.3	Laboratory and field tests to be made in order to verify the functionality of the electrodes	MOV, EDI	1	
S2.4	Aging in climate chamber required. Detailed specifications to be agreed.	TAU	1	
S2.5	Conductive traces should be curable < 150 ºC	SCR	1	
Safety aspects				
S3.1	Hydrogel or skin contact adhesive needs to pass ISO10993 cytotoxicity	SCR	1	
S3.2	Material breakthrough voltage > 1.5kV	SCR	1	
Sustainability				
S4.1	At least basis of LCA to be taught for pilot partners	VTT	1	Manufacturing and assembly processes must be taken into account regarding LCA impact.
S4.2	LCA made according to quide lines decided within the sustronics project.	VTT	1	

2.2.3. Pilot #2.3 Sustainable dashboard for automotive

Pilot description:

In automotive HMI (Human Machine Interface), fundamental changes have taken place in past years, with large plastic control panels integrating now large interactive screens. The trend is ongoing, and we are moving from the ‘push-buttons’ era to the ‘tactile’ era. In order to ever improve ergonomics for drivers’ operation as well as move towards a minimalist aesthetics, new electronic functions such as sensing, and lighting directly integrated in plastic control panel would be one more step in the digital transformation of the vehicle (Figure 7). Flexible and printed electronics are a good alternative to conventional PCB, especially when they are designed to be compliant with in-mold process: they enable seamless integration of new functions, leading to produce thin and lightweight automotive control panel.

Figure 7: Example of an IME Automotive control panel.

The specifications regarding Processes for Pilot#2.3 are in Table 7:

Table 7 - Process specifications for Pilot#2.3

Material and Process SPECIFICATIONS				
Nr	**Description**	**Leading Partner**	**Priority Level**	**Comments**
Process				
S2.1	Production of printable substrates (films) from granules/pellets	VTT/ CEA	1	Specific components subject this process to be listed as more developments arise
S2.2	Printing of the inks	SYM/ CEA	1	
S2.3	Pick & Place of components compatibility	SYM/ CEA	1	
S2.4	Possibility to thermoform the foils	CEA	2	
S2.5	Cutting of thermoformed films	CEA	1	
S2.6	Injection of the parts	SYM/ CEA	1	Specific components subject this process to be listed as more developments arise
Safety aspects				
S3.1	Compatible with EC21 crash test	FAU	1	
S3.2	Flame propagation speed= 100 mm/min max	FAU	1	
S3.3	COV emission submitted to automotive standards	FAU	1	
Sustainability				
S4.1	Dismantling of the 2 foils	TNO	1	
S4.2	Recycling resin	MIREC/ VTT	1	
S4.3	Use of bio-based or recycled materials for subtrates	VTT/ ARNP	2	Recycling processes must be analysed regarding their impact in LCA
S4.4	Use of bio-based or recycled materials for inks	RISE/ CSIC	2	Recycling processes must be analysed regarding their impact in LCA
S4.5	Recycling electronics films	MIREC	1	Recycling processes must be analysed regarding their impact in LCA
S4.6	Dismantling of functional foil	TNO	1	•Recycling of substrates (including the wastes from the fabrication) •Recycling processes must be analysed regarding their impact in LCA
S4.7	Recycling of the decorative films	MIREC	1	Recycling processes must be analysed regarding their impact in LCA

2.3. Use case #3

This use case will integrate pilots compatible with end-of-life management strategies, such as composting, biodegradability and recycling. The three pilots represent innovative new products for diagnostic purposes also from technical perspective. In this sector specifically new sustainable technologies will offer sustainability benefits, such as no need for separate dedicated readout device when using already available infrastructure of smartphones. This has all the capabilities to replace bulky, expensive, and energy consuming laboratory equipment with digital solutions. Use Case #3 consists of the following pilots:

- Pilot#3.1 Single-use diagnostic platform (IFAT),
- Pilot#3.2 Smart hygiene (ESS), and
- Pilot#3.3 Smart wound dressing (IFAG).

2.3.1. Pilot #3.1 Single-use diagnostic platform

Pilot description:

The goal of Pilot#3.1 is to develop an easy-to-use disposable point-of-care (POC) device linked to a smartphone app to help in the monitoring of patients' biomarkers, demonstrated for C-peptide detection in urine sample. Realization of the new POC device with sustainable and compostable materials (e.g., paper, not noble metals).

The specifications regarding Processes for Pilot#3.1 are in Table 8:

Table 8 - Process specifications for Pilot#3.1

Material and Process SPECIFICATIONS				
Nr	**Description**	**Leading Partner**	**Priority Level**	**Comments**
Process				
S2.1	Stability of sensor functionality in the printing and mounting process of whole cartrige system	SCR/VTT/ URV/CSE M/MEDUG	1	
S2.2	Chip measurement process to measure 2 3-electrode galvanically decoupled	IFAT	2	
S2.3	Process to run high volume (n ~100) sensor measurements for statisitcs	IFAT/MED UG	2	
Safety aspects				
S3.1	Provision of non-biohazard example test samples for sensor testing and demonstration	MEDUG	2	
S3.2	Provide Safety information regarding health hazards of used materials and handle advice	SCR/VTT/ URV/ CSEM/ MEDUG	1	
Sustainability				
S4.1	Environment friendly disposal	All	1	
Other Aspects				
S5.1	Operating temperature 0-70ºC	IFAT	1	Recycling processes must be analysed regarding their impact in LCA
S5.2	2 sub pilots:A-In Vitro Diagnostics; B-Smart skin patch	IFAT	1	

2.3.2. Pilot #3.2 Smart hygiene

Pilot description:

Hygiene and health companies are actively developing digital platforms and wearable sensors for both self-care and professional care to improve e.g., incontinence care. The goal of Pilot #3.2 is to develop a sensor that measures temperature (T), relative humidity (RH) and enzymes (ENZ) integrated in an incontinence product to increase the quality of care and decrease the cost of health care.

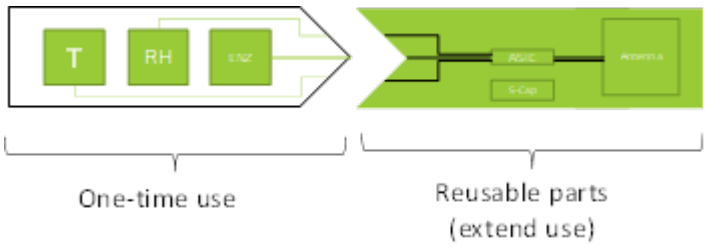

Figure 8: Pilot#3.2 consisting of a one-time use part and reusable parts.

The specifications regarding Processes for Pilot#3.2 are in Table 9:

Table 9 - Process specifications for Pilot#3.2

Material and Process SPECIFICATIONS				
Nr	**Description**	**Leading Partner**	**Priority Level**	**Comments**
Material				
S1.1	Printed electrodes	RISE	1	The printed electrodes need to perform 3-electrode electrochemistry
S1.2	Printed detection array- functional coating for Temp and RH	RISE	1	•System must notify the Temperature (T: 15°C to 40°C) in the microclimate. "90% accuracy, +/-0.5 °C". •System must notify the humidity (RH: 30%-100%) in the microclimate. "90% accuracy, RH +/-5%"
S1.3	Printed detection array- functional coating for ENZ and pH	UGOT	1	•System must notify the presence or absense of an enzyme (ENZ) in the microclimate, immediately (<1 minute). 90% accuracy. •pH is a support parameter
S1.4	Device must have an antenna, made out conductive ink	RISE/BEN/ VTT/CSEM	2	Only needed in the piece solution when the antenna is inside the incontinence product
S1.5	Paper substrate made of renewable, flexible and hypoallergenic resource	TER/UPM/ VTT	2	•Renewable resource and flexible with comfort towards body/skin. •Apply relevant ISO norms (to be shared by ESS) •Roughness and flexibility similar to materials that they will be in contact with
S1.6	Adhesive made of renewable, flexible and hypoallergenic resource	UPM	2	•Renewable resource and flexible with comfort towards body/skin. •Apply relevant ISO norms (to be shared by ESS)
S1.7	Release liner made of renewable, flexible and hypoallergenic resource	UPM	2	•Renewable resource and flexible with comfort towards body/skin. •Hypoallergenic feature on the liner may be difficult to realize
S1.8	Protective/semipermeable layer-sample uptake	TER	1	This has to receive the sample and transport to the detection parts. Porosity and wettability
S1.9	Conductive ink	RISE/VTT/ CSEM/BEN	1	Shall not be too resistive such that the detection fails. Need robust, flexible.
S1.10	Supercapacitor	TAU/CSEM	2	If we go for the two-piece solution then this is not needed, after the LCA from FGH
S1.11	Connection between sensor label and Transmitter	FGH/RISE/ ESS/CSEM /BEN/VTT	1	If we go for the two-piece solution then this is needed. Input from FHG is needed.
Process				
S2.1	Pilot manufacturing - Printed electronics	RISE/ UGOT	1	Namely: printed electrodes; printed detection array-functional coating for Temp, RH, ENZ and pH; printed antenna. Others may be needed as new developments arise.
Sustainability				
S4.1	LCA calculation of sensor label	FGH/ESS	1	Evaluate impact of manufacturing and assembly processes

S4.2	Circularity mapping of use	FGH/ESS	1	

2.3.3. Pilot #3.3 Smart wound dressing

Pilot description:

Pilot 3.3 will develop a sustainable smart wound dressing with optimised materials for printed electronics substrate, encapsulation in combination with the wound dressings materials. The wound of a diameter of maximally 3.6 cm will be monitored for pH, temperature and chemicals like uric acid in the first iteration. The smart wound dressing should allow to be left untouched for a period of at least 14 days, preferably 21 days. Because of the alarm functionality to detect infection or change of the status of the wound the dressing does not need to be removed and replaced as is currently the clinical practise. Health care professionals remove the dressings with risks of damaging the wound and it's healing process and discomfort for the patients without the smart electronics. Increase of the use period per wound dressing will also have a sustainability aspect in materials and energy terms.

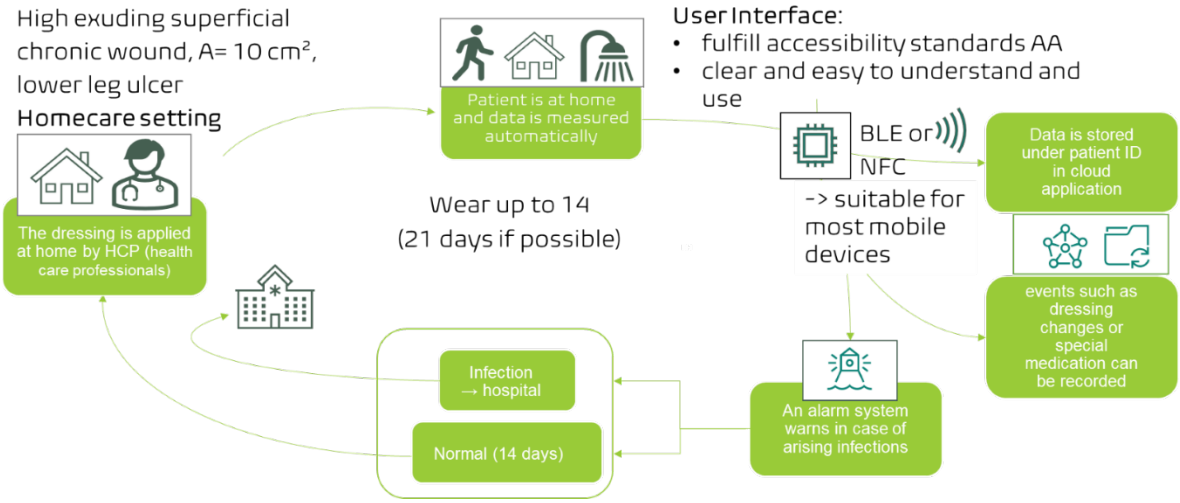

Figure 9: Description of the use case scenario of the smart wound dressing

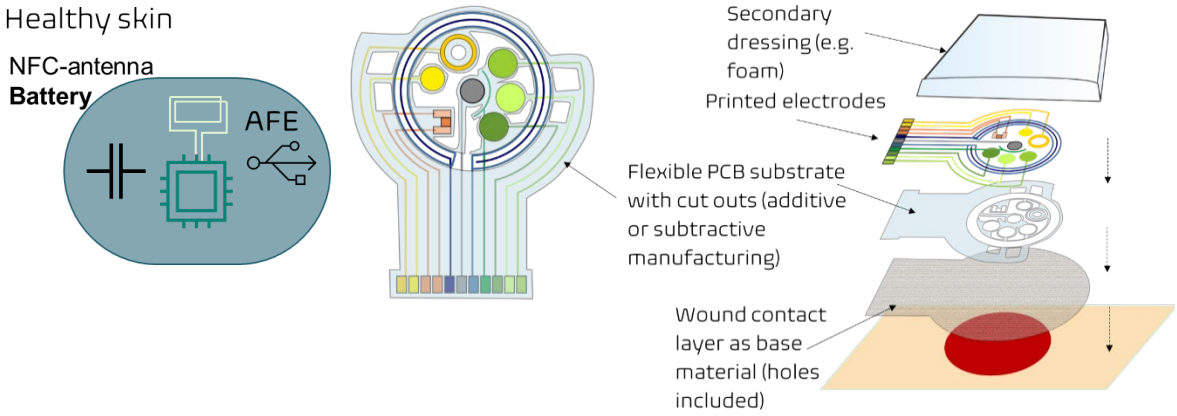

Figure 10: Schematic drawing of the smart wound dressing showing that the electronics will be in contact to the exudate and differentiate for the reusable part and the disposable part.

The specifications regarding Processes for Pilot#3.3 are in Table 10:

Table 10 - Process specifications for Pilot#3.3

Material and Process SPECIFICATIONS				
Nr	**Description**	**Leading Partner**	**Priority Level**	**Comments**
Process				
S2.1	Fabrication of hardware from raw materials and micro-components	SWA	1	Mass production volumes possible and provided by SWA foundry
S2.2	PCB fabrication and automated assembly of sensors and further components	IZM	2	
S2.3	Assembly of Sensors, further components and connectors onto substrates	IZM	2	In case of printed Ag-connectors: conductive glueing of components
S2.4	ASIC Footprints	IZM/WE	2	
S2.5	ASIC form (bare die/ CSP)	IZM/WE	2	
S2.6	Integration of electronic layer into wound dressing /incl. Potentially adhesive layers	IZM/Essity	2	
S2.7	Printed electronic circuit for system integration	TNO	2	
Safety aspects				
S3.1	ESD protection	SWA	1	ESD shielding to protect sensitive components and people from electrostatic discharge under real-world operation
Sustainability				
S4.1	Fiber optics don't wear out, and supports high throughputs ensuring forwards compatability	SWA	1	Optical connectors support over 100 gbit/sec networking, far faster than any ISP can deliver for the foreseeable future
S4.2	Stretchable PCB Substrates based on TPU	IZM/WE	2	reduction of TPU thickness from 100-200 µm down to 100 µm (including coverlayer). With future perspective to reduce down to 50 µm.
S4.3	Assembly of components using low energy (temperature) electronics interconnection techniques	IZM	2	Low temperature soldering or glueing or components to substrates
S4.4	Re-Use of electronic components, that have not been in contact with the wound	IFAG	2	

Conclusions and next steps

The clear discrepancies when it comes to TRL's between the various Pilots as well as their technical, commercial and user applications, make the full definition of every specification unavailable at this point. This, however, doesn't mean that the aspects already listed in this Deliverable (and in the Deliverables directly related) are insufficient to materialize fully functional pilots that answer the challenges set in scope of this project. Quite the contrary, as the information gathered is now the starting point for the next phases of the project.

As previously mentioned in Section 1.3, priority levels were assigned to every Specification. This means that those with level 2 assigned are more prone to update, partial execution or no execution at all, as long as those with level 1 are fully realized, which answer the project's goals.

There is however, as also mentioned, room to manoeuvre as new technological developments arise, shedding light on new and/or more relevant features on certain specifications. These developments may also reveal technical constraints not predicted at this point.