



**Developing scenarios of use for
food, health and energy in 2030**



Future visions of nanotechnology and health in 2030

Monitoring for (un)healthy control?



Sofia turns off the alarm clock, yawns and finally sits up. Time to get up. She turns off the flight mode on her phone, turns on the Bodysensor app and holds her breath for a few seconds as it updates. Then she sighs. No signs of cancer. Yet. Time to wake up the kids.

Since they installed nanorobot sensors in her breasts it has become a daily routine for Sofia to check the Bodysensor app first thing in the morning. Her mother died of breast cancer seven years ago. Apparently Sofia is also genetically predisposed to develop breast cancer. The nanorobot sensors were offered to her in order to detect eventual cancer cells as early as possible. As Sofia sets the table for breakfast, she thinks of her mother. If only her cancer had developed five years later, she would most likely have survived. Since the development of cancer treatments enhanced with nanotechnology, very few die from breast cancer, and no-one has to suffer from the terrible side effects of the out-dated chemotherapies and radiotherapies of the past. Today, they use tiny nanorobots to transport the therapeutic agents directly to the tumour, so that patients do not need to have their entire body bombarded with chemicals and radiation. Tiny nanosensors are installed in the breast tissue of cancer patients that kept track of how they react to the treatment. In

this way doctors can make adjustments as soon as it is needed – and monitor any recurrence of tumour cells.

Peter is getting the kids ready. Sofia sits down with a cup of coffee. She looks at her phone and fights the temptation to check the Bodysensor app. The app is her safety net, but also a daily reminder that one day the figures might not be as she hoped. And what if the app doesn't detect everything? What if someone hacks into her phone and changes the settings or reads her data? Before the nanosensors were installed, Sofia didn't think much about cancer. Now she thinks about it all the time. Peter comes in with the kids, and they all sit down to have breakfast. Sofia is grateful to be alive.

The questions that are introduced include:

- Distribution of responsibility: Should Sofia be able to monitor herself?
- Appropriation: Will Sofia get used to the BodySensor app and possibly forget about after a while?
- Trust and privacy: Could the sensors break down or need replacement? How is the data shared? How does the app look like? Can others see or hear it?



Smelling disease



John is sitting in front of a computer at the pharmacy for his yearly health check-up. The yearly check-up is mandatory for everyone above the age of 30. On the computer screen in front of him, he has a view of a doctor sitting in front of a desk looking into a computer screen. On John's side of the screen there is a mechanical device that looks a bit like a nose. An assistant cleans the noselike device and asks John to open his mouth and take the device into it and blow his breath back and forth for a minute. The artificial nose can detect many types of disease. It takes 15 minutes for the doctor to return with the test results.

As he waits, John speculates about all the different types of diseases he might have – hasn't he been a bit more tired lately, and what about the other day when he suddenly couldn't remember the name of one of his colleagues? He is scared he might be developing a mental health disorder like dementia or Alzheimer's disease, or neurological disease like ALS where your muscles slowly die. Imagine not knowing when or how the disease would develop. John knows that medications today are much better than they used to be – but what was it he read the other day, about some medications only working well for some people and not for others? Was it that people of African descent who had the worst coverage with the new

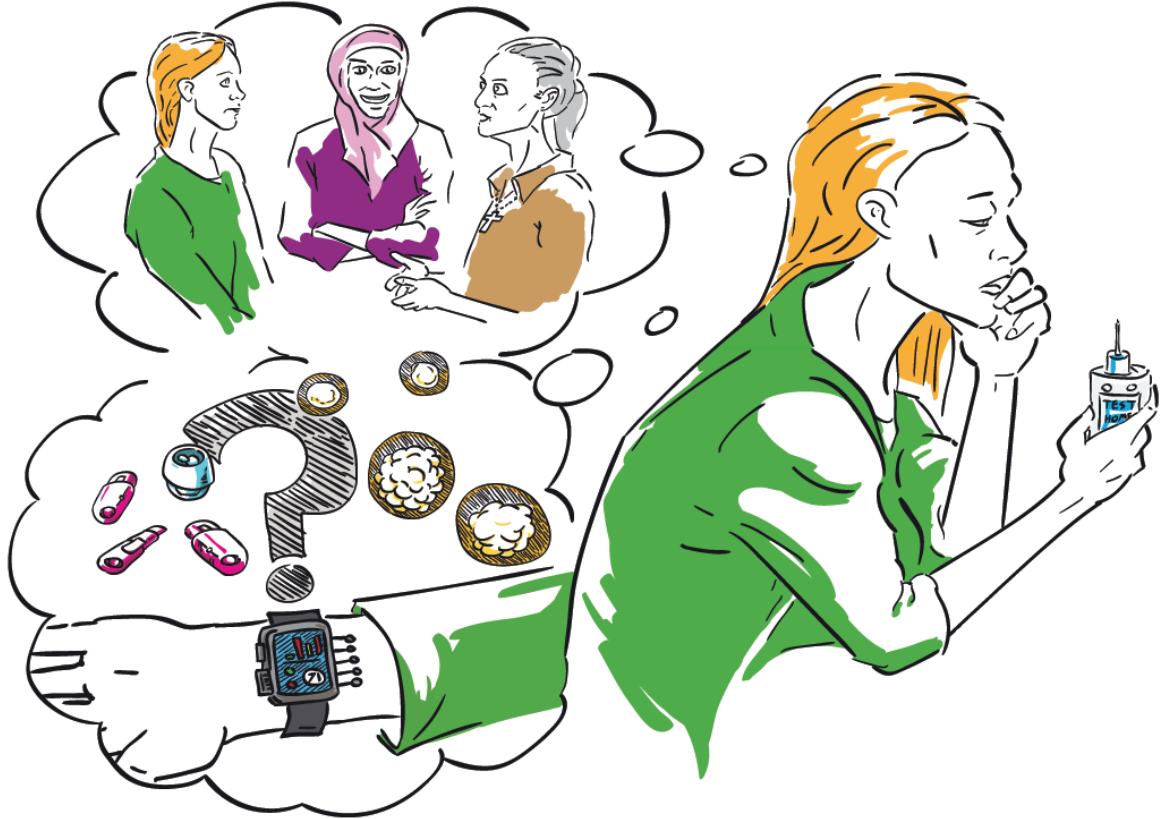
medications? The doctor returns to the screen. John's stomach is twisted up in a hard uneasy knot as he waits for the news. John is fine.

The questions that are introduced include:

- Societal and cultural implementation: What could the psychological effect of an increased focus on health and health control individually, and at a societal and cultural level be?
- Responsibility and trust: Would it be ok to have a diagnosis given at a distance? Where should a yearly-health check-up take place? Should everyone go to the pharmacy, or e.g. buy a 'smelling nose', would a nurse travel around with the "nose"?
- Justice and equality: Would it be ok to have medications that are only available for some ethnic groups (or genders)? How should health insurance look like in 2030?
- Privacy: how is data shared and protected?



Doctor at home



Sofia is sitting on the toilet in her bathroom at home. She is opening the package of a new home test for diabetes. The test is a needle with a nanochip. She will need to prick her finger to provide a blood drop for analysis on the nanochip. The chip can immediately detect if Sofia suffers from diabetes 1 or 2.

Recently, Sofia has felt very tired and thirsty and she constantly had to go the toilet. She searched online to check her symptoms and ended up on a webpage about diabetes. The website also described different treatment options. One option is a small wearable device developed using nanotechnology. This device constantly measures the level of insulin, and injects extra insulin when needed. Another option is to create new beta cells in the body. With diabetes type 1, beta cells in the body stop working. Using nanotechnology, doctors are able to create new beta cells from stem cells, and place those in the body. No other medication is needed.

Sofia considers her situation. She is already happy the home test for diabetes was cheap and easy to buy. Since health insurance does not cover check-ups at the general practitioner anymore, home tests are very useful. She is a little uncertain about using the needle to prick her finger. What if

she has diabetes? What treatment option would she choose? She imagines having to carry around a small device for the rest of her life. What if it breaks down or has errors? How would she know she was getting the right amount of insulin? The beta cells created from her own stem cells would cure her diabetes. She would never need to think about it again.

But her insurance does not cover the treatment, and it is very expensive. She also wonders how her religious community would feel about such a treatment. Would it be allowed? She takes a deep breath and pricks her finger with the needle.

In addition to questions already introduced by the two previous scenarios, the question that is introduced is:

- Culture and religion: How could and should culture and religion influence the implementation of nanotechnology enabled devices?



Future visions of nanotechnology and energy in 2030

A self-powered mobile



It's Sunday Morning. Andrew is sitting with his family around the breakfast table. An article on his news feed catches his eye; it's another piece about the latest trends in mobile phone technology. Six months ago, Andrew bought two new, self-powered, mobile phones; one for himself and the other for his daughter Emma. The mobile is coated with a nanomaterial that generates an electrical current when it interacts with common clothing materials – for example the lining of your pocket.

Andrew thinks about some of the other news articles he has read recently about the different nanotechnologies used in mobile phones these days. Most of the articles emphasise how the mobiles use much less energy and last much longer than they used to. However, a number of articles have raised questions about the environmental impact of the manufacturing process of the nanomaterials like the one used in the power-generating coating on his phone. An additional problem is that many of today's self-powered portable devices end up in the wrong bin at recycling centres because, at the moment, recycling centres are still not sure how to treat the waste from portable devices coated with nanomaterials. Andrew is not sure what to think. After all, many electrical devices have an environmental impact, and if we had to

consider the environment at every turn we would still be living in the Stone Age.

Andrew's thoughts are interrupted by Emma, who announces that she needs a new mobile phone. Andrew is surprised. He asks her if her mobile has stopped working. Emma explains that the mobile works perfectly, and the battery is never a problem. The problem is that there is new model on the market, and she needs it because all her friends already have it!

Questions introduced by the scenario include:

- **Environmental impact:** How will self-powered electronic devices enter into environmental recycling circuits? What broader environmental impacts could be imagined? How should the environmental lifecycle of nano-enabled devices look like?
- **Culture and appropriation:** Can business and consumer culture adapt to a future where devices will last (much) longer?



Doing the laundry



Anna and Emma are playing outside in the sun. The girls are playing in Anna's parents' garden. After a while they are hungry and go inside the house. As they search for food, Emma looks around. She sees laundry piled high around the house. It is very warm in the house. Emma cannot help but compare the house to that of her parents. Their house is always very comfortable to be in, and they can do laundry whenever they want. Emma knows she is lucky. Her family makes some money by selling energy to larger distributors, and they are able to produce much of their own energy as well. Her parents were able to buy new nano-windows that regulate the temperature in the house, and they also have nano-enhanced solar panels for producing their own electricity.

Emma thinks about how her dad complains about the bullying tactics of the larger energy distributors. They pay almost nothing for his electricity, but they ask for twice the amount when they want to sell it back. Her mom is advocating for the right of small energy distributors, like her parents, to be allowed to sell their electricity directly to consumers. Emma knows that Anna's parents cannot afford the new nanotechnologies that her family are so fortunate to have, which is why she never complains about the temperature in the house whenever she goes to visit Anna.

Questions introduced by the scenario include:

- Justice and equality: Should energy production be decentralised and how should such a system work? Could nano-enabled energy production systems be designed to favour small energy producers? Should we make sure everyone would have access to nanoenabled energy production, or must we accept inequalities in access?



A malfunction in the system



It is 6.15 am on Monday morning. As usual, Andrew is awake before the alarm clock rings. He needs to get ready to go to work. He goes into the kitchen to get a cup of coffee and check the news. He looks around to see if his daughter, Emma, is already awake. She isn't. He will have to go and wake her up soon. As he picks up his laptop from the kitchen counter, he notices the red light for low battery is still on. That's strange. The laptop should have charged itself overnight through contact with the kitchen worktop, one of the multiple wireless charging stations they have around the house. He probably just needs a new battery for his ancient laptop but he walks out to the hallway to check the house's system control panel. All the lights on the panel are flashing red. Great! He can forget about that cup of coffee before work. Emma has heard him in the hallway and comes out to see what is happening.

Andrew tries to call the maintenance service to arrange for someone to come and fix the installations in the house but there is no signal. Emma thinks the whole situation is very exciting. It's the first time she has experienced a malfunction in the control system for the house. Maybe it's a cyberattack! She looks at her dad and tells him that one of her friends told her that if the country's energy control system were hacked, then everything would stop working. There would be no trains,

no gas, no power, no TV, no air conditioning. Andrew looks at her and tells her to calm down and stop being so dramatic, as he makes his way toward the garage to check if the car has enough charge left to get him to work..

Questions introduced by the scenario include:

- Security and (inter) dependency: What are the trade-offs in an increasingly interconnected house and societal infrastructure? How should we develop and protect our infrastructure in our homes and societies in the future?



Future visions of nanotechnology and food in 2030

Pizza for two



Peter and Sofia are in the supermarket to shop for dinner. It's a little late, and they are both already starting to feel hungry. They decide on pizza. Neither of them have any interest in or patience for cooking tonight. They see some freshly made pizza - ready for the oven. Perfect. As they grab for two pizza's Sofia notices there is something different about the packaging. It must be the new smart nano packaging that they have heard so much about on the news!

Sofia reads aloud the text written on the packaging. Apparently, it is a new smart packaging that extends the shelf life of the pizza. It contains antibacterial nanoparticles, in-built sensors that warn you if the food is contaminated or has been exposed to harmful bacteria, and it is made of biodegradable plastic. Peter thinks it sounds great but Sofia is not convinced. She has just read that recent studies have shown that the nanoparticles can migrate into the food and contaminate it. The exact health related risks associated with the nanoparticles is still uncertain, but some researchers suspect that exposure to the nanoparticles might be related to infertility in women. The scientific community and the regulatory authorities are not in agreement on how to deal with this uncertainty. Sofia and Peter stare at each other in silence. They were planning to start trying for a baby soon, so they are not sure whether to eat the pizza or not. Glurg, glurg glurg, rumbles

Peter's tummy. They start laughing hysterically. They are both very hungry and they decide to eat the pizza. As they walk out the supermarket they continue to discuss the smart packaging. They both agree it is good to have food that can stay fresher for longer, but Sofia doubts that it is really necessary. She thinks she would always be able to see or smell if food is fresh. Peter wonders how it was possible for the packaging to be in the supermarket when there is still uncertainty surrounding the health effects of the nanoparticles. Sofia has to laugh a bit about Peter's concerns. She points out to him that we often accept health risks in relation to food, reminding him of the countless beers and cigarettes he had at the party last Saturday night.

Questions introduced by the scenario include:

- Risk and uncertainty: How should the benefits and uncertainties of new food packaging be managed in the future? Are they more or less than other health- related uncertainties we expose ourselves to?
- Distribution of risk, fairness: Would it be ok if uncertainty on possible health risks of nano-packaging only affected some groups (e.g. women or children) and how should that we managed?
- Environmental impact: How much uncertainty on environmental impact is acceptable, and how could we possibly manage nano-waste?



Dreaming of carrot cake



Theresa is 80 years old. She is living in a nursing home. Her family visit her often. She particularly likes the visits of her daughter, Sofia. She always brings a carrot cake, made from old-fashioned carrots and covered in thick sugary icing. The nurses at the home have told Sofia to stop bringing the cake. It's unhealthy. Luckily for Theresa, Sofia refuses to listen to the nurses. It makes Theresa happy to eat the cake. It reminds her of her own mother and her childhood in the countryside. She looks outside the window and dreams about when she was a young girl. She lived with her parents in a small village. She would spend her Saturdays at the local market with her mother, shopping for the best vegetables and meat. They would then take the rest of the afternoon to prepare the family meal for the Saturday evening. They would always make a carrot cake for desert.

Today, very few people cook a meal like she and her mother used to. Instead, most people eat the new super foods, made using nanotechnology and fancy processing techniques. The new super foods are a huge success. Everyone loves them. There are so many choices available: any flavour, any texture, any colour; ready to eat, hot or cold. And none of them are unhealthy! Even the triple chocolate hamburgers contain all the main vitamins and minerals you need. You can even buy

the food tailor-made for different age groups and genders to make sure all your nutritional needs are meet. Sofia is always telling Theresa how difficult it is these days to buy old-fashioned vegetables. They are very expensive, and only found in small exclusive shops. Theresa's daydreaming is interrupted as a nurse knocks on her door to tell her Sofia has arrived. She smiles. She can already smell the carrot cake as Sofia makes her way down the hallway.

Questions introduced by the scenario include:

- The meaning of food: How would we like our relationship with food to develop in the future?
- Equality: Will nano-enhanced food be a luxury product or the opposite?



Future party tricks



John looks around the room on the guest for his 35th birthday. Everyone seems to be having a good time. He walks over to the corner to speak to Peter and Andrew. They are busy trying to determine their next drink. For his party John has bought a lot of the new nano liquids. The nano liquids can be programmed to many different colours, tastes, nutrient and alcohol levels. All you have to do is decide the drink you would like to make, and then zap the nano liquid with a microwave transmitter. This will activate nano-capsules in the liquid that then turn the drink into your desired choice. John is relieved that no one has mentioned any concerns over the nano capsules in the liquid. The producer of the nano liquid writes the capsules are excreted out the body during normal digestion processes.

Peter is arguing for enhancing the wood smoke flavour of the next drink, while Andrew is more in favour of enhancing the taste of green pepper – maybe adding a bit of omega-3 oil to get a little bit of a health effect. Sofia comes over to join the conversation. She hands Peter a glass of white wine to ask for his opinion. Peter tries a sip, and almost spits it out as he discovers it is actually red wine. Sofia explains the wine was made using nano filters that can remove the red colour.

John laughs at them all, and suggests they set up a competition for the craziest combination of ingredients in a drink that still has to taste good.

Questions introduced by the scenario include:

- Desirability: What are desirable applications of novel nano food technologies?
- Justice and equality: If we have nano-enabled liquids (or super foods), how should they be distributed in our societies? Should everyone have access to them?

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The scenarios of use collect up on the analysis of future visions of nanotechnology application, questions on acceptability and sustainability (cultural appropriation, societal implementation) and desirability (gender and values). The scenarios take an everyday life situation as a starting point to illustrate how nanotechnologies could be implanted in the future.

The scenarios take the promise of the technology vision for granted. To introduce questions of desirability, sustainability and acceptability each of the scenarios play with how human, societal and cultural dynamics influence the way technologies become integrated in and part of people's lives.

In this booklet you will find twelve scenarios, the technology vision it depicts, and the societal, cultural and value questions it tries to open up for discussion.

This material was developed for the GoNano citizen meetings in fall of 2018 on future nanotechnology for health, energy, and food. The aim of the information material was to: present the citizen participants with short and easy-to-understand information about nanotechnology; align the discussion in the meetings with the research and innovation priorities with professional stakeholders; introduce visions of future nanotechnology in Health; and to introduce societal, cultural, legal and ethical questions and uncertainties.

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GoNano is a Coordination and Support Action funded by the European Union under the NMBP Programme of Horizon 2020, Grant Agreement n° 768622.