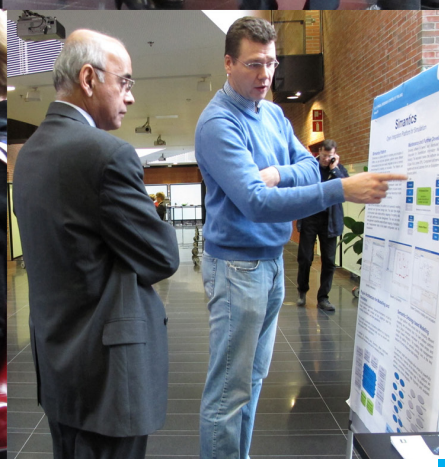

TECHNOLOGY • RESEARCH HIGHLIGHTS • VISIONS • SCIENCE

108

VTT Scientific Advisory Board

Final Report 2011–2012

Hannu Vornamo | Andreas Hafner | Riitta Keiski |Jørgen Kjems | Outi Krause | Colja Laane | Ian Oppermann | S. Shyam Sunder | Marco Taisch

VTT TECHNOLOGY 108

VTT Scientific Advisory Board

Final Report 2011–2012

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Kopijyvä Oy, Kuopio 2013

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Abstract

VTT Technical Research Centre of Finland appointed its third Scientific Advisory Board (SAB) for the period 2011–2012. The SAB held four thematic meetings during the period. The meeting themes were based on the VTT Research and Innovation Vision 2020. This final report describes the SAB's key findings regarding VTT´s research and scientific activities and competences within the selected thematic areas as well as its recommendations and proposals for the future.

Keywords VTT, scientific, advisory, board, final, report, research vision, 2011, 2012

VTT:n tieteellinen neuvottelukunta
Loppuraportti 2011–2012

Hannu Vornamo, Andreas Hafner, Riitta Keiski, Jørgen Kjems, Outi Krause, Colja Laane, Ian Oppermann, S. Shyam Sunder & Marco Taisch. Espoo 2013. VTT Technology 108. 23 s. + liitt. 11 s.

Tiivistelmä

Teknologian tutkimuskeskus VTT asetti kolmannen tieteellisen neuvottelukuntansa (Scientific Advisory Board) kaudeksi 2011–2012. Neuvottelukunta piti kautenaan neljä eri tutkimuskokonaisuuksiin liittyvää kokousta. Kokousten aiheiden lähtökohtana oli VTT:n tutkimus- ja innovaatiovisio 2020 (VTT Research and Innovation Vision 2020). Tässä loppuraportissa on kuvattu VTT:n tutkimusta ja tieteellistä toimintaa koskevat päähuomiot sekä valittujen aihealueiden osaamistaso. Lisäksi raportissa on annettu suosituksia ja ehdotuksia tulevaisuutta ajatellen.

Avainsanat VTT, scientific, advisory, board, final, report, research vision, 2011, 2012

Preface

The research activities of the VTT Technical Research Centre of Finland represent a significant proportion of all scientific and applied research conducted in Finland. VTT has a long track record of generating new business and promoting Finnish industry through leading-edge research. Key to this success has been VTT's willingness to listen closely to the needs and wishes of its clients and partners. This has been achieved in part through the valuable contribution of scientific and other advisory boards in different areas of research. The rapid changes in the operating environment over the past two decades, such as EU expansion and accelerating globalization, have presented huge challenges for business and industry – and also for research organizations. Here, the key challenges for VTT are ever-increasing international competition and the ability to focus strategically on essential research. Some years ago VTT took the far-sighted decision to define strategic research as its specific field. This has meant investing strategically in meeting the key challenges of the future and also embracing the global reality of these challenges. To achieve these purposes, VTT also established the international multidisciplinary Scientific Advisory Board (SAB) to support its strategic research.

The third Scientific Advisory Board, appointed by the Board of VTT and hereby presenting its final report, comprised eight invited international experts from different fields. In the four meetings of the SAB we thoroughly examined the most important areas of VTT's strategic research, with presentations by tens of leading VTT experts providing an excellent basis for our thematic discussions. White papers were written over the past two years on each of the four thematic areas, and the present final report provides a summary of this work.

The mission of the SAB has been to critically evaluate VTT's strategic research and to examine – from an outsider's perspective – the challenges and future potential of the different research areas. The conclusions and recommendations of the SAB are based on the material and discussions of the SAB meetings and are primarily aimed at VTT and the VTT Board in order to further develop VTT as a leading high-class and international research organization.

Hannu Vornamo
SAB Facilitator

Members of the VTT Scientific Advisory Board participating in the 4th meeting in Espoo, in November 2012. From the left: Ian Oppermann, Jørgen Kjems, Outi Krause, Andreas Hafner, Riitta Keiski, Anne-Christine Ritschkoff (VTT), Marco Taisch, Hannu Vornamo, Colja Laane and S. Shyam Sunder.

Contents

1. Introduction

VTT is a globally networked, not-for-profit and impartial multi-technological applied research organization. Today, VTT employs roughly 3,200 people and has an annual turnover of over EUR 300 million. VTT provides extensive cross-disciplinary technological and business expertise through a unique research infrastructure. According to VTT´s mission, VTT produces research and innovation services that enhance the international competitiveness of companies, society and other customers. VTT creates the prerequisites for society's sustainable development, employment and wellbeing.

VTT´s research and innovation strategy 2020 is driven to create value from sustainability. It addresses major societal challenges in six key areas of research and technology development with business potential: bioeconomy, low-carbon and smart energy, clean technologies, digital world, resource-efficient industries, and human wellbeing. Each of these six areas has a special impact on Finnish society and economy.

VTT´s role in Finland's national innovation system is to bring together capabilities and resources in the areas of basic and applied research, advanced engineering, design and development, prototype production, and industrial exploitation, through publicly-funded and contract research, licensing, and spin-offs. As a state-owned organization, VTT has a role and tradition of assisting the government in tackling major, technical and scientific challenges of the day.

The VTT Board established the Scientific Advisory Board (SAB) to serve as a forum for broad views on global trends in research and technology. The SAB is invited to suggest ideas and initiatives to develop and direct VTT´s research activities. The mandate invites the SAB to give feedback on the scientific competence of VTT. The third SAB was invited to examine five of VTT´s core thematic research areas: bioeconomy, low-carbon energy, digital world, clean technologies, and resource-efficient industries (Figure 1). The SAB was especially encouraged to evaluate the scientific quality, relevance and impact of the selected thematic areas together with VTT's key personnel. The SAB feedback was captured in a white paper on each selected thematic area as an outcome of the meetings.

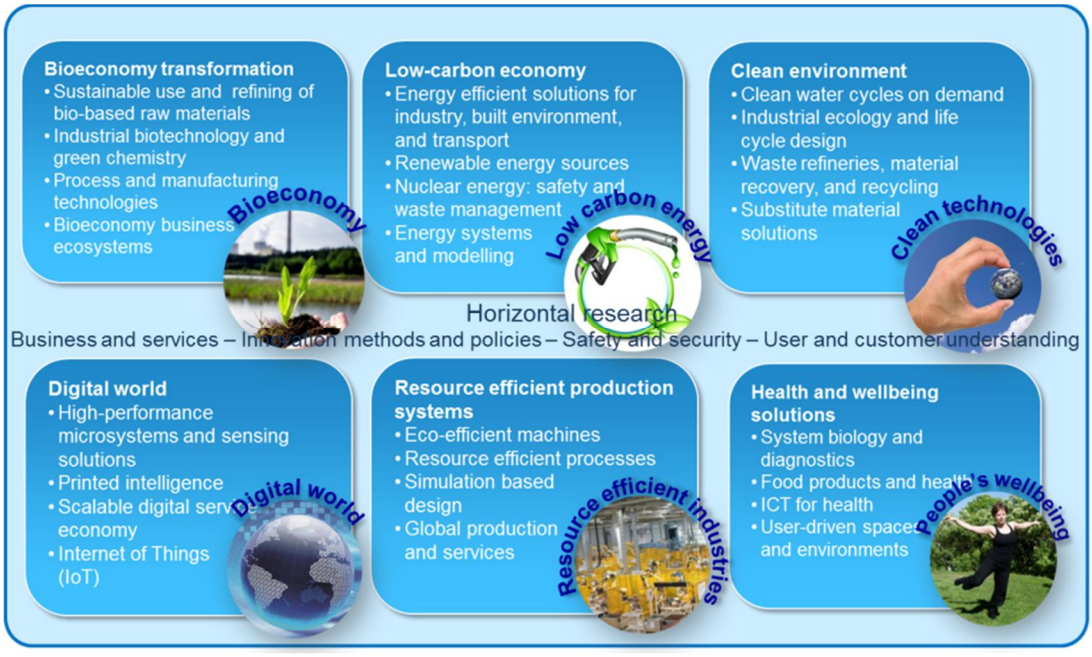

Figure 1. VTT's thematic research areas.

2. General observations and recommendations

VTT is a strong and trusted research organization held in high esteem within the Finnish national innovation system. VTT is also an internationally recognized member of the global innovation system with strong links to many international partners. Changes in the operating environment and social structure require changes in technologies. VTT is seen as a responsive multi-disciplinary organization, able to rapidly transform its focus as needed, while still keeping a long-term perspective on providing benefit to Finland's national interest.

VTT has been strongly encouraged to benchmark its core competencies with similar organizations with regard to their level of science and impact. It is important to identify which VTT competencies are world class, which are good and which are mediocre. Areas of mediocre competence are not sustainable in a research organization with a national mission, and VTT is encouraged to take corrective action when such areas are identified. In addition, the SAB recommends identification of technology areas in which VTT has developed strong competence. VTT is encouraged to strengthen these areas and develop global leadership. Identifying such areas of strength where VTT can create a substantial impact is essential.

VTT is also encouraged to embrace the big challenges, i.e. those of global significance, and to align its capabilities towards addressing these challenges. The SAB has encouraged VTT to raise its level of ambition in terms of science, commercialization and business. Measures appropriate to VTT which allow it to identify 'good' or 'excellent' performance can be found and must be applied when benchmarking VTT's performance. Benchmarking of VTT's competence is useful for internal identification of research areas that need development, and for external use in finding strategic partners.

Metrics for success should be formulated: clear outcomes and impacts of VTT's research and technology development (RTD) for end users, including economic impact, technical performance and/or environmental performance, or well-being. Increased use of organizational frameworks, such as roadmaps and value chains, is recommended to clarify and communicate VTT's performance and impact.

The SAB acknowledges that VTT has different goals (impact) than universities (new scientific knowledge, education) and thus should use different measures.

Delivering impact is a long-term endeavour, with timeframes of 10 or more years, compared to generating scientific papers with timeframes of the order of two years. Delivering impact also requires careful consideration of pathways for adoption and identification of interim measures (lead indicators) that show progress towards longer-term goals.

VTT should have clear processes for choosing which projects and applications to take further. Follow-up of results is also important to improve the impact of work. The method provided to the SAB for assessing competences was considered to be both interesting and useful. A methodology for systematic assessment would be helpful to VTT in developing competences to a higher level and identifying problematic areas.

2.1 Research and innovation strategy

VTT's strategy is defined by the key challenges facing Finnish industry and society, such as the decline of the pulp and paper industry and population ageing. VTT must therefore play a key role in facilitating industrial renewal while also providing technologies and concepts to help meet Finland's societal challenges. The SAB recommends clearly aligning VTT's choice of major research challenges with its key competences and leveraging its existing strengths as a multi-technology and trans-disciplinary operator to develop innovative solutions.

Sustainability should be a foundational principle underpinning all VTT operations. It should be seen as an integral part of the professional ethics filter that VTT applies to any endeavour. The Board advises VTT to pay particular attention to social sustainability. VTT is encouraged to either partner with other players in the field of social sustainability or to establish social sustainability as a VTT competence area. However, although sustainability must strongly underpin all research, other factors must not be forgotten.

VTT is advised to formulate unique selling points or value propositions for VTT as a whole and also for each research theme. Science must be the basis for this value proposition. VTT is advised to respect this and to value academic results, such as high-quality publications. It is recommended to formulate publication strategies in different research areas, particularly in those where there is valuable application-oriented research but no tradition of active scientific publication.

The SAB notes that there is misplaced modesty in presenting VTT's results. VTT must be bolder in presenting its achievements. Improvements in communication skills over a wide range of areas are needed. When communicating the results and impact made by VTT, the role of customer companies should be more clearly emphasized. Several of VTT's spin-off companies have generated considerable value and have received substantial attention, however, the impact through and with the customer companies must be recognized and emphasized.

2.2 Partnerships and international activities

Partnering and co-operation with organizations with complementary competences is strongly encouraged. It was recognized by the SAB that VTT should embrace international collaboration, and the SAB similarly recommends further internationalization, especially within Europe. The SAB acknowledges that such international activity requires considerable effort to establish firm strategic partnerships and, therefore, it was recommended that VTT focuses on a few strong competence areas and finds partnerships within those areas. Internationalization could be promoted through mobilization of VTT's staff, by assisting foreign visiting scientists and their families to settle in Finland, and, importantly, by providing opportunities for further employment after visiting periods elapse.

The motivation for engaging with partners in other countries, such as China and Russia, should, however, be clear and well-founded. For example, if VTT wishes to establish an official presence, the fundamental questions that this entails must all be addressed, such as how staff and resources are to be utilized, what goals are to be prioritized, how to gain market in-sight and understanding of how to attract new customers, whether to sell IP or technology, how to attract scientific talent, and how to clarify the benefit to Finnish industry and/or tax payers. More generally, it must be clear and justified why VTT should licence results to companies outside Finland when substantial amounts of Finnish public money have been invested in developing the technology or competence. In terms of benefit to Finland, VTT cannot justify having many sites outside Finland.

Partnership with domestic universities and research and technology organizations, such as Aalto University, and with other scientific parties is also of great importance. The role of esteemed professors and experts in creating inspiring and successful research groups must not be underestimated. The SAB encourages VTT to pay more attention to hiring and establishing partnerships with such scientists. The success of research and its value to industry is often based on a few outstanding individuals, and VTT needs to have clear ways of developing new staff and maintaining existing staff excellence. It is advised to document and report staff development actions in a succession plan.

2.3 Customer relationships and business development

Closer integration of marketing and design thinking into research plans is needed (showcases, payback time estimates). VTT research in certain areas (such as Low-Carbon and Smart Energy) is strong, but needs more compelling identification of value as well as improved communication, storylines, and sharpening of key messages. Guidelines and standards are one of the key parts of the market penetration of the new technologies and products. As VTT has a unique partnership with private sector technology and standards development activities, more work in this area would be a great opportunity for VTT to achieve global impact.

3. Thematic research areas

3.1 Bioeconomy

Description of the thematic area

The VTT bioeconomy vision encompasses three lines: i) an economy based on the sustainable manufacture of different products from renewable bio-based resources (biorefinery concept), ii) development of biological tools (enzymes, microbes) for processes, and iii) exploitation of biological phenomena in processing of non-biological raw materials or production of non-bio-products exploiting certain biological principles. Bioeconomy-related technologies are a significant part of the VTT research portfolio. The vision is to further strengthen the industrial biotechnology–green chemistry combination (biomass hydrolysis and conversion technologies) and to combine pulp and paper process expertise with new bio-based concepts. Material science competence will also be exploited for development of new value-added materials from bio-based raw materials with a special focus on packaging materials, barriers, new value-added fibres and composites.

Observations

In general, VTT's bioeconomy vision is in good shape and sufficient resources, such as research staff, equipment and facilities, are available. VTT has made the right choices by investing in bioeconomy-related disciplines. However, the current bioeconomy definition may be too broad. Stronger links between the vision, available technologies and new business (potential spin-offs) are needed. The bioeconomy vision should be clearly linked to measurable targets.

VTT is clearly a strong player in biomaterial research covering the whole value chain from raw material processing, analytics and bioconversion to material development. This value chain can be regarded as a differentiating factor for VTT research compared to other players in bioeconomy. It is highly important that this area is kept strong and further developed in the future, especially as the EU is considering setting up a major public-private partnership (PPP), Bridge, on (new) value chains in the bioeconomy. Here, it is essential that VTT clearly knows which

raw materials should be focused on. As examples, the SAB supports the current focus on Scandinavian wood- and crop- (barley) derived products.

Biorefinery is a key element in bioeconomy research, and VTT has made the right choices in focusing on a wide variety of biorefinery products. The central biorefinery-related expertise is important as it can be applied in other industries. In this context, the SAB noticed that the role of traditional biotechnology in biorefinery and bioeconomy activities is not as strong as it could be.

The SAB recommends that the use of traditional and modern biotechnology for flexible production of specialty chemicals could be more extensively studied. A recommended approach is to first identify high raw material volumes and to then identify optimal bulk and specialty products for each raw material type. Another suggestion relates to the use of a biomimetic approach to study the properties and applications of various bio-based products and their performance properties.

VTT's strong focus on material science (especially biomaterials) with many innovative bio-based and biodegradable material solutions was commended by the SAB. This link between biomass and materials was seen as a strong asset of VTT. It is important that applications with sufficient markets are developed for the selected main materials – a typical example could be different nanocellulose-based products.

VTT has several strong bioeconomy-related research areas, such as food and feed, pharma industry, forest industry, (bio)materials and chemicals, industrial biofuels, and microbial applications. Key technologies at VTT include thermochemical processing (pyrolysis and gasification) and chemical, mechanical and biotechnical processing (e.g. hydrolysis and fermentation). Through successful and innovative integration, these areas could be made even stronger.

Strengthening and further development are needed in weaker areas such as bioengineering, up-scaling and downstream processing, as well as in modern bio- and chemo-catalysis in biorefinery.

Key recommendations

VTT's bioeconomy research currently covers a wide range of raw materials, processes, products and applications. More focusing is recommended and strong links with the emerging European PPP on value chains in the bioeconomy (Bridge) should be established.

To that end, skills such as bio-engineering, up-scaling, downstream processing, recycling, as well as bio- and chemocatalysis and product development should be further developed and integrated within a societal-sustainability framework.

3.2 Low-carbon energy

Description of the thematic area

VTT's vision 2020 for low-carbon and smart energy solutions includes four areas of major contribution: i) low-carbon and smart energy enabled sustainable growth and well-being through 80% GHG (green house gas) reduction by 2050 in the OECD area, ii) Finnish solutions for GHG reduction and competitive economy – strong impact from VTT foresight and technology implementation, iii) massive growth in Finnish low-carbon and smart energy technology and services, and iv) energy conscious citizen – VTT providing low-carbon and smart energy solutions for everyday life. The portfolio of VTT's current research on low-carbon and smart energy comprises the following areas: nuclear energy, energy in transport, energy in built environment, smart machinery, efficient use of energy in industry, combustion and gasification technologies, bioenergy chains and concept solutions in bioeconomy, smart grids and distributed energy, energy systems, and climate change mitigation.

Observations

As general observations, the SAB recognized that VTT research is very strong in both the nuclear and bioenergy fields. VTT's nuclear energy research focus is strategically well-founded, placing VTT in a good position to contribute to global nuclear markets such as China. In direct spent fuel disposal VTT is one of the world's leading players, and VTT could offer this competence to other countries.

In biomass gasification and fluidized bed combustion, VTT enjoys unique collaboration with Finnish companies operating in the global technology market. Close co-operation with companies has led to VTT's establishment as a successful supplier of RTD support. VTT's strong patent portfolio, especially in gasification, is expected to generate a revenue stream.

In wind power, VTT's competitive edge is in cold climate and system integration issues. Due to global competition, partnership with industries and other RTD collaboration is a key element. Wind power technologies could be linked to intelligent manufacturing.

VTT's research on energy systems and modelling provides a multidisciplinary and systematic view of the whole energy value chain, including cost and sustainability assessments of low-carbon and smart energy by 2020–2050 at the national, EU and global level. The unique strength of VTT's energy systems research is based on its extensive competence in future technologies. Energy scenarios and energy system studies are considered to be highly important in supporting VTT's strategic decisions as well as government energy and climate policy.

The VTT spearhead programmes on Low-Carbon Energy and Smart Mobility and the innovation programmes on Safe and Sustainable Nuclear Energy and Arctic Technology with Wind Energy in Cold Climates are being used as dynamic

instruments for the development of VTT's RTD contributions towards a low-carbon energy system.

The 'smart cities' concept provides a framework with high societal and business impact. It is recommended that VTT could develop a more holistic approach integrating energy production and distribution and the physical built environment with ICT as a key enabler. However, due to the broad scope of this field, VTT's needs to define its key competences and impact strategies, where it can most efficiently align with national, European, and global strategies and industry customer needs.

The scope of low-carbon and smart energy research is recognised by the SAB as being very broad. A more holistic examination of this field is therefore recommended in order to incorporate perspectives from different fields of research, while at the same time enabling appropriate niches and focus areas for VTT research to be identified. The key elements of this holistic view are: i) system engineering and system performance, including modelling and simulation, ii) scenario analysis including cost efficiency, analysis of sustainability performance, life cycle analysis for all stages (from proto to industrial products), iii) cross-cutting solutions for low-carbon and smart energy, iv) management of sustainability in different contexts covering key sectors of society, and v) Social science and responsibility, human behaviour, and health issues with their impact on low-carbon and smart energy.

The SAB learned at the November 2012 session about further developments in the Low-Carbon Energy area and was presented with the report Low Carbon Finland 2050: VTT Clean Energy Technology Strategies for Society. The report documents how several of the recommendations presented here have been implemented and how the RTD efforts have been focused in the key areas: energy efficiency in buildings and industry; energy use in engines and vehicles; fluidized bed technologies and biorefineries, nuclear power, wind energy, solar energy; and energy system modelling and analysis methodologies.

Key recommendations

A more strategic framing approach is needed and roadmaps for future energy-related research are required. The following needs to be defined more clearly: What is the problem? What are the needs? What are the technical barriers? Why is it so hard to solve the problem? How is the problem currently being solved? Why should VTT be involved in this field? What is the new/unique idea? and, What is the impact if successful, and who cares?

VTT needs to focus on research areas where national priorities and industrial needs converge. In nuclear energy there is a clear national interest as well as strong industry engagement. In bioenergy, the research supports industrial needs as well as the national priority to increase exports. VTT could also consider partnering by contributing more actively in the European effort to attain low-carbon and smart energy systems cost effectively.

3.3 Digital world

Description of the thematic area

VTT's vision 2020 defines the four major contribution areas of VTT related to the digital world as follows: i) leading-edge ICT and electronics enablers from VTT vitalize the ICT business, ii) smart growth – totally new knowledge-based businesses are evolving, iii) ICT-enabled sustainable growth – a strong cross-disciplinary contribution from VTT, and iv) inclusive growth – everybody is invited to enjoy the social benefits of the digital world. VTT's strategic research portfolio in microtechnologies and electronics consists of four technology areas: photonic solutions, printed intelligence, diagnostic platform technologies, and micro- and nanosystems. VTT's ICT research covers the following six challenge areas ('baskets'): interaction with the real world, gratifying user experience, managing design complexity, moving 1 Gbit/s per user, finding relevant information, and serving 100M users. ICT research is organized into eight knowledge centres with a specific emphasis on telecommunications, information systems or other application fields.

Observations

Until recently, VTT has been working in an environment in Finland in which ICT was dominated by Nokia and companies in the Nokia ecosystem. Much of the work performed by VTT over the last decade in the ICT space has been of a supportive nature within this ecosystem (engineering or consulting), rather than developing cutting-edge or 'blue sky' activities.

With the decline of Nokia's dominance, there has been a reshaping of the demand for talent, and the need for near-term developments. VTT is well placed to take advantage of this environmental change.

In the domains of ICT and Electronics, the scope of potential research is extremely wide. It is therefore important for VTT to focus its research activities, clearly defining what it will do and what it will not do. The selection of these research focus areas must be considered through the lenses of: i) size of market opportunity – is it big enough to be important, ii) importance of the area to Finland – does Finland have or wish to build a competitive advantage in this area, iii) will research make a difference – some areas are already well advanced or advancing rapidly, and iv) does VTT have the capability to address the area; or could it build this capability within a reasonable timeframe.

VTT must also consider its pathways to impact. Working backward from the desired outcomes for Finland, VTT needs to consider its pathways to adoption of research outputs. These pathways include business and research partners, national versus international focus, business models and commercialization options. Clarifying these pathways will provide focus for VTT research activities in the short, medium and long term, as well as help clarify the capabilities that must be maintained, developed or found through partners.

In terms of the electronics vision, the SAB considers the potential scope of electronics research to be very wide. Specialization is therefore essential. This also means defining those areas that are not within the scope of VTT research. It is also important to decide and clearly state which research areas VTT will divest. Resources freed up by these divestments can be channelled to the chosen research areas, thus further reinforcing VTT's research focus. The level of focus should not be on technology alone, but oriented also towards vertical applications. The ambition level should be higher for both scientific quality and impact. Sustainability must underpin all research. For example, electronics researchers should consider rare earth metal usage and the sustainability of future products.

As regards the ICT vision, VTT is in a good position as the changes in the industry open up new opportunities and push towards renewal. Due to its transdisciplinary nature, VTT is well positioned to bring ICT competence to other fields. VTT must align its areas of excellence with national interests. This focusing requires the divestment of mediocre competencies or those with weak impact prospects.

In terms of the ICT and electronics research focus, the SAB advises further examination of possibilities for synergy between VTT's ICT and printed intelligence competences. This is an example of bringing strong existing capabilities to bear in an emerging area. Understanding the market potential is essential here in order to clarify the level of effort required. Is VTT's ICT and electronics research positioned in a business value chain where significant value is captured? Understanding VTT's position in the value chain is critical to deciding on the level of resourcing. Based on the figures shown, this is not clear.

Printed intelligence, being a disruptive technology, operates in technology-push mode. This was recognised as being a challenging area for VTT, whose role includes helping create new value chains as well as developing technological solutions. It was also noted, however, that no individual companies are willing to take on the technical and business risks attached to driving this disruptive technology. This is the logic for VTT's strong commitment to printed intelligence and also to international partnership. While the targets for printed intelligence in terms of start-ups and sales seem modest compared to the high risk level, the rewards for risk-taking are expected to be seen as the technology matures and the business sector enters rapid growth.

Diagnostic platform technology research investment is easy to justify, since it has both big societal potential and business possibilities. However, as the market is fragmented the choice of application areas is critical.

The SAB considers the use of disclosure fees and milestone payments to be worthy of closer consideration; positive experiences of their use have been gained in contract research.

VTT should avoid running successful (electronics) offerings dry. Portfolio renewal is therefore important. Contract research organizations should maintain a range of offerings at different phases of maturity.

There are clear, beneficial links between ICT and other VTT strategic areas; these could be further strengthened. VTT needs to consider which ICT focus areas to adopt in the 'post-Nokia' world.

Key recommendations

The emphasis in ICT – both in Finland and globally – is moving away from mobile communications devices and technologies towards ICT as a productivity enabler for health, energy, smart machines and built infrastructure applications. Identifying niches in which VTT can have a major impact is important. However, in some cases VTT should also address the wider challenges, i.e. those of mainstream research.

Partnering and co-operation with organizations having complementary competences is advisable, such as co-operation between VTT and CSIRO.

Society is reliant on ICT in many areas. Ensuring the dependability and security of ICT infrastructure is therefore critical.

3.4 Resource efficiency and clean technologies

Description of the thematic area

Resource efficiency is based essentially on the principle of 'doing more with less' (fewer resources, less pollution, fewer negative societal impacts), and is related to strategies of dematerialization and eco-efficiency. VTT's five areas of major contribution in promoting resource efficiency in industry are: i) distributed manufacturing – eco-efficiency over networks, ii) simulation-based engineering – real and virtual in parallel, iii) human – the most adaptable component of complex systems, iv) eco-efficient machines through environment-aware engineering, and v) eco-innovations – boosting new business opportunities. The three areas of major contribution to environmental innovation are: i) water (e.g. monitoring, new materials for water purification), ii) material resources (e.g. zero waste and waste refining concepts, recovery of scarce minerals from waste and wastewater), and iii) emission mitigation (e.g. clean processes, zero-emission transport).

Observations

VTT's vision for the resource-efficient industry research area is focused strongly on manufacturing industry and governed by sustainability as its driving force. Overall, the SAB considers the thematic research area to be fragmented and in need of further focus. Eco-design approaches, from individual components to whole systems, are executed in this research field. The SAB considers that material research and VTT's expertise in that area should be more strongly integrated with manufacturing. The eco-design concept includes multi-scale modelling, which covers, processes, material structures, properties and performance (such as wear

and corrosion resistance). Here, the availability of different modelling tools is considered a key asset.

VTT's competence in the field of simulation is acknowledged along with its great success in applying this expertise in a wide range of applications. Simulation work is carried out in close co-operation with customers as an integral part of the customer project. This deep customer focus in simulation work is valued, as it supports VTT's mission as a promoter for Finnish industry. However, its role in strategic research was questioned. Furthermore, besides raw material optimization, sustainability values were considered not to be taken sufficiently into consideration in simulation projects.

Business models are open to numerous drivers of change: changes in resources, population structures, environmental aspects, etc. Servitization has also emerged as a new business model. The possibilities of ICT within servitization processes were strongly emphasized by the SAB. In the business development research area VTT works closely with companies to develop tailored business solutions. This model naturally places certain limits on opportunities for publication of this work. The SAB considers the use of foresight research and foresight methodology to be useful in developing new business models. VTT has unique tools (foresight, modelling, simulation etc.) at its disposal which, particularly in the case of foresight methodology, could be exploited also outside VTT. The SAB considers VTT's modelling and foresight competencies to be of especially high quality.

The green water solutions competency area covers energy and resource-efficient membrane technologies and water monitoring. The SAB identified the green solutions for water technologies competency area as being of high quality. In particular, the spearhead programme with its clear strategic goals, expected achievements and impacts, is well structured and facilitates further strengthening of this area of core competency.

The green mining concept deals with efficient recovery of valuables from low grade sources, safe disposal of mining residues and optimal water management. The SAB recognises mining as an important industrial sector for Finland and that VTT has great potential to be a frontrunner in the field. However, this requires VTT to make bolder efforts to make its competence more widely known. The handbook of mine closure published by VTT could pave the way for greater publicity of VTT's competence. There is also urgent demand for a comprehensive handbook of sustainable mining, in particular, to serve as a guideline in decision making by authorities and legislators.

'Urban mining' refers to metal production from municipal and industrial waste. The SAB once again emphasizes sustainability as the key issue also in waste handling, and raises concerns regarding the use of chemicals in certain waste handling processes. Since bio-based methods could reduce chemical consumption, the SAB urges VTT to take the initiative to start working on these new solutions, utilizing its leading expertise in biotechnology.

Regarding eco-city design, the combination of technologies and services optimally to provide high quality of life and indoor and outdoor comfort are the prereq-

uisites for an eco-city concept. Here, VTT's framework tool for decision making in eco-city design is considered a valuable asset for VTT.

Key recommendations

Due to the country's considerable natural resources, mining is expected to offer great opportunities for Finland in the future. Finland, as with other Nordic countries, is attractive to mining investors for several reasons, such as political stability and developed infrastructure. VTT has great potential to be a frontrunner in the field of sustainable mining. VTT is recommended to take bolder efforts to make its competence widely known and to join forces with other actors.

Efficient use of natural resources and energy are the key driving forces throughout the value chain, from raw materials to final products, recycling and disposal. By combining VTT's broad expertise in different material types, including bio-based materials, unique opportunities for new materials development would be created.

4. Executive summary

VTT is advised to identify technology areas in which VTT can find a niche and establish and strengthen its global leadership. Systematic assessments must be carried out to identify which VTT competencies are world-class and which need development. The SAB considers bioeconomy to be a key potential focus area for VTT, and further recommends that VTT strives for global leadership in core strength areas, such as biotechnology.

In its research activities, VTT is advised to focus on aspects specific to Finnish conditions (e.g., arctic conditions, short growing season, ore deposits, population structure, forest resources) and to achieve global high-end competence in these specialized areas, such as wood biomass production and use or cold climate wind energy.

It is recommended to formulate success metrics that clearly indicate the outcomes and impacts of VTT's RTD for end users. Use of value chain roadmaps is recommended.

Sustainability should underpin all areas of research, and social sustainability should also be taken into account. Either combining forces with other players in the field of social sustainability or establishing VTT's own competence area around these issues is recommended.

Scientific and academic results are the measure of a research organization's credibility, and VTT is advised to strive for high-quality publications. It is recommended to establish publication strategies in different research areas. VTT must communicate more boldly about its achievements and the impact it makes through and with its clients and partners.

VTT has strong enthusiasm for internationalization. It is recommended that VTT focuses on a few competence areas and establishes firm strategic partnerships in those. Co-operation with international and domestic organizations having complementary competences is advisable. In addition, hiring and establishing partnerships with esteemed professors is beneficial by creating successful research and inspiring research environments.

Unique opportunities for new materials development would be created by combining VTT's extensive materials expertise, including bio-based materials. New materials development is recommended to be included as a core competency.

Through science and applied research, VTT has created the basis and competence to provide expert services for companies and authorities. Through these services, clients are able to rise to the challenges of the future and improve their operations and competitiveness. VTT thus has three main areas of operation, each interconnected and mutually supportive: science, applied research, and service.

Appendix A: Meetings and topics

1. May, 3rd and 4th, 2011, Espoo
    - Bioeconomy

2. November, 14th–16th, 2011, Espoo and Jyväskylä
    - Low carbon
    - Smart energy

3. May, 14th–16th, 2012, Espoo and Oulu
    - ICT
    - Electronics

4. November, 26th–28th, 2012, Espoo
    - Resource-efficient industry
    - Clean technologies

Appendix B: Scientific Advisory Board members 2011–2012

The members of the Scientific Advisory Board nominated by the VTT Board for the two-year period 2011–2012 were the following:

SAB Facilitator, Hannu Vornamo, Finland
Dr. Andreas Hafner, BASF Schweiz AG, Switzerland
Prof. Riitta Keiski, University of Oulu, Finland
Dr. Jørgen Kjems, Kjems R&D Consult, Denmark
Prof. Outi Krause, Aalto University, Finland
Dr. Colja Laane, Netherlands Genomics Initiative (NGI), The Netherlands
Dr. Ian Oppermann, CSIRO, Australia
Dr. S. Shyam Sunder, National Institute of Standards and Technology (NIST), United States
Prof. Marco Taisch, Politecnico di Milano, Italy

Brief curricula vitae of the SAB members are presented below.

VTT Scientific Advisory Board Final Report 2011–2012

VTT Technical Research Centre of Finland appointed its third Scientific Advisory Board (SAB) for the period 2011–2012. The SAB held four thematic meetings during the period. The meeting themes were based on the VTT Research and Innovation Vision 2020. The final report describes the SAB's key findings regarding VTT´s research and scientific activities and competences within the selected thematic areas as well as its recommendations and proposals for the future.

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VTT TECHNOLOGY 108

VTT Scientific Advisory Board. Final Report 2011–2012

Chairman of the Scientific Advisory Board:

Hannu Vornamo

Secretary General of Helsinki Chemicals Forum, Finland

- 1970–1983, various positions in the Finnish government.
- 1984–1985, Confederation of Finnish Industries.
- 1985–1992, Kemira Oy, Vice President (Head of Group Environment and Safety Department) and Assistant Director, responsible for the supervision of environmental protection policies, coordination of permit procedures, special advisory duties and issues related to control of chemicals. Since 1985 Vornamo has also served as Manager of Environmental Control, outlining the environmental protection of the company and coordinating permit procedures.
- 1994–2009, Director General of the Chemical Industry Federation of Finland (retired 2009); Deputy Director General since 1993.
- Other positions include several Board memberships and chairmanships in many Finnish and European companies and organizations, for instance in Cefic (European Chemical Industry Council). Vornamo has served in numerous governmental committees and working groups as a member or as a chair and has hold many honorary offices.
- Since 2011, Chairman of the VTT Scientific Advisory Board.

Other SAB members:

Andreas Hafner

Senior R&D Manager for Science and Innovation at BASF Schweiz AG

- PhD in Chemistry from the University of Zurich, Switzerland in 1986, followed by two years at Colorado State University (US).
- 1988–1992, Researcher at Central Research Laboratories Ciba-Geigy AG (Switzerland).
- 1992–1997, Team leader, Materials Research Ciba AG (Marly Switzerland). Area: Catalysis for novel polymer applications and organic functional materials for Optical Storage Medias. The developed CD-R system was for years the gold standard in the industry.
- 1994, Werner Price winner of the Swiss Chem. Society.
- 1997–1998, Team Leader, Additives Research Ciba Specialty Chemicals (Basel).
- 1999–2002, Technical director, internal start-up Ciba SC. Area: Solid-state engineering & catalytic processes for pharmaceutical ingredients.
- 2003–2008, Department Head Group Research Ciba SC. Area: printed organic electronic and opto-electronic.
- 2008–2009, Head Bio-Science Ciba SC.
- Since 2009, Senior R&D Manager for Science and Innovation at BASF Schweiz AG.
- Since 2011, Member of the VTT Scientific Advisory Board.
- Since 2012, Member of the Industrial Advisory Board EMPA.
- Since 2013, Member of the Industrial Advisory Board CSEM.

Riitta Keiski

Professor of Mass and Heat Transfer at the University of Oulu, Department of Process and Environmental Engineering, Finland
Docent in Chemical Process Engineering

- M.Sc.(Eng.) degree from the University of Oulu, 1981, and Lic.Sc.(Tech.) and D.Sc.(Tech.) degrees from the same university in 1984 and 1991.
- 1981–1982, researcher at Kemira Oy, and 1993–1994 at Kemira Metalkat Oy.
- 1984–1997 and 2010–2011, several research positions at the Academy of Finland.
- 1989–2000, University of Oulu, Assistant Professor and two Acting Professor positions. In 2006, Keiski served as Head of Department and in 2006–2009 as Vice Rector of the university.
- Keiski's research interests include mass and heat transfer, fluid dynamics, separation processes, downstream processes in bioprocess engineering, catalytic processes and environmental catalysis, kinetics and reactor design, environmental technology and waste and exhaust gas purification technologies.
- Since 2001, Professor of Mass and Heat Transfer in the Department of Process and Environmental Engineering at the University of Oulu, Finland. She is also a docent in Chemical Process Engineering, especially in Heterogeneous Catalysis and Environmental Technology.
- Since 2011, Member of the VTT Scientific Advisory Board.

Jørgen K. Kjems

Director and Owner of Kjems R&D Consult

- PhD in solid state physics, 1970, Technical University of Lyngby, Denmark.
- Kjems is trained as a condensed matter physicist and has had a distinguished career at Risø National Laboratory in Denmark, where he joined the laboratory management as Scientific Director in 1988.
- 1997, Managing Director of the Risø laboratory. Risø National Laboratory merged with the Technical University of Denmark (DTU) and four other government research institutes in 2007. Kjems served as a member of the management team at DTU until the end of 2008 with responsibility for energy programmes and international affairs.
- 2009, Kjems formed Kjems R&D Consult as owner and Director, and acts as a senior advisor to universities, ministries and international organizations.
- Since 2011, Member of the VTT Scientific Advisory Board.

Outi Krause

Dean of the School of Chemical Technology at Aalto University, Espoo, Finland

- M.Sc.(Eng.) degree from Helsinki University of Technology (TKK), 1972, Dr.(Tech) degree from Eindhoven University of Technology, the Netherlands, 1979.
- 1972–1975, Senior Assistant in Industrial Chemistry at Helsinki University of Technology.
- 1975–1979, researcher at Eindhoven University of Technology.
- 1987, became a docent in Chemical Technology at Helsinki University of Technology.
- 1979–1993, several research and management positions at Neste Oy, mostly in catalysis research.
- 1993, became a professor in Industrial Chemistry at Helsinki University of Technology.
- 2005–2009, Vice Rector of Helsinki University of Technology.
- 2008–2009, member of the transformation team at Aalto University.
- 2010, Vice Dean of the School of Science and Technology, Aalto University; 2011, Dean of the School of Chemical Technology, Aalto University.
- Since 2011, Member of the VTT Scientific Advisory Board.

Colja Laane

Director of NGI (Netherlands Genomics Initiative)

- Graduated in biochemistry from the University of Groningen; PhD at Wageningen University, the Netherlands, on the bioenergetics of nitrogen fixation.
- 1986, Laane joined Unilever Research Vlaardingen to set up a new section on bioorganic chemistry.
- 1990–1995, Director of Biosciences at Quest International, Naarden, the Netherlands.
- 1995, returned to Wageningen University as a full professor in Biochemistry. Main subjects of interest were molecular enzymology of flavin- and metal-containing enzymes, and microspectroscopy in living cells.
- 2000, joined DSM as Science Director and corporate scientist in white biotechnology.
- Since 2008, Director of NGI (Netherlands Genomics Initiative). NGI is a consortia of 16 public-private partnerships in the area of genomics.
- Serves as a member or chairman of several (inter)national committees involved in Industrial Biotechnology and Life Sciences.
- Since 2011, Member of the VTT Scientific Advisory Board.

Ian Oppermann

Director of CSIRO Digital Productivity and Services Flagship, Australia

- PhD in electrical engineering in mobile communications, University of Sydney, 1996; MBA in international business management, University of London, UK, 2005.
- An internationally respected expert in mobile communications, Dr. Oppermann's research interests include wideband channel modelling, code division multiple access (CDMA) receiver structures for high data rate/low mobility environments, and complex valued spreading sequences for CDMA systems.
- Chairman of the Executive Committee of the IEEE International Conference on Ultra Wideband.
- Served as Global Head of Sales Partnering for Nokia Siemens Networks' software business unit.
- Also served as Director of the Centre for Wireless Communications at the University of Oulu, Finland.
- Since 2011, Member of the VTT Scientific Advisory Board

S. Shyam Sunder

Director, Engineering Laboratory, National Institute of Standards and Technology (NIST), United States

- Undergraduate degree from the Indian Institute of Technology, Delhi, and Master's and Doctor of Science degrees from Massachusetts Institute of Technology (MIT).
- Until 1994 served at the faculty of the Massachusetts Institute of Technology (MIT) for 13 years.
- Former positions at NIST include: Manager of the High-Performance Construction Materials and Systems Program (1994-1996), Analyst and Senior Program Analyst in the Office of the NIST Director (1996-1997), Chief of the Structures Division and of the Materials and Construction Research Division (1998-2005), Acting Deputy Director and then Director of the Building and Fire Research Laboratory (2004-2007), and Acting Director and then Director of the Building and Fire Research Laboratory (2006-2010).
- Other positions: Led the federal building and fire safety investigation of the World Trade Center Disaster in the aftermath of the terrorist attacks of September 11, 2001, member of the Board of Directors of ASTM International (2010-2013), and Vice President (2010-2013) and incoming President (2013-2016) of the Board of the International Council for Research and Innovation in Building and Construction (CIB).
- Since 2011, Member of the VTT Scientific Advisory Board.

Marco Taisch

Professor of Operations and Supply Chain Management and Advanced Manufacturing Systems at Politecnico di Milano, Department of Management, Economics and Industrial Engineering

- Served as Director of the Executive MBA and Director of the International MBA programme at MIP, the business school of Politecnico di Milano.
- Chairman of the IFIP Working Group on Advances in Production Management, member of IFAC, member of IEEE, and senior member of IIE.
- His area of expertise is in the fields of Sustainable, Energy Efficient Manufacturing, and ICT for Manufacturing.
- Serves as Coordinator of the IMS2020 project, an EC funded initiative to support the development of roadmaps for the future of manufacturing at the global level. The project involves partners from Europe, USA, Korea and Japan and more than 80 companies worldwide.
- Since 2011, Member of the VTT Scientific Advisory Board.

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Tekijä(t)	Hannu Vornamo, Andreas Hafner, Riitta Keiski, Jørgen Kjems, Outi Krause, Colja Laane, Ian Oppermann, S. Shyam Sunder & Marco Taisch
Tiivistelmä	Teknologian tutkimuskeskus VTT asetti kolmannen tieteellisen neuvottelukuntansa (Scientific Advisory Board) kaudeksi 2011–2012. Neuvottelukunta piti kautenaan neljä eri tutkimus-kokonaisuuksiin liittyvää kokousta. Kokousten aiheiden lähtökohtana oli VTT:n tutkimus- ja innovaatiovisio 2020 (VTT Research and Innovation Vision 2020). Loppuraportissa on kuvattu VTT:n tutkimusta ja tieteellistä toimintaa koskevat päähuomiot sekä valittujen aihealueiden osaamistaso. Lisäksi raportissa on annettu suosituksia ja ehdotuksia tulevai-suutta ajatellen.
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