IRIS – Final Report

Research Initiative on Sustainable Industry and Society

2019/20–2023

Content

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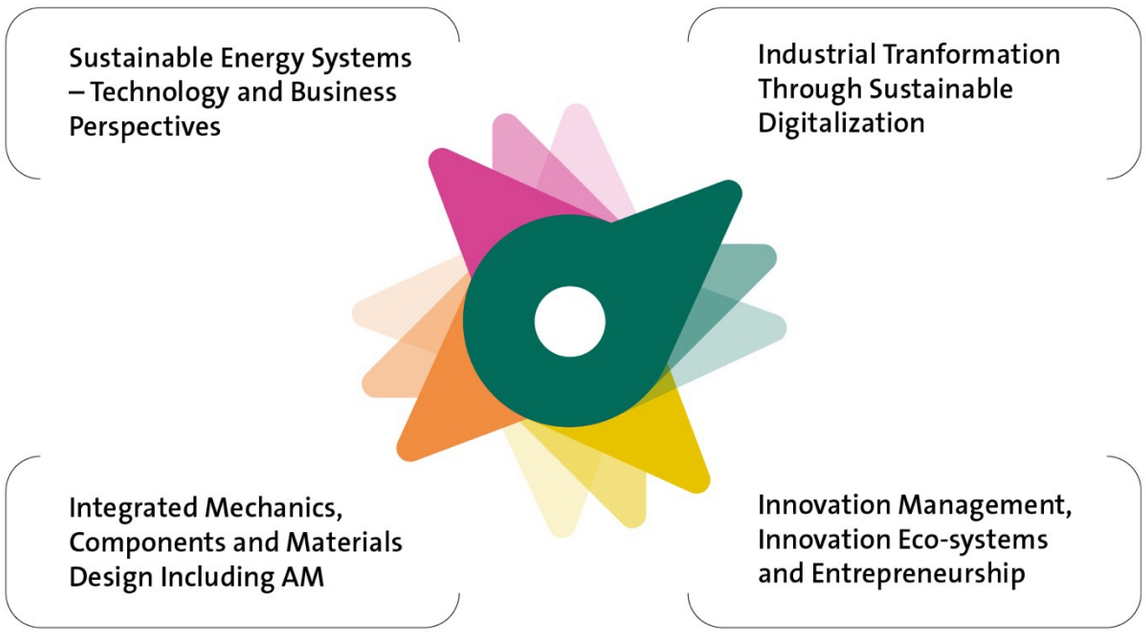
Executive summary



The IRIS project

The IRIS project at the ITM school was a strategic initiative with the purpose of promoting interdisciplinary collaboration and contribute to sustainable transformation through advanced research, education and innovation within four research areas:

1. industrial transformation through sustainable digitalization
2. integrated mechanics, components and materials design including additive manufacturing
3. sustainable energy systems, technology and business perspectives
4. innovation management, eco-systems and entrepreneurship.

The goal of the project was to increase the amount of inter-disciplinary research at the ITM-school, which would enable broader and deeper knowledge creation, use and dissemination of research, as well as increasing competences, capacity and infrastructure. This in turn would further improve conditions for inter-disciplinary research and increased long-term impact.

The overall result of the IRIS project is closer collaboration between departments at the ITM school in terms of both research and teaching, as well as a firmer basis for collaboration with industry and society within its research areas. The project has led to substantial amounts of new external funding, and has made possible important investments in infrastructure, which in turn continues to create opportunities for external collaborations.

71 researchers participated, developing new courses at all levels, publishing in excess of 155 journal articles, participating in conferences, engaging in broad societal outreach (including workshops, seminars, conference presentations and various events such as book releases and panel discussions), and strengthening collaboration within ITM as well as with industry (see appendix A – D, under the headings Participants, Publications, Teaching, and Outreach and collaborations respectively).

The project resulted in more than 120 research applications of which, at the time of publication of this report, 48 were successful, resulting in new funding for ITM in excess of 168,6 million SEK. This can be compared to the total cost of IRIS which was just over 75 million SEK. (For more information on successful research applications and external grants, see appendices A – D and F, under the heading Research applications. For more information on IRIS expenditure, see appendix F.)

Martin Edin Grimheden
Head of department of Engineering Design, MMK

"IRIS made possible some important investments in infrastructure, and we are now world leaders in some areas – this in turn will create opportunities for more external financing. We have also seen several individuals that has had opportunities to develop their fields, build networks and advance their careers, which is also an important outcome."

Björn Laumert
Head of department of Energy Technology, EGI

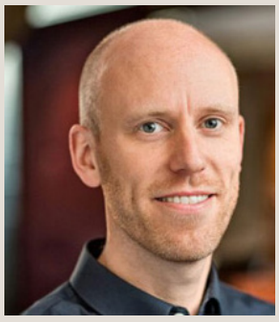
"For ITM as a whole and for EGI, IRIS opened up areas of collaboration that we were previously not aware of. We started to get to know each other which in turn led to exciting new research, great collaboration between departments and substantial amounts of new external funding."

Joakim Odqvist
Head of department of Materials Science and Engineering, MSE

"IRIS have meant closer collaborations between our department and others in terms of both education and research. In the area of additive manufacturing, we have created new courses and applied for financing together with IPU. New infra structure has meant new external collaborations, and more opportunities for external grants."

Cali Nuur
Head of department of Industrial Economics and Management, INDEK

"For ITM as a whole the greatest thing was that we got to know each other. You get to know colleagues that do the same thing as you but from a different perspective. You can never underestimate the power of meeting new colleagues and getting to know people. For Indek's part, we found new partners to collaborate with, which has given rise to some exceptional research, e.g. in the area of energy transformation. IRIS also provided the foundation for a new master's programme."



Magnus Wiktorsson
Head of department for Production Engineering, IPU

"IRIS contributed to the cohesion of ITM. We have good consensus and work well together, and IRIS was a contributing factor in this. For IPU, IRIS meant closer collaboration both internally and between departments, e.g. regarding additive manufacturing.

Introduction

The IRIS project at the ITM school was a strategic initiative with funding for the period 2019/2020 – 2023. The purpose of this interdisciplinary project was to contribute to sustainable transformation through advanced research, education and innovation within four key areas:

1. industrial transformation through sustainable digitalization
2. integrated mechanics, components, and materials design including additive manufacturing
3. sustainable energy systems, technology and business perspectives
4. innovation management, eco-systems and entrepreneurship.

This report presents the activities, achievements and impact of the project.

Background

KTH conducts Research Assessment Exercises (RAE) as a quality assurance measure. The 2012 RAE identified that the ITM school had research strengths in multiple areas relating to sustainable industrial transformation, including design of new materials, products/services, business models, manufacturing techniques and processes, energy systems and competence development. The RAE also identified the potential for researchers working within these individual areas to collaborate more and to enhance the scope for the ITM school achieving its ambition of leading the transition to a more sustainable industry.

In 2019, Jan Wikander, former head of the ITM-school, initiated a multidisciplinary project with cross-departmental research areas to contribute to a "sustainable industry and sustainable society", the Research Initiative on Sustainable Industry and Society (IRIS).

The ITM school decided to execute the IRIS project based on "Satsning med myndighetskapital 2020-2023" (V-2019-0942) during 2019/2020–2023, and the president of KTH set aside 42 million SEK of the agency capital at KTH level supporting the IRIS initiative. The president also authorized the head of school at ITM to dispose of the public authority capital at the school for the initiative. In total, the IRIS project budget was 75,3 MSEK, with 42 MSEK coming from the KTH agency capital, and 32 MSEK from the ITM school.

Purpose and objectives/goals

The purpose of the initiative was to enable inter-disciplinary research, educational activities and infrastructure investments, in order to:

- initiate interdisciplinary research activities
- build and maintain new research activities and collaboration on new areas (that had not been researched before) within and between ITM:s departments
- enhance external ITM/KTH visibility and recognition of IRIS research (joint projects etc)
- contribute to improvement of KTH's and ITM's rankings.

The goal was:
- increased inter-disciplinary research results
- broader and deeper knowledge creation, use and dissemination
- further improvements in competences, capacity and infrastructure
- further improvements in conditions for inter-disciplinary research projects
- increased long-term impact.

IRIS project phases

IRIS consisted of four interdisciplinary research areas, each focused on strategic fields from the viewpoints of research, education and impact. The project was executed from 2020 to 2023.

During the entire execution of IRIS, the Head of the ITM-school was the project owner. Four different project managers were involved. During the first phase, focused on planning and resource allocation, Martin Törngren was the project leader coordinating and facilitating the initiation of IRIS. Between 2020-2022 Denise McClusky took over the project management, focusing on organizational structure, decision processes, and establishing an IRIS community especially for the post-docs. The project manager during this period also facilitated a mid-term workshop where participants from all areas gathered and helped each area formulate their research roadmap. In 2022 until the project was finished in 2023 Anna Jerbrant (PM) and Martin Grimheden (vPM) took over as project manager and deputy project manager.

Highlights of results

IRIS had 71 participants in four research areas, and the project resulted in, among other things, more than 155 published journal articles, 43 articles presented at conferences, 88 societal outreach activities, including workshops, seminars, conference presentations and various events, such as book releases and panel discussions.

In terms of academic leadership, the IRIS project successfully engaged professors, associate professors, assistant professors and postdocs from six departments in the ITM School in research, and results from IRIS have been integrated in PhD courses, master courses, as well as in basic education (see further, Appendices A – D, “Teaching”). In addition, the project has been actively engaged with a number of societal, industrial and academic organizations, networks and societies on the topics covered by the four research areas (see further, Appendices A – D, “Outreach and collaborations”).

The project resulted in more than 120 research applications of which, at the time of publication of this report, 48 were successful, resulting in funding in excess of 168,6 million SEK. This can be compared to the total cost of IRIS which totaled just over 75 million SEK. (For more information on successful research applications and external grants, see under the heading “Research applications” in the appendix for each research area, i.e. appendices A – D. For more information on IRIS expenditure, see appendix F.)

Future impact

IRIS has contributed to closer collaboration between departments at the ITM school in terms of research as well as teaching, and provided a basis for collaboration with industry and society within its research areas. It has led to substantial amounts of new external funding, and has made possible important investments in infrastructure, which in turn continues to create opportunities for external collaborations.

The work of **IRIS Area 1**, Industrial transformation through sustainable digitalization, has been aimed at significantly enhancing the efficiency and sustainability of industrial operations by integrating advanced digital technologies. This integration not only promises to reduce the environmental footprint of production and logistics systems but also facilitates the development of novel value co-creation models and product-service systems that are pivotal for a circular economy. These advancements are expected to drive the global competitiveness of industries while ensuring environmental, economic, and societal sustainability.

As a result of the work of **IRIS Area 2**, Integrated mechanics, components and materials design, a number of research projects are under way, involving collaboration between different departments at KTH as well as with external partners and research centers.

IRIS Area 3, Sustainable energy systems – technology and business perspectives, has made a significant contribution to industry and society within its research fields. One example is its contribution to the development of a strong industrial, academic and research collaborative framework within the new competence center Dig-IT Lab on digitalization in the construction industry.

The research and initiatives within **IRIS Area 4**, Innovation management, eco-systems and entrepreneurship, will significantly impact the future by driving sustainable industrial and societal transformations. By established new bridges between MMK, INDEK and LES, cross-departmental research has been created that also enabled new initiatives that are currently ongoing and developing. Research results that provides information about the relationships between innovation and sustainability targets are of high importance for industrial and societal transformation.

Structure of the report

This report presents the activities and achievements of IRIS. It is structured as follows: each research area is presented in a separate chapter, describing the mission of each area, its activities and achievements as well as future impact. Detailed lists of participants, publications, research applications, teaching and collaborations are found in the appendix section, one for each area. Also in the appendix section there is an overview of the IRIS project organization, as well as the financial outcomes (appendix E and F respectively).

IRIS area 1: Industrial Transformation through Sustainable Digitalization

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Introduction

Digitalization is fundamentally reshaping the manufacturing landscape, offering broad advancements in operational efficiency and productivity across the sector. This digital transformation leverages technologies such as AI, automation, and advanced data analytics to streamline processes and enhance decision-making capabilities. As manufacturers adopt these innovations, they see tangible improvements not only in production but also in areas like environmental sustainability through reduced waste and emissions, and in agility, enabling quicker response to market changes and customer demands.

Overall, this transformation presents a clear path for manufacturing firms to modernize operations and achieve significant competitive advantages. This shift is not merely about technology implementation but about transforming business models to be more responsive and resilient in a rapidly changing global market.

The mission of IRIS Area 1

Although most agree that digitalization and sustainability will change management, business and society, sustainable technologies (as most novel technologies) are usually commercially inferior at their introduction on the market. Technology innovation is usually not enough to survive the “valley of death” between technological invention and market competitiveness: sustainable technologies must be combined with appropriate business and collaboration models if they should lead to novel, circular approaches to industrial operations.

The IRIS initiative on industrial transformation through sustainable digitalization was positioned at the research forefront of this new domain and focused on the following sub-areas that are at the intersection of the two main trends:

- Technologies related to the broad areas of internet of things, cloud computing, and machine learning, have the potential to enable more resource efficient production and logistics systems.
- Techniques for visualization, 3D-printing, and digital twins enable new product designs and challenge the logics of the traditional product development process.
- Technologies for connectivity, remote analytics and upgradeability enable increasing functional sales, where sales of physical products are replaced with provision of functional services.
- Sensor technologies in combination with big data analytics enable optimization of systems and better understanding of stakeholders´ behaviors.

The digital shift raises a number of issues concerning cyber security, ethics, and personal integrity. However, applied in the right way, digitalization enables a shift towards a more sustainable society and industry, from clean technologies and greening of production processes and materials (environmental sustainability) to healthier workplaces and more human centered products (social sustainability), as well as high-performing organizations which are competitive in the long run (economic sustainability). In addition, there is a need for understanding how the corresponding shift may reshape the market conditions in which organizations operate.

Consequently, IRIS Area 1 has addressed issues and processes of industrial transformation, which are trigged (and/or enabled) by technological shifts and sustainable challenges. The focus has not been on the novel digital technologies per se, but on their potentials when applied in products, industrial operations, and businesses.

Activities, achievements and impact

IRIS Area 1, therefore, embarked on an exploratory journey at the confluence of digitalization and sustainability, focusing on three pivotal areas of investigation that promise to reshape industrial paradigms:

- Application of digital technologies in industrial contexts: Firstly, IRIS Area 1 delved into the application of digital technologies within industrial contexts, scrutinizing how tools such as the Internet of Things, cloud computing, and machine learning can revolutionize production and logistics systems, thereby enhancing efficiency and reducing the environmental footprint.
- The impact of digital technologies on incumbent businesses and emerging industries. Secondly, it investigated the profound impact of these digital technologies on incumbent businesses and emerging industries, evaluating how digital transformation facilitates the creation of novel value co-creation models and challenges traditional product development processes.
- Industrial processes enabling transition towards circular and sharing economies. Lastly, IRIS Area 1 aimed to unravel industrial processes that enabled transitions towards circular and sharing economies. By fostering interoperability and developing suitable architectures and methodologies, this research has endeavored to support the shift from linear to circular economic models, thereby ensuring global industrial competitiveness alongside environmental, economic, and societal sustainability.

The result of this journey so far is 52 published articles (see appendix A), ranging from a business model perspective on ecosystem bottlenecks to manufacturing strategies impact on the goals of a firm; from multi-method simulation modelling of circular manufacturing systems to consumer perceptions of the circular business models; from frameworks for manufacturing system reconfiguration and optimisation to industrial internet of things-based digital servitization in smart production logistics; from the exploration of the socio-technical implications of machine learning in biopharmaceutical manufacturing to blended learning in the engineering field and virtual reality training of manufacturing operators. IRIS Area 1 has also produced two theses, one on the performance evaluation of machine tools and one on grease lubrication of bearings for e-motors.

Apart from this research, the area has created research applications, of which at the time of writing a total of 97,8 MSEK has been granted, of which 23 MSEK in funding to ITM (see appendix A and E).

16 courses have been fully or partially developed, improved or offered by IRIS Area 1 staff, and the IRIS Area 1 initiative has made significant strides in societal outreach through a variety of focused activities and events aimed at fostering sustainable industrial transformation via digitalization (see appendix A). One of the notable efforts includes organizing and participating in workshops, conferences, and seminars that bring together academia, industry professionals, and stakeholders to discuss and promote sustainable practices. For instance, the initiative has hosted multiple workshops such as the Business Model Lab Workshops on topics like truck charging and autonomous transportation in Stockholm, which were aimed at generating new business ideas and project collaborations. These workshops not only disseminate research findings but also actively engage industry partners in practical discussions, thereby enhancing the application of sustainable digital technologies in real-world scenarios.

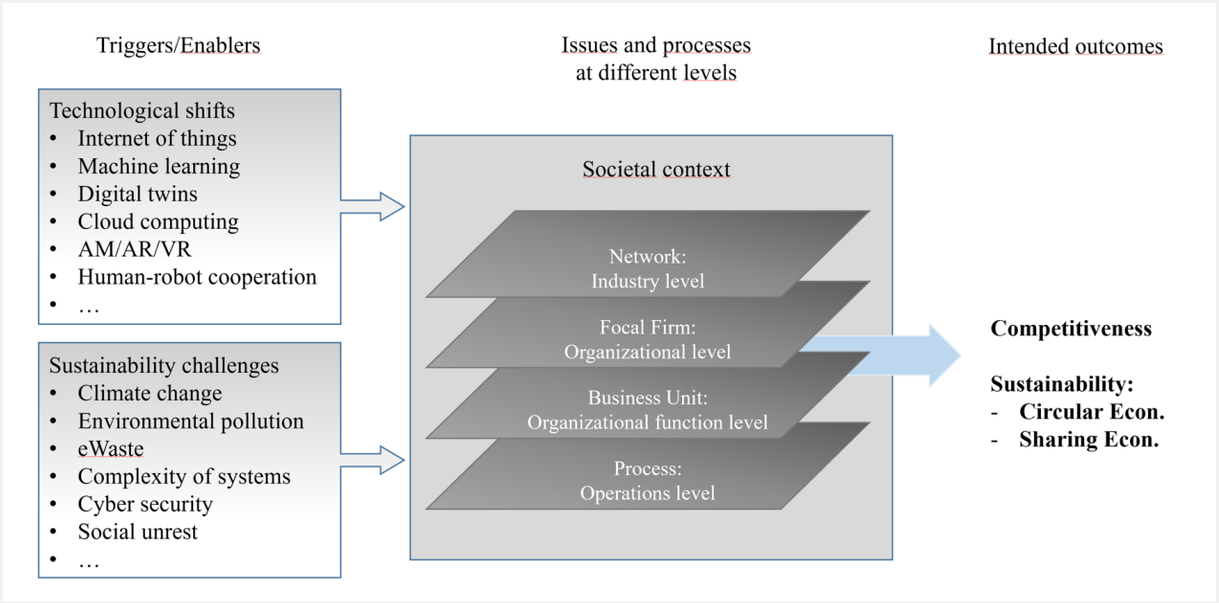

Figure 1. The scope of IRIS Area 1

Moreover, the IRIS Area 1 initiative has participated in international conferences and seminars to broaden its outreach and impact. Events such as the Academy of Management Meeting in Boston, where a paper on ecosystem bottlenecks was presented, and seminars at Chongqing University focusing on sustainable business models and manufacturing skills for sustainable development goals, illustrate the global reach of the initiative. Additionally, participation in local and international digital platforms like the EIT Digital Annual Conference and Södertälje Science Week underscores the initiative's commitment to fostering a dialogue on sustainable industrial practices across diverse audiences. These activities not only highlight the research advancements within IRIS Area 1 but also facilitate cross-cultural and cross-disciplinary collaborations, driving forward the agenda of sustainable industrial transformation.

Future impact

The mission of IRIS Area 1 was to initiate and strengthen research activities and infrastructure that enhance the capability to apply digital technologies, with the overall aim of decreasing the social, economic, and environmental footprints of industrial activities.

The future impact of IRIS Area 1, focusing on industrial transformation through sustainable digitalization, is poised to be profound and multifaceted. By integrating advanced digital technologies such as the Internet of Things, cloud computing, machine learning, and digital twins, IRIS Area 1 aims to significantly enhance the efficiency and sustainability of industrial operations. This integration not only promises to reduce the environmental footprint of production and logistics systems but also facilitates the development of novel value co-creation models and product-service systems that are pivotal for a circular economy. These advancements are expected to drive the global competitiveness of industries while ensuring environmental, economic, and societal sustainability. Notably, the IRIS Area 1 group has converged into the KTH initiative "Digital Future," which will further amplify its impact by continuing the cooperation within the group formed during the initiative, extending its reach through ongoing and future collaborative projects.

Moreover, IRIS Area 1's commitment to fostering interoperability and developing suitable architectures and methodologies will support the transition from linear to circular economic models. This shift is crucial for addressing the sustainability challenges posed by traditional industrial practices. The initiative's focus on predictive maintenance, anomaly handling, and the optimization of energy consumption through digital technologies will enhance the resilience and adaptability of industrial systems. Additionally, by addressing the ethical and cybersecurity concerns associated with digitalization, IRIS Area 1 will help create safer and more secure industrial environments. The continued research collaboration active in the three sub-areas—application of digital technologies in industrial contexts, impact on incumbent businesses and emerging industries, and enabling transition towards circular and sharing economies—will ensure that the transformative efforts initiated by IRIS Area 1 persist and evolve, setting new standards for sustainable industrial practices.

IRIS area 2: Integrated mechanics, components, materials design including additive manufacturing

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Introduction

The development of new technologies has traditionally been a linear process, in which the development of components, materials and manufacturing processes is largely disconnected from each other. However, the emergence of a new approach calls for a holistic view, where disciplines are integrated and the design of new technologies includes aspects related to materials, components and manufacturing processes from the start.

The mission of IRIS Area 2

Integrated, multi-scale modelling of materials and systems is a strongly growing field that combines methods from a wide range of scientific disciplines to design and develop new materials, components, processes and systems simultaneously. Advances in recent years in high-performance computation, new materials characterisation methods, and ICME (integrated computational materials engineering) have contributed to the field's growth and have driven significant progress in the area. However, the progress is limited by persistent technology and infrastructure challenges that need to be overcome to reach the full potential of integrated materials and system design throughout the whole supply chain. As described in NASA report Vision 2040, scientists and engineers are today designing materials and systems separately, rather than treating materials properties as variables in one integrated and concurrent design process . In addition, the stages of the product development life-cycle are segmented and is viewed as a linear process rather than an iterative process. A situation where the design of materials, components and system is intimately connected, enabling the simultaneous design and optimisation of materials, components, systems and manufacturing processes should be aimed for, so that factors such as manufacturability, physics behaviour, and sustainability aspects can be considered from the beginning of the design phase.

Additive manufacturing (AM) is a good example where the use of a more modern view of product development is crucial. Hence much of the research and education efforts of Area 2 are centred around AM. Interdisciplinary competence is developed by combining key expertise from the different departments at ITM. This is a necessary step to enable preparation of a future workforce with strong foundations in interdisciplinary fundamentals and system-level thinking as increasingly demanded by industry.

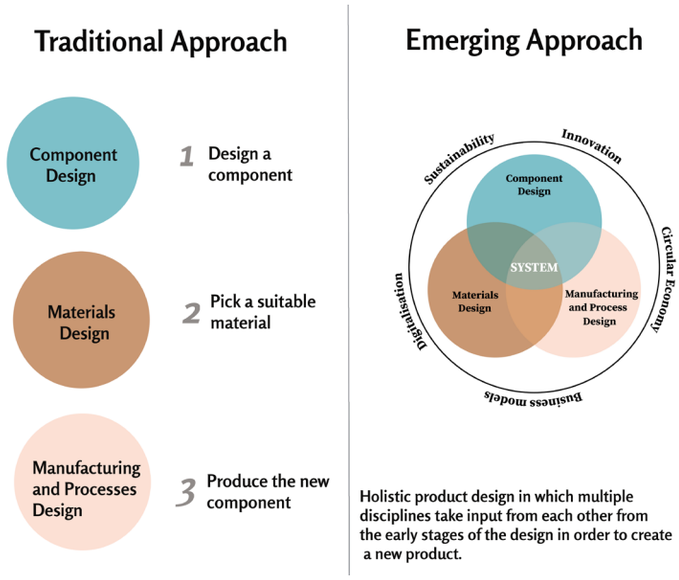

Figure 2: The IRIS Area 2 concept. Traditional and emerging approaches for product development

* X.L. liu, D. Furrer, J. Koster, J. Holmes; Vision 2040 - A road-map for integrated, multi-scale modelling and simulation of materials and systems, NASA, 2018.

Activities, achievements and impact

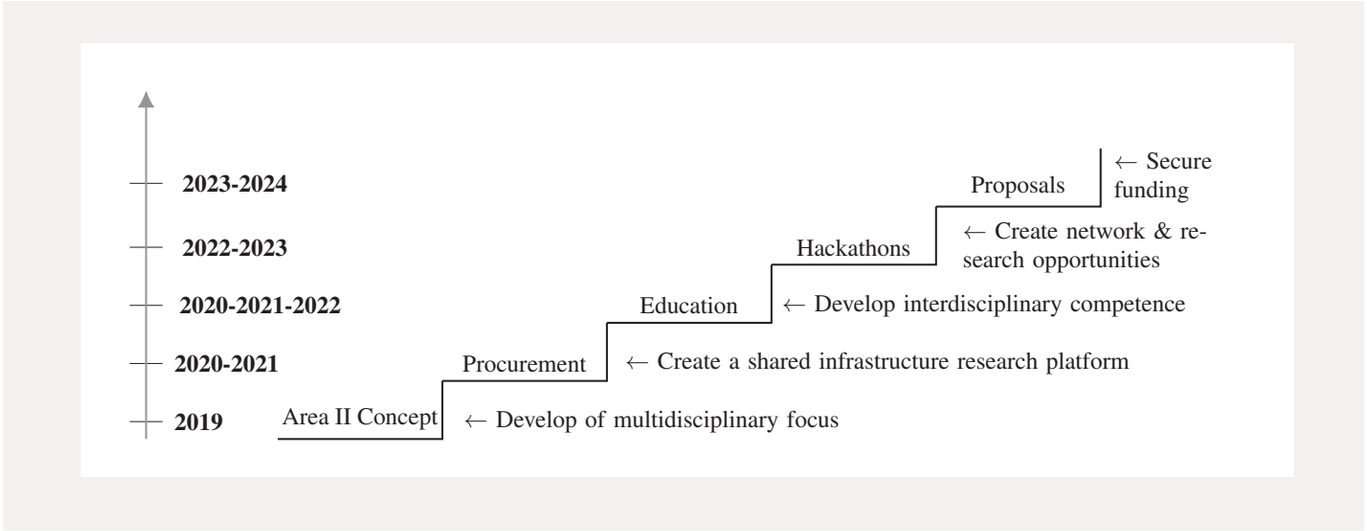

Figure 3: IRIS Area 2 Implementation (2019-2024).

IRIS Area 2 focused primarily on establishing shared ITM infrastructure and fostering research activities around it. During this period, Area 2 produced 30 scientific publications and submitted 24 collaborative applications involving various ITM departments and other schools. All in all, IRIS support enabled funding amounting to more than 269 MSEK, of which 73,3 MSEK in funding to ITM.

The development of IRIS Area 2 began with defining a multidisciplinary concept and laying the foundation for a shared ITM infrastructure research platform. The subsequent steps involved building interdisciplinary expertise and creating networking and research opportunities through hackathons. These hackathons featured participation from companies like Siemens Energy, VBN Components, SWERIM, and Sandvik. Lastly, we have focused on securing funding to support future research endeavours.Figure 3 illustrates the different stages in the implementation of area 2 (2019-2024). In the following we describe each step.

Area 2 concept

Area 2 worked on building a concept based on the development of technologies/products/systems with a multi-disciplinary focus. Workshops were organised to identify systems/technologies to be used as relevant examples of this concept and to build projects around them.

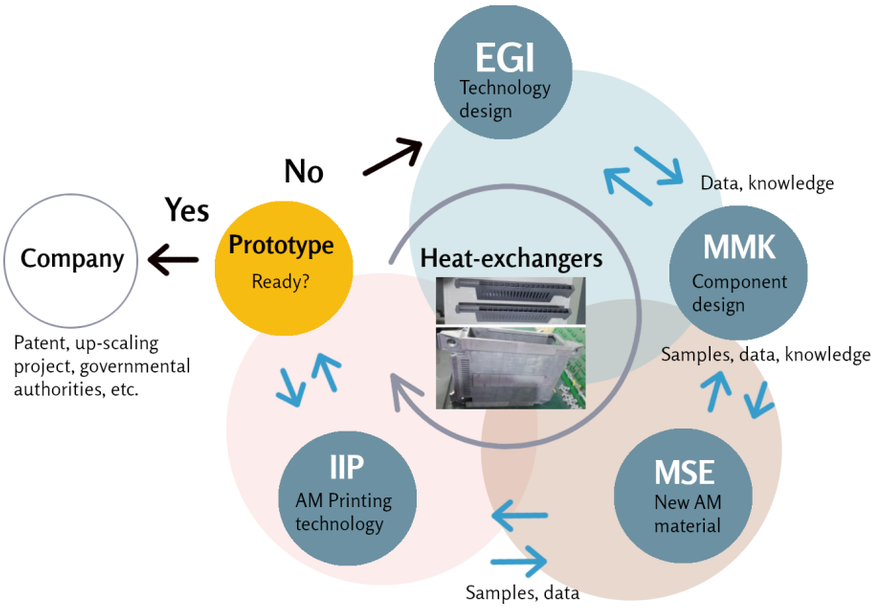

Figure 4: Design of heat-exchangers manufactured by AM

Heat-exchangers technology enabled by AM is an example of such project. Fig. 4 shows how the design of heat-exchangers manufactured by AM is envisioned by a multi- disciplinary team in Area 2 using the new infrastructure. EGI and MMK worked together to develop new geometries leading to faster heat transfer, and MSE and IIP worked together to develop copper electron beam powder bed fusion (PBF-EB).

Procurement: Several meetings with different parties i.e. reference group, researchers and head of departments were carried out to first compile a list of needed infrastructure at IIP, MSE and MMK. After the list was finished discussions followed to determine the priority each department wanted to place in these items. The general consensus was that the new infrastructure, PBF-EB, should be available for all the departments and that training should be possible for everyone with an interest in AM. Discussions continued to assess the possibility of buying

Freemelt ONE

- Experimental
- Installed 2021
- Shakedown printing only
- Open source, modular add-ons
- $100 \times 100 \times 100$ mm max. size
- Needs ≈ 5 kg powder
- Materials development
- Process development
- Large learning time
- Hosted at MSE

Arcam A2X

- Production-ready
- Installed 2016
- Successful prints
- Closed source
- $200 \times 200 \times 380$ mm
- Needs ≈ 40 kg powder
- Component development
- Process development
- Moderate learning time
- Hosted at IIP

Figure 5: Left: IRIS new infrasture, Freemelt ONE. Right: Complementary infrastructure, ARCAM A2X.

the second equipment in the list, unfortunately discussions did not prosper due to internal issues.

Education: Inter-disciplinary courses on AM were developed, which involved IIP, MSE, CBH and Engineering Mechanics, SCI. The aim was to create competence around AM to prepare a future workforce with strong foundations in inter-disciplinary fundamentals and system-level thinking as increasingly demanded by industry.

Hackathons: Companies have participated of these activities together with Area 2 researchers to create a strong network, which is also important to prepare future funding applications.

Proposals: All previous steps point to enable Area 2 to secure large funding to continue the activities initiated under IRIS. The creation of new knowledge, the development of new inter-disciplinary competences and the creation of a relevant network around the new infrastructure contribute to the consolidation of Area 2 and securing funding for research.

During the course of the project, we have developed a PhD-course in additive processes, materials and design for metallic components, and a master's course in additive manufacturing, and since the installation of the PBF-EB, two training sessions have been carried out. New infrastructure has been bought: the new PBF-EB printer is an open source printer, called Freemelt ONE (see figure above).

The Freemelt ONE is complementary to the existing equipment, ARCAM A2X installed at IIP. Projects have been organised so that both machines are used. The Freemelt gives the flexibility to design process and materials with optimised properties for a given application and to determine optimised process parameters that can be then be used in the ARCAM to print and optimise the final component.

Readiness level

Topic	Idea	In-progress	Proof of concept	Prototype
				Heat exchangers: Waste heat recovery (MSE/CBH)
Enhanced heat transfer enabled by AM			AM-Enhanced Heat exchangers (EGI/MSE/IPU)	
	3D-printed Cooling pipes (MSE/IPU/Boliden)			
Memory shape alloys by AM		Memory shape alloys development for AM (IPU/MMK/MSE)		
Mechatronics systems and soft robots enabled by 4D printing		KTH	Soft robots (MMK/IPU/MMD)	
		Tailored steels microstructures (MSE/MMD)		
PBF-EB competence development		Surface finishing for 3D printing (MSE/IPU/SWERIM/VBN Components)		
		Wear repair & resurfac-ing (MSE/IPU/Boliden)		

Table 1: Readiness level of projects in Area 2.

Future impact

A number of research projects are under way, in varying stages of readiness (see table 1), involving collaboration between different departments at KTH as well as with external partners and research centers. These projects are:

1. Enhanced heat transfer enabled by AM: Heat exchange design is limited by the manufacturing method. Nowadays, heat exchangers require excessive machining (up to 80-90 % waste of material). The question of whether additive manufacturing can enhance the performance of these devices and simultaneously help to reduce waste material is very important for sustainability issues and will be systematically explored. Within this topic, three sub-projects are under investigation: heat exchangers to recover waste heat, AM-enhanced heat transfer and 3D-printing of components of cooling systems.

2. Memory shape alloys by AM: There are few studies which have successfully fabricated a defect-free component from NiTi through PBF-EB technique. Work at IIP will concentrate in understanding the effect of processing parameters on transformation temperatures and shape memory response. Understanding material deformation mechanisms will be carried out at MSE and a researcher at MMK will focus on the application to robotics.

3.Mechatronic systems and soft robots enabled by 4D printing: Four-dimensional (4D) printing is a novel additive manufacturing technology that builds 3D printed structures with smart materials to enable the shape and/or property change with external stimuli after the printing process. The project aims to develop soft sensors and soft actuators using smart materials and integrate them into soft robots.

4. PBF-EB & competence development: The new PBF-EB printer purchased by IRIS is an open-source printer suitable for research. Because it is open-source, the new Freemelt printer has a steeper learning curve than a printer ready for production. Currently, three research activities are carried out with the aim to develop the E-PBF technology, new materials and research competence at ITM: AM surface treatment, tailored steel microstructures, wear repair and resurfacing with Boliden as a partner.

IRIS area 3: Sustainable energy systems – technology and business perspectives

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Introduction

Current energy systems face large transformation pressures to mitigate climate change. The transformation of energy systems will lead to far-reaching consequences for all critical areas of society including industry, services, transportation, and buildings. This is linked to all three dimensions of sustainability: environmental, social and economic sustainability.

A central part of the vision for the transformation of the Swedish, Nordic, European and world-wide energy systems is the transition to net zero emissions, relying on renewable production and storage of energy in terms of electricity, heat and cooling, with high stability and security of supply, with the user side characterized by significantly higher resource efficiency than today. This transition will require significant investments in new infrastructure, new efficient energy technologies, new business models, better integrated and more efficient policies, as well as changing consumption and local production patterns. In parallel, it is necessary to address the greatest bottleneck against lower emissions, namely the dependence on fossil fuels for transport and industry. Here, a carbon-neutral power system can play an important role in developing new technologies and processes for converting second- and third-generation biomass into gaseous and liquid fuels for road vehicles, ships, and aircrafts. Other important areas of research are sustainable energy transitions in industry, built environments and energy storage.

Energy systems are however special. They have significant historical inertia and a strong demand for backward compatibility in terms of new investments and innovations. Today's business models are adapted to the system logic that was created when the systems were built and therefore they are not at all adapted to sustainable resource utilization and the vision of carbon-neutral energy conversion and consumption.

The mission of IRIS Area 3

The aim of IRIS Area 3 on sustainable energy is therefore to initiate and strengthen research activities that promote sustainable energy technology, policy and business models to mitigate climate change.

IRIS Area 3 focused on four key areas of research:

- Energy transitions in the transport sector, towards biomass and renewable-based electricity in vehicles, including policy, business models and new fuels
- Energy transitions in the built environment and cities – technology and business models
- Energy-intensive industry – sectoral transformation, including technology, policy and business models
- Energy storage, especially batteries.

Table 1 indicates how the different research themes of IRIS area 3 are cross-cutting for energy transitions in transport, industry, built environment and energy storage.

Research area	Decarbonization	Energy storage	Sector coupling	Electrification	Business models	Policy	Socio-technical impacts	New fuels including hydrogen	Digitalisation	Energy security
Transport	X	X	X	X	X	X	X	X	X	X
Built environment	X	X	X	X	X	X	X	X	X	X
Industries	X	X	X	X	X	X	X	X	X	X
Energy storage	X	-	X	X	X	X	X	X	X	X

Table 1. Indicates cross-cutting research themes

Activities, achievements and impact

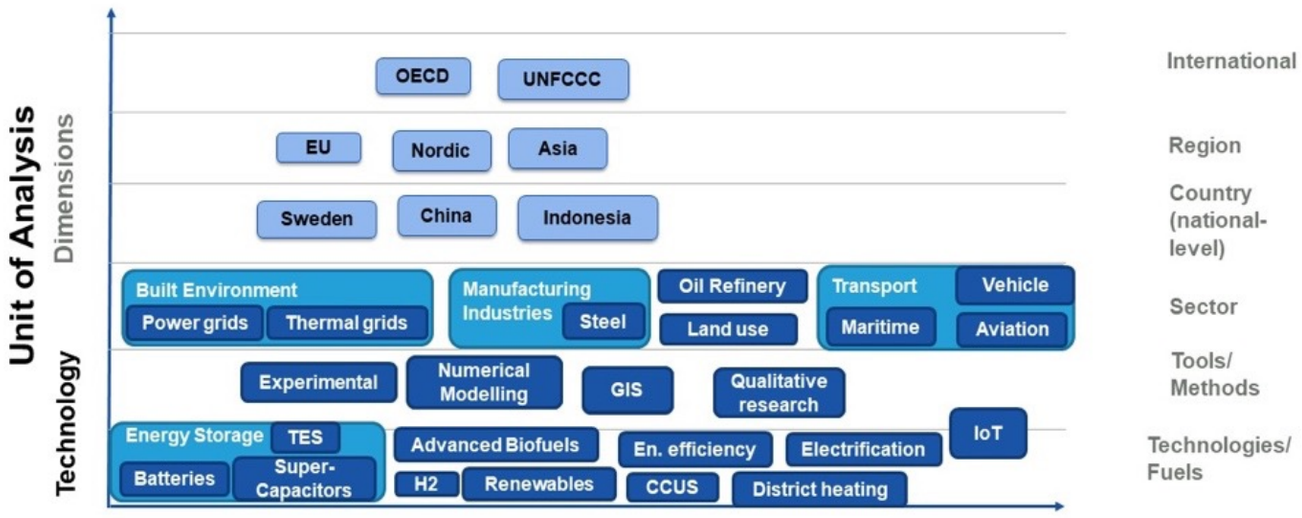

Table 2: Shows the research map for IRIS area 3, including thematic focus, technologies / fuels, tools and methods, sectors and regional perspectives

IRIS Area 3 has had numerous activities and events with significant societal impacts within its duration. Some examples are presented here. In March 2023, Fumi Harahap was a panel speaker for the live show organised by the Swedish Energy Agency on "Sweden Innovation Days – Side Event Sweden-Indonesia Sustainability Partnership. Industrial contributions on the use of data to make data driven decisions (by allowing e.g. access to relevant and actionable data and data visualization via dashboards) towards energy efficiency improvements, energy conservation and cost reduction strategies were achieved by Vincent Wang. This contributes overall towards energy conservation, increased stakeholder involvement, and reduced industrial carbon footprints and climate impacts. Another example is the outreach and establishment in the international research contexts, where e.g. Wujun Wang serves a member of SEK Svensk Elstandard, an expert board member of IEC International Electrotechnical Commission on international standard of solar thermal electric plants - Part 4-2: Heliostat field control system (TC 117/PT 62862-4-2), an editorial board member of international journal Energies, and as an associate editor of international journal Frontiers in Energy Research. Alberto Lazzarotti in the project RECOIN collaborates with Tekniska Museet, to showcase geothermal energy storage systems and ground source heat pumps with the museum in the newly built Wisdome. This has enabled outreach to a large audience and share knowledge about the technology and its benefits. Contributions to the Swedish and Nordic refrigeration and heat pumping industry were brought by Saman Nimali Gunasekara and colleagues concerning low global warming potential (GWP) refrigerants with the ongoing project TGM-LGWP Ref, together with many industrial stakeholders. A status-mapping of low GWP refrigerants' management throughout their useful life in the MSc. thesis of Sandra Parra Gimeno and two news articles in Kyla och Värme, 2023-2024 are some interesting results so far.

On climate change and technology, Frauke Urban and Johan Nordensvärd organized a book launch event for the Handbook of Climate Change and Technology, KTH, January 2024. The launch was supported by the KTH Energy Platform and the KTH Climate Action Center (with details here: https://www.kth.se/en/om/nyheter/centrala-nyheter/handbok-for-snabbare-omstallning-1.1314316, https://www.kth.se/climateactioncentre/news-event/news/the-handbook-on-climate-change-and-technology-published-1.1308739). Along this event, the climate minister Romina Pourmokhtari received a copy of the book (details: https://www.kth.se/en/forskning/forskningsplattformar/energi/nyheter/ny-antologi-lyfter-de-tekniska-losningarna-bakom-en-framgangsrik-klimatomstallning-1.1317350)

Energy transition in maritime shipping has also been a topic of impact, in Area 3. Frauke Urban presented about "the green transition and the future of maritime shipping fuels" to policy-makers and shipping industry at Riksdagen on 15 February 2024, Maritime Network. The event ended by suggesting policy recommendations to the Riksdags members, such as scaling-up investments for domestic production of electrofuels and biofuels for maritime shipping in Sweden and facilitating the process for increasing electric capacity for electrification of the transport sector, for example by having simpler and faster permitting processes for wind farms.

Climate impact of payment services (such as cash, card, payment apps, swish, giro and e-krona) were presented to Riskbanken by Frauke Urban, Fumi Harahap, Anissa Nurdiawati (with PI Niklas Arvidsson). This was done in a series of at least 4 presentations of preliminary and final results throughout autumn 2023 to February 2024. This is within a project collaboration with the Riksbanken, as well as other banks, banking association, suppliers of monetary services etc. The research results are directly being used to inform the decision-making process of Riksbanken.

Anissa Nurdiawati, in her Area 3 projects' engagement, has achieved strengthened collaboration between INDEK and other ITM departments, as an examples of multi-level societal impacts, starting from ITM-school. MSE focuses on clean, renewable materials, while INDEK emphasizes sustainability, industrial economics, and transition dynamics. This partnership has enabled the integration of MSE's experimental work with INDEK's economic and sustainability analysis, offering deeper insights and greater impact. Collaborations with other departments (MSE, EGI, HPU) have enriched the study of sustainability transitions by combining technical expertise and sustainability assessments. In their work, Anissa and colleagues also engaged policymakers through interviews, ensuring their research influences change. A feasibility study (e.g., biomass-based steel) they have done has secured funding for industry advancement, further demonstrating the impact of our work.

Short summary of some key achievements:

- Over 60 papers published in journals with good impact factors, e.g. Applied Energy; Chemical Engineering Journal; Chemosphere; Energy Conversion Management; Energy Research & Social Sciences; Renewable and Sustainable Energy Reviews; Resources, Conservation and Recycling etc.
- 16 successful grants, total value: ca 274,7 million SEK, of which 68 MSEK in funding to ITM
- New multi-disciplinary research activities across ITM: Sustainable energy transitions in maritime shipping (INDEK & EGI), steel production from iron ore and biogenic reduction gas (MSE & INDEK), links between various IRIS areas
- New PhD courses and joint collaboration on development of Masters programme across ITM
- Creating and establishing an informal multidisciplinary network of researchers within ITM school on the common theme of sustainable energy systems

Future impact

IRIS Area 3 founded a strong basis for inter-departmental collaborations within the ITM school, producing numerous fruitful and long-standing collaborations between, e.g. INDEK, EGI, MSE, HPU departments. These collaborations also evolved even beyond the ITM school to e.g. ABE school, Applied Physics department, at KTH, and also to many national and international universities, research institutes, industrial partners, public institutes and like, and other societal stakeholders (details in appendix C), reaching many levels of the society.

16 successful research applications were submitted, amounting to a total of 274,7 MSEK; over 60 peer-reviewed articles were published in scientific journals; at least 10 conference papers were accepted, 4 publications in the form of books and book chapters were published, and at least 18 presentations were held at conferences, workshops and podcasts.

A number of university courses were taught and developed at all levels, including a new PhD course on sustainable energy transitions that was multi-disciplinary and a collaboration between energy technology and industrial economics. The PhD course ran in 2023 and 2024 and educated about 50 PhD students from KTH and other universities in Sweden and internationally.

To industry, IRIS Area 3 contributed in the following ways:

- Helping improved decision-making based on data on energy efficiency, making available relevant and actionable data, as well as by visualizing data through dashboards making complex information more accessible and understandable
- Helping develop more robust and efficient implementations, by sharing findings with companies in the geothermal sector
- Paving the way for significant progress on e.g. biomass-based steel making by providing a basis for industry to secure funding to further advance to the demonstration stage
- Contributing to the Swedish and also regional refrigeration and heat pumping industry concerning low global warming potential (GWP) refrigerants with the ongoing project TGM-LGWP Ref composed of several industrial partners in the project team and many industrial stakeholders in the reference group team
- Development of a strong industrial, academic and research collaborative framework within the new competence center Dig-IT Lab on digitalization in the construction industry. Dig-IT Lab aims to reduce the environmental impact of buildings with the help of digitalization.

IRIS Area 3 also contributed to policy making, by presenting research on sustainable energy transitions to policy makers at Riksdagen, organizing a book launch event, engaging with policy makers by conducting interviews and dialogues, and by making various presentations. It also contributed to society at large by collaborating with Tekniska Museet in installing geothermal systems and ground source heat pumps within the museum in the newly built Wisdome, thereby providing a great opportunity to reach a large audience and sharing knowledge about the technology and its benefits.

IRIS area 4: Innovation management, innovation eco-systems and entrepreneurship

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Introduction

Innovation is crucial for addressing the pressing challenges of industrial and societal transformation. Area 4 of IRIS focused on research on innovation eco-systems, innovation management, and entrepreneurship to drive sustainable development. By bridging different theoretical perspectives and practical applications, this research aimed to create impactful solutions for a more sustainable future. Through cross-departmental collaborations, Area 4 has managed to tackle complex issues related to sustainability, innovation and learning, as well as their interaction. This integrated approach not only advances academic knowledge but also contributed to practical strategies that can be adopted by organizations, have implications for policy development and developed the borderland between learning and innovation for sustainable development.

The mission of IRIS Area 4

The overarching mission of Area 4 was to strengthen ITM as an environment for research in innovation management, innovation eco-systems and entrepreneurship through research focused on contemporary challenges in innovation management related to industrial transformation and sustainability concerns.

Area 4 was initiated with the goal of mapping and enhancing research activities within ITM related to innovation eco-systems, innovation management, and entrepreneurship. The initial efforts led by Jennie Björk from MMK and Anders Broström from INDEK focused on identifying existing research and forming a reference group consisting of members from all ITM departments to guide the development of the area. This groundwork established a foundation for advancing research focused on contemporary challenges and fostering collaborations across departments at ITM. The development and coordination of research in this area led to an initial research focus on how to support sustainable industrial practices, managerial sustainability practices, and focus specifically on how different types of organizations can attract ideas and innovation contributing to sustainable development.

In 2023, when the funding opportunities increased for Area 4 to also allow for involvement of present faculty, the area developed intensively. First, through increased engagement at INDEK through the involvement of Hans Lööf and Cali Nuur, which facilitated for increased cross INDEK and MMK collaborations when Emma Rui Lu, a new postdoc was requited in 2023 that had half of her time at each department. During the same time also involvement of faculty at MMK was initiated and Susanne Nilsson was further involved to work together on research in the group overarching INDEK and MMK. Reaching a certain critical mass within Area 4 was of high importance to identify the research avenues that lied between MMK and LES and further engagement within the research area was facilitated through the involvement of Anne-Kathrin Peters, Anders Rosén and Lena Gumaelius, all from LES and resulted in the development of the research area in the borderland between innovation research and learning research. In the final year all faculty and postdocs engaged in Area 4 continuously met and exchanged research ideas, plans, and outcomes. Moreover, reaching a critical mass facilitated for the engagement of non-IRIS funded collaboration which can be seen. Not financed but involved in projects and research applications related to Area 4 includes for example: Petter Dahlström INDEK and Jannis Angelis INDEK.

Activities, achievements and impact

Activities and achievements

The initial work of IRIS Area 4 included mapping all research activities taking place within ITM related to innovation ecosystems, innovation management, and entrepreneurship. The overarching mission of Area 4 was further developed into one stream of activities focused on supporting cross-departmental research activities and another to act as a facilitating networking and thereby act as a catalyst for new research cross-deparmental activities and research:

- Research focused on contemporary challenges in innovation management related to industrial transformation and sustainability concerns
- Networking and communication activities involving ITM, international and national actors.

Three overarching research areas were developed with the intention to support the development of sustainable industrial and societal transformation:
- Managerial practices for sustainability
- Innovation management and innovation ecosystems for sustainability
- Attracting ideas and innovation for sustainability.

The cross departmental research collaborations have created the possibilities for the combination of theoretical lenses, levels, and unit of analysis for industrial and societal transformation. Multiple forms of collaboration between INDEK, MMK and LES have resulted in new areas of research. More specifically, the research within Area 4 has paved new ground for the development of the research areas:

1. Green and just transformation
2. Innovation research and learning research
3. Innovation and sustainability regulations & SBTi.

All of these have at the time of writing ongoing cross-departmental collaborations in conference papers, as well as ongoing journal submissions and applications for funding.

In particular, we have strengthened the collaboration between KTH's different schools by bringing together stakeholders working with challenge-driven education in the application process for the education of the future. For this year's application, we will take an even broader approach, aiming to involve all of KTH's schools in applying for projects related to educational development, a project that will also be researched. Through the IRIS Project, we have contributed to strengthening the overarching goal of the KTH Global Development Hub, as we have developed methods to research this central educational development project. The IRIS Project has enabled us to make the applications we have submitted, not only by giving us time but also by allowing us to develop methods to conduct follow-up research on the projects for which we have sought funding.

Future impact

The research and initiatives within Area 4 will significantly impact the future by driving sustainable industrial and societal transformations. By established new bridges between MMK, INDEK and LES, crossdepartmental research has been created that also enabled new initiatives that are currently ongoing and developing.

Research results that has provided information about the relationships between innovation and sustainability targets are of high importance for industrial and societal transformation as will the new insights of how learning and innovation as research fields are interrelating to help shape a sustainable future.

7,3 MSEK in research funding granted, of which 4,1 MSEK in funding to ITM; 35 conference and journal publications; 10 courses were developed withing ITM; participation in more than 20 larger conferences, workshops, and presentations; multiple forms of cross-departmental collaborations within ITM for research, international conferences, workshops, presentations, and courses and collaborations with many different organizations in industry and with universities all over the world. Worth special mention are two ITM-arching workshops: The first one was initiated as the result of the overall publication strategy of KTH and focused on reviewing and writing scientific articles, held by Abbie Griffin, professor university of Utah, USA, and Gloria Barczak. Professor, Northeastern University, USA. The second workshop engaged participants from ITM, mostly INDEK and MMK, focused on Management and Economics of Innovation and networking.

Appendix A: Area 1

Participants

Position (Faculty/Postdoc)	Department	Name
Assistant Professor	EGI	Maryna Henrysson
Assistant Professor	HPU	Yongkuk Jeong (Jake)
Assistant Professor	HPU	Erik Flores Garcia
PostDoc researcher	HPU	Zuhara Chavez
Full Professor	HPU	Monica Bellgran
Coordinator- Associate Professor	IIP	Antonio Maffei
Researcher	IIP	Magnus Lundgren
Researcher	IIP	Gunilla Sivard
Associate Professor	IIP	Farazee Asif
Postdoc Researcher	IIP	Sayyed Shoaib
Associate Professor	IIP	Daniel Semere
Research Engineer	IIP	Theo Laspas
Associate Professor	IIP	Xi Wang
Researcher	IIP	Mikael Hedlind
Coordinator Full Professor	Indek	Mats Engwall
Postdoc IRIS	Indek	Adam Uhrdin
Associate Professor	Indek	Luca Urciuoli
Postdoc	Indek	Ebru Susur
Researcher	LES	Fredrik Enoksson
Full Professor	MMK	Sergei Glavatskin
Associate Professor	MMK	Ellen Bergseth
Postdoc	MMK	Fabian Schwack

Equipment

Description	Department
Mobile Robot vehicle with robotic arm	IIP HPU
Laser confocal microscope Olympus	IIP MMK

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- Examining the implementation of Blended Learning in the Engineering field. R Sala, F Pirola, G Pezzotta, F Enoksson, S Ljubić, A Skoki. 5th International Conference on Higher Education Learning Methodologies

- Legal requirement specifications (a deliverable in the DiCiM project). Authors: Maryna Henryson; Sayyed Shoaib-ul-Hasan; Farazee Asif; Bharghav Ganesh; Md Mahmudul Hasan

- Life Cycle Assessment of a Jet Printing and Dispensing Machine, 5th International Conference on Industry 4.0 and Smart Manufacturing, Lisbon, November 2023. Authors: Kokare, Samruddha, F. M. A. Asif, Gustaf Mårtensson, Sayyed Shoaib-ul-Hasan, Svanteson, K.

Theses

The following theses are partially funded by IRIS:

- Laspas, Theodoros. Performance Evaluation of machine tools: A methodology for loaded testing of machine tools. Diss. KTH Royal Institute of Technology, 2023.

- Reduced friction by ionic technology: Grease lubrication of bearings for e-motors (Doctoral thesis). Gabriel Calderon-Salmeron. May 2024.

- Zafarzadeh, Masoud. Data-driven Production Logistics: A value-oriented transition approach. Diss. KTH Royal Institute of Technology, 2023.

Succesful research applications

Project Title/ Information	Funding Body	Total Budget, SEK	Funds to ITM, SEK
ScAIEM Seed Money	ScAIEM	50 000	25 000
Feasibility study of integrating remanufactured gearboxes in production line of new trucks	Vinnova FFI	499 305	346 890
DYNASTEEL (Dynamic Scheduling and Transport Visibility in Steel Production)	Vinnova	600 000	600 000
Förutsättningar för eldriven 98-tons fordonskombination	Vinnova	800 000	550 000
Urban Logistics Barkarby	Vinnova	846 000	60 000
SHIFT-DT (Sustainable, Holistic, Integrated Framework for Ship Design and Production Transformation through Digital Twins)	Digital Futures	2 000 000	1 000 000
Unite! Seed Fund	Unite	2 086 608	865 561
VRP4Youth (Virtual Reality and 3d printing skills for Youth)	Erasmus+	2 750 000	511 500
TET (The Evolving Textbook)	Erasmus+	2 750 000	682 000
Drive Sweden Business Model Lab	Vinnova	2 868 965	1 812 965
ShiftBeds	Skövde Högskola	3 500 000	362 000

Project Title/ Information	Funding Body	Total Budget, SEK	Funds to ITM, SEK
BLISS (Blended Learning Implementation for reSilient, accessible and efficient higher educ.)	UHR	3 905 055	925 727
Dynamic SALSA (Dynamic Scheduling of Assembly and Logistics Systems using AI)	Eureka Smart, Vinnova	4 100 000	3 900 000
TIMEBLY (Time Data Management Automation for Manual Assembly)	Vinnova	5 166 000	1 800 000
Digitalised Value Management for unlocking the potential of the Circular Manufacturing Systems with integrated digital solutions	Horizon Europe	65 910 804	9 721 250
SUM TOTAL:		**97 832 737**	**23 162 893**

Teaching

The following table presents the courses that have been fully or partially developed, improved or offered by IRIS Area 1 staff.

Course title	Description	Collaboration within IRIS
(ME2312), 12 credits	Advanced studies in industrial economics and management	No
(ME2752), 6 credits	Challenge driven project in urban mobility	No
(ME2621)	Business opportunity development	No
(ME2502), 12 credits	Change Project in Industrial Management	No
Ing 4.0 – Cyber physical systems – How to realize them	Courses for industry professionals including an introduction to autonomous robots and cyber physical systems	Yes
Ing 4.0 – Autonomous robots – Deploying robots and automation tools	2026 Courses for industry professionals including an introduction to autonomous robots and cyber physical systems	Yes
BLISS Bundle	7 microcredential educational units based on Blended Learning strategies developed throughout the BLISS project. The material developed is, per EC policy, open access. The KTH contribution will be integrated in the MG2029 course. Two short courses on Constructive alignment and blended learning developed by KTH.	Yes
TET Bundle	4 microcredential educational units based on SDG developed throughout the MAESTRO project. The material developed is, per EC policy, open access. The KTH contribution will be integrated in the MG2040 course. A short course on Constructive alignment developed by KTH.	Yes
VRP4Youth Bundle	A list of 4 microcredential educational units based on additive manufacturing and virtual reality developed throughout the VRP4Youth project. The material developed is, per EC policy, open access	Yes
MAESTRO Bundle	A list of 7 microcredential educational units based on SDG developed throughout the MAESTRO project. The mate-rial developed is, per EC policy, open access. The KTH contribution will be integrated in the MG2029 course. In addition to that there is a short courses on Constructive alignment developed by KTH for the consortium.	Yes
ICARUS Toolkit	A general purpose toolkit for Industry 4.0 technologies that has been tought to support education in the field. It can be used in many different course related with process planning and product life cycle management	Yes
ML2302	Modelling, Simulation and Optimization of Sustainable Production	No
ML2303	Digitalisation for Sustainable Production	No
MJ111V Circular Economy and Industrial Systems	This a lifelong learning course focusing on Principles and strategies for the circular economy, methods and tools for circularity evaluation, Innovation management, operation and supply chain management, and value creation in a circular economy.	
Ingenjör 4.0 module on Circular manufacturing systems	An online lifelong learning course focusing on the fundamentals of Circular Manufacturing Systems (CMS) and the framework for CMS implementation. Introduction to the four enabling pillars of CMS, i.e., business model, product design, supply chain, and information and communication technology (ICT) and their interactions.	
MJ2513 Circular Economy and Energy System	The objective of the course is to provide an understanding of the circular economy from the perspective of lifecycle system in energy systems, circularity assessment approaches, and specific examples of the application of strategies in practice.	

Outreach and collborations

Internal collaborations

Adam Uhrdin
- With ITRL in several projects, in particular leading Drive Sweden Busines Model Lab and conducting a major pre-study on electrification of trucks to set a research agenda for ITRL and Scania.

Antonio Maffei
- Extensive cooperation with Fredrik Enoksson (and others) at LES on Blended Learning: joined project for the design of educational units (see specific sections). Several papers and proposal sent.
- Cooperation with Luca Urciuoli at INDEK on the definition of multimodal transport between town and airport using real time data.
- Recently emeged cooperation with Marco Molinari at EGI on smart building. Still under definition, plan to send a joined proposal.

Zuhara Chavez
- Unit of mechatronics and embedded control systems. Fredrik Asplund fasplund@kth.se, Martin Törngren martint@kth.se.

Yongkuk Jeong
- Martin Törngren from MMK for research projects and workshops

Farazee Asif and Sayyed Shoaib Ul Hasan
- EGI (Maryna H) and IPU Södertälje (Monica B) was very fruitful, and we applied projects together. IRIS has helped us to get access to and explore the skills and networks of colleagues. For example, Maryna H supported us in doing research and preparing a deliverable for the DiCiM project. Monica put together an excellent consortium using her network for the ProduCE proposal.

With national or international research groups

Adam Uhrdin
- (1) Strong research collaboration with Esko Hakanen from Aalto University and Thomas Draschbacher from University of Graz on the topic of business models, innovation ecosystem and sustainable transitions in the transport sector. (2) Strong collaboration with Krsto Pandza from University of Leeds.

Erik Flores Garcia
- Visiting scholar at Worcester Polytechnic Institute as part of the SME 5.0 project.

Antonio Maffei
- Cooperation with Prof Mario Romero at the Department of Computational Science and Technology (CST) at the School of Electrical Engineering and Computer Science (EECS) at KTH. Visualization of manufacturing processes and XR support. Resulting in different papers (see specific section).
- Cooperation with Prof Marco Bertoni at BTH on the concept of Feeding as a service. Resulting in paper. Other cooperation on industry 4.0 and Lean production under development.
- Cooperation with Prof Rene Laufer at Luleå University (Kiruna campus) on exchange of best practices for remote learning). Cooperation within the BLISS project

Theodoros Laspas
- Collaboration with RISE as part of PRODEQ project. Details of Collaboration: Collaboration with RISE as part of PRODEQ project for research on tolerance chain analysis and uncertainty evaluation of tolerance chains.

Yongkuk Jeong
- Abbas Dashtimanesh from SCI school for collaborative research project
- Chalmers University of Technology and University of Skövde for research project (TIMEBLY).

External collaborations

Adam Uhrdin
1. Sustainable Innovation. Nature of Collaboration: Leading Drive Sweden Business Model Lab together
2. Business Sweden. Nature of Collaboration: Leading Drive Sweden Business Model Lab together
3. Applied Autonomy. Nature of Collaboration: Partner in Drive Sweden Business Model Lab.
4. Bring. Nature of Collaboration: Partner in Drive Sweden Business Model Lab
5. DHL. Nature of Collaboration: Partner in Drive Sweden Business Model Lab
6. Elonroad. Nature of Collaboration: Partner in Drive Sweden Business Model Lab
7. Freelway. Nature of Collaboration: Partner in Drive Sweden Business Model Lab
8. Gordian. Nature of Collaboration: Partner in Drive Sweden Business Model Lab
9. Region Stockholm. Nature of Collaboration: Partner in Drive Sweden Business Model Lab
10. Ragn-Sells. Nature of Collaboration: Partner in Drive Sweden Business Model Lab
11. The Train Brain. Nature of Collaboration: Partner in Drive Sweden Business Model Lab
12. Univrses. Nature of Collaboration: Partner in Drive Sweden Business Model Lab
13. Vialumina. Nature of Collaboration: Partner in Drive Sweden Business Model Lab.

Erik Flores Garcia
14. SiB Solutions, Scania, Sungkyunkwan University, Seoul National University. Nature of Collaboration: Dynamic SALSA

project

15. Scania, AstraZeneca, MainlyAi, SECO Tools, ABB Hitachi. Nature of Collaboration: EXPLAIN project
16. EQ Pack, Husmuttern, Alisea, Revent, ReMade, Dandent, FROHE, Marcus Komponenter. Nature of Collaboration: SME 5.0 project
17. EQ Pack, Husmuttern, Alisea, Revent, ReMade, Dandent, FROHE, Marcus Komponenter, Worcester Polytechnic Institute, Chiang Mai University, University of Malta. Nature of Collaboration: SME 5.0 project
18. Södertälje Science Park, Chewfolk, ReMade, GE Healthcare. Nature of Collaboration: Course ML2308 CDIO in sustainable production

Antonio Maffei

19. University of Foggia – Italy. Nature of Collaboration: Joined study on the application of CA for high school teacher training. Will host a PhD student
20. Sabatjev University -Kazakhstan. Nature of Collaboration: Joined PhD project on the optimization of logistic for product remanufacturing. Will host a PhD student
21. University of Pisa Italy. Nature of Collaboration: Joined study on the concept of Visual Inspection as a service
22. Beijing Technical University BJTU. Nature of Collaboration: I currently host a PhD student from there for 1 year within the CSC program. Plan for future joined project
23. University of Pisa. Nature of Collaboration: Joined study on CAD file enrichment for automatic fixture design. Will host a PhD student
24. Politecnico Torino. Nature of Collaboration: Joined study on the Digital Twin. Planning for a joined postdoctoral project (already granted)
25. New University of Lisbon. Nature of Collaboration: Joined study on visual inspection technical requirement. Have hosted a PhD student that I co-supervise.
26. SenseAir AB. Nature of Collaboration: Development of design guidelines to include the assembly perspective into early stages of design phase.

Antonio Maffei Sergei Glavatskih

27. Axel Christiernsson International AB, Exxon, NYNAS, Novige, CorPower, Ghent University, Seoul National University, University of New South Wales, Tokyo University of Science and Technology. Nature of Collaboration: joint research related to materials, machine components and tribochemistry

Zuhara Chavez

28. Biophorum. Nature of Collaboration: As a component of the exploratory study "Single-Use Technologies in Pharma," we have collaborated with the Biophorum Plastics Working Group, consisting of diverse Biopharma members. This study is ongoing throughout Spring 2024, and our anticipated deliverables encompass a scientific paper and a white paper

Yongkuk Jeong

29. Seoul National University and Sungkyunkwan University from South Korea. Nature of Collaboration: Research project partners
30. Technische Universität Hamburg from Germany. Nature of Collaboration: Wrote a research paper together

Farazee Asif and Sayyed Shoaib Ul Hasan

31. Lexmark (Hungary), Arcelik (Turkey), Mycronic AB (Sweden), IDENER (Spain), IRIS (Spain), Asker Healthcare Group (Sweden) and STS AB (Sweden) Notably, collaborations with Scania and RISE, while ongoing with KTH and IPU for many years, represent the first instance of joint efforts specifically focused on the topic of CMS. Nature of Collaboration: Research collaborations which will lead to joint publications in near future. project partners.

Outreach and collaborations

Title	Location	Description
Workshop WP3 – Electrified Transports Stockholm South	Stadshuset, Södertälje	Presented results and held a workshop to map the ecosystem for electrified transportation around the logistic hub Stockholm South
Presentation at CISMOB conference	KTH, Kista	Presented business model lab and related projects
Presentation at ITRL General Meeting	KTH, Stockholm	Presented Electrified Transports Stockholm South
Business Model Lab Workshop – Lastbilsladdning vid logistikhubb	Sustainable Innovation's office, Stockholm	Presented results and held a workshop about truck charging to generate data and new business/project ideas
R&D Management Conference, Trento	Trento, Italy	Paper presentation at a conference
Business Model Lab Workshop, Autonomous transportation	KTH, Stockholm	Hosted a workshop about autonomous transports to generate new business/project ideas
Drive Sweden Thematc Area Meeting – Consolidation Hubs	Lindholmen, Gothenburg	Hosted a webinar and presented ecosystem research linked to consolidation hubs for last mile logistics
Business Model Lab Workshop – Micro Mobility Stockholm	KTH, Stockholm	Hosted a workshop about micro mobility to generate new business/project ideas
Business Model Lab Workshop – Micro Mobility Skåne	Lund	Hosted a workshop about micro mobility to generate new business/project ideas
Prerequisites for electric 98-ton vehicle combination	Aronborg, Bålsta	Presenting my study about electrification on a 98-ton truck to a group from the trucking business
Academy of Management Meet-ing	Boston, USA	Presented research paper: "A business model perspective on ecosystem bottlenecks"
Scania & ITRL Truck Electrification Prestudy workshop	KTH, Stockholm	Presented at and hosted workshop to set a re-search agenda and generate new research collabo-ration on electrification of truck transports
Scania Tech Day	Campus Södertälje	Presentation of logistics lab and ongoing projects to technology managers from Sweden, France, Brazil, Holland, and Germany
Science Week	Campus Södertälje	Presentation of logistics lab, collaboration with in-dustrial partners and students
Industrial Transformation Platform – Seminar series	Digital	Hosting and arranging seminars including dissemination of results from academia and industry leading to the sustainable transformation of manufacturing
Dynamic SALSA – Workshop between Sweden and Korea	KTH Södertälje & Scania Smart Factory Lab	Discussion of research results and next steps in Dynamic SALSA project
Digitalization and Operations and Supply Chain Sustainability: A Logistics Perspective	Worcester Polytechnic Institute, MA	Presentation of research results and opportunities for collaboration including sustainable and digital production logistics
SME 5.0 – Manufacturing oppor-tunities for the region of Worces-ter, USA	Worcester Polytechnic Institute, MA	Establishing synergies leading to the collection of empirical data, dissemination of results, and presentations together with the industry of Worces-ter MA about the topic of Industry 5.0
3 Workshops: Constructive alignment CA Course for the MAESTRO/BLISS/TET projects	KTH and Online	A short course on CA to synchronize the knowledge of the partners and enable better cooperation on defining the educational units resulting from the course

Title	Location	Description
Keynote speech at HELMETO conference in Foggia Italy	Foggia Italy	Keynote where I presented my research in the domain of course development
G-Seminar at Chongqing University: Sustainable business models for new automation technologies	Shanghai, China and Online	A seminar on how automation technologies needs new business models to be effectively implemented
G-Seminar at Chongqing University: Manufacturing skills in the context of Sustainable Development Goal	Shanghai, China and Online	A seminar on relevant manufacturing skills supporting SDG goals
Sustainable Transformation seminar: How the advancements in manufacturing automation are shaping a greener future	KTH and Online	A seminar In cooperation with KTH platform on industrial transformation. Explaining how the advancement on manufacturing can contribute to a greener future
Online TED talk: Collaboration between academia and the production industry	Hanoi, Vietnam and online	Organized by the Swedish Embassy in Hanoi, Vietnam within the event Pioneering the possible. I explained how we work together with industry in Sweden
XPRES Seminar: Towards autonomous manufacturing automation: Analysis of the requirements of self-x behaviours	KTH and Online	Organized by XPRES SFO center,I presented one of my papers on the topic of autonomous automation
HEIN4.0 Project: Boosting the role of HEIs in the industrial trans-formation towards the Industry 4.0 paradigm in Georgia and Ukraine	KTH (summer 2022). Georgia (winter 2023)	Organized by HEIN4.0 project,I presented the result of several projects I am involved in and that could be beneficial for this cooperation between KTH and several institution in Ukraine and Georgia
Receiving a delegation for South African partners in project with KTH international relations office	KTH	Organized by Internation cooperation office, I presented the result of several projects I am involved in and that could be beneficial for this cooperation between KTH and several institution in South Africa
Södertälje Science week 2023	Södertälje, Sweden	In this presentation we delved into the ways in which AI can contribute to the growth of sustainable and human-centered SMEs. Additionally, we addressed certain challenges and opportunities that emerge during this transformative journey. This session was together with Industrial partners in the Project ALISTAIR (Vinnova funded 2020-03404) and MMK colleague Fredrik Asplund.
The Sustainable Transformation Seminar series under the Industrial Transformation Platform ran all 2022 and 2023.	Södertälje, Sweden	The initiate has aimed to increase collaboration among disciplines to push the industrial and social transformation towards sustainability. The seminar series targets researchers and students at KTH and KTH's partners, offering a mix of inspirational con-tributors and different perspectives from all over the world. Yongkuk Jeong, Erik Flores Garcia – IRIS members collaborating in the management of this initiative.
Science Week 2022	Södertälje Science Park	Presentation of "Digitalization as a tool for sustainable production logistics"
Science Week 2023	Södertälje Science Park	Presentation of "Smart Production Logistics Open lab from data to service" and "Industrial Transformation: Changing together, deciding together"
Grow Digital 23 – EIT Digital Annual Conference	The Egg, Brussels, Belgium	Participated in Panel discussion – Industry 5.0
Digital Futures Digitalized Industry & KTH Industrial Transformation Platform Workshops	Digital Futures Hub, KTH	Organized a workshop titled "Digitalized Industry 5.0 Workshop: Industrial Needs and Challenges"

Outreach and collaborations

Title	Location	Description
Digital Futures Digitalized Industry & KTH Industrial Transformation Platform Workshops	Digital Futures Hub, KTH	Organized a workshop titled “Digitalized Industry workshop: Exploring the Possibilities of Industry 5.0”
Workshop on sustainability-focused manufacturing research, collaboratively hosted by Mines Saint-Étienne and the Technical University of Munich	Online	
KTH’s Transformation Day “Industry transforms towards circular economy	Online	
Sustainability trade-offs in the circular economy: A maturity-based frameworkKTH’s Transformation Day “Industry transforms towards circular economy	Online	
Developing New Circular Roles for Waste Management via Partnership, Research, and Innovation	Online	
Constructed wetland systems for water purification and reuse as a naturebased solution in the CE	Online	
Remanufacturing and the Circular Economy	Online	
A circular economy is about more than energy, materials, and business models	Online	
The need for standardization within the Circular Economy	Online	
ready2LOOP: making the transition to Circular Economy	Online	
Circular transition in the plastics industry	Online	

Appendix B: Area 2

Participants

Position (Faculty/Postdoc)	Department	Name
Associate Professor	MMK	Lei Feng
Full Professor	IPU	Lihui Wang
Associate Professor	IPU	Sasan Dadbakhsh
Postdoc	MSE	Ethan Sullivan
Assistant Professor	MMK	Georgios Andrikopoulos
Postdoc	MSE	Lisa Toller-Nordström
Coordinator - Researcher	MSE	Raquel Lizárraga Jurado
Coordinator – Assoc. Professor	MSE	Greta Lindwall
Postdoc	IPU	Maheshwaran Gopalakrishnan
Postdoc	IPU	Karoly Szipka
Professor	MMK	Kjell Andersson
Professor	INDEK	Luca Urciuoli
Professor	MSE	Stefan Jonsson
Professor	IPU	Andreas Archenti
Professor	EGI	Björn Palm

Publications

Published articles

1. Q. Ji, J. Jansson, M. Sjöberg, X.V. Wang, L. Wang, Lei Feng, "Design and calibration of 3D printed soft deformation sensors for soft actuator control", Mechatronics, 92, 2023, doi: https://doi.org/10.1016/j.mechatronics.2023.102980
2. K. Tan, Q. Ji, Lei Feng, M. Törngren, "Edge-enabled adaptive shape estimation of 3D printed soft actuators with Gaussian Processes and Unscented Kalman Filters", IEEE Transactions on Industrial Electronics, 71(3):3044-3054, 2024, doi: 10.1109/TIE.2023.3270505
3. S. T. Muralidharan, G. Andrikopoulos and Lei Feng, "A Survey on the Current Trends and Applications of Design Optimization for Compliant and Soft Robotics," 2023 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), Seattle, WA, USA, 2023, pp. 47-53, doi: 10.1109/AIM46323.2023.10196108.
4. Qinglei Ji, Shuo Fu, Kaige Tan, Seshagopalan Thorapalli Muralidharan, Karin Lagrelius, David Danelia, Georgios Andrikopoulos, Xi Vincent Wang, Lihui Wang, Lei Feng, "Synthesizing the optimal gait of a quadruped robot with soft actuators using deep reinforcement learning", Robotics and Computer-Integrated Manufacturing, Volume 78, 2022, 102382, doi: https://doi.org/10.1016/j.rcim.2022.102382.
5. Q. Ji,. Xi Vincent Wang, Lihui Wang, Lei Feng, "Online reinforcement learning for the shape morphing adaptive control of 4D printed shape memory polymer", Control Engineering Practice, Volume 126, 2022, doi: https://doi.org/10.1016/j.conengprac.2022.105257
6. K. Tan, Q. Ji, L. Feng and M. Törngren, "Shape Estimation of a 3D Printed Soft Sensor Using Multi-Hypothesis Extended Kalman Filter," in IEEE Robotics and Automation Letters, vol. 7, no. 3, pp. 8383-8390, July 2022, doi: 10.1109/LRA.2022.3187832.
7. Ji, Q., Wang, X.V., Wang, L. Wang, Lei Feng. "Customized protective visors enabled by closed loop controlled 4D printing". Sci. Rep. 12, 7566 (2022). https://doi.org/10.1038/s41598-022-11629-3.
8. Q. Ji, Mo Chen, Xi Vincent Wang, Lihui Wang, Lei Feng, "Optimal shape morphing control of 4D printed shape memory polymer based on reinforcement learning", Robotics and Computer-Integrated Manufacturing, volume 73, 2022, doi: https://doi.org/10.1016/j.rcim.2021.102209.
9. Q. Ji, M. Chen, C. Zhao, X. Zhang, X. Wang, L. Wang, Lei Feng, "Feedback Control for the Precise Shape Morphing of 4D-Printed Shape Memory Polymer," in IEEE Transactions on Industrial Electronics, vol. 68, no. 12, pp. 12698-12707, Dec. 2021, doi: 10.1109/TIE.2020.3040668.

10. Zhao, X., Wei, Y., Mansour, R., Dadbakhsh, S. & Rashid, A. (2023). Effect of Scanning Strategy on Thermal Stresses and Strains during Electron Beam Melting of Inconel 625 : Experiment and Simulation. Materials, 16(1).
11. Lin, Z., Surreddi, K. B., Hulme-Smith, C., Dadbakhsh, S. & Rashid, A. (2023). Influence of PBF□EB process Parameters on Transformation Temperatures and Pseudoelasticity of Shape Memory Nickel Titanium. Advanced Engineering Materials.
12. Zeyu, L., Dadbakhsh, S. & Rashid, A. (2022). Developing processing windows for powder pre-heating in electron beam melting. Journal of Manufacturing Processes, 83, 180-191.
13. Dadbakhsh, S., Zhao, X., Chinnappan, P. K., Shanmugam, V., Zeyu, L. & Hulme-Smith, C. (2022). Process and geometrical integrity optimization of electron beam melting for copper. CIRP annals, 71, 201-204.
14. M. Subasic, M. Olsson, S. Dadbakhsh, X. Zhao, P. Krakhmalev, R. Mansour, Fatigue strength improvement of additively manufactured 316L stainless steel with high porosity through preloading. International Journal of Fatigue 180 (2024) 108077.
15. Z. Lin, K.B. Surreddi, C. Hulme, S. Dadbakhsh, A. Rashid, Influence of PBF-EB Parameters on Transformation Temperatures and Pseudoelasticity of Shape Memory Nickel Titanium, Advanced Engineering Materials, (2023) 2201818.
16. X. Zhao, Y. Wei, R. Mansour, S. Dadbakhsh, A. Rashid, Effect of Scanning Strategy on Thermal Stresses and Strains during Electron Beam Melting of Inconel 625: Experiment and Simulation. Materials 16 (2023) 443.
17. S. Dadbakhsh, X. Zhao, P. K. Chinnappan, V. Shanmugam, Z. Lin, C. Hulme, Process and geometrical integrity optimization of electron beam melting for copper, CIRP Annals, 71 (2022) 201-204.
18. X. Zhao, A. Rashid, A. Strondl, C. Hulme-Smith, N. Stenberg, S. Dadbakhsh, Role of Superficial Defects and Machining Depth in Tensile Properties of Electron Beam Melting (EBM) Made Inconel 718, Journal of Materials Engineering and Performance 30 (2021) 2091–2101.
19. Sullivan, E.M., Hedås, S.S., Engström, M.J. et al. Effect of powder particle size distribution and contouring on build quality in electron beam powder bed fusion of a medium C hot work tool steel. Int J Adv Manuf Technol 128, 2969 (2023). https://doi.org/10.1007/s00170-023-12184-5
20. Sullivan, E.M., Thébaud, L., Bredel, J., Oikonomou, C., Holmström, C., Lindwall, G., Microstructural tailorability in hot-work tool steel via electrob beam powder bed fusion, In submission (2024).

Conference papers

1. Q. Ji, S. Fu, L. Feng, G. Andrikopoulos, X. V. Wang and L. Wang, "Omnidirectional walking of a quadruped robot enabled by compressible tendon-driven soft actuators," 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Kyoto, Japan, 2022, pp. 11015-11022, doi: 10.1109/IROS47612.2022.9981314.
2. Q. Ji, S. Fu, Lei Feng, G. Andrikopoulos, X. Wang, L. Wang, "Development of a 3D Printed Multi-Axial Force Sensor", the 10th Swedish Production Symposium (SPS), Skövde, Sweden, 2022.
3. S. T. Muralidharan, R. Zhu, Q. Ji, L. Feng, X. V. Wang and L. Wang, "A soft quadruped robot enabled by continuum actuators," 2021 IEEE 17th International Conference on Automation Science and Engineering (CASE), Lyon, France, 2021, pp. 834-840, doi: 10.1109/CASE49439.2021.9551496.
4. Q. Ji, C. Zhao, M. Chen, X. Wang, Lei Feng, L. Wang, "A flexible 4D printing service platform for smart manufacturing", in Swedish Production Symposium, Jönköping, Sweden 2020.
5. M. Chen, Q. Ji, X. Zhang, Lei Feng, X. Wan, L. Wang, "Study on efficient fused deposition modeling of thermoplastic polyurethane inflatable wall features for airtightness", in Swedish Production Symposium, Jönköping, Sweden 2020.
6. Q. Ji, X. Zhang, M. Chen, X. V. Wang, L. Wang and L. Feng, "Design and closed loop control of a 3D printed soft actuator," 2020 IEEE 16th International Conference on Automation Science and Engineering (CASE), Hong Kong, China, 2020, pp. 842-848, oi:10.1109/CASE48305.2020.9216946.
7. C. Andreanidis et al., "On the Design and Development of a Tabletop Robot for Interaction with Children," 2023 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM), Seattle, WA, USA, 2023, pp. 1232-1237, doi: 10.1109/AIM46323.2023.10196188
8. M. Milenovic, H. Mao, B. Peukert, G. Tibert, S. Dadbakhsh, Design and Development of Damping Sandwich Panels for Satellite Housing Using Additive Manufacturing, International Conference on Design for 3D Printing 2022, Singapore, Singapore.
9. M. Wiele, M. Abulawi, X. Zhao, Z. Lin, C. Hulme, S. Dadbakhsh, Poster presentation, Optimization of electron beam melting parameters for intricate vs. bulky geometries, Euspen SIG: Advancing Precision in Additive Manufacturing, 19th – 21st September 2023, KU Leuven, Belgium.
10. R. Mansour, S. Gillgren, S. Dadbakhsh, Topology optimization and residual stress in additive manufacturing – a numerical study on the influence of build direction, 10th Swedish Production Symposium 2022 (SPS2022), Skovde, Sweden.

Successful research applications

Project Title/ Information	Funding Body	Total Budget, SEK	Funds to ITM, SEK
	Industrial Transformtion Platform	25 000	25 000
	KTH Life science platform	50 000	50 000
	KTH platform for industrial transformation	50 000	50 000
	Vinnova	720 000	620 000
	STINT	1 000 000	1 000 000
HV and GKN Aerospace	Vinnova	1 470 000	1 070 000
Advancing re-al-time exoskeleton control for human-in-the-loop optimi-zation	Digital Futures	2 000 000	1 000 000
Advancing real-time exoske-leton control for human-in-the-loop optimization	Digital Futures	2 000 000	1 000 000
	Hugo Carls-sons Stiftelse	2 000 000	2 000 000
Scavenger: Real-ti-me logic based control for an autonomous scavenger	Digital Futures	2 000 000	600 000
	VR	8 086 745	8 086 745

Project Title/ Information	Funding Body	Total Budget	Funds to ITM
On the Compliance, Reliability and Motion Control of a Tabletop Robot	Honda Research Institute of Japan	9 486 000	9 486 000
	Energimyndigheten	10 165 000	3 994 000
	Vinnova Competence center	112 971 055	21 125 000
	EU Horizon	116 989 847	23 238 043
SUM TOTAL:		**269 013 647**	**73 344 788**

Teaching

i. FMG3920 Additive processes, materials and design for metallic components
Teachers: Sasan Dadbakhsh and Amir Rashid (IPU); Greta Lindwall and Chris Hulme (MSE); Rami Mansour (Engineering Mechanics, SCI)
ii. MG2044 Additive Manufacturing
Teachers: Sasan Dadbakhsh and Robert Tomkowski (IPU), Raquel Lizárraga and Chris Hulme (MSE); Rami Mansour (Engineering Mechanics, SCI); Anna Finne Wistrand (CBH)
iii. E-PBF Training
iv. Master thesis collaborations:
- 2021, Developing Robot assisted Plastic 3D Printing Platform, by Fahad Ahmad Khan, Sasan Dadbakhsh supervisor and Xi Wang co-supervisor
- 2021, Development of NiTi Shape Memory Alloys using EBM Processing, by GEORGIOS MANOLIOS, Chris Hulme supervisor and Sasan Dadbakhsh co supervisor
- 2022, ADDITIVE MANUFACTURING OF PURE COPPER USING ELECTRON BEAM MELTING (EBM), by Prithiv Kumar Chinnappan, Vishal Shanmugam, Sasan Dadbakhsh supervisor and Chris Hulme co-supervisor

Outreach and collaborations

Conference organized by IRIS researchers

Academic conference for Additive Manufacturing 2023, 11-12 January, Stockholm, Sweden.
Organizers: Sassan Dadbakhsh (Industrial Production), Raquel Lizárraga, Ethan Sullivan and Greta Lindwall (Materials Science and Engineering).

Possible new external or inter-departmental collaboration created thanks to IRIS fundings

a. Associate professor Mahiar Hamedi, Dept. Fibre and Polymer Technology. The lab will collaborate with us on electroactive materials, 4DP of soft actuators, and e-textiles.

b. KTH MoveAbility Lab: The lab will collaborate with us by providing technical requirements for rehabilitation and assistive robots and real data for trainin ML models.
c. Professor Malin Åkermo, Dept. Enineerin Mechanics. Her lab will help us with novel sensing composite materials, including carbon nanotubes (CNT), and 4D printing technologies.
d. Assistant professor Sasan Dadbakhsh, Dept. Sustainable Production Development. He will help us on additive manufacutring of shape memory alloy and metal matrix compoite.

e. Assistant Professor Huina Mao, Dept Enineerin Mechanic. She will collaborate with us on 4D printing and additive manufacturing of metamaterials. She will also help us on the modeling and control of soft robots.

f. Prof. Christophe Duwig, Dr. Kai Zhang (CBH) and Dr. Ali Najarnezhadmashhadi (CBH): design and experimental testing of heat exchangers.

g. Boliden: Ronne Hamerslag <Ronne.Hamerslag@boliden.com.
Siemens: Jan-Erik Lundgren and Pajazit Avdovic

h. Prof. Bjorn Palm, Department of Energy, design and experimental testing of heat exchangers.

i. Prof. Anna Finne Wistrand, CBH school, DEPARTMENT OF FIBRE AND POLYMER TECHNOLOGY she will help us with analysing the polymer properties allowing us to develop new systems and parameters for 3D printing

j. Prof. Inger Odnevall, CBH school, Department of Chemistry, will help us with analysis the biological influences of the surfaces after 3D printing.

k. Prof. Mårten Olsson and Assistant Prof. Rami Mansour, Department of engineering mechanics, they will help us with characterisiong the fatigue of the 3D printed components and topology optimisation.

Appendix C: Area 3

Participants

Position (Faculty/Postdoc)	Department	Name
Professor/Coordinator	INDEK	Frauke Urban
Assistant Professor / Coordinator	EGI	Saman Nimali Gunasekara
Professor / Coordinator	EGI	Andrew Martin
Postdoc	INDEK/IPU	Anissa Nurdiawati
Postdoc	EGI/INDEK	Fumi Harahap
Postdoc	EGI/INDEK	Chang Su
Postdoc	MSE/EGI	Tong Han
Postdoc	MSE/IPU	Veena Singh
Postdoc	INDEK	Kateryna Morozovska
Researcher	EGI	Alberto Lazarotto
Professor	IPU	Antonio Maffei
Professor	INDEK	Cali Nuur
Associate Professor	EGI	Dilip Khatiwada
Adjunct Professor	IPU	Jafar Mahmoudi
Researcher	EGI	Jagruti Thakur
Researcher	EGI	Mahrokh Samavati
Researcher	EGI	Monika Topel
Professor	MSE	Natalia Skorodumova
Associate Professor	IPU	Natalia Skorodumova
Researcher	MSE	Weihong Yang
Researcher	EGI	Wujun Wang

Postdoc projects

- Anissa Nurdiawati (INDEK/HPU) – energy transitions in energy- and carbon-intensive industry & transport, including maritime shipping
- Chang Su (EGI/INDEK) – energy transitions in built environment, especially heating systems
- Fumi Harahap (EGI/INDEK) – energy transitions in transport, including road transport, aviation and maritime shipping
- Kateryna Morozovska (INDEK) – energy transitions in maritime shipping & circular economy for electricity system
- Tong Han (MSE/EGI) – new fuels for transport sector & batteries
- Veena Singh (MSE/IIP) – battery technology

Publications

Published articles

1. Abuasbeh M., Acuña J., Lazzarotto A., Palm B. (2021). Long term performance monitoring and KPIs' evaluation of Aquifer Thermal Energy Storage system in Esker formation: Case study in Stockholm. Geothermics, vol. 96. PP 102166. https://doi.org/10.1016/j.geothermics.2021.102166
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11. Khatiwada, Dilip, Rohan A. Vasudevan, and Bruno H. Santos. (2024). Decarbonization of Natural Gas Systems in the EU – Costs, Barriers, and Constraints of Hydrogen Production with a Case Study in Portugal. Renewable and Sustainable Energy Reviews 168, (2022): 112775. https://doi.org/10.1016/j.rser.2022.112775.
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Conference papers

- Agrawal, T.K., Angelis, J., Thakur, J.R., Wiktorsson, M. and Kalaiarasan, R. (2021). Enabling circularity of electric vehicle batteries-the need for appropriate traceability. 2021 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD) (pp. 1-6). IEEE. https://doi.org/10.1109/ICTMOD52902.2021.9739531

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- Harahap, F., Mohammed, H., et al. (2023). Policy Tools for Electric Vehicle Adoption in Curitiba City. ustainable Built Environment and Urban Transition October 12-13, 20233, Linnaeus University, Växjö. https://open.lnu.se/index.php/sbut/article/view/3818

- Harahap, F., Khatiwada, D., et al. (2023). Building integrated framework for assessing biogas-based circular solutions in the Nordics. ICEEE 2023: New Energy, New Ecology and New Environment August 14-17, 2023, in London, UK Building, pp. 1–2.

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- Trevisan, S., Wang, W., Rafael Guédez, R., Laumert, B. (2022). Laboratory prototype of an innovative radial flow packed bed thermal energy storage. AIP conference

Other publications

- Harahap, F., Samavati, M. and Nurdiawati, A. (2023). Sustainable energy transitions in maritime shipping: a global perspective. Handbook on Climate Change and Technology, pp. 205–226. https://doi.org/10.4337/9781800882119.00021.

- Khatiwada. D., Kapothanillath. A., Harahap. F., Almeida. C., Hagström. P. (2023). Towards a bioeconomy: An integrated approach for biogas utilization and policy analysis in the Nordic Region.

- Urban, F. and Nordensvärd, J., (2023). Handbook on Climate Change and Technology. Edward Elgar Publishing, London. https://www.e-elgar.com/shop/gbp/handbook-on-climate-change-and-technology-9781800882102.html

- Wolfgang, O. et al. (2022) Bioenergy and links to agriculture & LULUCF in a Nordic context.

Succesful research applications

Project Title/ Information	Funding Body	Total Budget, SEK	Funds to ITM, SEK
Biomaterial för kolanod vid aluminium produktion	Vinnova	–	–
ScAIEM Winter PhD School – Sustainable Energy Transitions	ScAIEM	50 000	50 000
FME3550 PhD Course – Sustainable Energy Transitions - Technology and Management Perspectives	KTH Sustainability Office	150 000	150 000
Bioenergy and links to agriculture and LULUCF in a Nordic context	NordForsk / Swedish Energy Agency	520 550	520 550
Nordic Energy Outlooks: Bioenergy and links to agriculture & LULUCF in a Nordic context	Swedish Energy Agency	614 249	614 249
Storage Research Infrastructure Eco System - StoRIES	Horizon 2020	968 847	968 847
The climate impact of payment services	Riksbanken	1 600 000	1 600 000
Digitalization of energy system using machine learning	Vinnova	2 500 000	–
Optimal flow rate for maximizing ground source heat pump performance	Swedish Energy Agency - Termo	2 644 849	2 428 182
Konvertering av avfall till natriumjonbatterier	Vinnova	3 858 873	2 315 373

Project Title/ Information	Funding Body	Total Budget, SEK	Funds to ITM, SEK
Carbon-negative valorization of biomass waste into affordable green hydrogen and battery anodes	Energimyndigheten	3 858 873	2 315 373
Recycling of waste photovoltaic modules through renewable energy driven molten salt pyrolysis	Energimyndigheten	5 076 087	2 521 087
ERANET-Geothermica Joint Call 2021 - HECTA-PUS	Geothermica ERA Net/Swedish Energy Agency	5 116 660	5 081 655
Towards Zero-Waste through Bio-based Circular Recovery Model – BioCircularR	Formas	5 994 200	3 841 019
Sustainable Energy Transformations in Aviation	Energy Agency	13 841 511	5 568 414
Uses4Heat	EU Commission	106 126 086	7 351 190
Dig-It-Lab – A competence centre accelerating digitalization in the construction industry	Vinnova	121 783 000	32 750 000
SUM TOTAL:		**274 703 785**	**68 075 939**

Teaching

Teaching of courses as part of IRIS

- 4BT312 Life Cycle Analysis (MSc Course, LNU)
- 4BT315 Evaluation and Design of Energy Policies (EDEP) (MSc Course, LNU)
- FMG3401 Cloud-Based Cyber-Physical Systems in Manufacturing 6.0 credits
- FME3550 Sustainable Energy Transitions - Technology and Management Perspectives (PhD level)
- FMJ3411 Numerical Heat Transfer in Energy Technology (PhD level)
- Lecturer MJ312 Life Cycle Analysis (MSc Course, LNU)
- ME2085 Transformation in Energy Systems and Industries
- ME2086 Global Energy Markets and Systems in Transition
- ME2312 Advanced Studies in Industrial Economics and Management
- MH2045 Energy and Materials Sustainability
- MJ2411 Renewable Energy Technology
- MJ2424 Computational Methods in Energy Technology
- MJ2477 Energy Policy and Planning
- MJ2505 Optimization of Energy Networks
- MJ2508 Energy Systems for Sustainable Development
- MJ2510 Methods of Research in Sustainable Energy
- MJ2512 Transformation in Energy Policy and Climate Agenda
- ML2307 Theory of Science and Research Methodology
- PhD level: Advances in LCA together with Chalmers and SLU. https://student.slu.se/sw-kalender/2023/4/phd-lca-course/ USING ELECTRON BEAM MELTING (EBM), by Prithiv Kumar Chinnappan, Vishal Shanmugam, Sasan Dadbakhsh supervisor and Chris Hulme co-supervisor.

Development and teaching of new courses as part of IRIS

- PhD level: ScAIEM PhD school 2023, then developed and upgraded to FME3550 for course offerings in 2024 onwards, a joint collaboration between INDEK and EGI.

- Master programme development: development of new Master programme "Climate Change and Energy Management / Klimatförändringar och energihantering (TKFEM)", a joint collaboration between INDEK, EGI and TU Darmstadt (currently on hold due to delay at Darmstadt, but might be taken forward as INDEK / EGI programme in the future)
- Course design MJ2512 (6 ECTS) Transformation in Energy Policy and Climate Agenda
- Module development in course for SIDA- Energy for Developing Countries
- Module development international Europe-Sri Lanka Capacity Building in Energy Circular Economy (EUSL-Energy) programme on resource recovery and circular economy).

Outreach and collaborations

Presentations at conferences, seminars, workshops, events

- 2020 International Conference on Applied Energy 2020, Bangkok, Thailand. Plenary Lecture: The role of energy systems' planning in meeting the climate targets: the case of Indonesia, Thailand and Vietnam.
- 19 October 2021, Conference Center for Sustainable Aviation, presentation "Sustainable Energy Transformations in Aviation (SETA) – a systems perspective".
- 24-27October, 2021, "Performance evaluation of high-temperature BTES through energy and exergy efficiency" World Geothermal Congress 2020 + 1, Reykjavik, Iceland.
- 2022: Low carbon transitions in the oil refinery industry: A technological innovation system analysis. 3rd International Conference on Energy Research and Social Science.
- October 2022: "Sustainable Energy Transformations in Aviation" at the ScAIEM conference (Scandinavian Academy of Industrial Engineering and Management), Uppsala.
- March 2023, Panel speaker for the live show organized by the Swedish Energy Agency on "Sweden Innovation Days – Side Event Sweden-Indonesia Sustainability Partnership" (see documentation attached with this application).
- 2023 International Conference Sustainable Built Environment and Urban Transition, Linnaeus University, Växjö, Sweden. Plenary lecture: Policy Tools for Electric Vehicle Adoption in Curitiba City.
- 2023 International Conference on Energy, Ecology and Environment, London, UK. Plenary lecture: (a) Renewable marine fuel production for decarbonized maritime shipping: pathways, policy measures and transition dynamics – BEST PAPER AWARD (b) Building integrated framework for assessing biogas-based circular solutions in the Nordics.
- 7-9 June 2023, Presented at Nordic STS Science & Technology Studies conference Oslo. Conference title: Sector coupling for sustainable energy transitions in maritime shipping.
- August 2023. Presented at IST conference 29-31 Conference title: Decarbonizing maritime shipping and aviation: Breaking through carbon lock-in and path dependency in hard-to-abate transport sectors, Utrecht.
- 2023-08-31. Recent progress in factory energy strategies. Research workshop, August 31, Scania Smart Lab, Stockholm.
- Sept 2023, RECOIN Project Meeting in Baden Switzerland.
- 3rd December 2023.Panel discussion for side event of COP28, Business Sweden & Climate View.
- Book launch: 29 January 2024, Handbook on Climate Change and Technology, KTH.
- Presented to policy-makers and the shipping industry at Riksdagen on 15 February 2024, Maritime Network. Presentation title: The green transition and the future of maritime shipping fuels.
- Presented to Riksbanken: Climate impact of payment services, at least 4 presentations of preliminary and final results throughout autumn 2023 to February 2024.

Podcasts

- Spotify: https://lnkd.in/d7gVC6Vx and Apple Podcast: https://lnkd.in/dNVtjHSw
- The decarbonization of steel and oil refineries – part of NTNU's Energy Transitions Podcast

Collaboration within ITM School and KTH more widely

- Aprilice AB, collaboration on the research of new PV recycling process and optimal PV installation angle in Sweden.
- Collaboration between EGI and INDEK on research on climate impact of payment services.
- Collaboration between EGI and INDEK on research on decarbonizing the maritime shipping industry.
- Collaboration for a new research area, namely sustainable energy transitions in maritime shipping, with Fumi Harahap, Anissa Nurdiawati, Kateryna Morozovska, and Mahrokh Samavati.
- Collaboration on the development of high efficiency micro gas turbine with Compower AB.
- Collaboration on the research of distributed energy solution for railway system in Sweden with Zhendong Liu (Rail Vehicle Technology, KTH).
- Collaboration on the research of future hydrogen jet engine with GKN.
- Collaboration on the research of high temperature thermal process for hard carbon production with Weihong Yang (Material Science, ITM, KTH).
- Collaboration on the research of hydrogen utilization with Zemission AB.
- Collaboration on the research of new process for recycling waste wind blades with Vattenfall.
- Collaboration on the development of high efficiency steam engine with Ranotor AB.
- Collaboration with post-docs based both at INDEK and EGI: Fumi Harahap, Chang Su, which led to publications and new projects.
- Collaboration with post-docs based both at INDEK and HPU: Anissa Nurdiawati, which led to publications and new projects.
- ElectriCITY, collaboration on the new energy solutions for buildings.
- Joint collaboration between INDEK and EGI for setting up a joint PhD course on sustainable energy transitions (FME3550) and a joint Masters program (TKFEM).
- Joydeep Dutta and Fei Ye (Applied Physics, KTH), collaboration on the research of functional material for solar energy application.
- KTH ITM Sodertalje Campus.
- Research funding application and collaboration: ABE school, MSE department.
- Teaching: INDEK & EGI Frauke and Saman – PhD school/course.
- Teaching: MSc thesis co-supervision (EGI Area 3, SNG & Jagruti Thakur).

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Collaboration with national and international actors (research groups, business, authorities, societal actors)

- Airbus
- AstraZeneca
- Aviation industry (Swedavia airports, Swedish Regional Airports, SAS, BRA, fuel producers, aircraft manufacturers, regulators etc)
- Banking industry (including Riksbanken, Swedish Bankers association, various commercial banks, credit card institutes, cash producers, cash distributers, payment service providers etc)
- Bengt Dahlgren Stockholm Geo AB
- Brazilian Biorenewables National Laboratory
- Borås Region
- Chalmers
- Danish Energy Agency
- Danish Technical University DTU
- Deep Drilling Equipment & Services Oy Ab
- EDF – Environmental Defence Fund
- Energy industry (Vattenfall, Stockholm Exergi, Fortum etc)
- Ferrosilva AB
- Focali - Focali Forest, Climate, and Livelihood research network
- Heart Aerospace
- Hitachi-ABB
- IIASA - International Institute for Applied Systems Analysis
- Institute Technology of Bandung Indonesia
- International university: Universidade Tecnológica Federal do Paraná Brazil
- IVL
- Geothermal branch industry (heat pump manufacturer, drillers, consultants): Thermia, Wilo, Deep Drilling Equipment & Services Oy Ab, SINDEQ Borrteknik AB, Asplan Viak AS, Bengt Dahlgren Stockholm Geo AB, NIBE, H P-BORRNINGAR I KLIPPAN, NOWAB, Rototec, SGU.
- HYSTORE project
- Hitachi-ABB
- Indian Institute of Technology
- International Institute for Applied Systems Analysis (IIASA)
- Jönköping Region and Municipality
- Japanese Institute of Energy Economics (IEEJ)
- KTH
- Ministry of Foreign Affairs Indonesia
- Martin Luther University at Halle (MLU)
- Maritime shipping industry (shipping lines including major ones like Maersk, ship builders, ports, fuel providers, regulators etc)
- LiU (Linköping University)
- MainlyAI
- Martin Luther University at Halle (MLU)
- Ministry of Foreign Affairs Indonesia
- SINTEF
- Svebio
- Swedish Central Bank (Riksbanken)
- Swedish Energy Agency
- Swedish and international agencies/institutions
- National Institute of Technology, Rourkela, India

- Norrtälje Municipality
- NOWAB
- NTNU (Norwegian University of Science and Technology)
- Ports of Stockholm
- Polytechnique Montreal
- Quebec Ministry of Economy and Innovation
- Ranotor AB
- Riksbanken
- RISE - Research Institutes of Sweden
- RISE IVF
- Rototec
- Scania CV
- SECO Tools
- SINDEQ Borrteknik AB
- SINTEF
- SWS Heating (Horizon project)
- Svebio
- Swedavia
- Swedish Energy Agency
- Swedish and international agencies/institutions
- Task 35 (IEA Energy Storage TCP)
- Task 41 (IEA Energy Storage TCP)
- Tekniska Museet
- Thermia
- University of Brawijaya Indonesia
- University of Oslo
- Uppsala University
- Tekniska Museet
- The Norwegian Institute of Bioeconomy Research
- Uppsala University
- University of Brawijaya Indonesia
- University of Oslo
- University of Technology Federal do Paraná Brazil
- Utrecht University
- Wilo
- WMU (World Maritime University)
- WBA (World Bioenergy Association)
- Xergi
- Zhendong Liu (Rail Vehicle Technology, KTH)
- Zemission AB
- Zero Emission Buildings Accelerator

Appendix D: Area 4

Participants

Name	Role	Organisation
Anders Broström	Faculty, Coordinator	INDEK
Jennie Björk	Faculty, Coordinator	MMK
Mats Magnusson	Faculty, Coordinator	MMK
Hans Lööf	Faculty	INDEK
Susanne Nilsson	Faculty	MMK
Anne-Kathrin Peters	Faculty	LES
Anders Rosén	Faculty	LES
Lena Gumaelius	Faculty	LES
Per Fagrell	Postdoc	LES/EGI
Qian Chen	Postdoc	MMK/INDEK
Hadar Gafni	Postdoc	INDEK/MMK
Emma Rui Lu	Postdoc	MMK/INDEK
Cali Nuur	Faculty	INDEK

Publications

Published journal articles

Chen, Q., Magnusson, M., & Björk, J. (2022). Exploring the effects of problem-and solution-related knowledge sharing in internal crowdsourcing. Journal of Knowledge Management

Chen, Q., Magnusson, M., & Björk, J. (2023). Selection bias of ideas for sustainability-oriented innovation in internal crowdsourcing. Technovation, 102761.

Chen, Q., Magnusson, M., & Björk, J. (2024). How do ideas gain legitimacy in internal crowdsourcing idea development? Exploring the effects of feedback on idea selection. Innovation, organization and management, 1-32.

Dahlström, P., Lööf, H., Sjöholm, F., & Stephan, A. (2023). The EU's competitive advantage in the" clean-energy arms race" (No. 1483). IFN Working Paper.

Dong, C., Yang, Y., Chen, Q., & Wu, Z. (2022). A complex network-based response method for changes in customer requirements for design processes of complete mechanical products. Expert Systems with Applications, 199, 117124.

Dzhengiz, T., Riandita, A., & Broström, A. (2023). Configurations of sustainability□oriented textile partnerships. Business Strategy and the Environment, 32(7), 4392-4412.

Fagrell, P., Fahlgren, A., & Gunnarsson, S. (2020). Curriculum development and quality work in higher education in Sweden: The external stakeholder perspective. Journal of Praxis in Higher Education, 2(1), 28-45.

Fagrell, P., & Anund Vogel, J. (2024). Building The Future: Unveiling Educational and Competence Demands for Smart and Sustainable Buildings. Civil engineering research journal, 14(3).

Fagrell, P., & Anund Vogel, J. (2024). Building The Future: Unveiling Educational and Competence Demands for Smart and Sustainable Buildings. Civil Engineering Research Journal, 14(3), DOI: 10.19080/CERJ.2024.14.555888.

Gafni, H., Hudon, M., & Périlleux, A. (2020). Business or basic needs? The impact of loan purpose on social crowdfunding platforms. Journal of Business Ethics, 1-17.

Gafni, H., Marom, D., Robb, A., & Sade, O. (2021). Gender dynamics in crowdfunding (Kickstarter): Evidence on entrepreneurs, backers, and taste-based discrimination. Review of Finance, 25(2), 235-274.

Keraga, M. N., Lööf, H., & Stephan, A. (2024). Innovation and employment in sub-Saharan Africa: New evidence from the World Bank Enterprise Survey (No. 497). Royal Institute of Technology, CESIS-Centre of Excellence for Science and Innovation Studies.

Lööf, H., Sahamkhadam, M., & Stephan, A. (2022). Is Corporate Social Responsibility investing a free lunch? The relationship between ESG, tail risk, and upside potential of stocks before and during the COVID-19 crisis. Finance Research Letters, 46, 102499.

Lööf, H., Sahamkhadam, M., & Stephan, A. (2023). Incorporating ESG into optimal stock portfolios for the global timber & forestry industry. Journal of Forest Economics, 38.

Nilsson, S., & Ritzén, S. (2023). Maneuvering responsive, tactical, and preventive innovation in an innovation ecosystem to address the grand challenge of organized crime. Creativity and Innovation Management.

Riandita, A., Broström, A., Feldmann, A., & Cagliano, R. (2022). Legitimation work in sustainable entrepreneurship: Sustainability ventures' journey towards the establishment of major partnerships. International Small Business Journal, 40(7), 904-929.

Xuefeng Zhang, & Qian Chen (2021), Towards an understanding of the decision process of solvers' participation in crowdsourcing contests for problem solving, Behaviour & Information Technology, 1-19 .

Xiaohua Xin, Xiaoming Miao, & Qian Chen, Tiantian Shang (2021). User participation, knowledge management capability and service innovation: E-commerce enterprises in the digital age, Asia Pacific Journal of Marketing and Logistics (https://doi.org/10.1108/APJML-10-2020-0724.(SSCI,)

Conference papers

Arekrans, J., Nilsson, S., Ritzén, S. (2023). Management Controls in a Circular Economy Transition, 30th Innovation and Product Development Management Conference (IPDMC), Lecco, Italy, 7-9 June, 2023

Arekrans, J., Nilsson, S. and Ritzén, S. (2024). Incumbent industrial manufacturers in a fair and circular transition, R&D Management conference 2024, Stockholm, Sweden.

Darwish, R., Uhrdin, A., Engwall, M. och Magnusson M.(2024) Overcrowded or Avoided? How Business Model Ambiguities Inhibit Ecosystem Transformation, Submitted to AoM annual meeting 2024.

Lu, Emma Rui, Angelis, Jannis, & Björk, Jennie. (August 2024). AI Technology and Knowledge Worker Coexistence. Academy of Management's PDW: Bridging Organizational Behavior and Entrepreneurship for August 2024 in Chicago, USA.

Lu, Emma Rui, Dahlström, Petter, Lööf, Hans, Björk, Jennie, & Nilsson, Susanne. (June 2024). Identity Signaling of Innovative Firm Behavior through Sustainability Reporting: SBTi and Green Patents of Listed Firms. Accepted into the Innovation and Product Development Management Conference (IPDMC) for June 2024 in Dublin, Ireland.

Lööf et al (2021) Conference paper submitted and accepted for "8:e Utvecklingskonferensen för Sveriges ingenjörsutbildningar", Karlstads universitet, 24 november – 25 november 2021

Nilsson, S., Janhager, J., Ingels, A., Sannerud, Y. (2022) Involving Users in the Development of Digital Business Platforms 29th IPDMC:, Hamburg, Innovation and Product Development Management Conference Germany, July 17-19, 2022

Nilsson, S., Rosén, A., Gumelius, L., Peters A-K., Shibwabo, B., Shayo, E., Ismail, M., Ibwe, K., Rwegasira, D., Maziku, H., and Misso, A. (2023). Investigating Innovation and Learning in Challenge-Driven Education. 24th CINet conference, Linz, Austria, September 17-19, 2023.

Nilsson S., Rosén A., Gumaelius L., Peter A-K, Schibwabo B., Shayo E., Ismaael M., Ibwe K., Rwegasira D., Maziku H.H., Misso A. (2023) Investigating Innovation and Learning in Challenge-Driven Education. CINET conference 2023 17-19 sept. Linz, Austria.

Nilsson, S., Arekrans, Samuelsson, M., Nordling, L., Marmolin, F., Ritzén, S. (2024). Multinational corporations' social sustainability practices and perspectives on a just circular transition – missed opportunities for innovation? 25th CINet conference, Hamburg, Germany, September 15-17, 2024.

Report to KTH Live-In Lab, published 2021-10-14, https://www.liveinlab.kth.se/en/nyheter/aktuellt/ny-rapport-kompetensbehov-for-framtidens-smarta-byggnader-1.1110328

Viklund-Ros, I., Baum, C. F., Lööf, H., & Stephan, A. (2023). Directed technical change in clean energy: Evidence from the solar industry. Paper presented at the ZEW Conference, Mannheim, Germany.

Qian Chen, Mats Magnusson, Yue Han, , Jennie Björk (2022). Fulfilling the idea in real life? The roles of communication information on the success of the campaign in reward-based crowdfunding, CINet conference, Pisa, Italy.

Qian Chen, Mats Magnusson, Jennie Björk , Yue Han, Xue Feng Zhang(2021). Is environmental innovation driven by emotional cues? The antecedents and motivation for prosocial behavior in crowdsourcing, CINet conference, Stockholm, Sweden.

Submitted papers to journals

Gafni, H., Jeppesen, L. B., (20xx) Is the Crowd Wise enough to recognize creditworthy borrowers? (under review with a developed title)

Gafni, H., (20xx) Does Financial Inclusion Foster Female Entrepreneurship in Developing Countries?

Gafni, H., (20xx) Garofalo, O., Jeppesen, L. B., Zunino, D., The Missing Crowdfunding Platform? Willingness to crowdfund microfinance in distinct funding models.

Research applications

Project Title/ Information	Funding Body	Total Budget, SEK	Funds to ITM, SEK
Employee Motivation, Innovation and Transformation of Traditional Industries	FORTE	–	–
Som ringar på vattnet	Riksbanken		
Algorithmic Management for Fostering Employee Engagement	Jan Wallanders och Tom Hedelius stiftelse		
AI Technology and Knowledge Worker Coexistence	Lundbergsstiftelsen		
AI Technology and Knowledge Worker Coexistence	(RJ) Riksbanken	–	–
Hybridarbete i F&U verksamhet - utmaningar och möjligheter för kreativitet och innovation	AFA	–	–
AI Technology and Knowledge Worker Coexistence	(VR) Swedish Research Council	–	–
Creativity and Innovation in Blended In-office and Digital Distributed Work in R&D	FORTE Working Life Challenges 2024	–	–
Designing Innovation idea Creation and Development Systems (DICES)	FORTE	–	–
Innovation behaviors for transformation	FORTE	–	–
Fair and Circular Innovation Ecosystems (FACE)	Vinnova	5 090 000	3 095 087

Project Title/ Information	Funding Body	Total Budget, SEK	Funds to ITM, SEK
Framtidens utbildning	KTH	275 000	275 000
Stakeholder Training for Reinforcing and Enhancing African Innovaton Ecosystems (STREAMIE)	Svenska institutet	2 000 000	745 000
SUM TOTAL:		**7 365 000**	**4 155 087**

Teaching

- ME2323 New course. Research Frontiers in Industrial Management Corporate Governance/ Asset pricing and climate mitigation. 61 students spring 2024.
- MF2085 Innovation and product development processes: Developed a module Innovation Ecosystems + a module on Social and Frugal Innovation.
- MF2046 New course content of sustainability in Product Innovation course.
- MF2084 increased focus on circular economy.
- ME1316 development of project work.
- Master theses 2021-2023: enabled through access of ESG data.
- ME2323 Advanced Operations Coures: new industry contacts enables through IRIS for project assignments.
- ME2623 Tech Venture Realization. Development of new format as an industry panel discussion on building a successful startup with speakers representing diverse viewpoints of the startup industry.
- MF220X: Masters thesis projects developed within the frame of IRIS Area 4.
- LH233V: Development of modules in Learning for Challenge-Driven Education with Global Development Goals.
- XXXX: A new scalable course on resource-efficient innovation (3, 7.5, and 15 credits), in collaboration between MMK, Learning, and Materials Science at ITM and CBH, is planned to be developed in the spring of 2025. A 3-credit course has been applied for at the ITM school, along with funding to develop an online version as part of the call for Short Courses for Professionals for Green Transition, June 2024.

Outreach and collaborations

Presentations and workshops

- Panel symposium on AI technology and labor management at the biggest conference for management research on August 13 – the Academy of Management Conference (AOM) in Chicago, USA, let by Emma Rui Lu (MMK/INDEK). Panel included Mats Magnusson & Mats Engwall (KTH/MMK), Katerina Bezrukova (U. at Buffalo), Paavo Ritala (LUT Business School), and Sebastian Krakowski (Stockholm School of Economics)
- 1st Area 4 workshop linked to the overall publication strategy of KTH and focused on reviewing and writing scientific articles, held by Abbie Griffin, professor university of Utah, USA, and Gloria Barczak. Professor, Northeastern University, USA.
- 2nd Area 4 workshop: participants from ITM, mostly INDEK and MMK, focused on Management and Economics of Innovation and networking
- 2023, continuous workshops for all involved within area 4
- Public seminar 2021-05-28 “Will smart buildings of the future change the real estate industry’s competence needs?” https://www.liveinlab.kth.se/en/nyheter/kalender-live-in-lab/gor-framtidens-smarta-byggnader-att-fastighetsbranschens-kompetensbehov-forandras-1.1065860?date=2021-05-28&orgdate=2021-05-28&length=1&orglength=1
- 30 Jan 2023: IRIS departments presentation of work progress and planned activities. at INDEK
- 24 April 2023: IRIS Data meeting with Indek MMK
- 12 May 2023: IRIS Area 4 meeting and presentation
- 25 May 2023: SBTi presentation at Indek. feedback from faculty: Hans Lööf (Indek), Christian Thomann (Indek), Jannis Angelis (Indek) and Mark Sanctuary (Indek affiliate and vice director of Vinnova Sustainability Lab).

- 21 June 2023: SBTi panel meeting: IRIS Area 4, mid 2023 conference
- 25 Oct 2023: Tillväxtananlys SBTi conference and industry round table.
- Keynote of Professor Mats Magnusson at the 2023 International Conference on Innovation and Knowledge Management (iKM2023), Research Center of Technological Innovation, Tsinghua University, School of Management of Wuhan University of Science and Technology
- The research in area 4 has enhanced the collaborations with other international research group in USA and China, as a consequence of Qian Chen's two year IRIS postdoc.
- Co-organization of a workshop for the doctoral students of INDEK about the publishing process.
- Four Scandinavian magazines reporting on Hadar Gafni's published research article, and he presented in a number of conferences and had invited talks.
- The EU's Competitive Advantage in the'Clean-Energy Arms Race.
- ISGEP 2023, Pescara Italien
- Directed Technical Change in Clean Energy: Evidence from the Solar Industry
- Tillväxtanalys, collaboration with survey and round table discussion
- Presentation spring 24 at MMK about LES-MMK IRIS Area 4.
- Presentation autumn 2023 TREES research group, LES.
- KTH Afrika Week: One on Challenge-Driven Education and one on how to create innovation in resource-complex environments
- Paper session developed and held at R&D Management conference 2024: P.15 Innovation under resource constraints. Collaboration with University of Cape Town, Cape Town, South Africa. KTH, Stockholm, Sweden, June 17-19.
- Workshop developed and held at R&D Management conference 2024: W3. Fostering Collaboration between Academia and Industry for Challenge-Driven Innovation. collaboration between LES and MMK. KTH, Stockholm, Sweden, June 17-19.
- Workshop developed and held at the18th Annual Engineering, Social Justice and Peace Conference Chalmers University of Technology, Gothenburg, Sweden, August 12-15, 2024. Special session 1B: How can society be improved through peace innovation? Collaboration between LES and MMK.

Collaborations at ITM

- Research collaboration between INDEK and MMK, increased collaboration between the departments has had many direct and indirect effects, for example the i) collaboration between INDEK and MMK to co-host the R&D MANAGEMENT 2024 conference "Transforming industries through technology" at KTH in June 2024, and ii) collaboration between the departments to further develop and exploit the research area of electrification and innovation eco-systems.
- Research collaboration between MMK and LES, strengthened to further focus and develop the research area in the intersection of innovation and education.
- Completed post doc, new positions internationally. For example collaboration with Professor Jin Chen, research center for technological innovation Tsinghua Uniersity, China.
- Creation of a Nordic entrepreneurship research network with KTH as the hub (https://www.nordicentrepreneurship.org/), including a workshop at KTH in June 2022.
- Research collaboration with the Research Institute of Industrial Economics (IFN).
- Research collaboration with Linné University in Växjö and Jönköping International Business School. Paper: Innovation and Employment in Sub-Saharan Africa: New Evidence from the World Bank Enterprise Survey.

Collaborations externally

- Ericsson
- Husqvarna AB
- Fastighetsbranchens utbildningsnämnd (www.fastun.se)
- Toyota Material Handling
- Tillväxtanalys
- Scania
- Pollen AB
- Getinge
- Collaboration with Volvo Group och Umeå Municipality initiated related to building innovation ecosystems for circular economy.
- Coauthors from Copenhagen Business School, SKEMA Business School, Hebrew University of Jerusalem, Mzumbe University.
- Yu Yang, a professor from Industrial and Engineering Department of College of Mechanical and Vehicle Engineering, Chongqing University.China
- Yue Han, an associate professor from the Department of Decision Sciences and Marketing, Robert B. Willumstad School of Business, USA
- Xuefeng Zhang, an associate professor from Anhui Polytechnic University, China
- Xiaohua Xing, a Ph.D student from the School of Management, Northwestern Polytechnical University. China
- Institutet för näringslivsforskning (IFN).
- Linnéus universitetet Växjö,
- Internationella Handelshögskolan Jönköping
- KTH Live-In Lab, including various meetings 2021-2023 with KTH Live-In Lab as the contact hub
- Participation in a conference with the Real Estate Industry's Competence Council Stockholm/Gotland 2023-04-04
- Conducted a research project together with our African partners at Strathmore University and the University of Dar es Salaam. A total of 12 researchers participated.
- Through application collaboration, we have expanded our network with additional African universities as well as European universities, including Aalto University, TU Eindhoven, University of Rwanda, Rwanda Polytechnic, University of Nairobi, University of Dodoma, University of Kinshasa, and the Catholic University of Bukavu.

Appendix E: The IRIS project organization

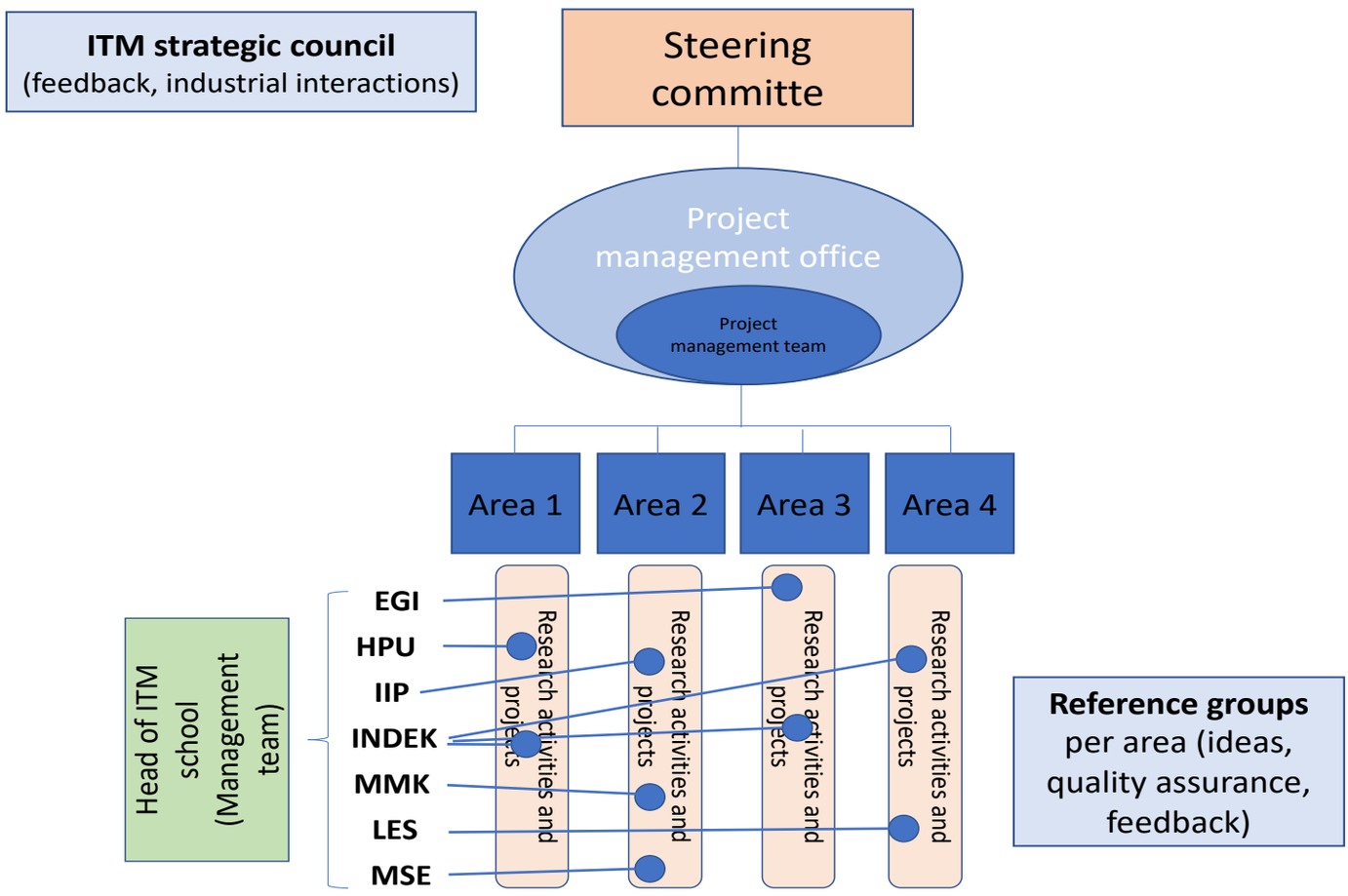
The IRIS Project is a research project executed at ITM School level and managed in accordance with best practices from contemporary research and practice. A project manager, a vice project manager and a project controller were appointed to ensure this.

The project management team has the overall responsibility and mandate to coordinate the work with the area coordinators towards the IRIS project's objectives - within the project's allocated financial resources and time frames. Which means responsible for the IRIS financial decisions and proactively lead both the IRIS project so that its goals are achieved within budget.

The project also has a Steering Committee that meets once per semester, comprising of:

- Head of the ITM School (chairman of the steering committe)
- The Head of Administration
- One representative from the coordinators'

Each area in the IRIS project is also supported by a reference group consisting of other experts that adds competences to the project team without being formally assigned to it,or have any authorization to govern it.



Appendix F: Financial outcome per area

Radetiketter	Summa av Projektledning / Koordinator-kostnader	Summa av EGI	Summa av MMK	Summa av IIP	Summa av MSE	Summa av LES	Summa av INDEK	Summa av HPU	Summa av Budgeterade Total kostnad på IRIS inkl OH 2020-2027
Area 1: Industrial Transformation through sustainable digitalization	1 921 016	1 165 385	3 667 355	5 254 886		283 799	3 154 236	4 367 707	19 814 384
Area 2: Integrated mechanics, components and materials design	1 151 944		3 332 482	3 500 610	7 459 814			1 089 272	16 534 122
Area 3: Sustainable Energy Systems – Technology and Business Perspectives	1 621 688	9 746 397	809 048	2 691 628	3 980 477		5 197 051	1 693 113	25 739 401
Area 4: Innovation management, eco-systems and entrepreneurship	1 287 230	552 376	3 659 969			2 083 847	2 983 777		10 567 200
Projektledning	1 899 079					522 395			2 421 474
Totalsumma	**7 880 957**	**11 464 158**	**11 468 854**	**11 447 124**	**11 440 290**	**2 890 042**	**11 335 065**	**7 150 091**	**75 076 582**
Inbetald Samfinansiering December 2023		24 158	28 854	7 124	290	42		91	
Totalt nyttjande av IRIS-medel	**7 880 957**	**11 440 000**	**11 440 000**	**11 440 000**	**11 440 000**	**2 890 000**	**11 335 065**	**7 150 000**	**75 016 023**

External funding generated by IRIS

Area	Sum of Total Budget, SEK	Sum Funding to ITM, SEK
Area 1	97 832 737	23 162 893
Area 2	269 013 647	73 344 788
Area 3	274 703 785	68 075 939
Area 4	7 365 000	4 155 087
Sum total	**648 915 168**	**168 698 707**

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