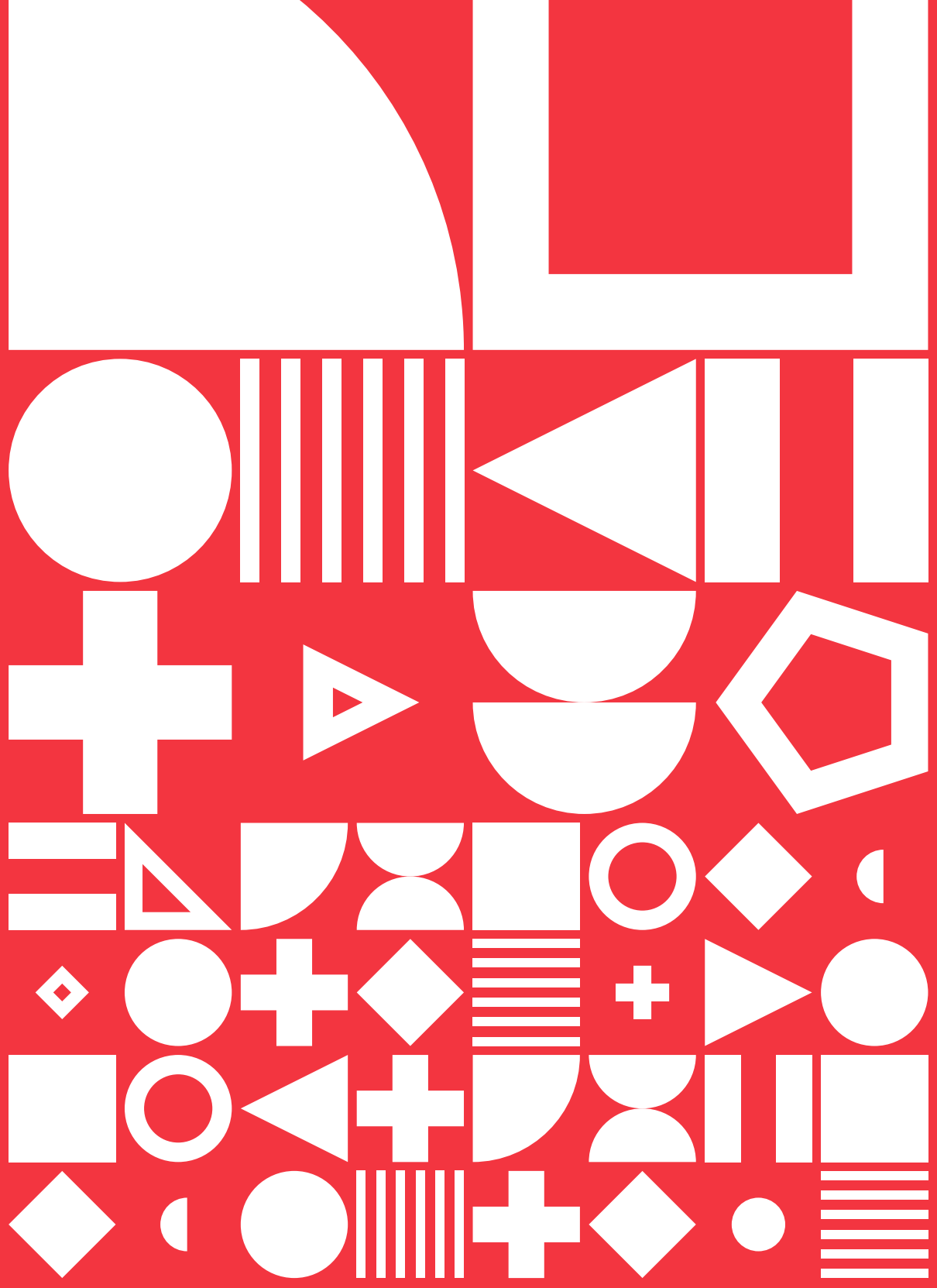
The Aalto Effect

Aalto University



The Aalto Effect

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Science and art help us make sense of our complex world and, at the same time, challenge our own ways of thinking. Together they bring new knowledge and perspectives, which we need more than ever to solve global grand challenges.

Ilkka Niemelä
President of Aalto University

Research is fun and exciting! I can learn new things for when I grow up to be a chemist or a game designer.

Oliver Tejera
First grader and Aalto University Junior member

Smarter energy

The world has come a long way in moving to a cleaner energy future, but there is still much to be done.

From research into electro-chemical conversion, to initiatives for recycling precious metals – technology needs to meet policy at every step of the way.

OVER the past few decades, the world has made significant progress in developing renewable sources of energy. While fossil fuels still account for the largest share of electricity in most grids, energy providers are increasingly investing in sustainable alternatives like wind, solar and hydro power.

Until now, most research and development work in this area has focused on the production side of the energy ecosystem. But as supply-side technologies have matured, so attention has begun to shift towards other areas – including storage, conversion and demand-response cycles – all of which have an important role to play in the sustainable energy systems of the future.

Towards clean conversion

Tanja Kallio, Associate Professor in Aalto University's Department of Chemistry, has been working with hydrogen fuel cells and other electro-chemical conversion devices for more than two decades. Capable of both generating and storing electricity, these devices have the potential to live alongside renewables in sustainable grids, supplying intermittent energy when needed.

'Electro-chemical devices are an extremely effective way to produce and store energy, but they're also incredibly expensive to make,' says Kallio. 'So either we need to lower their development costs by using cheaper materials, or we must find ways to significantly extend their lifecycles.'

The high cost of electro-chemical devices is directly related to the market price of the precious metals – typically platinum and iridium – used to catalyse the chemical reactions that create or store energy. The finite amount of these metals in the earth's crust not only drives up their cost, but also means that alternative catalysts will eventually be needed when mineral reserves run out.

A component used in laboratory tests on batteries.

'If you count the world's known reserves of platinum and iridium, and factor in the predicted growth in electro-chemical devices, it's very clear there will not be enough of these precious metals to cover our needs in 10 or 20 years' time,' she says. 'This is driving us towards developing earth-abundant alternatives that are not geo-politically problematic, and that will last longer in whatever applications we use them for.'

Kallio is part of a research group that has been working with several small- and medium-sized companies to reduce the role of these metals in the catalytic process. In laboratory experiments, the group has been able to successfully create ways to store energy in hydrogen using no platinum at all. But as these processes are difficult to recreate at scale, Kallio is instead focusing the team's efforts on a nanomaterial-based alternative that reduces the amount of platinum to just 10% of current levels.

Closing the loop

Recycling precious metals from end-of-life devices is already an important step in sustainability, for reasons of both efficiency and safety. But this practise becomes more challenging when the amount of metal in a device is reduced.

Kallio is addressing this through the CloseLoop consortium, a project funded by the Academy of Finland's Strategic Research Council. The group is collaborating with Aalto University's Associate Professor Mari Lundström and Professor Maarit Karppinen on developing recycling processes that can effectively separate rare materials like lithium and cobalt, purifying them to a level where they can be reused in lithium-ion batteries.

'Waste material contains precious metals in very low quantities, which renders their separation difficult,' she says. 'For lithium batteries, material with high purity are required, as impurities reduce a battery's lifespan. Our ongoing research demonstrates that precious metals can be recovered from battery waste and processed to active materials that have excellent initial performance.'

Energy in transition

In addition to the work Aalto University is doing on electro-chemical devices and their catalysts, there are also research groups taking a sociological perspective on the world's transition to sustainable energy. Professor Armi Temmes from the School of Business leads much of this work.

'As intermittent energy production from renewables is increasing all the time, so the ways to manage this energy are becoming more and more important,' says Temmes. 'Major technology shifts like this not only change the way people think and act, they also change the actors behind the scenes.'

A case in point is the way in which the electricity production and heat generation industries are becoming more intertwined. Until now, electricity has

been generated from heat, which in turn has been generated through burning various fuels. But today, with more and more renewable power being fed into the grid, electricity is increasingly being used to produce heat with heat pumps, for example. This supply-side shift is particularly pertinent in Finland, where central heating is so important for much of the year.

Working together with VTT, Finland's state-owned research centre, Temmes and her team have modelled a way in which the entire grid for both electricity and heating could, in the future, be based on renewable energy sources.

'To eliminate coal and other fossil fuels in Finland, we need much deeper integration in the production, use and distribution of electricity and heat,' she says. 'We would need a massive increase in wind energy for generating electricity to power large-scale heat pumps, which are very flexible and could meet a lot of our heating needs.'

Another area of Temmes's team's work is studying demand-response flexibility in the power grid, i.e. finding ways to smartly adjust electricity consumption without a noticeable effect on people or commerce. Systems for automatically managing these adjustments are beginning to come into use with industrial customers, such as shopping centres, but it will be some time before we see widespread adoption at the consumer level.

'Precious metals can be recovered from battery waste and processed to active materials that have excellent initial performance.'


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Battery cells labelled for experiments in Aalto University's laboratory.

'Demand-response models are developing, but they're still very difficult to introduce at the consumer scale, as the equipment behind them is far too expensive to make this business profitable,' says Temmes. 'So we're looking into the emerging business models in this area to understand how they could develop.'

Planning policy together

Aalto University has also been active in studying the policy implications of the transition to a sustainable energy grid, acting as a facilitator in bringing actors with different interests together at the same table. Under the leadership of Professor Sampsa Hyysalo at the School of Arts, Design and Architecture, paths were developed for eight different areas of the energy transition challenge. The advantage of this collaborative method is that the participants can constructively find ways to achieve the ambitious but necessary objectives for mitigating climate change.

'The crucial thing is that in the future we need to look beyond just energy production,' says Temmes. 'We now have a way to produce clean energy, but we just don't have the rest of the system in place yet.'

Five tips for tackling climate change

Karoliina Auvinen
Smart Energy Transition's Stakeholder Relations Director and Researcher

Illustration by Aino Salonen

1 **Cast your vote.** During elections, choose a candidate who understands climate change and knows ways to reduce greenhouse gas emissions. A large proportion of emissions are produced in ways that consumers can't influence through their own choices – these emissions can only be reduced by politicians.

2 **Travel smarter.** Where possible, avoid flying and using your own car. Favour cycling, public transport and new kinds of mobility services such as Whim. If owning your own car is unavoidable, go for either an electric car, a biogas car or a plug-in hybrid. It's also worth replacing diesel with renewable fuel.

3 **Eat smarter.** Choose vegetable proteins and increase your overall vegetable consumption. There are so many different options available today; try hummus on your bread instead of cheese, for example. Pay particular attention to reducing consumption of red meat.

4 **Heat smarter.** Switch to geothermal heating if possible and buy solar panels to go with a heat pump. Buy a home automation system that you can use to set room temperatures via an app.

5 **Invest in reducing emissions.** Choose investment funds and stocks of companies whose business is focused on reducing greenhouse emissions. Remove companies that deal with fossil fuels from your portfolio, and stop using service providers that do the same.

We need to make polluting costly

Slowing climate change demands comprehensive understanding of energy markets and resolute decision-making.

I study large-scale energy systems, such as international electricity markets, as well as district-heating systems. With my background as a specialist in curbing climate change, I'm interested in energy policy, the measures it involves and their impacts.

Together with my research group, I do a lot of work to sketch out scenarios for the energy systems of the future. Most recently, we mapped possible development trajectories up to 2030, and next we will be looking to the years 2040 and 2050. There are a lot of questions still open: Will the demand for electricity increase or decrease? What will happen to the price of electricity? Will Finland build more nuclear power stations? And will Sweden get rid of nuclear power altogether? Our goal is to be able to assess these different development trajectories and their pros and cons as accurately as possible.

It is certain that radical, large-scale changes will be needed in the near future. According to the report published by the Intergovernmental Panel on Climate Change (IPCC) in October 2018, Europe has to quickly give up fossil fuels altogether if it wants to fulfil its part in keeping global warming below 1.5° Celsius.

Carbon trading has a key role here. During the depression, the prices of emission allowances dropped so low that the mechanism actually favoured more polluting fuels. Thankfully, prices have now increased, and a tonne of carbon dioxide currently costs around €20.

It is important that carbon trading becomes a credible mechanism. Polluting must be made costly – permanently costly. This will mean that different actors will dare to invest and cleaner options will become more competitive. This change will take place through market mechanisms, without subsidies, which, according to our research, simply serve to fragment the market.

Directive measures must be ambitious and resolute; they must also have a sufficient geographical scope. In Central Europe, fossil fuels are used a lot for electricity and heat production, so the first step in the right direction would be to replace coal with natural gas. All of Europe could also see an increase in solar power and wind power, as well as hopefully an increase in nuclear power and carbon

capture in industries and power stations that are aiming for zero emissions.

The energy industry requires a wide variety of expertise and close cooperation between different sectors. It was a great moment when, soon after my arrival here, Aalto initiated a five-year, €12 million research programme on energy efficiency. Among other things, the programme included research on lighting technology, developing better materials for energy applications and promoting the use of wood for construction. We focused on Europe's electricity markets and how to reduce their carbon dioxide emissions – with great results. One doctoral candidate, for example, developed a model of the Nordic electricity market which we are still making use of in our research.

For me, training the experts of the future is the most important way to have an impact. Every year, I have around 300 students taking my bachelor's level course, and I take around 100 master students to deeper learning. I want to give them a realistic perspective on large-scale energy systems and what can, and should, be done to change them.

Sanna Syri
Professor of Energy Technology and Economics

Five alternatives to fossil fuels

Martti Larmi
Professor of Energy Technology

Illustration by
Tuomas Kärkkäinen

1 **Renewable diesel,** made from biomasses and waste flows, produces up to 90% less greenhouse gas emissions than normal diesel. It is an excellent fuel, and can be used as is in diesel-powered vehicles.

2 **Biogas** is an alternative to natural gas, both in heat and electricity production, and as a fuel for vehicles. Hydrogen, which can be produced from water using renewable energy, could potentially be added to biogas to further improve its properties.

3 **Synthetic fuels,** such as methanol, could be produced with renewable energy for wide use in maritime transport, renewable energy storage, and road transport. Synthetic fuels may be on the market within ten years.

4 A more environmentally-friendly aviation fuel, **biokerosene,** is already being produced, though it's more expensive than crude oil-based kerosene. Large-scale production of biokerosene requires more demand – and consumers will need to get used to higher prices for air travel.

5 Maritime transport is a large source of greenhouse gas emissions. **A bio-oil,** produced from various raw materials and other materials such as forest industry by-products, is currently under development and, potentially, could be further refined to produce an economical fuel for maritime transport.

Small Finland is a big player in the circular economy of metals

With its high-level research and close cooperation, Finland will lead strategic planning for battery recycling in Europe.

My field of research is hydrometallurgy, which is the science of processing metals through aqueous materials. At the same time, I am also an expert in metal recycling and lead the BATCircle consortium, which has received a large amount of funding to promote a circular economy of battery metals.

When I moved from industry to the university, I wondered if there was some new expertise that the university could offer the sector. The rapid mainstreaming of solar panels and electric cars means that we will soon have a huge amount of metal containing waste on our hands – and no one has any broad industrial experience of how to recycle it. Industry naturally focuses on operations which can bring profit in the fairly short-term; so, it cannot alone solve all the new challenges that the circular economy of metals brings. Universities can help in this by carrying out research and, at the same time, influencing society.

Two years ago, Finland hadn't even made it into the drafting group for the European Union's Strategic Energy Technology Plan (SetPlan). Then we gathered together four universities, two research institutes and 22 companies to form the BATCircle consortium. The EU saw the potential for cooperation, and this consortium – led by Aalto and Finnish mining-technology company Outotec – was given the responsibility for the battery recycling strategic planning for Europe as a whole.

With a grant of €10 million to BATCircle from Business Finland in 2019, the consortium seeks to increase the value of the Finnish battery market as high as €5 billion. Our expertise encompasses the whole product life cycle, from boosting the efficiency of primary mining operations to improving recycling processes and developing new business models. At the European level, this is something unique.

I am particularly interested in how metal recycling can be made truly profitable. In our research, this has sometimes even received criticism: reviewers of publications have taken issue, for example, with the heterogeneity of the raw materials that we use and asked why we don't use purer, more representative samples. We, howev-

er, want to use real battery waste that comes for recycling so that the research is representative and useful in practice.

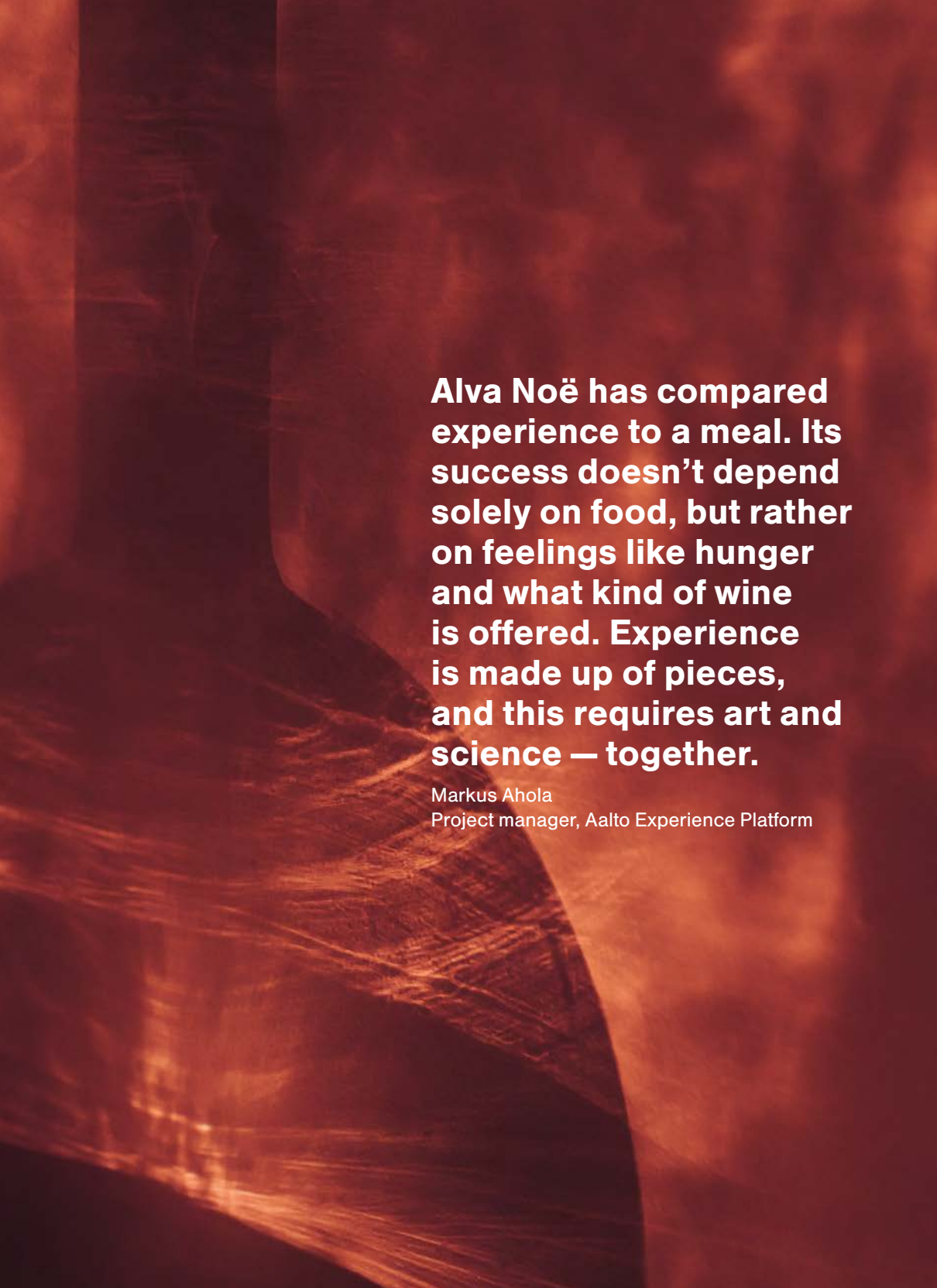
There are many challenges in the circular economy for metals. One is how recycling is organised. At the moment, old mobile phones get stored in people's cupboards instead of being recycled. There is also a need for discussion within the industry and in society on how products could be made more recyclable. Digitalisation and new business models could revolutionise many areas. At the moment, for example, a car battery is a bit of a black box from the recycling perspective, since its exact chemical content is not precisely known. In the future, we could use technology to mark and track metals; in fact, we could have fair trade metals in the same way that we now have fair trade bananas and coffee. It may also be that a car's metals are not sold on but are instead returned to the manufacturer, or that the whole car is simply leased to begin with.

I hope that in the next two years BATCircle will produce research through which Finnish businesses will be able to create new products and services: integrating recycled raw materials into traditional processes, salvaging new metals or selling our recycling expertise overseas. We want to do the kind of work that will mean that Finland and Aalto University continue to be seen worldwide as the top partners to work with in the circular economy of metals.

Mari Lundström
Assistant Professor in Hydrometallurgy

Art, research and science help us understand the world, and through this understanding the world becomes a better place for us all.

Tua Videman
Student of Industrial Engineering and Management



Alva Noë has compared experience to a meal. Its success doesn't depend solely on food, but rather on feelings like hunger and what kind of wine is offered. Experience is made up of pieces, and this requires art and science — together.

Markus Ahola
Project manager, Aalto Experience Platform

Wiser decisions

Innovation and bright ideas exist everywhere. But they are not always discovered, or may get lost in the noise of modern life.

The solution is to develop ways to listen to everyone; to bring people together on the same path so we can make the decisions that are best for us all.

SOME 750 million people around the world lack access to clean drinking water. Many of them live in East Africa, where people typically kill bacteria and viruses in available water by boiling it over charcoal fires. This not only contributes to deforestation and the release of carbon; smoke can also affect human health when fires are lit in poorly ventilated houses. There is a cost consideration too, with many families spending a considerable portion of their income on charcoal.

Nanomaji ('maji' means 'water' in Swahili) is a startup created by Master's students at Aalto University that has developed an innovative water-purifying solution. Recognising that (unsafe) water is typically collected and carried in jerry cans, the students – working with Finnish fibre-materials company Ahlström-Munksjö – designed a carbon-based filtration device that attaches to the mouth of a jerry can. When the jerry can is upended, water flows slowly through the device and becomes safe for drinking.

The project, which won a prize in Europe's largest climate-innovation competition (ClimateLaunchPad), is a prime example of what's known as *frugal innovation*: stripping a product down to its essentials to make it affordable.

'We use the term frugal innovation to talk about reducing the use of energy and materials to make something accessible to people who earn less than five dollars a day,' says Professor Minna Halme, who has been working in sustainability management for more than 25 years. Part of her work looks at how poverty alleviation can be addressed through business models that work as a force for change.

'While teaching executive education in the 2000s, I noticed that managers always became excited when asked to think about innovative solutions to environmental problems that also make

commercial sense,' says Halme. 'This can be applied in the societal development context too. By designing business models that provide people with products and services they wouldn't otherwise be able to afford, we can do a lot to alleviate poverty.'

Innovation for everyone

Frugal innovation is closely related to another concept that is core to the work of Halme and her research colleagues: *reverse innovation*. When you innovate to create something with frugal means – often in a lower-income context – that innovation can then be brought into higher-income markets too. With sustainability concerns increasingly in the spotlight, the concept is gaining ground around the world.

One of the best-known examples of reverse innovation is a line of electrocardiogram (ECG) systems first developed for the Indian market by GE Healthcare – a leader in ECG equipment. An ECG is the most common cardiac test, but the equipment for it is traditionally expensive. This was until GE engineers in India developed the company's MAC 400, a portable and battery-powered machine with two-button operation that simplifies training and use. The MAC 400 cost hundreds of dollars instead of thousands, which turned out to be a compelling proposition for markets in Europe, the US and elsewhere as well. Today, GE Healthcare's MAC products are available across the world.

Reverse innovation is core to the *New Global* research project that Halme leads. Backed by the Finnish Funding Agency for Innovation, the project has supported Halme's colleague Professor Peter Lund in a solar electricity initiative for rural India. Lund and his team worked with local company Boond Engineering to create a smart-metering solution that helps village dwellers manage their consumption of solar-generated electricity.

'When the pico-, micro- and mini-grids of rural villages rely on solar power, the network collapses if too many households use electricity at the same time,' says Halme. 'Smart metering addresses this by adjusting the price of electricity according to demand.'

'The solution we developed with Boond presents variable electricity prices in colour codes that are easy for illiterate people to understand, so they can save money by reducing their consumption at peak times. This, in turn, means grid overloads can be avoided.'

'These types of decentralised energy solutions and smart metering are very relevant for the future of energy provision in many parts of the world, including developed countries,' says Halme.

Design for transition

The transition to future energy models is central to the work of Professor Sampsa Hyysalo. His research team has been using the principles of co-design to bring multiple stakeholders together to

build the roadmap for Finland's shift to a clean-energy future.

'Co-design is about devising and researching arrangements by which different stakeholders can effectively collaborate,' says Hyysalo. 'The methodology is not only used in product and service design, but increasingly also in broader social reforms. It's about how we can reach wiser decisions by tapping into the competency pools of a wide range of stakeholders.'

'By designing business models that provide people with products and services they wouldn't otherwise be able to afford, we can do a lot to alleviate poverty.'

To plan Finland's energy transition up until 2030 – the year by which many measures that limit global temperature rises need to be in place – the researchers brought together 23 people from across society. The group included members of parliament, officials from four government ministries, mayors from carbon-neutral cities and municipalities, business leaders from energy companies, representatives from NGOs, and energy-active citizens.

Hyysalo had originally planned to use a transition-management approach developed by Dutch researchers. But this method focuses on implementing change over longer timescales of between 40 and 100 years, whereas the transition in Finland needs to be much quicker. So Hyysalo's team developed their own approach, broadly re-designing the transition management process.

'For climate change mitigation, the rubber must meet the road by 2030,' he says. 'The hard decisions need to be made by then if we're ever going to

‘Even extremely tough subjects can benefit from broadening the group making a decision, rather than leaving it to a narrow group of elites.’

meet our longer-range climate change targets.’

Walking the same path

The researchers developed a new kind of mid-range planning process, and then ran a year-long workshop series with a meeting approximately every six weeks. The participants articulated goals for eight transition paths up to 2030, and then together planned the steps needed to meet the goals. They defined and agreed upon concrete actions in regulation, business, investment, consumer behaviour, energy production and more.

‘What society can do in reaching wiser decisions is create ways for people to directly negotiate with each other,’ says Hyysalo. ‘This is very different to traditional forums, such as hearing procedures and roundtables, in which each stakeholder is prone to defending their own interests.’

‘Co-design principles can help us to get beyond the political cycle of elections, and move away from stop-start planning. We need a degree of permanency in these long transition projects, such as those related to energy and resource use. These are issues that will not be solved by any one government alone.’

‘What a small country like Finland can do is set an example to the rest of the world on how to run these kinds of important societal processes on a more democratic footing,’ says Hyysalo. ‘Even extremely tough subjects can benefit from broadening the group making a decision, rather than leaving it to a narrow group of elites.’

Five tips for a happier life

Esa Saarinen
Professor of Applied Philosophy

Illustration by Milja Komulainen

1 **Look for the hidden good in people.** Your own attitude affects how situations appear to you – and how you appear to others.

2 **Take charge of your own life by listening to the voice of your heart** through deeper reflection – delving into what you know is right. A gloomy atmosphere might feel real, but there's always a way out towards something more positive.

3 **Regularly switch off performance mode.** Pick up a random book, have a chat with a friend or work colleague, or go for a walk. Allow your mind to wander without the pressure to achieve or perform, and new ideas will start to flow.

4 Wise decisions can't be made without taking other people and the broader context into account. Everyone benefits if you **show interest, ask questions, examine alternatives and keep things in perspective.**

5 **Love your loved ones.** Open up channels for kindness in your daily life by daring to believe that good will prevail.

Social welfare and health care reform should be implemented in stages

Creating markets requires patience: the introduction of prices and competition encourages new and innovative solutions, but also generates new challenges.

I am an economic theorist by training, and my primary research focus is the effect of information on economic outcomes. Although my own research is classified as theoretical basic research, it intersects directly with the development of practical solutions to large societal challenges. A good example is the transition of services provided by public authorities, such as social welfare and health care services, towards a more market-based model.

As is common for economists, I believe in the efficiency of competitive procurement methods, such as auctions, in situations where the services and products to be procured are easily definable. I have participated in the planning of the 4G bandwidth auction, together with the Finnish Communications Regulatory Authority, and in conditions like these, markets function well.

When the quality of the service to be procured is less easily defined – for instance, care services for the elderly – introducing competition to markets is much harder. In such cases, it is also more difficult to verify the benefits gained through competition. Without clear rules about service quality or the selection of customers eligible for the service, the pursuit of profit by private companies may be in conflict with the social good.

It is clear that political pressure to provide public services privately and fund these services from outside the public budget will increase for future governments. When dealing with large-scale reforms that change social structures and activities, it is vital to accumulate information and experience on impact.

In this context, a theoretical model works like a flight simulator in the development of a new airplane. By analysing the model, we can predict the behavioural impacts on service providers and customers that the reforms will bring. If reforms are implemented in stages, valuable information from the initial stages can be used for planning later steps. For example, the social welfare and health care reform in Finland should be implemented in stages, as the country did with basic education reform in the 1970s.

Sensible decision-making requires thoroughly researched information. Procurements and competition are at the heart of both

the theoretical and empirical research carried out in my department. Finnish data on procurements is unique and opens up possibilities for comparing and assessing different forms of competitive procurement. This benefits both service users and society, which ultimately funds service provision.

Societal decisions are formed under the pressures and tensions of conflicting objectives. Good decision-making recognises these conflicts and uses available knowledge and data to find good compromises. The Aalto Economic Institute, based in our department, helps public and private operators to conceptualise their operations within a broader economic framework, and provides concrete advice on finding good solutions.

In my own teaching, I seek to train students to value and respect others, have a broad understanding of the social impacts of economic activities, and gather and use data to support their own decision-making.

Juuso Välimäki
Professor of Economics and Head of the Department of Economics

Five foundational principles for decision-making in living environments

Aija Staffans
Platform Manager for the Living+ Platform

Illustration by Safa Hovinen

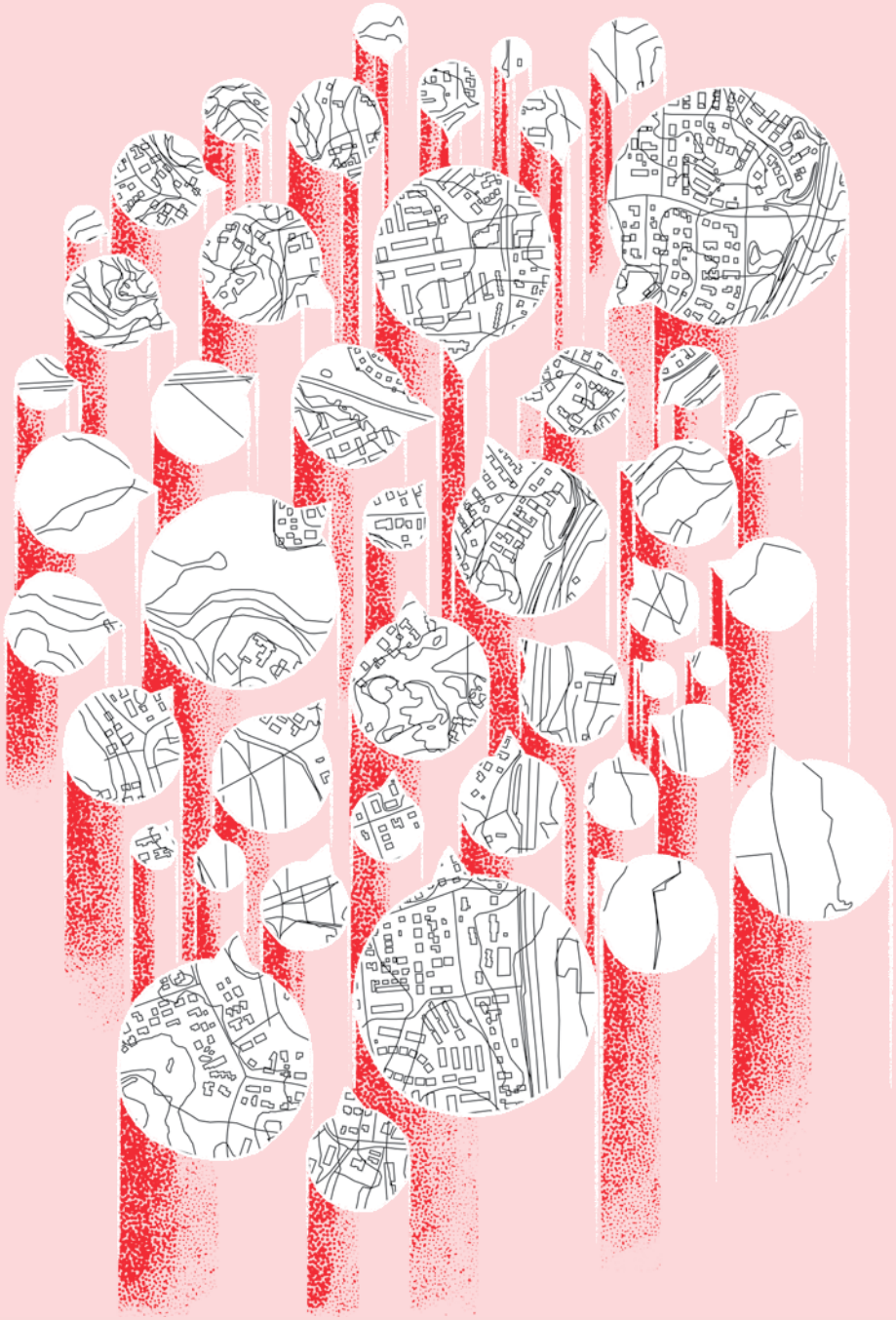
1. Plenty of information exists for making decisions. However, this **information must be easily accessible, reliable and as up-to-date as possible.**

2. Decision-making should be based on **broad dialogue between experts, residents and users,** and this process should make diverse use of different sources of information. Dialogue builds and strengthens both trust and commitment.

3. **Planning decisions have both direct local impacts as well as indirect systemic impacts.** We should identify these impacts during the decision-making process.

4. Decision-making is about making choices, and these **choices must be explained and justified in a transparent and understandable way.**

5. **Collaboration** is an attitude that produces good decisions and a commitment to implementations.



Increases in health care efficiency can also improve quality

Billions of euros could be saved in social welfare and health care with key changes.

I am a professor of accounting, and in recent years I have focused my research on two large areas: the role of accounting in corporate management systems, and health care and opportunities for boosting health care efficiency.

I have trained a large number of health care professionals, as matters of accounting and finance have not traditionally been part of studies in this field. Now the situation is changing, as we are forced to think about how to obtain the greatest possible health benefits with a limited amount of money.

Social welfare and health care costs have, for a long time, been growing faster than GDP, which is an unsustainable trend. Nor is it any kind of natural law that just needs to be accepted, at least as the population ages. In fact, for the majority of people the need for care increases only during the last one or two years of their life.

Finland is ranked high on World Health Organization lists in terms of the numbers of operations carried out. There are, however, massive differences in these figures between different regions, and these differences cannot be explained by sickness rates or other patient- or region-related factors alone. This suggests that the number of operations is being determined, at least partly, by supply rather than demand. Changing this situation requires effective leadership and changes to production structures, and this, once again, is not possible without larger social welfare and health care regions.

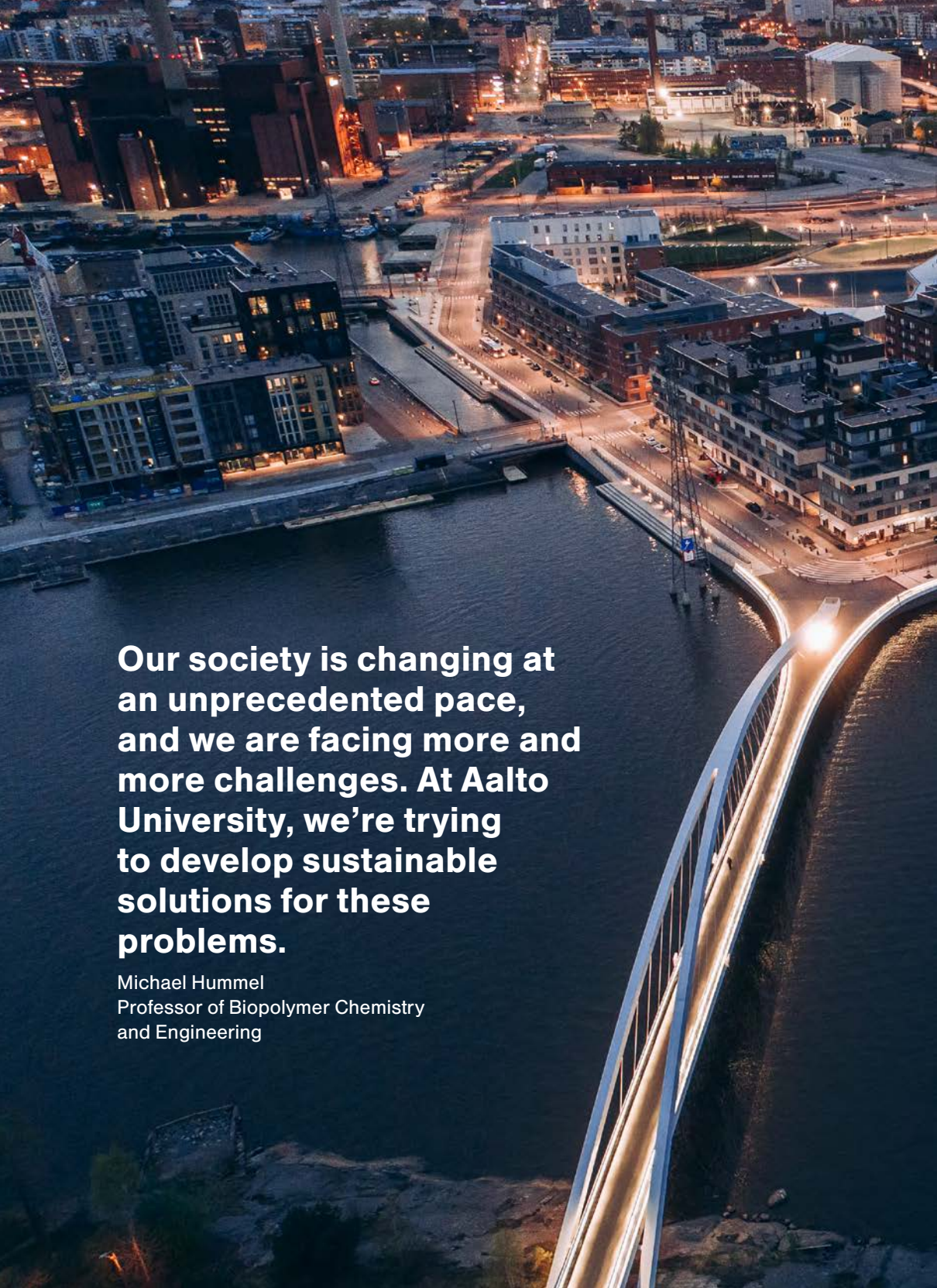
In a study funded by the Foundation for Municipal Development and nine hospital districts, we compared the expenses of different hospital districts. We calculated that there is an opportunity to achieve savings in social welfare and health care expenditures of as much as €2.6 billion without significantly affecting the level of service. This could be achieved by following the example of the most efficient hospital districts: reduce the number of operations, increase the operational efficiency of operating rooms, laboratories and imaging services, direct resources towards rehabilitation, and invest in elderly care. In Finland, for example, dementia patients continue to receive care in hospital bed wards, which is often both expensive and inhumane for the patients.

There was a serious defect in the social welfare and health care reform proposal that recently collapsed in Finland: price competition was not included. Instead, the price to be paid to private and public social welfare and health care centres was to be calculated according to the public operator's cost levels. According to market logic, private companies will be particularly drawn to areas where there are more patients. In this way, the public sector is forced to take care of areas on the margin, which causes their cost level to rise. The companies would have received larger payments, amounting to an income transfer from society to these companies.

After these society-level calculations, we have turned to examine individual organisations and how to improve the efficiency of their operations, as well as seeking methods for getting personnel inspired about productivity development. One central thought is that operational management and planning should be fact-based. In psychiatric care at the Helsinki University Hospital (HUS), for instance, they have started to code patient treatments. With these we can know precisely what has been done to patients, and better monitor and compare the effectiveness and costs of treatments.

In many ways, Finland has an excellent health care system, one which fares very well in international comparisons. But, nevertheless, it would be foolish to think that further development and changes are not necessary. In health care, as in any industry, we can improve both productivity and quality simultaneously – and all the while make progress.

Teemu Malmi
Professor of Accounting

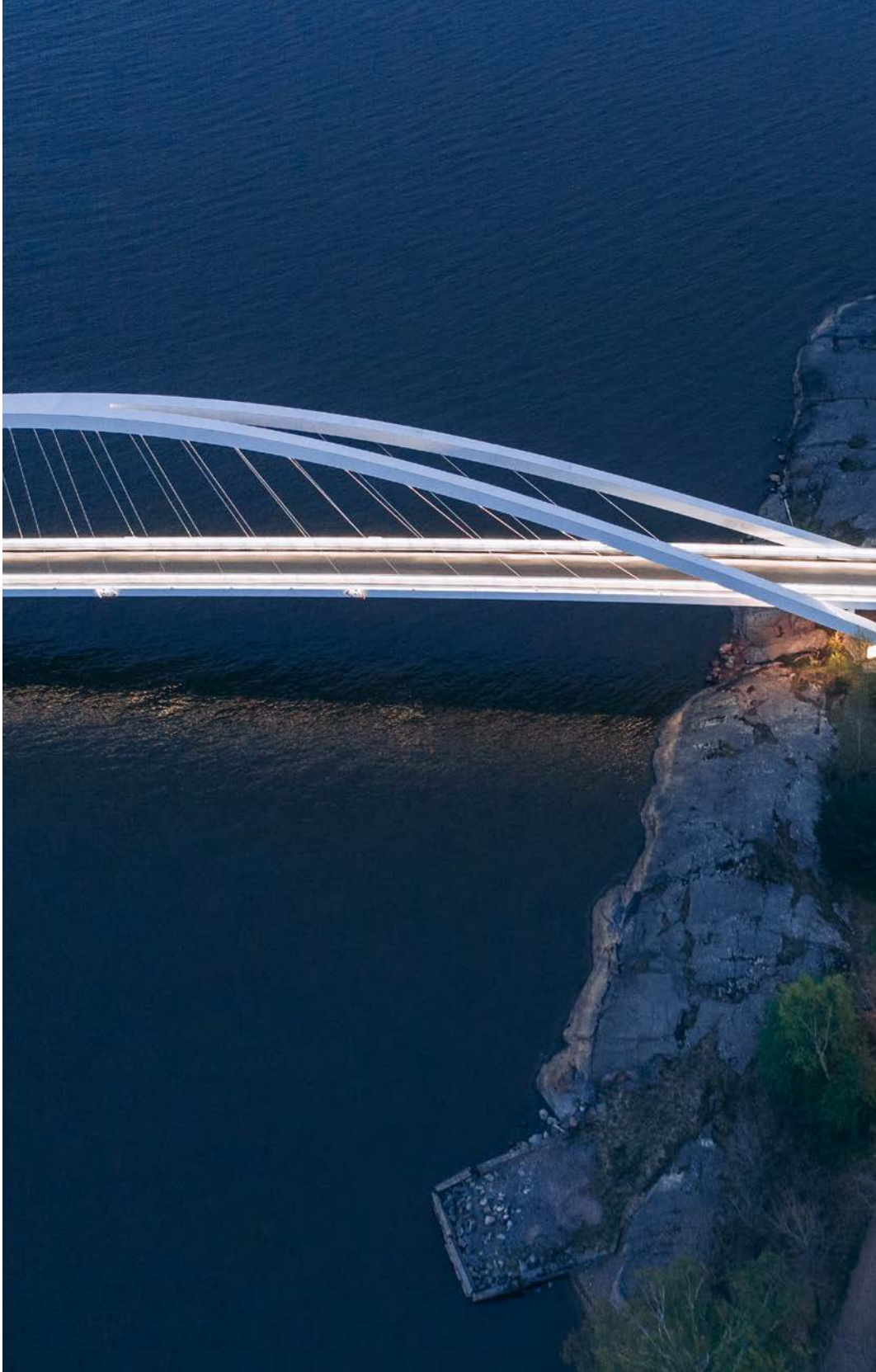


Our society is changing at an unprecedented pace, and we are facing more and more challenges. At Aalto University, we're trying to develop sustainable solutions for these problems.

Michael Hummel
Professor of Biopolymer Chemistry and Engineering

Without science, art, research and their lessons, our world would not be the one we know. We've created lots of good, but also problems that need to be solved. To have outstanding art and science, on top of asking smart questions, we need to find potential answers and ways to spread understanding and solutions.

Ossi Naukkarinen
Aalto University Vice President for Research



Happier living

People often feel better on the inside, when things are good on the outside. Green spaces, safe streets, and access to education – our well-being is intrinsically linked to the environment in which we live.

But happiness is not spread equally. So we need to show empathy towards those who are not as fortunate, and find ways to help them live happier lives too.

IN both 2018 and 2019, the United Nations World Happiness Report ranked Finland as the happiest country on the planet. While there are many factors that influence happiness, it's the sense of trust and security in one's own environment that has the biggest impact. Personal safety, civic engagement and access to education – these are some of the things that count the most.

Better lighting, safer streets

Assistant Professor Matti Vaaja is an expert in the use of digital photogrammetry and laser scanning to map and monitor the physical aspects of urban environments. His work is used to make our surroundings safer, as well as to create 3D models for planning the cities of the future.

One of Vaaja's signature studies measures road lighting conditions at night, with the aim of determining the safest and most energy-efficient lighting solutions for a given environment. Vaaja says the techniques and algorithms his team is developing will help mapping and navigation providers to develop their night-time services.

'We believe that in the future, location-based services like Google Street View will display night-time mapped environments that help people to learn the appearance of an area they enter for the first time during darkness,' says Vaaja. 'These kind of night-time city models will also help people to assess the after-dark safety and attractiveness of a district they are planning to move to, for example.'

Interacting in virtual worlds

Vaaja's team also develops models, algorithms, sensors and data-visualisation techniques for creating interactive 3D environments. These realistic virtual worlds are built using technology from the video game industry.

Helsinki's Isoisänsilta bridge (previous spread) connects the forested island of Mustikkamaa with the modern urbanism of Kalasatama (pictured here).

‘Natural environments promote mental health, while densely built urban environments promote active lifestyles and physical health.’

‘We are now working with an application where different people can simultaneously go to the same virtual space, represented by a customisable avatar,’ he says. ‘They can put on 3D glasses and we can study their experience in these virtual realities to see what physical elements we should or should not bring into real environments.’

‘Game engines can bring a lot to this kind of work, especially in terms of introducing sound effects and visual details that help to create a realistic setting.’

Asking questions, mapping experiences

Professor Marketta Kyttä takes a different approach to studying physical environments, looking at how our surroundings can promote or impede healthy lifestyles.

Kyttä’s team has developed a tool called ‘Maptionnaire’ that integrates survey questionnaires with a map-based interface. By bringing the individual experiences of citizens closer to the planning process, the tool allows researchers and urban planners to collect, analyse and visualise data in a richer way than with traditional surveys.

‘We ask participants to plot their urban experiences and daily movements on a map,’ says Kyttä. ‘With this place-based information from users, we can model the activity space of each individual, for example, and find out which characteristics of urban space the person is actually exposed to.’

'We see that some areas are used intensively, and some areas are barely used at all. This allows us to give weights to the characteristics of the different parts of the urban environment that people use.'

To date, the Maptionnaire methodology has been used in over 2,000 projects in more than 80 countries, with responses from some 400,000 participants. The cities of New York, Denver, Stockholm and Helsinki have all included it in their urban planning processes.

Green means go

In 2018, Kyttä's team completed a study involving 1,000 Helsinki residents over 55 years of age. The researchers were looking to find out what kinds of urban environments inspire less active people to get outside and move around more.

'We hadn't previously found a direct association between green environments and health,' she says. 'But with our new place-based research strategy we discovered that the greener the space, the healthier the people perceive themselves to be. We also discovered that the denser the urban setting, the more active people are in their everyday lives, even if they are not especially interested in an active lifestyle or in taking care of their health.'

'Health is a very wide concept that includes mental health, social well-being and physical health. I would say that natural environments promote mental health, while densely built urban environments promote active lifestyles and physical health. The challenge is how to combine both of these in an urban environment.'

Kyttä has also studied the use of urban environments in Helsinki and Tokyo from the perspective of children. Both Finland and Japan are considered child-friendly countries where minors have a great deal of freedom to move around unaccompanied by adults. But the study revealed some interesting differences about how children use this freedom.

'Here in Finland, the territorial range used by children is larger, and they also use natural areas like forests and parks more,' she says. 'But in both countries they use institutional settings too. In Japan, it's the schoolyard, and in Finland, it's shopping centres.'

'We also discovered that Japanese kids are very active in terms of spending time with their peers, but children in Finland spend a lot of time alone. In fact, they are perhaps the most independent children in the world.'

A voice for everyone

Associate Professor Mira Kallio-Tavin, who works with arts-based research and pedagogy, is concerned with the topic of inclusion as it relates to societal well-being.

'At the core of our research into happiness, we need to be thinking about alternative futures for those people in our society who may not be all that happy,' she

‘Instead of having an external expert telling you what kind of life you need to live, we look at empowering people to live the lives they want to.’

says. ‘Many of our research initiatives and creative projects deal with immigrants’ experiences of living in Finland, viewing and expressing life through their lens.’

One of Kallio-Tavin’s doctoral students, Iranian-born Sepideh Rahaa, is doing an artistic research project on the experience of Muslim women who move to Finland. Rahaa has a massive archive of interviews that she is turning into documentaries and exhibitions. Another doctoral student, Abdullah Qureshi, is doing similar work by studying the experience of homosexual Muslim men in Finland.

Kallio-Tavin has also done a lot of arts and education work with disabled people. Aalto University has become a world leader in this field, establishing the first international conference of its kind and publishing a wide body of research.

‘From the pedagogical perspective, our work is about helping people to gain agency in their own lives,’ she says. ‘It’s the idea of creating an affirmative model, rather than a prescribed one. Instead of having an external expert telling you what kind of life you need to live, we look at empowering people to live the lives they want to. There are lots of ways to share and discuss these issues through visual arts.’

‘Our work is about engaging people in society to make a positive impact. It’s about communication, activity and activism, through a combination of different kinds of research and creative projects,’ says Kallio-Tavin.

‘The power of Aalto University is that we have the ability to look at things from these many different perspectives – not just technical, but also humanistic and artistic.’

People celebrating May Day with a traditional picnic in Helsinki's Kaivopuisto park.

Five ways to increase urban health

Pirjo Sanaksenaho & Laura Arpiainen
SOTERA Professors

Illustration by Ella Eiranto

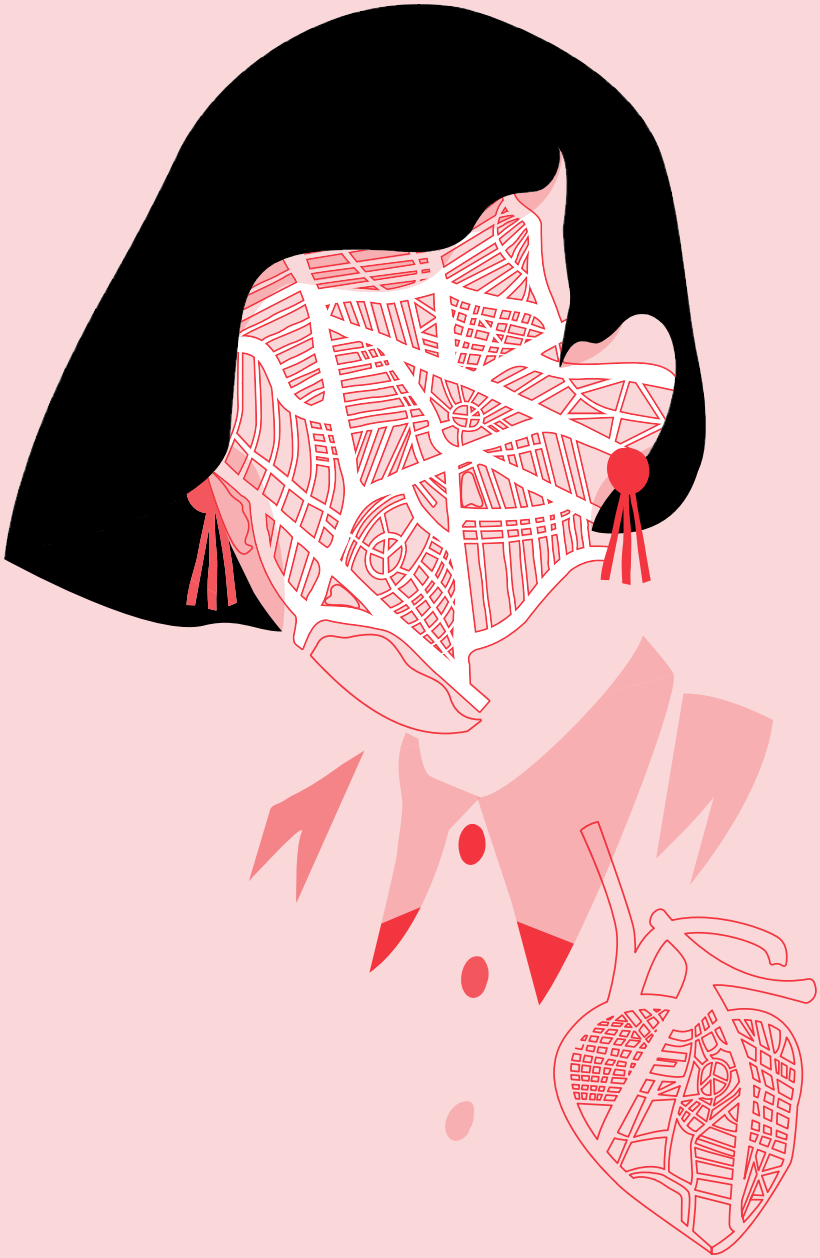
1 **Travel by foot and use the stairs.** An urban structure that encourages exercise also improves health.

2 **If you need some means of transport, choose public.** This reduces air pollution, which normally accumulates in built-up areas.

3 **Buy local goods and use local services.** You will support your neighbourhood's shops, production, industry and vitality.

4 **Try to become 'invisible'.** Parks, cities and nature are grateful when you don't litter or consume natural resources!

5 **Help a friend.** A sense of community and inclusion reduce inequality and increase well-being.



Successful urbanisation hinges on good urban policy

At the same time, good policy needs research-based information.

Firms and workers are more productive in large and densely populated urban areas, but urbanisation also poses problems through congestion and deteriorating air quality.

New firms and households entering the city often don't take these types of spillovers – in other words, benefits and costs to others – into account in their decision-making. This means that successful housing and urban policy has a crucial role to play in successful urban development.

My research focuses on identifying and measuring the benefits and costs of urbanisation, as well as evaluating housing and urban policy.

Much of city growth happens through densifying existing residential neighbourhoods. This may change the character of the area; residents often oppose the new development, which slows down urbanisation. We analyse the effects of densification on the quality and the socio-economic structure of the neighbourhood. The results provide valuable input on the various stages of the urban planning process.

One of the features of large cities is the segregation of neighbourhoods according to the socio-economic background of the residents. Segregation may be harmful, for example, if where a child grows up has an effect on the opportunities that child has in life. Social-mixing policies can prevent segregation; public housing units directed to low-income households can be built around the city. In one of our projects, we study the effects of social mixing on the neighbourhood quality of low-income households, and the effects of the childhood neighbourhood on educational attainment and labour market outcomes during adulthood.

Increased demand for city living increases the demand for housing in cities. This, together with inelastic housing supply, leads to high housing prices and rents. In other words, affordability issues, especially for low-income households. One of the most important goals of housing policy is to subsidise housing for low-income households. We study the effects of housing allowances and affordable public housing on the housing costs faced by low-income households, and compare how these two subsidy schemes are targeted at low-income households.

The fact that the professorship in urban economics is funded by four cities in Finland's capital region, as well as other key organisations, indicates that policy-makers understand the importance of housing and urban policy. They recognise the usefulness of economic analysis in answering questions relevant for policy-making.

I am jointly appointed by Aalto University's Department of Economics and the Department of Built Environment, which facilitates teaching urban economics to students from various backgrounds. My aim is to develop teaching in this area and provide research-based information on urban issues to policy-makers.

Tuukka Saarimaa
Assistant Professor of Urban Economics

Five ways to reduce stressful noise

Vesa Välimäki
Professor of Audio Signal Processing

Illustration by Matias Ylikangas

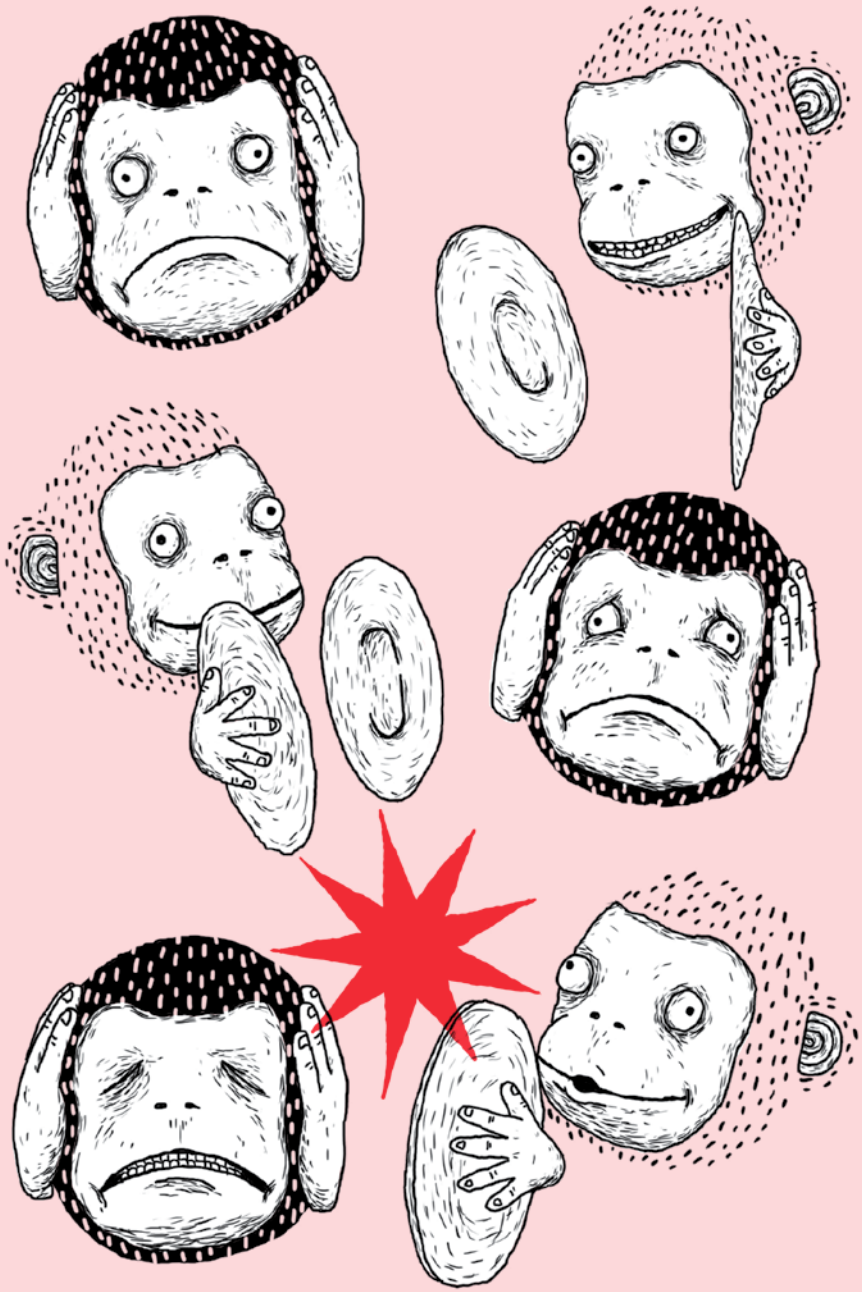
1 **Use the right kind of headphones.** The best way to shut out noise on a bus or aeroplane is to use insert earphones or noise-cancelling headphones so the listening volume stays low. Earbuds and earphones are not airtight and don't prevent noise reaching your ears, which means it's best to use them in quiet spaces.

2 **Reverb increases the noisiness of a space,** which makes it less pleasant to be in. This can be reduced using mats, rugs or curtains. Wall rugs, a fine old Finnish invention, are also effective in reducing echo, for example, in a stairwell.

3 When flying, choose a seat towards the front of the aeroplane or at least in front of the wings, as the aircraft engines are louder towards the back. **Opt for noise-cancelling headphones** – the best way to cancel out low-level rumbling aircraft noise.

4 **You can easily use paper tissues to create emergency earplugs at a rock concert or in a noisy bar.** Take a piece of paper tissue, wet it, and shape the wet tissue paper into an earplug that fits your ear. Wetting the tissue paper helps the earplug to stay in your ear and means that it doesn't make a rustling sound when you move your head.

5 **Use two sets of headphones:** earbuds in your ears and normal headphones on top. You can have different sound sources for the earphones and headphones, for example, if you are playing a synthesiser and want to hear how it sounds with music from another source. Alternatively, you can use earbuds together with hearing protectors – an effective combination for blocking out external noise.



Not pity, but compassion

A documentary film reveals new worlds and helps viewers to put themselves in other people's shoes.

I lead the 'Images of harmony and rupture' project, funded by the Kone Foundation, in which documentary film-makers and maker-researchers approach the transformation taking place in our society from different perspectives.

From its inception, documentary film has addressed societal problems and inequalities. Often, these societal crises have been visually dramatic, such as during the depression of the 1930s. In wealthy societies, however, transformations are less visible, which presents a challenge to documentary film-makers.

One of the project's films is Boiling Point, directed by Elina Hirvonen as her Master's thesis work; it follows the 2015 refugee crisis as well as the upheaval it caused for a whole year. During the promotional campaign following completion, the film was available for free for those who organised screenings, which encouraged dialogue between people who would perhaps not otherwise meet one other. Over 700 of these events were held in Finland.

I am currently making a documentary film on care workers, partly being composed as a choral work, as I think a realistic approach would not have been the best way to explore this topic. I have read a lot of economic policy literature because I'm interested in how we speak about the economy. Take, for example, the term 'sustainability gap', which has become an economic-political mantra – it really means that care for the elderly is expensive and cannot be funded. When we speak of the sustainability gap, we're speaking of certain age groups.

As a documentary filmmaker I feel that I am privileged: I get to end up in strange places where I meet people and learn things that I wouldn't otherwise have had the opportunity to learn. And I can show the viewer pieces of that world, a different kind of reality. People are terribly prone to concluding that their reality is the same as others' – that if they are able to do something, then others must be able to as well. In these times, there's a lack of social imagination and compassion. This is what social fragmentation is about: people are no longer able to and no longer want to imagine the experiences of people living in a different kind of reality. Compassion is not pity, but rather the desire to truly see things from another person's per-

spective. It's difficult, and it's the thing that I want to facilitate in some way.

In the US, there is a cruel myth – one that is alive and strong – that says each person can decide the course their life takes. This is, of course, not true. The burdens we carry don't all weigh the same: it only takes one bout of depression as a young person to make the future look very different. We don't all start the race from the same point.

The concept of the welfare state is certainly in need of repair, but, at the global level, the idea that your fate is not fully determined by the conditions of your birth and whose child you are is quite a unique one, and is worthy of being safeguarded.

Susanna Helke
Professor in charge of research at the Department of Film, Television and Scenography

Research is crucial because it generates fresh knowledge, ideas and technology for society.

Zhipei Sun
Professor of Photonics

My original background is in engineering, which is very much about numbers, not users or human beings. Art and design give that human perspective needed to create value.

Masahiro Kunieda
Student of International Design
Business Management

Healthier people

Magic happens when medicine meets computer science. Bio data is the key to a healthier future, and computing power is the hand that unlocks it.

As data reveals patterns that were previously unseen, medical professionals can diagnose proactively, and make even more accurate prognoses about patient health.

PERSONALISED health care is the new frontier in medicine.

In the future, doctors will be able to tell us which conditions and diseases we're susceptible to well in advance of us falling ill. They'll also be able to inform us about any medical, nutritional or lifestyle adjustments required by our specific genetic makeup or environmental circumstances so we can work to prevent the onset of disease.

This vision is becoming reality through the merging of two distinct disciplines: medicine and computer science. Over the past several decades, visionary medical professionals have been collecting the lifelong patient data at the core of predictive treatment. In the hands of computer scientists, this data is now revealing insights that are changing our approach to health care.

Intensive care, extensive knowledge

Professor Simo Särkkä works closely with medical doctors from Helsinki's neonatal intensive care unit, developing sensors and computational methods that are used to analyse the health of preterm infants.

Babies born before 37 weeks of gestation and with a birth weight under 1,5 kilograms typically experience health and developmental problems. By analysing their breathing, heartbeat and oxygen content – and by correlating these measurements with variables such as weight and gestational age – Särkkä and his team are developing a clearer picture on the treatment and prognosis of preterm infants.

'Certain diseases can only be diagnosed from long-term measurements, so you need to design systems that are robust enough to be used over extended periods of time,' says Särkkä.

‘Certain diseases can only be diagnosed from long-term measurements, so you need to design systems that are robust enough.’

‘Some of the data sets we’re looking at in Helsinki’s neonatal intensive care unit span a period of more than two decades. By analysing this data, we’re able to more precisely predict the needs of new babies that arrive in the unit.’

One of Särkkä’s students, Olli-Pekka Rinta-Koski, wrote his doctoral dissertation on the subject, demonstrating how sensor data can be used to build mathematical models that forecast prognosis for infants in intensive care. Rinta-Koski successfully defended his thesis in late 2018.

Measurements in motion

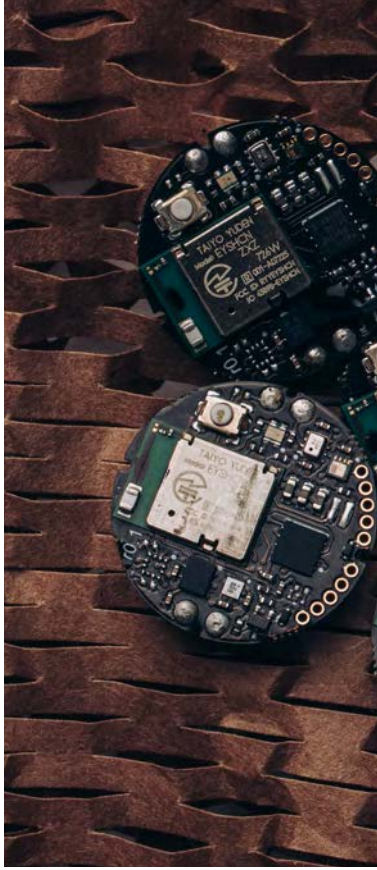
Särkkä and his team have also applied their knowledge to designing sensors and data analysis systems that can accurately perform cardiac measurements while patients are going about their daily lives. These sensor models can be used to detect conditions such as atrial fibrillation, a dangerous irregular heartbeat that’s difficult to diagnose and, thus, requires measurements to be taken over a long period through sensors worn by patients.

‘We’ve developed systems that combine motion compensation and measurement with different types of sensors,’ says Särkkä. ‘We’re now exploring the use of heartbeat, breathing and inertia measurements together, and then we’re using signal-processing methods and the latest machine-learning methodologies to execute the diagnosis.’

Much of this work is done in collaboration with international companies such as GE Health care, as well as global leaders from Finland including sports-watch brand Suunto and cardiac-data analysis expert RemoteA.

Sampling over decades

Professor Harri Lähdesmäki is a specialist in the development and application of computational tools for studying



biomarkers for better predictive care. His team typically works with the massive data sets generated by mass spectrometry and gene sequencing.

'We collaborate a lot with biologists and medical doctors to analyse huge sets of biological data collected from cohorts that include both healthy people and people who have a specific condition,' he says.

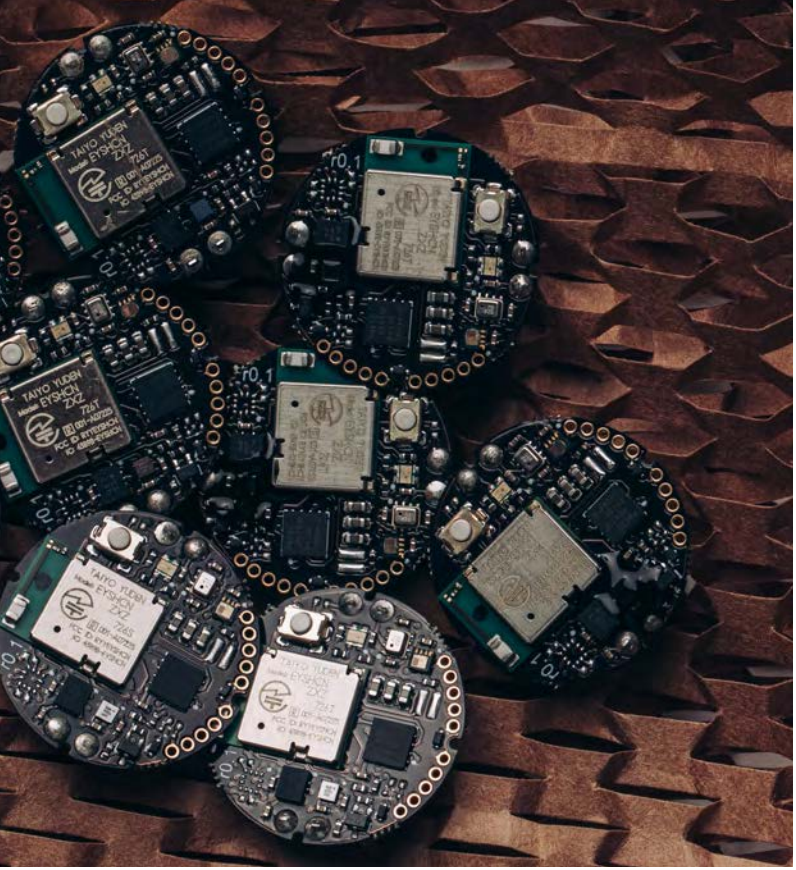
'There are studies in Finland that collect nasal, blood, stool and other bio samples from volunteers starting at birth and continuing into adulthood, so that medical doctors can try to better understand disease causality and progression.'

One of the team's most influential findings comes from a long-term study looking at how the bacteria in children's gut influences their overall health and immunity, specifically in relation to the onset of type 1 diabetes. While the root cause of type 1 diabetes remains a mystery, the team's findings reinforce the view that gut health plays a key role in triggering the condition.

The study looked at the gut bacteria of children in three cities: Espoo in Finland, Tartu in Estonia, and Petrozavodsk in Russian Karelia. The locations were chosen as their populations are genetically similar, yet they are geographically diverse enough to reveal the role of environmental factors in the development of gut bacteria.

Lähdesmäki and his colleagues found that the bacteria responsible for producing molecules called lipopolysaccharides – known to inhibit the human immune system – are highly abundant in children in Finland and Estonia, but much less so in Russian Karelia. This led the research group to the hypothesis that children in Finland and Estonia have an increased risk of an inhibited immune system, and thus of contracting diseases like type 1 diabetes. It helps to explain why the incidence of auto-immune diseases is approximately five-fold higher in Finland and Estonia than in Russian Karelia.

'The findings from the sequencing data came via the use of computational techniques, and were then experimentally tested in a lab,' says Lähdesmäki. 'This



Bio sensors (pictured here and on spread 61–62) record the data that is key to predictive diagnoses and a healthier future.

was highly interdisciplinary work that involved close collaboration between teams in several countries, including representatives from the Broad Institute of MIT and Harvard University.'

A medical vision comes of age

Lähdesmäki says Finland's approach to bio-medical studies is unique, in that some projects have been going on as long as 25 years and have taken samples from tens of thousands of people.

'Biomedical research in Finland wouldn't be as competitive as it is today without visionary medical doctors like Mikael Knip, Sture Andersson and several others,' he says.

'Given Finland's biomedical expertise, extensive biobanks and our national health care system – together with Aalto University's world-leading research capability in statistical data analysis and artificial intelligence – the country is in an excellent position to continue making a significant scientific impact as health and medicine go digital.'

Five ways biomaterials could improve your health

Orlando Rojas
Professor of Biobased Materials

Illustration by Iisa Pappi

1 Forest biomaterials can be used to make new high performance and safe **medical products.** Bacterial cellulose, for example, is a promising material for implants, wound dressing and artificial blood vessels.

2 Biomaterials can improve the performance of **air and water filtration and purification devices,** as well as lower the cost of producing them.

3 In personal care, biomaterials are suitable for strong, absorbent and biodegradable **personal hygiene products.** They can also be used as stabilisers in creams, lotions and emulsions.

4 Thermoplastic cellulose can be used for **food packaging.** Like plastic, it protects the content from moisture, and ensures the safe use of foods for longer periods of time. Cellulose is a safe, renewable and recyclable material.

5 Wood is a source of many healthy agents, such as bioactives, which can be used for health-enhancing food. Plant nanocelluloses are sources for gelling and viscosifying agents. There is also potential for use as natural and **safe additives in food products,** such as ice cream and yoghurt, to improve their texture.

Machines to make sense of our health

Making use of artificial intelligence methods for personalised medicine.

My research focuses on machine learning algorithms, which are powerful AI tools that benefit many areas in our day-to-day lives. They power things like automatic text translation, face recognition in pictures, and voice assistants like Siri and Alexa. There's hope that soon these powerful computer-driven predictions will be put to work in hospitals assisting clinicians in making diagnoses – a method commonly referred to as personalised medicine. If we can make a deep learning algorithm that can spot your face in a busy crowd, can we detect when you're getting ill and identify how to best treat you?

Cancer samples make up one successful example. Using algorithms, we've been able to find out what information is relevant in datasets, and in their dependencies. These tools improve prognoses of what kinds of therapies are effective for each patient, based on a specific tissue sample.

However, one of the main challenges we face in this task is data quantity. Successful deep learning methods currently require huge datasets to train on. Before a computer can detect a face in a picture, it needs to see thousands of photos of faces and more of things without faces before it can tell them apart. For patient data, though, the datasets we have to train with are much smaller. For some rare diseases there will only be information on a handful of cases. So we need to develop new methods that can provide the great predictive power of deep learning algorithms, but with much less training data. To create algorithms that would mean a computer could monitor your own health, the dataset available shrinks even further to only one person: you! This is why my research group is working on designing new approaches better suited to smaller data sets.

As well as being able to handle smaller amounts of data, we need to be able to make algorithms explain what they do. When your smartphone's keyboard suggests a word to you based on what you typed, you don't really think about how it reached that suggestion. However, if Siri started suggesting that you need to take expensive medication with side effects, or undergo a risky operation with a long recovery time, you'll definitely want to know why it gives this suggestion.

I co-supervise a group that is looking to develop AI methods that can explain how they have reached their conclusions, which will greatly help integrate the strength of new artificial intelligence tools into existing health care infrastructure.

These problems are not unique to health applications for artificial intelligence. The best way that we can develop AI for a full range of advanced applications is by building expert communities that can work on different aspects in close collaboration. I am the director of the Finnish Center for Artificial Intelligence (FCAI), a joint initiative by Aalto University, Helsinki University and Technical Research Centre of Finland Ltd. Our slogan is that we create 'Real AI for Real People in the Real World' and our work on developing new AI methods for personalized medicine is an example of this. FCAI brings together engineers and scientists with expertise and experience across a number of fields to develop the next generation of AI together – and use it to solve society's grand challenges.

Samuel Kaski
Professor of Computer Science

Five steps towards making use of robots in care work

Ville Kyrki
Associate Professor of Intelligent Machines

Illustration by Inka Salminen

1 **Be bold with participating in experiments** – only by trying things out can we learn how to use new technology in the best way.

2 **Educate yourself.** Robots don't steal jobs – they are the tools of the future.

3 **Think broadly.** There are many kinds of robots and they can assist in a large variety of different tasks. In hospitals, they are already used for transporting laundry, and and for retrieving medication in pharmacies. But in the future, robots will increasingly be involved in dispensing medicines and in rehabilitation work too.

4 **Don't be timid.** Research results show that people who are suspicious of robots are positively surprised after trying out working together with them. Robots can be of help in mechanical and repetitive tasks.

5 **Think of robots as the smart devices of the future.** Have the same attitude towards them as towards the first computers, and set yourself to the task of relearning.

The development of health technology thrives thanks to cooperation

Advanced implants, health care AI applications and brain imaging devices are created through cooperation between companies, researchers, doctors and patients.

I lead the Aalto Health Platform, which connects companies, health care providers and other actors of society with the more than 90 research groups in Aalto's health and wellbeing sector. The sector involves the development and design of technologies, processes and facilities which are, at times, very significant for human health. These include, for example, devices used for brain imaging, new implant materials for surgery, innovative hospital architecture, and research methods for neuroscience – a field of study at the Helsinki University of Technology and Aalto University for more than 40 years.

One of the most interesting innovations in recent years is a neurosurgical instrument developed by Surgify Medical that prevents damage to nerves and veins during operations. Aalto's researchers developed this technology in cooperation with Helsinki University Hospital and the world-famous neurosurgeon Juha Hernesniemi.

In addition to developing technology, researchers also produce information that supports decision-making in organisations and throughout society. For example, industrial engineering and management researchers have been involved in planning the national social welfare and health care system.

Artificial intelligence (AI) and machine learning also open up many opportunities for patient work. For example, the sometimes difficult diagnoses of rare diseases are sped up when computers are trained, using large amounts of data, to support doctors in decision-making.

As the population ages, the costs of and needs for health care increase. We live longer and end up being ill for longer times. In the future, cost savings will be achieved as medical care is individualised. Artificial intelligence will enable the more precise selection of treatments based on factors such as the patient's genome, and this will make treatments more effective. With AI, we can also identify patients that are susceptible to chronic diseases, and then attempt to significantly reduce the incidence of such diseases through lifestyle changes. Here at Aalto, our AI expertise, which is among

the best in Europe, is integrated with biomedical research and applications.

I represent Aalto in the Health Capital Helsinki alliance (HCH), which promotes business in the life sciences and health technology sectors. We initially established the alliance together with Helsinki University Hospital, the University of Helsinki and the City of Helsinki. Now it also includes the Laurea, Metropolia and Haaga-Helia universities of applied sciences and the City of Espoo. Numerous companies have participated in the alliance's various projects too.

HCH brings together companies, public administration and research institutes within the Helsinki metropolitan area. One aim is also to attain increasing involvement from large foreign companies. Entrepreneurs benefit from services provided by, for example, the health-accelerator track of the HCH organisations: Spark Finland and Biodesign Finland, both brought from Stanford University, and Terkko Health X.

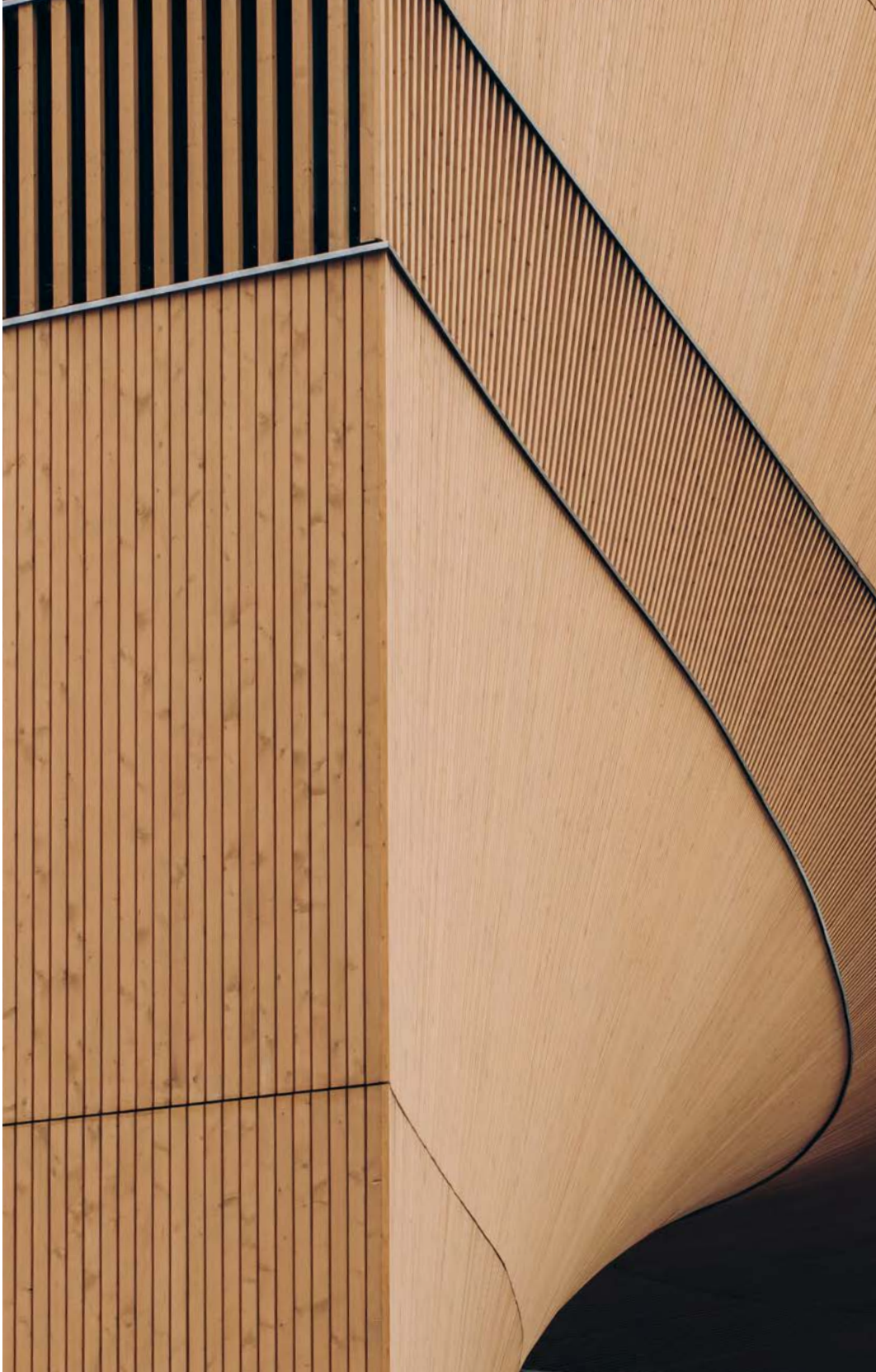
Markus Mäkelä
Executive in Residence

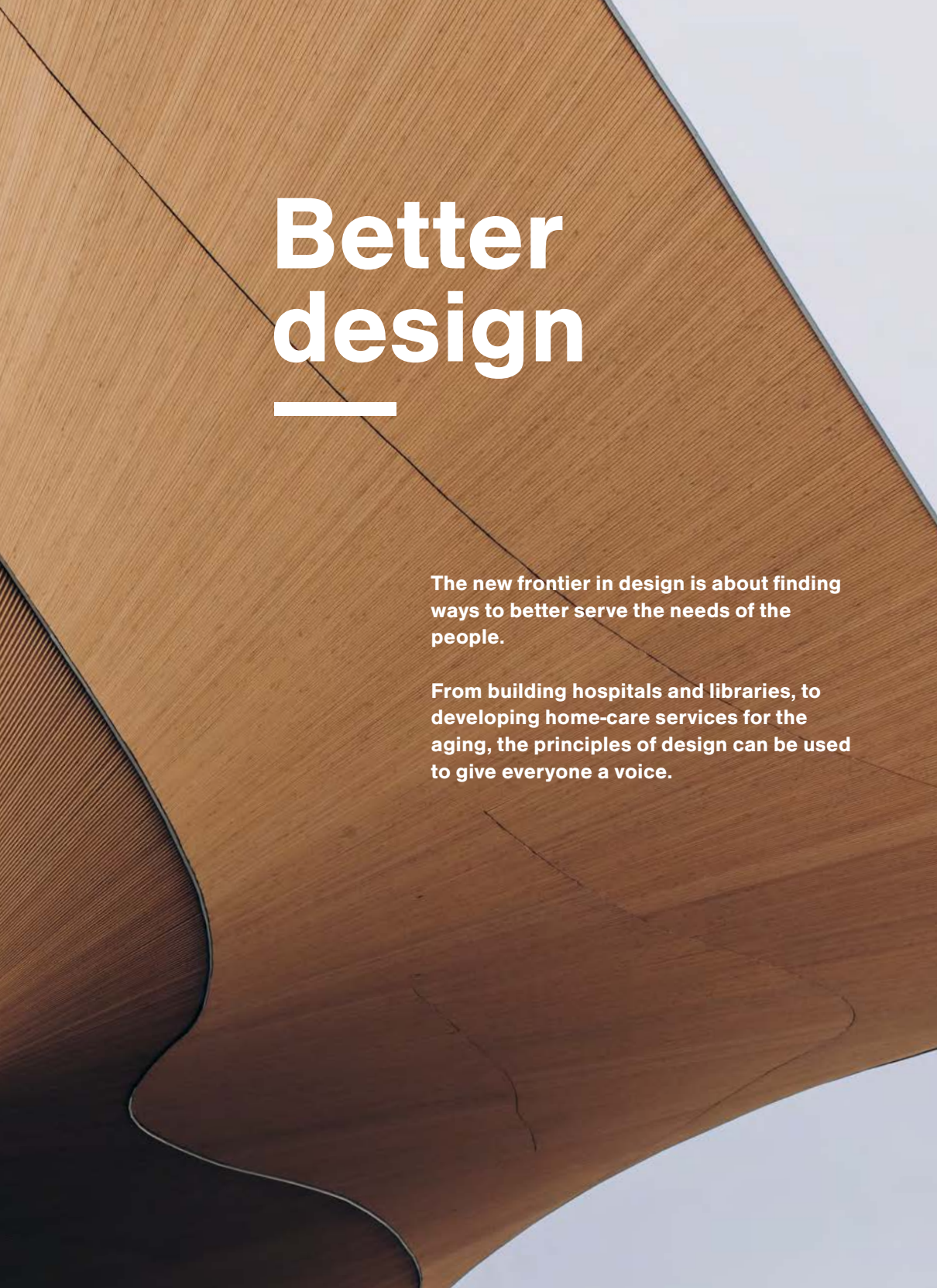
I believe that research can bring new ways of thinking about artistic practices, as well as fresh creative thinking.

Sofia Pantouvaki
Professor of Costume Design for Theatre and Film

I’m so proud of our progress. Excellence in research and art is the foundation for game-changing education, as well as our innovation and entrepreneurial activities and societal impact.

Kristiina Mäkelä
Aalto University Provost





Better design

The new frontier in design is about finding ways to better serve the needs of the people.

From building hospitals and libraries, to developing home-care services for the aging, the principles of design can be used to give everyone a voice.

IN 2018, the City of Helsinki opened the doors to its New Children's Hospital – the largest paediatric-care facility in Finland. The hospital is a masterpiece of design and architecture, with each of its floors built around different themes that bring visual and aural elements together to represent a journey through a fairy-tale world of natural wonders.

The car park under the hospital is sea, the first floor is *shore*, then one passes through *jungle*, *forest*, *valley*, *magic*, *mountain* and *space*, before reaching *star* on the top floor. This approach was part of helping the hospital to win the prestigious Finlandia Prize for Architecture in 2018.

The sonic dimension to the project was led by composer, sound designer and Aalto University lecturer Antti Ikonen. For more than two years, Ikonen and students from Aalto University's Media Lab worked with the hospital's architects, engineers, designers, and medical staff to create a dynamic soundscape that would bring the themes to life inside the hospital.

'If you go for a walk in the forest, on a beach, or in another kind of natural environment, you typically hear a limited number of different sounds. But you never know quite what mix you're going to get,' says Ikonen. 'It's this generative nature of the actual soundscape around us that we wanted to re-create for the hospital.'

'We didn't want to just do sounds on a loop, but rather create a soundscape that would be rendered on the fly, and never play the same way twice.'

One system, many sounds

Ikonen and his students designed a 60-channel IP-audio system that plays from a single computer. Using speakers from Finnish manufacturers Genelec and Panphonics, the team created a soundscape that covers all the floors and

Helsinki's Oodi Central Library (previous pages) and New Children's Hospital (pictured here) both opened their doors in 2018.

The award-winning design of Helsinki's Oodi Central Library combines traditional timber elements with steel and glass.

‘The quality of the applicants into Aalto ARTS degree programmes is extremely high. We get brilliant students who do brilliant work.’

elevators of the building. The sounds only play in these common areas, not in patient rooms, and the volume is programmed to automatically go lower during the night hours.

Ikonen’s team used both library sounds and original recordings. From Tibetan bells and violins, to shakers, synths and sounds from nature, each sample can be controlled individually from the computer.

‘Because it’s not a loop, you can pick any detail and make it behave as needed,’ says Ikonen.

‘We used some copyright-free catalogue sounds, but many of the students in my course are good field recordists and have their own sound libraries. For the second floor – where the theme is *jungle* – one of the students had been on holiday in Indonesia and had actual jungle sounds from there that he’d recorded himself.’

‘It’s an excellent outcome, because the quality of applicants into Aalto ARTS degree programmes is extremely high,’ he says. ‘We get brilliant students who do brilliant work.’

Influencing library legislation

In another design project with a civic dimension, Professor Kimmo Lapintie led a research group that conducted an empirical study of people’s use of libraries, coffee shops and other public spaces. Lapintie says the researchers discovered that today many people use libraries primarily for work.

‘In addition to being places of study and research, libraries are used as informal offices by entrepreneurs and freelancers, as well as by employees of large- and medium-sized companies,’ says Lapintie. ‘So, libraries should correctly be viewed as the ’spatial incubators’ they have become.’

The research findings, published in *Library & Information Science Research* – the leading journal in the field – came as the Finnish government was in the

process of renewing the legislation that defines library usage in the country. Certain cities had been considering reducing the number of local libraries, replacing them instead with facilities for automated borrowing and returns. But when Lapintie's group put forward their findings, the idea that libraries are for more than borrowing books became enshrined in Finnish law.

'The function of libraries in the previous act of law was that they're places for information provision, such as providing access to books and computers,' he says. 'But the information from our research went directly into the government debates over the renewed library act.'

'The information from our research went directly into the government debates over the renewed library act.'

'The act was eventually amended, so we now have legislation that defines the role of libraries in Finland as places for work and other civic activities – not just for lending books.'

Designing for public service

Aalto's Department of Design is increasingly turning its attention to the public-service context, employing the principles of co-design to bring the views of various stakeholders into different decision-making processes. Professor Turkka Keinonen says the Nordic countries are a good laboratory for this kind of work, as co-design principles match with participatory Nordic values.

'Service design has been growing very fast in the Nordic region,' says Keinonen. 'Design is part of our DNA here – as is working together to a common goal – so

people have been enthusiastically participating in various public-sector design challenges.'

One of the Keinonen's colleagues, Professor Tuuli Mattelmäki, has applied co-design principles in a research project aimed at creating new support services for Helsinki residents who are the first point of care for their aging family members. Mattelmäki used a research technique called 'probing', where subjects are given written assignments to complete over a certain period, before interviews are conducted with selected participants.

The researchers found that creating an opportunity for self-documentation helped participants to be more prepared for the interviews, as they could reflect in advance on their challenges and needs. The City of Helsinki has since started to use this method in other development projects as well.

Mattelmäki's students have also been working with the Finnish Immigration Service to create new services for integrating immigrants, and helping them with their online communication.

'In the 1990s, design was focused on usability, on how to help people cope with complicated technologies,' says Keinonen. 'Then we started to speak about user experience, which is not just about being capable of doing something with technology, but that the technology should be meaningful and relevant, creating emotional excitement and engagement.'

'Now we're seeing a shift towards service design and co-design. This comes with an understanding that technology is just one component in a big system, and that in order to design the whole service – including its technical components – you need to understand the whole structure.'

'So when it comes to serving patients in the children's hospital, then the patients have a role, the parents have a role, the doctors and nurses have a role, the cleaning staff have a role,' he says. 'You need to include the passions and needs of everyone to design the best possible service or environment.'

Five tips for dressing responsibly

Kirsi Niinimäki
Associate Professor in Fashion Research

Illustration by Jolanda Kerttuli

1 **Buy little.** Worldwide clothing production has doubled in the last 15 years. This trend is unsustainable for the environment.

2 **Buy quality.** Manufacturing one cotton shirt takes 2,700 litres of water, so make the most of the material by using high-quality production processes.

3 **Where possible, avoid clothes that contain elastane.** Elastane weakens fabric durability and colour.

4 **Think of your purchases as investments.** Only go for clothes that really inspire you, as you'll likely want to use them for longer. This significantly reduces their environmental impact over the long term.

5 **Take care of your clothes.** Use clothing repair and adjustment services to be part of the circular economy for fashion.


Vintage

People are at the heart of transport system design – not technology

Designing a sustainable transport system means recognising societal values.

Our current transport system is not ecologically, socially or economically sustainable. We have succeeded in reducing emissions in many sectors, but transport emissions continue to grow.

A lifestyle based on private vehicle use also causes health problems. Besides a lack of physical activity, sitting alone in a metal box separates us from others, often leading to psychological issues. At the same time, constructing parking areas in increasingly dense urban environments is a poor economic investment.

How did we end up here? Because we – engineers, planners, architects and economists – do not understand how multidimensional human beings are, and often end up developing our systems for the hypothetical 'average' person.

Emerging technologies, such as self-driving vehicles, drones, and mobility-as-a-service, are now revolutionising the transport sector. As their role in and impact on society are still taking shape, we have the opportunity to re-invent the rules of the game.

For many engineers, thinking about the relationship between technology and values feels foreign. Technology, however, is never neutral. There are value choices involved, which inevitably impact people's behaviour and wellbeing. When designing new technological systems, there is always the question of what values we want – and what values we don't want – to promote.

I ended up researching transport because it satisfies my endless curiosity: the research covers everything from physics to information technology and philosophy to sociology. There is no sector which does not in some way connect with the movement of people.

Training human-centred thinkers is a key part of value-sensitive planning and design. For example, we are currently developing a new Europe-wide master's programme in urban mobility, as part of the European Innovation and Technology Institute (EIT). This is aimed at meeting the huge need within the sector for a new generation of specialists.

In my research, I aim to help close the gap between research and practice. By creating cooperative networks, I maintain deep understanding of the challenges that transport service providers

and city governments face. Among other things, I am helping draw up recommendations for the European Commission on the ethical challenges associated with self-driving vehicles.

We also need to have the organisations carrying out the practical work involved in our research projects from the very beginning, so that future transport researchers are in touch with everyday challenges.

Milos Mladenovic
Assistant Professor of Transportation Engineering

Five steps to make your space mission sustainable

Jaan Praks
Assistant Professor

Illustration by
Veera Kortelainen

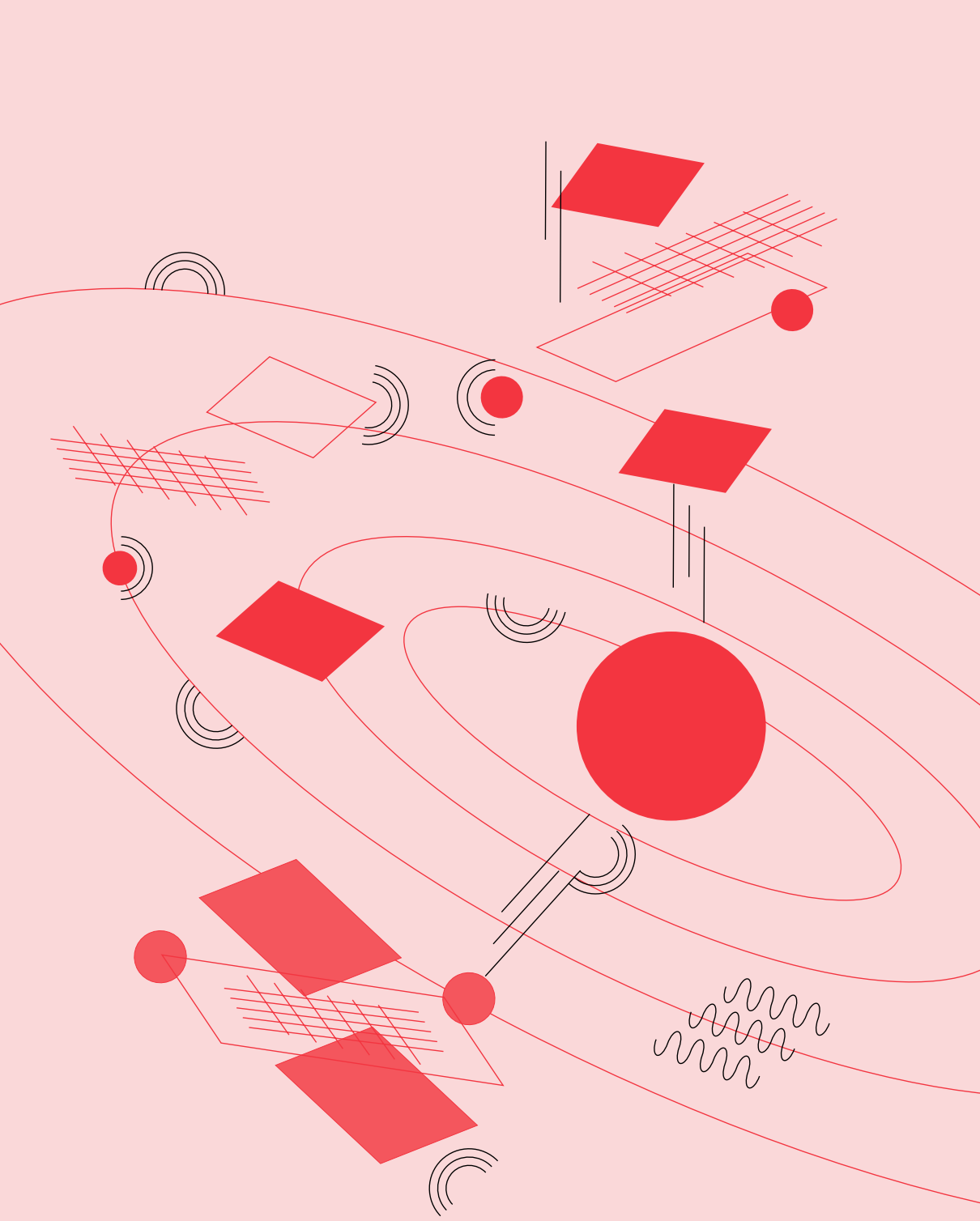
1 **Think about the goal.** Do you actually need a space mission to get what you need? Could you solve the scientific problem without going to space?

2 **Use as small and light a spacecraft as possible.** Additional mass in orbit carries more risk for other satellites. A smaller mass is also cheaper to launch.

3 **Go as low as you can go.** In low orbits, the atmospheric drag helps to remove spacecraft from space. Remember that small spacecraft can only be launched to orbits where they come down to our atmosphere in less than 25 years.

4 **Build your spacecraft carefully and take time to test the software.** Many small spacecraft don't function properly because of poor workmanship, and they just contribute to space debris.

5 **Design with the end-of-life in mind.** The satellite needs a brake that lowers the speed of the satellite and isolates batteries at the end of the mission. Remove your equipment from space as soon as your mission allows.



Science makes ships lighter and more environmentally friendly

With new structures and materials, we can reduce cruise ship hull weight by as much as 20%.

I am an Assistant Professor of Marine Technology, and my field of research is advanced ship structures. We look for solutions to the large global challenges within the engineering sciences, like how to build and maintain large-scale social infrastructure that is sustainable and energy efficient for coming generations.

The solution is science-based structural design that combines theoretical modelling, experimental research and digital technologies. The same principle can also be applied in the design of other large steel structures such as skyscrapers and steel bridges.

Cruise ships are, in fact, Finland's largest individual export product. One cruise ship costs over €1 billion, and total sales amount to around 1.5% of Finland's international exports. The size of the ships has gradually increased from the 1970s up to the present day, but the next generation of ships will be lighter, more energy-efficient, more user-friendly, and more competitive. At the moment, the objective is to produce a ship with a steel weight 20% lower than current levels.

In our marine technology research group, we examined three strategic factors in ship design: new kinds of structural solutions, the use of high-strength steel, and efficient structural design. In science-based structural design, these three areas are combined.

Using theoretical modelling that covers different levels of scale we can discover, for example, how the properties of the materials used affect the strength of the structure, and what kind of materials are needed for making this new ship concept a reality.

At the same time, we can use digital measurement technology to specify the geometrical and material properties of the finished structure. A good example of this is the thin superstructures of ships, where the strength of the metal sheet has been reduced from six millimetres to four. In millimetres, this is a small number, but the impact on the weight of the vessel is large.

Although the classification rules for ships do not yet allow the use of high-strength steel in vessel structures, we have observed that a bulkhead structure constructed from high-strength steel,

for instance, better withstands applied loads than a traditional steel structure.

The use of high-strength steel combined with thinner superstructures would make a decrease of hull weight by between 15 and 20 percent possible. This would mean that an extra cabin deck could be added to the cruise ship, or alternatively the ship's energy consumption could be reduced. The new structures also make possible a new kind of cabin design: our students have designed a two-storey cabin module which has caught the interest of shipbuilders in other countries too.

Innovations utilised in the industrial sphere require scientific breakthroughs.

For this reason, basic scientific research is foundational for impact maximisation. At the same time, however, producing more knowledge and innovations creates the need for more industrial experts that are able to put this research into use at the practical level. In marine technology, we focus on educating masters of science in engineering, doctors of engineering, and postdoctoral researchers. Our research group is continually developing new marine technology researchers that have succeeded excellently in finding employment in different parts of the world as specialists and professors – to continue researching and training others.

Heikki Remes
Assistant Professor of Marine Technology

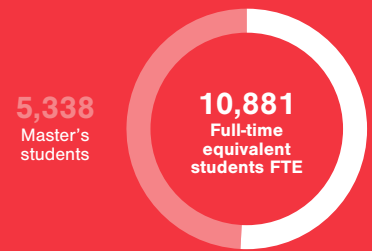
About Aalto University

Aalto University is a multidisciplinary community of bold thinkers, where science and art meet technology and business. We are committed to identifying and solving grand societal challenges, and building an innovative future.

In field-specific university comparisons, Aalto has risen to the top 100 universities in its key areas and in most areas up to the top 50 in the world. For example, the QS World University Rankings placed Aalto's Art & Design 7th in 2019.

The QS World University Rankings Top 50 Under 50, which features the world's 150 best universities under 50 years old, placed Aalto 9th worldwide and 3rd within Europe. In the Times Higher Education University Rankings, the university was ranked the 50th most international university in the world in 2019.

Key figures 2018



263
Doctoral degrees

2,166
International peer-reviewed articles in scientific journals

40%
International academic faculty

Photo: Roee Cohen

Key research areas

ICT and digitalisation

Materials and sustainable use of natural resources

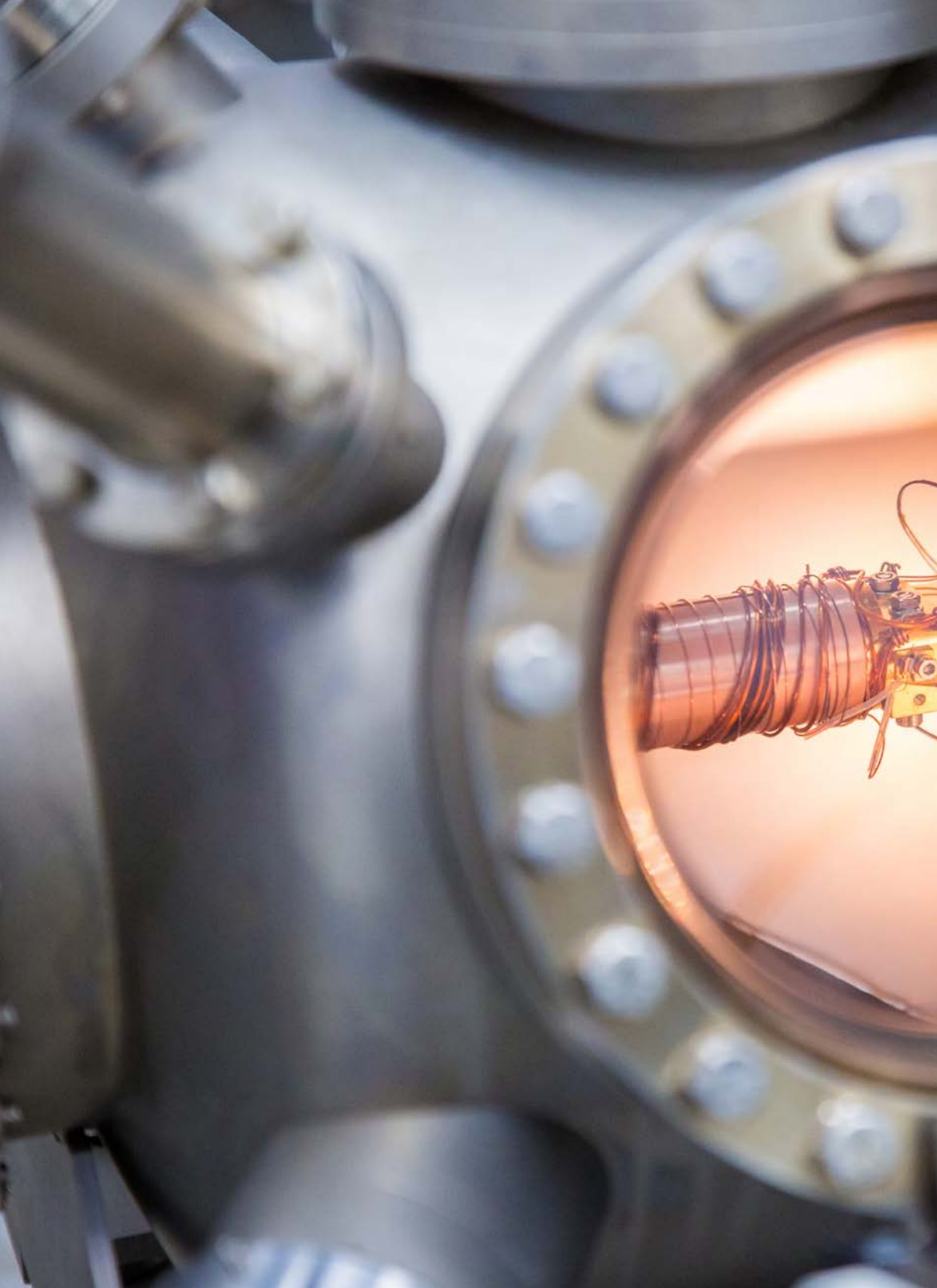
Global business dynamics

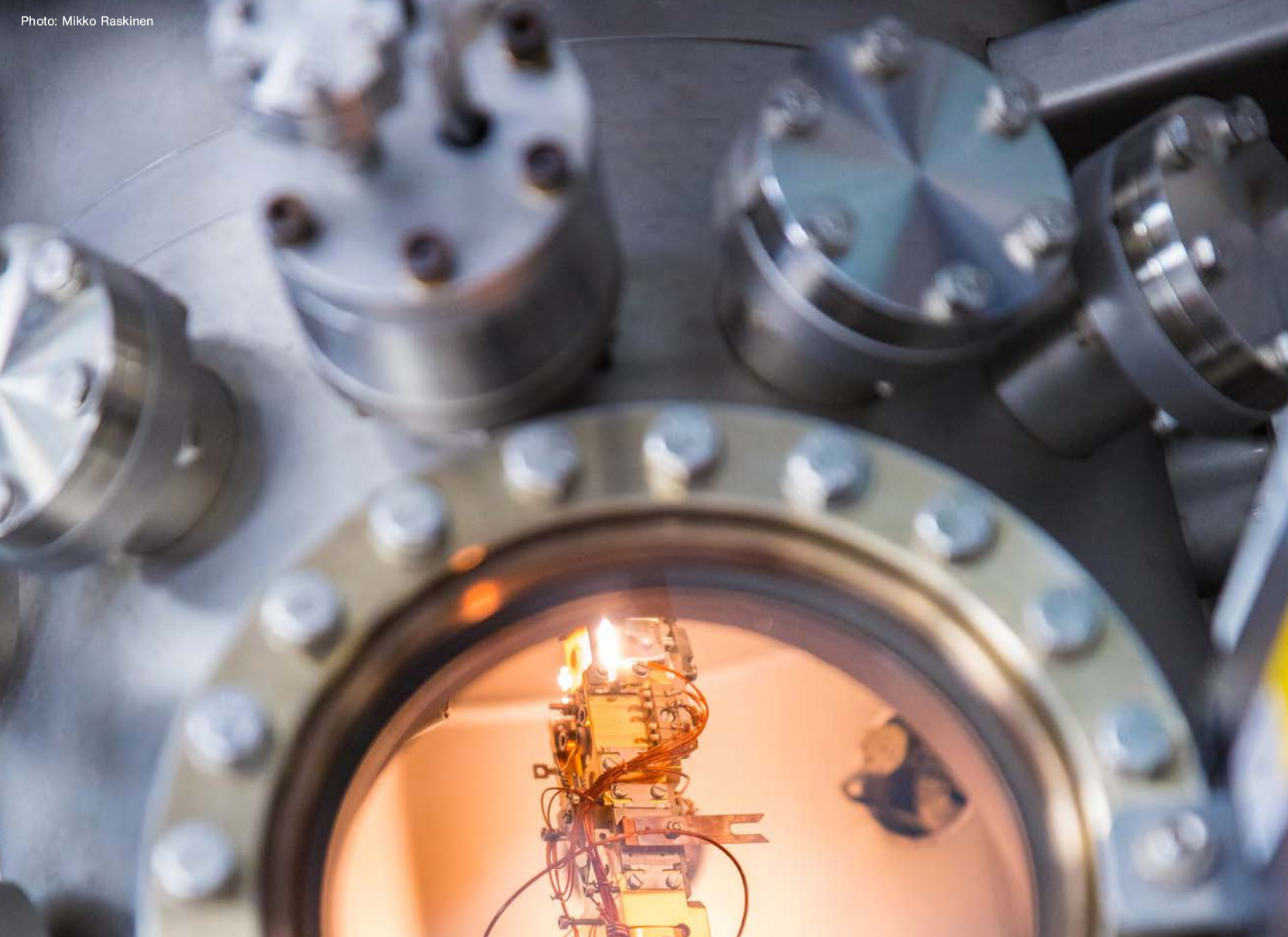
Arts and design knowledge building

Health and wellbeing

Advanced energy solutions

Human-centered living environments

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Marketta Kyttä


Kimmo Lapintie


Martti Larmi


Peter Lund


Mari Lundström


Harri Lähdesmäki


Teemu Malmi


Milos Mladenovic


Markus Mäkelä


Kirsi Niinimäki


Jaan Praks


Heikki Remes


Orlando Rojas


Tuukka Saarimaa


Esa Saarinen


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Aija Staffans


Sanna Syri


Simo Särkkä


Armi Temmes


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