# Responsiveness to societal values: an opportunity for responsible innovation of nanotechnologies

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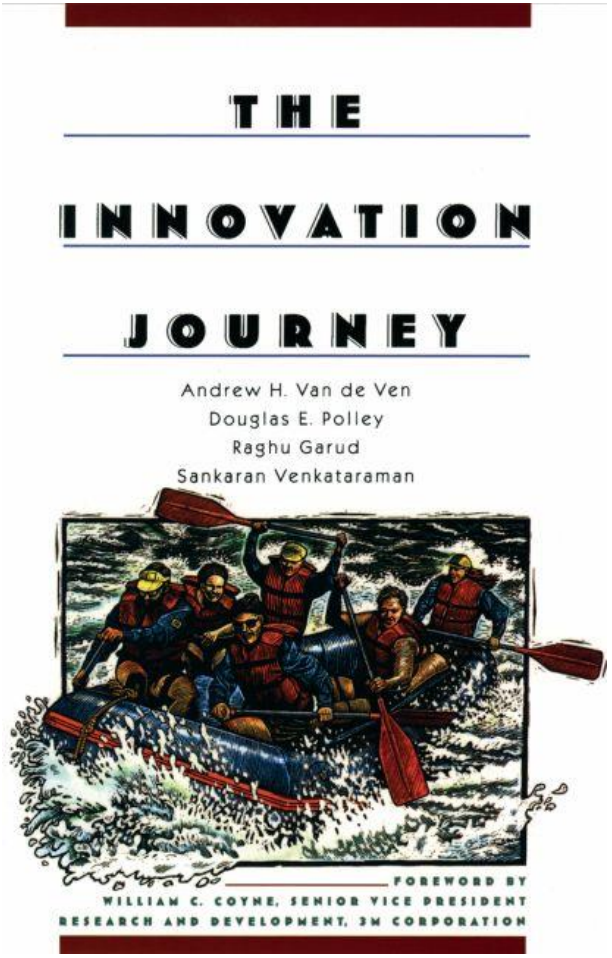
CREATING SOCIETY TOGETHER

# Nanotechnologies for society?

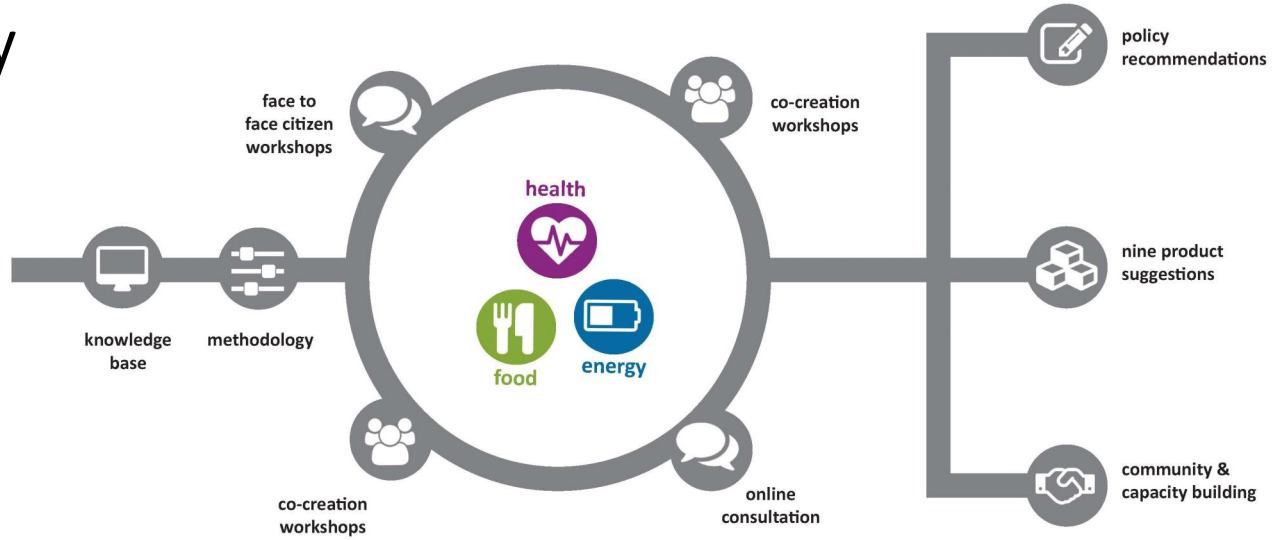
- Creating value for society
- What is value for society?
- Democratise research, innovation and agenda-setting processes, for:
  - Overview – several types of knowledge needed and no one has the overview
  - Understanding of societal values and needs
  - Addressing issues of inclusion, gender and diversity
  - Educating professionals and lay publics alike
  - Steering innovation journeys towards societal benefit – because innovation is not only about technology or scientific discovery..



# Nanotechnologies for society: how?

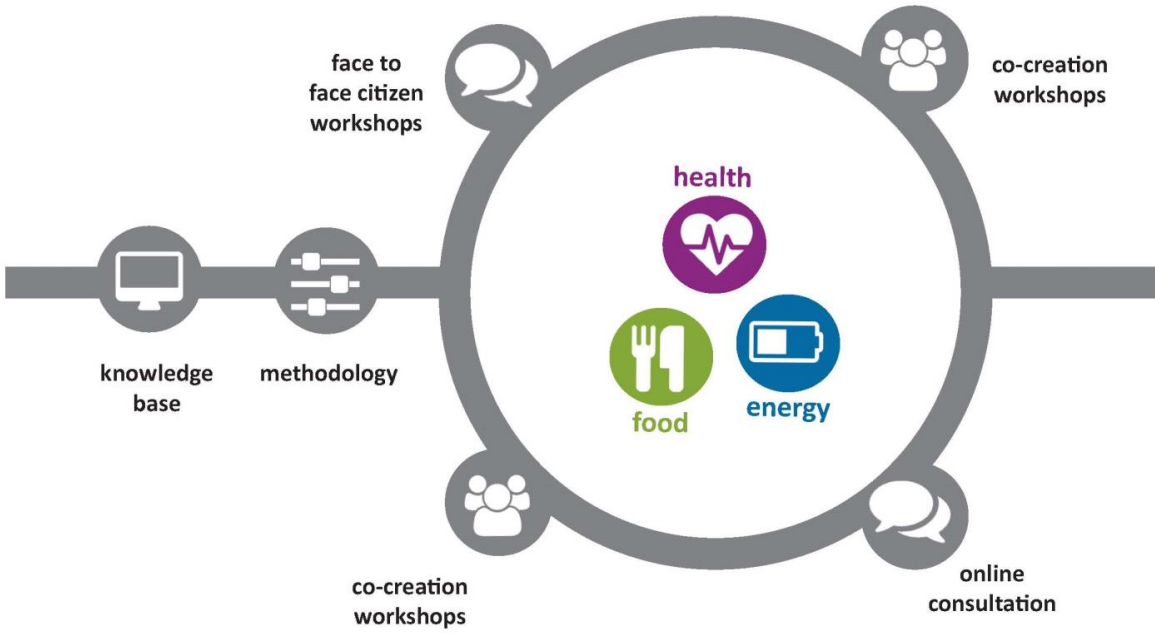
- Developing ‘Responsiveness’, by:
  - Inviting different perspectives to address complexity and uncertainty
  - Including societal values and needs
  - Building understanding and trust

**GONANO project: Demonstrating the value of co-creation for a R&I system responsive to societal needs and values**

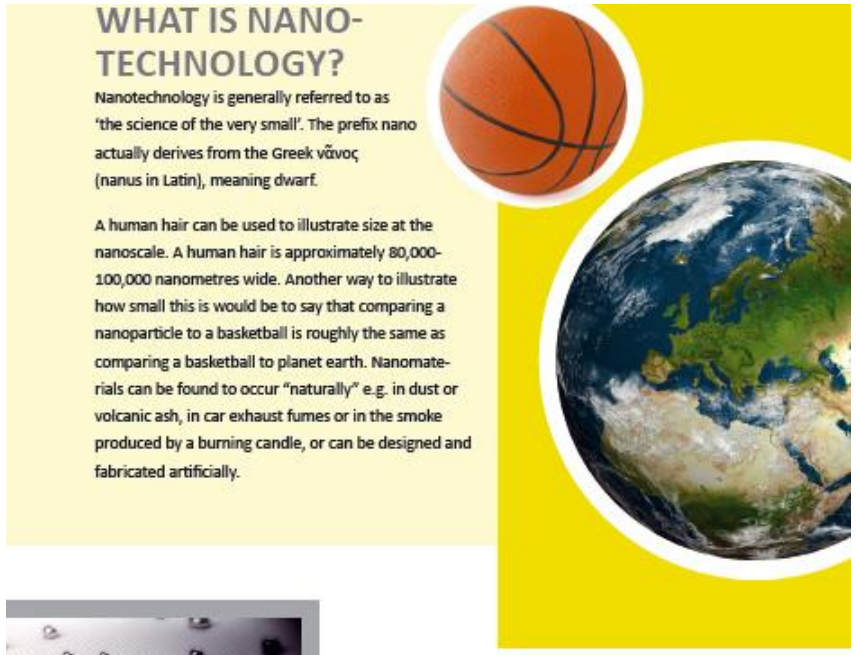


# Addressing uncertainty and complexity

- Representation of different perspectives and knowledge
- Illustrating opportunities and uncertainties for nanotechnologies
- Participation of citizens and different groups of professional stakeholders to include a broad range of expertise and types of knowledge



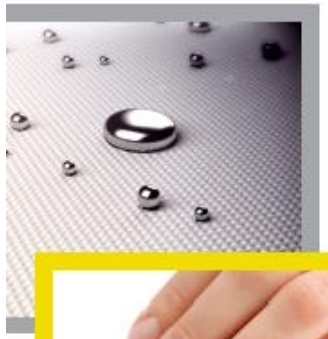
# Introducing nanotechnology



## WHAT IS NANO-TECHNOLOGY?

Nanotechnology is generally referred to as 'the science of the very small'. The prefix nano actually derives from the Greek νᾶνος (nanus in Latin), meaning dwarf.

A human hair can be used to illustrate size at the nanoscale. A human hair is approximately 80,000-100,000 nanometres wide. Another way to illustrate how small this is would be to say that comparing a nanoparticle to a basketball is roughly the same as comparing a basketball to planet earth. Nanomaterials can be found to occur "naturally" e.g. in dust or volcanic ash, in car exhaust fumes or in the smoke produced by a burning candle, or can be designed and fabricated artificially.



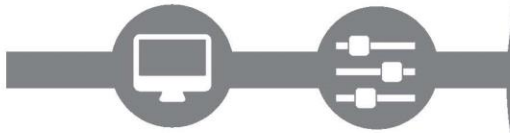
## NANOTECHNOLOGY TODAY

**Water-repellent fabrics:** Some water-proof fabrics are not actually water-proof. In fact, the natural fabric may not repel water at all; however, nanotechnology can be used to create tiny patterns or nanostructures, or to add very thin layers, that then make the surface water-repellent.

**Nano-cure for nail fungus:** A new treatment for nail fungus is under development that combines nanoparticles with anti-fungal medication to deliver the drugs more effectively to affected area of the nail.

**Nano-robots clear away bacteria and toxins:** Researchers are developing tiny nano-robots (made from gold nanowires) that can be controlled with ultrasound. The nano-robots can be used to quickly clear bacteria and toxins from biological fluids like blood.





knowledge base

methodology

# Presenting visions of research and industry

## NANOTECHNOLOGY AND ENERGY: WHAT ARE THE VISIONS?

### GREEN ENERGY PRODUCTION

Imagine a future with flexible solar panels, which were only possible to manufacture due to the incorporation of ultra-thin layers (nanolayers) of light absorbers, or a paint full of semiconductor nanoparticles that could convert any surface into a photovoltaic panel. The widespread use of such technologies could help reduce our dependence on fossil fuels, and thus help reduce the emission of CO2 and other greenhouse gases.

### PORTABLE ENERGY DEVICES

What if we could harvest the energy we produce when we walk and drive around every day? You could, for example, have nanofibers integrated into your clothes. The clothes would transform the energy produced by walking into electrical energy for powering your cell phone or smart watch. And what if the batteries in your cell phone had a higher storage capacity, a shorter charging time, or a longer shelf-life? More efficient batteries could prolong the useable life of our electronic devices, and therefore reduce the waste coming from them.

### ENERGY IN THE HOME

Today you can harvest and store your own electrical energy at home, using solar panels and large batteries like the Tesla Powerwall, but nanotechnology could make it possible to create and store energy in places you never imagined. You could install "smart windows" with a special nano-coating that would keep your house cool in Summer and warm in Winter – and generate electricity at the same time. The electricity could be stored in the structure of your house: the bricks in the walls, in wireless charging coils on the floor, on the kitchen worktop and in the furniture. Your smartphone and laptop could then be charged automatically no matter where you left them.

## NANOTECHNOLOGY AND FOOD: WHAT ARE THE VISIONS?

### SMART FOOD PACKAGING

Today, plastic is widely used for food packaging. Plastic presents a threat to the environment in the form of greenhouse gas emissions, and micro plastic in our oceans. Scientist imagine nanotechnology will lead to smart food packaging in biodegradable materials with e.g. anti-microbial, anti-fouling, stain-resistant, water repellent properties. In addition, nanosensors in the food packaging may in the future detect contaminated food and warn you by showing a red dot on the package. Overall, these properties could be used to realize so called "customer specific" packaging solutions. Benefits include: extended self-life, improvement of food security, and reduction of the environmental impact from production and degradation of food packaging.

### NOVEL FOODS

Imagine if we could optimise our food, so that we would be sure to get all the nutrients we need for a healthy body. Imagine if we could offer healthy, cheap and nutritious food to the global population, ending malnutrition, hunger and disease caused by a lack of (good) food and water. Researchers imagine it will be possible to encapsulate vitamins and other nutrients in nanoparticles, add it to our food, and thereby improve the nutritional value in everyday food. Nanoscale approaches could also be used to develop low fat foods or to change how certain foods taste or how they look like.

### NANO FILTERS

Water pollution is a global societal issue. Nanofiltering for purification of drinking water is already providing low-cost solution for water purification in some developing countries. Nanofilters can remove bacteria, viruses, heavy metals and organic materials from water.

## NANOTECHNOLOGY AND HEALTH: WHAT ARE THE VISIONS?

### EARLY DETECTION OF DISEASE

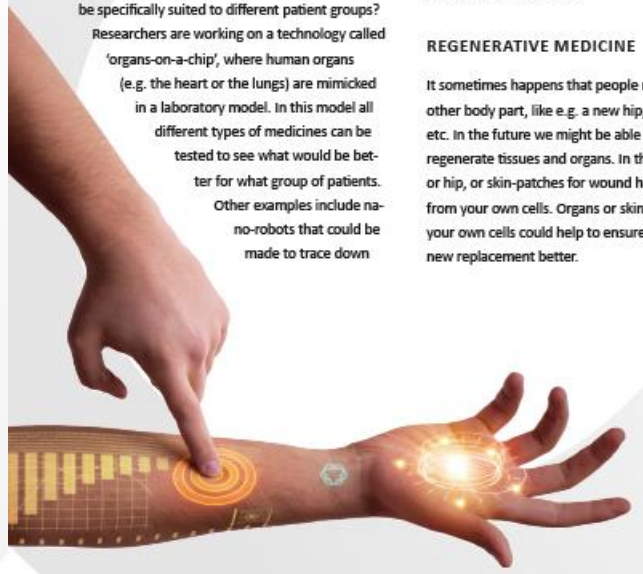
Nanotechnologies are imagined to provide new opportunities for diagnosis and prevention: for example the possibility of early and more accurate detection of disease. Researchers are developing sensors that for example measure your urine or breath. Imagine you would carry such a sensor you with you all the time. The sensors would collect data about our health condition throughout the day and night. In the future, they might even allow people to monitor their own health without the need of a doctor.

### MORE PRECISE AND PERSONALISED TREATMENTS

Imagine if in the future medical treatment would be specifically suited to different patient groups? Researchers are working on a technology called 'organs-on-a-chip', where human organs (e.g. the heart or the lungs) are mimicked in a laboratory model. In this model all different types of medicines can be tested to see what would be better for what group of patients. Other examples include nano-robots that could be made to trace down e.g. cancer cells and release medication in the diseased area of your body. The mechanism is for example promising in cancer treatment.

### REGENERATIVE MEDICINE

It sometimes happens that people need a new organ, or other body part, like e.g. a new hip, heart, lung, kidney etc. In the future we might be able to use stem cells to regenerate tissues and organs. In the future, a new lung or hip, or skin-patches for wound healing could be made from your own cells. Organs or skin patches made from your own cells could help to ensure the body accepts the new replacement better.



# Introducing societal needs and concerns

## RISKS AND REGULATIONS

### NANOTECHNOLOGY, HUMAN AND NVIRON-MENTAL HEALTH

There are many types of engineered nanomaterials; some are potentially hazardous but can be used safely under controlled circumstances. Most concerns relate to nanoparticles in free form, where they are harder to control and are not particles bound up in solid materials or fluids. But even then, are we able to control them? Are they toxic? Do they evade the natural defences of the body, and what are the implications of this? Do they damage cells? Could nanotechnologies have different effects on men than women, and could there be differences in effects across ethnicities?

Some people argue that we already use many dangerous technologies and substances in our everyday life (e.g. gasoline). They think we should talk about how we regulate and use dangerous technologies and substances, instead of talking about if we should use them. Others worry that the very properties that make nanomaterials desirable, are the very properties that make them hard to control and regulate. They therefore think that we should talk about whether or not we should be developing nanotechnologies as all.

#### YOUR SUNBLOCK COULD CONTAIN NANOPARTICLES

Many products already contain nanoparticles. E.g. A sunblock that rubs in clear on your skin could contain nanoparticles. Producers of sunblock are not obliged to indicate on the label if your sunblock contains nanoparticles. They are obliged to tell you what is in your sunblock, but not how small the particles are. A lot of research has been carried out to confirm that sunblock containing nanoparticles is safe to use for humans, but what about when we wash the sunblock off our skin? Has enough evidence been gathered about the possible environmental impacts of such products before allowing their use?

#### HOW IS NANOTECHNOLOGY REGULATED?

The question of whether and how to regulate nanomaterials has been ongoing in the European Union (EU) for over a decade. The EU was the first jurisdiction in the world to provide nano-specific legal provisions to address health and safety concerns of nanomaterials. Implementation of the EU legislation has, however, proven challenging. The various EU agencies need time to figure out who has the responsibility to implement oversight and regulation. Regulators need time to keep up with scientific developments. Industry and business need time to understand how to categorise and index their products.

## HOW SHOULD WE DESIGN NANO-TECHNOLOGIES?

#### WILL NANOTECHNOLOGY LEAD TO DIFFERENCES IN TREATMENT AND ACCESS TO TREATMENT?

In order to work, nanotechnology innovations need to be implemented in our societies, everyday lives and (inter)national systems. We are not sure how nanotechnology applications would affect the organisation of our healthcare systems, or how they could affect your privacy. We don't know if nanotechnology will deepen the divide between 'rich' and 'poor' patients, consumers and countries. We also do not know if better individual treatments would favour some groups over others. ? Could we see more treatments available for men than for women, or for some ethnic groups above others?

Many healthcare applications involve the development of sensors. Nanotechnology sensors could be used to detect early signs of disease, and combine data on your biology with your eating habits to support a healthy lifestyle. It could prevent intoxicated person from driving, by detecting traces of alcohol in the air. One could imagine that insurance companies, businesses, employers or others would also like to have such information. Could the collection of such information change the way we perceive ourselves and others? Who should own your data?

## HOW COULD NANO-TECHNOLOGIES BE DEVELOPED TO SUIT YOUR NEEDS?

#### HOW DO WE MAKE SURE THAT:

- We design nanotechnologies that fit with the wishes of citizens across the world?
- We avoid the risks and enjoy the benefits of nanotechnologies?

Research has shown that because nanoscience is dominated by men, ideas of future nanotechnology products are also male oriented. Men and women also think differently about risk. Perceptions of risk vary between some ethnic groups, with some men having a lower perception of risk. Women are more likely to think nanotechnologies are dangerous, and are less likely to engage with nanotechnologies because of this.

Research has also shown that religious beliefs and differences in culture can play a role in how we judge the potential of nanotechnologies, as well as how we believe nanotechnologies should or should not be used.

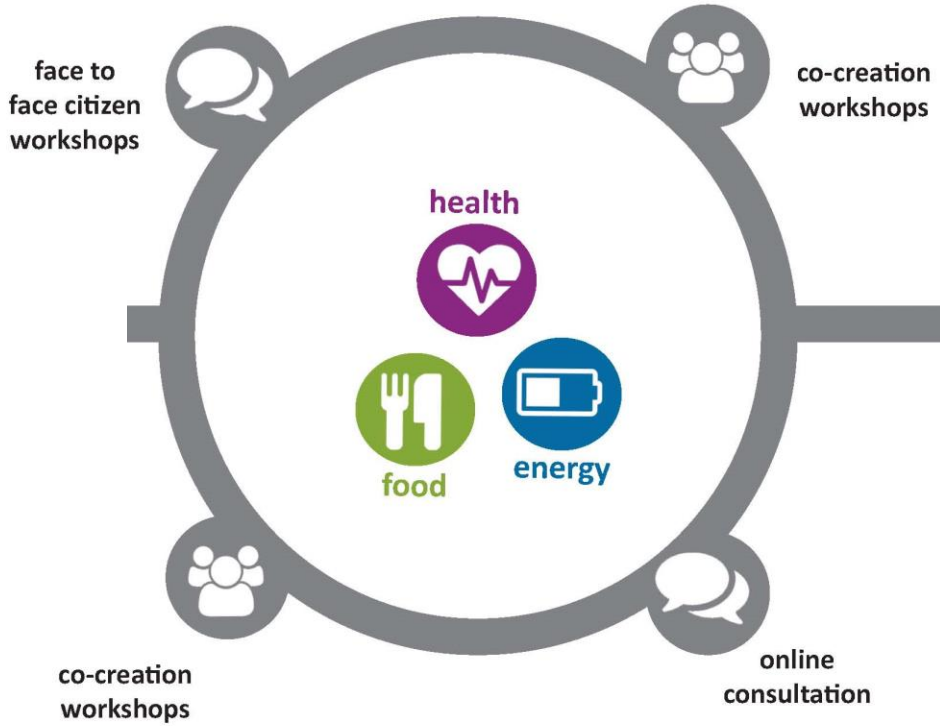
## WHAT DO YOU THINK?

- Do you think culture, gender or religion influence how you think about using nanotechnologies for applications in healthcare and to support healthy living?
- Do you think there are some traditional and cultural values we should support with new technologies for in healthcare and to support healthy living?
- How should nanotechnologies for health and healthcare be developed?

# Illustrating complexity and uncertainty in context of everyday life


# Inclusion, reflection and alignment with societal values and needs

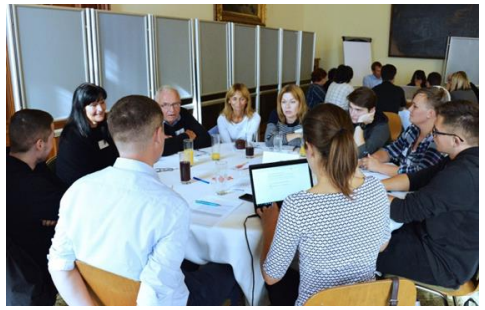
- Three pilots
  - Food: Czech Republic
  - Energy: Spain
  - Health: The Netherlands
- The circle of co-creation
  - Citizen workshops
  - Co-creation workshops

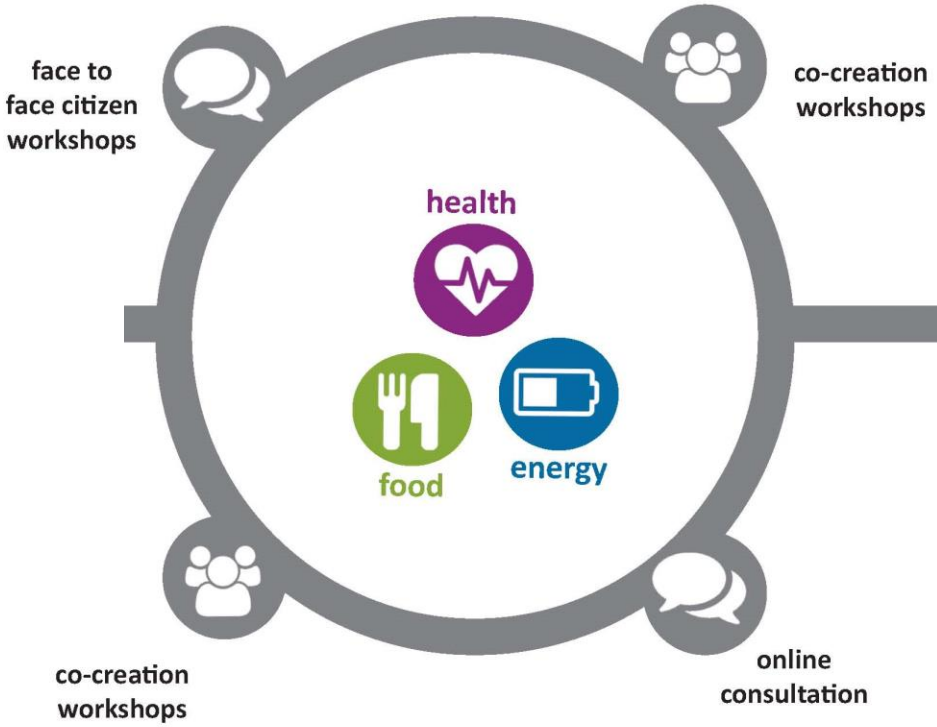


# Including societal values and norms

Across all three countries:

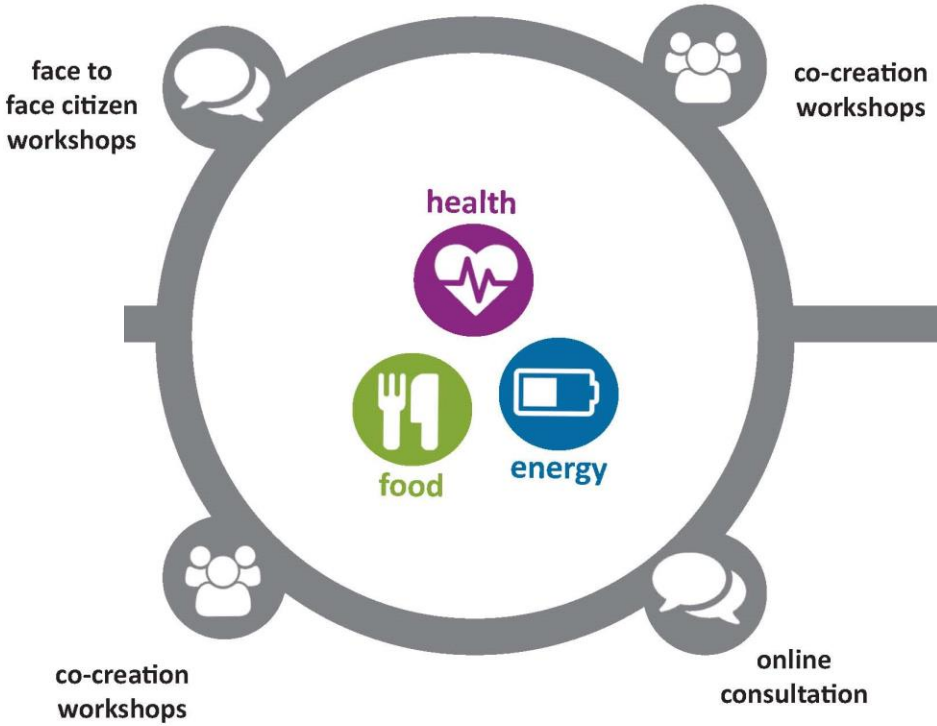
- Sustainable development,
- Consumption,
- Human health,
- Environmental protection,
- Safety aspects,
- Affordability,
- Accessibility.





# Reflection and alignment with societal values and norms

| Social values | Social needs | Citizen suggestions |
| --- | --- | --- |
| • Accessibility<br>• Wellbeing | • E.g. Health tech should be for all societal groups<br>• E.g. Nonintrusive, and ‘caring’ | • E.g. attention to user experience, criteria for selection of tech<br>• E.g. easy to understand device, health professional in the loop |

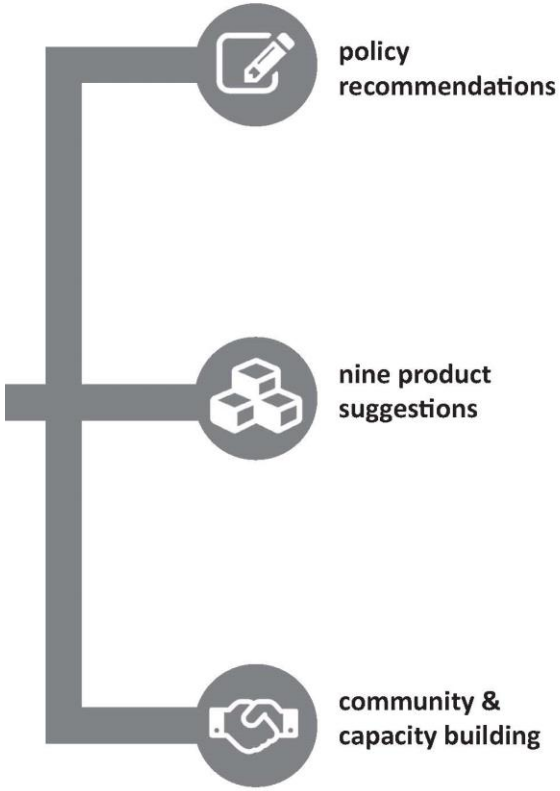


# Reflection and alignment with societal values and norms

| Social values | Social needs | Citizen suggestions | Expert feedback |
| --- | --- | --- | --- |
| • Accessibility<br>• Wellbeing | • E.g. Health tech should be for all societal groups<br>• E.g. Nonintrusive, and ‘caring’ | • E.g. attention to user experience, criteria for selection of tech<br>• E.g. easy to understand device, health professional in the loop | • Increased sensitivity to performance criteria that determine acceptability and desirability |

# Next steps: Building capacity on co-creation

- Second phase of co-creation loop
- White papers and policy recommendations
- Training and materials for researchers and engineers
- Guides for societal stakeholders and publics



# Nanotechnologies for society

- Responsiveness to societal needs and values necessary for societal value creation
- Frameworks and methods exists that can help
- Added value of considering societal needs and values in design and exploration  phase of research and innovation

# The GoNano consortium

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