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**4.5**

## CONCRETE PRODUCT SUGGESTIONS FOR FUTURE NANOTECHNOLOGIES



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## EXECUTIVE SUMMARY

This report presents product suggestions for future nanotechnologies resulting from a series of co-creation activities in the GoNano project. GoNano established an iterative, four-step co-creation process to integrate societal considerations in nanotechnologies: the first step consisted of a series of citizen workshops (one in each of the three pilot countries: the Netherlands, the Czech Republic and Spain)<sup>1</sup> where citizens expressed their wishes and concerns with respect to each of the application areas (health, food and energy, respectively). In the second step, the pilot partners organised co-creation workshops with stakeholders to explore ways to take the wishes and concerns of citizens into account in nanotechnology research and innovation. The results from this first stakeholder workshop were subsequently discussed in the third step of the co-creation process: an online citizen consultation to get responses from citizens from various European countries to the product suggestions of the first round of stakeholder workshops. The fourth and final step of the co-creation process consisted of a second round of stakeholder workshops organised in October and November 2019 in each of the pilot countries. These workshops explored how the product suggestions derived from the first workshops and subsequent input from the online consultation could be integrated in concrete research and innovation decisions.

The GoNano co-creation process has produced a wealth of creative ideas for future nanotechnologies. Some 92 product suggestions have been collected over the course of the project. These suggestions vary wildly in scope and nature. Some may be optimistic, like 'Easy Paint': a paint that is permanent yet easy to remove from walls if one decides to redecorate the house. Others are very concrete, pointing to incremental innovations in medicine, like mobile diagnostic and monitoring devices for specific afflictions. Some of these suggestions were discarded or amalgamated during the workshops themselves through brainstorming, focussing and selection procedures. The suggestions were also categorised by GoNano partners after each step in order to produce viable options for workshop participants in subsequent steps.

Given the specific objectives and limited timeframes of the project, it was impossible to follow up on every single suggestion. Still, each of the 92 ideas could in principle serve as the start of a new cycle of co-creation – provided that one of the participants sees merit in the idea (deliverable D4.4 will provide a more elaborate assessment of the engagement process as a whole. It will also consider in further detail why some ideas were taken up and others were not, with the aim to shed further light on the preconditions for co-creation).

The co-creation process was not just intended to generate wild ideas, however. It was also meant to produce concrete 'responsive' design suggestions which can be fed back in ongoing research and innovation activities. This is why the product suggestions became more focused and directed towards concrete suggestions over the course of the events. This report presents five narratives from the different pilot studies that suggest how key suggestions evolved over time, maturing from an initial suggestion made in the expert interviews at the beginning of the project into a highly specific proposition towards the end:

1. Developing a data management plan for the artificial pancreas.

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<sup>1</sup> The partners organising the workshops in the respective countries are: the University of Twente (UT) in The Netherlands, the Technology Centre of the Czech Academy of Sciences (TC CAS) in the Czech Republic and the Royal Melbourne Institute of Technology (RMIT) in Spain.

2. Strengthening user-producer interactions in the development of new diagnostic tools for cancer detection.
3. Designing a packaging system for perishable foods.
4. Defining safety measures for the use of nanomaterials in food.
5. Capturing energy from the environment and converting it to electrical energy for clean storage and use.

These cases suggest that focused, guided interactions between different stakeholders can in principle lead to novel suggestions on how to integrate broader considerations in research and innovation decisions. Each pilot study offers suggestions in its own way. In the case of the artificial pancreas, the discussion led to data management considerations that may be relevant for future data sharing agreements between the producer and users of the device. For the post-doc researcher working on a biosensor for cancer diagnostics, interactions with prospective users helped shape future research directions. The proposal for a packaging system for perishable foods can be seen as a concrete suggestion for demand-driven innovation. The suggested safety measures for the use of nanomaterials in food are an example of how multi-stakeholder interactions can serve to provide advice to policy makers on the governance of nanotechnologies. And the discussions on energy storage and capture suggested how societal considerations can be productively integrated in the development of the wireless sensor nodes.

The product suggestions are not the “concrete” products we ambitiously envisaged at the outset of the project; however, they are the truest reflection of the GoNano co-creation process that produced them (deliverable D4.4. will consider the extent to which the workshops succeeded in promoting changes in research and innovation decisions, and will review the preconditions for enabling concrete change through co-creation).

# 1. INTRODUCTION

This report presents product suggestions for future nanotechnologies resulting from a series of co-creation activities in the GoNano project. The GoNano project is built on the assumption that several types of knowledge are needed to define sustainability, acceptability, and desirability of nanotechnologies. To test this hypothesis, GoNano explored opportunities and barriers for co-creation, combining face-to-face citizen engagement, stakeholder workshops and online consultations (see Figure 1).

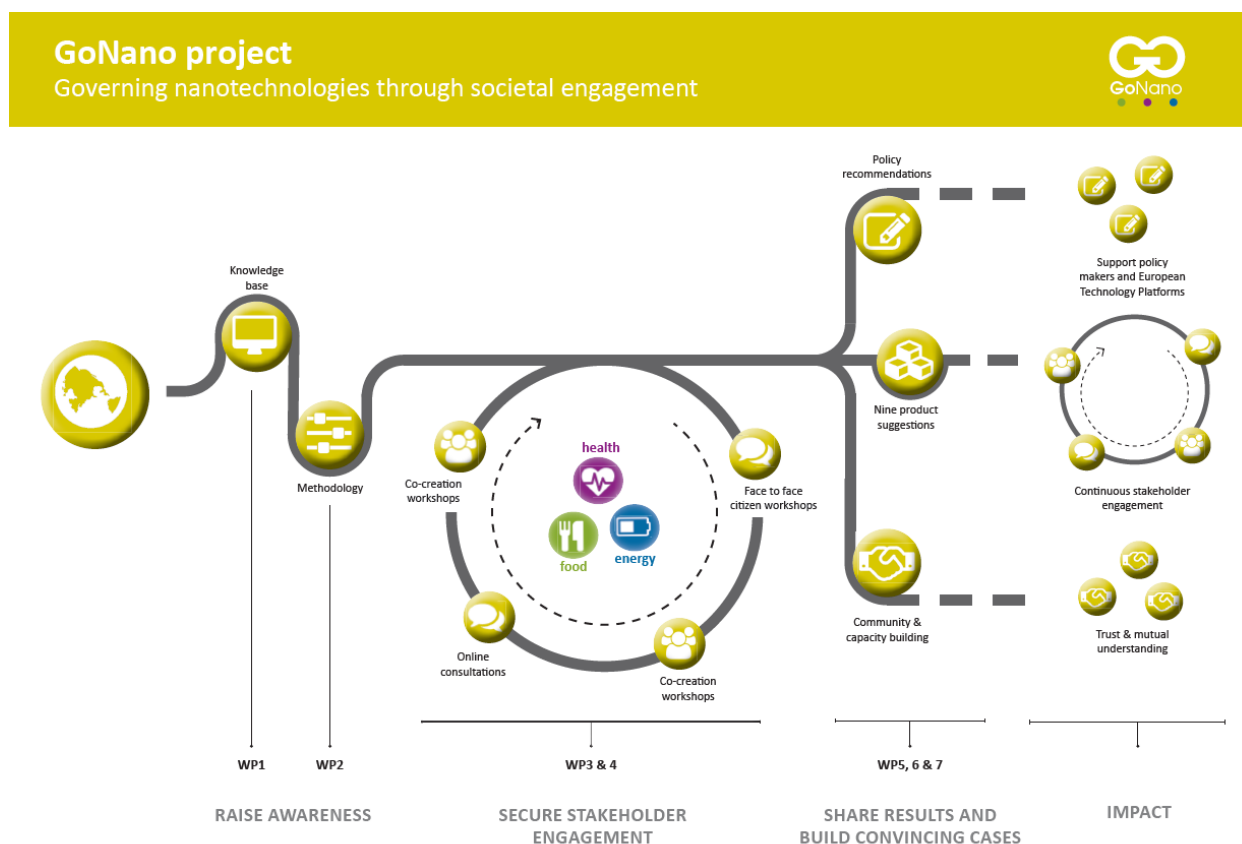


Figure 1 – Overall design of the GoNano project

Building on the knowledge base and the methodology developed in earlier stages of the project, GoNano established an iterative, four-step co-creation process to integrate societal considerations in nanotechnologies: the first step consisted of a series of citizen workshops (one in each of the three pilot countries: the Netherlands, the Czech Republic and Spain)<sup>2</sup> where citizens expressed their wishes and concerns with respect to each of the application areas (health, food and energy,

<sup>2</sup> The partners organising the workshops in the respective countries are: the University of Twente (UT) in The Netherlands, the Technology Centre of the Czech Academy of Sciences (TC CAS) in the Czech Republic and the Royal Melbourne Institute of Technology (RMIT) in Spain.

respectively). The workshops were organised in October and November 2018.<sup>3</sup> In the second step, the pilot partners organised co-creation workshops with stakeholders to explore ways to take the wishes and concerns of citizens into account in nanotechnology research and innovation. During these workshops, which were organised in February and March 2019, stakeholders proposed possible product suggestions for future nanotechnologies based on the input from citizens.<sup>4</sup> The results from this first stakeholder workshop were subsequently discussed in the third step of the co-creation process: an online citizen consultation, held in the summer of 2019. The aim of this consultation was to get responses from citizens from various European countries to the product suggestions of the first round of stakeholder workshops. The consultation was also meant to evaluate the desirability and perceived safety of such suggestions.<sup>5</sup> The fourth and final step of the co-creation process consisted of a second round of stakeholder workshops organised in October and November 2019 in each of the pilot countries. These workshops explored how the product suggestions derived from the first workshops and subsequent input from the online consultation could be integrated in concrete research and innovation decisions.<sup>6</sup>

### 1.1 OBJECTIVE: DEVELOPING CONCRETE PRODUCT SUGGESTIONS FOR NANOTECHNOLOGIES

This report focuses on one specific objective of the GoNano co-creation process: the aim to develop concrete product suggestions for future nanotechnologies (Deliverable D4.4 will provide a more general assessment of the co-creation process as a whole, reporting on the overall insights and lessons from the engagement activities). The objective, as stated in the Description of Action (DoA) was to: *“Develop nine concrete product suggestions for future nanotechnologies in each of the nanotechnology research areas ‘Health’, ‘Energy’ and ‘food’ (three for each area), which are aligned with societal needs, values and concerns.”* (p. 6 of the amended GoNano Part B, version 27-11-2018).

These nine product suggestions were meant to demonstrate the possibility of aligning research and innovation outcomes with societal needs, values and concerns. As the DoA notes: *“GoNano will support the practical process of co-creating suggestions for concrete future nanotechnology products. The product suggestions will be co-created through a coordinated process of deliberative design and evaluation workshops and online consultations, held together through an online co-creation platform.”*

The method and manual for the pilot studies developed in the first year of the GoNano project furthermore stated that: *“The nine product suggestions are: judged as acceptable, sustainable, socially desirable by the participants in the co-creation process; aligned to societal values; solutions to societal challenges in nanotechnology research and innovation for Food, Health or Energy”* (p. 6 of the manual for the pilot studies, deliverable D2.1).

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<sup>3</sup> See the briefing report on the citizen workshops: <http://gonano-project.eu/wp-content/uploads/2019/02/D3.2-Briefing-report-from-the-citizen-workshops.pdf>

<sup>4</sup> See the working paper on the design and outcomes of the first round of stakeholder workshops: [http://gonano-project.eu/wp-content/uploads/2019/07/GoNano\\_D4.2\\_Working\\_paper\\_on\\_the\\_designs\\_and\\_outcomes\\_of\\_round\\_1.pdf](http://gonano-project.eu/wp-content/uploads/2019/07/GoNano_D4.2_Working_paper_on_the_designs_and_outcomes_of_round_1.pdf).

<sup>5</sup> See the briefing report on the outcomes of the citizen consultation: <http://gonano-project.eu/european-respondents-perceive-nanotechnology-positively-however-emphasize-the-efforts-to-make-the-possible-products-safe/>.

<sup>6</sup> See the report on the outcomes of the second round of stakeholder workshops: <http://gonano-project.eu/d4-2-b-outcomes-of-co-creation-workshops-round-2/>.

The manual identified the pilot studies as the unit within which co-creation takes place.<sup>7</sup> It suggested that each of the four co-creation events would contribute to the co-creation process by providing specific outcomes:

*“The citizen workshop will feed into the process a list of wishes and concerns, [...] a clear message to an actor group [...] and a list of needs and values. [...] Stakeholders will relate citizens’ input (messages/wishes and concerns) to existing R&D activities. Citizens’ input will help them to develop concrete research lines (or design suggestions) and recommendations regarding their implementation (boundary conditions).*

*Research lines here means that the proposal of the stakeholders will be application related, however, most likely not restricted to one concrete product. Rather, it will provide a direction of possible development for a group of future products (e.g. targeted medicine) and the product suggestions will follow. Recommendations take into account the context conditions that need to be considered when implementing such research lines. Thus, this broadens the view beyond a strict product/application based focus and allows for even more embedded discussions of nanotechnology applications. Research lines and respective recommendations together make up a product case within the pilot studies” (p.12 of the method and manuals for the pilot studies).*

A wide range of product suggestions have been suggested in the different stages of the GoNano co-creation process. Chapter 2 summarises the suggestions made in the citizen and stakeholder workshops (the complete overview of suggestions from each of the co-creation events is provided in the appendix). Chapter 3 presents a selection of narratives from each of the pilot partners that highlight how specific product suggestions developed over the course of the co-creation process, becoming more specific with each workshop. Chapter 4 briefly reflects on the overall process and the resulting product suggestions (Deliverable D4.4 will provide a more detailed assessment of the overall GoNano co-creation process and its outcomes).

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<sup>7</sup> See the report on the method and manuals for the pilot studies: <http://gonano-project.eu/wp-content/uploads/2018/08/2.1.pdf>.

## 2. PRODUCT SUGGESTIONS

An extensive range of product suggestions was developed over the course of the project. There were three main opportunities for collecting creative inputs: the citizen workshop and the two stakeholder workshops. Each of these events followed the creative design process of exploration, ideation, prototyping and reflection. Previously conceived ideas and concepts could be explored and then further developed, while allowing freedom for new ideas to be introduced and developed as well.

In total, 92 suggestions were captured across the workshops (see Table 1). Some of these suggestions were discarded or amalgamated during the workshops themselves through brainstorming, focussing and selection procedures. The suggestions were also categorised by GoNano partners after each step, in order to produce viable options for workshop participants in subsequent steps.

**Table 1 – Overview of product suggestions made over the course of the GoNano co-creation process**

Pilot study	Citizen workshop	Stakeholder workshop 1	Stakeholder workshop 2	Total
Health: UT, NL	15	5	2	22
Food: TC CAS, CZ	14	5	3	22
Energy: RMIT, ES	41	5	2	48
<b>Total</b>	<b>70</b>	<b>15</b>	<b>7</b>	<b>92</b>

### 2.1 SUGGESTIONS FROM THE CITIZEN WORKSHOPS

The input from citizens collected during the three citizen workshops on health, food and energy already included many ideas for future applications of nanotechnology. Citizens reflected on major nanotechnology application areas identified in a series of expert interviews held at the beginning of the project.<sup>8</sup> Their messages and wishes were very often illustrated with an imagined nanotechnology application.

In the workshop on health organised by UT in the Netherlands for example, 15 wishes in total were developed. The suggestion that received most support was the ‘Sensorpatch’, a renewable, environmentally friendly monitoring device in the form of a non-invasive patch that monitors various reference values in the body. Other suggestions included a ‘Medical-record-on-a-chip’, a biometrical chip that measures blood values, but also contains information about an individual’s

<sup>8</sup> See the report on the findings of a series of expert interviews on the main technological developments in food, health and energy sectors: <http://gonano-project.eu/nanotech-in-food-energy-and-health-what-areas-and-issues-for-a-dialogue/>.

medical history; and a non-invasive mobile diagnostic device that can measure multiple components and can detect anomalies (for the full list of suggestions, please see the appendix).

Participants of the workshop on food organised by TC CAS in the Czech Republic derived 14 concrete suggestions from a larger number of individual wishes. Among these, the 'Nanococktail', a complex nutrient providing personalised nutrition to customers, was most popular. Participants also suggested the 'Desalinator 3000', a desalination filter for sea water, and the 'Nano-ball', a 100% recyclable, biodegradable nano-packaging system that monitors the quality of the product it contains.

In the workshop on energy organised by RMIT in Spain, the participating citizens pointed to a number of application areas where they think nanotechnologies can play a role: (1) capturing and converting energy (e.g. solar and kinetic) to electrical energy for storage and use; (2) different ways of adapting structures around the home to make use of renewable energy, for example, building integrated photovoltaics; (3) home climate systems that control the atmosphere around the home and also inform inhabitants of usage in simple terms; (4) smart home appliances and operating systems; (5) general technologies or products that are more sustainable and do not adversely affect health or the environment. The participants derived 4 group wishes from more than 40 individual wishes. The suggestion that received most support was entitled PUSH (Power Unit Surface Hub): a multilayer structure including nanostructured materials that could be used in consumer products to generate energy, for instance to power mobile devices. The 'Mobile Energetic Sheet (MES)', a lightweight, recyclable, transparent building material that captures solar energy, was second on the list. The 'Internet of Energy', a collaborative network of energy generating and harvesting systems, came third, and 'Save Water', a device that measures water and energy consumption in households, was fourth on the list.

## 2.2 SUGGESTIONS FROM THE FIRST STAKEHOLDER WORKSHOPS

The objective of the first stakeholder workshop, according to the DoA, was:

*"...to come up with concrete 'responsive' design suggestions which can be fed back in ongoing research and innovation activities. The workshop is designed so to follow-up on the workshops with citizen from task 3.2 to explore and evaluate which and how future products can align with preferences and values voiced in the citizen workshops. The design suggestions will align research and design with societal needs and values: Responsive Designs." (p.20).*

To realise the dual objective of responding to the preferences and values voiced in the citizen workshops and providing feedback to ongoing research and innovation activities, all workshops followed a similar structure, building on the four pillars of co-creation: exploration, ideation, prototyping and reflection. In the exploration phase, participants got to know each other and explored the needs and values expressed by citizens as well as their own needs and interests. In the ideation session, participants imagined and co-created responses to the needs and values expressed by the citizens by imagining revisions of ongoing research and innovation trajectories. In the prototyping session, participants generated a storyboard that visualized how research lines and product suggestions could be designed in relation to the needs and values expressed by the citizens and suggested concrete actions to realise this vision. In the concluding reflection, participants presented their visions and reflected on the overall workshop outcomes.

In the stakeholder workshops on health organised in the Netherlands, this resulted in the following concrete suggestions (please see the appendix and corresponding deliverables D4.2a and D4.2b for further details about the origins and development of these suggestions):

1. Promoting an early diagnostic device for type 2 diabetes;
2. Building a data management plan for the artificial pancreas;
3. Enhancing the accuracy of protein analysis to improve cancer diagnostics;
4. Strengthening the link between research and business in nanosensor research;
5. Developing a field lab for health technologies in a local medical centre.

The workshop on food organised in the Czech Republic delivered the following suggestions:

1. A food that contains a balanced mix of nutrients;
2. Analytical methods for the detection of nanoparticles;
3. An antimicrobial meat packaging solution;
4. A packaging solution for fruits and vegetables;
5. Specific applications for nanofilters.

The workshop on energy organised in Spain led to the following suggestions:

1. Developing autonomous sensor technologies for smart homes and smart cities;
2. Exhibiting piezoelectric materials to raise awareness of renewable energy solutions;
3. Utilising schools to educate the public about green energy;
4. Using smart materials and devices to save energy and reduce workload at home;
5. Enabling a shift from fossil fuels to renewable energy in the power grid.

The suggestions from the workshops were shared and discussed more widely through an online citizen consultation which ran from July to September 2019. The results from the citizen consultation fed into the second round of stakeholder workshops, which focused on the uptake of the responsive design suggestions of the first round.

## 2.3 SUGGESTIONS FROM THE SECOND STAKEHOLDER WORKSHOPS

The aim of the second round of stakeholder workshops, according to the DoA, was to:

*“...evaluate the uptake of the responsive design suggestions of the previous round, to follow up on the online consultations with citizens in task 3.3, provide input for the development of business cases on the concrete design suggestions to show the value of a collaborative and co-creative approach to integrating societal values in R&I, and as part of company portfolios” (p.20).*

The workshops therefore explored how input from citizens can be productively engaged in concrete research and innovation decisions, taking the product suggestions derived from the first workshops and subsequent input from the online consultation as a starting point (see deliverable D4.2 for a more detailed description of the process). The workshops explored how the main actors identified in these product suggestions – the so-called ‘problem owners’ – could mobilise the

considerations of citizens and other stakeholders to co-create more ‘socially robust’ research and/or product designs.

To enable focused discussion on concrete design suggestions that demonstrate the value of a co-creative approach to integrating societal values in research and innovation, the workshop on health organised in the Netherlands addressed two specific topics:

1. The value of data for technological applications for improved monitoring and treatment of diabetes;
2. Involving industry in the development of sensor technology for cancer detection.

The workshop on food in the Czech Republic focused on three application areas:

1. Safety aspects of the use of nanomaterials in food;
2. Opportunities and challenges of smart food packaging for fruits, vegetables and meat products;
3. Opportunities and drawbacks of the use of nanofilters in food production and water treatment.

The workshop on energy in Spain focused specifically on the integration of broader societal considerations in the development of autonomous wireless sensor nodes for the future Internet of Things. This led to two concrete product suggestions, both focusing on the possibility of using wireless sensor nodes in mobile health monitoring devices.

The specific focus areas of the second round of stakeholder workshops were not coincidental: they were the outcomes of a process of selection and refinement that ran through the consecutive stages of the co-creation process. The next chapter presents a selection of narratives from each of the pilot partners that may help to explain how topic areas evolved and became more refined along the way.

### **3. PROBING CO-CREATION: EVOLUTION OF KEY PRODUCT SUGGESTIONS IN THE PILOT STUDIES ON HEALTH, FOOD AND ENERGY**

The citizen and stakeholder workshops were meant to probe co-creation: to what extent is it possible to develop concrete product suggestions for future nanotechnology applications based on the needs, values and desires of citizens? Clearly, it proved impossible to turn each and every suggestion from the workshops into a concrete product suggestion that could be fed back into ongoing research and innovation processes. Many ideas fell to the wayside, because they failed to carry enough support from citizens, or because they were simply impossible to realise (going against the fundamental laws of nature), or because there were no ongoing research and innovation processes to connect to (the overall assessment of the GoNano co-creation process in deliverable D4.4 provides further analysis of the various reasons why some ideas were taken up, and others weren't). But some ideas evolved over the course of the co-creation process, maturing from an initial suggestion made in the expert interviews at the beginning of the project into a highly specific proposition towards the end. The narratives below aim to illustrate that maturation process for a selection of product suggestions in each of the pilot studies.

#### **3.1 PROBING CO-CREATION IN HEALTH (1): DATA MANAGEMENT FOR THE ARTIFICIAL PANCREAS**

One of the suggestions that evolved over the course of the co-creation process was the development of a data management plan for the artificial pancreas (see figure 2 below). The idea to focus on a diagnostic and monitoring device originated from the interviews held at the beginning of the project. Experts identified three promising application areas in health for nanotechnologies: diagnostic and assistive medical devices, personalised medical treatments and regenerative medicine.

When these application areas were presented in the citizen workshops by means of scenarios, citizens predominantly paid attention to diagnostic devices and personalised medical treatments. Little attention was given to regenerative medicine. Citizens had various concerns in relation to nano-enabled monitoring devices placed in the body that continuously monitor health indicators (see the briefing report on the citizen workshops, deliverable D3.2). They appreciated how personalised medical treatment might increase a patient's autonomy, but were also concerned about the ways in which the continuous awareness of health indicators might affect the patient's well-being, and about the possible privacy and security risks in relation to the collection of sensitive personal data.

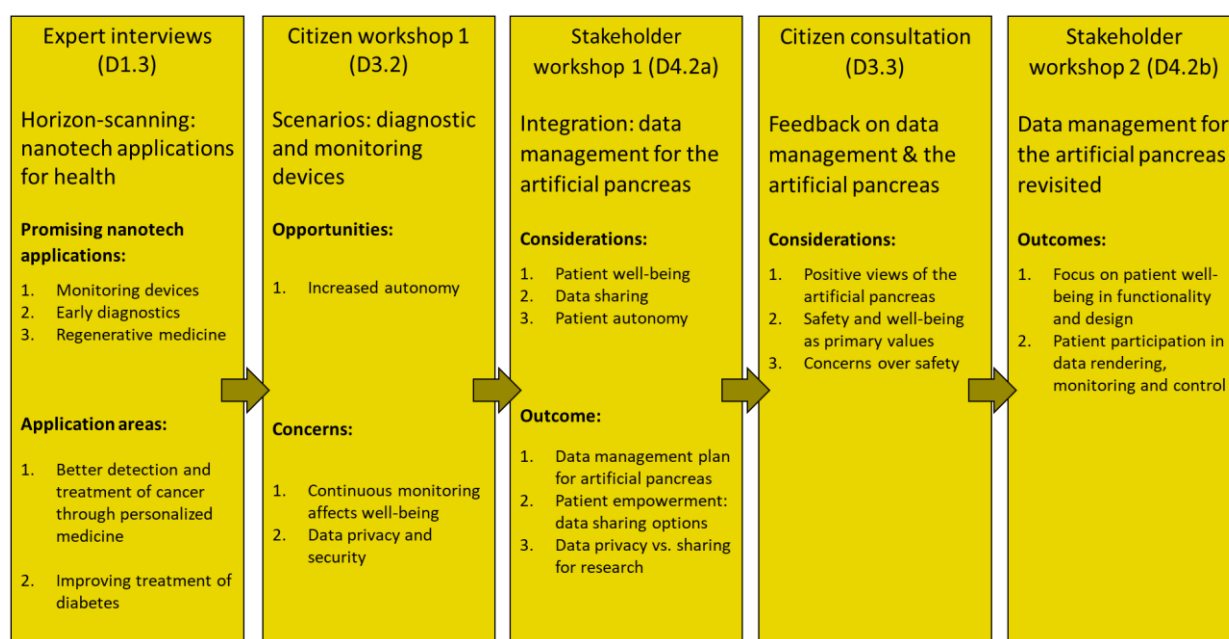
These considerations led the organisers to think about monitoring and personalised treatment as a starting point for the first stakeholder workshop. Through a series of interviews with stakeholders (including the Dutch Diabetes Fund) that might have an interest in participating in the co-creation process, the organisers heard of a start-up company that was developing an artificial pancreas for diabetes patients. The artificial pancreas is a monitoring device for diabetes type 1 patients that continuously measures glucose levels of the patients and adds insulin and glucagon when needed. The device is in its final developmental phase, just before the commercialization phase (market introduction).

Since this device falls within the promising application areas identified in the expert interviews and touches on the opportunities and barriers identified by citizens in the workshops, the artificial

pancreas was one of the applications that were discussed in the first stakeholder workshop. The business representatives were interested in discussing the possible concerns of patients about the influence of the device on their well-being through the awareness of health indicators and concerns regarding data privacy and security and the need for autonomy.

During the stakeholder workshop, which brought together representatives from the company developing this device with policymakers, CSOs, researchers and a diabetes patient, a discussion emerged about the use of the data produced by the artificial pancreas. In principle, the aggregate data from many patients could be used to optimise the administration of insulin by the device, but this would require all users to share their data. At the same time, the developers wanted to give users maximal control of their own data for reasons of data privacy and security. Concluding that there might be a tension between the two objectives (it is not guaranteed that all users will share their data for scientific purposes if they can determine who to share the data with), the workshop participants agreed that the artificial pancreas could benefit from a data management plan that maps options for data sharing (full, partial or no data sharing) against the potential effects on optimised treatment.

**Figure 2 – Evolution of the product suggestion on a data management plan for the artificial pancreas**



In the online consultation, a large group of citizens responded to the idea of the data management plan. On average, citizens were positive about the idea of the artificial pancreas, but were not convinced about the safety of it. They regarded researchers as the most important actor to tackle the safety issues. Interestingly, for the citizens who participated in the online consultation, safety and well-being were regarded as the most important values – they considered privacy and security of health data to be the least important.

Considering the different views towards data management, it was decided to focus the second stakeholder workshop again on data management for the artificial pancreas, but this time the focus was on the value of data. The same stakeholders of the first stakeholder workshop were present, as

well as a stakeholder who already used a software application with a similar function of the artificial pancreas, and a social science researcher working on data and privacy. Further opportunities and pitfalls of the data management plan were discussed, with a focus on patients' well-being. The workshop participants concluded that patients should have a say not just in question of autonomy and data sharing, but also in the way the data are rendered and visualised. The artificial pancreas was designed to take away the burden of diabetes from the patient by not displaying the data and health indicators that are being measured. However, some patients might rely on this data to feel secure and in charge. They might have a preference for displaying this data.

This example suggests that guided interactions between different types of stakeholders (in this case product developers, prospective users and researchers from related areas) can lead to insights for product design.

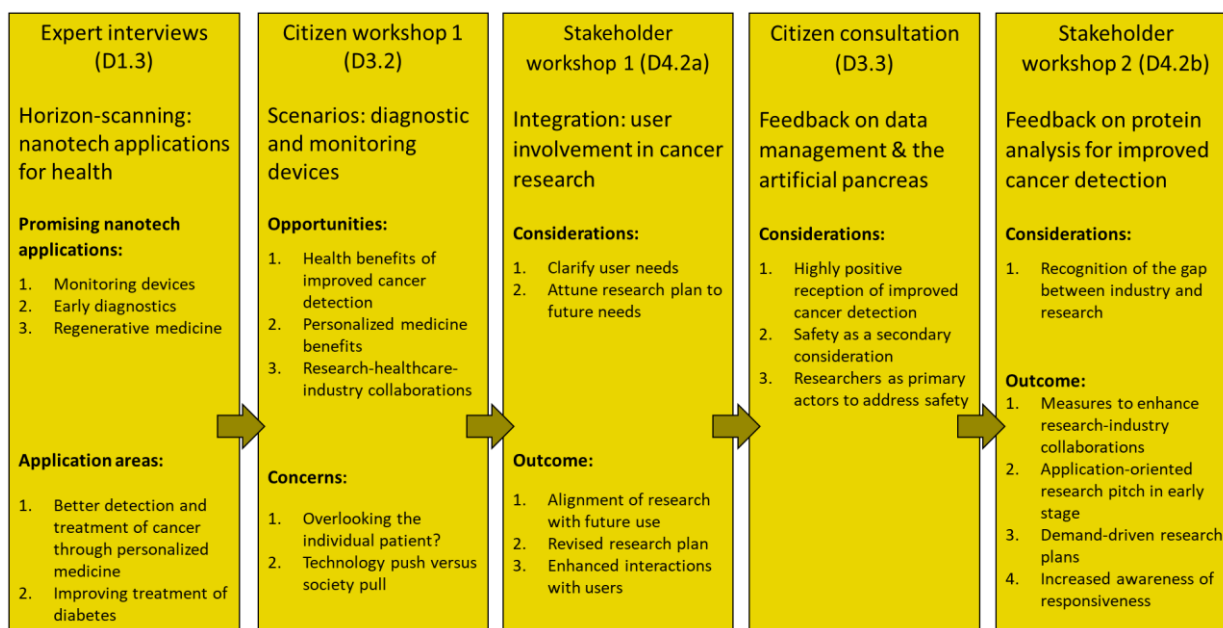
### **3.2 PROBING CO-CREATION IN HEALTH (2): WHOLE-CELL PROTEIN ANALYSIS FOR IMPROVED CANCER DETECTION**

Another suggestion that evolved over the course of the co-creation process was the idea to strengthen user-producer interactions in the development of new diagnostic tools for cancer detection. In the first citizen workshop, citizens were enthusiastic about the potential of cancer detection and treatment, which was identified as one of the promising application areas for nanotechnologies in the expert interviews held at the beginning of the project. However, citizens emphasized that developers of nanotechnologies should always keep in mind how improved diagnostics should benefit the potential users (rather than the researchers). Some citizens suggested that developers and researchers were mainly concerned with the technological potential of new medical technologies (technology push), without having in mind the 'problems' or 'issues' that should be solved (technology pull) or the patient's well-being. They emphasized that researchers should collaborate with medical professionals and industry in this regard. When they designed their 'ideal technologies' a number of citizens emphasized that, when given the choice, they would prefer in vitro diagnostic devices over in vivo devices.

These considerations were taken up in the first stakeholder workshop by focusing on the involvement of users in the development of biosensors for cancer diagnostics. The workshop organisers identified an ongoing research project within the Sensing programme of MESA+ at the University of Twente that aims to develop a medical biosensor that will measure expression levels of rare proteins in individual tumour cells. The stakeholder workshop thus brought together the post-doc researcher involved in the development of the biosensor with potential users of the technology: a cancer diagnostics researcher from the Academic Medical Centre in Amsterdam, a representative from a tech start-up developing nanosensors for detecting cancer in urine, and researchers from different disciplines with a potential interest in the biosensor.

During the workshop, the post-doc realised how early engagement with prospective users could improve the design of the sensing platform by shedding light on practical requirements: how does the platform align with current medical and research practice? What specific proteins and cancer cells should the biosensors target? How does the platform compare to existing diagnostic standards? What level of specificity and accuracy is required for the biosensor to become medically relevant and applicable? The participants agreed that further interactions with potential users to target the research and develop a concrete time-plan and budget would help to speed up the development from basic research to application.

**Figure 3 – Evolution of the product suggestion on whole-cell protein analysis for improved cancer detection**



In the subsequent online citizen consultation, a large group of citizens responded to the idea of improved cancer diagnostics through protein analysis. Citizens were most positive about this idea in comparison with all other suggestions from the GoNano co-creation process (including those within the area of food and health).<sup>9</sup> Furthermore, citizens were not very worried about the safety of the suggestion, and regarded researchers as the most important actor to tackle the safety issues. For the citizens who participated in the online consultation, safety and well-being were regarded as the most important values and autonomy of patients and privacy and security of health data the least.

During the second stakeholder workshop, the idea of user-producer interactions was developed further by exploring how industry could be productively involved in the development of medical technologies for cancer diagnostics. Stakeholders present at the workshop identified a gap between industry and research. The funding system requires involvement of private partners, which are difficult to attract for researchers who work on a technology in an early phase. They emphasized that both representatives of industry and researchers should search for shared objectives in order to bridge this gap. By including industry in the developmental process, researchers might become more aware of societal and market needs. Scientists should therefore turn research questions into a business canvas, and industry should turn business questions into research questions. Additionally, scientists should spend more time in engaging with industrial partners (e.g., through business events, disseminating their results through media outlet), or developing their research into spin-offs and SMEs. The participants made various suggestions to enhance industry relationships, including: think of a clear ‘story’ about the research that answers what’s in it for the partners and define potential application areas, identify shared objectives with industry, find potential ‘problem-owners’ and build long-term relationships with them, engage different types of potential users in

<sup>9</sup> See the briefing report on the outcomes of the citizen consultation: <http://gonano-project.eu/european-respondents-perceive-nanotechnology-positively-however-emphasize-the-efforts-to-make-the-possible-products-safe/>.

the development and explore various scenarios of the application of the technology, and take small steps when looking for funding (see GoNano deliverable D4.2).

In the evaluation interviews, the post-doc researcher emphasized the importance of including perspectives from different disciplines in product development, and welcomed the specific advice for how to get in touch with industry. Furthermore, she was able to start building her network with people she met during the co-creation process (see GoNano deliverable D4.3).

This example suggests that exposure to prospective users can help researchers tweak their research lines and prototypes according to future needs, thus facilitating the future uptake of new technologies.

### 3.3 PROBING CO-CREATION IN FOOD (1): A PACKAGING SYSTEM FOR PERISHABLE FOODS

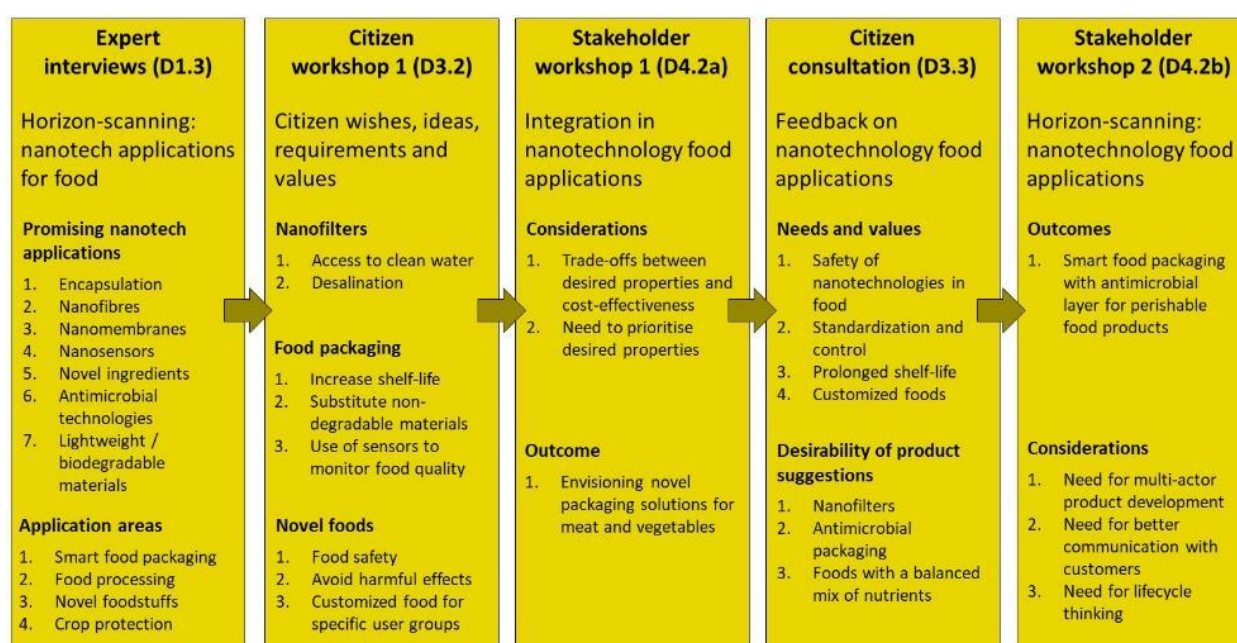
The idea to develop a packaging system for perishable foods is an example of an evolving product suggestion in the food area. In the citizen workshops on food organised in the Czech Republic, citizens came up with wishes and ideas for what they thought could result in future nanotechnology products. They connected smart food packages with their needs to have fresh and long-lasting food at the same time. Nanotechnology should provide a substitute for plastics or other non-ecological and non-decomposable packaging systems that increases shelf-life duration. The workshop participants also suggested that smart food packages should enable personalized customization of the products, using sensors to signal the freshness and safety of its content.

In the first stakeholder workshop, researchers and other stakeholders agreed that many of the needs and values expressed by citizen are contradictory: that the dominating packaging material still would have to be plastics – because of its properties or cost effectiveness. Nanotechnology itself does not change the use of conventional materials. Nanotechnology should not be perceived as a technology that works on its own, but rather a technology that is a part of a complex development of technologies. In contrast, it can lead to newly emerged (research) problems – biodegradable plastics could lead to a proliferation of plastic particles on a very small scale, leading to questions of degradability. Real advantages of using such procedures or processes should be justified and should be a part of a more deliberate approach on packaging systems, including ideas on the final disposal and re-use of the food packaging waste. The desirability of such processes was therefore still an ongoing question for some of the stakeholders. Moreover, according to some stakeholders, there is a need to decide between many of the wishes, e.g. the food staying consumable for a longer time or to be able to produce food in a more sustainable way. The participants exchanged ideas for a meat and vegetable packaging solutions. For vegetables, long lasting shelf-life would require packaging of each single vegetable product. Justifiability of such packaging system remains an important question, especially when it comes to its sustainability aspects when used on a mass scale.

In the second stakeholder workshop, participants further develop the idea that usefulness of such package would be mostly connected to easily perishable food products. The discussion narrows down the product suggestion as a two-layered smart food packaging system that would include the packaging material itself, and that would contain a second anti-microbial layer. Using various new materials is further problematized with some researchers claiming that biodegradable plastics could in the end of their lifecycle contaminate the biological waste and cause newly emerged issues. Advances in intelligent packaging solutions should therefore mind the overall lifecycle and waste management. The discussion results in a multi-track solution:

1. Multi-actor development of the products is required, as nanotechnology is only part of the development.
2. A better communication of products and packages to customers with appeal on their customer behaviour and continuous dialogue between researchers, businesses, civic organizations or the final customers of such products.
3. Improvement of current technologies – thinning down materials, adding microbiological layers on materials already in use.
4. A necessity to think through the whole lifecycle of the packaging system with the application of principles from circular economics.

Figure 4 – Evolution of the product suggestion on a packaging system for perishable foods



### 3.4 PROBING CO-CREATION IN FOOD (2): SAFETY MEASURES FOR NANOTECHNOLOGY

Another example of a maturing suggestion from the food area concerns the development safety measures for the use of nanomaterials in food. Citizens emphasised the various possible uses of novel foods based on nanotechnology: they connect the applications with effectiveness, low transportation costs, availability or possible customization by end-users, but also call attention to possible safety considerations. Citizens seem to relate these needs to potential products especially designed for specific group of customers, such as astronauts, people with allergies and specific diseases. A superfood product suggestion became the most popular idea at the citizen workshop as citizens picture superfood: a rectangle-shaped food having various shapes, taste and other properties.

During the first stakeholder workshop, stakeholders acknowledged the safety concerns of the citizens expressed at the citizen workshop. During the online consultation, citizen reconfirmed safety as the most important need and value. This was followed by the need to standardize

nanotechnology applications in food and to have an effective control system. In contrast with the outcomes of the citizen workshop, ideas for superfood were dismissed as the least desirable idea of all the food application ideas.

In the second stakeholder workshop, participants argued that superfood applications do not necessarily require nanotechnology as a method to produce this type of food products. Examples that are already in use were mentioned (such as titanium dioxide particles, or homogenized fat particles), and so were the possible negative aspects of a long-term nutrition using such products. Stakeholders were quite sceptical about the future need to develop superfoods, claiming that mostly just additives in form of nanoparticles could be useful when it comes to future nanofood applications. This is also given by the safety aspects – the fact that different shapes of nanoparticles may interact with each other or cumulate in the human body. Dangerous nanoparticles should be defined including dangerous interactions with other substances. This requires multidisciplinary analytical approaches.

**Figure 5 – Evolution of the product suggestion on safety measures for the use of nanomaterials in food**



In further discussions, stakeholders developed ideas on how to shape effective control. In comparison with the first stakeholder workshop, ideas covered the legislation aspects of the current control mechanisms more thoroughly. Participants set desirable goals and emphasized blind spots. They agree that:

1. There is a need to create a definition for nanoparticles in food, which would be placed under control.
2. Having such definition, producers of food should explicitly declare if the food product to be produced contains artificial nanoparticles. If there would be nanoparticles additives contained in a product, this should be explicitly stated by the producers. Producers should already follow given Safe-by-Design guidelines.

3. For the safety analysis of such food, a cooperation between European and state authorities and businesses is needed. Businesses should provide authorities with referential material of the products to be analysed before a large-scale production of such product.

### 3.5 PROBING CO-CREATION IN ENERGY: CAPTURING AND CONVERTING ENERGY FROM THE ENVIRONMENT FOR CLEAN STORAGE AND USE

In the co-creation workshops on energy organised in Spain, one product suggestion in particular was elaborated throughout the entire process: capturing energy from the environment and converting it to electrical energy for clean storage and use. The seeds for this suggestion can be traced back to the expert interviews conducted in the early stages of the GoNano project. Three areas of focus related to energy were identified – green energy production, portable energy devices, and energy in the home – which were presented to citizens before the citizen workshop in the form of scenarios in an information booklet (see deliverable D3.2).

Citizens at the envisioning workshop formulated several wishes for the future applications of nanotechnology in energy. These individual wishes were grouped by thematic relevance and further developed through group exercises. Some of the most frequently recurring themes that were agreed upon or positively viewed by the groups or most individuals were:

- Capturing and converting kinetic energy to electrical energy
- Adapting structures around the home to make use of renewable energy sources
- Home climate control systems
- Smart home appliances and operating systems

In the first stakeholder workshop, participants (mostly researchers from the local research community in Barcelona), were presented with several societal needs and values derived from the citizen workshop. They explored the importance and relevance of these needs and values to nanotechnology research and development and subsequently worked together to create new product suggestions in keeping with selected needs and values. The stakeholders produced high quality, descriptive storyboards that could be easily followed to explain their product suggestions. Some of the product suggestions that the stakeholders came up with were:

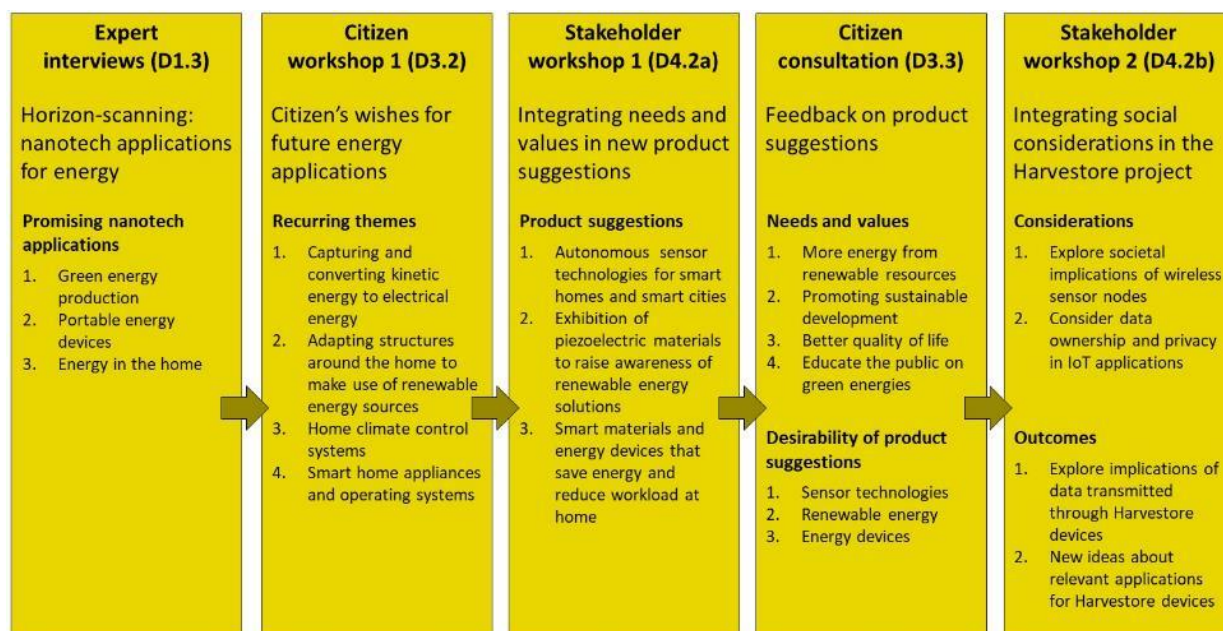
- Autonomous sensor technologies for smart homes and smart cities
- Exhibition of piezoelectric materials to raise awareness of renewable energy solutions
- Smart materials and energy devices that save energy and reduce workload at home

The validity of the product suggestions was tested by means of an online public consultation; however, neither support for, nor rejection of, such suggestions was established in this step (see the report on the online consultation, deliverable D3.3). All product suggestions were therefore presented to the stakeholder group as valid options for further elaboration in the final step of the GoNano co-creation process, the final stakeholder workshop.

The stakeholders engaged in the first stakeholder workshop were given the opportunity to continue developing the product suggestions by proposing (new or existing) projects related to the product suggestions or by simply expressing their desire to continue their involvement in the co-creative process. Deeper discussions with those stakeholders identified a principle investigator from a local research centre (IREC) who recognised the potential value that the co-creative process

could bring to one of their projects called Harvestore. The Harvestore project aims to develop materials and devices with applications as wireless sensor nodes (WSN) for the future Internet of Things (IoT), which aligned well within the product suggestions, ‘Smart materials and energy devices’ and ‘Autonomous sensor technologies’.

**Figure 6 – Evolution of the product suggestion on capturing and converting energy from the environment for clean storage and use**



Identifying the problem owner (the Harvestore project researchers) and centring the workshop agenda on co-creating within the context of the Harvestore project (i.e. identifying new WSNs for IoT) before the workshop offered a platform around which to invite relevant stakeholders and have a more focussed discussion on the impact of the ongoing and envisaged research within the project. It was during these discussions where we came closest to witnessing a tangible change in the research direction in response to considering social or environmental impacts. The Harvestore project had already considered some of the benefits its technology would bring, e.g. replacing devices reliant on Li-ion batteries with Harvestore devices would be good for the environment as the materials being used (mostly silicon and metal oxides) are more accessible and abundant than lithium. But there were some implications they had not considered, namely issues related to data ownership and data privacy in the area of IoT. The Harvestore devices are proposed as an enabling technology for the widespread adoption of IoT but the researchers had not considered the political, legal and social implications related to the data their devices would be used to record and transmit. The Harvestore researchers were open to the idea of including this as a more prominent theme to consider within the scope of the project and is something they are presently exploring. The workshop also gave them new ideas about the application areas their devices could be relevant for.

## 4. CONCLUSION

The GoNano co-creation process has produced a wealth of creative ideas for future nanotechnologies. Some 92 product suggestions have been collected over the course of the GoNano co-creation process. These suggestions vary wildly in scope and nature. Some may be optimistic, like 'Easy Paint': a paint that is permanent yet easy to remove from walls if one decides to redecorate the house. Or the 'Daily nano-tablet', a pill that treats all pains and illnesses, whatever the disease. Others are very concrete, pointing to incremental innovations in medicine, like mobile diagnostic and monitoring devices for specific afflictions. Yet others are may be appealing at first glance but prove more complicated on closer inspection like the 'Nanoslim', a sensor in a person's body that helps against obesity by releasing a substance that activates a feeling of satisfaction when it measures sensations of hunger.

Given the specific objectives and limited timeframes of the project, it was impossible to follow up on every single suggestion. Still, each of the 92 ideas could in principle serve as the start of a new cycle of co-creation – provided that one of the participants sees merit in the idea (deliverable D4.4 will provide a more elaborate assessment of the engagement process as a whole. It will also consider in further detail why some ideas were taken up and others were not, with the aim to shed further light on the preconditions for co-creation).

The co-creation process was not just intended to generate wild ideas, however. It was also meant to produce concrete 'responsive' design suggestions which can be fed back in ongoing research and innovation activities. This is why the product suggestions became more focused and directed towards concrete suggestions over the course of the events.

The selected narratives in chapter 3 suggest how a smaller number of concrete suggestions evolved over time. The product suggestions are not the "concrete" products we ambitiously envisaged at the outset of the project; however, they are the truest reflection of the GoNano co-creation process that produced them. These cases suggest that focused, guided interactions between different stakeholders can in principle lead to novel suggestions on how to integrate broader considerations in research and innovation decisions. Each pilot study offers suggestions in its own way. In the case of the artificial pancreas, the discussion led to data management considerations that may be relevant for future data sharing agreements between the producer and users of the device. For the post-doc researcher working on a biosensor for cancer diagnostics, interactions with prospective users helped shape the direction of the research. The discussions on the Harvestore project suggested how societal considerations can be productively integrated in the development of the wireless sensor nodes. The proposal for a packaging system for perishable foods can be seen as a concrete suggestion for demand-driven innovation. And the suggested safety measures for the use of nanomaterials in food are an example of how multi-stakeholder interactions can serve to provide advice to policy makers on the governance of nanotechnologies (deliverable D4.4. will consider the extent to which the workshops succeeded in promoting changes in research and innovation decisions, and will review the preconditions for enabling concrete change through co-creation).

## APPENDIX

The product suggestions made during the consecutive co-creation events of the GoNano project are reproduced below. Please see the related deliverables (the briefing report from the citizen workshops (deliverable D3.2), the report on the online citizen consultation (deliverable D3.3), and the report on the first and second rounds of stakeholder workshops (deliverable D4.2a and D4.2b, respectively)) for more detailed descriptions of how these suggestions were developed and documented.

### 1. WISHES EXPRESSED BY CITIZENS DURING THE CITIZEN WORKSHOPS

The pilot partners organised a series of face-to-face citizen workshops in the Netherlands, the Czech Republic and Spain in October/November 2018 (see the briefing report for further information on the outcomes of the citizen workshops).<sup>10</sup> Participants at the workshops formulated a number of wishes, needs and values related to the future applications of nanotechnology in health. Their suggestions are reproduced below.

Table 2 – Overview of the social needs and values coming from the citizen workshops on food, energy and health.

Social needs / values	Food	Energy	Health
Sustainability (development, consumption)	x	x	x
Affordability	x	x	x
Accessibility	x	x	x
Human health	x	x	x
Trust			x
Environmental protection	x	x	x
Respect for nature	x	x	
Family (future generation)	x		
Responsibility	x	x	x
Safety	x	x	x
Reliability	x	x	x
Openness	x	x	x
Well-being	x	x	x
Transparency	x	x	x
Recycling (circular economy)	x	x	

<sup>10</sup> <http://gonano-project.eu/wp-content/uploads/2019/02/D3.2-Briefing-report-from-the-citizen-workshops.pdf>

Water protection	x	x	
Freedom of choice		x	x
Privacy (data)			x
User-centric			x
Prevention			x
non-pervasiveness			x
Empowerment			x
Appreciation of professional role/judgement			x
Ease-of-use			x

### 1.1 CITIZENS PREFERENCES FOR NANOTECHNOLOGY APPLICATIONS IN HEALTH

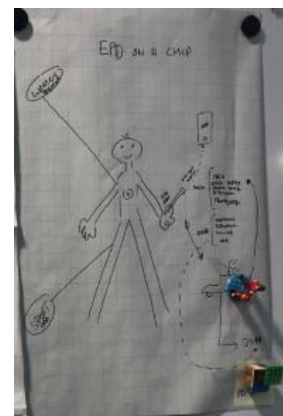
The citizen workshop focused on nanotechnology applications in health was held on November 24, 2018 in the Design Lab at the University of Twente in Enschede.<sup>11</sup> Participants formulated the following wishes, principles and rules related to the future applications of nanotechnology in health.

Wish 1	Sensorpatch	Number of votes
		30
<p><b>Reference to the application area:</b> monitoring device</p> <p>Renewable (environmentally-friendly patch) that monitors various reference values in body. The patch can be used or taken off whenever a person wants to, and it is non-invasive. The patch is connected to a smart-device.</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Non-invasive</li> <li>• Autonomy of user</li> <li>• Environmentally-friendly</li> </ul> <p>Target group: For everyone, but only by free choice</p>		

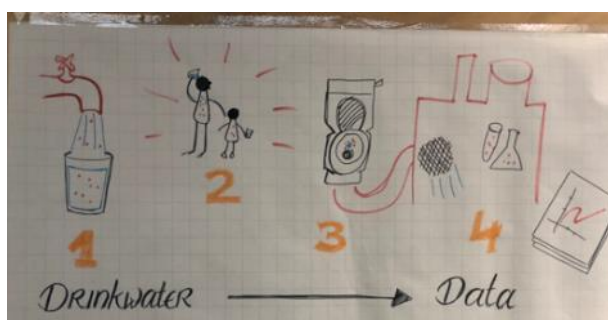



<sup>11</sup> See also this brief workshop report on the GoNano website: <http://gonano-project.eu/dutch-citizens-about-the-future-of-nanotechnology-in-health/>

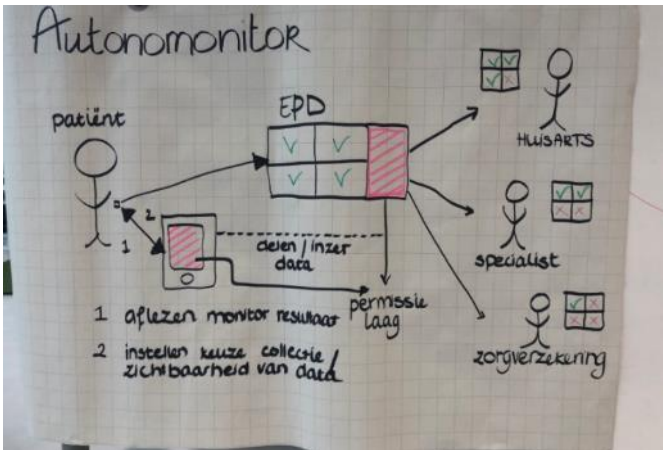
<b>Wish 2</b>	<b>Medical-record-on-a-chip</b>	<b>Number of votes:</b>
		<b>28</b>
<p><b>Reference to the application area:</b> monitoring device</p> <p><b>Description:</b>          Biometrical chip that can measure blood values, but also contains information about an individual's medical history. The chip is implanted in the fingertip. Medical data can only be read by approval of an individual, and data is encrypted. In case of emergency, healthcare professionals have access to basic information about the person on the chip (name, identity, donor, and acceptance for reanimation), and an individual can decide for allowing access to other information (medical history, allergies, etc.). Everyone should have access to the chip, but only by free choice.</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Autonomy in collection and sharing of data</li> <li>• Security of data</li> <li>• Relevant information in case of emergency</li> <li>• Unawareness of health data</li> </ul> <p>Target group: Everyone who wants to use the chip</p>		




<b>Wish 3</b>	<b>Health monitoring through urine</b>	<b>Number of votes:</b>
		<b>25</b>
<p><b>Reference to the application area:</b> monitoring device</p> <p><b>Description:</b>          A device that can be placed on toilets and measures biomarkers in urine. Data is going to a regional database, that measures and recognizes patterns of health on a regional scale. Based on these data the municipal health authority can launch targeted health campaigns, and targeted actions (e.g., regional health check). Also (potential) epidemics can be detected.</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Not individual based, but based on large amounts of data</li> <li>• Regionalized healthcare</li> <li>• Targeted campaigns</li> <li>• Early detection of epidemics</li> <li>• Pattern recognition</li> <li>• Non-invasive</li> </ul> <p>Target group:</p> <ul style="list-style-type: none"> <li>• Can be placed in public toilets</li> </ul>		




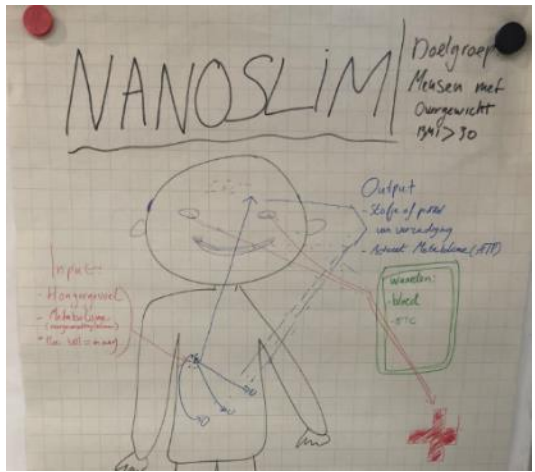
<b>Wish 4</b>	<b>Blood for blood</b>	<b>Number of votes:</b>
		<b>19</b>
<b>Reference to the application area:</b> regenerative medicine		
<p><b>Description:</b>  A medical device that generates new blood based on own blood. Through a very sensitive sensor the exact characteristics of an individual's blood can be detected. Based on these characteristics new blood can be created in an external device outside the body.</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Replacement of blood donations</li> <li>• Identical blood</li> <li>• Helps with shortage in particular types of blood</li> </ul> <p>Target group:</p> <ul style="list-style-type: none"> <li>• People who need blood (e.g. with trauma patients, accidents)</li> </ul>		
		

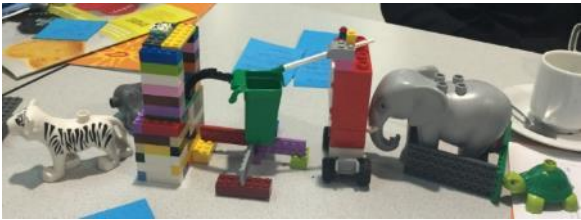
<b>Wish 5</b>	<b>Autonomonitor</b>	<b>Number of votes</b>
		<b>18</b>
<b>Reference to the application area:</b> early-detection device		
<p>Nano-chip implanted in body, which is linked to a smart device. Individual can decide which data will be collected by chip, stored and shared, through a smart device. The smart device is linked to a national electronic medical file. The individual can decide which actors have access to which data (e.g. general practitioner has access to a lot of data, while insurance company to only limited amount of data).</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Solution of discussion around electronic medical file</li> <li>• Autonomy and ownership of data by individual</li> <li>• Medical professionals are included in the healthcare process</li> </ul> <p>Target group:  Everyone, but only by free choice</p>		
		


<b>Wish 6</b>	<b>Medical POD / scanner</b>	<b>Number of votes</b>
		<b>18</b>
<b>Reference to the application area:</b> regenerative medicines / monitoring device		
<p>Cells that are generated and manipulated by adding a nano-sensor that can monitor various reference values in the body. These 'fake cells' will not be rejected by the body, and become part of your body, once injected. Data are sent to an external smart device, which is secured and only accessible by permission of the patient.</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Bodily substance</li> <li>• Not rejected</li> <li>• No nano-parts in body</li> <li>• Secure monitoring device</li> <li>• Medical professional is included in the monitoring process</li> </ul> <p>Target group: For everyone, but only by free choice</p>		
		

<b>Wish 7</b>	<b>Regenerative 2.0</b>	<b>Number of votes:</b>
		<b>14</b>
<b>Reference to the application area:</b> regenerative medicines		
<b>Description:</b>		
<p>Self-regulating cell-structure based on nanotechnology. The cell-structure monitors specific reference values and can detect a shortage of particular components (e.g., insulin, vitamins, or hormones) in the body and automatically refill these components, despite contextual factors (food, physical efforts, etc.). Data will be stored in a secured database.</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Cell-structure can be adapted and taken out of the body</li> <li>• Autonomous</li> <li>• Internal (unawareness of device/regulation mechanism)</li> <li>• Periodically check-up at GP's office</li> <li>• Won't be rejected by body</li> <li>• Half-biological (e.g. stem cells) and half smart material</li> </ul> <p>Target group:</p> <ul style="list-style-type: none"> <li>• People who have a shortage for particular components</li> </ul>		


<b>Wish 8</b>	<b>Mobile diagnostic device</b>	<b>Number of votes:</b>
		<b>13</b>
<b>Reference to the application area:</b> early-diagnostic devices		
<p><b>Description:</b>          This product is a mobile diagnostic device that can measure multiple components and can detect anomalies. It is used by medical professionals at people's homes. It is non-invasive and external, and after the diagnosis the collected data will be stored in an anonymous database for analyzing and recognizing patterns.</p>		
<p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Non-invasive</li> <li>• Interpretation by medical professionals</li> <li>• Applied in the home environment</li> <li>• Decreases burden and stress of patient/citizen</li> </ul>		
<p>Target group:</p> <ul style="list-style-type: none"> <li>• For everyone, but not obligatory</li> </ul>		
		


<b>Wish 9</b>	<b>Nano-slim</b>	<b>Number of votes:</b>
		<b>12</b>
<b>Reference to the application area:</b> monitoring device		
<p><b>Description:</b>          A sensor in a person's body that measures the feeling of hunger (either based on hormones or neurological indicators). When the feeling of hunger arises, the chip can release a substance that activates a feeling of satisfaction. Helps against obesity.</p>		
<p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Measures indicators of hunger</li> <li>• Measures metabolism</li> <li>• Output can generate a signal (to create awareness)</li> <li>• Output can generate a substance that creates metabolism</li> </ul>		
<p>Target group:</p> <ul style="list-style-type: none"> <li>• People who suffer from obesity or eating disorders</li> <li>• Diseases that slow down metabolism</li> </ul>		
		

<b>Wish 10</b>	<b>Nano-thirst meter</b>	<b>Number of votes:</b>
		<b>10</b>
<b>Reference to the application area:</b> monitoring device		
<p><b>Description:</b>          This technology is a nanochip that is implanted in the body of people who have been or are addicted to alcohol or other substances. The nano-sensor constantly monitors reference values in the body and can detect a feeling of thirstiness (longing for alcohol), before the person can feel it him or herself. When this feeling arises, a substance will be released that solves the longing for alcohol. In extreme cases, the data of the chip can be linked to a device that is monitored by a medical professional or care-giver.</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Semi-automatic behavioural change</li> <li>• Instrument for helping with recovery of an addiction</li> <li>• Focus on fysiological processes in case of addiction</li> </ul> <p>Target group:</p> <ul style="list-style-type: none"> <li>• People who have problems (are addicted to) with substances</li> </ul>		
		

<b>Wish 11</b>	<b>Remote doctor</b>	<b>Number of votes:</b>
		<b>9</b>
<b>Reference to the application area:</b> monitoring device		
<p><b>Description:</b>          Device that monitors reference values, but sends the data to the general practitioner. In case of anomalies, the general practitioner can contact the patient.</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Multi-functional</li> <li>• Intermediate role of medical professional</li> </ul> <p>Target group: Patients</p>		
		

<b>Wish 12</b>	<b>Nano-detectives</b>	<b>Number of votes</b>
		8
<b>Reference to the application area:</b> early-detection device Nano-pill with sensor that can detect anomalies in blood.  Quality of the technology: <ul style="list-style-type: none"> <li>• Multi-functional</li> <li>• No use of needles</li> <li>• Sensitive</li> </ul> Target group: People who need blood tests		

<b>Wish 13</b>	<b>Baby-tummy-registration</b>	<b>Number of votes</b>
		7
<b>Reference to the application area:</b> monitoring device  <b>Description:</b> A nano-chip that is placed in the placenta during a pregnancy and monitors the development of the baby in the mother's tummy. In case of problems or anomalies, a signal is sent to a smart device.		
Quality of the technology: <ul style="list-style-type: none"> <li>• Feeling of security during pregnancy</li> <li>• Positive for development of fetus</li> </ul> Target group: <ul style="list-style-type: none"> <li>• Pregnant women</li> </ul>		

<b>Wish 14</b>	<b>Nano-medicine</b>	<b>Number of votes</b>
		7
<b>Reference to the application area:</b> monitor  <b>Description:</b> A very thin nano-film that can be attached underneath the tongue. In case of a migraine attack, the film can release immediately a medicine.		
Quality of the technology: <ul style="list-style-type: none"> <li>• A sensor is placed in the film that can signal the beginning of a migraine attack</li> </ul> Target group: <ul style="list-style-type: none"> <li>• People with migraine</li> </ul>		

Wish 15	Nanosensors for population studies	Number of votes
		5

**Reference to the application area:** monitoring device

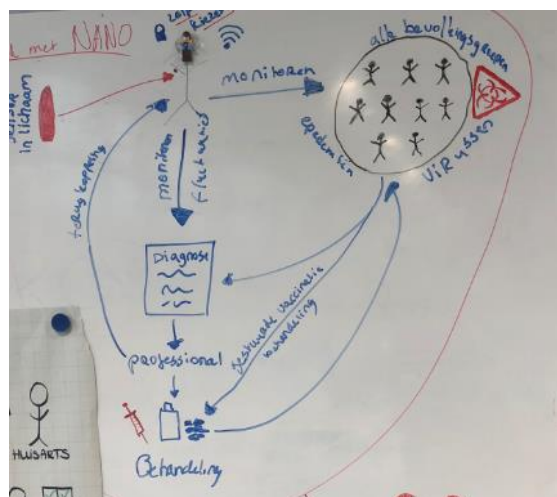
Nano-chip implanted in body to monitor for diseases. Data is linked to a database of professional, which is linked to a large national database. Individual does not need to worry for interpreting data, when something is wrong medical professional will give a signal. Large scale database can be used to detect epidemics and viruses.

Quality of the technology:

- Medical professional is included in monitoring process
- National database with a lot of information
- Detection of epidemics


Target group:

For everyone, but only by free choice



## 1.2 CITIZENS PREFERENCES FOR NANOTECHNOLOGY APPLICATIONS IN FOOD

The citizen workshop in Prague was organised by TC CAS on 20 October 2018.<sup>12</sup> The participants suggested the following wishes for possible future development:

Wish 1	Nanococktail	Number of votes:
		42
<b>Reference to the application area:</b> Novel foods		
<p><b>Description:</b></p> <p>This product is a complex nutrient providing customer with a complex diet. The quantity of the nutrient equals one swallow. The content of the nutrient is optimized for a certain group of people, it is possible to personalize it. The package (can, capsule, gift package) has specific colors, it is selfcleaning and selfdegradable.</p> <p>Quality of the technology:</p> <ul style="list-style-type: none"> <li>• Cheaper production in the case of a can</li> <li>• More expensive production in the case of a selfdegradable (biodegradable) package</li> </ul> <p>Given use of the nanotechnology deals with the according problems:</p> <ul style="list-style-type: none"> <li>• The effectiveness of packages contributes to smaller amount of overall waste</li> <li>• Decreases emissions during the production and waste management</li> <li>• Decreases the time needed for the preparation of cocktail</li> <li>• Helps to increase the profit of the companies decreasing the overall sickness rate and increasing the overall effectivity of the employees</li> <li>• It supports the possibility of shortening the working hours (with increased effectivity), which would mean cost savings in electricity, commodities etc.</li> <li>• Decreasing importance of the traditional medicines</li> </ul> <p>Situations to-be-used in:</p> <ul style="list-style-type: none"> <li>• Critical situations – wars, floods, earthquake, epidemics</li> <li>• In hospitals, institutions for long-term sicknesses, senior houses</li> <li>• For prevention in schools and nursery schools</li> <li>• In stressful work positions – workers (in car industry, Amazon etc.), at the ministry (politicians), mobile operators workers, bank officers</li> <li>• Top sportsmen</li> <li>• Maintaining a good health condition</li> </ul> <div data-bbox="938 1509 1334 1767" data-label="Image">  </div> <p>Target groups:</p> <ul style="list-style-type: none"> <li>• Men, women, children, sportsmen, pensioners, ill (according to further specifications) and other specific groups of people</li> </ul>		

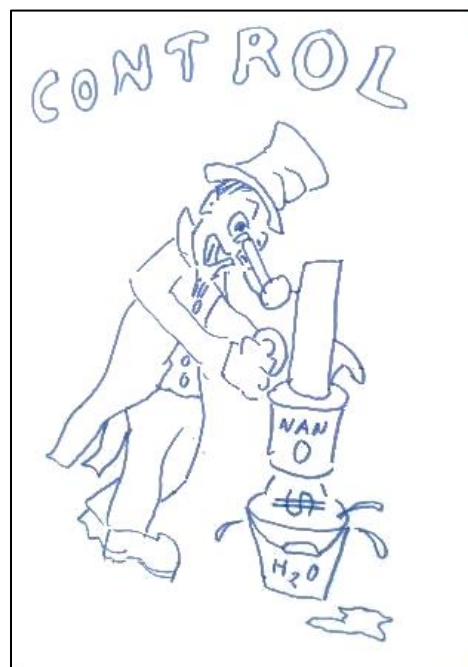
<sup>12</sup> See also this brief workshop report on the GoNano webpage: <http://gonano-project.eu/prvni-ceska-obcanska-konzultace-o-nanotechnologiiich-v-potravinarstvi/>.

Wish 2	Control of misuse of nanotechnologies in food	Number of votes:
		39

Reference to the application area: General wish

**Description:**

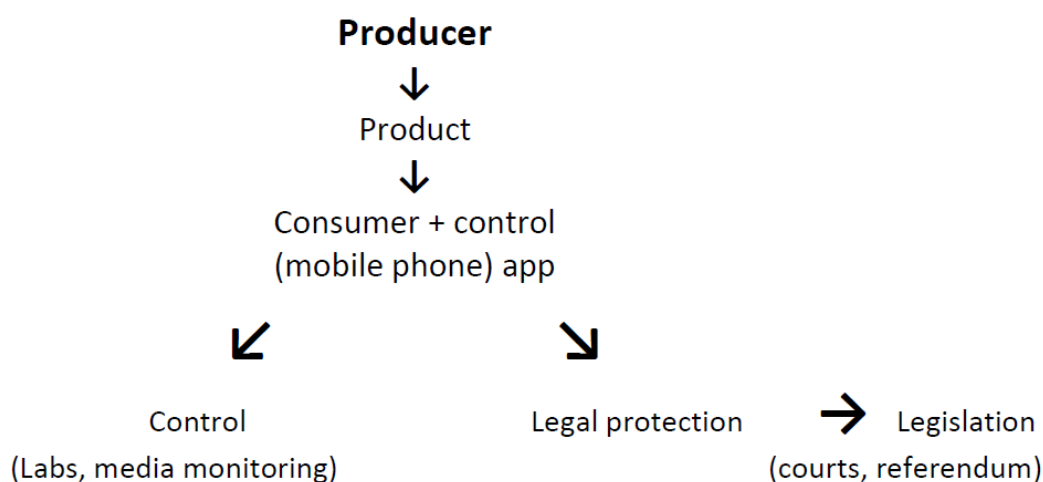
It is necessary to develop control mechanisms in parallel to the development of nanotechnologies – mainly through generally used mobile applications, from which it is possible to transfer the data to control labs. Outcomes from this analysis might be used as an input to a state supervision which would regularly present its findings in media for potential legislative changes. These changes shall lead to control and ensuring impossibility to misuse the technologies. In case of wider / national impact of nanotechnologies (e.g. on water cleaning) it is necessary to make such decisions through a referendum.

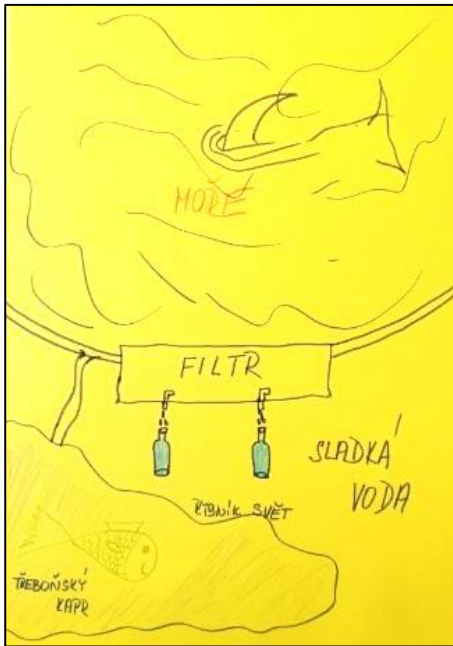


These technologies and their potential side effects must be eliminated in order to avoid:

- a) collapse of the system in emergency situations
- b) latent contaminations of the system by nanotechnologies as well as
- c) wider / national effects of such technological failures.

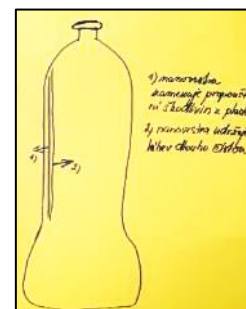
Control system, based on subsidiarity – on the level of the smallest self-governing units as possible, shall be functional for this purpose.



<b>Wish 3</b>	<b>Desalinator 3000 – Filter for desalination the seawater</b>	<b>Number of votes:</b>
		<b>35</b>
<b>Reference to the application area:</b> Nanofilters		
<p><b>Description:</b></p> <p>This product reacts on growing lack of drinking and service water and limited (bad) access to water in general, mainly due to climate change. Desalinator 3000 can desalinate the sea water and remove its pathogens thanks to the use of nanofilters. A related application is nanofilter for cleaning the contaminated water.</p> <p>It's use is wide:</p> <ul style="list-style-type: none"> <li>• Citizens of the third world, affected by catastrophic drought</li> <li>• Submarines crews as a tool for gaining the drinking water</li> <li>• Agriculture</li> <li>• Urban environment: maintenance of green areas as well as streets</li> <li>• Industrial production</li> <li>• Prospectively: afforestation of the Sahara</li> </ul>		



<b>Wish 4</b>	<b>Super water</b>	<b>Number of votes:</b>
		<b>34</b>
<b>Reference to the application area:</b> Nanofilters		
<p><b>Description:</b></p> <p>This product is a multi-functional Nanofilter for the water filtration. It is independent on any energy source, user friendly and affordable. Filter can be portable. It's function is to:</p> <ul style="list-style-type: none"> <li>• Produce high quality drinking water</li> <li>• Edit it according to requests (add minerals, vitamins, ions, ...)</li> </ul> <p>Use and benefit:</p> <ul style="list-style-type: none"> <li>• All the population</li> <li>• It shall solve the lack of water in the future (it shall prevent from possible global conflicts)</li> </ul> <p>This Nano filter can be used for all, even service water. Anyway, it is necessary to ensure it's 100% health harmlessness and find out the real impact on human health and environment (cumulation of nanoparticles, life cycle of nanoparticles).</p> <p>It will be possible to ecologically eliminate the Nano filter after the lifetime date.</p>		

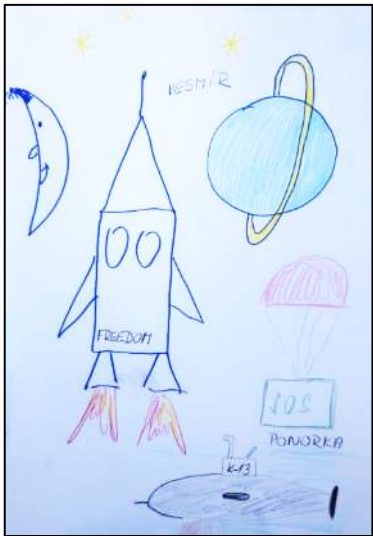

<b>Wish 5</b>	<b>Drink without worries</b>	<b>Number of votes:</b>
		<b>29</b>
<b>Reference to the application area:</b> Intelligent food packages		
<p><b>Description:</b></p> <p>This product is a food package ensuring longer durability of food. It is resistant, recyclable (usable more times), decomposable (nanoparticles accelerate the decomposition process) and it's shape adapts to concrete foodstuff. Product is affordable.</p> <p>It's further functions are the following:</p> <ul style="list-style-type: none"> <li>• It indicates the end of durability of the food to the customer through a change of colour of the packaging</li> <li>• It controls it's own harmlessness</li> <li>• It avoids secretion of harmful substances</li> </ul> <p>It's use has a positive effect on environment thanks to (i) lower material demands (and through that also lower materials consumption), (ii) lowering the amount of other packages, mainly plastic ones. In the end it leads therefore to lowering of ecological trace, eliminates the transmission of substances from packages to the food.</p> <p>Target groups:</p> <ul style="list-style-type: none"> <li>• Sportsmen and sportswomen</li> <li>• Children.</li> </ul>		



<b>Wish 6</b>	<b>Nano-bal (IQ bal)</b>	<b>Number of votes:</b>
		<b>28</b>
<b>Reference to the application area:</b> Intelligent food packages		
<p><b>Description:</b></p> <p>This product is a smart package which can be used mainly in the food area, where people produce all food packages. The plastic bottles, sachets, bags etc. will not be used anymore. This nano-package is able to monitor the durability of the product (in the form of colour scale of the traffic lights). By using this product, there is no remaining waste (namely plastics) – it is 100 % recyclable, it can be used in composting where it biologically decomposes and it becomes fertilizer.</p> <p>The time of it's durability is possible to regulate according to the type of product and the way of its usability thanks to so called accelerator in a powder form, which enables the package to decompose within a few months).</p> <p>Product is a benefit for:</p> <ul style="list-style-type: none"> <li>• End users (quick orientation in the time of durability products)</li> <li>• Store chains (dtto)</li> <li>• Farmers (source of fertilizer)</li> <li>• Next generations (sustainability of landscape, inner waters will not be contaminated by pesticides).</li> </ul>		



<b>Wish 7</b>	<b>Nano spray</b>	<b>Number of votes:</b>
		<b>26</b>
<b>Reference to the application area:</b> Intelligent food packages		
<p><b>Description:</b></p> <p>The product is recyclable (decomposable) type of food package in spray, which aims at ensuring quality and durability of food during transport). By its character it will also contribute to lowering negative impacts on the environment. Package is affordable for wider public.</p> <p>Usage (based on various food types) mainly during natural disasters in affected areas:</p> <ul style="list-style-type: none"> <li>• Spray on food packages</li> <li>• Spray on food itself</li> </ul>		
		


<b>Wish 8</b>	<b>Strategic food</b>	<b>Number of votes:</b>
		<b>26</b>
<b>Reference to the application area:</b> Novel foods		
<p><b>Description:</b></p> <p>Product is a novel type of food in form of small cubes of standart size, various colours a various flavours, packed in nano foils.</p> <p>Advantage of this novel food is the simplicity of their transport, storage, harmless, balance and variety of the content, simple and quick preparation, durability and low weight.</p> <p>Usage:</p> <ul style="list-style-type: none"> <li>• Deliveries for Integrated rescue system units</li> <li>• Deliveries during catastrophes</li> <li>• Deliveries for the army</li> <li>• Expeditions</li> <li>• Prospectively it can be used in ordinary life. Also the product can be modified to the form of nano cigarettes.</li> </ul>		
		

<b>Wish 9</b>	<b>Clean water for everyone</b>	<b>Number of votes:</b>
		<b>17</b>
<b>Reference to the application area:</b> Nanofilters		
<p><b>Description:</b></p> <p>This product (nano filter) has wide usage – from central level as filter for cleaning wastewater to local level as filter cleaning water in households.</p> <p>Nano filter is affordable for the majority of population and it is used on the following levels:</p> <ul style="list-style-type: none"> <li>• Central / national, on the level of wastewater treatment plant and waterworks.</li> <li>• Industry – nano filters would be legally binding for business companies (mainly in chemical and automotive industry) and for power stations. In this case the nano filters would not be used just for the water filtration but they would have even wider usability – they would avoid leakage of pollutants from chimneys and they would be added to every car.</li> <li>• Households – every house will have it’s own water cleaner with nano filters which will filter even the rain water. Nano filter will get rid of viruses, bacteria and mechanical impurities from the water.</li> </ul> <p>Filter works the way that at the same time it keeps healthy minerals in the water. This product is affordable for people from developing countries or people living in worse and more demanding conditions.</p> <p>This product will significantly contribute to global solution of water cleaning and it will decrease the expenses for the availability of drinking water. It will also contribute to decrease of health risk caused by bad quality of water.</p>		

### 1.3 CITIZENS PREFERENCES FOR NANOTECHNOLOGY APPLICATIONS IN ENERGY

The citizen workshop on energy was held on 26 October 2019 in Barcelona, Spain.<sup>13</sup> Participants at the deliberating and envisioning workshop formulated the following wishes for the future applications of nanotechnology in energy. The first four wishes were produced by each of the four tables of participants working in groups, with the most popular wish being identified by a plenary vote. The other wishes were produced separately by the individuals at each table, with the most popular of those wishes forming the basis of the group wish.

#### 1.3.1 Group wishes

<b>Wish 4</b>	<b>Title: PUSH (Power Unit Surface Hub)</b>	<b>Number of votes:</b> <b>13</b>
<b>Reference to the application area:</b> NA (Portable energy devices / Green energy production)		
<p><b>Description:</b> The power of contact! Generate your own energy. Power your devices.</p> <ul style="list-style-type: none"> <li>• Generates energy through contact, pressure, or movement.</li> <li>• Flexible.</li> <li>• Resistant.</li> <li>• Adaptable to any size.</li> <li>• Versatile.</li> <li>• Sensitive to different modes of movement and grades of pressure.</li> <li>• Nanostructured materials.</li> <li>• Multilayer system contains a protective isolating layer, a contact layer, a pressure sensing layer, conducting gel layers, and a storage layer.</li> </ul> 		

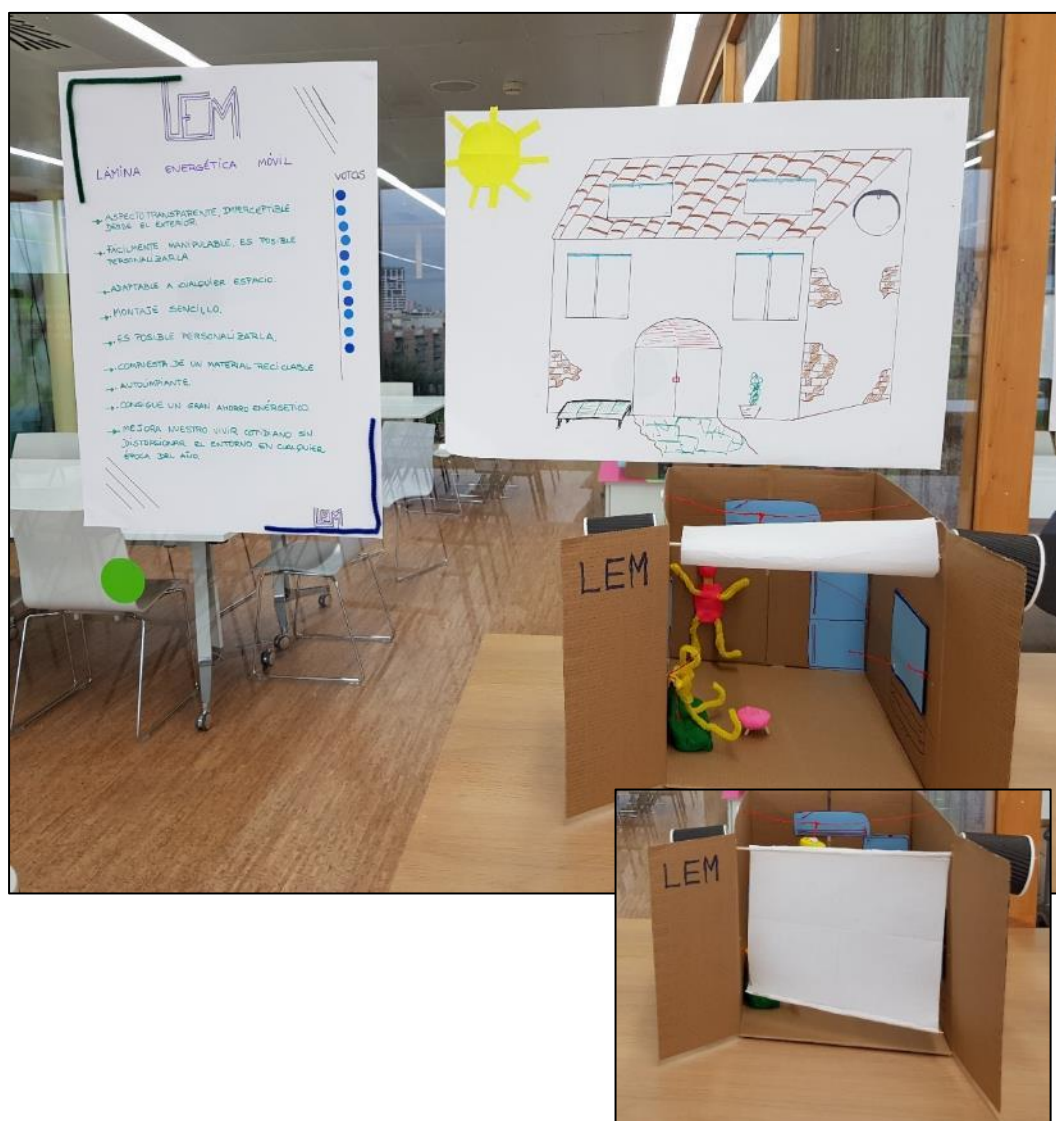
<sup>13</sup> See also this brief workshop report on the GoNano website: <http://gonano-project.eu/valuable-contributions-during-citizen-workshop-on-energy-at-rmit-barcelona/>

<b>Wish 1</b>	<b>Title: MES (Mobile Energetic Sheet)</b>	<b>Number of votes:</b>
		<b>11</b>

**Reference to the application area:** NA (Energy in the home / Green energy production)

**Description:**

- Transparent appearance, unnoticeable from outside.
- Lightweight and rollable.
- Easily to use and possible to personalise.
- Adaptable to any space.
- Easy to mount.
- Made from recycleable materials.
- Self-cleaning.
- Blocks infra-red. Capures solar energy. Results in huge energy savings.
- Improves our daily lives without disrupting the surroundings at any time of the year.



Wish 3	Title: Internet of Energy	Number of votes:
		11

Reference to the application area: NA (Green energy production)

**Description:**

Develop energy generating and energy harvesting systems that are collaborative, efficient, economical, non-contaminating, and not harmful to health.

- The network includes all types of energy that is sustainable and not harmful to health.
- Collaborative model (autoproduction plus public and private participation).
- System supervised and regulated by the government.
- Incorporates the latest materials available and encourages reduced energy consumption.

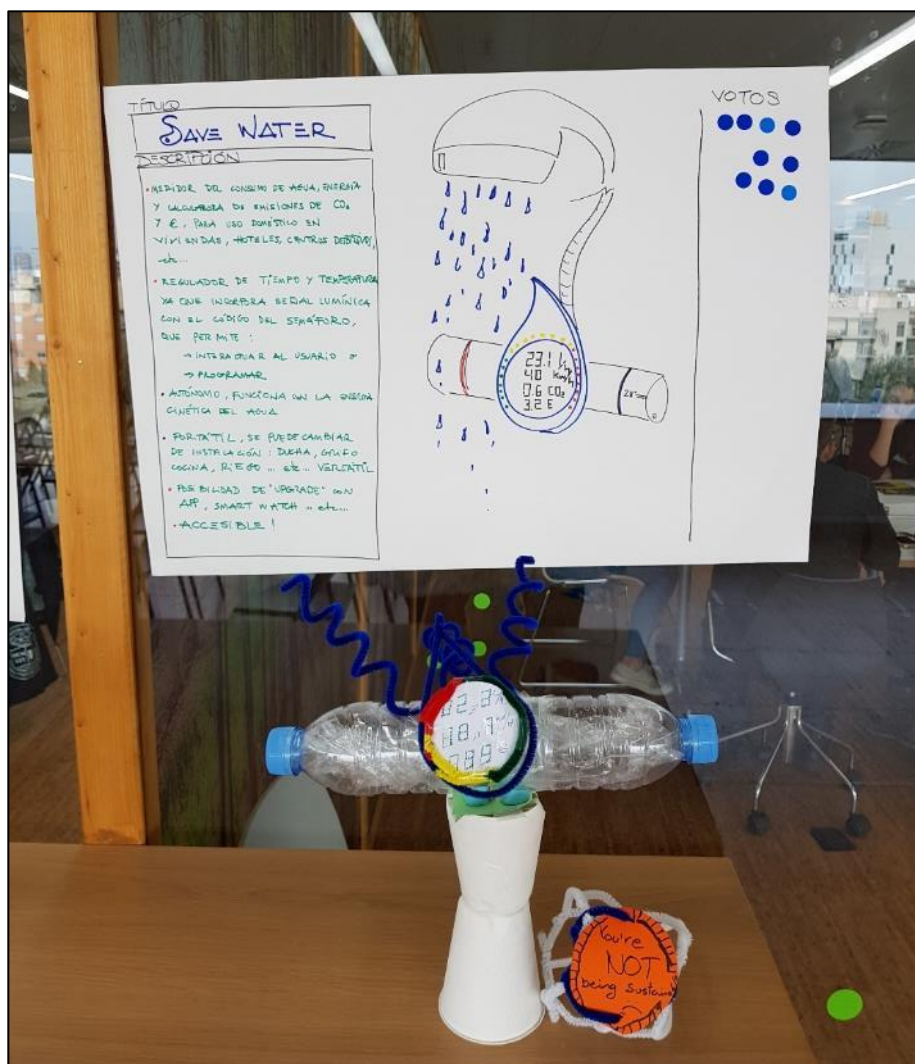


Wish 2	Title: <b>Save Water</b> (initial title: Smart-Eco-Live)	Number of votes:
		9

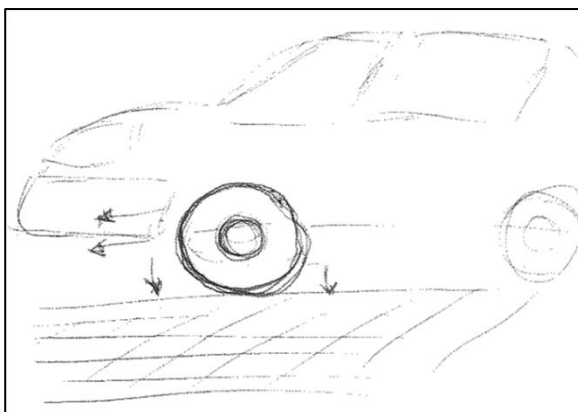
Reference to the application area: NA (Energy in the home / Green energy production)


**Description:**

- Meter for measuring consumption of water and energy, and calculator of CO<sub>2</sub> emissions and costs (€).
- For domestic (and commercial) use in homes, hotels, sport centres, etc.
- Regulates time and temperature through its traffic-light indicator system, which also allows user interaction and programming.
- Automated and works using the kinetic energy of the flowing water.
- Portable and versatile: One can easily move it from one place to another e.g. shower, kitchen tap, garden hose, etc.
- Programmable: Possibility to enhance with the additional App and smart watch compatibility.
- Economically accessible.

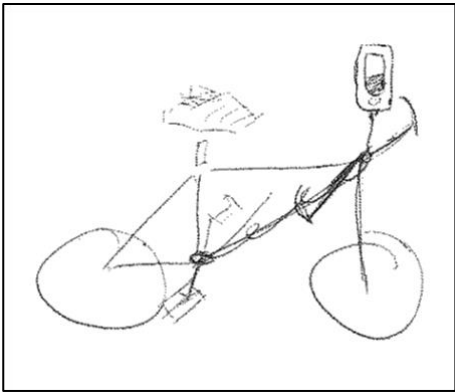


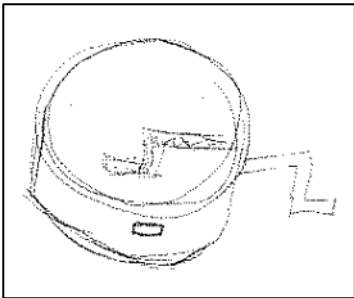
### 1.3.2 Individual Wishes


<b>Wish 4.10</b>	<b>Title: Energy capture and generation for surfaces</b>	<b>Number of votes:</b>
		<b>5</b>
<b>Reference to the application area:</b> NA (Portable energy devices / Green energy production)		
<p><b>Description:</b></p> <ul style="list-style-type: none"> <li>• Material that produces or captures energy in response to pressure or manipulation.</li> <li>• Covers paths, pavements, roads, general ground surfaces.</li> <li>• Clean, efficient, renewable energy within everyone's reach.</li> <li>• Wireless devices for distribution or connection.</li> </ul>		
		

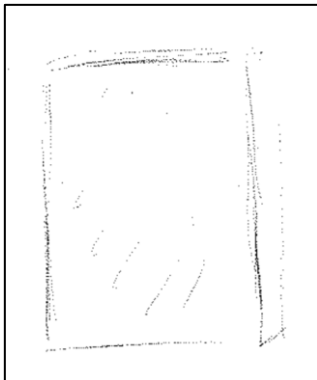
<b>Wish 2.8</b>	<b>Title: We are energy</b>	<b>Number of votes:</b>
		<b>3</b>
<b>Reference to the application area:</b> NA (Portable energy devices / Green energy production)		
<p><b>Description:</b></p> <p>Urban structures that generate (and store) electricity. E.g. children's parks (slides, paving).</p>		
		

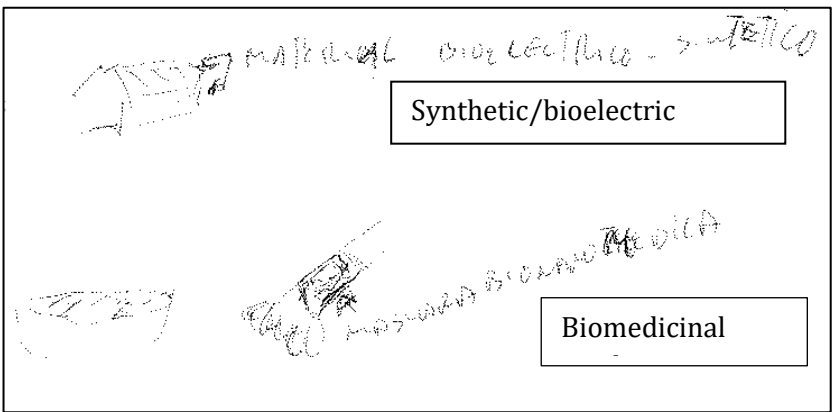
<b>Wish 3.3</b>	<b>Title: Constant energy without wires</b>	<b>Number of votes:</b>
		<b>5</b>
<p><b>Reference to the application area:</b> Energy harvesting systems, recuperation of personal energy and energy in the home. (Portable energy devices / Energy in the home / Green energy production)</p> <p><b>Description:</b></p> <ul style="list-style-type: none"> <li>• Development of systems for energy harvesting and generation for personal use and use around the home.</li> <li>• For mobiles, watches, and personal devices through clothes or portable devices.</li> <li>• For the home through panels, paint, or economic and sustainable decorations installed in the buildings.</li> <li>• Must demonstrate that the systems have a minimal effect on health.</li> </ul>		

<b>Wish 2.4</b>	<b>Title: Plug-in charger for bicycles</b>	<b>Number of votes:</b>
		<b>2</b>
<p><b>Reference to the application area:</b> NA (Portable energy devices / Green energy production)</p> <p><b>Description:</b> A charger to attach to your bicycle so that you can charge your phone when you pedal.</p>		
		

<b>Wish 2.3</b>	<b>Title: Electric charger with a dynamo and/or kinetic sensor</b>	<b>Number of votes:</b>
		<b>2</b>
<p><b>Reference to the application area:</b> NA (Portable energy devices / Green energy production)</p> <p><b>Description:</b> A portable device that can accumulate the kinetic energy from carrying it around with you.</p>		
		

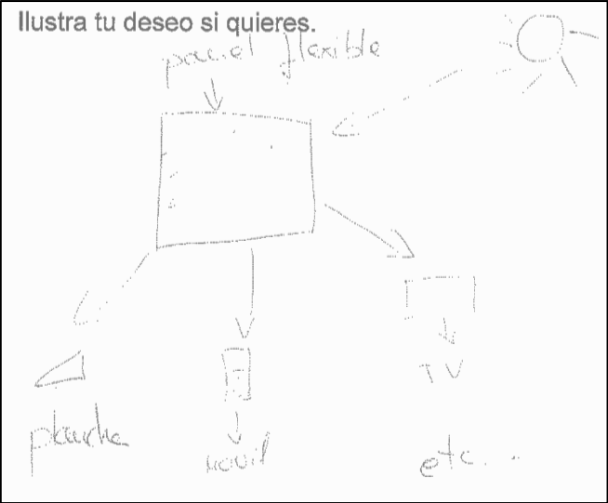
<b>Wish</b> 4.4	<b>Title: Energy-to-go</b>	<b>Number of votes:</b> 1
<b>Reference to the application area:</b> Solar energy (Portable energy devices / Green energy production)		
<p><b>Description:</b> Fibrous material that could be used to make clothes. This material absorbs sunlight and converts it to electricity that can be used to charge devices on-the-move. This material could be used to make any type of clothing.</p> <div data-bbox="815 521 1353 1205" style="border: 1px solid black; padding: 5px;"> <p>Ilustra tu deseo si quieres.</p>  </div>		

<b>Wish</b> 1.10	<b>Title: Mobile Energetic Sheet</b>	<b>Number of votes:</b> 8
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<p><b>Description:</b> I am referring to the possibility to use the energy around the home and condition it to be seasonal. This would help to eliminate in part the dependence on electrical energy and not generate as much waste.</p> <ul style="list-style-type: none"> <li>• Reasonable set-up procedure and cost (understanding that it will be an investment).</li> <li>• Recyclable material.</li> <li>• Adequate durability.</li> </ul> <div data-bbox="1045 1559 1362 1937" style="border: 1px solid black; padding: 5px;">  </div>		

<b>Wish</b> 4.8	<b>Title: Comfort and health</b>	<b>Number of votes:</b>
		5
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<b>Description:</b>		
<ul style="list-style-type: none"> <li>i. Material for auto-consumption/production of energy at home. Roofs and walls capable of generating electricity.</li> <li>ii. Masks or creams with biotechnology capable of controlling certain illnesses and eliminating viruses.</li> </ul>		
		

<b>Wish</b> 2.7	<b>Title: Eco smart building</b>	<b>Number of votes:</b>
		3
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<b>Description:</b>		
<ul style="list-style-type: none"> <li>• Intelligent building that produces 100% of its energy from renewable sources.</li> <li>• Transparent windows covered with solar panels with regulators to control the temperature inside (no need for AC/heating).</li> <li>• Bricks (and construction materials in general) that convert solar energy to electrical energy.</li> <li>• Integration of wind energy on rooftops and terraces where solar panels cannot be placed – on the condition that there is no environmental impact.</li> <li>• Better air conditioning/heating for buildings with better materials without increasing the energy used.</li> </ul>		

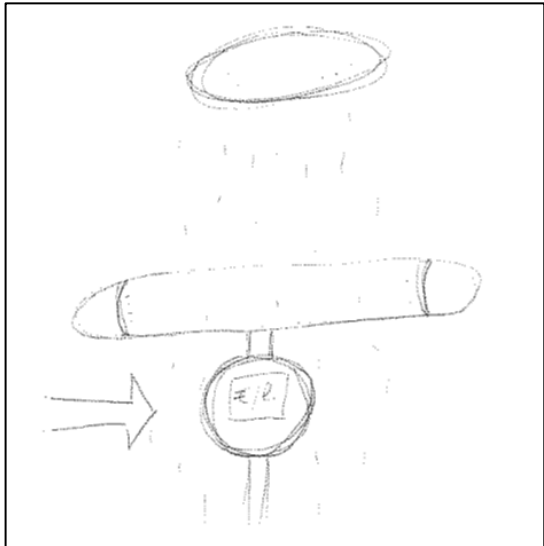
<b>Wish 2.6</b>	<b>Title: Continuous natural light</b>	<b>Number of votes:</b>
		<b>3</b>
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<b>Description:</b> Diurnal: Internal lighting that takes advantage of the natural light energy.  Nocturnal: Internal and external lighting using the energy stored during the day.		

<b>Wish 1.1</b>	<b>Title: Flexible panels with nanotechnology installation</b>	<b>Number of votes:</b>
		<b>0</b>
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<b>Description:</b> To take advantage of the sunlight reaching my home, I would like to be able to install an awning or array of panels that could capture the energy from the solar radiation and transform it into energy I could use for the appliances around the house.		
 <p>Ilustra tu deseo si quieres.</p> <p>Diagram description: A hand-drawn sketch titled 'Ilustra tu deseo si quieres.' shows a central box labeled 'panel flexible'. An arrow points from a sun icon to the box. Three arrows point from the box to three separate icons: a 'plancha' (toaster), a 'móvil' (mobile phone), and a 'TV etc.'. The drawing is done in pencil on a white background.</p>		

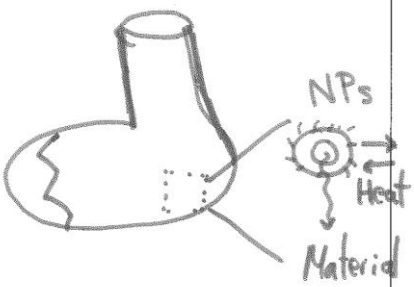
<b>Wish 4.2</b>	<b>Title: Sunflower roofs</b>	<b>Number of votes:</b>
		<b>0</b>
<b>Reference to the application area:</b> Solar panels (Energy in the home / Green energy production)		
<b>Description:</b> Create solar roofs capable of following the Sun to always receive the maximum amount of light possible.		


<b>Wish 3.2</b>	<b>Title: Free energy</b>	<b>Number of votes:</b>
		<b>2</b>
<b>Reference to the application area:</b> Batteries (Portable energy devices / Green energy production)		
<b>Description:</b>		
<ul style="list-style-type: none"> <li>• A system for storing electrical energy that is compatible with solar energy.</li> <li>• More promotion from the governments to change the energy model. Taxes, subsidies.</li> </ul>		

<b>Wish 1.2</b>	<b>Title: Independent</b>	<b>Number of votes:</b>
		<b>0</b>
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<b>Description:</b>		
<ul style="list-style-type: none"> <li>• Possibility to store energy that can then be used when needed but general supply is low. E.g. keep fridge running during power cuts.</li> <li>• It could be that the energy is stored externally or perhaps the fridge could be capable of storing it or recovering it from somewhere else.</li> </ul>		

<b>Wish 2.9</b>	<b>Title: Water meter</b>	<b>Number of votes:</b>
		<b>5</b>
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<b>Description:</b>		
<ul style="list-style-type: none"> <li>• Powered by kinetic energy, taking advantage of the flowing water.</li> <li>• Apparatus that helps to control (reduce) the cost and quantity of water used while showering</li> </ul>		
		

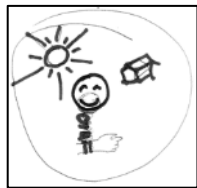
<b>Wish</b> 2.5	<b>Title:</b> NA	<b>Number of votes:</b>
		2
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<b>Description:</b> An application for climatizing the home that links costs with internal climate.		

<b>Wish</b> 4.6	<b>Title:</b> Core socks	<b>Number of votes:</b>
		4
<b>Reference to the application area:</b> Textiles (Portable energy devices / Green energy production)		
<b>Description:</b>		
<ul style="list-style-type: none"> <li>• Heat regulating socks.</li> <li>• Material with bistability in heat capacity.</li> <li>• Depending on body temperature, the socks transmit or absorb heat.</li> </ul>		
 <p>SOCKS. Calor que genera cuerpo Almacenamiento → liberación</p>		

<b>Wish</b> 1.8	<b>Title:</b> Magic paint	<b>Number of votes:</b>
		4
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<b>Description:</b>		
<p>Transparent coating so as to avoid any aesthetic problems or incompatibility issues with other decoration. It insulates the home from the heat and the cold, resulting in lower running costs for the home.</p>		

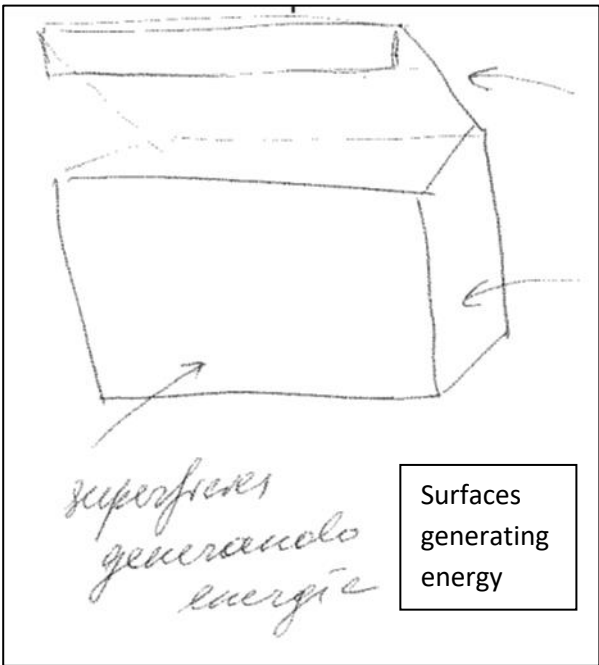
<b>Wish 1.9</b>	<b>Title: Easy paint</b>	<b>Number of votes:</b>
		<b>1</b>
<b>Reference to the application area:</b> NA		
<b>Description:</b> When one applies normal paint to walls in the home it is almost permanent because it is so difficult to remove. It would be good to have a paint that is easy to apply and to remove.		

<b>Wish 1.12</b>	<b>Title: No title</b>	<b>Number of votes:</b>
		<b>3</b>
<b>Reference to the application area:</b> NA		
<b>Description:</b> I continue to think that I am not very technologically minded. Technology is very good for many things but in the end there are also secondary effects. I would like new technologies to not generate so much waste.		

<b>Wish 3.4</b>	<b>Title: 100% natural energy</b>	<b>Number of votes:</b>
		<b>3</b>
<b>Reference to the application area:</b> NA		
<b>Description:</b> I wish that the production of energy and the science behind it would not affect my health or not create an unhealthy atmosphere/environment. I think the key could be in the transformational moment for storage. This way one won't harm the environment		
		

<b>Wish 1.7</b>	<b>Title: Eco home</b>	<b>Number of votes:</b>
		<b>2</b>
<b>Reference to the application area:</b> NA (Energy in the home)		
<b>Description:</b> <ul style="list-style-type: none"> <li>• System for the entire home, optimizing energy, cleanliness, and comfort.</li> <li>• Different unnoticeable and intuitive applications that make the home a better space to live in.</li> <li>• Fully incorporated within the entire house, in any space, on any surface.</li> <li>• Spray-on?</li> </ul>		


<b>Wish</b> 1.11	<b>Title: Eco mobility</b>	<b>Number of votes:</b>
		2
<b>Reference to the application area:</b> NA (Energy in the home)		
<b>Description:</b> <ul style="list-style-type: none"> <li>• Eliminate heating appliances within the home (radiators, boilers, mini-splits etc.)</li> <li>• Reduce consumption of energy in the home, improve insulation, and make the production of energy more efficient.</li> <li>• Mobility without creating a need for energy. E.g. electric skates and bicycles.</li> </ul>		

<b>Wish</b> 4.5	<b>Title: E-box</b>	<b>Number of votes:</b>
		1
<b>Reference to the application area:</b> NA (Portable energy devices)		
<b>Description:</b> A box for charging any type of electronic device (e.g. smart phone, laptop, e-reader). All surfaces of the box are active i.e. you can put your device inside or on top of the e-box and it will charge without having to plug anything in.		
		

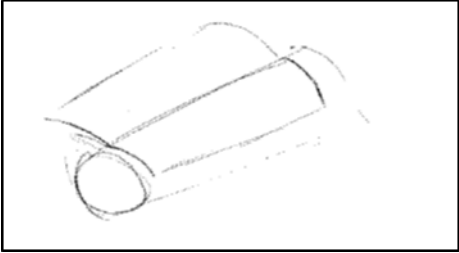
<b>Wish</b> 3.1	<b>Title: Fresh breezy home</b>	<b>Number of votes:</b>
		1
<b>Reference to the application area:</b> NA		
<b>Description:</b> It would be wonderful to have a single technology adapted to the variations in the climate all year round, especially where there are four seasons. In this way we can protect ourselves from the variations in the weather.		

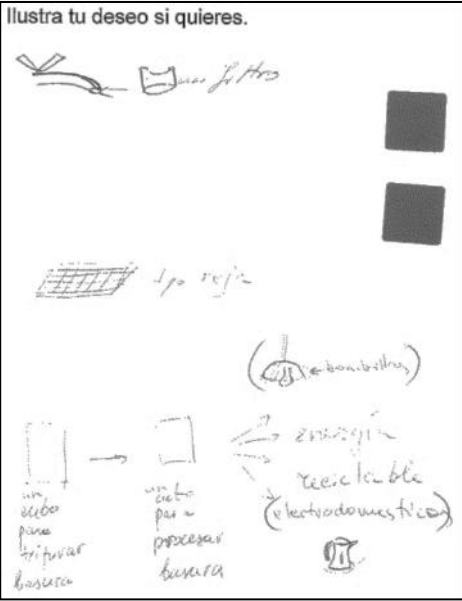
<b>Wish 1.5</b>	<b>Title: No water boilers</b>	<b>Number of votes:</b>
		<b>0</b>
<b>Reference to the application area:</b> NA (Energy in the home)		
<b>Description:</b> [I wish that] we would not need boilers to fulfill our need for large quantities of clean, hot water; which could free up space and avoid health problems and maintenance issues.		

<b>Wish 1.4</b>	<b>Title: Light sensors in bedrooms</b>	<b>Number of votes:</b>
		<b>0</b>
<b>Reference to the application area:</b> NA (Energy in the home / Green energy production)		
<b>Description:</b> I would like to reduce my energy consumption at home via sensors in the bedrooms that could automatically switch the lights on and off as I enter and leave the room.		

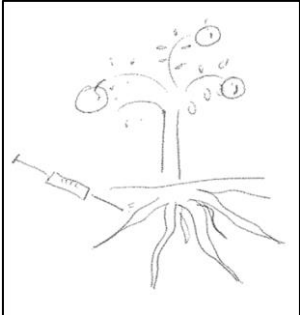
<b>Wish 2.1</b>	<b>Title: The music charges the batteries</b>	<b>Number of votes:</b>
		<b>0</b>
<b>Reference to the application area:</b> NA (Portable energy devices)		
<b>Description:</b> A loud-speaker that charges (wirelessly) with the music.		
		

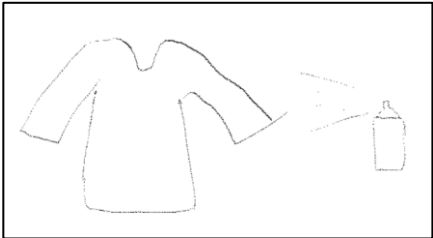
<b>Wish 2.2</b>	<b>Title: NA</b>	<b>Number of votes:</b>
		<b>0</b>
<b>Reference to the application area:</b> NA (Energy in the home)		
<b>Description:</b> A fridge that doesn't require electricity and that you can easily know the contents.		

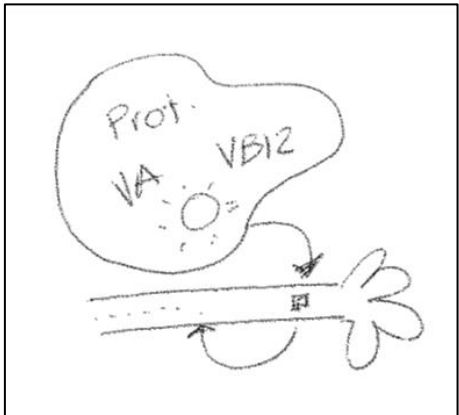
<b>Wish 1.3</b>	<b>Title: Total control bracelet</b>	<b>Number of votes:</b>
		0
<b>Reference to the application area:</b> NA (Portable energy devices / Energy in the home)		
<b>Description:</b> <ul style="list-style-type: none"> <li>• A bracelet with which one can control any appliance in the home.</li> <li>• Remote control. Locator. Smart phone control. Health monitoring.</li> <li>• Self-sufficient.</li> </ul>		
		

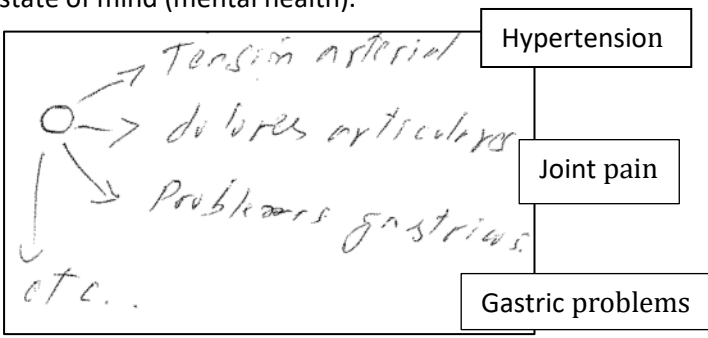
<b>Wish 4.9</b>	<b>Title: E-filters</b>	<b>Number of votes:</b>
		5
<b>Reference to the application area:</b> nano-filters		
<b>Description:</b> <ul style="list-style-type: none"> <li>• Water filter: Analyse the composition of tap-water in a particular place or at the effluent of a water provider, and manufacture filters so people no longer need to buy bottled water.</li> <li>• Recycling plant: create a huge surface of a material that attracts metal particles, plastics, organics to separate them from other materials ready for processing. Produce green energy.</li> <li>• Home: The same idea as the recycling plant but for the home/kitchen.</li> </ul>		
		

<b>Wish 4.3</b>	<b>Title: Reuse waste water</b>	<b>Number of votes:</b>
		0
<b>Reference to the application area:</b> NA		
<b>Description:</b> <p>A year ago I was in a hippy commune where the water they used in the showers, bathroom, kitchen was reused. It might be interesting to make the water we waste available in other parts of the home. e.g. invent soaps that don't contaminate the water so that it can later be used for watering plants</p>		

<b>Wish 4.7</b>	<b>Title: Nano-vegetation</b>	<b>Number of votes:</b>
		<b>4</b>
<b>Reference to the application area:</b> Plants		
<b>Description:</b> <ul style="list-style-type: none"> <li>• Technology that allows plants to grow in foreign or harsh conditions.</li> <li>• This provides essential nutrients for the plant to develop.</li> <li>• The technology can be applied in the plant itself, in the ground, or in the supplements one gives it.</li> <li>• It will serve to supply oxygen, food and vegetation to zones where the necessities for growth are absent (water, sunlight)</li> </ul>		

<b>Wish 1.6</b>	<b>Title: Intelligent clothes</b>	<b>Number of votes:</b>
		<b>1</b>
<b>Reference to the application area:</b> NA		
<b>Description:</b> <ul style="list-style-type: none"> <li>• Absorb and generate information</li> <li>• Not seasonal. For all year round.</li> <li>• Durable</li> <li>• Sustainable.</li> <li>• Records information (Health, hygiene)</li> <li>• Spray-on application?</li> </ul>		

<b>Wish 4.1</b>	<b>Title: High performance chip</b>	<b>Number of votes:</b>
		<b>0</b>
<b>Reference to the application area:</b> NA		
<b>Description:</b> <p>This would be a chip or “charger” that could charge itself with different types of energy/energizers.</p> <ul style="list-style-type: none"> <li>• Sunlight</li> <li>• Proteins</li> <li>• Vitamins</li> </ul> <p>This would be used to “recharge” a person, for example during a race or exercise activities, long days, in space, at times of illness, etc.</p> <p>It would be like a type of solar cell with nutrients for people.</p>		

<b>Wish 3.5</b>	<b>Title: Nano-health</b>	<b>Number of votes:</b>
		<b>3</b>
<b>Reference to the application area:</b>		
<p><b>Description:</b>          This daily nano-tablet or nano-pill reduces each of one's pains or illnesses, i.e. this nano-pill contains medication for all afflictions that a person has. This will improve the quality of life of people who take numerous pills and medications each day. It will also improve their attitude and state of mind (mental health).</p> 		

<b>Extra Wish</b>	<b>Title: Medical treatment capable of preventing and curing cancer</b> (not on topic but still interesting to include since it received a vote)	<b>Number of votes:</b>
		<b>1</b>
<b>Reference to the application area:</b> Genetics, environment, health, etc.		
<p><b>Description:</b>          Cures and preventions for illness.</p>		

## 2. PRODUCT SUGGESTIONS RESULTING FROM THE FIRST ROUND OF STAKEHOLDER WORKSHOPS

The first stakeholder workshops aimed to explore opportunities and barriers for co-creation in the three thematic areas, suggesting concrete actions to be taken to integrate the needs and values expressed by the citizens. A major difficulty during the organisation of the workshop was the application of the suggestions from the citizen workshops to concrete nanotechnology research projects in the areas of food, energy and health. How to relate the interests of citizens in 'sustainable development and consumption, human health, environmental protection, safety aspects, affordability, and accessibility' (for overall results, please see the report on the citizen workshops) into a concrete nanotechnology research line that any of the stakeholders present in the stakeholder workshop would consider worth developing? How do concerns like safety, reliability or well-being translate into concrete design requirements for the research of a postdoctoral researcher working on whole-cell protein analysis, or a PhD-student working on novel functional arrangements of nanographene structures?

To address this incommensurability between the broad needs and values expressed by citizens and the specificity of design options in research and innovation, the workshop programme was structured around four interrelated co-creation sessions: an exploration phase, where participants got to know each other and explored the needs and values expressed by citizens as well as their own needs and interests; an ideation session, where participants imagined and co-created responses to the needs and values expressed by the citizens by imagining revisions of ongoing research and innovation trajectories; a prototyping session, where participants generated a storyboard that visualized how the resulting research lines and product suggestions could be designed in relation to the needs and values expressed by the citizens and suggested concrete actions to be taken to realise this vision; and a concluding reflection, where participants presented their visions and reflected on the overall workshop outcomes.

Over the course of the co-creation process, there were three main opportunities for collecting creative inputs. Within the energy pilot study, more than 50 product suggestions were captured across the workshops. Some of these suggestions were discarded or amalgamated during the workshops themselves through brainstorming, focussing and selection procedures. The suggestions were also categorised by Gonano partners after each step in order to produce more palatable inputs for the stakeholders in the following step(s). The table(s) above summarises the product suggestions collected throughout the energy pilot following the GoNano co-creation process. These product suggestions are derived mainly from the citizen workshop and the first stakeholder workshop, some of which were then validated in the online consultation or were discussed or further developed at the second stakeholder workshop. The product suggestions are not the "concrete" products we ambitiously envisaged at the outset of the project; however, they are the truest reflection of the GoNano co-creation process that produced them. Expressing the product suggestions devised by individuals (citizens and stakeholders) would offer more examples and more concrete products, but they are a representation of participants' individual ideas that have not been created nor developed with others and thus not products of co-creation.

## 2.1 PRODUCT SUGGESTIONS FROM THE FIRST STAKEHOLDER WORKSHOPS ON HEALTH

Three stakeholder workshops were organized in the Netherlands on three different areas within the context of health: ‘diabetes’ (12 February 2019), ‘sensor technologies’ (5 March 2019) and ‘health and policy’ (7 March 2019). All workshops took place in the DesignLab at the University of Twente (UT) in Enschede. Each workshop had a different emphasis on nanotechnology, depending on the specific area and the composition of stakeholders.

### 2.1.1 Workshop on diabetes

The first stakeholder workshop dealt with diabetes. The promising technologies that were discussed include the artificial pancreas (a device that continuously measures glucose levels and automatically injects insulin when needed), an early diagnostic device (which detects type 2 diabetes ten years before the symptoms occur), and regenerative medicine (regenerating the insulin-producing islets of Langerhans of the pancreas from human cells). These technologies for diabetes are in accordance with promising nanotechnologies that were mentioned in the interviews with experts connected to nanotechnology.

Participants were asked to split into two groups, to choose one of the dilemmas that were formulated as conclusions of the citizen workshop, and to discuss how this dilemma potentially affected their organization.

#### *Group 1 – Early diagnostic device*

One group, consisting of a policy maker, a researcher, a CSO representative and an entrepreneur, discussed an early diagnostic device: a lab-on-a-chip device that can detect type 2 diabetes based on a small droplet of blood taken from the finger. They chose to discuss the dilemma from the citizen workshop about ‘focus on prevention of diseases versus limited use of monitoring/diagnostic devices’.

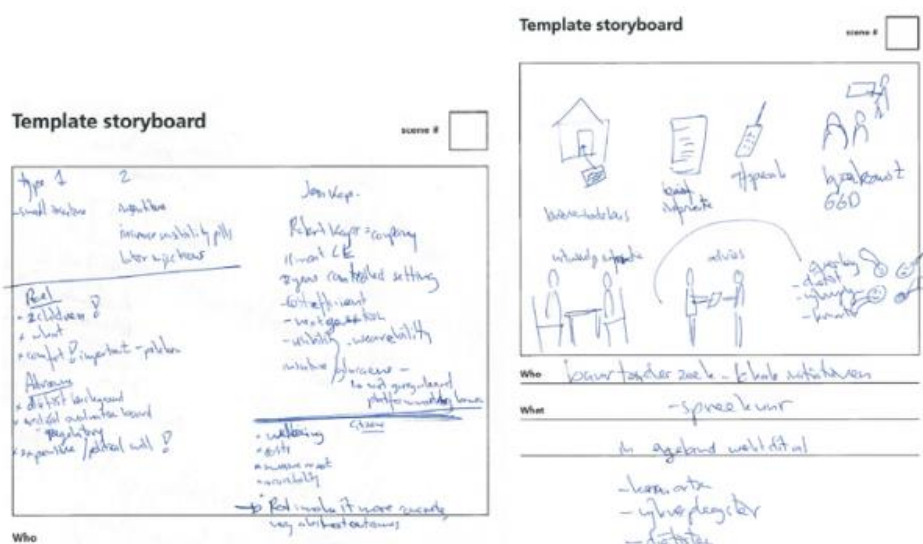
While the participants were convinced about the added value of the device, an interesting discussion took place about the implementation. The discussion included questions about the availability of the device (high-risk individuals vs. everyone), the accessibility of the device (at the GP’s office, communal centres, or another public place), the context for offering the diagnostic test (through a national public campaign or by request of a citizen), and the sender/agent who offers the test and or launches the campaign (health professional, government, insurance company). These were interesting questions as the entrepreneur who is developing the device did not think of them before. They had mainly considered the technical development of the diagnostic device. By combining the different stakeholders in one group, different perspectives on early diagnosis of diabetes and the complexity of implementing a preventive health care device became apparent. This is a very clear example that is in line with the hypothesis of the GoNano-project, that ‘exposure’ to broader societal views can add value to product development.

After the ideation phase participants expressed their ideas in the form of a storyboard. The group came to the following output:

The device will be available for *all/high* people at the *general practitioner’s office / communal centre / other public places, namely\_\_\_\_\_*. People are motivated to make use of the device through a *national campaign / GP / other health professionals / peers*. The organization who initiates the

campaign and pays for using the device is the *GGD (local government) / national government / insurance company / citizens*.

In this group, participants were enthusiastic to collaborate and to define questions to explore implementing the device. An interesting aspect of this discussion was that every stakeholder could add their own perspective. For example, the policymaker explained how the organization of a national campaign works and whether that is relevant for this context, and the CSO explained how awareness among citizens for diabetes was created and focused on the difference between type 1 and 2 diabetes. For the business representative, the output was especially relevant as they had gained insights into the societal context in which his product would land. Also, during the prototyping phase a network was created between the business developer and the CSO for an exploration of potential funding sources.



**Figure 5. Storyboard for the implementation of an early diagnostic device for type 2 diabetes**

### Group 2 – Artificial pancreas

The second group was composed of two researchers, a representative of a CSO, two entrepreneurs, and a diabetes patient who was present at the citizen workshop. They discussed the artificial pancreas, which constantly detects levels of glucose and automatically injects insulin when needed. They chose to discuss the dilemma of ‘ownership of data vs. inclusion of health professional in monitoring and diagnosis’, which was one of the conclusions of the citizen workshop.

During the discussion, the group focused on what to do with the data and how to include this in the design of the device. The main topic that was discussed was about the accessibility of data. Different types of data were distinguished (personal, trends), and different types of stakeholders were detected (user, caregiver/family member, health professional, insurance company, device operator). Questions about these types of data were discussed, such as which data should be accessible to whom? Should the data only be available by the user or also by the health

professional, caregiver/family member and/or another actor? How should this availability be organized, through the interface of the device or in a different way?

While the stakeholders did not see the immediate value of the citizen workshop during the exploration phase, they did acknowledge the value after the ideation phase. Especially the entrepreneurs who were working on the product applications gained new insights from this phase.

### Output 2 – Data management of artificial pancreas

The group focused on suggestions for collecting and sharing of data obtained by the artificial pancreas, which is used for continuously monitoring glucose levels and injecting insulin levels when needed. Through this monitoring, a lot of data about the patients' health is collected. Different suggestions were made on how to handle this data:

- Loop between *patient* and *health professional* → daily use by patients, signal when *anomalies* happen / quarterly use by health professional, analysis of *trends*
- Loop between *patient* and *care giver* / parent → in the case of less 'skilled' people using the device and interpreting *personal data* (e.g., elderly people, children)
- Loop between devices and *company* → *big data* (anonymous), for detecting *trends* to develop personalized medicines.

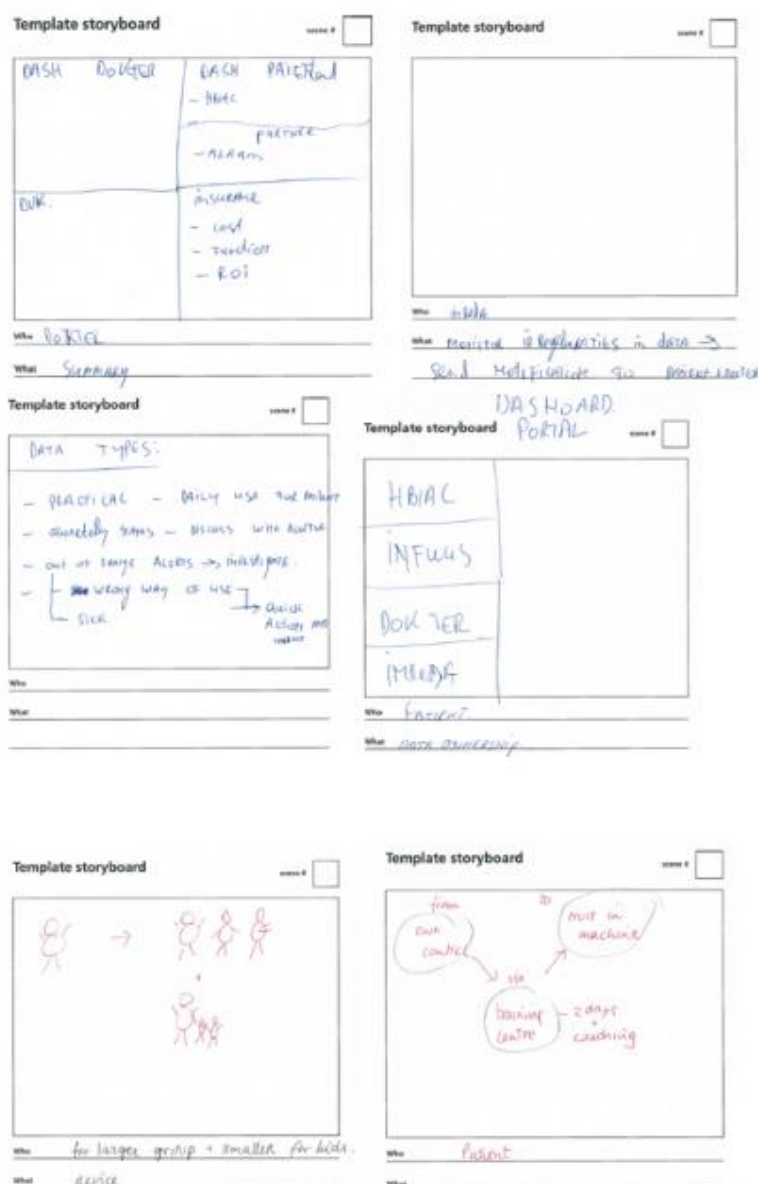


Figure 6. Storyboard on data management of artificial pancreas

### 2.1.2 Workshop on sensors

The second workshop explored the development of sensors. For this workshop, the organisers collaborated with a post-doc researcher working on the diagnosis of cancer tumours through the detection and measurement of specific proteins. In the prototyping phase of this workshop, participants developed the following action plans:

#### *Group 1 – Improvement of diagnoses of cancer through monitoring proteins*

This group consisted of researchers with different backgrounds, including the post-doc. The other researchers had backgrounds in nanomaterials, medical oncology, and medical cell biophysics. Various specific suggestions for improvement in the research project were addressed, including:

- Identify for which types of cancer a need exists for better diagnosis – by talking to professionals and other researchers;
- Specify and detect a treatment plan for these specific types of cancer by talking to oncologists and pharmacists, to clarify the need for a better diagnosis of tumour cells;
- Improvement of the device by labelling cell-specific proteins – to have a working device, first various proteins should be labelled, this should be done through desk research, interviews with other researcher in this field and empirical research;
- Developing the device from research to application – talk with potential users (oncologists) about their needs and business developers, and make a time-plan for development and budget financial resources;
- Make a plan for getting tumour cells to study and using laboratory equipment.

The discussion provided constructive input for possible adjustments of the research trajectory. Additionally, participants emphasized that it would be interesting to see how potential users of this technology, in this case oncologists, would evaluate the suggestions. This particular stakeholder group can be included during the second stakeholder workshop.

#### *Group 2 – Better link between research and business within the Sensing-programme*

This group consisted of one policy maker, two representatives of business, and one social science researcher. The discussion focused on how to establish communication between the core expertise within the institute about materials, sensor systems and technology, and end-users. The Sensing-programme could link with researchers at UT, but also externally with business partners. In the latter case, timely information should be shared, before patents are drafted and research has been published.

The output of this discussion was that there should be an institutionalized network with internal and external relationships. It should not just be based on individual researchers' interests. An example is to provide an opportunity for business partners (innovative start-ups) to bring in questions for more application-oriented test research within the Sensing-programme, without having these partners financing a PhD-project or post-doc project. Similar to the output of group 1, this outcome might also be quite abstract for citizens, and it is therefore interesting to see how

citizens will judge it in the online consultation. The focus in this discussion was on different stakeholders relevant for different product development phases. End-users, rather than citizens, are important actors in this regard

### 2.1.3 Workshop on health and policy

The third stakeholder workshop explored the policy context of nanotechnology and health. The organisers invited stakeholders connected to nanotechnology and health in general who are in a position to influence policy making. In the ideation phase, participants were asked to write down on a post-it their suggestions for a meaningful realization / set-up of societal engagement in research and implementation of nanotechnology in the area of health. They had to write down the context of this set-up, the methodology, the initiating party, and the target audience, and were invited to place their post-it on a whiteboard (see Figure 11).

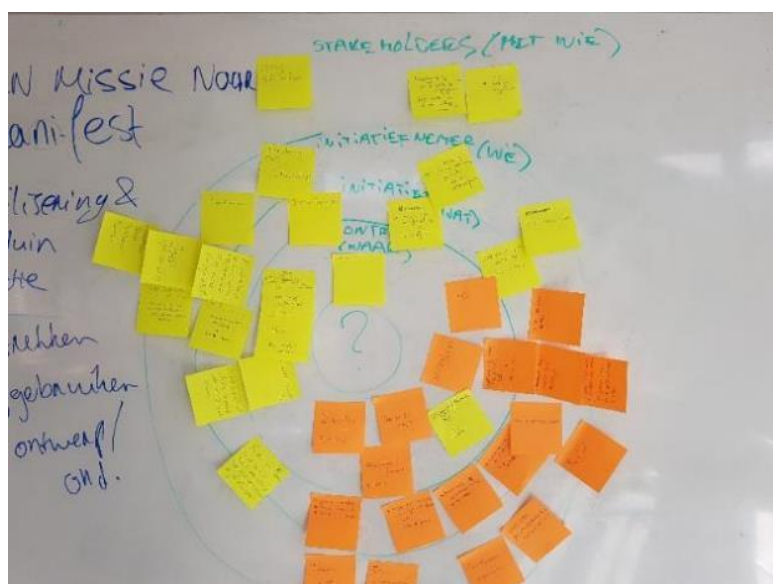


Figure 11. Post-its of the ideation session

After placing the post-its on the whiteboard, participants were asked to come up with suggestions for initiatives for structural societal engagement in research and innovation of nanotechnology in health. Based on these suggestions a mind-map was created (see Figure 9). Participants were able to give suggestions, in more general terms, of how societal engagement could be better embedded in research and innovation (e.g., funding, product-design, mission-oriented research, education and information, involvement of patients). They could also mention relevant actors to these suggestions (e.g., nano-medicine platform, 'health users', chain of actors, science policy makers at relevant ministries). However, they had difficulties with defining specific suggestions from their own organization's point of view. They thought the question was too broad and too abstract for this. Nevertheless, during the prototyping phase, some participants were able to come up with specific actions and input from their organization's point of view on this subject.



the market that might be useful for diagnosis, treatment or curing of diseases. Also, many users and citizens are not aware of all technologies that are being developed.

As a solution this group proposed to create a field lab where scientists can test their technologies with (potential) users. To make this idea feasible the lab should first include non-invasive and less-invasive technologies (e.g., sensor-technologies or lab-on-a-chip). The field lab should be situated at a public place, for example a hospital, to make sure that everyone has access to the technologies. In addition to collecting input from users (patients, potential patients, health professionals), the field lab also functions as a way of disseminating scientific developments in the area of health, and creating awareness

## 2.2 PRODUCT SUGGESTIONS FROM THE FIRST STAKEHOLDER WORKSHOP ON FOOD

The first stakeholder workshop on nanotechnology and food was held in the Technology Centre of the Czech Academy of Sciences on 28 February 2019. The workshop focused on three topic areas: novel foods, nanofilters and smart food packaging. The first part of the programme dealt with the needs and values of the citizens and their possible incorporation into future products and research aim design. Subsequent ideation and prototyping sessions tried to define concrete product suggestions. It appeared that the specific product suggestions were quite an obstacle for many, since expertise differed and it proved especially difficult to explain to experts, why would concrete product suggestion be useful for their research aims, activities they are already involved in, or what is the relation with the policy making process. Nevertheless, in two from three groups, this effort led to specific product suggestions and to research aim in the third one.

### 2.2.1 Novel foods

The group concentrated mostly on the resolution of the research questions and aspects of the products that have something to do with research. That could be either given by the composition of the group and also by the research background of the participants. In general, representatives of business were relatively less active than researchers or citizens. This can be due to several reasons: citizens could feel connected to their needs and values and therefore presented them and reacted in a more active way. It could however also be due to the topics discussed – in the matter of safety or e.g. a certification system, it is understandable that the representatives of the state or NGOs would be more informed. The main ideas circulated mostly around nanoparticles, as can be seen in both product suggestions – a novel food using nanoparticles for the sake of balance and efficacy, and with analytical methods responding directly to the citizens' needs and values.

#### 1. *A food that contains a balanced mix of nutrients*

A target group would be all the customers, since the product would be personalized to the needs and specifics of the customer: Research should concentrate on making the particles smaller and make their homogenization in the nanoscale possible; secondly on the encapsulation of the nutrients and their delivery to the desired spots. Legislation should concentrate on the composition of the particles of the products.

## 2. *Analytical methods for the detection of nanoparticles*

Methods would be used according to the size of the particles – electron microscopes, structural analyses, spectroscopy, etc. There should be a kit for detection and analysis of the nanoparticles developed. However, this method should be accredited at the international level first. From the legislation point of view: there would be a need to create a definition for nanoparticles in food, which would be placed under control. Stakeholders thought that it would be useful to reliably identify safe numbers of artificial nanoparticles contained in food. Experts also discussed possible dystopic scenarios concerning sensors that would be used to detect nanoparticles, as this could supposedly lead to the contamination of the body – this requirement should be legislatively based.

### 2.2.2 Nanofilters

The nanofilters group dealt with many topics – in part it was a specific debate on the current state-of-the-art in the Czech Republic as the participants were discussing the production of nanoyarn compared to the rest of the world. They concluded that there is an excellence in the local production these days, as there is no other place where they have nanoyarn on such a small scale. Experts then came up with ideas on rather specific applications.

The most promising specific ideas that were mentioned were filtration of enzymes, specific sorptions, and the depletion of specific acids, pesticides and heavy metals during oil production. One of the most specific ideas were the Enzymatic flow reactors that, according to the experts, had one of the biggest potentials for future use as they represent a unique and advanced technology concept of filtering.

Later on, the discussion steered into the topic of informing the wider public and the media. Experts agreed that it is difficult to get concrete and understandable educational material from research. It is important to work more precisely with the public – to not underestimate the importance of informing and making an understandable experience with the wider public.

### 2.2.3 Smart food packaging

Throughout the discussion it seemed quite difficult to get the ideas that mostly came from the researchers' side into concrete product suggestions, since there was a consensus that such activity is not particularly efficient due to the various expertise of the participants. However, the idea of the packaging product protecting the food from both the inside and outside eventually lead to two specific suggestions:

#### 1. *An antimicrobial meat packaging solution*

The package would bring barriers against both outside effects and the undesired microorganisms that could be contained inside the package, e.g. in the form of antimicrobial coating. The package would also include a sensor – indicating the defectiveness of meat products. The packaging could be considered active as it would prevent proliferation of bacteria. In addition, according to some stakeholders, it would be desirable that the packaging would contribute to overall food waste reduction.

## 2. *A fruits and vegetables packaging solution*

In parallel to the initial idea, is a packaging system for vegetables. It would provide food to the customer with a prolonged shelf-life, and controlled atmosphere, temperature and ripening of the food. The packaging solution would also be microbiologically coated to protect the food from listeria. An ideal package could be used for each piece of fruit or vegetable. This was largely discussed since such an idea could also potentially be in contradiction to the other important requirement – for the food waste to be as low as possible.

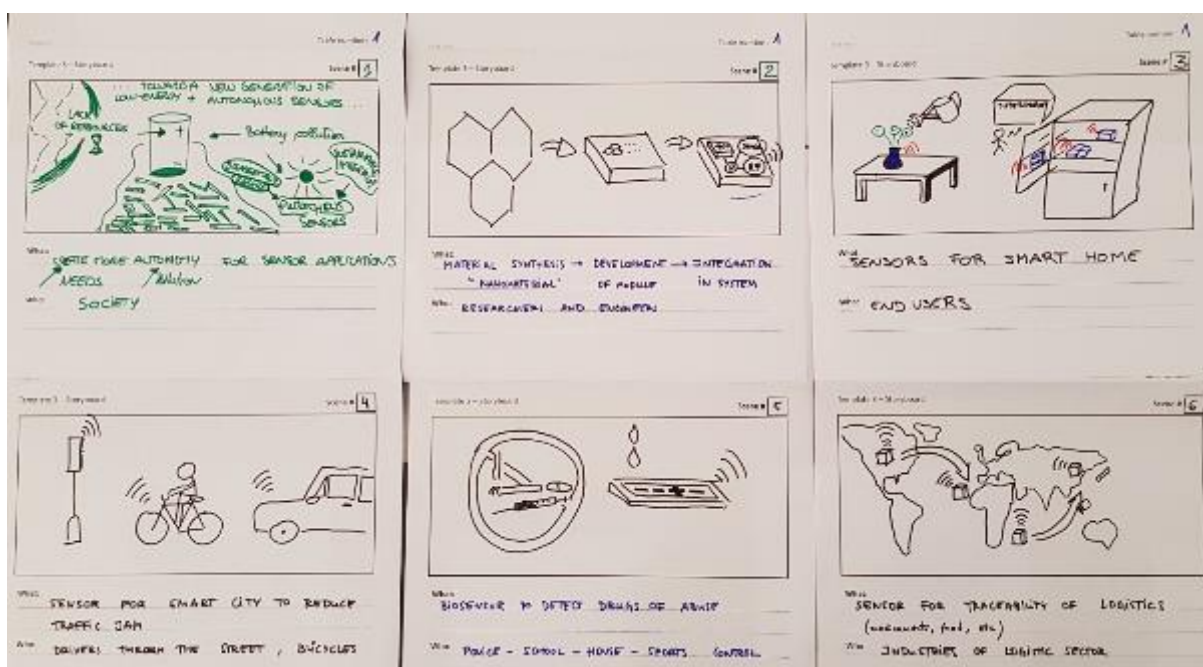
In addition, several other points were discussed, including the notion that research without application doesn't make much sense, and that the fears of the public should be allayed by the media. An often-discussed topic was the barrier properties of packaging systems.

## 2.3 PRODUCT SUGGESTIONS FROM THE FIRST STAKEHOLDER WORKSHOP ON ENERGY

The “GoNano Innovation and Co-Creation Workshop: Nanotechnology for Energy” took place at the offices of RMIT Europe in Barcelona, Spain, on 7 March 2019. The participants were a group of 27 stakeholders, including 21 researchers from science and engineering backgrounds, 2 researchers in design, 2 CSO representatives, a teacher, and a researcher in social sciences.

The prototyping phase was where the groups took their initial ideas for activities, research lines, and product suggestions, and elaborated them through the medium of storyboards. All of the groups completed the activity by producing high quality, descriptive storyboards that can be easily followed and understood. However, some of the ideas were possibly a little too broad to serve as a basis for a real work plan. Additionally, a few of the items lacked a direct link to nanoscience and nanotechnology. Despite being mostly scientists and engineers working within the nanoscience and nanotechnology field, while creating and describing their ideas for future activities, many focussed on the societal problem and offered general solutions, but shied away from the chance to offer their own research and expertise as a solution or to deal with some of the more specific technical challenges. It is possible that too much weight was placed on the societal needs at the start of the day, or their desire to be inclusive of all group members directed them along these lines. Or it could be that the timeframe was just too short for them to make the link between the societal values and their own projects or areas of expertise. With more time and complementary stakeholders (e.g. companies, policy makers), this may be achieved at the second round of stakeholder meetings.

**Figure series. The 5 storyboards produced during the *Prototyping* session.**



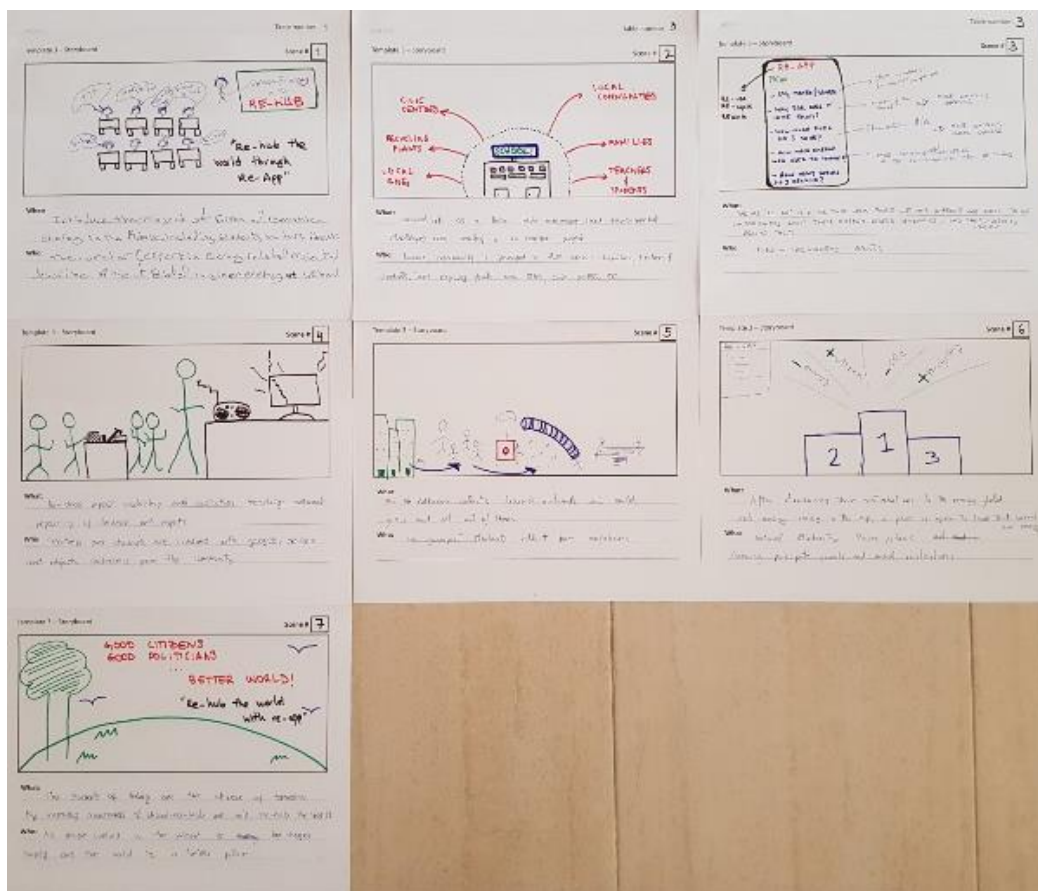
**Storyboard 1. Central citizen need or value: More energy from renewable sources.**

The storyboard above describes a number of applications for autonomous sensor technologies, such as in smart homes, smart cities, drug tests, and supply chains. The sensors would be developed by researchers and engineers and then integrated into the various application areas. The materials used in the sensors, including nanomaterials (although no specific materials were mentioned), would all need to be sustainable or recycled to prevent putting further stress on global resources.



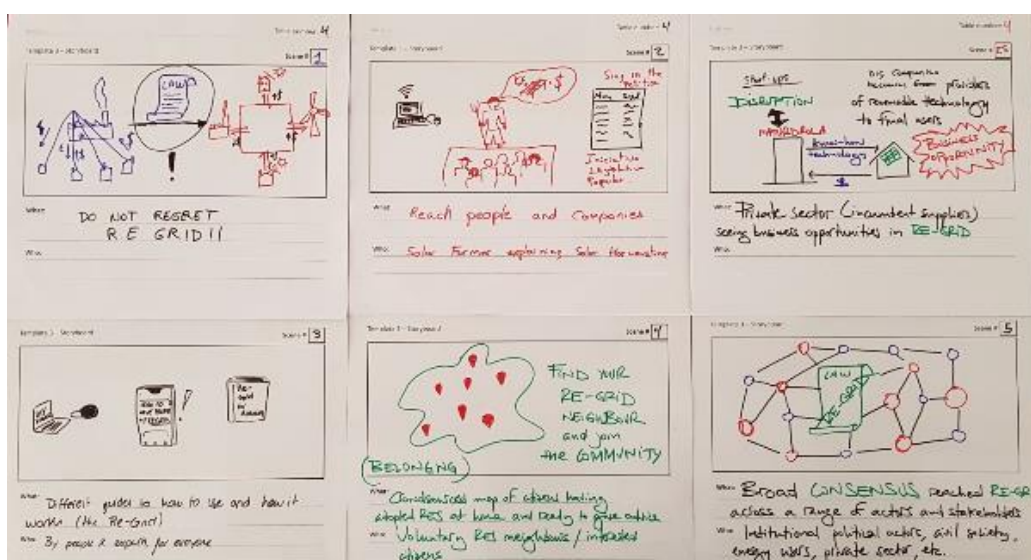
**Storyboard 2. Central citizen need or value: Promote sustainable development.**

The storyboard above describes a “Piezo Festival” for showcasing piezoelectric materials and devices to raise people’s awareness of renewable energy technologies. Funding, advertising, organisation and impact of the festival are considered.



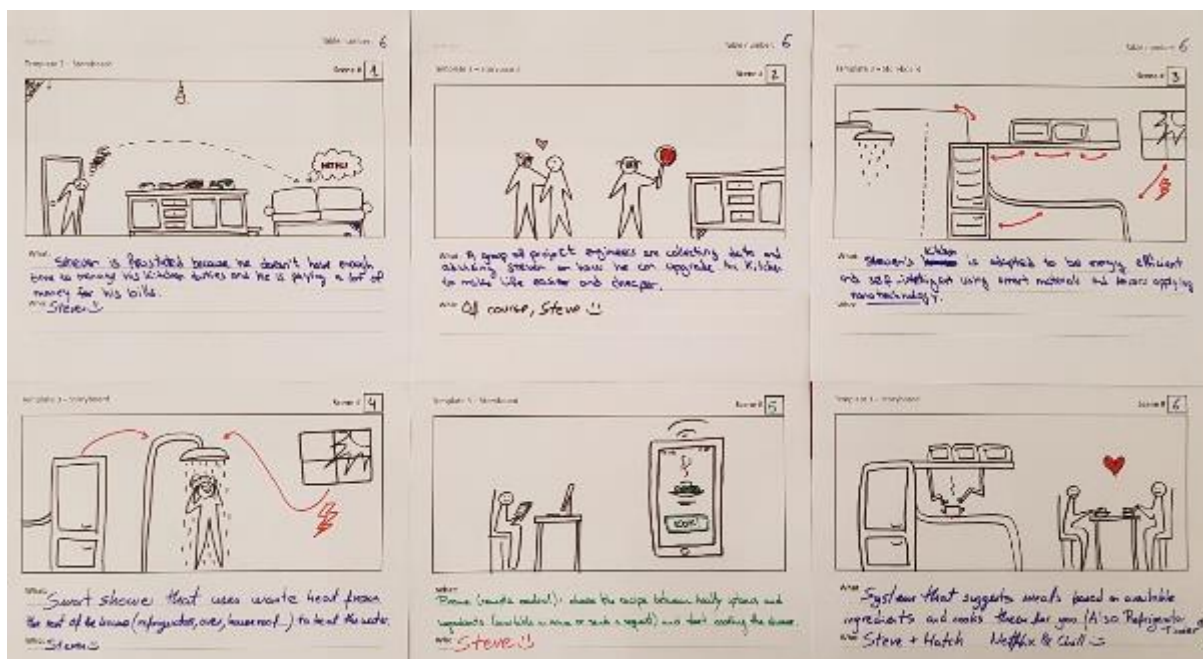
**Storyboard 3. Central citizen need or value: Educate the public on green energy.**

The storyboard above outlines a strategy to promote schools as the central hub for educating the entire public body (e.g. students, teachers, families, local businesses and CSOs) about green energy and addressing local environmental challenges.



**Storyboard 4. Central citizen need or value: More energy from renewable sources.**

The storyboard above examines how both top-down legislation and bottom-up community actions can be used to help the transition of the power grid from fossil fuels to renewable energy.



**Storyboard 5. Central citizen need or value: Better quality of life.**

The storyboard above vividly describes the daily routine of an over-worked individual who has little money and no time or willingness to cook their dinner when they arrive home from work. A group of engineers provide the solution in the form of smart materials and intelligent devices that can save energy and reduce the workload around the home.

### 3. FEEDBACK ON THE PRODUCT SUGGESTIONS FROM THE CITIZEN CONSULTATION

The suggestions resulting from the workshops were shared and discussed more widely through an online citizen consultation which ran from July to September 2019. One of the aims of the citizen consultation was to compare the product suggestions when it comes to their potential desirability and subjectively perceived unsafety. The results from the citizen consultation were expected to feed into second round of stakeholder workshops, focusing on the uptake of the responsive design suggestions of the previous round.

Standardized “vignettes” were used for five concrete product suggestions or research aims that came out from a collaboration between citizens (Citizen workshop), and stakeholders including citizen (Stakeholder workshop I) from each of the pilot countries – energy in Spain, food in the Czech Republic and health in Netherlands.

In the energy area (Spain), five product suggestions were introduced:

- 1) Autonomous sensor technologies for smart homes and smart cities
- 2) Exhibition of piezoelectric materials to raise people’s awareness of renewable energy solutions
- 3) Strategies to utilise schools for educating the entire public body about green energy
- 4) Smart materials and energy devices that save energy and reduce workload at home
- 5) Ways to translate power grid from fossil fuels to renewable energy

In the food area (Czech Republic), the suggestions were the following:

- 1) A food that contains a balanced mix of nutrients
- 2) Analytical methods for the detection of nanoparticles
- 3) An antimicrobial meat packaging solution
- 4) A packaging solution for fruits and vegetables
- 5) Specific applications for nanofilters

In the health area (Netherlands), another five product suggestions were introduced:

- 1) Early diagnostic devices
- 2) Improvement of diagnoses of cancer through monitoring proteins
- 3) Field lab for health technologies
- 4) Data management of artificial pancreas
- 5) Better link between medical research and business

To understand the desirability and subjectively perceived unsafety of the product suggestions, two scales containing three questions were used. Respondents answered on a 5-point Likert scales

ranging from ‘certainly not to surely would’. For all these product suggestions, two question scales were used. The **desirability** scale consisted of three questions:

1. Would this product (idea) be desirable to you?
2. Would you consider using this product (idea) yourself?
3. Would you recommend this product (idea) to your friends and family?

With 5-point answers: 1= Certainly not; 2= Rather not; 3= Neutral; 4= Rather would; 5= Surely would.

The **subjectively perceived unsafety** scale consisted of another three questions:

1. Would you have concerns about the safety of this product (idea)?
2. Would you be worried about unknown consequences of using this product (idea)?
3. Would you feel safe using this product (idea)? R14

With 5-point answers: 1= Certainly not; 2= Rather not; 3= Neutral; 4= Rather would; 5= Surely would.

When it comes to the desirability of all product suggestions compared, the three most desired were:<sup>15</sup> **Improvement of diagnoses of cancer through monitoring proteins** ( $M = 4.35, SD = 0.776$ ), **Early diagnostic devices** ( $M = 4.17, SD = 0.824$ ) and **Strategies to utilise schools for educating the entire public body about green energy** ( $M = 3.98, SD = 1.01$ ). This aligns with findings from the field of biotechnology where people showed more interest in medical applications than in food applications as well.

The least three desired/least enthusiastically perceived product suggestions were: **A food that contains a balanced mix of nutrients** ( $M = 2.99, SD = 1.07$ ), **Analytical methods for the detection of nanoparticles** ( $M = 3.36, SD = 1.01$ ) and **Exhibition of piezoelectric materials to raise people’s awareness of renewable energy solutions** ( $M = 3.42, SD = 1.03$ ).<sup>16</sup>

Safety concerns were most intensively perceived in the three following cases: **A food that contains a balanced mix of nutrients** ( $M = 3.51, SD = 0.849$ ), **Analytical methods for the detection of nanoparticles** ( $M = 3.28, SD = 0.902$ ) and **Autonomous sensor technologies for smart homes and smart cities** ( $M = 3.21, SD = 0.786$ ).

After choosing the area of interest (energy), respondents prioritized needs and values. The final prioritization is a sum of a score that was assigned to each ranking (1. – 4 points; 2. – 3 points; 3. – 2 points; 4. – 1 point).

Ranking	Need and value	Number of points
1	More energy from renewable resources	527
2	Promoting sustainable development	430

<sup>14</sup> R= Rotated item.

<sup>15</sup> The full description of the product suggestions is available in the Annex I.

<sup>16</sup> For more information about the desirability, please see the results for the respective topic areas.

3	Better quality of life	409
4	Educate the public on green energies	364

**Table 2: Energy sample – Prioritization of the needs and values**

After choosing the area of interest (food), respondents prioritize the needs and values that come as a mutual result of a cooperation of citizens and stakeholders from the previous parts of the project: The final prioritization is a sum of a score that was assigned to each ranking (1.: points; 2.: 3 points; 3.: 2 points; 4.: 1 point).

Ranking	Need and value	Number of points
1	Safety of the Nanotechnologies in food with special focus on nanoparticles	930
2	Standardization and a control system	753
3	Prolonged shelf-life of the food	690
4	Customization of food	590

**Table 6: Food sample – Prioritization of the needs and values**

The most „desired” product suggestion in Food are the „**Specific applications for nanofilters**”, followed by „**An antimicrobial meat packaging solution**“, the least „desired” product suggestion is quite surprisingly “**A food that contains a balanced mix of nutrients**” – a novel food suggestion that was voted as the most popular idea of all during the first citizen consultation on Nanotechnology and Food (see Deliverable 3.2). It seems that citizens choose the less invasive option, which is similar to some surveys provided in the biotechnology field.

After choosing the area of interest (Health), respondents prioritized needs and values. The final prioritization is a sum of a score that was assigned to each ranking (1. – 6 points; 2. – 5 points; 3. – 4 points; 4. – 3 points; 5. – 2 points, 6. – 1 point).

Ranking	Need and value	Number of points
1	Safety of the Nanotechnologies in health	1622
2	Well-being of the customers	1401
3	Accessibility of products and treatment	1372
4	Costs of medical treatment	1141
5	Autonomy of the users in using medical products and treatments	1079
6	Privacy and security of health data	1071

**Table 10: Health sample – Prioritization of the needs and values**

Of the six needs and values, for the health respondents the most important are the “Safety of the nanotechnologies in Health” (1622 p.), followed by the “Well-being of the customers” (1401 p.), “Accessibility of products and treatments” (1372 p.), “Costs of medical treatment” (1141 p.), “Autonomy of the users..” (1079 p.) and “Privacy and security of health data” (1071 p.).

## 4. PRODUCT SUGGESTIONS FROM THE SECOND ROUND OF STAKEHOLDER WORKSHOPS

A second round of stakeholder workshops was organised in the Netherlands, the Czech Republic and Spain in October and November 2019. The aim the workshops was to elucidate the preconditions for co-creation, building on the insights gained in the earlier stages of the project. The workshop programme was designed to deliver:

1. The outline of an 'action plan' that sets out how societal input will be organised in the further development of the product suggestions;
2. The formation of a 'community of a practice', consisting of the problem owners, relevant societal stakeholders and facilitating researchers who will support the 'translation' and integration of societal feedback into the product suggestions.

### 4.1 SUGGESTIONS FROM THE SECOND STAKEHOLDER WORKSHOP ON HEALTH

The second stakeholder workshop in the Netherlands was organized on 7 November, 2019. This workshop focused on two thematic areas in the context of health: 1) the value of data for diabetes technology and 2) involving industry in the development of sensor technology for cancer detection. The workshop took place in the Design Lab at the University of Twente (UT) in Enschede. In total, sixteen stakeholders with different backgrounds participated: six researchers, three stakeholders connected to policy making, three representatives from businesses, one person from a civil society organization (CSO) and three citizens who attended both the citizen consultation of GoNano in November 2018 and the first stakeholder workshops in February and March 2019.

Like the first series of stakeholder workshops, the workshop consisted of four phases derived from design thinking methodology: exploration, ideation, prototyping and reflection. During the prototyping phase, the stakeholders were divided into two groups connected to the two main themes (tables) based on their area of expertise. Participants discussed the theme from their own perspective and then came up with an action plan for the coming years.

#### *Group 1 - The value of data for diabetes technology*

The group connected to value of data for diabetes technology discussed the importance of health data (glucose values) for diabetes type 1 patients, and the function of the artificial pancreas in this regard. Participants discussed that even though treatments for diabetes type 1 has been developed, the disease puts a high burden on patients, and there is a need for technological solutions that increase well-being of diabetes patients. Interestingly, with the technological solutions that have been developed so far, from the insulin pen, to the insulin pump, to the mobile app that continuously monitors glucose levels, the consciousness of health data has also increased. With the current technologies, much more data is collected and monitored. While this data makes it easier to live with diabetes type 1, it does not relieve the burden of the disease. An important development in this regard is the artificial pancreas that continuously monitors glucose levels and automatically injects insulin when needed, and thereby relieves the burden of the awareness of the disease. A start-up company has developed an artificial pancreas based on a hardware device, and is working

on its final CE certification. Although the idea of this technology was developed a decade ago, it takes time to bring a medical device to market.

While the artificial pancreas seems to be the solution for diabetes type 1 patients, during the workshop a number of (potential) issues and suggestions were discussed (see Figure 9). First, participants discussed the system in which the artificial pancreas is being developed. In the current regulatory system it takes a long time to bring a medical technology to market due to tests and certifications, while the software artificial pancreas, an open platform based on algorithms developed by computer scientists, could be on the market right away (the developer was present at the workshop). A number of patients across Europe (including the patient present at the workshop) are already using the software artificial pancreas, but it requires highly technological skills and the patient still needs to act based on the data. Also, the safety of the software artificial pancreas is not guaranteed as there is not regulatory framework for it. Health professionals are therefore reluctant to include the software artificial pancreas in their treatment. At the workshop it was concluded that regulations should be adapted to the technology and not the other way around. Furthermore, medical technologies should be distinguished from pharma, and especially in vitro technologies should be easier to bring to market. The policymaker and the representative of the CSO both argued that this was an action for them to take bring back to their organization.

Second, the value of data for diabetes technologies was discussed. Health data can be of value for a number of actors, including: developers of the artificial pancreas to optimize diabetes technologies (e.g., to optimize personalized algorithms that detect the best time to inject insulin); health professionals, to optimize treatment plans; patients, to create better insights in their health; insurance companies, policymakers, and funding organizations, to get insights in the effectiveness of solutions and technologies for diabetes patients. Data of individuals has already been collected in an open platform to optimize the algorithms for the software artificial pancreas. The developers of the hardware AP work on a data management plan (which was the outcome of the first stakeholder workshop of GoNano) in order to make use of different types of data for different purpose.

Third, the user perspective on data was pointed out, which is closely related to well-being of patients and trust in technologies. With the development of diabetes technologies, insight in and the amount of data has increased (see Figure 8). However, this does not automatically lead to more trust in technologies and a better well-being, because the increase of data also leads to a more complex way of

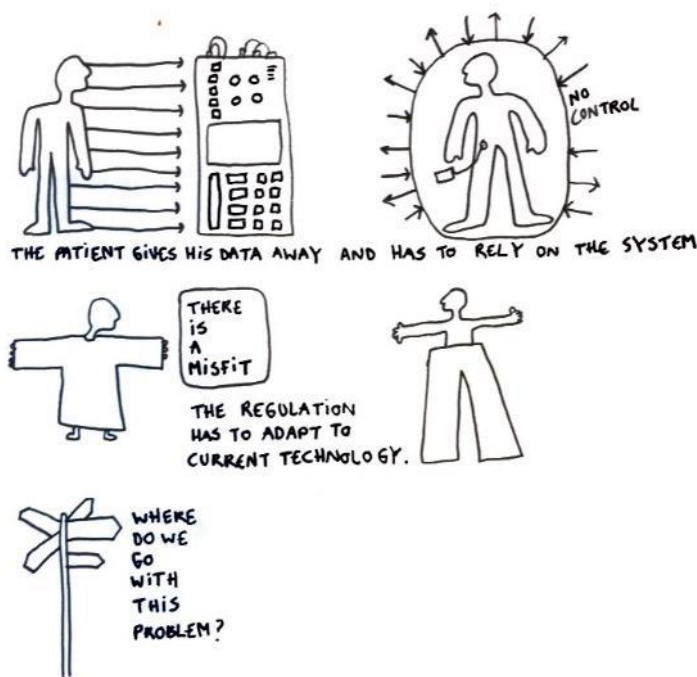


Figure 9. Prototyping phase value of data for diabetes technology

dealing with the diabetes in terms the number of actions needed and interpretation of data. The artificial pancreas, which is a closed loop system, might offer the solution for this problem. However, participants argued that for diabetes type 1 patients health (data) has always played an important role in their lives, and a closed loop system that takes away the awareness and control, might lead to a feeling of loss of control. Therefore, patients should be given the opportunity to keep insight in their data when having the artificial pancreas. This suggestions was specifically useful for the business developer of the artificial pancreas.

### *Group 2 - Involving industry in the development of sensor technology for cancer detection*

The group discussing this theme consisted of seven stakeholders: a junior researcher (post-graduate student) working on sensors for nanotechnology and health, a senior researcher focusing on research on cancer, a senior researcher on design thinking, a policymaker working on research funds, a policy maker working on RRI, a representative of a business consulting firm for start-ups working on nanotechnology and health, and a citizen. Unfortunately, the post-doc researcher who was present at the first stakeholder workshop, had to cancel the workshop last-minute. Instead, she was present via Skype at the beginning of the prototyping session. During this session, the post-doc researcher first explained her research and the difficulties she encountered in involving private partners. This was the same research that was also discussed in the first stakeholder workshop, focusing on the development of sensors for improvement of diagnoses of cancer through monitoring proteins. While the technology might lead to personalized treatment of different types of cancer in the future, the researcher had difficulties with involving private partners in her research as the research is still in an early technological phase. The junior researcher who works on the development of an organ-on-a-chip model for a liver encountered similar problems. During this phase several suggestions and issues were discussed for involving industry in research development (see Figure 10).

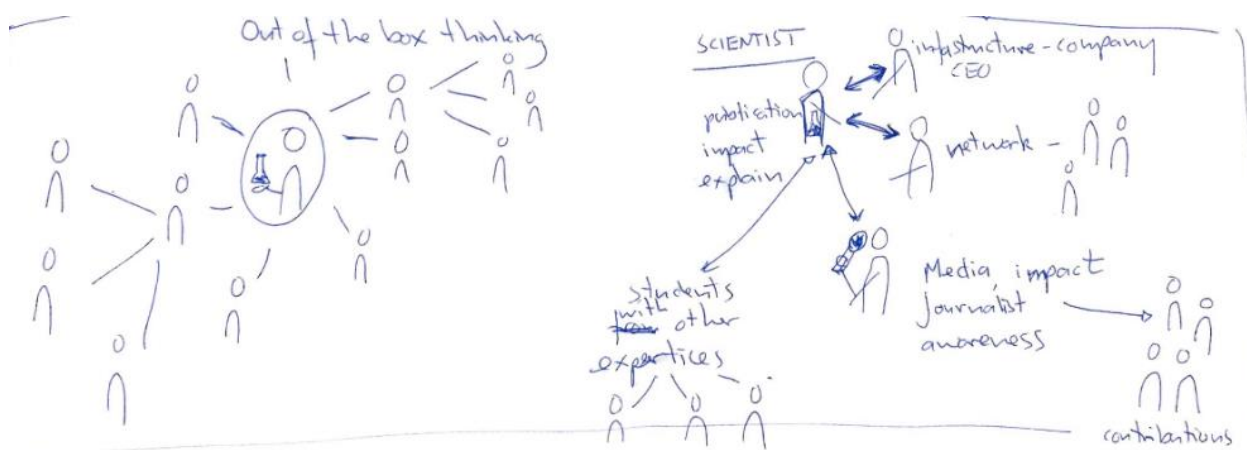
First, researchers need to think of a strategy and 'story' about their research, and this should be done in an early phase. They should be able to answer what's in it for the partner, and define potential application areas. The researcher should find common objectives with private partners and frame and explain the technology in such a way that it meets these objectives. They should take into account that they explain their technology in such a way that lay-people can understand it. The 'story' can be directly told to the private partners through networking activities, or the attention of businesses can be attracted via media exposure.

Second, stakeholders mentioned that it is crucial to build relationships with potential partners through networking activities. It is important to find a 'problem-owner', who has an intrinsic motivation in supporting the research activities. Researchers should take into account that these networking activities cost a lot of time and effort, and it is important to not just start with networking around the funding call, but much earlier. Researchers should invest time in building a network and build a reputation around themselves. For junior researchers it might be helpful to use the network (and reputation) of their supervisor or senior researchers.

Third, stakeholders pointed out that it would be helpful to engage potential users in the development of the research in order to detect the demand these users and the solutions the

technology can offer. Researchers could explore various user scenarios and should be flexible in the application area of their technology/research.

Fourth, when looking for funding it could be helpful to start with small steps. A Lorentz funding, for example, provides a compensation for costs being made for a workshop that focuses on bringing various actors together connected to a technology. This workshop could be used a starting-point to attract business. In this way, the researcher does not initially asks for resources (funding), but first brings knowledge to the private partners.



**Figure 10. Prototyping phase research-industry relations**

## 4.2 SUGGESTIONS FROM THE SECOND STAKEHOLDER WORKSHOP ON FOOD

The second stakeholder workshop was held at the Technology Centre of the Czech Academy of Sciences headquarters on 22 October 2019. In what was to be a direct continuation of the previous activities, the aim was to create a workshop with a slightly more focused perspective in contrast to the first stakeholder workshop: to (1) re-invite the most interested stakeholders from the previous stakeholder workshop; (2) to re-identify key stakeholders as ‘problem owners’ according to the product suggestions / research aims that were co-created by citizens and stakeholders.

The prototyping session aimed to come up with product suggestions or action plans which would describe the actions to be taken concerning the activities of the stakeholder – this worked out differently throughout the different application areas. In the case of novel foods, there is indeed a sort action plan guiding the new nanotechnology production and how these novel ideas should be treated. In the case of smart food packages, it seems that both aims were achieved: there was a crystalized idea of a product that indeed is worth of developing/continuing to develop, and a vague action plan on what and who should act in the further development in general.

### 4.2.1 Novel foods

The discussion in the novel foods group continued within the safety/regulation aspect detail. The representative of the Ministry of Agriculture claimed, that there is a legislation frame existing, but

at the same time there are missing methods that would be applicable in all the EU countries. The inquiry if nanomaterial is present is quite demanding from the technical point of view. The technology of the food production is still evolving and therefore it is difficult to effectively test the products. The research centers on the European level are well equipped to study the presence of nanomaterials in food. However, it is still not possible to do so on the mass scale.

The important recommendation is that the representatives of the companies should cooperate with the state authorities in the phase when they plan to put the products on the market. In such cases, it would be possible to decide if a product is safe before it is being produced on the mass scale. This would also give the producer first information on how difficult it will be to approve such product. Safe approaches to apply new technologies however already exist and are e.g. summed in the methodical guide: *Safe-by-Design*.

Participants continued with claims that the current development is not fully under control of the producers as well. E.g. nanoparticles, that can prolong the shelf-life of the food products can under certain conditions evaporate and lose its potentially desired effects. From the regulation point of view, nanoparticles could be by definition “a helping technological substance” (e.g. in a form of nano-capsule) and not a food product itself.

If the nanomaterial would only change the taste of the food product, then it would have a different approval process and different legislation frame, then if it has a specific function. Which form? That would also set the legislation frame. In normal circumstances, there is already a European Commission procedure that usually lasts for two years and which is lead by European agency for the safety of food (EFSA). However, it does not work as a control mechanism institute. They approve processes, compare the empirical/scientific evidence and let the other laboratories control the food.

Contrary to Germany or France, in the Czech Republic there is no control institute that would analyze if a product indeed contains nanoforms, if that is labelled as such. However, Czech companies could be somewhat disadvantaged compared to companies in the EU, since the customer protection in the Czech Republic is more strict.

#### **4.2.2 Nanofilters**

In the Nanofilters group, the need to develop filters for cleaning the industrial waters was stressed as one of the most important application areas. One of the companies that already produces advanced filtering systems using nanotechnology however claimed that it is still very difficult to come up with filtering systems with such technical parameters and construction characteristics that would be suitable for such high volume and high pressure of water. Later it was once again remarked that water contains many already liquid contaminants that would have to be filtered by other ways including using specific enzymes or the reverse osmosis. In other words – many of the current issues with cleaning water are not solvable through Nanotechnology.

Discussion later came back to the questions raised by citizens during the online consultation. The public have ideas that for example cleaning of waste water or disposing of the contaminants of medicine or washing powders should all be solved by filtration and through Nanotechnology.

However, the representant of the Czech membrane platform claimed that for these problems, nano-filters are not suitable and that one would have to use different methods which are at this point financially demanding and at the same time not so effective. In other words: During the last session participants touched upon the topics of expectations people hold when it comes to Nanotechnology.

#### **4.2.3 Smart food packages**

During the last session, the participants in the smart food packages group discussed topics such as regulation and certification system. Should there be some authority stepping in to decide on the simplification of the certification systems? For the bioplastics there is not a unified standardization system, as there are yet many certificates. Currently at the EU level *N1321* is being used. However, it is being often criticised by businesses. The more general reason can be that – according to one of the participants – such regulations are being set for the ideal conditions and not the real-life situations the packaging systems are exposed to.

One of the business representatives describes an example of how the regulation and certification works for the company: The certification companies provide the client with a certificate that it is possible to use the given “filter” in food. This certificate is valid for three years, after the three years, company has to renew the certificate according to the new legislation. Filters have to fulfill criterias that are both connected to the “cleanness” of the substance and at the same time to preserve the taste of it. When it comes to filtration, there is no risk of contamination of the food chain – and that is given by the shape of the “nanoparticles” which are in this case nanofibres. When it comes to nanoparticles themselves, the risks of the contamination indeed exist – at least according to the experts. One of the representatives of the business made a remark that nowadays it is studied how the nanoparticles accumulate in the kidneys and that effective regulation means to standardize all kinds of nanoparticles, and to determine, from what size they can be contained in the food products.

The last point was about communication and possible future cooperation. All of the experts agreed that the public feedback is welcomed and that especially cooperation with researchers and further standardization of the contents that the companies use would be appreciated.

### **4.3 SUGGESTIONS FROM THE SECOND STAKEHOLDER WORKSHOP ON ENERGY**

The “*GoNano-Harvestore workshop on autonomous wireless sensor nodes for the future Internet of Things*” took place at the Catalonia Institute for Energy Research, in Barcelona, Spain, on the 30<sup>th</sup> of October 2019. There were 9 participating stakeholders, including 1 from industry and 8 researchers from universities or research centres, but from different fields.

The prototyping phase was where the group was asked to elaborate on the suggested applications by associating them to the parameters discussed in the ideation session. The objective was to demonstrate how relatively high levels of design detail, which is useful for technology developers, could be devised through this group activity. The completed templates from this session are shown

in Figures 3 and 4, and are summarised below. The two groups were instructed to set the range for the parameter, although a suggestion was already included in the template, and then to individually indicate their opinion of the optimum parameter setting for a WSN device in the selected application area (in this instance, the health monitor).

**Group 1 Summary. Health Monitor.**

Material: biocompatible (silicon, zirconia, ...), light, flexible, cheap, abundant, environmentally friendly.

Cost per unit: under 100€

Device lifetime: more than 10 years

Size: less than 1 cm

Colour: customisable or not important

Wireless range: greater than 1 m

Charge duration: greater than 1 day

Q. Who would benefit from this (directly/indirectly)? A. Everyone from developed countries.

Q. Who would be negatively affected (directly/indirectly) by this? A. Everyone from developed countries (but for different reasons).

Q. Are there any societal or environmental barriers that would limit the use of this technology for this purpose? A. Privacy barrier.

A positive point to note is that both groups managed to complete the activity, just not to the full effect that was expected. It was hoped that the groups would have had enough time to complete the activity for at least two application areas. However, this was not achieved, in part due to overrunning in previous sessions and in part due to the participants taking longer than expected to understand and complete the exercise. It is our feeling that with enough time to repeat this exercise, and with a wider variety of stakeholders, valuable insights could be gathered and really influence the decisions being made in the Harvestore project. Those workshop participants involved in Harvestore agreed with this conclusion and are considering how this may be implemented in the following phases of the project, as evidenced by the discussions in the reflection session.

<p>Who would benefit from this (directly/indirectly)?</p> <p>Everyone from "developed" countries</p>	<p>Who would be negatively affected (directly/indirectly) by this?</p> <p>The same</p>	<p>Material</p> <p>HEALTH MONITOR</p> <p>* BIOCOMPATIBLE</p> <ul style="list-style-type: none"> <li>- Silicon</li> <li>- Zirconia (...)</li> </ul> <p>* LIGHT</p> <p>* FLEXIBLE</p> <p>* CHEAP / ABUNDANT / ENVIRON. FRIENDLY</p>																									
<p>Are there any societal or environmental barriers that would limit the use of this technology for this purpose?</p> <p>Privacy barrier</p>		<p>Device lifetime</p> <table border="1"> <tr> <td>&gt;1 month</td> <td>&gt;1 year</td> <td>&gt;10 years</td> <td>&gt;100 years</td> </tr> <tr> <td></td> <td></td> <td>   </td> <td>≠  </td> </tr> </table>	>1 month	>1 year	>10 years	>100 years				≠																	
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<p>Wireless range</p> <table border="1"> <tr> <td>&gt; 1 m</td> <td>&gt; 10 m</td> <td>&gt; 100 m</td> <td>&gt; 1 km</td> </tr> <tr> <td>   </td> <td></td> <td></td> <td></td> </tr> </table>	> 1 m	> 10 m	> 100 m	> 1 km						<p>Charge duration</p> <table border="1"> <tr> <td>&gt; 1 min</td> <td>&gt; 10 min</td> <td>&gt; 1 h</td> <td>&gt; 1 d</td> <td>&gt; 1 wk</td> <td>&gt; 1 yr</td> </tr> <tr> <td></td> <td></td> <td></td> <td> </td> <td> </td> <td>  </td> </tr> </table>		> 1 min	> 10 min	> 1 h	> 1 d	> 1 wk	> 1 yr										
> 1 m	> 10 m	> 100 m	> 1 km																								
> 1 min	> 10 min	> 1 h	> 1 d	> 1 wk	> 1 yr																						

Figure 3. Completed template from Group 1 for the discussion and selection of device parameters during the Prototyping session.

Template 1 - Prototyping

Who would benefit from this (directly/indirectly)?

SOCIETY ISOLATED  
PEOPLE ELDERLIES  
PEOPLE WHOSE CHILDREN  
DEPART

Who would be negatively affected (directly/indirectly) by this?

DOCTORS (JOBLESS)  
HEALTH INDUSTRY  
LOW-INCOME POPULATION

Are there any societal or environmental barriers that would limit the use of this technology for this purpose?

TRUST  
PRIVACY  
USE OF THE INTERFACE  
ANTI-CYBER  
ATTACKS BY HACKERS  
USED IN ELECTRICAL CIPHERS

Template 2 - Prototyping

Material

SOFT (FLEXIBLE)  
BIOCOMPATIBLE  
DURABLE  
WATER RESISTANCE  
RECYCLED 70%  
NON BIODEGRADABLE (COR. RESISTANT)  
LIGHT  
STORE MEMORY  
COMPACTIBLE WHEN NEEDED

Template 3 - Prototyping

Cost per unit

< 10c < 1€ < 10€ < 100€

		X	X
			X
			X
			X

Template 4 - Prototyping

Device lifetime

>1 month >1 year >10 years >100 years

	/	X	X
		X	
		X	
		X	

Template 5 - Prototyping

Size

HEALTH MONITOR

< 1 m < 10 cm < 1 cm < 1 mm

X	X		X
	X		X

Template 6 - Prototyping

Colour

Bright Dull Transparent NA

X		X	X
		X	X

Template 7 - Prototyping

Wireless range

HEALTH MONITOR

> 1 m > 10 m > 100 m > 1 km

X	X		X
X			X

Template 8 - Prototyping

Charge duration

HEALTH M.

> 1 min > 10 min > 1 h > 1 d > 1 wk > 1 yr

			X		X
					X
					X
					X

Figure 4. Completed template from Group 2 for the discussion and selection of device parameters during the prototyping session.

**Group 2 Summary. Health Monitor.**

Material: biocompatible, soft, flexible, water-resistant, 70% recycled, light, non-biodegradable (corrosion resistant), shape memory, compactable when needed.

Cost per unit: under 100€

Device lifetime: more than 10 years

Size: no consensus

Colour: bright, transparent or not important

Wireless range: no consensus

Charge duration: greater than 1 year

Q. Who would benefit from this (directly/indirectly)? A. Society, people who are isolated, elderly people, people with chronic diseases.

Q. Who would be negatively affected (directly/indirectly) by this? A. Doctors (lose jobs), health industry, low-income populations.

Q. Are there any societal or environmental barriers that would limit the use of this technology for this purpose? A. Trust. Privacy. Use of interface. Anti-cyborgs. Attacks by hackers. Use in electoral campaigns.