

research
estonia

Estonia – the smartEST research country



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Cover photo of Tartu Observatory, photo by Renee Altrov

Introduction

Looking back in time, one might see the path that paved Estonian (tiny North-European country with a population of 1.3 million) success in becoming one of the most advanced digital societies and e-states in the world. The whole population is seamlessly integrated with using information and communication technology in almost every aspect of life, while pushing the limits in health technologies and using resources in smart ways. All of this means smart specialization strategy in constant action.

Around twenty years ago, Estonia took the initiative Tiger's Leap to bring computers and internet to every school. From then on, the journey led to educating 200,000 people in using ICT and making internet accessible virtually everywhere. Today, 99% of Estonian public services are online 24/7. e-Identity, e-Tax Board, e-School and i-Voting with e-Health are some of the landmark solutions invented by Estonians and exported to 130 countries across the world with their global approach.

Estonia's main focus in smart specialization is to boost the growth of research in ICT, health technologies and services, and effective use of resources.

This brochure aims to show that Estonian science is just like Estonia itself: innovative, dynamic and smart.

A young man with dark hair, wearing a red sweater over a white collared shirt, is sitting at a desk in an open office. He is looking towards the camera with a slight smile while his hands are on a black laptop. The laptop has the 'ThinkPad' logo on the bottom left. The background features a dark grey acoustic panel and a yellow wall. The overall lighting is bright and professional.

Businessman Working in Open Office
Photo by Renee Altrov



Focus on ICT

The ICT sector in Estonia is visible: around **22,000 individuals** work in **3,700 companies** and the growing rate is 1,000 individuals per year. Praised by international media as a tech-savvy nation, Estonians have changed the game in the online communication and finance technology world.

Most people active in the ICT sector are alumni of the University of Tartu (UT) or the Tallinn University of Technology (TTÜ) – code writers, cybersecurity experts, engineers and developers for every possible field in the society. The foundation of Estonian e-success have been increasing ICT education and opening of the IT Academy. Its brand StudyITin.ee is a cooperation project between the universities, ICT companies and the state, and hopes to catch the best talents.

From code writing to robotics

Computer scientists from the UT are currently working on exceptional research projects in deep learning and machine learning, quantum cryptography and cryptography, including e-elections. The other research projects, such as information systems, business process analysis and mining, as well as bioinformatics and personalized medicine applications, are on a high level.

Alumni of the UT are behind start-up companies like [Skype](#) that made a revolution in online communication and Playtech that is the gaming industry's leading software and services supplier. [Transferwise](#) has changed the finance world with a peer-to-peer money transfer service and [ZeroTurnaround](#) makes revolutionary tools for faster quality software development.

TTÜ's School of Information Technologies is a home to around 70% of all Estonian IT students, while 2/3 of Estonian IT science is born in there, benefitting from strong

international research groups and the existence of world-class ICT research laboratories.

Remarkable RD&I projects include the high-assurance software laboratory, the centre of dependable computing systems design, centres for biorobotics and biomedical engineering, the centre for digital forensics and cyber security and the project researching cognitive electronics and communication technologies. R&D in TTÜ also focuses on the large IT systems, model-based software, AI, social engineering systems, non-linear control systems, language technology, e-health, cyber-physical systems and the Internet of Things.

TTÜ scholars have been the founders of several successful companies: [Testonica Lab](#) is an R&D company acting in the sectors of Information Technologies and Electronics Production. [Rakuten Fits.me](#) combines shoppers' personal data with the garments' data, so shoppers can see exactly how the garment will

look and feel. [Optofluid Technologies](#) is developing an online sensor for dialysis machines.

[Guardtime](#) uses blockchain technology and has built a platform called KSI that tackles complicated problems in security, supply chain, compliance and networking. KSI is a blockchain technology designed in Estonia and used globally to make sure networks, systems and data are non-compromised, while retaining 100% data privacy. [SafeToAct](#) is a medical device start-up dedicated to developing high-fidelity kidney replicas. There are tens of direct contracts with companies and the most interesting recent examples are accelerated sensor algorithms in cooperation with Bosch Sensortec and the new generation of working clothes [Ragnarok 2.0](#).

In addition to the IT College of TTÜ, Tallinn also hosts Estonian Centre of Excellence in ICT Research or EXCITE – an institution that focuses on topics related to IT security and reliability, uniting Estonia's 16 most prominent IT researchers.

Various incubators and accelerators have been called into action provide support to start-ups and companies.

Hackaton Garage48 has been the seedbed for companies like VitalFields, Qminder, PipeDrive and MSQRD, while cooperation centres Prototron, StartUp Wise Guys, Lift99, TTÜ Mektory, sTARTUp HUB and SPARK HUB are helping fresh enterprises to grow and bloom.

[Accumulation of expertise, easily accessible supporting infrastructure and digital mindset in terms of business are the key factors, why Estonian ICT sector contributes its outstanding 7% to national GDP.](#)



[OptoFluid's online dialysis sensor.](#)



Estonian Genome Center at the University of Tartu.
Photo by Renee Altrow.

Focus on health technologies

With more than 10 years of experience in e-health planning and design, Estonia is currently heading towards becoming one of the first countries in the world to implement personalised medicine on a national scale. In the field of health tech and services, interdisciplinary collaboration is active with researchers in IT, technical engineering, design and arts. This has resulted in working on countermeasures to emerging virus threats (Zika or Ebola), personalising medicine with genetic testing, developing non-invasive medical monitoring and smart needles, plus combining design and technology for healthcare.

Several universities and R&D institutions are contributing to health technology as Estonia is one of the world leaders in the provision of public digital services. The national communications and transactions' platform X-road provides modern and safe governance by allowing for transparency, security, privacy, entrepreneurship and, among other things, a trusted way to exchange health data between healthcare professionals and the resident. The Estonian e-Health system is globally unique, as it covers the whole country, integrates data of all healthcare providers and gives an overview of the health condition of every resident from birth to death.

The use of e-Health system among healthcare professionals has increased constantly during the first 8 years, reaching more than 1.6 million queries per month. It contains data on 1.5 million people, including 176 million out-patient and 1.75 million in-patient summaries and 8.3 million diagnostic examination reports. The patient portal has been used by 21% of the whole population (2016). 99% of prescriptions are issued in electronic form.

Personal, local and global solutions

Regenerative medicine, reproductive medicine and cancer research are actively practiced at the University of Tartu's Institute of Molecular and Cell Biology. In 2017, its research underwent successful international assessment in both Medicine and Natural Sciences. The major research directions of the University of Tartu's Institute of Technology include synthetic biology, biomedical and environmental technologies, intelligent materials and computer vision.

UT is also home to Estonian Genome Centre (The Estonian Biobank), that has collected the genome data of **52,000 individuals** and all participants have been genotyped for over **700,000 different genetic variants**. In 2018, a joint development project of the Ministry of Social Affairs, the National Institute for Health Development and the Genome Centre aims to collect the genetic data of 100,000 people and integrate it into everyday medical practice by giving people feedback on their personal genetic risks. The data generated in



the Biobank enables using individual genomic variation obtained from genetic analysis and computational methods to predict and prevent diseases and optimise drug treatment.

The ongoing research of the National Institute of Chemical Physics and Biophysics (KBFI), which focuses on cancer diagnostics, is using a



Dr. Tuuli Käämbre and Dr. Kersti Tepp measure oxygen consumption of the tumor cells.

recent methodological approach – Molecular System Bioenergetics – to provide ground-breaking solutions in the field of cancer and muscular cell bioenergetics.

Nearly 44 million people in the world have Alzheimer’s disease or related dementia, which generates global costs of approx. \$ 605 billion.

Researchers of the Tallinn University, in collaboration with the Stockholm Karolinska Institute’s AD Centre, are working on several human BRICHOS proteins in order to combat the Alzheimer’s.

Competencies of TTÜ’s Department of Health Technologies include diagnostics of cardiovascular

diseases, brain diagnostics, chronic diseases: optical kidney dialysis monitoring, wearables: sensors and monitors plus e-Health. The research is targeted to society providing early detection of cardiovascular, cerebral and renal disorders, and has impact to prevent the world's most-occurring diseases according to the statistics of WHO.

The strategic vision of research is to develop tools for early diagnostics and prevention of complications via new paradigms: one example is patient-centred healthcare, creating and validating a novel technology incorporated into the ICT monitoring tools.

eMed Lab of the Department of Health Technologies of TTÜ includes researchers with [leading e-health and e-government expertise](#). There, some of the world's leading Internet solutions are being created and implemented in practice. The research fields are Big Data, clients' on-line access to medical data and monitoring the effectiveness and the potential adverse effects of new e-services or digital technologies in health care. eMed Lab operates as a science, study and development establishment in the e-health, clinical medicine, public health and medical data analytics areas. TTÜ has been involved in several European telemedicine projects (eMedic, PrimCareIT, Chromed,

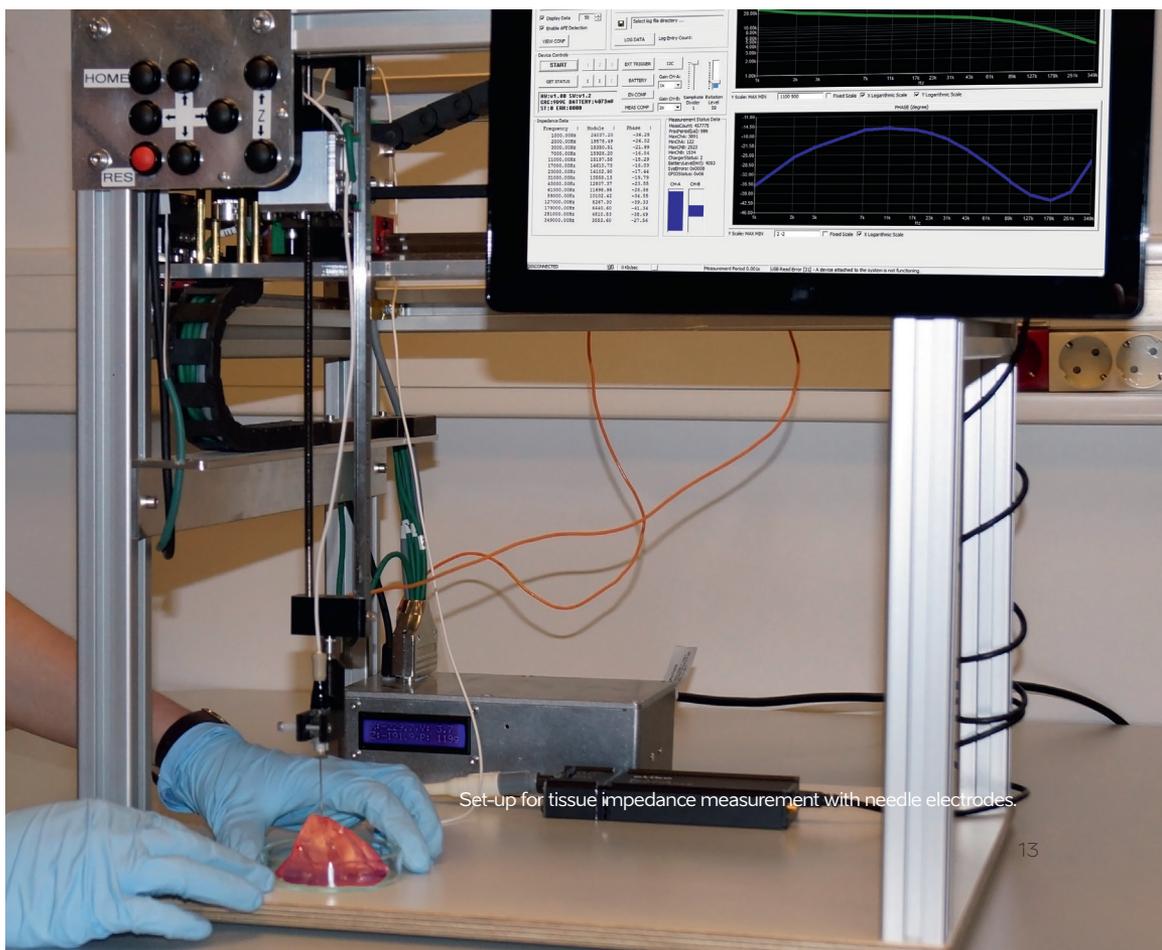
MasterMind) and has comprehensive knowledge and experience in e-health development and e-health applications.

The Thomas Johann Seebeck Department of Electronics of TTÜ is developing smart needles and non-invasive monitoring of central blood pressure, using wearable devices, fast detection of pathogens in point-of-care devices, detection of lesions in organs and controlling of localized drug administration and control of heart pacing rate in implantable cardiac pacemakers. Wearable robots for augmentation, assistance or substitution of human motor functions are also studied at the department.

The Competence Centre on Health Technologies or CCHT is a biotechnology company focused on research and product development in personal medicine, drug development and both human and veterinary reproductive medicine. In the Reproductive Medicine Development Area, the CCHT projects are contributing to solving some of the most pressing issues in contemporary reproductive and foetal medicine. CCHT is creating [diagnostic systems for female reproductive diseases](#), while developing new solutions for identifying foetal genetic diseases by [non-invasive prenatal testing \(NIPT\)](#), and continues developing clinically proven probiotic strains for female and male reproductive disorders.

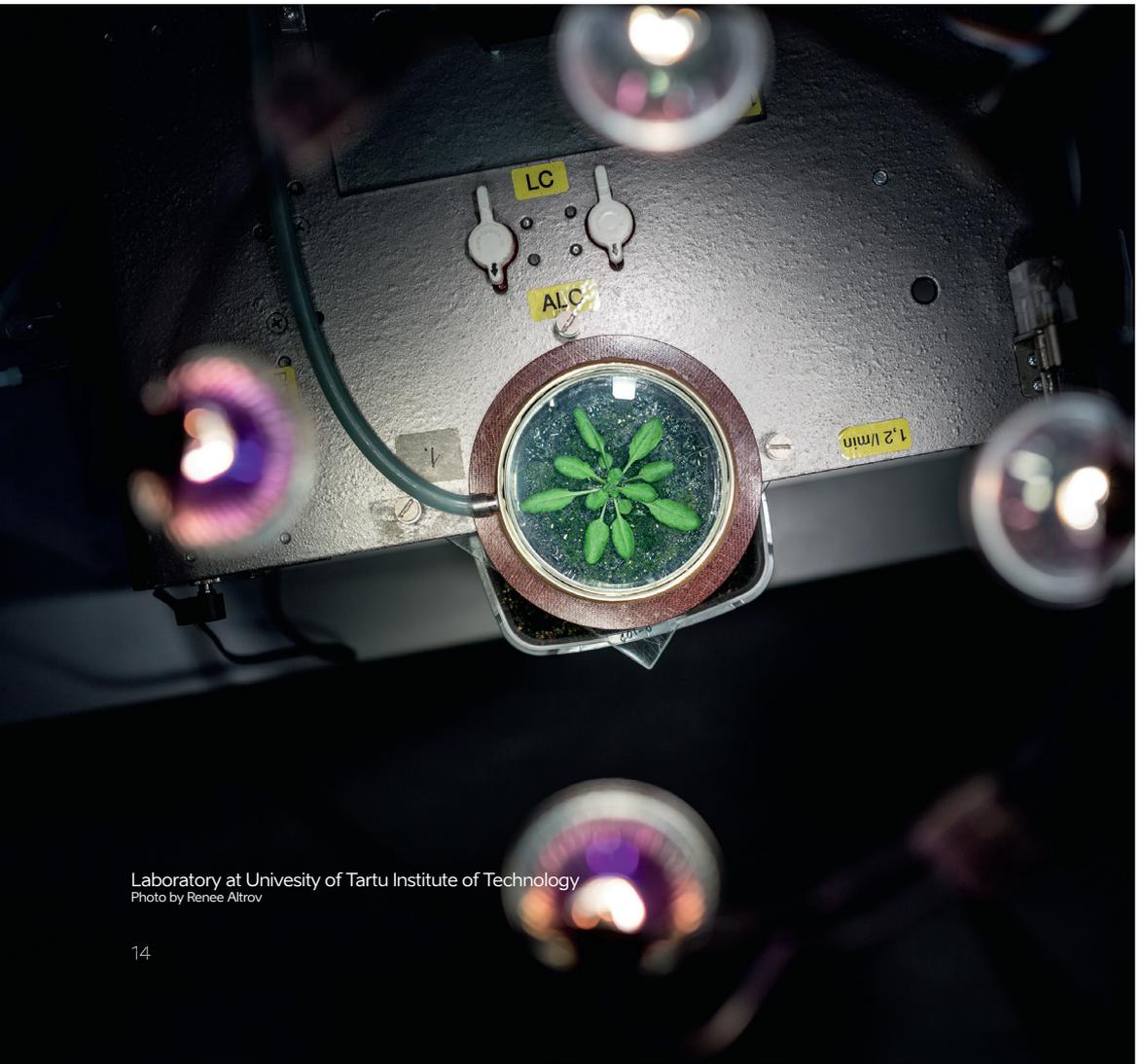
Estonian HealthTech Cluster **Connected Health** is a country-wide partnership between health stakeholders in Estonia, which is committed to accelerating the adoption of connected health solutions on an international scale and on commercial terms. The cluster brings together 70+ partners, including 43 companies, R&D partners, health and wellness service providers, patient organisations and user communities, and the public sector.

Closely collaborating research community, availability of health related data, entrepreneurial spirit and unique ways to solve some of the most challenging health issues in smart ways make Estonia a world class innovator in medicine technologies.



Set-up for tissue impedance measurement with needle electrodes.

Focus on effective use of resources



Laboratory at University of Tartu Institute of Technology
Photo by Renee Altrov

The state's strategy is also focused on more efficient use of resources. In this area, potential is the highest in materials science and industry, not to mention development of the 'smart and passive housing' concept and health-supporting food.

The Estonian materials science is under intensive development stage. The University of Tartu is researching materials for super-capacitors and fuel cells. In 2015, the university started cooperation with NT Bene AS for the development of the hydrogen filling station (H2Nodes) project in Pärnu. Local companies, such as the European Space Agency's supplier [Skeleton Technologies](#) and [Elcogen](#) are using the fundamental physical chemistry and electrochemistry results and knowledge that has been collected and generated by electrochemists working at the University of Tartu's Institute of Chemistry since 1997. Having strong ties with the National Institute of Chemical Physics and Biophysics KBFI, once a small start-up, Elcogen is now the manufacturer of the world's most efficient solid oxide fuel cell technology and has more than 60 customers globally.

In the KBFI Centre of Excellence "Emerging orders in quantum and nanomaterials" (EQUITANT), researchers are exploring new materials of various ferroic orders and their potential applications. Examples include ferromagnets, ferro-electrics and ferro-elastics, which occur due to onset of spontaneous magnetization, polarization or strain.

TTÜ's Department of Materials and Environmental Technology is working on the development of [new materials for solar cells and design developments](#) (mono-powders, nanomaterials, thin films), whereas mono pulp technology has taken the form of a spin-off enterprise.

The nano- and composite materials for environmental applications (cleaning air and wastewater from micro-pollutants, sensors); water, soil and air purification technologies; sensory materials for molecular imaging of polymers for medical diagnostics and environmental monitoring; electrodes and capacitors for energy storage devices and other functional applications are in the invention phase. Departments' wide scope reaches to mineral exploration, materials and technologies to reduce industrial emissions.

Sustainable approach in materials science, depends on wise design too. The active smart interior



Production of highly efficient and low-cost solid oxide fuel cells at Elcogen.

textiles are being investigated at the Estonian Academy of Arts. These are materials that behave and change depending on the environmental stimuli. In the world that currently wastes enormous

amount of raw materials in fashion industry **reuse and upcycling** are hot topics – therefore new ways in fashion design are researched from theoretical and practical perspectives at the academy.

Energy efficiency in buildings and health in food

When it comes to building a new house, the builder must remain focused and engage in active calculations. Soon, we will face a change that happens only once in a century – transition to building nearly zero-energy buildings (ZEB). From 2020 onwards, all constructed buildings must have near-to-zero energy consumption and current projects of public buildings are already planned this way.

Energy and resource efficiency improvement in buildings and districts is researched at the ZEBE Centre of Excellence in Research. It consolidates six existing research groups active in ZEBE domain at three Estonian universities in order to build up its key competences. Research is centred on [zero energy and resource-efficient smart buildings](#), resource-efficient wooden structures, composites, intelligent and efficient energy management for ZEB.

ZEBE also conducts research in the smart house concept and digitalization of the engineering and planning. The institution is one of the leading pioneers in

Europe, especially when it comes to calculating the economic impact of resource-effective constructing and finding an optimal resource efficiency.

As more and more people are switching to conscious and healthy lifestyles, Estonia is no exception. Estonian food industry produces close to 100% of the food used by the Estonian population and is one of the leading sectors of the local economy. One might say it is quite traditional – from the use of novel replacements of traditional sugars, non-traditional packaging materials and plant-origin raw materials to zero-waste production technologies. Novel treatment technologies to produce novel foods are also among the topics discussed.

Research Centre of Organic Farming of the Estonian University of Life Sciences brings together organic farming and food studies to initiate further activities in this field. The centre's main activities include research into [organic food](#) and agriculture, promotion and education, plus finding the best solutions for

developing the organic sector in cooperation with many entrepreneurs. Organic production volumes have increased in Estonia and the country is already among the leading organic producers in Europe. The [share of organic farming reached 1/3 of agricultural land in 2017](#). This emerging high demand of organic markets creates great potential for the country. In addition, the university also studies the impact of pesticides on pollinators.

Centre of Food and Fermentation Technologies conducts quite intensive R&D and the new products based on other than lactic acid bacteria will appear soon. The health-promoting product from plant materials (vegan foods etc.) have shown growing popularity. CFFT cooperates with more than 40 food industrial enterprises from Estonia and abroad. It has successfully joined forces with the local enterprises in the development of novel cheese and rye bread production technologies, supported ice-cream and cider product development, created new recipes for functional foods and herb mixes.

[Affordable and clean energy, responsible consumption and production, plus zero hunger](#) are among the United Nations Sustainable Development Goals. Estonian research institutions are making their best to meet these global challenges at home and at abroad.



Zero-energy test building in Tallinn, Estonia. Tallinn University of Technology.
Photo by Robert Treier



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